Gestural Patterns: A new method of printed textile design using motion capture technology

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Abstract

The aim of this research is to develop a new method, Hybrid Printing System (HPS) to explore digital craft methods to create surface patterns for printed textile design. This novel method of creating 'handcrafted' prints is a result of the integration of two technologies such as motion-capture (MOCAP) and digital textile printing (DTP). The research towards such an innovation required a current, historical, contextual and experimental study of use of motion capture in Art &Design.

The research contextualises the hand and its relationship to digital crafting methods in printed textile design, the digital medium and the process of audience participation in printed textile design to create a new conceptual framework balanced in practice and theory. The practical research then develops three new methods of motion capture such as, motion tracing, motion sensing and motion tracking to generate gestural motifs and gestural patterns.

This thesis and the accompanying set of experimental work demonstrates that HPS culminates in developing new aesthetics through a new mode of creation in a new medium, which will impact the user, the designer and the product as a part of the cyclical process. HPS is an advancement of printed textile design, centred in active participation of its audience at the generative stage of design. This results in a shifting role of a designer and subverts the current model of printed textile design practice. HPS is a democratic design process where the participants design for themselves, have their own voice, which induces a sense of community, togetherness and harmony in the creative process.

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Thanks are extended to my friend and peer, Dr. Guy Birkin who contributed his considerable expertise to the proofreading of this thesis.

I would also like to thank Elvira Roberts for her professional assistance in translating " The Tiger" in British Sign Language.

Finally, I would like to give special thanks to all my friends and family who have encouraged and supported me, in particular my mother Mandakini Paramanik, for maintaining her faith in me, my best mate, Amit Gupta to share difficulties and help me see the things that matter.

This thesis is dedicated to the memory of my father Dr. Sudhir Chandra Paramanik (1950-2008), and wishes to seek his eternal blessings.

Foreword

A DVD accompanies this thesis; however, it is not necessary to access the information on the disk in order to read it. Where appropriate, the disk has been referred to in the text as a source of extra information.

Included in the DVD are: Digital video films of the final experiments, and Elvira Roberts's professional translation of William Blake's poem "The Tiger" in British Sign Language.

Glossary of Acronyms

2D - Two Dimensional

3D - Three Dimensional

6DOF - Six Degree of Freedom

A.P.O.C. - A Piece of Cloth

BSL - British Sign Language

CAD - Computer Aided Design

CAM - Computer Aided Manufacturing

DPTD - Digital Printed Textile Design

DPT - Digitally Printed Textile

DTPT- Digital Textile Printing Technology

ENIAC - Electronic Numerical Integrator And Computer

F - Female

GUI - Graphic User Interface

HCI - Human-computer interaction

HPS - Hybrid Print System

M - Male

NVC - Non-Verbal Communication

NTU – Nottingham Trent University

MOCAP – Optical Motion Capture Technology

PNG - Portable Network Graphic

QTM - Qualisys Track Manager

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Chapter 1

INTRODUCTION

1.1 Personal Background

As an alumni of Pearl Academy of Fashion, New Delhi, India (1997 -1998) having studied textile design, I joined the department of Fashion and Textile Design as a Lecturer to teach computer-aided -design (CAD) to both undergraduate and postgraduate students. Apart from teaching, I was given opportunity to work on a variety of consultancy projects for the Indian Export Industry. During my tenure, I had established, Pearl Design Studio and served as a design consultant to the large textile export market. As a part of the studio my role was to research trends for a yearly workshop in trend forecasting. During my tenure in Pearl Design Studio I extended my textile design knowledge to work on graphic design projects such as Pearl Academy of Fashion's yearly prospectus. When I began working on the first prospectus the learning curve was steep. Following the success of graphic design project, I was offered a faculty exchange program with Nottingham Trent University (NTU) in 2003-04.

During my early career as a Textile Designer, I often faced difficulties in translating conceptual and complex printed textile designs into a viable means of production. Sometimes the patterns were too photorealistic which meant that they would require more than 16 to 20 colours. The Indian export industry caters mainly to the European and American markets and their main aim is to reduce cost so as to gain increased profits. Therefore, in many cases we had arguments that complex textile designs not suitable for the export market. These situations arose from the use of off the shelf digital image manipulation software available at that point. What could be visualised on the computer screen and could be printed on paper was not quite possible to be printed on textiles. In India, at this time, we still didn't have access to digital inkjet printing technology. Therefore when I had an opportunity to use digital inkjet printing technology I chose to work on a complete digital workflow.

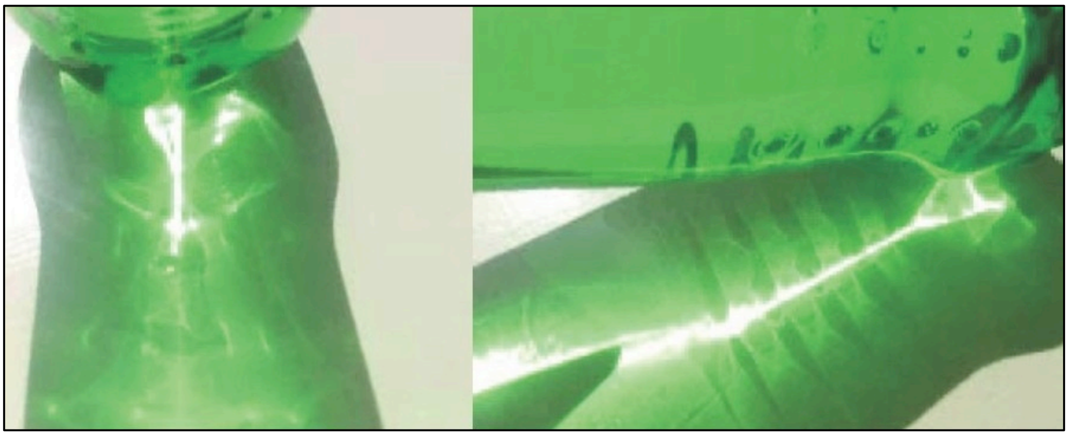

Fig. 1.1.1 Digital photographs of shadows casted by a PET bottle, (Paramanik 2003)

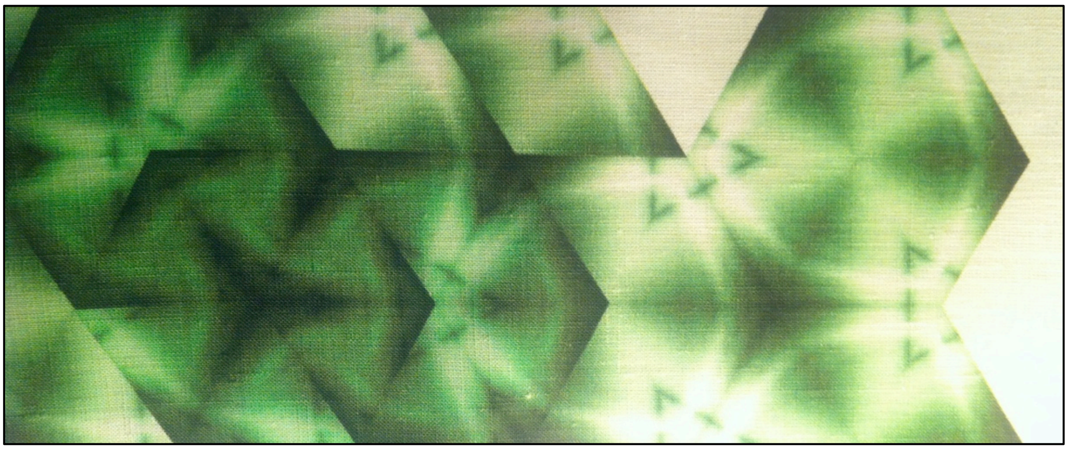

Fig. 1.1.2 Kaleidoscope-I, Digitally printed on 100% hemp fabric (Paramanik 2003)

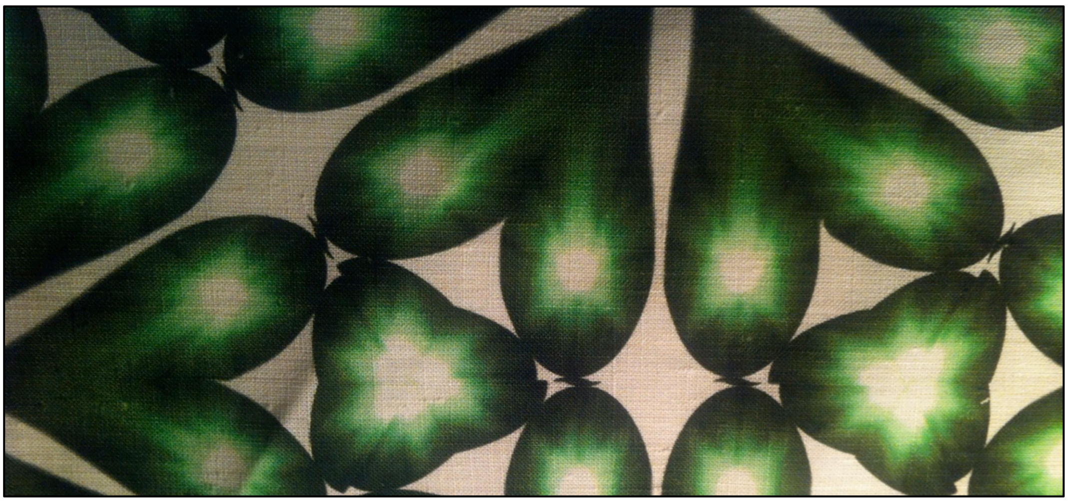

Fig. 1.1.3 Kaleidoscope-II, Digitally printed on 100% hemp fabric (Paramanik 2003)

This ‘workflow’ included the use of digital photography to acquire images, which were then digitally manipulated on a computer to be printed on textiles using digital inkjet printing technology (Fig. 1.1.1, Fig. 1.1.2, Fig. 1.1.3).

The project I completed during this exchange was to promote sustainability by recycling PET bottles. The concept of the project was to capture abstract photographs of the light shadows cast by the bottle and create patterns using them. I explored digital photography and digital image manipulation to create patterns for printed textile design. The designs were then printed at the Centre for Advanced Textiles, Glasgow School of Art using digital inkjet printer.

Reflecting on the outcomes of this project, I began to think if in the future such technology could change the way designers think about and practice textile design. That, designers would be able to materialize conceptual, photorealistic renderings, engineered images in a short period of time. I envisioned that in the future the challenge for Indian textile designers would be to produce authentic and handcrafted textiles using digital technology. In India, the common methods of printing textiles commercially are through block, screen and rotary methods, all of which require a translation process to develop the design idea into something that can be practically produced. Whereas, digital inkjet printing removed all the restraints that these methods imposed on my printed textiles.

Having returned to India in 2004 to continue teaching I was able to return to NTU in 2005, to complete a masters programme in Textile Design and Innovation. In this project I chose to research mark making and meaning and their connection to each other. I used digital printing and combined it with natural mark making techniques (Fig. 1.1.5). I also found the new method of creating pleated fabrics by heat setting silk and polyester fabrics using a microwave oven. The final outcomes of this project were a 3D textile sculpture using oak wood blocks, copper wires and pleated fabric pieces (Fig. 1.1.4).

Fig. 1.1.4 Krsna, 3D textile sculpture, (Paramanik 2005)

After my Master's I was offered an opportunity to work by KJAER Global Ltd , a future trend forecasting company in London. While working for them on global trends

I was able to work on a project with mobile manufacturing company Nokia.. The company, at this time, were interested in emotional design, their aims for consumers in the future was based upon looking at more experiential and interactive approaches to technology . One of the mottos of the company was, “The future is not some place we are going to, but one we are creating. The path is not found but made.”- Annalise Kjaer, Kjaer-Global Ltd. It was during this time that I began in early 2007, writing my research proposal towards a PhD in printed textile design, which bought together my interests in printed textiles and the progression of digital and mobile technologies.

Fig. 1.1.5 Coin Pattern, digital print combined with natural rusting process (Paramanik 2005)

1.2 Research proposal

In search of creating new visual imagery for printed textiles and finding an exploratory method of creating surface patterns, my interest in ‘pattern formation in natural sciences’ combined with my previous knowledge of working on CAD/ CAM in fashion and textile industry has been a great stimulus. The research proposal towards a PhD was submitted, which aimed to investigate ‘Digital Craft’ with an extensive use of Computer Aided Design (CAD) to create digital print patterns with data generated from motion sensing devices, to create “one-off” textile prints.

The research that was carried out specifically investigating the use of digital technology in textile design found that the generative ideas in pattern construction could harness a creative use of technology and link with the traditions of printed textile design to create a radical new style (Bunce, 1993). It became clear that aspects of digital craft had been explored by academic researchers who had questioned different aspects of this new powerful technology and its impact on: the design process, creative possibilities and the visual language of this field. Briggs (1997:174) questions what happens when computer aided textile design is approached as a media, rather than as a tool, and argues that it diverges established traditions and styles and contributes to a 'new visual language'. Townsend (2003) uses technology to approach the assimilation of 2D garment shapes with 3D visualisations, through a simultaneous approach to the body, thus the cloth and print result in a print pattern that is empathetic with the natural body shape. Carlisle (2005) develops a new design strategy of constructing non-repeating patterns by computer programming and simultaneously printing them onto textiles to create individualised prints. The haptic connections between the remembered physical experience of the hand, and the generation of digital images based on specific thematic memories, reveal the ways in which metaphors can combine physical experiences to generate novel ideas for textile prints is revealed by Treadaway (2006). The Textile Futures Research Group, University of the Arts, London work considers the versatility of digital technology to replace traditional craft techniques whilst retaining the beauty and quality of hand crafted design (Bowles, Isaac, Delamore, Earley, Harris et.al). Or as an alternative way for surface design, creation & integration of digital print patterns on ceramic surfaces that is currently being explored by the *Autonomatic* Research Cluster, University of Falmouth (Bunnell, Marshall, et al). Isaac's research at the London College of Fashion in 2006/ 07 integrated 3D body scanning, automatic pattern generation, digital printing and digital embroidery to design one-off fitted and digitally printed jeans (Bowles & Isaac 2012 : 20).

While digital printing can be used to make one-off fitted designs, the technology can also be used for mass customisation. Sportswear brands such as Nike and fashion designer, Anya Hindmarch use the Internet as a vehicle for mass customisation, providing customers with the ability to individualize and build a product by allowing them few options to choose such as colour, pattern and image.

This emerging 'digital craft aesthetic' evident in these approaches and practices are creating entirely new conceptual print patterns exploring the hybrid connections or realms between digital/virtual and hand/real expressions, and moving beyond usage of the tools to simply aid in the speed or ease of production (Campbell 2007).

1.3 Research questions

The research hypothesis posed is based on a set of research questions such as; can motion capture technology be seamlessly integrated with CAD to produce 'virtual imagery' for printed textiles? Could the use of CAD in transformation of data generated from natural body movements to a visible print lead to a new method of creating patterns for printed textile design? Will the above-mentioned method change the process of printed textile design? For example, instead of drawing stylised motifs from visual sources, designers could capture body movements of a group of participants and transform them to a rhythmic set of patterns, which can then be printed on to fabrics by using digital printing technology. Can such design and production methods be employed to create bespoke textile prints? The research questions culminate into a hypothesis, which is as follows: *Motion capture technology can be harnessed to provide imagery for the use in the design of printed textiles, and connected to inkjet technologies to create a hybrid printing system.*

1.4 Aim of the Research

The main aim of this research is to create a new method of printed textile design by integrating motion-capture technology and digital inkjet printing of textiles.

This aim is then further expanded into:

To create a Hybrid Print System (HPS) for printed textile design that incorporates integration of two diverse technologies motion-capture technology and digital inkjet printing of textiles.

To use the HPS to demonstrate that hand gestures of a participant will generate a motif, which is then designed as patterns for printed textile design.

To evaluate the HPS by qualitative analysis of the technical process, aesthetic qualities of the printed textile outcomes.

1.5 Objectives of the Research

In order to achieve these aims; the following research objectives were explored:

To critically review and analyse recent work within the field of printed textile design, undertaken by other academic researchers, practitioners and commercial industry, to gain an understanding of the field and contextualize the research.

To access and investigate motion-capture technology and digital inkjet printing on textiles, which will inform the experimental phase of the development of HPS.

To use the insights revealed in all strands of the project to inform the creative practice, enabling the exploration and development of effective strategies for the digital image generation, image manipulation and designed patterns for printed textiles.

To identify and evaluate the effectiveness of HPS in peer review following conference presentations and publication of papers, posters as well as the exhibition of artifacts, resulting from practical investigations.

To set out in this thesis a full account of the project, including experiments, findings and proposals for future research.

1.6 Rationale and scope of research

The research is rationalised through a study of historical development of techniques of movement capture through 'Pre-Computational period' photographic tools (Marey, 1873 & Muybridge, 1887) and post-photographic digital constructions in fashion and textiles, integration of motion-capture techniques and virtual reality has resulted in representation of non-dimensional form in virtually printed garments, Digital Reflection (Morrow, Du Preez & Thornton-Jones, 2004), (Harris, 2000). The combination of such emerging technologies in Telematic Dress & Wearable Performance (Birringer & Danjoux 2005, 2009) capturing body movements of a performer (fashion performance) to interact virtually with another 'absent body' in a dispersed location. It was found that within this work there is a 'convergence of digital technology' as philosophized by Michael Century (1999) as such categories of work bring us closer to the idea of *Gesamtkunstwerk* or 'total work of art' (a term attributed to the German composer Richard Wagner) meaning an artwork which is a synthesis of music, theatre, and the visual arts (Marshall 2008: 68).

The research then contextualises 'hybrid practice' in printed textile design to explore new image capture methods and develop visible patterns from invisible body movement patterns. This led to the study of body movements such as; gestures in non-verbal communication (Michael Argyle, 1975) can be captured and expressed visually as print patterns.

A set of experiments was conducted to test if capturing such gestures (encoding) can create print patterns (decoding) and if they have a relationship between them (4.3). Critically reflecting on these experiments showed me the way forward. The implications those were found for future research were:

1 Capturing hand movements and manipulation of the data resulted in a variety of visually abstract designs to be printed onto textiles but they would not have a relationship to non-verbal communication as it was proposed.

2. Considering hand movements in relation to social interaction is a wide area of research and it would invite more complex studies to be undertaken, which were out of my own expertise. It would be challenging to underpin hand movements so that they can have a direct relationship to printed textile design.

3. The outcomes of some experiments which dealt with open source programming (4.3.7) were distorted by their separation from the gestural approach I intended to explore. Although the printed outcomes were aesthetically pleasing and could be seen as tangibles, they did not adhere to the original idea of translating gestures as print patterns and their recognition.

4. Re-visiting the rationale of the proposed research found instead of revealing gestures made in a conversation, it should be directed to other means such as describing an object, describing a shape, gestural drawing of the object, representing emotions and drawing in 3D space?

1.7 Methodology

The interdisciplinary nature of this practice-led investigation led to a research approach that encompassed historical, contextual, experimental and practice-based research methods. The approach is underpinned by current debates and out comes in digital printed textile design for fashion and interiors. Current publications addressing digitally printed textile design provided valuable insights into recent and on-going developments in practice-based research.

1.7.1 Research *through* Art & Design

In his seminal work, *Research in Art & Design* (Royal College of Art, Research Papers 1:1, 1993/94) Christopher Frayling, suggested practice-led research in art and design could be categorised in three main categories. They are:

- Research *into* art and design

- Research *through* art and design

- Research *for* art and design

These categories are adapted from Herbert Read's model of teaching for, through and into a discipline to research. Research *into* art and design would encompass studies where art and design is the subject of the research. It includes theoretical perspectives on traditional, historical and aesthetic studies in these fields. Research *through* art and design would use creative interdisciplinary as an integral part of the research, the vehicle of the research and a means of communicating the results. It could include developmental research such as, customizing an accepted technology and documents experimental work. Research *for* art and design would result in creation of artefacts that embody the thinking and the results of the research. Frayling considers this later category the most problematic.

This project draws upon Frayling's proposition of research *through* art and design, and it is concerned with research towards a developmental and innovative work (customizing a piece of technology to do something no one had considered before, and communicating the results). It is concerned with research towards a developmental and innovative work of customizing motion-capture technology to generate patterns in printed textile design. This research is also concerned with creating alternative ways of motion capture by using digital video and photography.

This doctoral thesis is being used as a vehicle to communicate outcomes of the research and not artefacts created through practice.

1.7.2 Reflective Practice

In *Visualizing Research: a guide to the research process in art and design*, Gray and Malins (2004: 20) locate the position of a researcher as

"…the practitioner *is* the researcher, the practitioner identifies researchable problems raised in practice, and responds through aspects of practice."

They further discuss the multifaceted role of 'practitioner-researcher' in research such as, 'a practitioner is generator of research materials', 'a practitioner as self-observer who acts through reflection on action' and as 'a practitioner as an observer of others for placing the research in context'.

The 'practitioner-researcher' generates research materials such artworks/designs. In this process he also plays the role of being a participant in the research. Which means being involved in stages of idea generation, process and making. The decision being made in these stages are those of the researcher, which may have been informed by practice in the past. This acknowledges subjectivity, involvement, and reflexivity of the 'practitioner-researcher'.

Being a self-observer and an observer of others recognizes that the 'practitioner-researcher' interacts with research material in two perspectives, from inside and from outside. Therefore, the generation of knowledge is negotiated inter-subjective; context bound and is a result of personal construction. In order to make research material accessible and articulate, the research methodology should therefore be explicit and transparent and transferable in principle.

By reflecting on the design practice, this knowledge in action becomes a form of research. Design is a 'reflective conversation with the materials of a situation' (Schön 1983:78). However, to become a valid form of research, there should be some reflection and evaluation of the aim of the practice, the processes and the outcomes.

The research methodology draws upon my own design practice, which is creative, experimental, self-reflective and iterative as an approach towards naturalistic inquiry in relation to socio-technological issues that build up the HPS and explore 'what's out there in an external 'realist' sense. This approach is much more pro-active, reflection-in-action (Schön 1983 in Gray & Malins 2004: 22).

1.7.3 Creative Practice

Creative practice could be interpreted, as an individual's creative activity or perhaps 'making', or it could be that of a facilitator and disseminator. In this research, the creative practice as a research method aims to generate new information by gathering and structuring information, and critical evaluation of the information.

In defining the method of practice, Gray and Malins (2004: 104) state "developing and making creative work as an explicit and intentional method for specific research purposes, gathering or generating data, evaluation, analysis, synthesis, presentation and communication of research findings".

Practice within an academic research framework, which is accessible, transparent and transferable (in principle if not specifics); the work might embody the research concepts, provide visual evidence and/or illustrate research findings in some way.

Advantages of this method is a means of generating new data through real experiential activity that's researching and learning through doing to develop 'deep' understanding; the practitioner researcher has informed perspective on issues relating to practice.

1.8 Research methods

This section details how this research has been conducted. Firstly, a list of generalized research methods is documented and then a diagrammatic explanation of the research journey undertaken.

1.8.1.1 Visualisation

Visual thinking is making visual ideas through a range of techniques in order to explore research project issues and/or present research findings. In this research visual thinking is aided by drawing in all forms for example diagrams, concept maps, mind maps, flowcharts, storyboards etc.

1.8.1.2 Digital Photography

In this research, digital photography is used to capture images as visual data and use them further to generate patterns for printed textile design (section 4.4 – 4.5). It is also used extensively to document research findings especially to photograph the printed textiles in Chapter 4 -7. The images are stored in specific folder with details such as name of the event, date and time for analysis during the research (Fig. 4.4.1-4.4.5).

1.8.1.3 Digital Video

Similar to digital photography, digital video is used to capture video film as visual data and use them to generate patterns for printed textile design (section 4.6 – 4.7). It is also used extensively to acquire data of live events in detail such as experiments in Chapter 7. The video could be replayed with details of sound and vision given frame by frame, forwards and backwards. In this research digital video is used as an analytical tool that also provides evidence of the research in progress.

1.8.1.4 Digital sketchbook

In this research, digital sketchbook provides the research with knowledge of how it is done, why it has been done and the thought process. The digital sketchbook is a record of exploration, experimentation recorded with intention, outcomes and reflections in Chapter 4 -7. Software such as Adobe Photoshop, Adobe Illustrator, Microsoft word etc. is used to create the digital sketchbook.

1.8.1.5 Processing: Open source programming language

In this research, Processing, an open source programming language and environment is used to develop an alternative method of motion capture system (5.2 - 5.5). Although other programming languages were available, processing was a choice because it is free to download and open source. It facilitates programming to create interactive programs using 2D, 3D or PDF output and it operates on both Mac OS X and Windows.

1.8.1.6 Motion Capture Technology (MOCAP)

In this research, Qualisys motion capture system is used. It is located in the Performance Analysis Laboratory in the University's School of Science and Technology.

It is equipped with Seven Pro-reflex MCU 500 digital infrared cameras that focus on body movements, recording the motion and images of infrared reflective markers attached to key landmarks on the body. The location of each marker can be accurately mapped in 3D up to 500 times every second.

The resultant data, including linear and angular position, velocity and acceleration are analysed by a network of computers. Movements can then be mapped on specialist software to improve technique and movement such as Qualisys Track Manager (6.2.1).

1.8.1.7 Digital Inkjet Printing on textiles

In this research the practical outcomes of experiments; printed textile designs are printed using a digital inkjet printer provided by the University. The Digital Ink jet printer is Mimaki TX2-1600's and is located in the university's Digital Printing Bureau. It uses piezo electric drop on demand technology, similar to that of a standard inkjet printer. It uses reactive dye in eight colours such as, Grey, black, cyan, blue, magenta, light magenta, yellow and orange. Reactive dyes work only on fabrics made up of cellulose-based fibres such as cotton, silk, linen and viscose. The Bureau supplies the pre-coated fabrics and this is included in the costs of the printing.

1.8.1.8 Exposition and peer feedback

During this research in order to receive peer feed back, participation in conferences especially related to the field of study, publication of research papers, poster and demonstration of prototypes was required to receive peer feed back. The feedback received is then used to inform and shape the research (Appendix II – III).

1.8.1.9 Research journey

A contextual review was undertaken to establish the area of research. The diagram (Fig. 1.8.1) shows that the contextual review explored three areas – digital craft in printed textile design, motion capture technology and non-verbal communication.

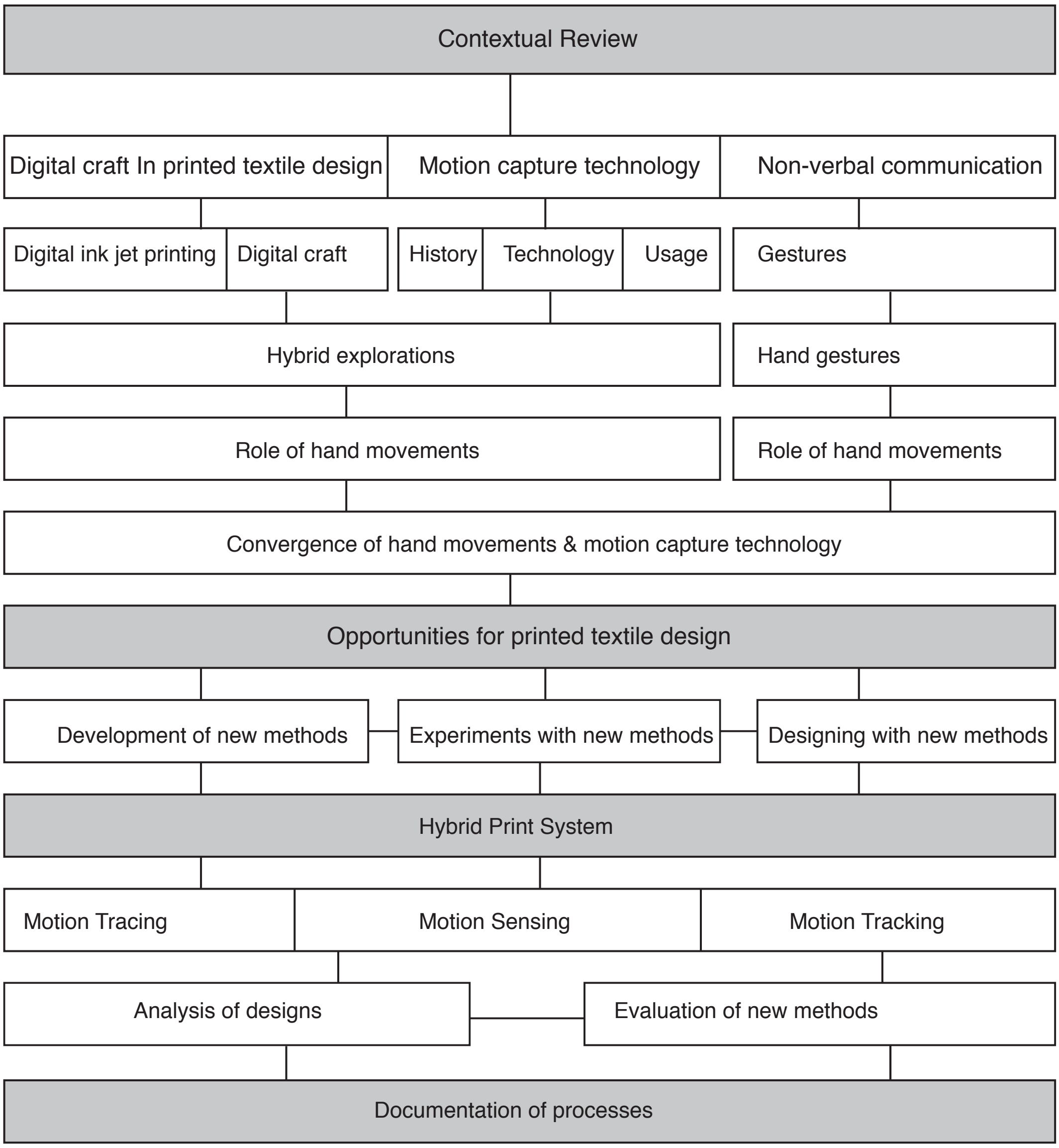

Fig. 1.8.1 Diagram showing research process undertaken

Through critical review, opportunities for inquiry were selected. These formed the initial questions for creative practice. As can be seen in diagram (Fig. 1.8.1), there were initially two main areas of enquiry namely hybrid explorations of digital craft and hand gestures. Research commenced initially by studying the role of hand movements common in both areas (Fig. 1.8.2). This was required to find convergence of hand movements and technology (3.7) as new opportunity for printed textile design. The theoretical research is documented in Chapter 2 & 3 respectively.

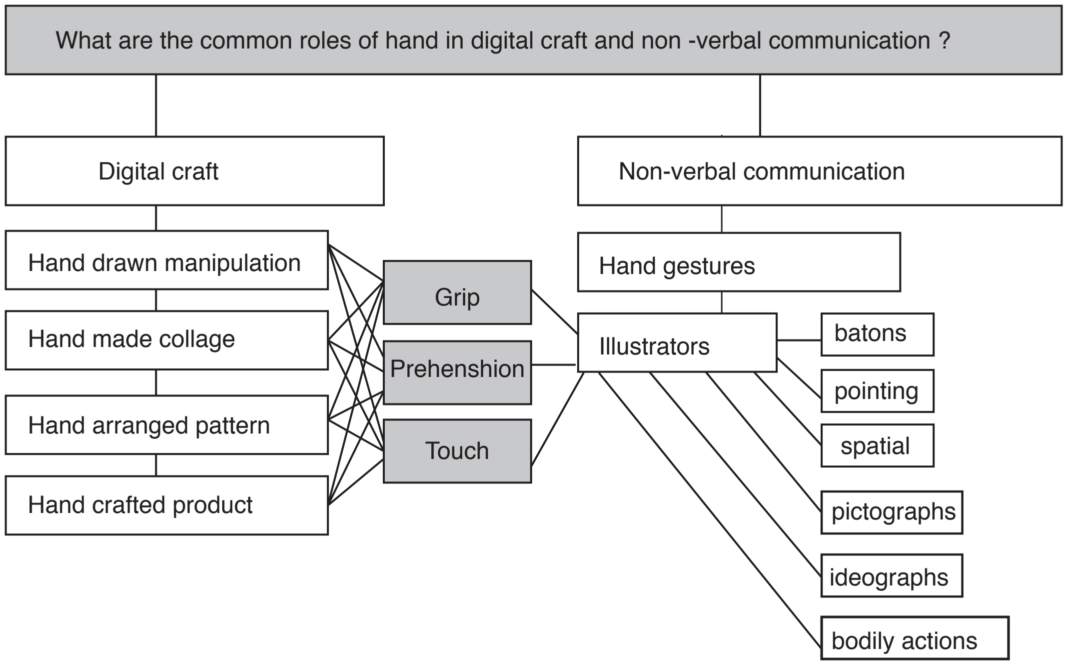

Fig. 1.8.2 Diagram showing overview of research for investigation into role of hand movements

After the research focus was found, practical research took place and experiments were conducted. Analysis of printed outcomes was conducted and a full description of the process was documented. This is evident in the practical research Chapter 4 -7.

Iterative cycles took place where an idea was explored through the construction of documented repeatable experiments. Reflection took place before, during and after each experiment. Where results were consistent with expectation, further iterations were made to confirm outcomes and refine new developments.

The documentation of experiments took the form of digital logbooks, which are custom and practice in design, and they are normally referred to as sketchbooks. These were recorded on experiment-to-experiment basis

• *Reflection-prior-to-action* - aims and intentions of experiments, questions to which answers were being sought and potential issues and problems that may arise

• *Reflection-in-action* - changes that were made to experimental set-up, observations that were made, ideas that occurred, new questions and problems that were encountered

• *Reflection after action* - results of experiments, observations, new questions and what to do next

The diagram (Fig. 1.8.3) shows an overview of research methods used to find out multiple ways visualizing hand gestures. Digital photography and video were initially selected as they have been intensively used in my own textile design practice. It was also required to find out alternatives to optical motion capture technology. A series of experiments were conducted as described in Chapter 4, 5 & 6.

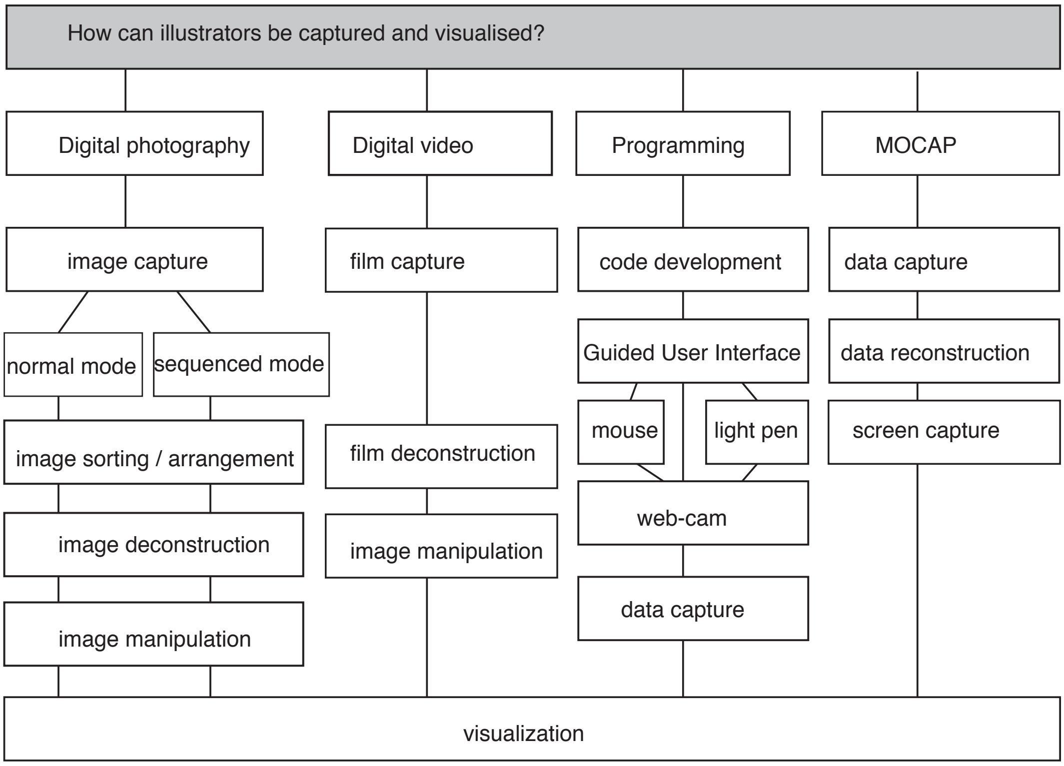

Fig. 1.8.3 Diagram showing overview of research for investigation into capture and visualisation of illustrators

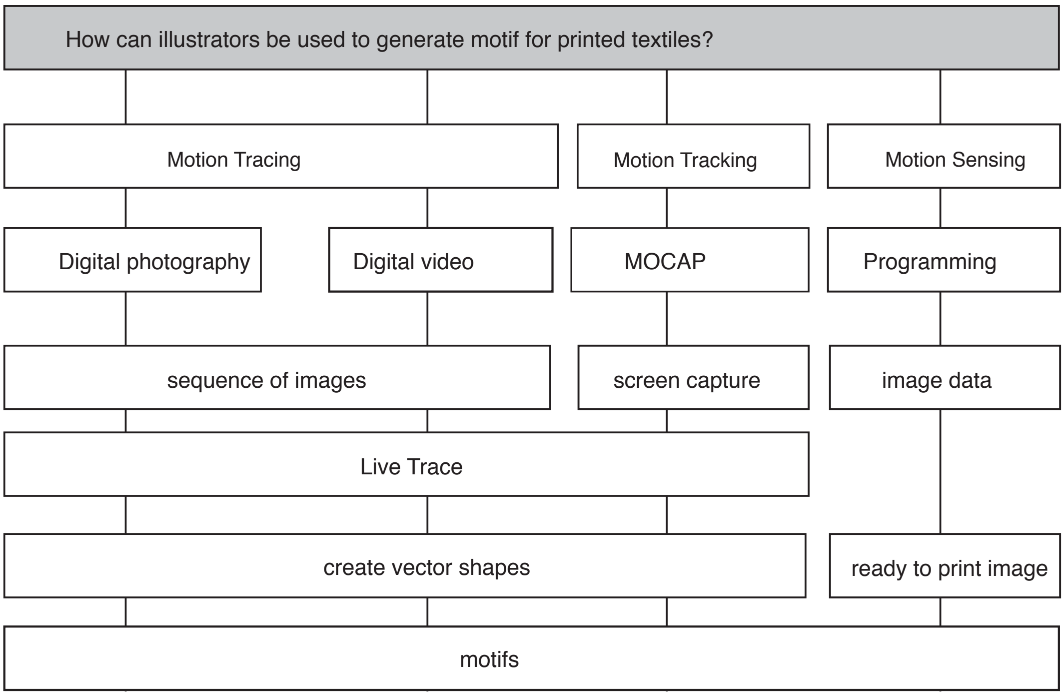

Fig. 1.8.4 Diagram showing overview of research for investigation into creation of motifs to be designed as patterns

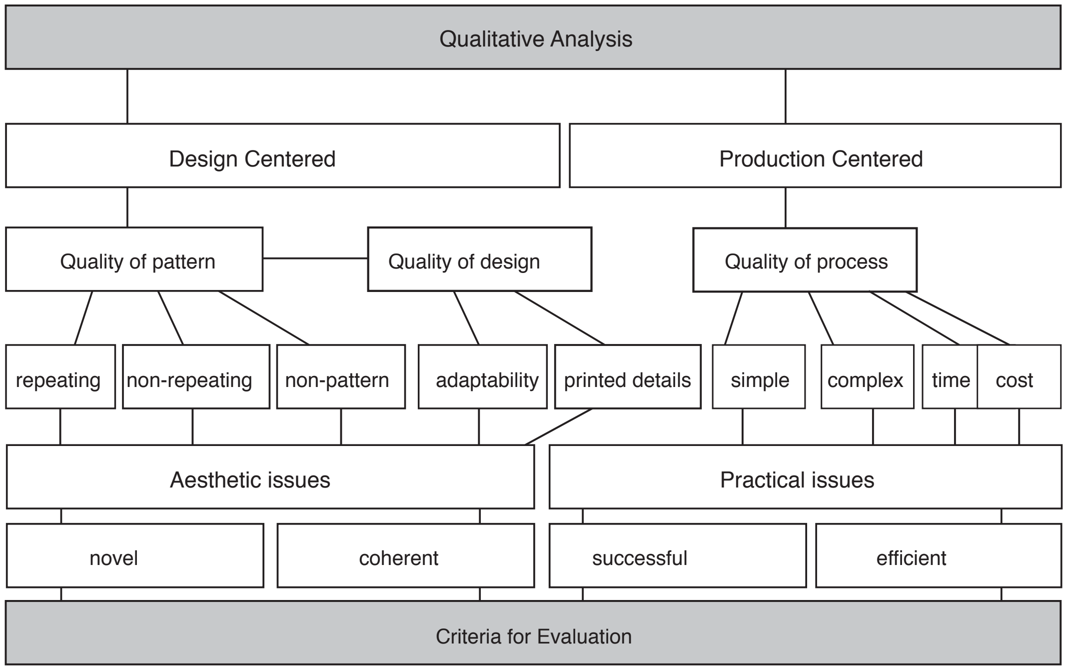

Fig. 1.8.5 Diagram showing overview of analysis and development of criteria for evaluation

Based on the outcomes of these experiments, three new methods of motion capture are created such as, motion tracing, motion sensing and motion tracking to be used in HPS to generate gestural motifs and gestural patterns for printed textile design (Fig. 1.8.4).

The printed outcomes such as gestural motifs and gestural patterns of motion tracing, motion sensing and motion tracking were then analysed for development of criteria for evaluation (Fig. 1.8.5). This is documented in the conclusion of Chapter 6.

1.9 The Chapters

The thesis is constructed in eight chapters. Chapter 1 introduces the background to the research during the construction of the research proposal including the hypothesis, research questions, rationale of the research, with aims and objectives of the project (1.2). It is followed by a discussion of Frayling's proposition of research through Art & Design. The implications for the research that were found out in the initial experiments are presented in a list format so that the reader is guided towards the outcomes at the end (1.7). The research carried out by research clusters such as 2D-3D in Nottingham Trent University, Textile Futures Research Group, University of

Arts, London, Autonomatic Research, Falmouth, Centre for Advanced Textiles, Glasgow in textile design and technological advancements is discussed briefly.

Chapter 2 considers and discusses the core theme of the research in 'Digital Craft in Textile Design'. The chapter is presented in a chronological order and it begins with the clarification of the term 'pattern' used in the field of research outlining the etymology, classification and how patterns are visualised i.e, the role of perception in visualizing patterns and the methods used by the practitioners to generate interesting imagery (2.2).

Section 2.4 discusses the development of ink jet printing in textile design including the role of imaging software.

Section 2.8 deals with Key developments in surface patterns aimed to technologies particularly abstract, kinetic, and spontaneous and discusses them precisely through Art Movements such as Dada, Futurist, Impressionist, Modern, Digital Art and artists Bridget Riley, Jackson Pollock, Lucienne Day. Towards the end of the section examples of designers has been included that articulates how these developments have been used by designers such as Projected Prints (Jacob Anke, Morrow), Subjective Mapping (News Knitters) and Algorithmic prints (tissue collection, Cait Reas). The next section documents the histories of motion capture, present and futuristic representations in relation to the creative industry (2.7). The theme that runs through out the chapter deals with patterns, what are they and how they have been incorporated in art & design which seems to be incomplete without understanding 'if there is a need' to create patterns. Section 2.6 documents the research into surface patterns in contemporary printed textile design by key fashion and interior designers, their approaches and outcomes. In this section the references are only made to the key contributions so that it is brief and precise.

The next section then deals with hybrid explorations of digital craft that has been developed through this research that deals with drawing in 3D space through optical motion capture (MOCAP), resulting in the changing roles of the designer and the participants are explained towards the end of the section (2.8).

Chapter 3 focuses on the theoretical basis of the research, which leads to the contribution of new knowledge.

In section 3.5- 3.6, the concept of digital craft and the role of computer –aided- design and integration of hand crafted techniques is contextualized and articulated through craft and theories of craft which deal with subtopics such as the hand, the medium and the object (Senett (2008), McCullough(1998), Dunn & Seago (1999), Manzini, Baudrillard ('The System of Objects', 1988),Virilio (1991, 1995)). Finally, how the philosophy has been adapted in printed textile design by practitioners in their doctoral research published prior to this research.

The notion of a 'hybrid' print practice is not directly associated within biological terms but is build upon as metaphor through the media theories by Marshall McLuhan (3.2). This section deals with the philosophical construction of the HPS in both micro level and macro level. There is a comprehensive discussion on the emergent properties of the HPS such as the changes in the process of printed textile design. These changes are than pointed out as a list of implications for the research.

The empirical part of the project aims to contribute to knowledge by studying the HPS through creative experiments as both a hybrid medium and a hybrid tool as a holistic approach. Chapter 4, 'Motion Tracing' documents the initial, experimental stage of the practical research. The experiments were centered on the initial idea, 'gestures in non-verbal communication (Michael Argyle, 1975) can be captured and expressed visually as print patterns' (4.1).

The experiments were contextualized through key concepts such as study of hand movements, capturing hand movements through digital and analogue means (digital film and photography), manipulation of hand movement images through vector software (Adobe Illustrator), computer vision combined with open source programming language (Processing) (4.2). Section 4.3 deals with clear and precise documentation of the seven experiments those were conducted in chronological order. The research found that there is a difference between visualizing patterns on the computer screen and printing them out. The concept of 'materialisation' i.e, printing on paper and fabric has been explained in section 4.4. It includes the decision making process that is required in image generation, manipulation, scale and choice of colours. Towards the end of the chapter, results of the experiments (4.5), qualitative analysis of results (4.6), conclusions drawn from the outcomes (4.7) and further experiments (4.8) are evaluated, which become the key factors in shaping the second set of experiments discussed in Chapter 5.

The Chapter 6 then contextualises the need to experiment with optimal requirements through the concept of Gestural drawing in 2D and 3D media, paper and space respectively. In doing so, a new design method originated, performance (solo, group) as a design method. The next section deals with clear and precise documentation of the experiments those were conducted in chronological order.

Finally, the conclusion shows how HPS has developed as a novel method of creating 'hand made prints' through the use of technology during the process of research by bringing together the concepts which run through the thesis, highlighting the appropriateness of the research methods, the multidisciplinary approach taken.

Then, the HPS, together with the design method and the design examples, which culminate in developing new aesthetics through a new mode of creation, are considered for their contribution to knowledge and wide-ranging usefulness to fellow researchers and practitioners. The thesis is completed by an exploration of future possibilities and directions for furthering the research.

Table of Contents

Chapter 2

DIGITAL CRAFT IN PRINTED TEXTILE DESIGN

2.1 Introduction

The purpose of this chapter is to establish the meaning of digital craft, which will be discussed in the forth coming chapters in the thesis. Digital craft, in this context, refers to either; the development of designs for printed textiles, which are explored, created and technologies with traditional forms of craft. Briggs (1997) argues that digital *media* relates to the use of computers and its peripherals in a holistic manner as both *tool* and *medium* and thus becomes both a process that needs to be mastered as well as presenting its own visual language. Some of the examples that I have chosen to demonstrate how the concept of digital craft has evolved belong to diverse fields of creative practice, such as music, sculpture and have been included so as not to miss out on iconic works of art during the period, that encapsulated either digital craft as a concept or within the process.

This chapter precedes, the theoretical chapter so as to build upon cohesion in arguments with practical research that will continue in the rest of the thesis.

The chapter explains the chronology of ink jet printing developments for textile design production, the role of software in ink jet printing in textile design, the roots of digital craft, and digital craft in contemporary printed textile design.

These sections are followed by an introduction to the history of motion capture technology and the concluding section of the chapter discusses and analyses the underlying connection between previous digital art practices (2.6) to current practices (2.8) in printed textile design this will help in creating arguments to support the Hybrid Print System in forth-coming Chapters 4 -7.

2.2 Pattern and repetition

The basic definition of pattern provided by (Bunce & Phillips, 1993: 6) is ‘a design composed of one or more motifs, multiplied and arranged in an orderly sequence, and a single motif as a unit with which the designer composes pattern by repeating it at regular intervals over a surface’. Similarly, (Grünbaum & Shephard 1989:204) have agreed that patterns may be described as repetition of a motif in the plane in a regular manner, subject to certain restrictions. Gell (1998:77-78) has pointed out the actual mathematical basis of all patterns as variations on only four ‘rigid motions in the plane’; to which repeated motifs can be subjected. These are, a) reflection, b) translation, c) rotation, and d) glide reflection (Fig. 2.2.1).

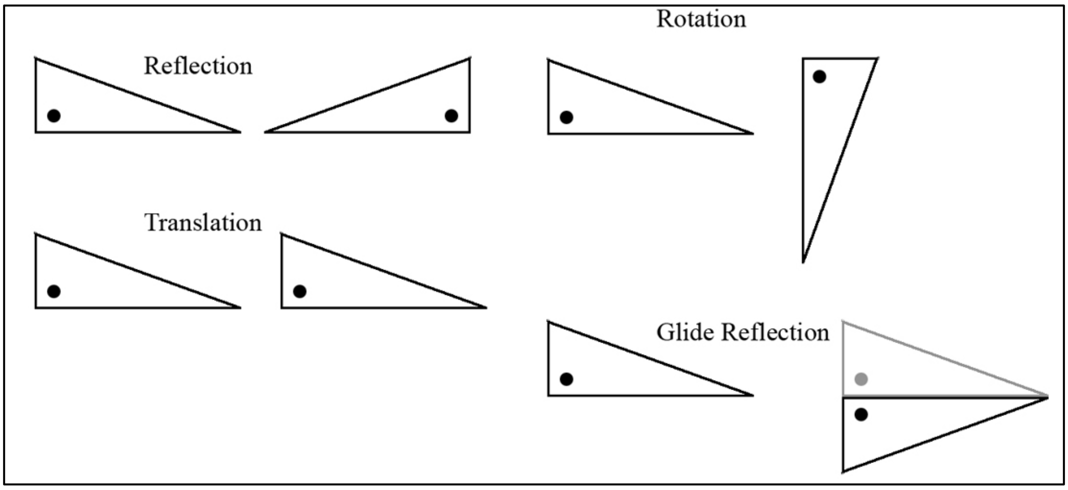

Fig. 2.2.1 The basic motions of pattern formation (Gell 1998:78)

Also, (Christie 1969: 1) stresses that a complicated motif is not a pattern, but it is a unit with which the designer may compose a pattern. Whereas, Carlisle (2005), has shown that non-repeating pattern exist but they need some form of continuity to be classified as pattern, meaning some consistency in the elements although the periodicity of their appearances within a pattern could be highly differentiated.

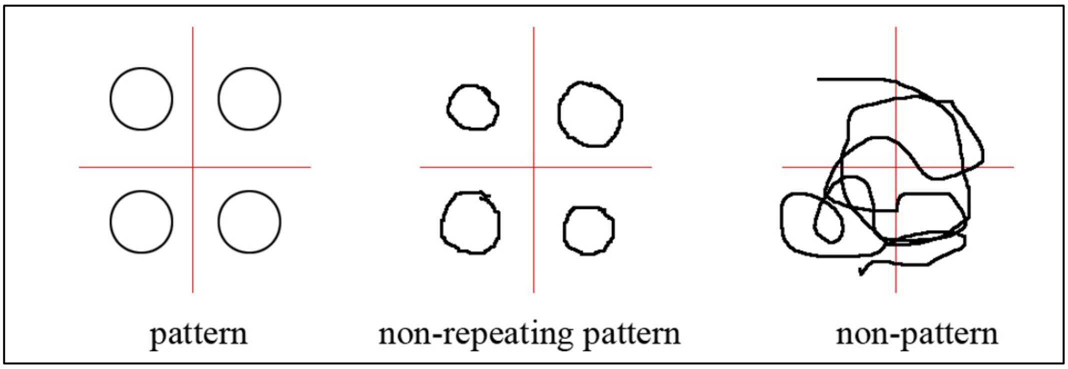

Fig. 2.2.2 Diagram representing pattern, non-repeating pattern and non-pattern

Drawing upon these arguments, the research defines non-repeating pattern as a similar motif but not exactly the same and presented within a regular grid (Fig. 2.2.2).

2.3 **The Development of Ink jet Printing in Textile Design**

Printing is the most prevalent method of decorating fabrics, because it is fast, cheap and offers a great variety of expressions (Riisberg 2007). With the invention of mechanized roller printing in 1783, printed fabrics became some of the first mass produced goods. And during the 19th century they played an important economic role and became a pivotal point in the discourse of ornament in the UK. Printed fabrics also introduced fashion to the lower classes, and affected the reversal to modern industrialized consumer societies (Forty 1986). In outlining the origins of digital textile printing technology Ujiie (2006, 12) states that digital printing evolved as early as 1686 when Edme Mariotte first suggested the basis for inkjet printing in his seminal work of fluid dynamics, *" Traité du movement des eaux et des autres corps fluids"* by observing drop formation of fluid passing through a nozzle. In 1748, in addition to

Mariotte's work Ebenezer Kinnersley demonstrated that electrical currents could pass through water. In the following year, 1749, l' Abbé Nollet did the earliest experiments with electrostatic ink drops on paper, and in 1867, Lord Kelvin (Sir William Thomson) received the first patent for inkjet printing system. In the 1920s and -30s some of the notable contributions to the progression of inkjet printing were made by Ranger and Morehouse (1928), Hansell (1929), Carlson (1938) and Gemscher (1938). Later, in 1959, first office plain paper copier with Xerox 914 was delivered (Ujjie, 2006: 2) During the 1960s and -70s inkjet printers were developed first for typewriters and later computers (Bunce 1999). In 1991, Stork marketed their first inkjet printer for sampling fabrics, and subsequently Canon/Kanebo presented a production printer in 1995.

Fig. 2.3.1 Gary Martin 1996 : *Malice* (Braddock & O' Mahony 1999)

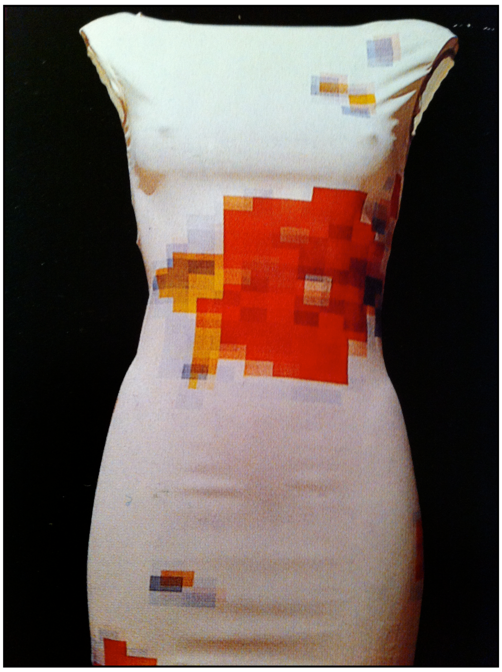

Fig. 2.3.2 Hussein Chalayan, S/S 1996, fabric designed by Eley Kishimoto : Pixelated cotton dress (Braddock & O' Mahony 1999)

During the early years, in 1996, Textile designer, Gary Martin created *Malice* by using CAD programs such as Infini-D, which was then printed on silk twill by computer jet printed by Stork BV in the Netherlands using Reactive dyes (Fig. 2.3.1). To create a striking three-dimensional effect he used photorealistic rendering of the thorn like features, which is further heightened, by use of silk as a base material and Reactive dyes. Hussein Chalayan's pixilated cotton dress with fabric designed by Eley Kishimoto in which photocopies of hand drawn flowers were scanned into a computer to enhance colour and were pixilated (Fig. 2.3.2). The design relies upon the concept of 'proximity' to be interpreted, which is the key to perception for the natural human eye. From a distance what appears to be a blurred blob of colour also reveals itself as a floral motif at a closer look.

Although computer aided design was still in infancy during these years the above-mentioned works clearly shows designers affinity towards working with these technological advancements. Since then, design and production technology has constantly improved, and the use of inkjet has increased worldwide (Riisberg 2007).

In Europe Italian Mantero and Swiss Jacob Schlaepfer have been pioneers in digital printing of high-end fashion fabrics. Mantero started in 1999 and by 2005 10% of the production was done by digital printing (Mantero 2005). Since 2001 Jacob Schlaepfer has utilized inkjet on paper -followed by a dry heat process transferring the decoration to polyester fabrics. *Wassily* by Jacob Schlaepfer (Fig.2.3.3) was digitally printed with its design reference to the 20th century fine artist Wassily Kandinsky. It is designed for interior textile, with its myriad of hallucinating endless colours gradations it not only captures the spirit of Kandinsky but also inspired others to adapt technological innovation such as digital printing.

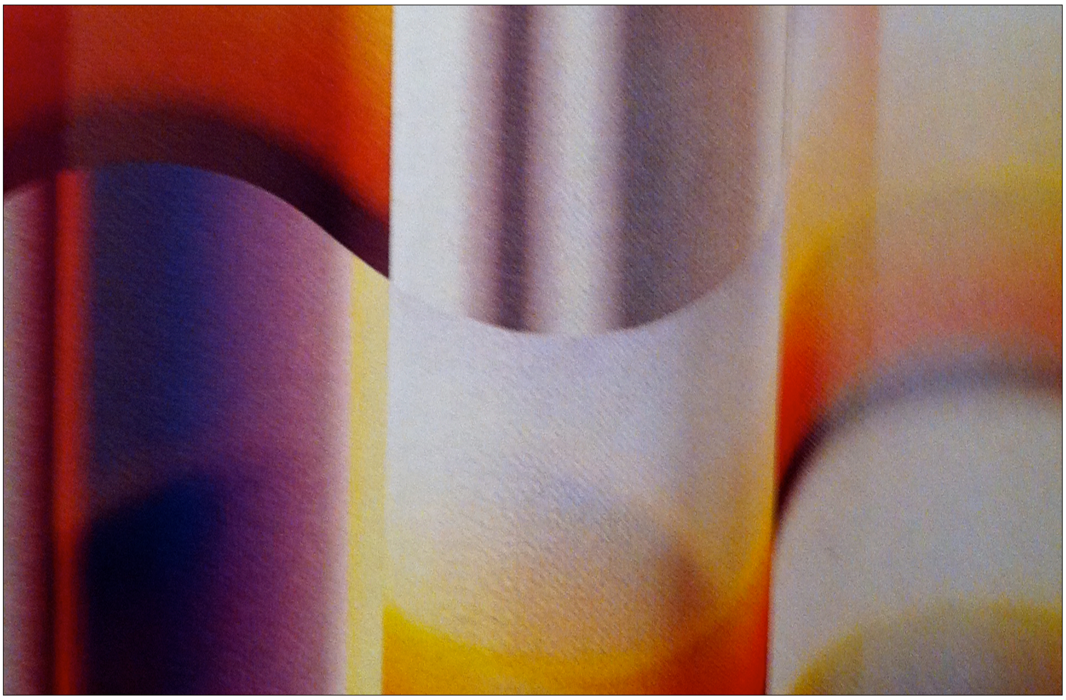

Fig. 2.3.3 Jakob Schlaepfer 2004 :*Wassily* (Braddock & O' Mahony 2005)

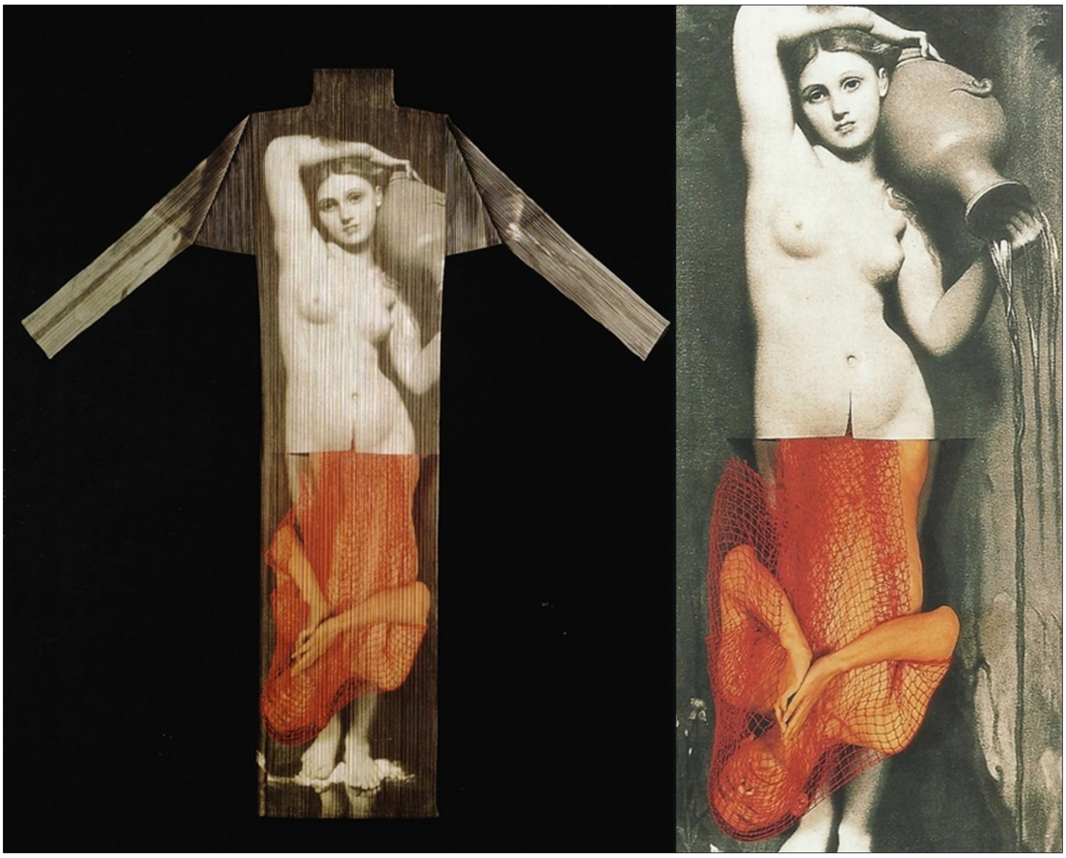

Fig. 2.3.4 Issey Miyake and Yasumasa Morimura A/W 1996 – 97: Guest Artist Series No.1 (Braddock & O' Mahony 1999)

Fashion designers such as Issey Miyake and Jean Paul Gaultier embraced digital printing technology at its early stage starting in the late-90s. For example, in Issey Miyake and Yasumasa Morimura A/W 1996 – 97: Guest Artist Series No.1 (Fig. 2.3.4) Morimura joined the image of his own body, to that of an idealized, neo-classical beauty from the oil painting 'La source' by French artist Jean-Auguste Ingres in a form of photographic collage and was printed using heat transfer. High-end designers such as, Prada, Paul Smith, Alexander McQueen, Jonathan Saunders and Hussein Chalayan started incorporating digital printing technology in their collections. However, inkjet printing has also become profitable to the middle market –the American print service First2Print and Seiren Viscotec from Japan have developed middle market clients. The emergence of large format digital textile printers, such as Mimaki in 1998, and then the release of industrial scale printers in 2003 by companies such as Konica, Minolta, Regianni, Robustelli and Dupont. Lately, the introduction of high speed ISIS printer by OSIRIS in 2008 means that fashion and textile industry might use digital printing in large scale production in future. (Bowles & Isaac 2009: 12) & (Briggs-Goode 2011:126)

The Digital Ink jet printer used in the research is Mimaki TX2-1600's and is located within Nottingham Trent University's School of Art and Design. The Mimaki uses piezo electric drop on demand technology, similar to that of a standard inkjet printer. It uses reactive dye in eight colours: grey, black, cyan, blue, magenta, light magenta, yellow and orange. Reactive dyes work only on fabrics made up of cellulose-based fibres such as cotton, silk, linen and viscose. The service supplies the pre-coated fabrics and this is included in the costs of the printing.

2.3.1 Role of software in Ink jet Printing in Textile Design

In parallel to the development of inkjet printing in textile design, software to support digital creation was also being developed. Companies such as Lectra Systems and Nedgraphics provided specialist software to be used in printed textile design focused on translating textile design processes such as repeat and colour palettes which were essentially pre-production tools. Now, software; such as Adobe Photoshop and Adobe Illustrator not just offer many of these textile design functions, with different nomenclature but photographic image manipulation such as layers and filters. (Briggs-Goode 2011:117-122) By using filters and layers, textile designers are creating abstract surrealistic images as patterns exploiting the 'boundless' possibilities that are offered by inkjet printing technology.

2.4 Digital craft

The term 'digital craft' is being widely used in describing a product developed using computer-aided design and manufacturing systems. McCullough, (1998: 23) states "the first glimmer of digital craft, and the main breakthrough to popular computation as we know it, was the introduction of pointing. "Direct manipulation" is a term coined in 1983 by software designer Ben Schneiderman to describe the principle of pointing at our work with the mouse. Also, Oxman (2007:1) addressing fabrication-based design suggests that, digital craft is a skill acquired through customization processes and it may contribute to fabrication-guided design protocols. Considering these two parallel arguments, the research defines digital craft as a method, which is developed by working extensively in iterative digital environment to create an artefact.

2.5 **The Roots of digital craft**

The roots of digital crafting methods lie in the technological advances in art and design that have been made since the 1946. ENIAC (Electronic Numerical Integrator And Computer) was launched as the world's first digital computer during World War II. It was after this point that creative uses of computers began to be considered.

The development of Computer art is often considered to begin with Ben Laposky's *Oscillon 40, Plate1* (1952)

Fig. 2.5.1). Laposky used analogue methods of photography to capture algorithmic signals generated by an electronic machine (Beddard & Dodds 2009). At that time of the emerging global Computer Art movement, the groundwork for much of today's technology and its artistic exploration was laid such as the development of Graphic User Interface (GUI) by Douglas Engelbart (1968), Ivan Sutherland and Alan Kay (1970), which extended the user's hand movements into the two dimensional, pixel based data space.

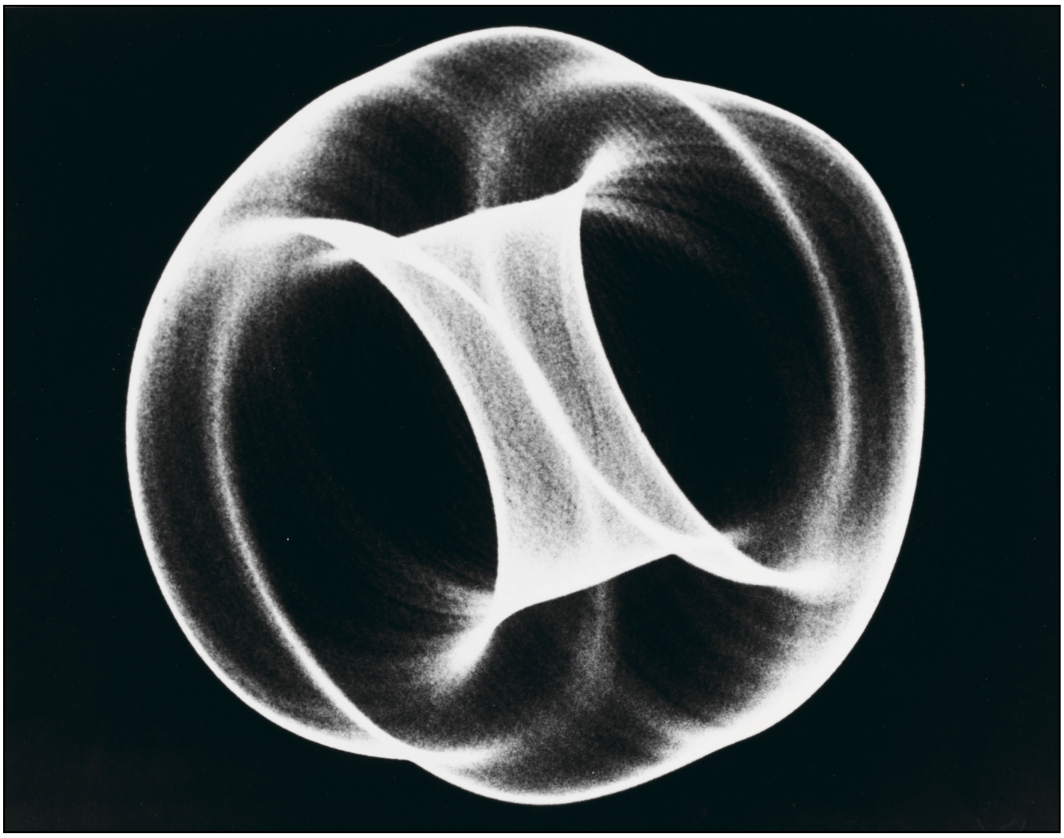

Fig. 2.5.1 Ben Laposky 1952: *Oscillon 40, Plate1* (Beddard & Dodds 2009)

Computer Art and its connection to previous art movements such as Dada, Fluxus and Conceptual Art can be seen in the notion of interaction and 'virtuality' in art explored early on by Duchamp (1920) &Laszlo Moholy-Nagy (1933).

" Dadaist poetry aestheticized the construction of poems out of random variation of words and lines, using formal instructions to create an artifice that resulted from an interplay of randomness and control… is a clear connection with the algorithms that form the very basis of all software and every computer operation…"(Paul, 2008, 12-13).

Such forms of practice were crucial to musical works of American composer, John Cage (1950s & 60s), who pointed this as one of the basic principles and the most common paradigms of the digital medium: the concept of random access as a basis for processing and assembling information (ibid.). This also formed a core concept in

Nam June Paik's installation, *Random Access* (1963), where the 'user' as a means to access information in segments played strips of audiotapes stuck to the wall.

During the 1960's digital artists such as Michael Knoll, Georg Nees, Freider Nake, John Whitney, Charles Csuri, Vera Molnar were amongst the other practitioner of such forms of art, who captured essential aesthetics of the *medium* such as, computer generated drawing and transformations of visuals through mathematical functions. Kenneth Knowlton and Leon Harmon's *Studies in Perception* series, 1966, developed a scanning technology to convert analogue photographs into typo-pictographic design, relating to similar perceptive values of an impressionist or a pointillist painting.

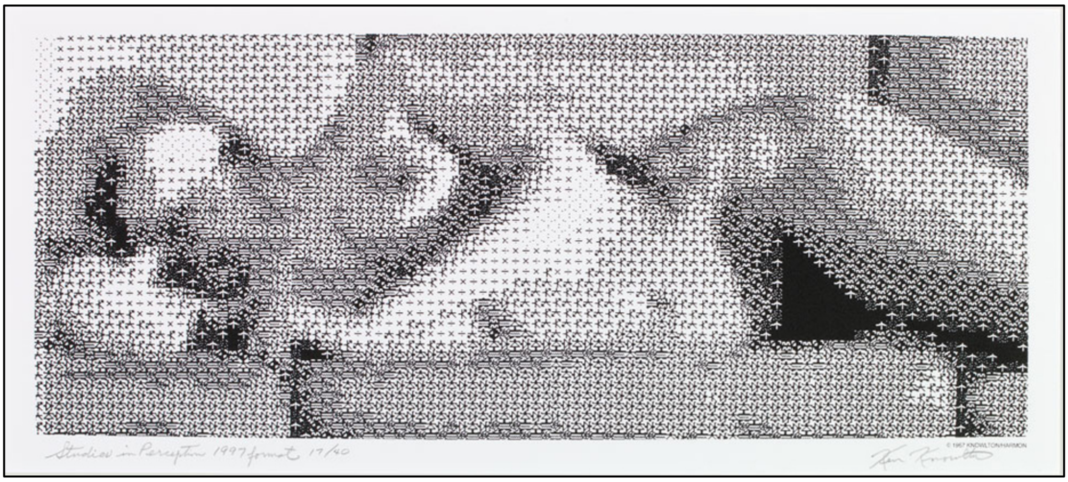

Fig. 2.5.2 Kenneth Knowlton and Leon Harmon's *Studies in Perception* series, 1966 (Beddard & Dodds 2009)

During the mid 1970's, Manfred Mohr, Sol Le Witt and Paul Brown initiated *Generative Art,* which were development of automated systems that could create self-evolving and propagating patterns as artworks.

While artists such as Harold Cohen and Roman Verostko developed their own software's and customised machines to explore their conceptual artworks. Cohen's AARON (1979), used code to generate artworks whereas Verostko's development of bespoke multi-pen plotter (1987), driven by his own computer program generated pen drawings. Such examples of modification and adaptations of both the tool and the medium laid foundation for the current digital craft practice. The limitations of such devices contributed to the minimal, geometric aesthetics with apparent simplicity, which was often a result of a complex mathematical process. As artists became familiar with the new technologies, they began to experiment with writing random variables into their programs, introducing genuine autonomy into creative process.

For example, Roman Verostko deliberately uses a random number generator to distribute and position the computer-generated images (Fig. 2.5.3). While some artists concentrated on algorithmic works, others saw the potential of computers for three-dimensional design. The breadth and variety of the works demonstrated by digital pioneers demonstrate the unique relationship between them and the computer.

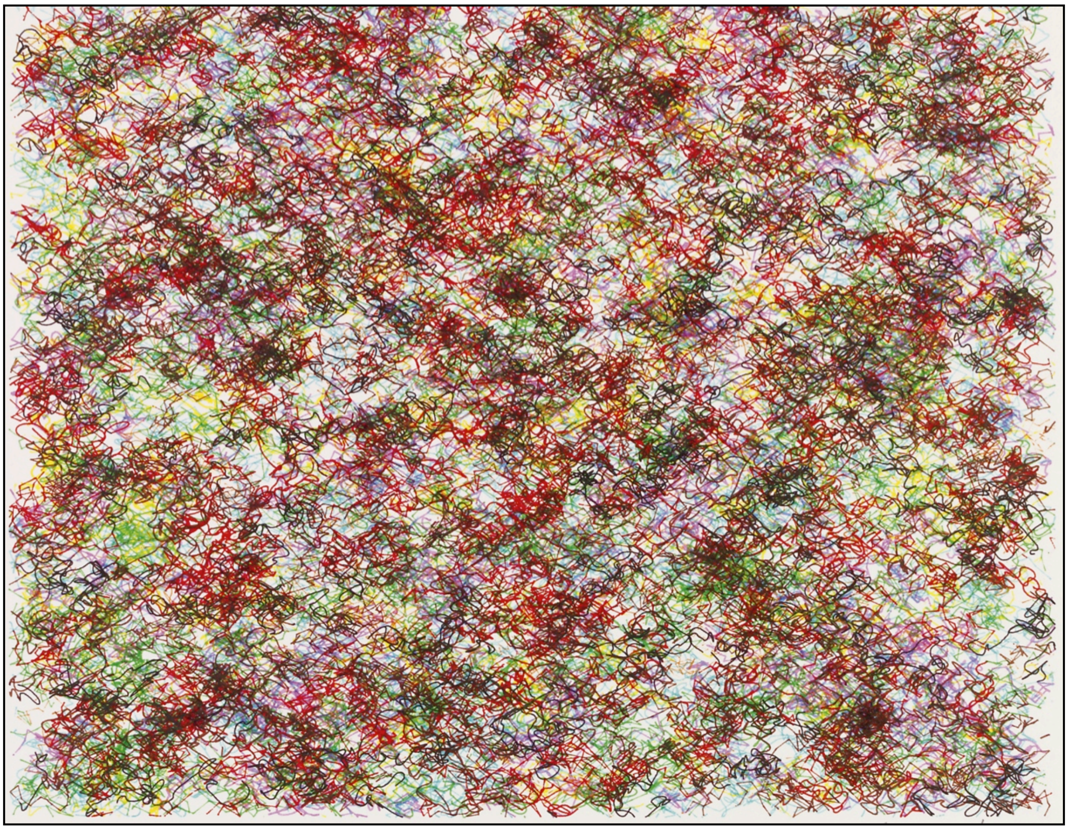

Fig. 2.5.3 Roman Verostko 1987: *Pathway series* (Beddard & Dodds 2009)

They opened up a new field to subsequent generations of artists and designers, and continue to inspire. Paul Brown's computer aided artwork *Gymnasts* incorporates random element; often using simple motif is based around a grid (Fig. 2.5.4).

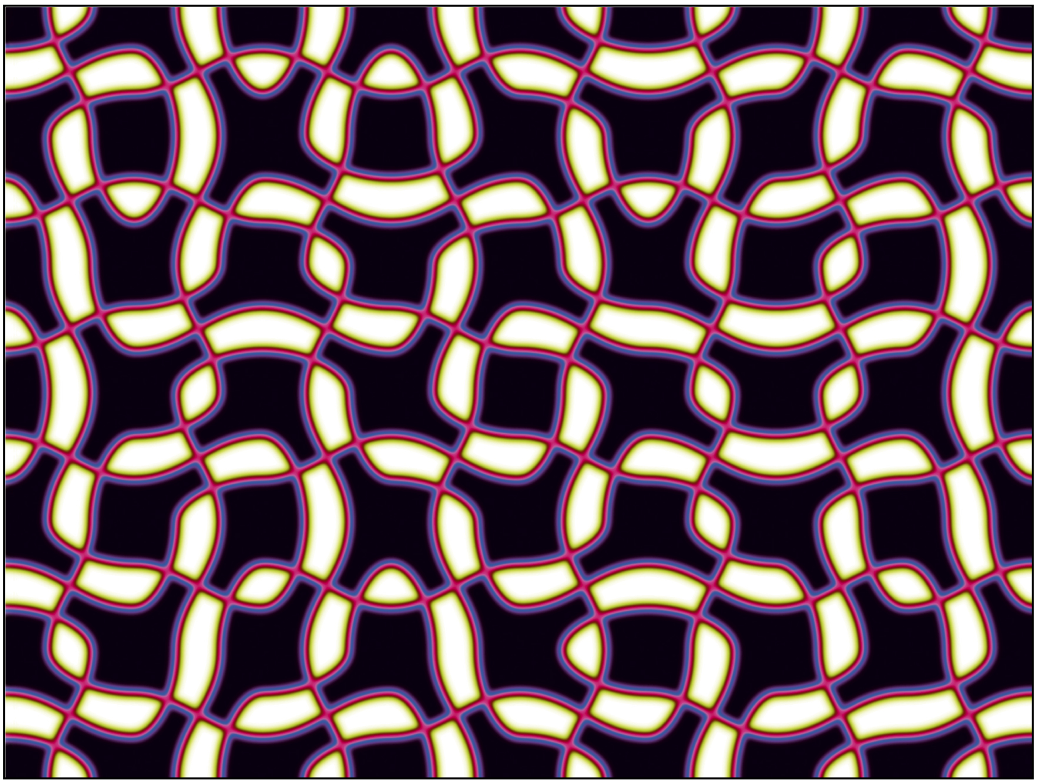

Fig. 2.5.4 Paul Brown 1997: *Gymnasts* (Beddard & Dodds 2009)

As the industrial age made its transition into the electronic era in the 1970's, use of 'new technology' such as video and satellites by Douglas Davis, Charlotte Moorman and Josef Beuys introduced the ideas of 'networked' and 'live performances'. Performative works such as *Send/Receive Satellite Network* (1977), *The World in 24 Hours* (1979), were early explorations of 'connectivity' an inherent characteristic of networked digital art. Performative events such as Robert Adrian's *The World in 24 Hours* (1979), in which artists in 16 cities on three continents were connected for 24 hours by fax, computers and videophone to explore connectivity in networked digital art. The notion of *craft* within these developmental artworks can be seen as a choice of material, production method and concept, corresponding to computation, printing method and generating patterns / artworks respectively. Expanding on the concepts of

Art movement such as *Fluxus* and *Conceptual Art*, digital technologies and interactive media such artworks often transformed into process that relied on a constant flux of information and engaged the viewer or participant as in a performance. The public or audience became a participant in the work. Rather than being the sole creator of the work of art the artist often played the role of mediator or facilitator for audiences.

2.6 **Digital craft in Contemporary Printed Textile Design**

This section will discuss the current context of contemporary printed textile design with an unbiased emphasis to surface patterns irrespective of the end product, which could be either belong to fashion or interior design. It was found within the research that the existing categorisations of prints are based on visual cues. For example, in Textile Designs: 200 Years of Patterns for Printed Fabrics, the collections were categorised by Motif, Colour, Period, Design and Layout (Elffers &Meller, 1991 and 2002). Some of the recent publications by Blackley (2006), Fogg (2006), Cole (2007), Dawber (2008), Bowles & Isaac (2009) and Quinn (2009) arrange their pattern collection using similar categorisation.

However, in this section the researched examples are classified into groups based on visual qualities, technical process and conceptual means in order to point out the notion of digital craft that resides within them. The choice of the examples are based on their iconic qualities that show the current technological, social and economical changes within the context as well as for their novelties.

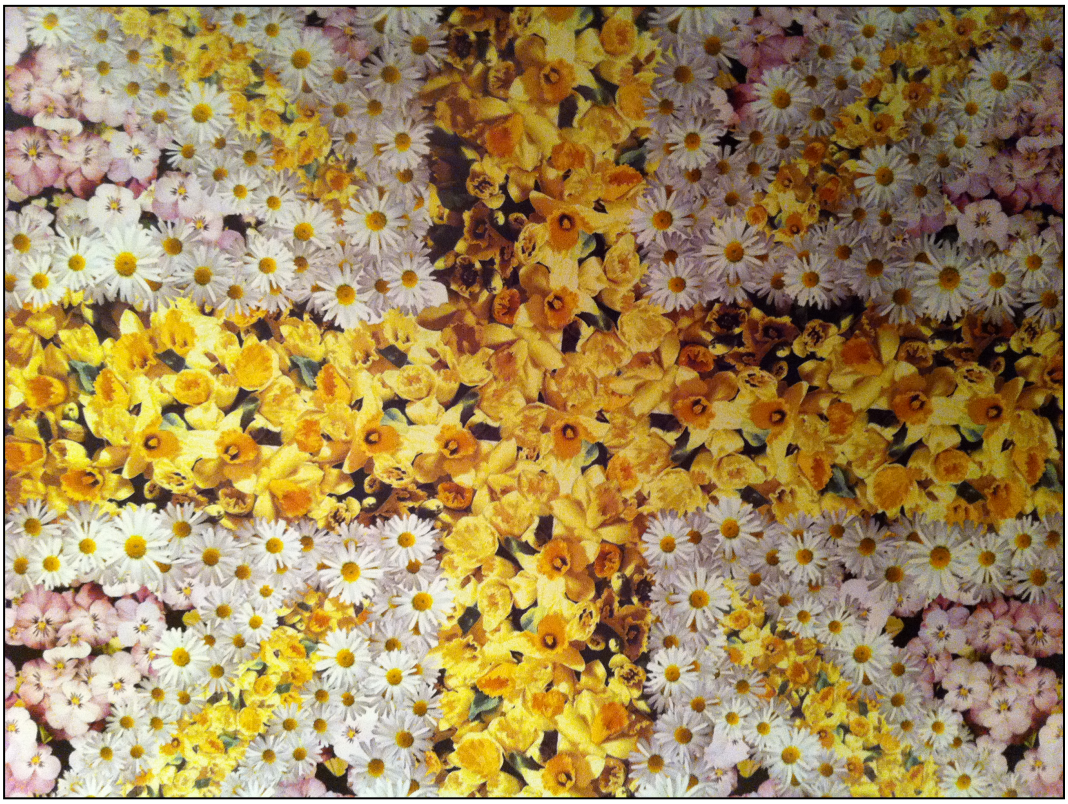

Fig. 2.6.1 Paul Smith 2006: ***Floral print design for a scarf*** **(Fogg 2006)**

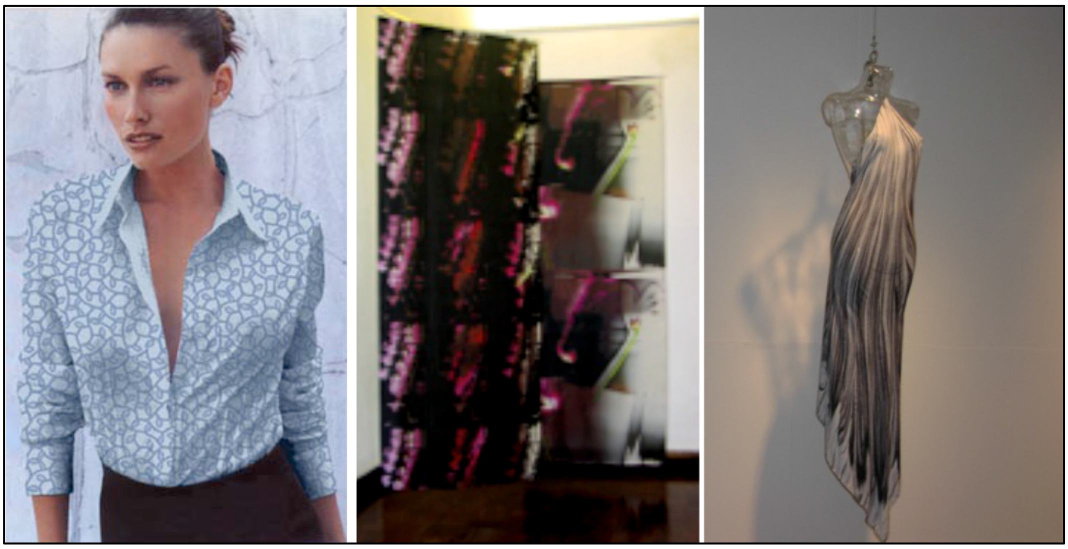

Fig. 2.6.2 Dr. Hilary Carlisle, 2005, Dr. Amanda Briggs-Goode, 2007, Dr. Katherine Townsend, 2003,

Fig. 2.6.3 Prada Digital prints summer (2010)

Photographic prints by designers such as Paul Smith (Fig. 2.6.1), Prada (Fig. 2.6.3), Jula Reindall, Alexander McQueen, Nicollete Brunklaus, Mary Katranzou (Fig. 2.6.6), Boudicca (Fig. 2.8.1), textile artist such Shelley Goldsmith (Fig. 2.6.4) and academic researchers, such as, Amanda Briggs-Goode (2007), Katherine Townsend(2003), Hilary Carlisle(2005) and explore imaging through digitally printed textiles (Fig. 2.6.2). In a sense, the process of transferring an image onto textile, either as a product or a length of fabric could be viewed as a craft.

Fig. 2.6.4 Fragmented Baptism, Shelly Goldsmith, 2003

The category of accidental mark making or pure abstract hand made prints as marked by designers such as Dries Van Noten, Kenzo, Jean Paul Gaultier and Kris Van Assche in their forth coming collections (2011) borrow the concept from Abstract Expressionist (Pollock 1949). Previously both Hussein Chalayan(1995), Martin Margiela(1997) had used the concept of decay and bacterial growth to explore the universal patterns that living organisms follow. Within this category 'chance' is a notion of craft. Whereas, in the category of engineered prints, applicable to body form evident in the work of Jonathan Saunders, Mary Katranzou , Katherine Townsend and Gill Bunce (2005) exploits the digital technology to explore the three dimensional physical form.

The transformation of 2D image into a 3D product, not only requires technical manipulations but aesthetic considerations such as 'printed patterns to accentuate a body form'. Thus, in this category the role of concept becomes the notion of craft. Creative practice by Reas (2008), Carlisle (2005), Kurbak& Yavuz (2008) have conceptualised their work from the previous concepts of algorithmic artworks (Fig. 2.6.5). Thus computer-generated code becomes a notion of craft in this category.

Fig. 2.6.5 Cait and Casey Reas 2008: *Tissue Collection* (Exhibition at Concrete Image Store, Amsterdam 2008)

Fig. 2.6.6 Mary Katrantzou Spring 2011

2.7 The History of motion capture technology

In 'Pre-Computational period' chrono-photography was used to capture animal and human body movements (Marey, 1873 & Muybridge, 1887); the outcomes were two-dimensional photographs of body displacements (Fig. 2.7.1).

Fig. 2.7.1 Eadweard Muybridge, Animal Locomotion, Plate 532 *(Movements of the hand, drawing a circle.)*, 1887. http://www.laurencemillergallery.com/muybridge_animalLocomotionEx.html

Louis Lumière in the mid-1890's invented cinematic devices that could play moving images with sound. These works inspired futuristic paintings such as Duchamp's *Nude Descending a Staircase No.2* (1912) and Balla's *Dynamism of a Dog on a Leash* (1912) that depicted body movements within a single frame of work.

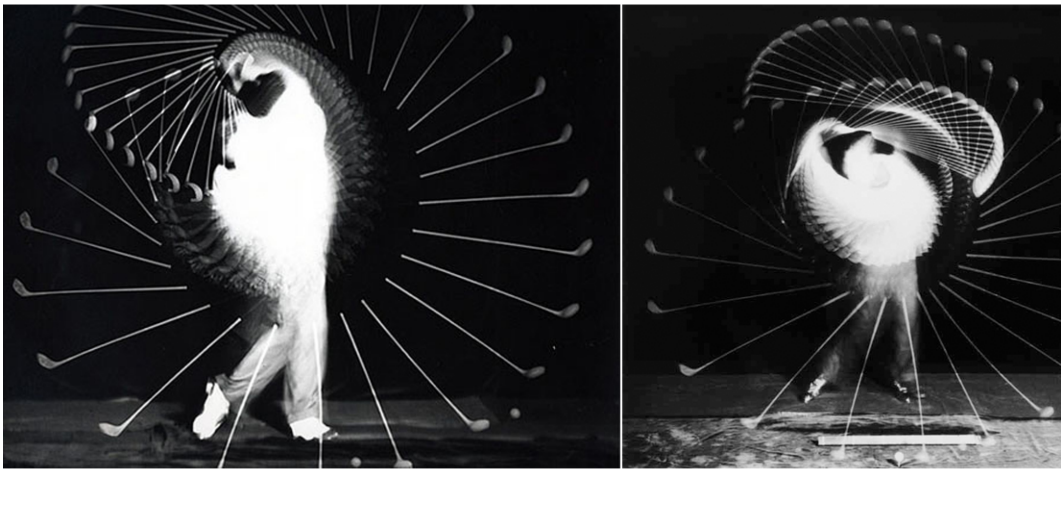

Fig. 2.7.2 Dr Harold Edgerton, Densmore Shute Bends the Shaft, 1938

Dr Harold Edgerton stroboscopic photography resulted in further detailed image body displacement of the body such as the *Densmore Shute Bends the Shaft*, 1938 (Fig. 2.7.2).

With the introduction of the computer (ENIAC) in 1946, in 'Post-Computational period' mathematically generated movement patterns (Henry, 1960 & Noll, 1966) could either be plotted in two dimensions on paper or they could be materialised as three-dimensional artefacts (Rashid, *Mutablob*, 2004). With the introduction of sensor technologies physical phenomenon and choreographed body movements could be captured and materialised as objects such as Marcel Wanders, *Airborne snotty vase*, 2001, FRONT Design, *Sketch Furniture*, 2006 and Geoffrey Mann, *Flight takeoff*, 2008(Fig. 2.7.3, Fig. 2.7.4 & Fig. 2.7.5).

Fig. 2.7.3 FRONT design, SKETCH, 2004

Fig. 2.7.4 Marcel Wanders, *Airborne snotty vase*, 2001

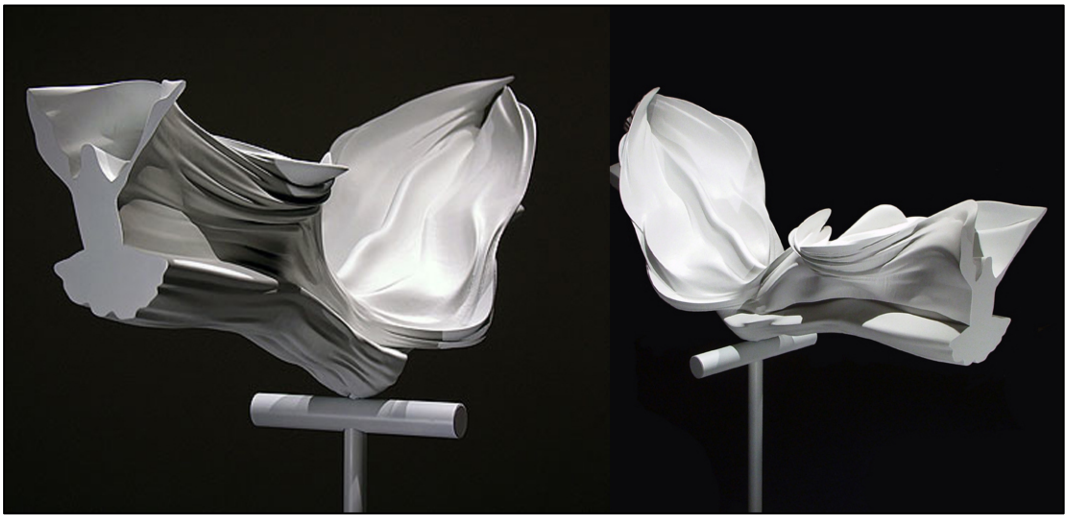

Fig. 2.7.5 Geoffrey Mann, *Flight take-off,* 2008

This post-photographic technology constructs images ("unseen" data from remote sensors and data banks), and generates images (from raw numbers); it treats them, stores them, associates them, disburses them, and transmits them into a media…that is— in every serious sense— unending and ubiquitous (Ascott 2003: 249). This phenomenon of changes that the digital media goes through is endless and is in a continual state of change. It is only when this media is materialised as an object that we are able to grasp what the technology is and what it is capable of. The object is a reference to the physical disturbances that happened in time and space but its attributes are only associated with its grounded commonality such as its primary function as a furniture or a vase.

Similarly the *Light Tracer* captures the participant's hand movement and allows him to write, draw and trace images in real physical space (Willis, 2005). Drawing upon Roy Ascott's *Behaviourist Art and the Cybernetic Vision*, 'the role of the artist could be to provide 'a more or less empty receptacle (the canvas) into which the spectator can project his own imaginative world' (2003: 128). This concept shifts the role of a designer from being an 'active participant' to become a 'passive observer' and reverses the role of audience to become a creator of art themselves. Meanwhile, Jen Hui Liao's *Self-Portrait Machine*, 2009 is a device that takes a picture of the user and draws it but with the model's help (Fig. 2.7.6). The wrists of the individual are attached to the machine and it is his or her hands that are guided to draw the lines that will eventually form the portrait. While both the experimental works allow participants to draw by their hand movements, the former is much more open ended and the later restricted.

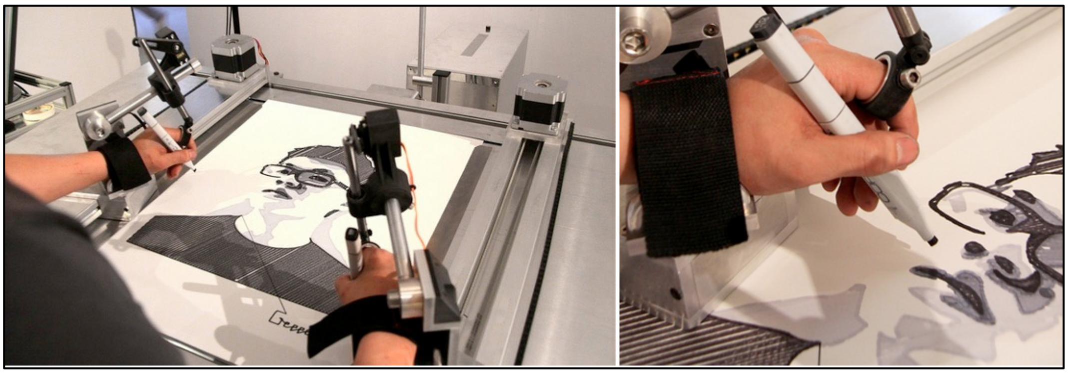

Fig. 2.7.6 Jen Hui Liao 2009: *Self- Portrait Machine*, (we-make-money-not-art.com)

In fashion and textiles, integration of motion-capture techniques and virtual reality has resulted in representation of non-dimensional form in virtually printed garments, Digital Reflection (Morrow, Delamore, Du Preez & Thornton-Jones, 2004)(

Fig. 2.7.7). The 3D animated work Potential Beauty informs us of an alternative digital construction, one that looks beyond simulation to represent the 'absent body' (Harris, 2005).

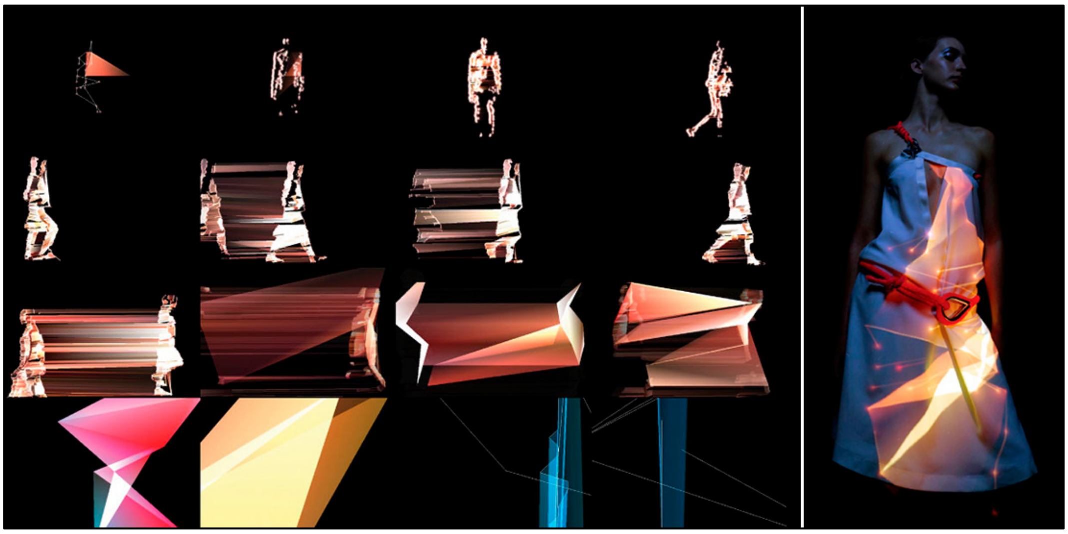

Fig. 2.7.7 *Digital Reflection* (Morrow, Delamore, Du Preez & Thornton-Jones, 2004)

The combination of such emerging technologies in Telematic Dress & Wearable performance (Birringer & Danjoux 2005, 2009) captures body movements of a performer (fashion performance) to interact virtually with another 'absent body' in a dispersed location. The implication of the use of such technologies in fashion and textiles is contained in its forward use such as the absence of physical print, the material, and the materialised in the current usage of digital medium.

The Integration of New Technologies by in *Nervous System, Fluid Forms, News Knitter* (CSTEM 2008) (Fig. 2.7.8) involves a crucial paradigm shift: not only they are changing the use of the digital tools but also the capacity to invent, modify and produce new instruments by combining tools. Their activity forms part of a current digital manufacturing revolution – a revolution that has the potential to enable mass customization, D.I.Y (Do-it-Yourselves) and highly responsive localised production, perhaps even in the home.

Fig. 2.7.8 ***News Knitters*** **Kurbak and Yavuz (2008)**

These work inform this practice based research about the implications, the outcomes and materialisation of data and create opportunities in the interdisciplinary spaces of digital practices.

2.8 **Hybrid Explorations of Digital craft**

The most significant advancement in digital inkjet printing technology in recent years has changed the face of textile design. Designers have now developed several new methods of incorporating visual imagery, style, new visual languages and have also sought inspiration from previously unexplored image sources to create spectacular surface design. The impact on the fashion and textile industry, from new appearances to new innovations result from the designers experiment with digital printing techniques, which is growing richer and more diverse day by day.

As Bunce argues "patterns must not be seen purely as reactive or as deliberate expressions *of* significant concepts, now they must also be seen as the outward manifestations of an underlying consciousness of the human relationship with the natural world” (Bunce 1993: 50).

The cross-disciplinary use of graphics software, digital photography, video and special effects by a hybrid generation of young designers is creating a new look for printed fabrics (Bowles and Isaac: 10). Designers are able to work with limitless colour pallet into print

the finest and boldest marks, enabling them to approach print design in a completely new way where the fabric literally becomes an art canvas and design becomes the artwork. The new hybrid approach is to reconfigure patterns in a non-traditional way. This research finds that, any visualisation that can be realised on a computer screen can now be printed onto textiles. The simplest method of screen capture enables designers to visualise graphics from almost any source of information. In the light of such finding some of the current designs are considered as hybrid explorations. The notion of a ‘hybrid’ approach in this section is considered as a biological metaphor. According to Oxford English Dictionary hybrid means “*The offspring of two animals or plants of different species, or (less strictly) varieties; a half-breed, cross-breed, or mongrel*.” The word ‘hybrid’ as a metaphor indicates the increasing predisposition and ability of textile designers to incorporate creative fields and the potential of emergent new innovative ideas and forms of practice from this activity. For instance, in the Boudicca's latest MOCAP collection for autumn - Winter 2010-11(Fig. 2.8.1), the printed skirt uses video graphic imagery extracted from a video projection for a project for the opening of a new Masters course at Parsons School of Design, New York.

Fig. 2.8.1 Boudicca's MOCAP collection for Autumn – winter, 2010-11

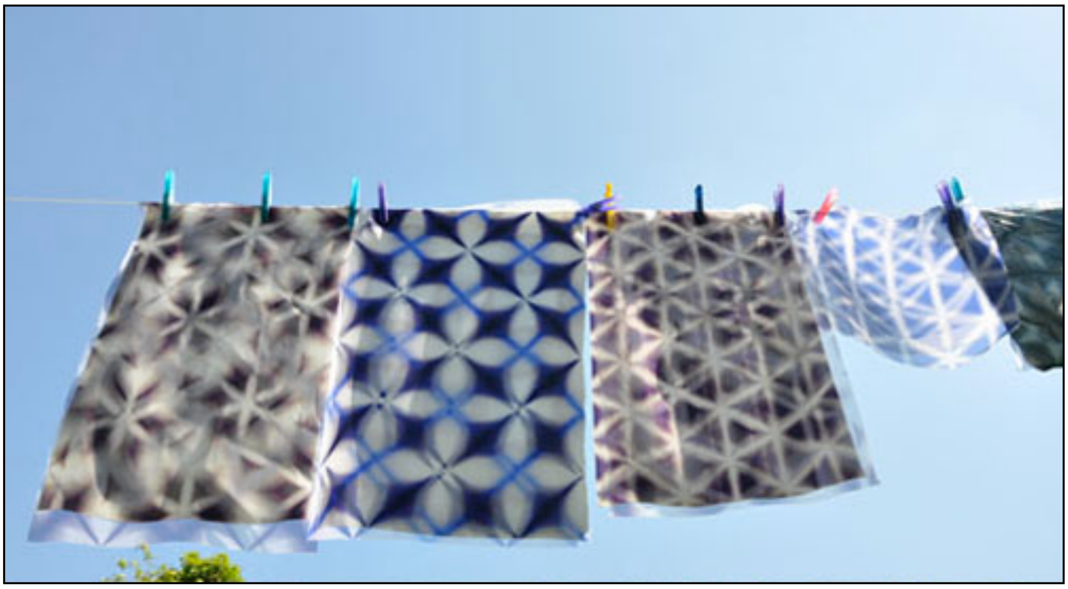

Fig. 2.8.2 Digital Shibori, Melanie Bowles, 2010, Silk Organza

In 'Digital Shibori' Melanie Bowles reinterprets the technique of *shibori* dyeing using digital media by manipulating complex mathematical graphic geometrics to create light effects, folds and blends that retain the original essence of *shibori* (Fig. 2.8.2). Australian designers such as Glory Scarves use algorithmic design to automate the production of one-off prints show the changing look of printed textiles using a digital medium. Entering an individual equation into a computer – creating a mathematically valid fractal, creates each scarf – each scarf is therefore unique (Fig. 2.8.3).

Similarly a collaborative project between textile designer Cait Reas and generative software artist Casey Reas for *The Tissue Collection* (Fig. 2.6.5) The artist generates the patterns using computer algorithms; a digital textile printing technique is then used to apply the patterns to fabric.

Fig. 2.8.3 Glory Scarves, Australia, use algorithmic design to automate the production of one-of-a-kind printed scarves

Fig. 2.8.4 Basso & Brooke Spring Summer 2010 Print

Fig. 2.8.5 Basso & Brooke Spring Summer 2010 Fashion Collection

Basso & Brooke's (2010) and Hussein Chalayan's (2009) collections feature large-scale abstract pattern with lush colours using either Japanese imagery or large-scale prints of crushed cars, which appear to be photographic but in fact they have been meticulously hand-painted before being digitally printed onto the fabrics, therefore retaining the infinite details within each print (Fig. 2.8.4, Fig. 2.8.5 & Fig. 2.8.6).

Fig. 2.8.6 Hussein Chalayan, Spring Summer 2009

Fig. 2.8.7 'Moment' by Front Design for Morosso, 2008

Clever use of knots and panelling, cutwork creates collages, which not only distort the imagery and add volume but also reorder the imagery into an interesting new form.

This particular way of approaching textile design clearly shows the way forward for hybrid thinking as well as execution of such ideas. Front Design's *Moment* for Morosso, 2008 is based on hybrid approach to digital printing on textile (Fig. 2.8.7). In this collection they have created a *trompe le'oil* effect depicting a used sofa, with reflection of daylight on the carpet.

In her graduate collection Joanna Fowles artistically mixes hand and digitally together to create her collection 'Order & Disorder', an exploration of opposites (Fig. 2.8.8).

Fig. 2.8.8 Joanna Fowles, Graduate collection, Chelsea School of Art & Design, 2011

Multiple layers of moving images and text are commonly used for computer games and media for the youth market. When similar collage techniques are applied to static designs they can produce busy effects, which due to their unstructured and unpredictable character, often seem monotonous and chaotic (Bunce 1993: 51).

2.9 Conclusion

This chapter on digital craft has outlined the development of inkjet printing in textile design, roots of digital craft and research into surface patterns in contemporary printed textile design. Also, it has encapsulated the histories of motion capture present in futuristic representation in relation to the creative industry, which culminates in hybrid explorations of digital craft. The development of digital inkjet printing for textiles is not only revolutionary in terms of removing traditional constraints imposed on the design of repeats but it is no longer necessary to take into account the number of spot colours previously been used to treat flatbed screen-printing. Due to the previous technical constraints being removed, such as eliminating the need for repetition in a design, high-speed printing is adding new dimensions to the field of printed textile design. Traditional patterns such as stripes, dots flowers are being replaced by more abstract patterns and they can capture the real spirit of the time which is a new reality and emerging from the use of this advanced technology. Designers are now looking into stories through illustrations and creating highly conceptual pieces, which blur the boundaries between textile design and art.

In outlining the development of inkjet printed textile design it was found that in previous years when digital printing on textiles was still in its infancy, artists and textile designers were attracted to the new 'visual language' that could result from using such technology. The argument that Briggs (1997) makes in relation to the then emerging visual language states that the use of peripherals such as scanners and digital cameras would not only result in a new design aesthetic but it will also alter the way we view the world around us. The roots of digital craft were aimed at bridging the gap between computers and art, which resulted in an emerging computer art movement. Much of the outcomes of these explorations were algorithmic and mathematically precise however, such works still stimulates and continues to inspire a current generation of designers. The concept of art movements, such as Fluxus and Conceptual Art where a participant becomes an artist is a core concept of this research with its aims to create a hybrid print system. The concept of digital craft that guides this research is divided in three strands. They are digital imaging, manipulation and production. It was found that currently designers are employing contrasting methods such as mixing previously polarized styles; traditional with contemporary, hand drawn effects with vector graphics to name a few. The list of methods is getting more and more diverse day by day as we designers think hard to create something new. This hybrid thinking and hybrid approach is clearly seen where histories of motion capture and futuristic representation led Front Design to create the ‘first hand sketched furniture’. Such work informs practice-based research about the implications, the outcomes and materialisation of data and creates opportunities in the interdisciplinary spaces between the various digital practices.

There appears that there is an increased desire for consumers or participants to become more actively involved in design. Thereby they could have much more freedom and also pleasure in the act of creating a new product. Such products could have a commemorative value. The ownership of this product would be much more shared rather than owned. Therefore the concept of hybrid print system, a new novel method of creating printed textile design will follow the path of digital craft, hybrid approaches that are dictated by the three-strand method of design. In forthcoming chapters the hybrid print system will be theorised and discussed explicitly. And in the concluding chapters, which are focused on the practice-based research and the projects, which involved participants engaging with group creativity.

Table of Contents

Chapter 3

LITERATURE REVIEW – THEORY OF DIGITAL PRINTED TEXTILE DESIGN

3.1 Introduction

As outlined in Chapter 1, the purpose of this thesis is to investigate digital craft practice within printed textile design with the aim of developing a novel method to create motifs, images and patterns for printed textile design. The function of this chapter is to provide theoretical discourse as a part of literature review. As discussed in the methodology (section 1.4) this practice based research is informed by Christopher Frayling's model of research *through* art and design (Frayling 1993:5). This research is concerned with new developmental and innovative work that engages with customizing motion capture technology (MOCAP) to create non-repeating surface patterns for printed textile design. This results into a direct manipulation process as a new method of creating a 'handcrafted' product through technology. In Chapter Two, the research outlined the historical and current developments in digitally printed textile design; and in particular discussed digital craft and hybrid explorations (section 2.2 – 2.6). The various contrasting methods and techniques used by textile designers to create new designs leads to a general perception that any image or object that can be visualised and recorded via digital technology can be printed on to textiles using an inkjet printer. Digital printing means that there is virtually no limit to the kinds of images that may accurately be reproduced using inkjet technology (Bowles & Isaac 2009:12). Which is to say digital production methods are radically changing the design and production of printed textiles (Ujiie, 2006). The examples discussed in Chapter Two also illustrate that currently designers are employing contrasting methods such as mixing traditional hand drawing with vector graphics and digital photography. The process of digital design and digital printing has facilitated a situation whereby designers seek to incorporate 'handmade' artisanal methods and techniques into their practices. Treadaway has pointed out earlier that, ‘textile practitioners think that the hands-on working with the print process is important. Practitioners comment on the perceived flatness of the colours and lack of ownership or connection to their digitally printed product (Treadaway 2004: 301). Brandeis (2003) advocates the need to `re-establish a relationship with the materials, to reclaim the images from the machine, and to convert the monologue of the machine printed product to a dialogue between artist and cloth' (Brandeis 2003:17).

Both Treadaway and Brandeis argue that digitally printed product lacks rigor, which devalues it in comparison with hand printed products. Digital printing eliminates labour-intensive methods such as colour separations and conventional silkscreen printing which for some designers is an intrinsic element in their creative process (Fogg 2006:14). Similarly, Bowles & Isaac (2009:142) have pointed out that textile designer’s need to have physical relationship with cloth has driven them to find new methods of physical interventions such as over- printing and embellishment on digitally printed textiles to put back tactile qualities into the creation of the printed surface. Such physical interventions may provide us with “material evidence of tool usage, about its authorship and origins”(McCullough 1996: 165 -166).

Fogg (2006:15- 23) quotes views of traditionalist textile designers such as Phillip De Leon of Alexander Henry Fabrics, Wakako Kishimoto, Fleet Bigwood, and Patricia Belford who have pointed out the lack of intimacy in digital prints. Phillip De Leon states, “ When we present a collection, our clients approach each painted piece as something original, where the hand of the artist is definitely in evidence. You do not have this kind of emotional experience with digitally produced work”. Both Bigwood and Kishimoto have similar views and favor the purity of handcrafted process. Patricia Belford of Belford Prints Ltd. fears that with the onset of digital printing, some of the creativity, which is contained in silkscreen process, may be lost. She further remarks, “With digital printing, designers don't need to know anything about print. I don't like getting an image from the designer just to scan it and send back the printed cloth.”

These research findings indicate that in the field of digitally printed textile design there is an opportunity for the development of a new method to be introduced, which involves hand movement in a wider context of use such as in art and design and in non verbal communication.

In the light of such findings the research questions were formulated as: How can motion capture technology be used to create printed textile patterns based on hand gestures (as opposed to a motif drawn by the hand)? In what ways can we capture hand movements? How can we visualize /represent this captured movement? How well does this process of printed textile design works for real application?

In order to answer these questions the research contextualises the role of the hand and its relationship to digital crafting methods, the digital medium and the process in printed textile design to create a conceptual framework balanced in practice and theory.

Firstly, section 3.2 in this chapter, the model of Digital Printed Textile Design (DPTD) is identified to provide a structure for theoretical discourse. Also, this section provides clarity towards understanding the scope and limits of this research. Section 3.3 establishes DPTD as medium through which message is conveyed. The following section deals with establishing MOCAP as both medium and tool. Then, the role of hand movements in non-verbal communication and digital craft is described in terms of the convergence of medium and skills.

Drawing on this, the Hybrid Print System (HPS) is theorized, outlining its emergent properties, and its contributions to the change in the DPTD process.

3.2 A Model of Digital Printed Textile Design as practice

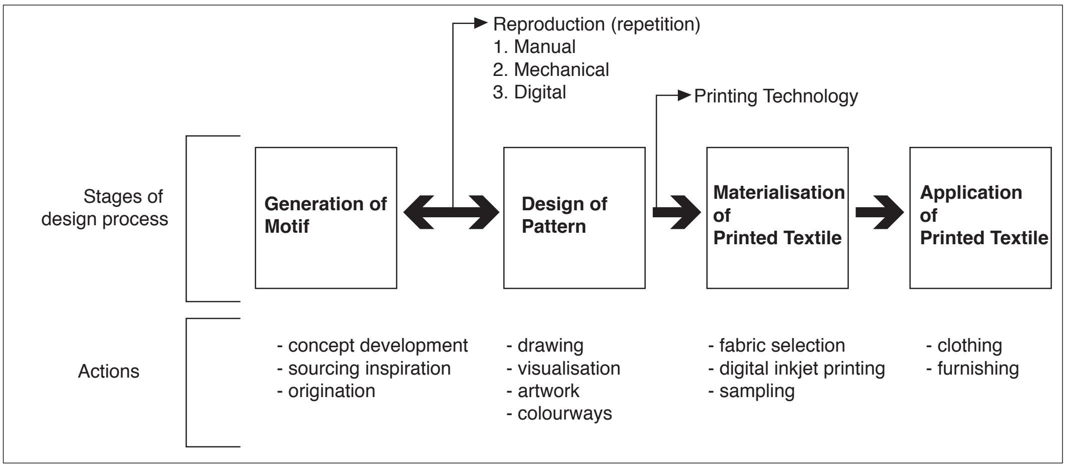

Fig. 3.2.1 Model of Digital Printed Textile Design Practice (Paramanik 2008)

This section identifies a model of Digital Printed Textile Design (DPTD) in four distinct stages specific to generating surface patterns. This model is then used to structure the rest of the literature review and practical experiments.

Firstly, the discussion, surrounding the development of digital textile technology's influence on the workflow of manufactured printed textiles. Which is, introducing numerous image-making possibilities without the limitation of number of colours and screen sizes.

Ujiie (2006:339 -343) points out the difference between traditional textile printing workflow and full digital textile printing production workflow. The workflow in a traditional textile printing workflow such as rotary printing consists of process such as design concept development, design modification and engraving for strike-off.

Both in-house designers and freelance designers follow a trend related brief and create designs. They are responsible for visually indicating number of spot colours and repeat size in their designs. The initial design is then passed on to jobbers, converters and manufacturers for design modification. By using CAD systems, the designs are inevitably edited and translated into a limited number of spot colours and repeat sizes for rotary printing. The edited design is then sent to engravers for creating screens. The engravers then use CAD systems and manual skills to separate and convert textile designs into spot colour separations. After the design has been engraved, strike-offs are printed for approval. This is an iterative process and strike-offs are often sent back and forth between the engravers and design studios for approval. After the strike-offs are finally approved the bulk production is executed.

In contrast to such laborious and lengthy process, full digital textile printing production workflow allows streamlined operations of design development, design modification and strike-off to production under one roof using CAD systems. This workflow uses information technology, including digital data and asset management intensively to minimise production time. It is highly adaptable to the current market demands of rapid trend cycles and short-run printing lengths with quick a reliable response.

The research identified that full digital textile printing production workflow can be reconfigured in four stages. The four stages are:

1. Generation: In this stage, the role of a textile designer is usually to create a concept, a brief towards visual research such as a storyboard, a short narrative or an inspiration that will inform the rest of the design process to create patterns and finally a collection of fabrics.

2. Design: In this stage the textile designer selects visual elements from the generation stage together to create motifs, arranges them in a composition, in different colour ways and artworks. Various techniques and processes of rendering such as drawing, digital imaging and digital manipulation are explored in this stage. Finally, selections of art works are organized in sets to be printed.

3. Materialisation: In this stage the textile designer finalizes and edits selections of art works to be printed. Also, if any further embellishment is required then those are considered.

4. Application: In this stage the textile designer then either collaborates with a manufacturer or passes the printed fabrics to be made into products. The products are broadly categorized as either clothing or furnishing.

In the Fig 3.2.1 the first three stages Generation, Design and Materialisation are shown as iterative, due to the nature of creative process. It means that unlike scientific research approaches, which are designed to find an optimum solution, a designer's solution deals with range of potential resolutions and more over an acceptable aesthetic solution. This is further explained through the concept of a textile designer as a 'reflective practitioner', 'reflective practice' and 'reflection in action' derived from Donald Schön (1983), *The Reflective Practitioner: How Professionals Think in Action*. Schön proposes that much of design activity is personal knowledge, not usually articulated, sometimes indescribable, and that it relies on improvisation learned in practice (Gray & Mallins 2004).

For example, in printed textile design, decisions that are made regarding colour composition, arrangement of motifs, scales etc. are less logical and more personal. In this sense a designer's solution is improvisational which relies on feeling, response and adjustment. Reflection in action is a particular activity of professional practitioners and involves thinking about what we're doing and reshaping action while we're doing it (Schön 1983:78).

Further to reflective practice, textile designers also constantly seek change in their prospective works. This could be due to the socio economic condition that entails their career in competitive fashion and clothing industry. One such condition could be that they are not acknowledged for their creative work. Briggs-Goode (2011:123) states, "In almost all cases, printed textile designers remain anonymous". She refers to the textile design resource book by Meller and Elffers, which is one of many which shows examples of historic textile designs, to suggest that textile designers do not create new designs but instead they rework existing themes. For example, clothes sold in the high street always bear a brand name but in rare cases do they celebrate the textile designer's name. However, the celebration of the fashion design process and the genius attributed to it is evident in the 'celebration' of fashion designers in the media and through the global fashion context.

3.3 Digitally Printed Textile as a Medium

Within the context of this research Digitally Printed Textiles (DPT) is re-established as a medium. It begins by defining the word medium. According to the Oxford English Dictionary (online 2011), the word medium means-

a) An intermediate agency, instrument, or channel; a means; esp. a means or channel of communication or expression.

b) Any of the varieties of painting or drawing as determined by the material or technique used. Hence more widely: any raw material or mode of expression used in an artistic or creative activity.

c) An intervening substance through which a force acts on objects at a distance or through which impressions are conveyed to the senses; any substance considered with regard to its properties as a vehicle of light or sound.

The first two definitions of the word medium seem to be more closely related to a general notion of what printed textile design could be such as mean or channel of expression in an artistic or creative activity. Which in this case is printed textile design. However, it is the third definition which puts forward a thought process that begins by understanding that printed textile design is "something through which impressions are conveyed to the senses with regard to its property as a vehicle of light". This provides a helpful way of defining or describing that the surface pattern, which constitutes a printed textile by means of colour, shape and texture, contributes towards sensorial attributes such as vision.

"Print in fashion is rarely connected to performance, which is reason enough for its detractors to consider it as less than cerebral. Print is a distraction and yet invites recognition; it is an affirmation that there is time in the world to play, and that decoration is, in itself, a purpose." (Fogg 2006:8).

Print on a piece of clothing causes a certain sensation to its viewer. This sensation would either attract or distract the viewer. This activity then forms a continuous dialogue between the printed textile product and the viewer.

For example, Hussein Chalayan's pixelated cotton dress, which was discussed earlier, designed by Eley Kishimoto, 1996 (Fig. 2.3.2) uses proximity, which is the key to perception for the natural human eye. From a distance what appears to be a blurred blob of colour also reveals itself as a floral motif at a closer look. The print is viewed in two ranges of distances, such as far and near. The viewer perceives the pattern through its visual accents. Bunce has defined visual accents as a method of pattern perception that uses differences in texture, direction of pattern elements, breaks in continuity, and other irregularities, which act as visual accents (Bunce 1993, 35). According to her explanation patterns tend to work on two levels, which correspond, to Gibson's definitions of 'visual world' and 'visual field'. They usually contain primary and subsidiary visual accents. Primary visual accents are the dominant forms, noticed while scanning the pattern from a distance, and they determine the first impression. Subsidiary visual accents are not always 'seen' at first glance, they are design details, detected on closer viewing. The primary visual accents in Chalayan's pixelated cotton dress are randomly placed rectangular blocks of red and orange. The subsidiary visual accents then are layers of semitransparent color blocks, which appear to be a result of digital manipulation of the image. We are able to understand how the viewer engages with the dress, the print and the context of view. McLuhan (1964:19-20) states:

…characteristic of all media, means that the "content" of any medium is always another medium. The content of writing is speech, just as the written word is the content of print, and print is the content of the telegraph. If it is asked, "What is the content of speech?" it is necessary to say, "It is an actual process of thought, which in itself is non-verbal. An abstract painting represents direct manifestation of creative thought processes as they might appear in computer design.

In relation to DPT the content of a printed pattern is the combination of thought process in relation to the arrangement of the images. Through these arguments we are now able to establish that DPT is a medium in which a message resides.

3.4 Motion capture technology (MOCAP): Medium or tool

Furniss (1999) addresses the most basic question, 'What is Motion Capture?' through an overview of 'Motion Capture White Paper' on the subject in 1995, Dyer, Martin, and Zulauf explain that motion capture "involves measuring an object's position and orientation in physical space, then recording that information in a computer-usable form. Objects of interest include human and non-human bodies, facial expressions, camera or light positions, and other elements in a scene."

Another definition offered by Menache (2000) is "Motion capture is the process of recording a live motion event by tracking a number of key optically reflective markers."

The technology of 'motion capture' or more simply 'MOCAP' has previously been employed in the fields of music, fine art dance/performance, sign language, gesture recognition, rehabilitation/medicine, biomechanics, special effects for live action films, and computer animation of all types, as well as in defence and athletic analysis training. MOCAP neither as a medium nor as a tool has been explored previously in printed textile design and this project is the first occasion when it has been used extensively to create a novel method of design.

Broadly categorised, there are three types of MOCAP that are currently used in the art and entertainment industry. They are mechanical, optical and electromagnetic. A comprehensive overview list of these three types, drawn from Furniss (1999), Menache (2000) and Guerra-Filho (2005) is:

In Mechanical MOCAP, a performer wears a set of straight metal pieces on his body in a skeletal-like structure, to form an exoskeleton. When the performer moves his body, the articulated mechanical parts of the exoskeleton are forced to move and sensors in each joint record the rotations to generate data measuring the performer's relative motion.

Advantage: a) It generates real-time 3D data of the body movement at a low cost, b) and there is no interference from light, which means it, could be used in an open space.

Disadvantages: a) the performer's body movements can be restrictive at times due to skeletal-like structure worn on the body, b) the equipment very often requires calibration which can hinder continuous performance, c) and it requires external sensors to generate the performer's absolute body positions.

In Electromagnetic MOCAP, performer wears an array of magnetic receivers on his body. It tracks the performers body movement by calculating position and orientation with respect to a static magnetic transmitter.

Advantages: a) It generates Real-time data of performer's body movement along with the their orientation in space, b) and it is relatively cheaper than optical MOCAP

Disadvantages: a) magnetic distortion occurs as distance increases, b) being prone to interference from surrounding magnetic fields means that it is required to build a special stage using non magnetic material, c) also, due to such interference more than one performer cannot be on the stage at the same time, d) and the performer wears cables connecting them to a computer, which limits their freedom

In Optical MOCAP, a performer wears reflective dots or markers on his body. Several infrared cameras follow the markers as the performer moves. The information received from the cameras is then triangulated to generate 3D positions of the performers body in real-time.

Advantages: a) offer complete freedom of movement due to no cables connecting body to the equipment, b) larger volumes of data can be generated, c) more performers can perform at the same time with little or no interference in generating data

Disadvantages: a) it is prone to light interference, b) reflective dots can be blocked by performers or other structures specially reflective or shiny wearable, causing loss of data, or occlusion-this can be compensated for with software which estimates the position of a missing dot, c) rotations of body parts must be solved for and are not absolute, d) information has to be post-processed or 'tracked' before viewing so performer cannot see his or her image and so cannot be as creative or identify any immediate potential problems

Gordon (2003: 12) states, outlining McLuhan's media theory:

We think of media principally as media of communication: press, radio, and television. McLuhan thought of a medium as an extension of the human body of the mind such as clothing extends skin, housing extends the body's heat regulating mechanism. The stirrup, the bicycle, and the car are all extensions of the human foot. A medium, or a technology, can be any extension of the human being.

Based on this argument MOCAP is a technology, which is an extension of human being. Lets consider if it is an extension, what is it that it extends, through understanding MOCAP in mechanical terms.

Earlier we have stated that in optical MOCAP a performer wears reflective dots that are followed by several cameras and the information is triangulated between them to calculate the position of the dot. Also, a performer could wear more than one marker, each one placed on various joints on the body so that simple movements such as walking could be captured. If the markers are worn on the body, they are close to what McLuhan states in “clothing- skin” relationship. However, MOCAP records bodies, skeletal movement as shown in the Fig. 3.4.1, Issey Miyake’s A-POC.

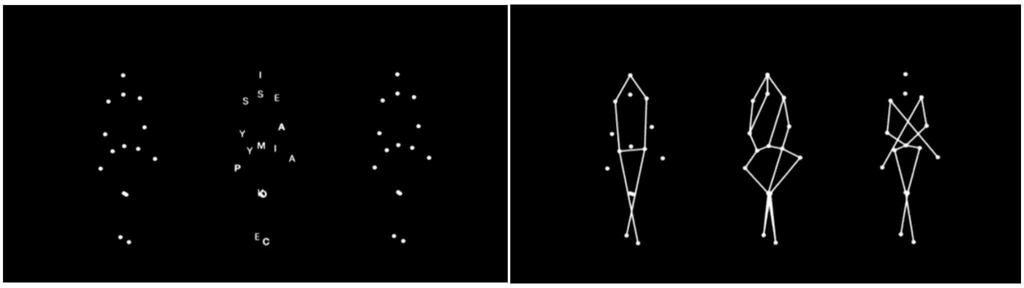

Fig. 3.4.1 Stills from Issey Miyake’s A-POC, animation film, 2007

As we see from both these arguments MOCAP as a medium extends the presence of a body whose presence is recorded by the markers worn on the body. The 'restructuring of human work and association' was shaped by 'technique of fragmentation' is the essence of machine technology (McLuhan 1964:19). MOCAP records body movements as in fragments and restructure the 'happened' action. Which also, means that it is a tool without which such recording cannot take place. In this research MOCAP will be used as both medium and tool.

3.5 The Role of Hand Movements in Non Verbal Communication (NVC)

The research was inspired by bodily movements such as making gestures during a conversation through hand movements. It was found that such hand movements add to verbal speech and in fact make it much more interesting in terms of a live dialogue. It is important to note that the scope and the intention of this research is not to deal with decoding non-verbal communication (NVC) but to use specific bodily movements especially the hands, which are involved in bodily communication as part of the design process. The part they play is in creating motifs, for later use in construction of patterns.

NVC, or bodily communication uses non-verbal signals such as facial expression, gesture, posture, bodily contact, spatial behavior and clothing to communicate. The project explored Argyle's (1975: 2) basic paradigm of NVC, which briefly states the process of encoding and decoding non-verbal signals between two people in a conversation.

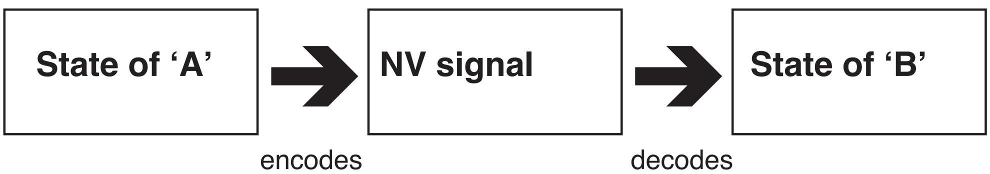

Fig. 3.5.1 Argyle's model to represent basic paradigms of NVC

In this paradigm Argyle states, “there is encoding by ‘A’ of his state, e.g. of emotion, into a NV signal, which may be decoded by ‘B’ and they depend on a number of possibilities such as using shared code, poorly received or sent codes and deceptive codes” (Argyle, 1975: 2).

This research is concerned with NV signal such as gestures. Gestures usually mean voluntary bodily actions, by hands, or by other parts of the body, which are intended to communicate. Emotional expressions, e.g. gripping the hands together with anxiety, are something different (Kendon 1983)

There are mainly two types of gesture such as speech independent and speech related. Speech independent gestures are not tied to speech, but they have a direct verbal translation and usually consist of a word or a phrase whereas speech related gestures accompany speech often illustrating what is being said verbally (Hall & Knapp 2006:226- 254). Ekman and Friesen (1969) had distinguished these two types of gestures as *emblems* (speech independent) and *illustrators* (speech related).

3.5.1 Emblems and Illustrators

Emblems are non-verbal acts which have a direct verbal translation, the dictionary’s definition usually consisting of a word or two, or perhaps a face ... (and) is well known by all members of a group, class or culture (Ekman and Friesen 1969: 63). *Illustrators* are movements, which are directly tied to speech; serving to illustrate what is being said verbally (Ekman and Friesen 1969: 68). They may also show bodily action, draw a picture or show a direction of thought.

This research is mainly focused on *illustrators*, which may be of several different kinds such as:

- *batons*, showing tempo or rhythm
- *pointing*, to people or objects

- *spatial* movements or relationships, e.g. under, round
- *pictographs*, showing shapes, e.g. a spiral staircase
- *ideographs*, tracing your line of thought
- showing *bodily actions* (Efron, 1941 cited in Argyle 1964:195).

All *illustrators* add considerably to the amount of information conveyed by speech, especially about shapes, physical objects, and spatial relations.

Hall & Knapp (2006) have further identified these illustrators in four common types.

The four types are: a) Gestures related to the speakers referent- concrete or abstract, b) Gestures indicating the speakers relationship to the referent, c) Gestures that act as visual punctuation for the speakers discourse and d) Gestures that assist in regulation and organization of the spoken dialogue between two interactants.

Of these the two types that inform the research and will be explored are:

Gestures related to the speakers referent- concrete or abstract: Concrete referent related illustrators are used while speaking to characterize the content of speech, such as pointing movement for example could help indicate a specific person, place or a thing being discussed. Such illustrators that draw the referent's shape or movement and depict spatial relationships can help a listener visualise features associated with referents. Whereas, illustrators in which hand movements are mere expressions but do not add to the meaning of the word are abstract referents.

Gestures that act as visual punctuation for the speakers discourse: Punctuation gestures accent, emphasize, and organize important segments of the speech. These types of illustrators are used to emphasize a particular word or phrase and often coincide with the primary voice stress. For example, when we speak of a series such as ‘a list of things to do today’. Counting with fingers or pointing with closed, open fingers, etc. fall under this category.

Graham and Argyle (1975: 57-67) carried out an experiment in which subjects had one minute to describe each of a number of shapes to a decoder with or without hand movements. The decoders drew what they thought the shapes were. These drawings were then studied by judges for their similarity to the originals and found that the drawings were more accurate when the hand gestures could be used. In this research such attributes of NVC were found to contribute to the generation process of the DTPD.

3.6 The role of hand movements in Digital Textile Craft

In this section, we will first establish the role of hand movements informing craft and craftsmanship, which will then be discussed in the context of digital textile craft. This research does not intend to study musculoskeletal actions related to the biological function of the brain as in scientific research. Instead, it focuses on the study of hand movements related to activities such as drawing, through which new skills are learned and deciphered.

In *The Craftsmen* (2008), Richard Sennett explores dimensions of skill, commitment and judgement by focussing on the intimate connection between hand and head. For him, being skilled means being able to think about practice, in this case it is craft. In this thesis his first argument, that states, “ (…) all skills, even the most abstract, begin as bodily practices” adheres to this research as it focuses on “knowledge gained in the hand through touch and movement” (Sennett 2008: 10).

Of all the human limbs, the hands make the most varied movements, movements that can be controlled that will. Science has sought to show how these motions plus the hands varied ways of gripping and sense of touch, affect how we think (Sennett 2008: 149).

3.6.1 Grip

As noted by ethnologist Mary Marzke three basic ways we grip things such as pinching small objects between the tip of the thumb and the side of the index finger, cradle an object in the palm and then move it around with pushing and messaging actions between thumb and fingers. The third way is the cupping grip used when an object is held by the rounded hand, thumb and index finger placed opposite the object (Marzke 1997: 91-110).

Interactions such as those between the thumb and fingers play an important role in this research towards understanding the way the hand works in creating craft.

3.6.2 Prehension

To ‘grasp’ something, meaning that we physically reach or visualise reaching an object, is similar to a physical gesture. For example in a familiar gesture of holding a spherical object such as a tennis ball the hand will assume a rounded shape, suitable to grip the ball before it actually touches its surface. The technical name for such movements in which the body anticipates and acts in advance of physical sensation is *prehension* (Sennett 2008: 154). It is through prehension that we build a repertoire of shape and sizes of various objects in memory. This is used in circumstances when one has to describe an object by gestures without having to show a real object. In *The Hand* (2003: 329) Raymond Tallis, has further organised the phenomenon of prehension into four dimensions such as: anticipation, the form or shape our hand will make. Contact, the physical sensation sensed through the actual touch of the object. Language cognition or putting into words the ideas formed, and lastly reflection about it and what has been done.

Concentration consummates a certain kind of technical development in the hand. The hands have had before to experiment through touch, but according to an objective standard; they have learned to coordinate inequality; they have learned the application of minimum force and release.

The hands thus establish a repertoire of learned gestures. The gestures can be further refined or revised within the rhythmic process that occurs in, and sustains, occurs in, and sustains, practising. Prehension presides over each technical step, and each step is full of ethical implication (Sennett 2008:178).

We have found in the previous section how gestures contribute in communication. In fact hand movement in gestures are not very different from Sennett's description of hand movements as skills in a craftsman. They are not separate from each other but intertwined.

3.6.3 Touch

According to Malcolm McCullough, in *Abstacting Craft: the Practiced Digital Hand* (1998) hands are versatile, they serve as conduits through which we extend our will to the world, bringing us the knowledge of the world, not a linguistic or symbolic knowledge but something based on concrete action such as sculpting plaster or clay. The knowledge in these actions is not only physical but also experiential. The way of hands is personal, contextual and indescribable. He argues through Michael Polanyi's study of scientific learning, *Personal Knowledge* (1958) that aimed to show that even factual knowledge is acquired through personal commitment. He references how Polanyi's study probes *tacit* knowledge in a non scientific setting such as 'the hands playing a piano', the pianist's touch, that can lead to sounding of a note in different ways, yet when analysed, is difficult to account for the existence of touch.

In sum, hands are the best source of tacit personal knowledge because of all the extensions of the body; they are the most subtle, the most sensitive, the most probing, the most differentiated, and the mostly connected to the mind.” (McCullough 1998: 7)

The knowledge in craft comes from hand, which is not just symbolic knowledge, but something that is used to give a form such as in a drawing; a circular hand wrist movement attains a circular form. This kind of knowledge is not just physical but also something, which we experience within ourselves. To draw a circle is to experience a circle, which is a circular motion, which then the hand executes. (Itten 1975:110) This kind of experience is theorised as tracking, which is a combination of eye and hand movement.

McCullough references "Henry Focillon's *The Life of Forms in Art* (1934) which addresses the dynamics of creativity, for which he argues that art must be tangible. He asserts that a form in an object is one way to record the several kinds of skilled hand movements that would have finalised the form. This is a dynamic process in which the hands are the giver of the form (McCullough 1998: 7-10).

The research identifies hands as a strong protagonist of creation, in printed textile design.

3.7 Convergence of hand movements & technology

In the previous sections (3.5-3.6) we have discussed the role of the hand in NVC and in digital craft methods. Also, we have theorised digital printed textile design (DTPD) and motion capture (MOCAP) as both medium and tool. The word convergence means putting together various elements in a way that they serve each other to fulfill a goal. In this case, it is hand movements and digital technology to generate motifs and patterns, which will be used to create printed textile design. The research identified that hand movements in NVC are similar to the hand movements used in craft methods, to give shape or form to both analogue and digital media. Hand movements in NVC converge with digital media to form a new hybrid design process. This is further explained through McLuhan's media theory. In *Understanding The Media* (1964) Marshall McLuhan theorised *medium* (technology) as an extension of the human body or the mind that acts as agents of change in our experience of the world. Hybridisation of *medium* results in 'release of great new force and energy as by fission or fusion', meaning this process not only changes form and usage of existing media but our behaviour with such *medium*.

> The hybrid or the meeting of two media is a moment of truth and revelation from which a new form is born. For the parallel between two media holds us on the frontiers between forms that snaps us out the Narcissus-narcosis. The moment of the meeting of media is a moment of freedom and release form the ordinary trance and numbness imposed by them on our senses. (McLuhan 1964: 80)

Both NVC and MOCAP are extensions of our body that use our physical senses, the senses that media extends. While NVC is a form of gestural language and MOCAP's primary function is to capture body movements. When NVC and MOCAP are combined, both their form and usage change.

Therefore, the convergence creates a new medium, Hybrid Print System (HPS) to explore the 'fusion' of two media such as MOCAP and DTPD to capture, visualise and materialise hand movements in gestural form into printed patterns.

3.8 Conclusion of Chapter

So far in this practice-led research, an opportunity has been identified for the development of a new method of printed textile design that will involve the study of hand movements in a wider context of use such as art design and communication based on theories of psychology and sociology. The research question that was formulated is now given shape underpinned by this theoretical research. Firstly, the research has identified a new model of printed textile design, which includes stages of generation, design, materialisation and application. It was found that the first three stages generation, design and materialisation are iterative. Although, the application stage of DTPD is not considered in this chapter but it will be part of the practical outcomes disseminated in Chapters 4, 5 and 6. It was found that printed textile design is a medium through which a designer conveys a message to the rest of the world. It has also been established that motion capture technology (MOCAP) could prevail in the experimental chapters as both medium and tool. It has also been rationalized that optical marker-based motion capture technology is appropriate for further experimentation. The roles of hand movements in non-verbal communication are similar to those used in hand crafted prints. In section 3.7 it was found appropriate to discuss convergence of gestural hand movements role in digital craft. Convergence creates a new space, a medium and a tool, which has been theorised as Hybrid Print System. The model of HPS shows that it would largely depend on audience participation, as a set of changes that could occur in the field of printed textile design in parallel with the changing role of the designer, audience participation and gestural mode of drawing.

The next chapters deal with the practical research of the project, identifying and exploring the methods to be used to create the HPS.

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Chapter 4

MOTION TRACING

4.1 Introduction

Previously in this thesis, Chapter Two contextualized hybrid explorations of digital craft as a method, through historical studies and current practice, of creating surface patterns in printed textile design. Chapter Three then proposed and theorized a novel method of digitally crafting prints using a Hybrid Print System (HPS). HPS proposes the generation of motifs and design of surface patterns for printed textile design. HPS generates motifs from hand movements such as gestures, by integrating two technologies such as MOCAP and DTPT (Digital Textile Printing Technology). Chapters Four, Five & Six are concerned with the experimental research that was carried out to integrate the two technologies, whereby MOCAP was employed to generate the motifs, which were then used for the design of patterns to be materialized as printed textiles using DTPT. This chapter specifically focuses on the process of motion tracing. It need to be stated that all the images that are featured in this chapter and forth coming chapters 5-7 were outcomes of the practical research and they were produced by me.

4.2 Hybrid Print System (HPS)

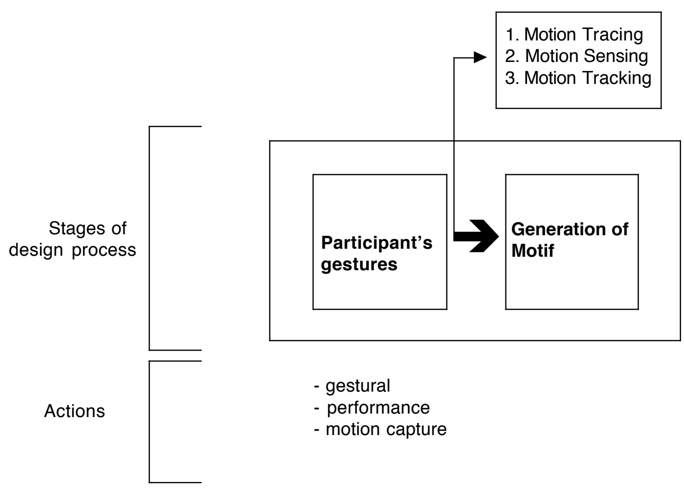

Fig. 4.2.1 The model of Hybrid Print System

The model of DTPD (Digital Printed Textile Design) as discussed earlier in the previous chapter (Section 3.2) is then applied complete the HPS and realize the outcomes as physical designs. This model forms the basis for further experiments in this Chapter, as well as Chapters Five and Six. In the model of HPS (Fig. 4.2.1), a change that has been made is the addition of audience participation to the model of DTPD (Fig. 3.2.1). The practical part of the project aims to contribute to knowledge by studying the HPS through creative experiments as both as a hybrid tool and as a holistic design approach. HPS is used to create patterns for printed textile designs in unconventional and innovative ways, such as by drawing motifs using hand gestures in a 3D space.

The generative stage of design required the staging of experiments to capture hand movements using three practical methods. The research identifies these practical, experimental methods as being based on the concepts of manual, semi-automated and automated processes. HPS is developed through triangulation of the outcomes and reflections on these experiments.

The three experimental methods are:

1. **Motion tracing** – an established method of *rotoscoping* revisited through digital imaging tools such as Adobe Photoshop and Illustrator in combination with digital photography and digital video film.

2. **Motion sensing** – a combination of computer vision (external webcam) and programming language such as *Processing*.

3. **Motion tracking** – optical motion capture and visualization of the acquired 3D data.

The second phase of the HPS deals with the materialization of surface patterns as printed textile designs using DTPT. The surface pattern is visualized on a computer screen and subsequently printed on paper. But, printing on a textile using DTPT requires planning such as the dimension of the pattern should not exceed the dimension of the fabric and the colour mode needs to be calibrated in line with the choice of fabric. Therefore the research question that was raised in this phase was how to transpose a screen visualisation of surface patterns onto cloth to create a printed fabric. The concept of fabrication was explored as a design method, which allowed the pixel-based screen visualizations to be printed onto an analogue medium by considering the surface pattern creation through the stages of image generation, scale of the image and choice of fabric.

The explicit documentation of the experiments using the three different experimental methods aims to develop new practical knowledge and approaches, which current and future practitioners of printed textile design will find useful. Since the visual outcomes of these experiments are graphical in nature, practitioners from related fields such as graphic design, visual communication design and multimedia design could also adopt these experimental research procedures as part of a design methodology. An evaluation of the three experimental methods explored in Chapters Four, Five and Six is provided in Chapter 7.

4.2.1 Contextualisation of Experiments

Since the onset of the practical research, the capturing of hand movements to create surface patterns has been a key focus of the investigation. Initially, this research was influenced by the psychological studies in non-verbal communication (NVC). The project explored Argyle's (1975) basic paradigms of NVC, which briefly explains the process of encoding and decoding gestures between two people in a conversation. According to Ekman and Friesen (1969) the intentional hand gestures produced through conversation can be distinguished as *emblems* and *illustrators*.

Emblems are non-verbal acts which have a direct verbal translation, the dictionary definition usually consisting of a word or two, or perhaps a face ... (and) is well known by all members of a group, class or culture (Ekman and Friesen, 1969: 63). *Illustrators* are movements, which are directly tied to speech; serving to illustrate what is being said verbally. They may also show bodily action, draw a picture or show a direction of thought (Ekman and Friesen, 1969: 68).

This research is mainly focused on *illustrators*, which may be comprised of several different kinds of bodily actions such as pointing, showing a spatial relationship or conveying tempo and rhythm.

Primarily, the practical research questions were formulated as:

1. How can *illustrators* be captured and visualised?

2. How can *illustrators* be used to generate motif for printed textiles?

3. How can HPS generated motifs be used to design patterns?

The solution to these questions required hand movements such as *illustrators* to be studied as sequenced images. The sequenced images were acquired through digital photography and digital video. A photograph is a representation of an object or space in a 2D format so these images are assessed as 2D visual data. The visual analysis of the 2D visual data informed the research about the physical displacements of the hands, including the change in shape that occurs whilst making simple *illustrators* such as ‘hello’, ‘stop’, ‘open’, ‘waving’, ‘grasping’ etc. Information about the changing shapes was then used to create transitional shapes from the acquired images to create surface patterns. A transitional shape is an interpolation between two shapes in sequence to create a third shape (

Fig. 4.2.2).

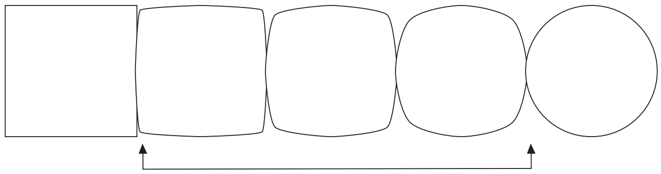

Fig. 4.2.2 Process of creating transitional shapes

Thus, the transitional shape is a new shape that acquires the geometric properties of both the shapes that inform it. The research found that if a digital video is deconstructed into frames, it results in a large sequence of images. For example, one minute of digital video deconstructed at a rate of 25 frames per second would produce 1500 images. The experiments undertaken should be seen as sketches from a reflective practitioner's 'reflection-in action' work in progress methodology (Gray & Malins 2004: 22). The documentation of experimental research by previous practice-based textile design researchers (Briggs, 1997, Townsend, 2003) was usefully adapted in terms of formulating a formal analytical structure through stages of: 'Intention, Process and Reflection.'

4.3 Motion Tracing

The concept of Motion Tracing was inspired from research into Muybridge's study of 'Movements of a hand drawing a circle, 1887' (Section 2.5). In this work, he photographed the hand from multiple perspectives whilst in action, and the resulting twenty-four images were laid out in a grid of six rows and four-columns, so that the sequence could be viewed as a whole rather than as fragmented actions. From a printed textile designer's perspective the sequence of images and the layout shows a regular grid format, in which the hand represents a non-repeating motif. It was considered that the hand movements in a gesture are continual in sequence and, similar to Muybridge's study, could provide a source for a continuous pattern.

According to Sturman (1994): "motion capture of human body movement for immediate or delayed analysis can be as general as the simple position of the body in space or as complex as the deformations of the face and muscle masses." This means that a sequence of images of the hand movements in a gesture could become a simple method of motion capture. Printing such a sequence of images directly, as depicted in Muybridge's study, was not the intended outcome of the research experiment, but rather to obtain an element such as a shape or an outline of the hand from the images, which could be further used in pattern construction. The method of digital tracing was found to be an optimal solution to obtain such elements from an image. The trace of the shape of the hand in the image is seen as a simplified, minimal and realistic representation of the hand's spatiotemporal movement. Menache (2000: 2) has reinstated motion capture as the descendant of the rotoscoping technique. Therefore, motion tracing was finalised as a method of combining the rotoscoping technique with digital imaging software to capture hand movements and construct surface patterns from them. This concept was realized as a hybrid approach to create surface patterns, which explores and combines an established method of animation / rotoscoping with new digital media.

4.4 Experiment 1: Simple Gestures I

4.4.1 Intention

The experiment was conducted to explore the concept of motion tracing using digital photography. It was devised to capture a sequence of hand movements through digital photography while making simple *illustrators* (hello', 'stop', 'open' etc.). The sequence of images was digitally traced to obtain an element such as the shape of the hand. The sequence of shapes was then arranged in a linear sequence, which could be either horizontal or vertical. This linear arrangement was based on the concept of representing time and space graphically.

4.4.2 Process

4.4.2.1 Motif Generation

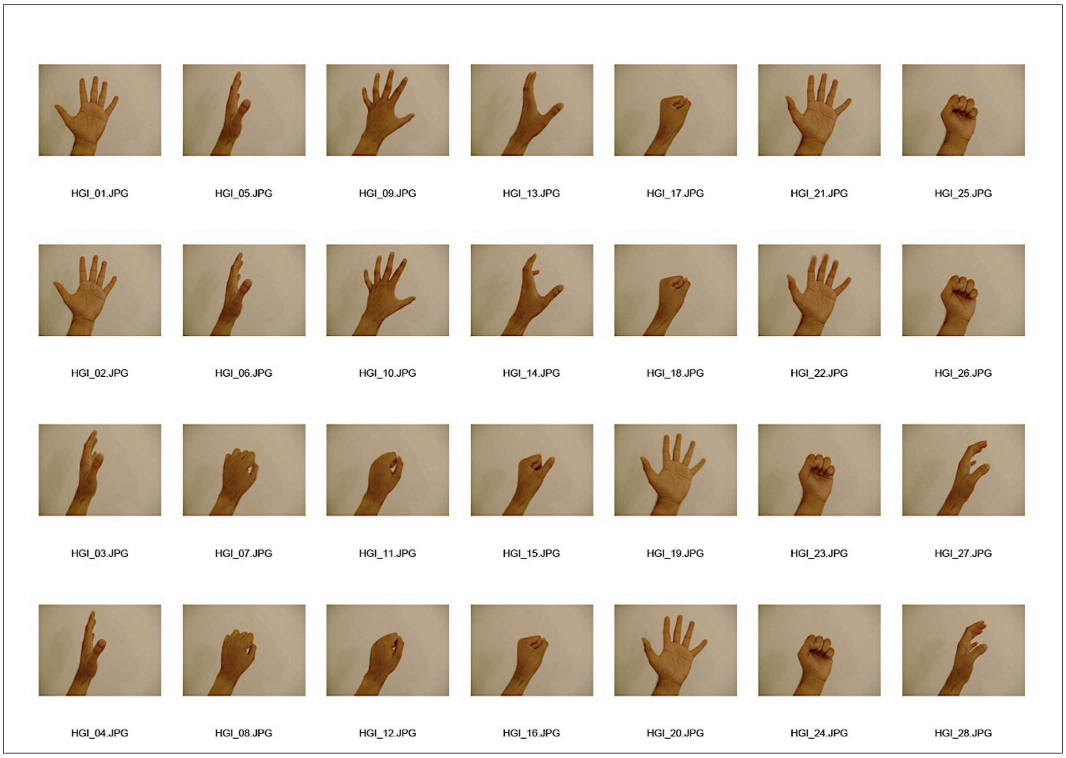

Fig. 4.4.1 Hand Gesture Images in sequence

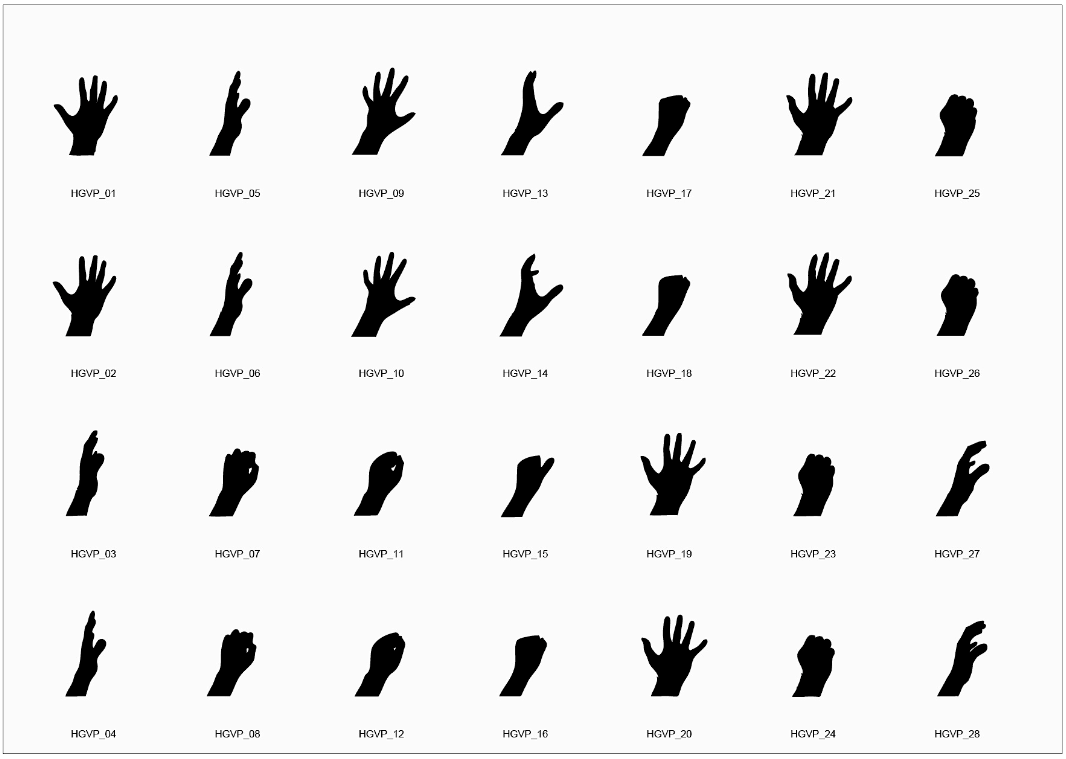

Fig. 4.4.2 Hand gesture vector path shapes in sequence

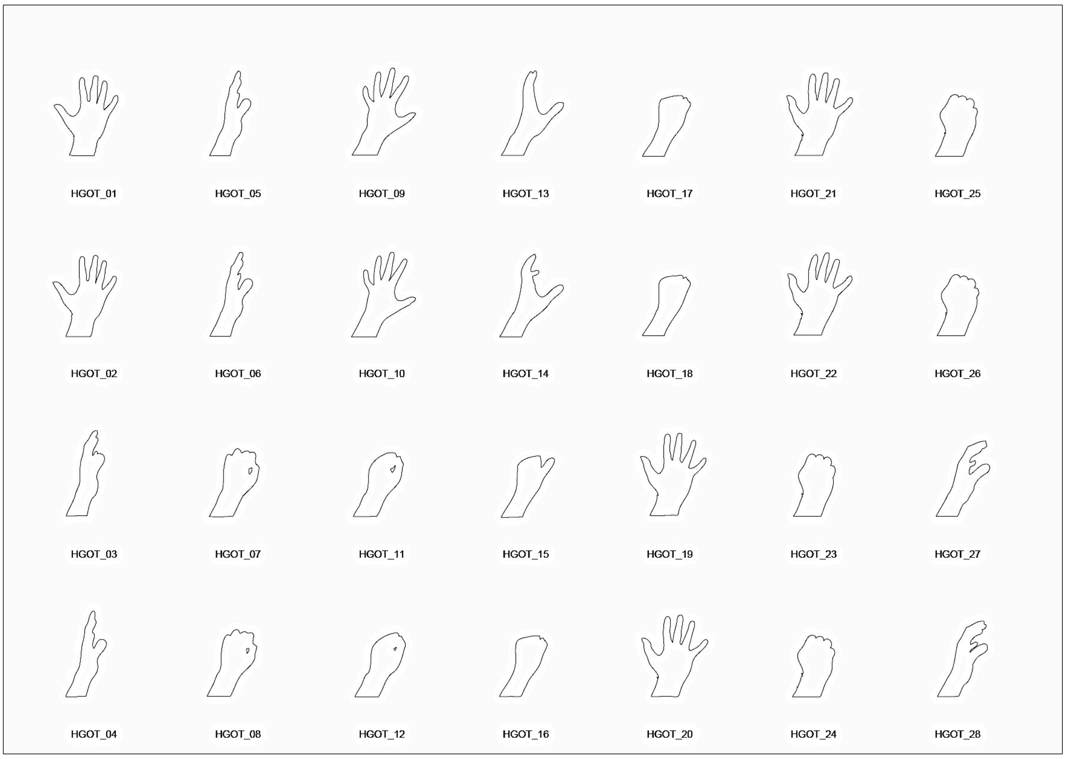

Fig. 4.4.3 Hand Gesture vector shapes in sequence

The process began by digitally photographing hand movements of an individual in close-up focus against a light background. The idea behind such conditions was that it would be simpler to separate the object (the hand) from the background, making it easier to select the shape of the hand.

By exploring the digital still camera's capabilities, it was discovered that the 'burst photography' mode could be used to capture a sequence of images at regular time intervals of approximately 0.46 of a second. Each sequence was timed at 1520 seconds.

After a few trials, sequences of 28 images were selected on the basis of the distinct pose, clarity of the image and representation of continuous motion (Fig. 4.4.1). The selected images were then downloaded and processed using Adobe Photoshop. As discussed, in the Intentions (4.4.1), the 'trace' is the outline of the shape of the hand in each pose. Manually drawing an outline on each image, was found to be time consuming and tedious. However, if the same process were approached by the image background separation method, it would be efficient and consistent. The choice of the image's colour adjustment through the *threshold* command was found to be optimal because it converted these images to high-contrast, black-and-white images. When applied to the image the hand appears as a solid black form against the background in white. It was found that due to the use of digital photographic properties such as *colour value* and *light intensity*, the images were similar to each other. Therefore, it became appropriate to apply the same threshold level to the entire sequence of images. From the resulting images, the colour black was selected, and defined as a vector path (Fig. 4.4.2). Thus the trace (the outline of the hand's silhouette) was created as a vector shape (Fig. 4.4.3). The amount of time required for this repetitive task was minimized later by batch processing the entire sequence of images.

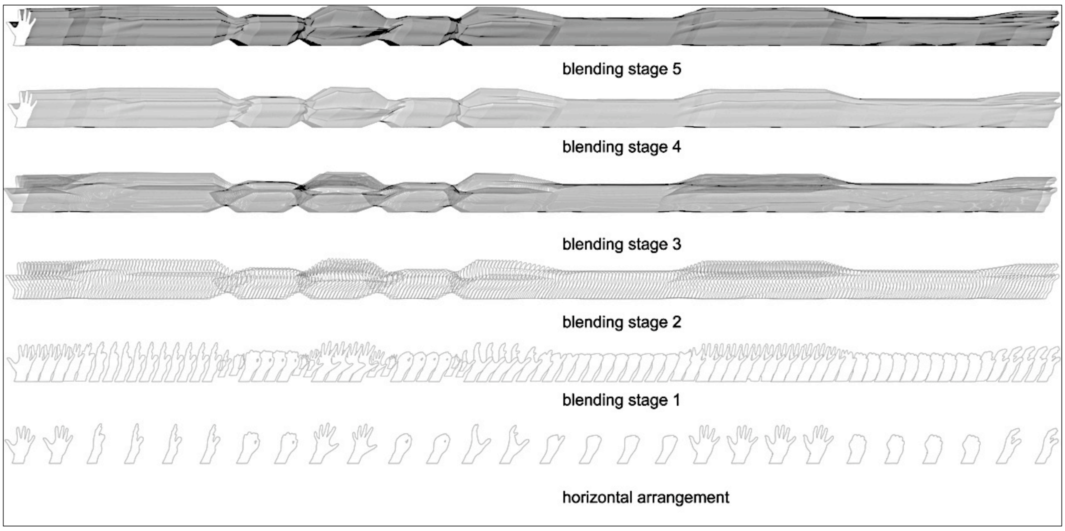

Fig. 4.4.4 Simple Gestures I, Pattern construction

4.4.2.2 Pattern Design

The vector shapes resulting from the capturing of hand movements, described above, were then imported into Adobe Illustrator to construct a continuous pattern. The pattern construction was based on the concept of a linear arrangement of the vector shapes in a horizontally equidistant position creating new transitional shapes to fill the spaces in-between. The *make blend* command was applied to generate transitional shapes. The vector shapes along with their transitional shapes in a linear arrangement comprise the surface pattern. The number of transitional shapes between two vector shapes can be defined before the *make blend* command is executed. This is illustrated by the various stages (Fig. 4.4.4).

4.4.2.3 Textile Materialisation

The pattern was further developed by filling the vector shapes with colour white and outlined in black. This pattern was the then materialized by using DTPT to print onto 100% Silk Crepe Satin (Fig. 4.4.5). The decision to use this fabric was based on the texture, soft handle and fluid quality of the fabric. However, this pattern could be printed onto various other fabrics.

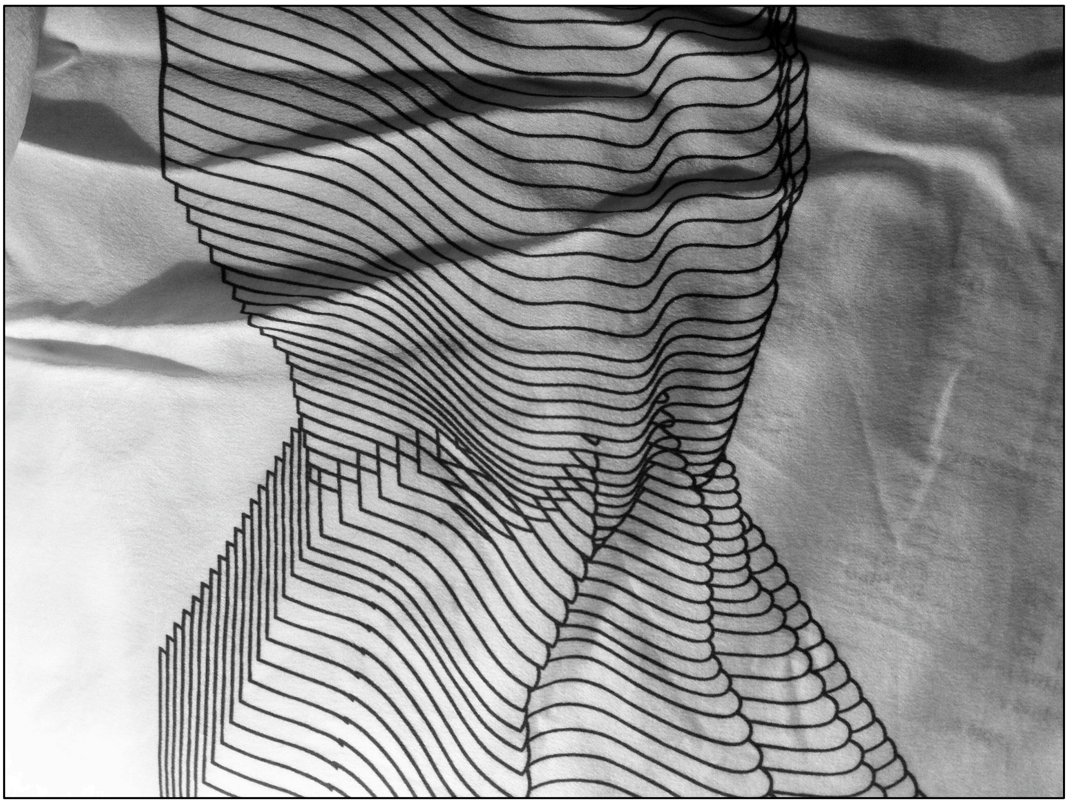

Fig. 4.4.5 Simple Gestures I, materialised pattern in detail

4.4.3 Reflection

The outcome of this experiment is a continuous pattern that represents a gestural hand movement in transition. When the vector shapes are filled with colour the resulting pattern depicted 3D, kinetic and sculptural rendered forms, in which, gestures representing actions such as 'stop, close and open' seemed to alter the continuity of the motifs in the pattern resulting in the simulation of a sculpted 3D form (Fig. 4.4.6). The experiment required the colour scheme to be kept monochromatic, so that the pattern could be distinguished by a figure and ground relationship.

This method showed a great deal of potential for the construction of continuous patterns. The relationship between the gesture and the resulting pattern is significant in the sense that it's meaning could be understood as a symbol or a sign representing a gesture. This process of creating surface patterns is new and it could be improvised using different variations. Firstly, the number of frames could be increased to see if this could result in a different pattern. The thickness of the lines could be reduced to produce an intricate pattern.

In the explorations the variations between patterns illustrated that the *make blend* tool's parameters could be specified by the number of steps between two vector shapes. The specified number of steps resulted in creating the same number of transitional shapes. This parameter could be explored to alter the density of the resulting pattern.

The choice of a vector path rather than a raster image was based on the following technical considerations:

1. The *make blend* command can be executed via the vector paths to generate a continuous pattern is available in Adobe Illustrator.

2. The vector files occupy less memory space.

3. The resulting pattern can be scaled up in size without losing the quality of line, which otherwise results in a grainy image commonly known as pixelation. This occurs when a low-resolution image is scaled up in size in Adobe Photoshop.

Although batch processing, recording actions, and the make blend tool provide a series of continuous operations it would be useful in future if the entire process could be automated. In this way gestures of a participant could be recorded and designed as a pattern simultaneously. The implication of this process is it could negate the intervention of decision-making in between stages of motif generation and design of pattern. However, such a concept could result in creating new patterns. For example product designer Geoffrey Mann (2008) has employed a similar concept to construct 3D decorative objects such as Flight take-off , depicting a solid trace echo of a bird's flight (Section 2.8). This method of generating a pattern has not been explored in printed textile design and therefore offers an opportunity for further experimentation.

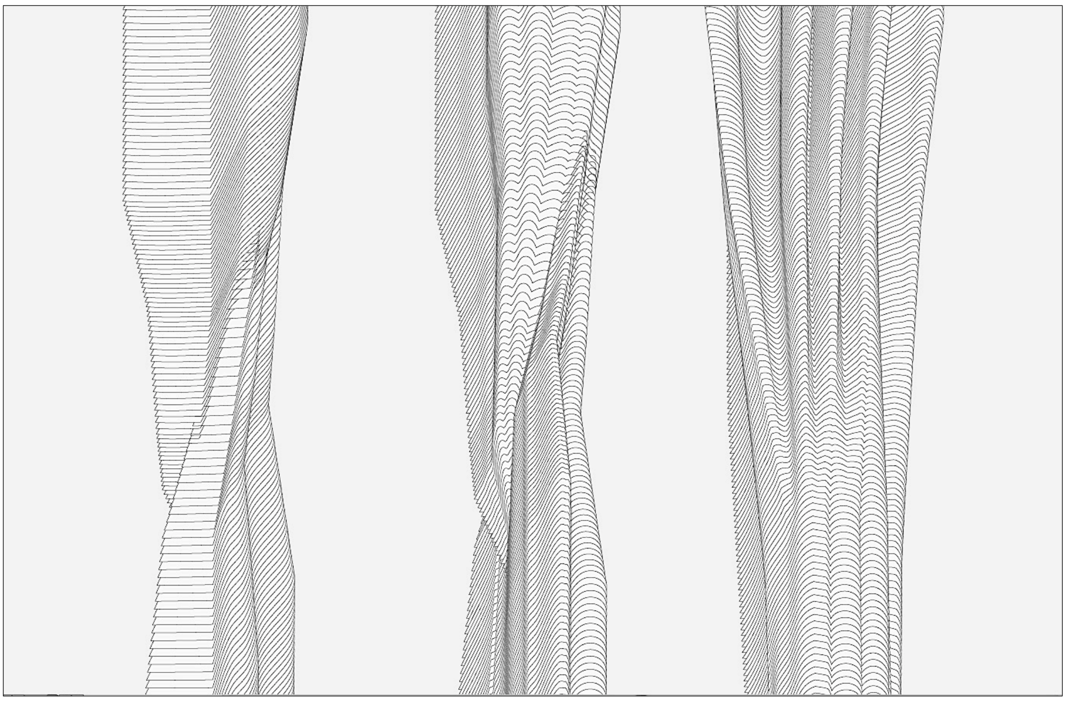

Fig. 4.4.6 Simple Gestures I, Pattern in detail

4.5 Experiment 2: Simple Gestures II

4.5.1 Intention

During the first few trials (Simple gesture I), it was found that some of the hand movements were so vivid that within the given time interval, certain parts of the hand appeared to be blurred in the photographs (Fig. 4.5.1). The resulting images were interesting visually as they represented the fingers transitional movements, thus creating a temporal shape, which otherwise cannot be seen by a naked eye. It was realised that such images cannot be traced precisely and that they should be reconsidered through a variation of the process.

4.5.2 Process

4.5.2.1 Motif Generation

In this process the sequence of blurred images were applied with the same threshold level as in the previous experiment. From the resulting images, the colour black was selected, and the selection was defined as a vector path (Fig. 4.5.2). It was observed that the image background separation method resulted in irregular and speckled vector shapes.

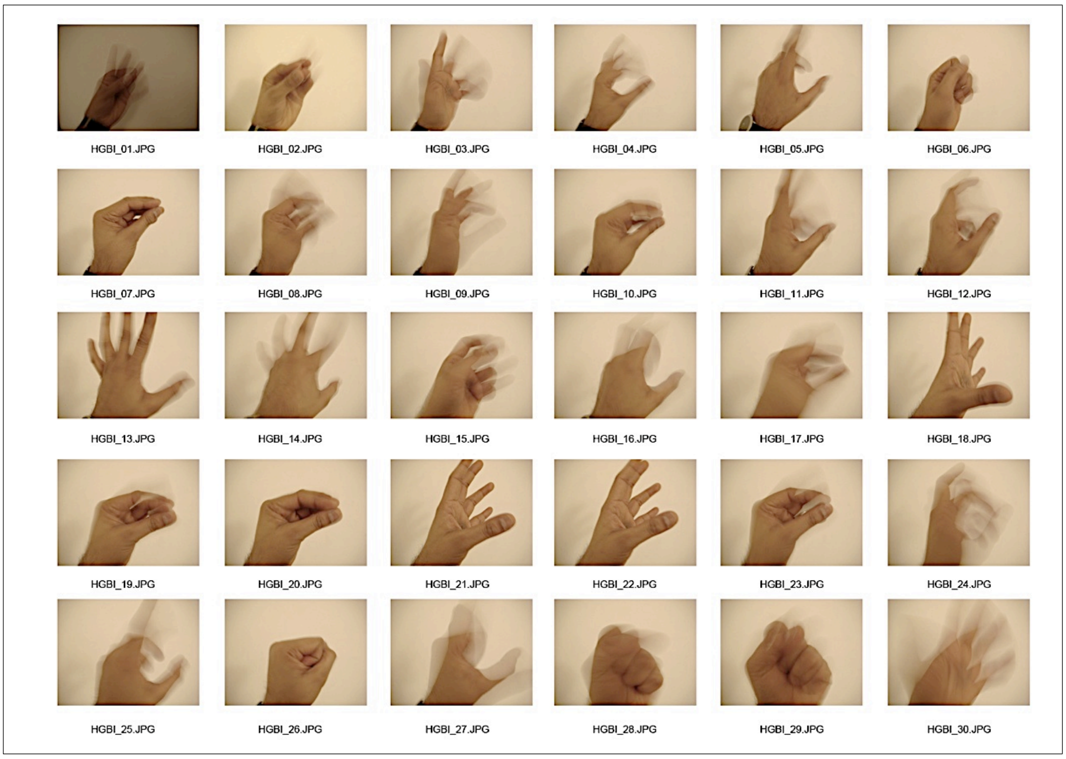

Fig. 4.5.1 Hand Gesture Blurred Images in sequence

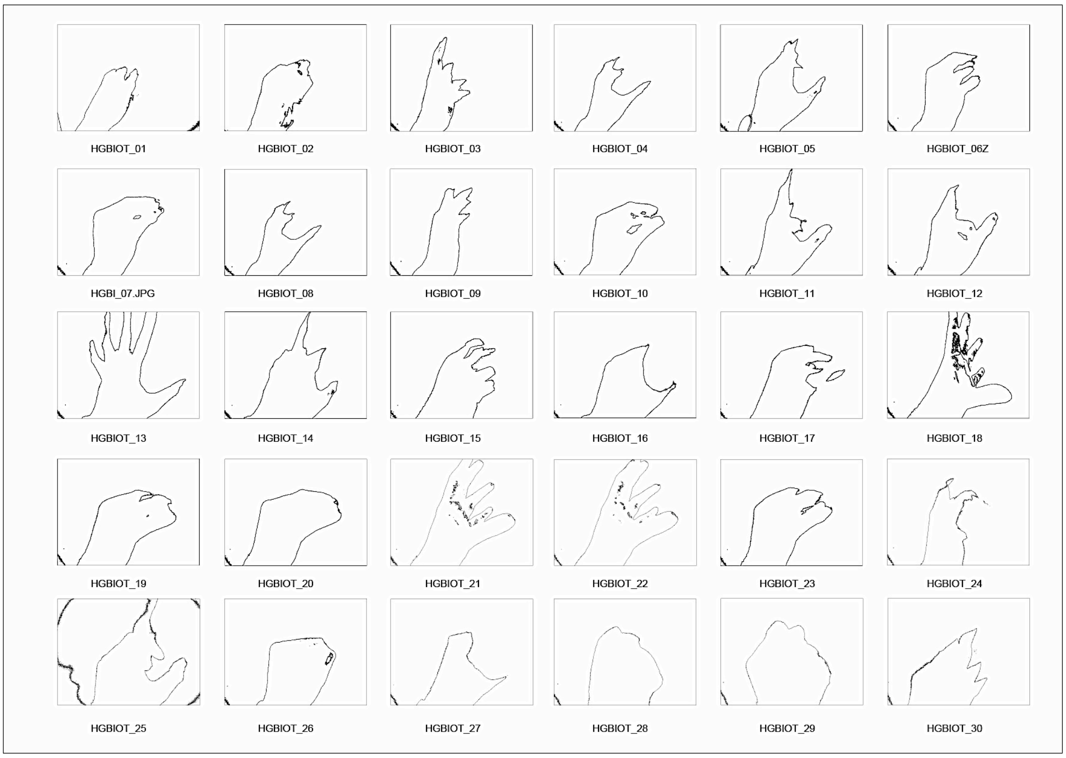

Fig. 4.5.2 Hand Gesture Blurred Images vector shapes in sequence

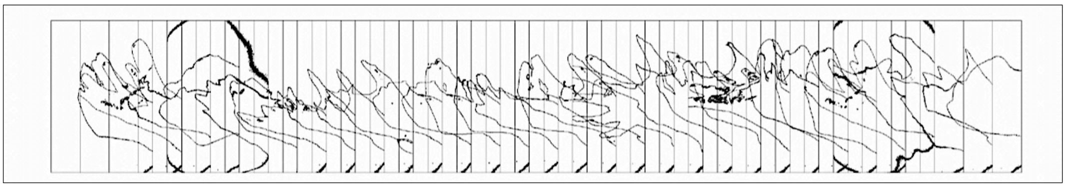

Fig. 4.5.3 Layered and Distributed, pattern construction of Simple Gestures II

4.5.2.2 Pattern Design

Blending vector shapes of blurred hands to create a transitional shape resulted in errors. Therefore, the vector shapes required a different approach than the previous 'transitional shapes' approach to create surface pattern. Following experimentation it was discovered that these vector shapes could be arranged in layers and distributed to create a new style of surface pattern (Fig. 4.5.3). As a variation, the vector paths were arranged in layers and superimposed resulting in a continuous surface pattern (Fig. 4.5.4).

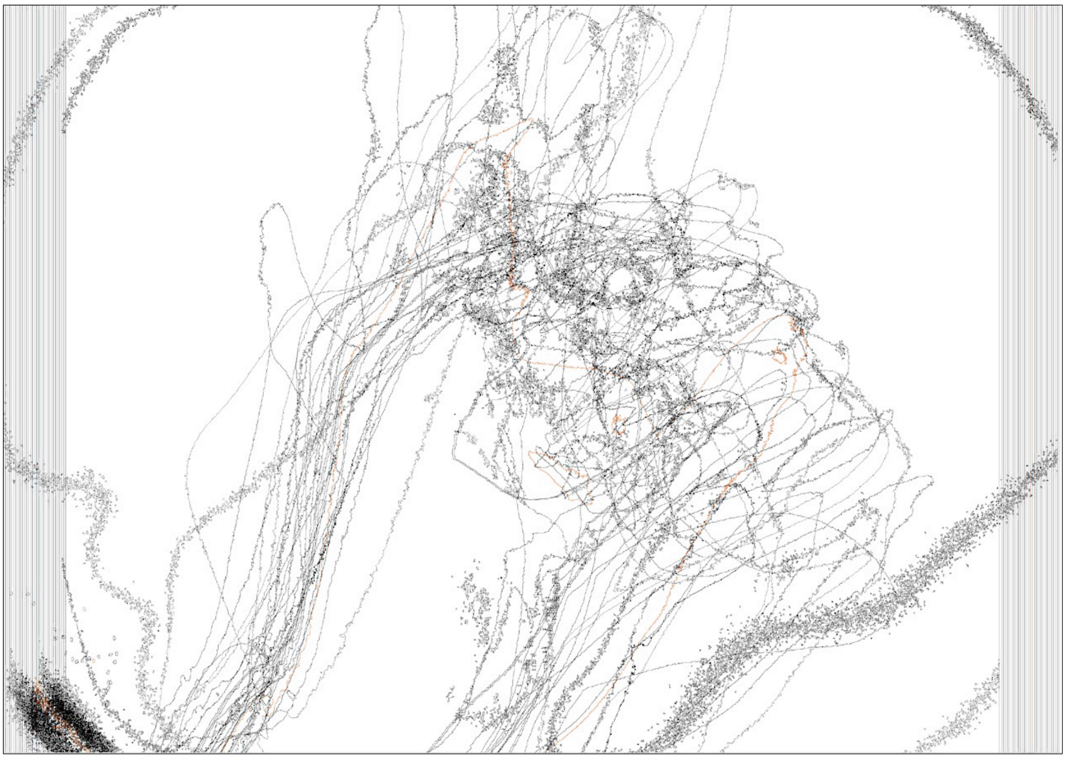

Fig. 4.5.4 Layered and Superimposed, pattern construction of Simple Gestures II

4.5.2.3 Textile Materialisation

In between the two generated patterns, the second pattern (Fig. 4.5.4) was selected to be materialized by using DTPT to print on a 100% Silk Habotai fabric. The pattern was selected on the basis of intricate fine lines that constituted the designed pattern, which further complimented the visual characteristics of a fabric with a fine sheen and smooth handle (Fig. 4.5.5).

Fig. 4.5.5 Simple Gestures II, materialised pattern in detail

4.5.3 Reflection

The set of blurred image sequences presented a point of view similar to the *Futuristic* depiction of Giacomo Balla's, painting "*Dynamism of a Dog on a Leash*" (1912) (Section 2.5). The resulting pattern created from these images appeared intricate, textural and complicated. This could be simplified by arranging the shapes in a quarter-drop repeat to create a pattern (Fig. 4.5.3). However, the original, complicated version of the pattern appeared to be more intriguing and innovative. In the next experiment video film would be utilized to obtain even more detailed hand movements to create gestures.

4.6 Experiment 3:Simple Gestures III

4.6.1 Intention

This experiment was conducted to explore the concept of motion tracing using digital video film, which was used to capture hand movements making simple *illustrators* (hello', 'stop' etc.). Simple Gestures 3 was devised following reflection on Simple Gestures 2, which demonstrated that more images of hand movements in a sequence could lead to a different style of surface pattern (section 4.5.3).

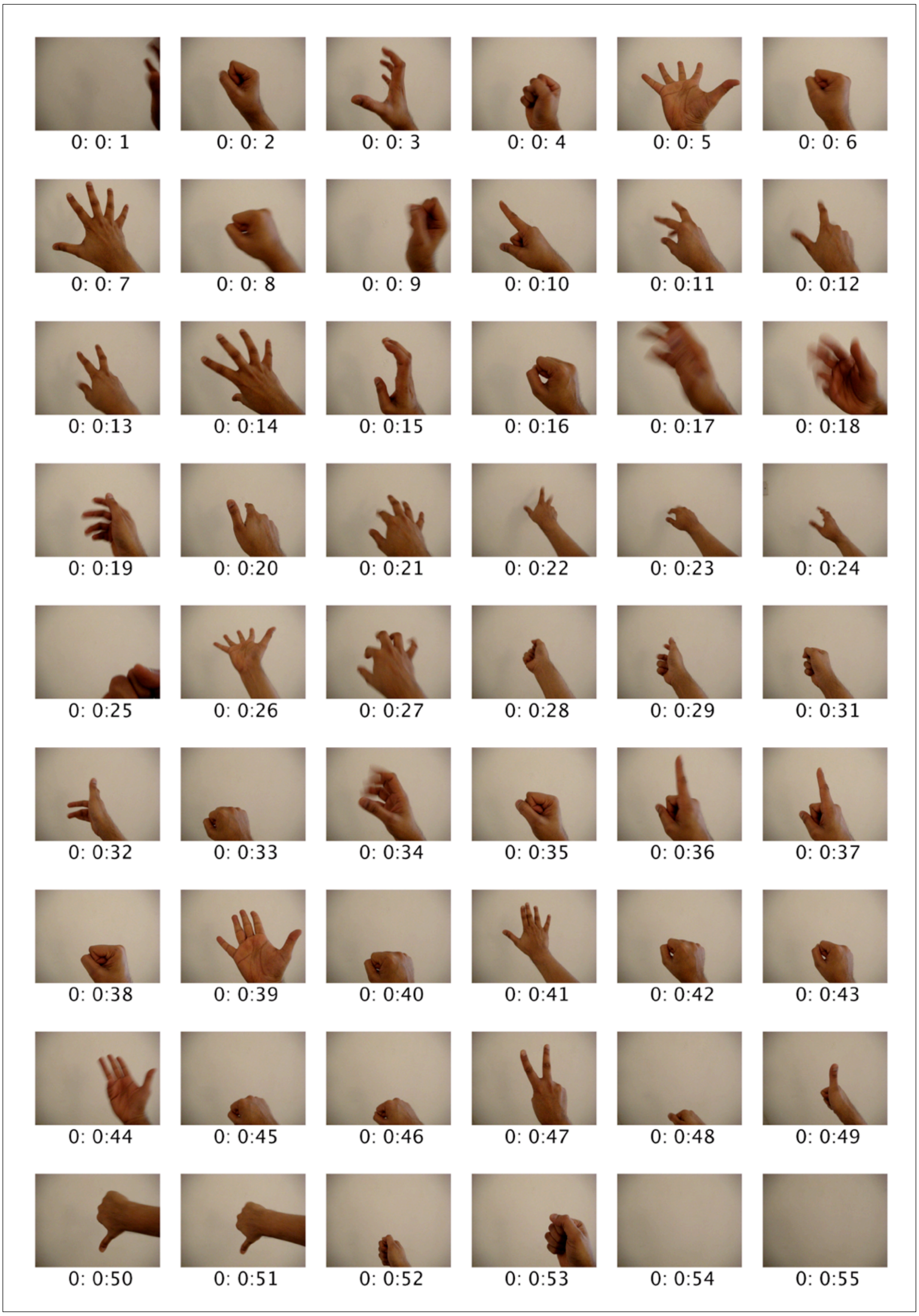

Fig. 4.6.1 Images of deconstructed video film of hand gestures into frames

A digital video film can be deconstructed into images at a rate of 25 frames per second, meaning that film footage of 1 minute will provide 1500 images in a sequence. In order to process 1500 images to obtain the shape of the hand in required automation. It was found that automation could be achieved by batch processing the images with the *live trace* tool available in Adobe Illustrator. The live trace tool has the capability to apply a pre-defined threshold level to an image and simultaneously create a vector shape.

4.6.2 Process

4.6.2.1 Motif Generation

The process began by digitally filming the hand movements of a participant with a close-up focus against a light background (similar to the photographic process). The film was then downloaded and deconstructed into individual images using Adobe Premier Pro (Fig. 4.6.1). The entire sequence of images was saved in a specified folder. These images were then examined to see if all of them had slight or significant variations. It was found that variations occurred in every 10th image. Based on this, a sequence of 155 images were selected to be batch processed with the *live trace* tool and the resulting vector shapes were placed in layers in a single file (Figure 4.14).

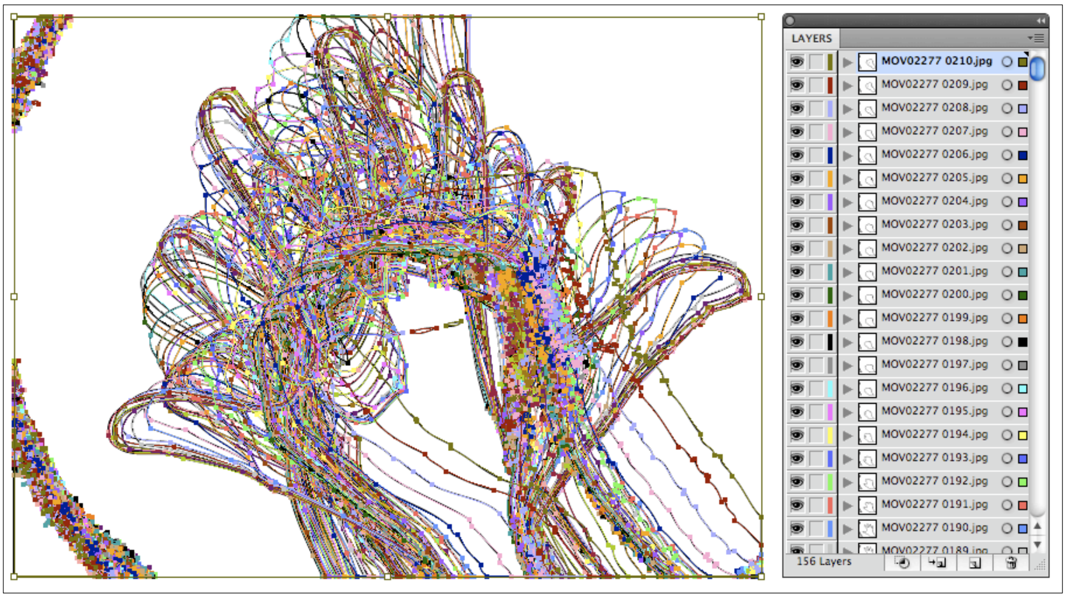

Fig. 4.6.2 Live traced vector shapes of the sequence of 155 images in separate layers

Fig. 4.6.3 Simple Gesture-III, Pattern construction by rearranging live traced images of hand gesture

4.6.2.2 Pattern Design

The vector shapes were then simplified to smooth the rough edges. The resulting vector shapes are defined with a fill colour white and outlined in black. This step was identified as a key method for creating distinct shapes. The selections of vector shapes were then vertically distributed along the axis to create a surface pattern (Fig. 4.6.3).

4.6.2.3 Textile Materialization

The generated pattern was printed on a 100% Silk Crepe fabric using DTPT. The fabric was selected on the basis of its sheen and handle.

4.6.3 Reflection

The outcome of this experiment was a continuous pattern that represented a gestural hand movement in transition. The automation technique that was suggested in the previous reflection on Experiment 2 (section 4.5.3) was successfully tested and employed. This improved the overall appearance of the surface pattern by introducing new visual characteristics that were more organic and less algorithmic when compared to the previous outcomes (Fig. 4.5.5). Using the automation technique minimizes the difficulties faced in tracing blurred photographic images. In Section 4.2.1 the method of creating transitional shapes was suggested to create surface patterns from a sequence of images. This was then explored in practice (section 4.4 & 4.5) by using shape blending tools. In contrast, the automation technique used in this experiment demonstrates a new method of creating such transitional shapes, which is more realistic than the previous outcome. Up until this point in the experiments, the relationship between the gesture and the resulting pattern was based on the symbolic representation of a gesture. It was felt that this required further clarification, through the introduction of a new method of visual analysis, explored in the next experiment.

4.7 Experiment 4: Gestures using British Sign language I

4.7.1 Intention

The intention in this experiment is the translation of a poem in British Sign Language (BSL) to create surface patterns. BSL is an established form of language, which partly involves hand movements such as gestures as a visual means of communication. The idea was triggered while watching a television programme that was translated simultaneously by a BSL interpreter for people with hearing disabilities. The poem ' The Tyger ' by William Blake is a description of the animal Tiger as 'God' created it in a poetic language. In " *The Illuminated Blake*" (1974), David V. Erdman annotates 'The Tyger' (Experience): "In short, this picture, like the poem it illuminates, remains one of Blake's contrived enigmas — a contrivance forced upon him by the truth, one feels". This means the picture represents Blake's imagination of the fearful and beautiful sides of the ferocious animal, which have been imparted by God. Likewise, the translation of the poem in British sign language which would be motion traced could provide a graphical view of such an imagination.

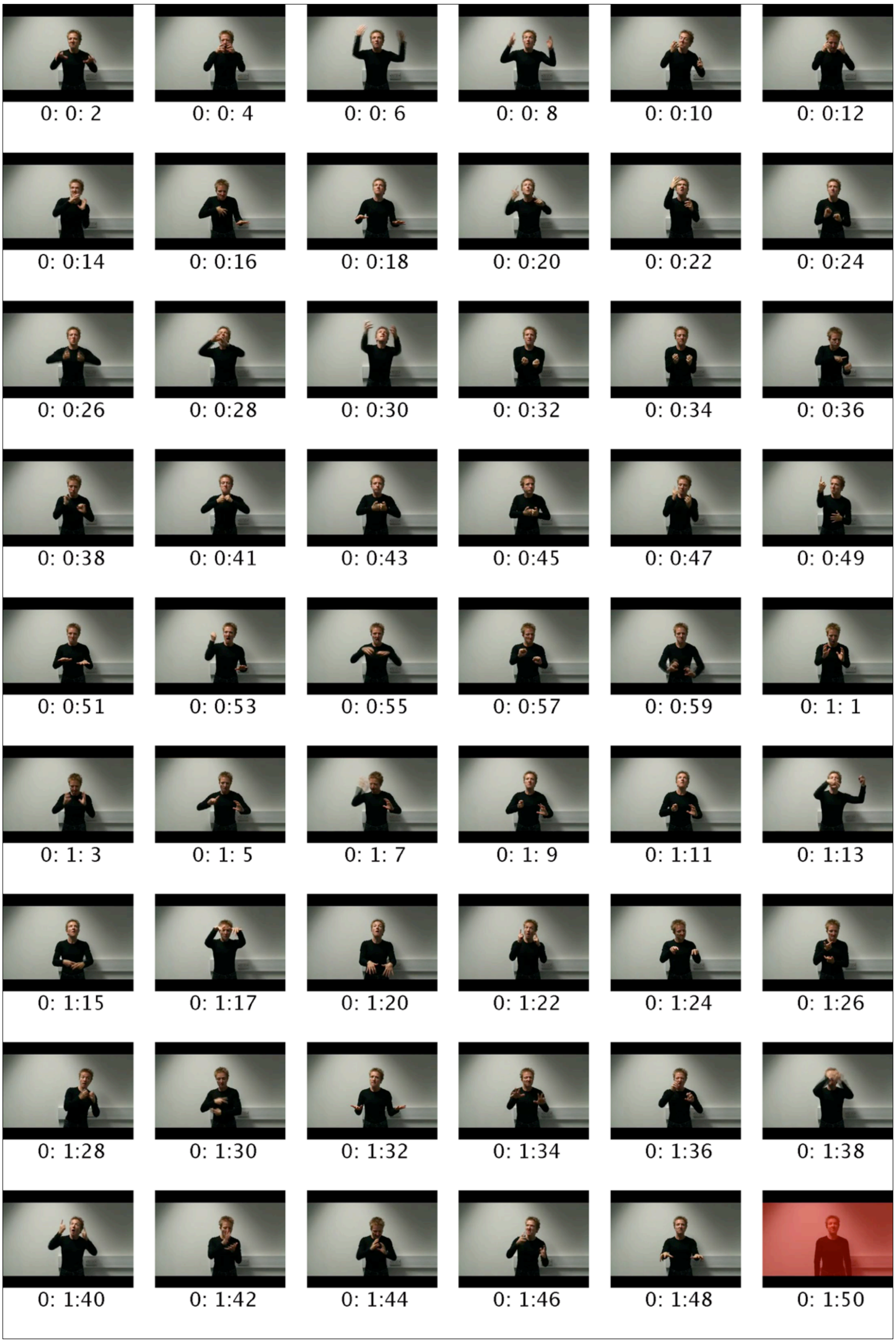

Fig. 4.7.1 Images of deconstructed video film of the poem 'The Tyger' in British Sign Language

Nottinghamshire Deaf Society was contacted to find out if they could provide a BSL interpreter. Elvire Roberts, a senior BSL interpreter agreed to translate the poem. She also informed aspects of sign language which made it much more clear that apart from hand movements, BSL uses a lot of facial expressions. Therefore, it would be appropriate to film the whole body movements rather than just the movement of the hands.

4.7.2 Process

4.7.2.1 Motif Generation

The BSL interpreter was advised to dress in dark, fitted clothing so that her hand movements could be seen distinctly. The poem's translation was digitally filmed and deconstructed into images using Adobe Premiere Pro. The total duration of the film was 1.51 minutes, resulting in a sequence of 2775 images (Fig 4.7.1). The automation technique (section 4.6.2) was applied which resulted in a figural shape of the BSL interpreter against the background (Fig 4.7.2).

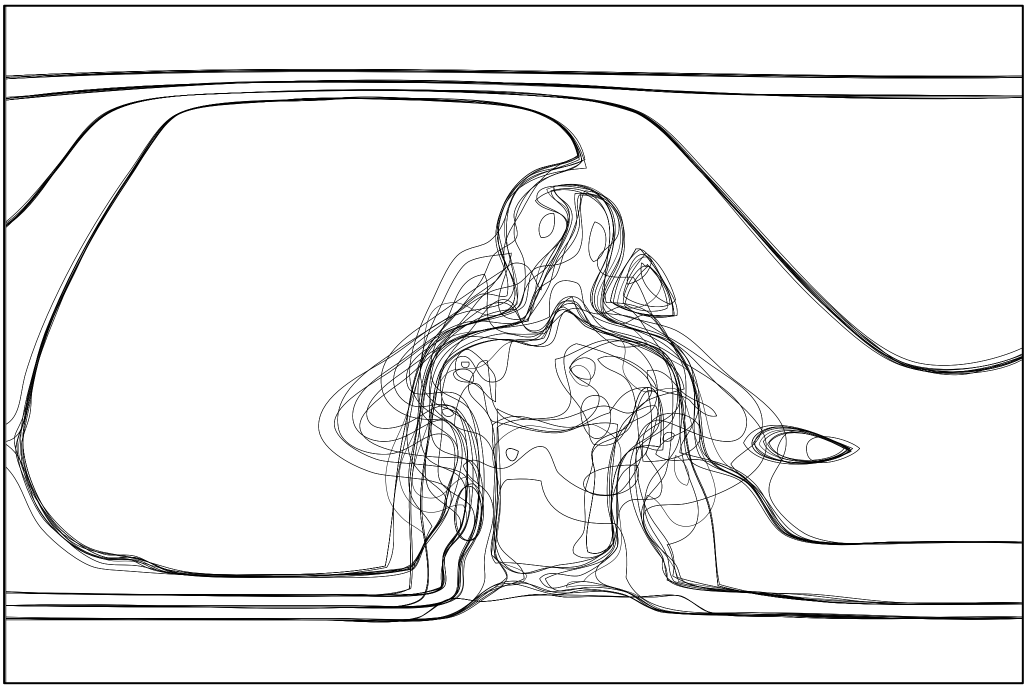

Fig. 4.7.2 Pattern of figural shape of the BSL interpreter against the background

It was discovered that the resulting patterns of hand movements were indistinct and appeared textural when compared to the outcomes of previous experiments. Therefore, a new approach was tried which was to manually trace finger movements in each image as lines. Samples of five images representing the first verse of the poem were traced.

4.7.2.2 Pattern Design

The traced finger movements were then blended on a linear path to create a transitional shape. The analysis of the deconstructed video images showed that the hand positions in the sequence followed a curvilinear path rather than a linear one. Therefore, the blend was recreated to follow a curvilinear path (Fig. 4.7.3). In a variation of pattern, the traced finger movements were superimposed and blended to create new transitional shapes (Fig. 4.7.4).

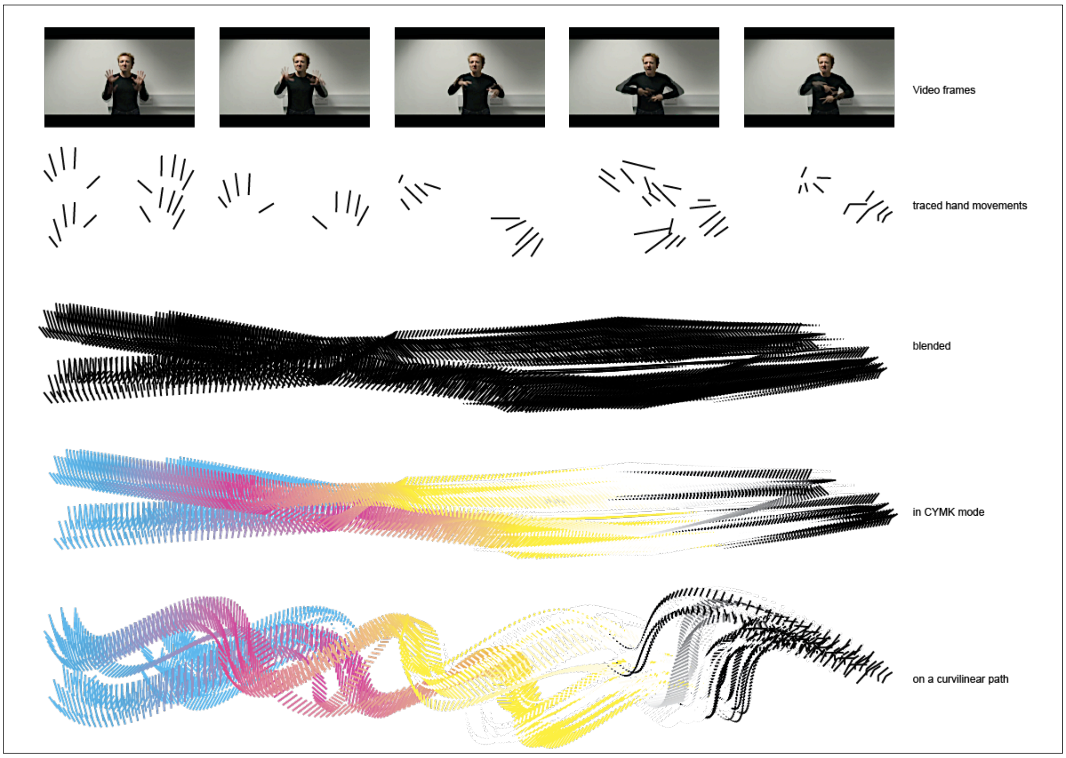

Fig. 4.7.3 Process of creating Gestures in British Sign Language –II

4.7.2.3 Textile Materialisation

The generated pattern and its variation were printed on 100% Viscose Lining. The intention to use shiny fabric in comparison to matt was to explore the role of texture and light reflection. It was found that the sheen of the fabric added to the visual complexity of the printed pattern. The pattern appeared much darker and distinct on the fabric in comparison to the visualisation on the screen.

4.7.3 Reflection

This technique improved upon the previous versions of creating transitional shapes used in the current research by tracing finger movements to create a surface pattern. Finger movements show more detailed aspects of a hand's movement in a gesture. The *shape-blending* tool was found to be effective for creating transitional shapes from traced finger movements especially in a curvilinear path. The shortfall of this method is manual drawing of lines on each image, which could be replaced by the video film editing techniques such as Chroma Key. However, at this stage of the research it needs to be clarified that such techniques were not required. The technique of creating a figurative shape is new and could contribute to the design and creation of new surface patterns. Therefore the next experiment could use the same set of video images and create new vector based textures rather than shapes. The final outcome of this translation is a non-representational form (abstract) in itself.

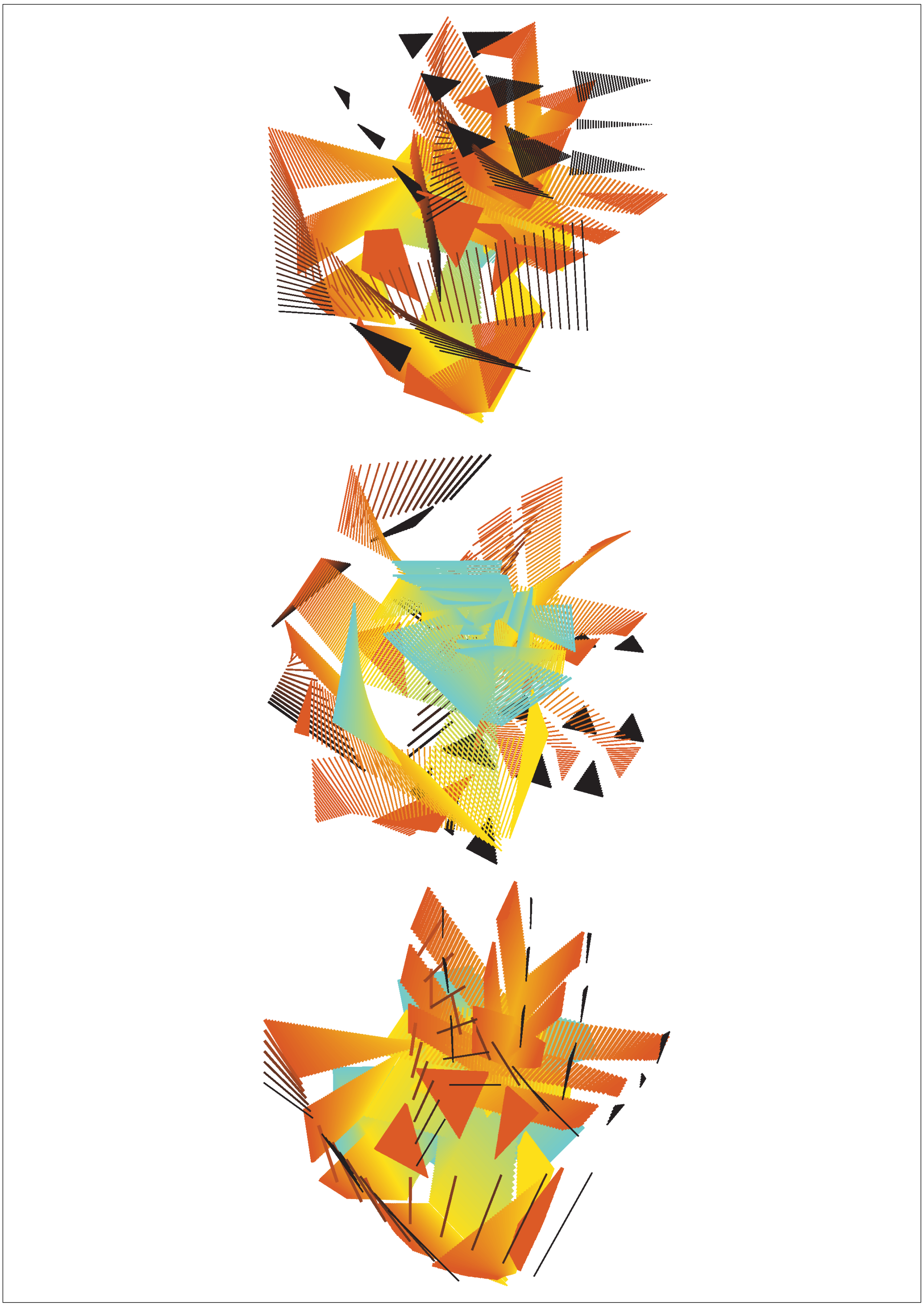

Fig. 4.7.4 Gestures in British Sign Language –II, variation of pattern

The form does not convey the meaningful expression used either in the poem or in the BSL interpretation but creates a new expression, which stands for itself. It represents the possibility that a poem could be translated into a visual form. If so does the form represent continuity in terms of visual communication, similar to what the poem and the sign language intended to achieve?

What does the abstract pattern communicate? Is it legible? Visually the form is a composition of fine curvaceous lines and it can be perceived as a silhouette in motion only in relation to the video film that represents BSL recitation. The BSL recitation can be understood in relation to the poem and the poem can only be understood in relation to its literature context. This relationship suggests an ontological enquiry into whether the form actually means or relates to anything. Briggs (1997) states that within the formal boundary of Textile Design "communication is not the explicit intention and that the decision is made purely upon the aesthetic pleasure derived."

The patterns were visually analyzed through a semiotic study of their appearance. Semiotics is the study of sign processes (semiosis), or signification and communication, signs and symbols, both individually and grouped into sign systems. It is a study of how meaning is constructed and understood by eminent semioticians such as Ferdinand de Saussure, Charles Sanders Pierce, Roland Barthes and Charles Morris who have explored images/ text, into categories, which relate to language, image and meaning.

(a) Icon: As an Icon (… a sign that denotes its object by virtue of a quality which is shared by them but which the icon has irrespectively of the object) the form resembles closely to "*Boccioni's Fist"* produced by Giacomo Balla in 1914. In this context the generated pattern represents a dynamic, energetic and ferocious subject (The Tiger) in digital media notation. It also signifies that digital translation can lead to visually unpredictable form.

(b) Index: As an Index (…a sign that denotes its object by virtue of an actual connection involving them, one that he also calls a real relation in virtue of its being irrespective of interpretation) the pattern represents digital expression. If compared to Paul Henry's *Picture by Drawing Machine*, the linear form resonates that a computer draws the pattern. It communicates the poem in BSL interpretation as Art, whose meaning resides in the process of translation.

(c) Symbol: As a Symbol (… is a sign that denotes its object solely by virtue of the fact that it will be interpreted to do so.) Its close resemblance to Japanese script explains that although the pattern is abstract in nature, it can possibly have a literal meaning that could represent "The Tiger" in a new visual sign language (digital media).

This analysis identifies the generated pattern as an art form that signifies that digital translation can lead to visually unpredictable forms, whose meaning resides in the process of translation and which can have a literal meaning that could represent the subject in a new visual sign language (digital media).

4.8 Experiment 5: Gestures in British Sign language II

4.8.1 Intention

In this experiment the main intention was to explore the newfound technique of creating vector textures from the deconstructed video images. Once such textures were obtained they could be arranged horizontally or vertically to create a visually complex pattern.

4.8.2 Process

4.8.2.1 Motif Generation

Prior to the automation technique described in section 4.6.2, the sequences of images were applied with a half-tone filter to reduce the visual quality of the image into a dot pattern (Fig. 4.8.1). The automation technique was used to trace the half-toned dot pattern of each image to create a vector texture of the image (Fig. 4.8.2). Each textural image represents a motif.

4.8.2.2 Pattern Design

The resulting motifs or textural images were arranged vertically with a slight overlap to create a pattern, resonating a textural space captured by digital video film. The vertical arrangement of the pattern was intended to cover the cloth horizontally, while maintaining the motifs width with the width of the fabric. It was also found that this method of pattern design could produce a print in which the textures appear animated horizontally (Fig. 4.8.3). The pattern was designed as a variation in which the colours were reversed.

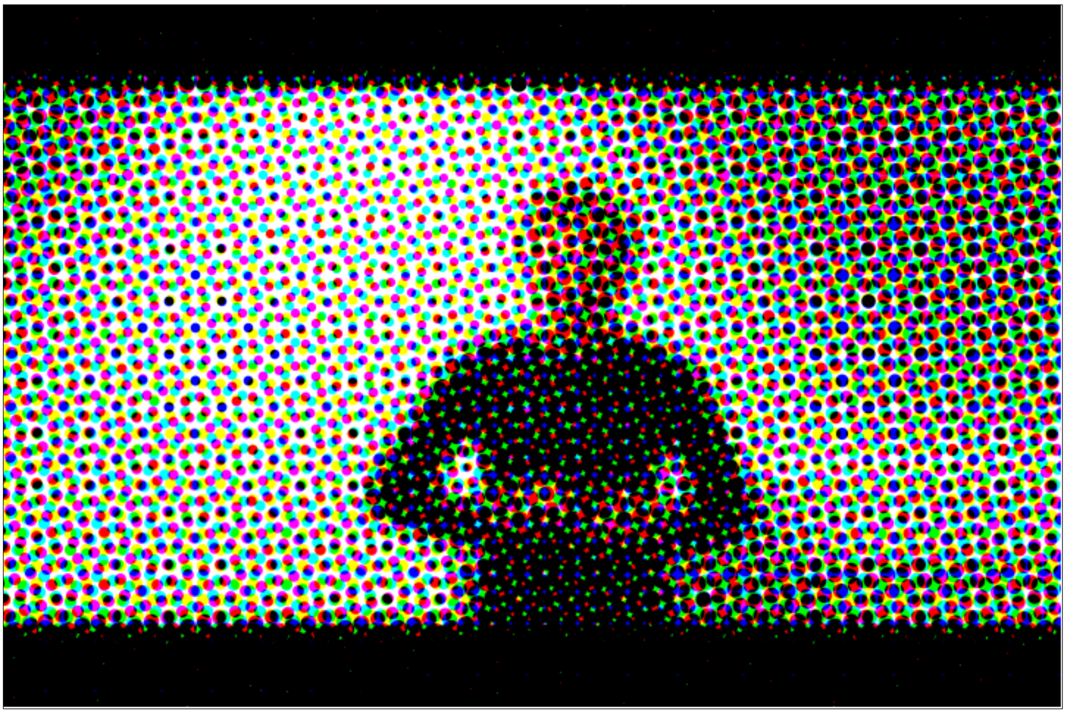

Fig. 4.8.1 Application of half-tone filter to the image

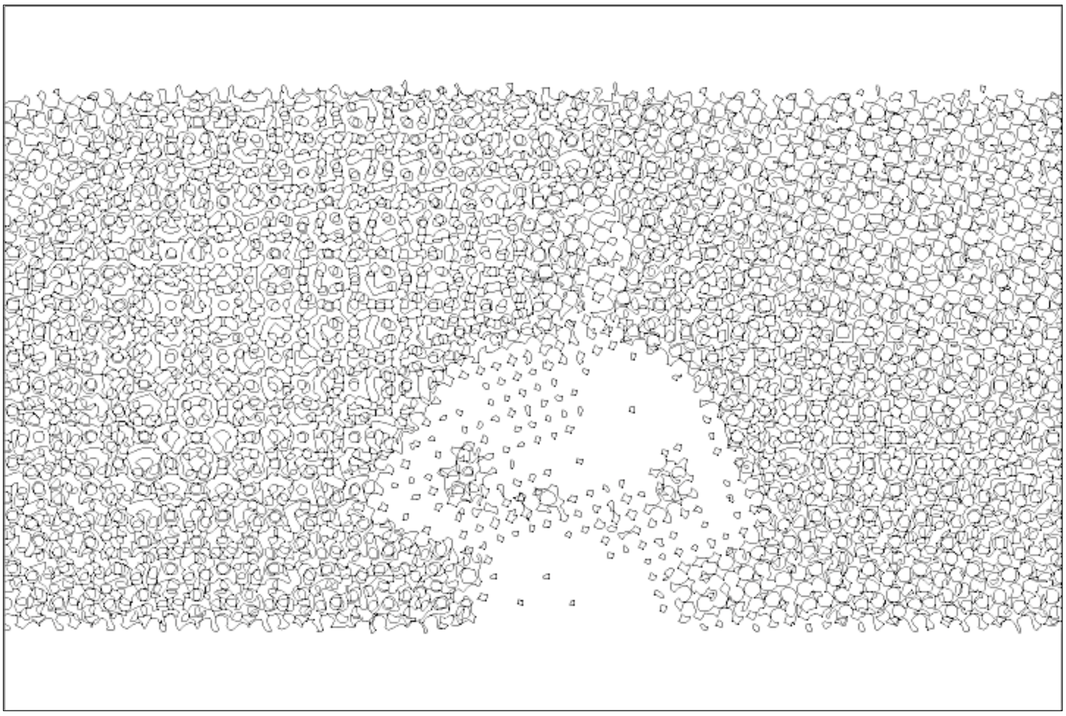

Fig. 4.8.2 Live traced image to create textures

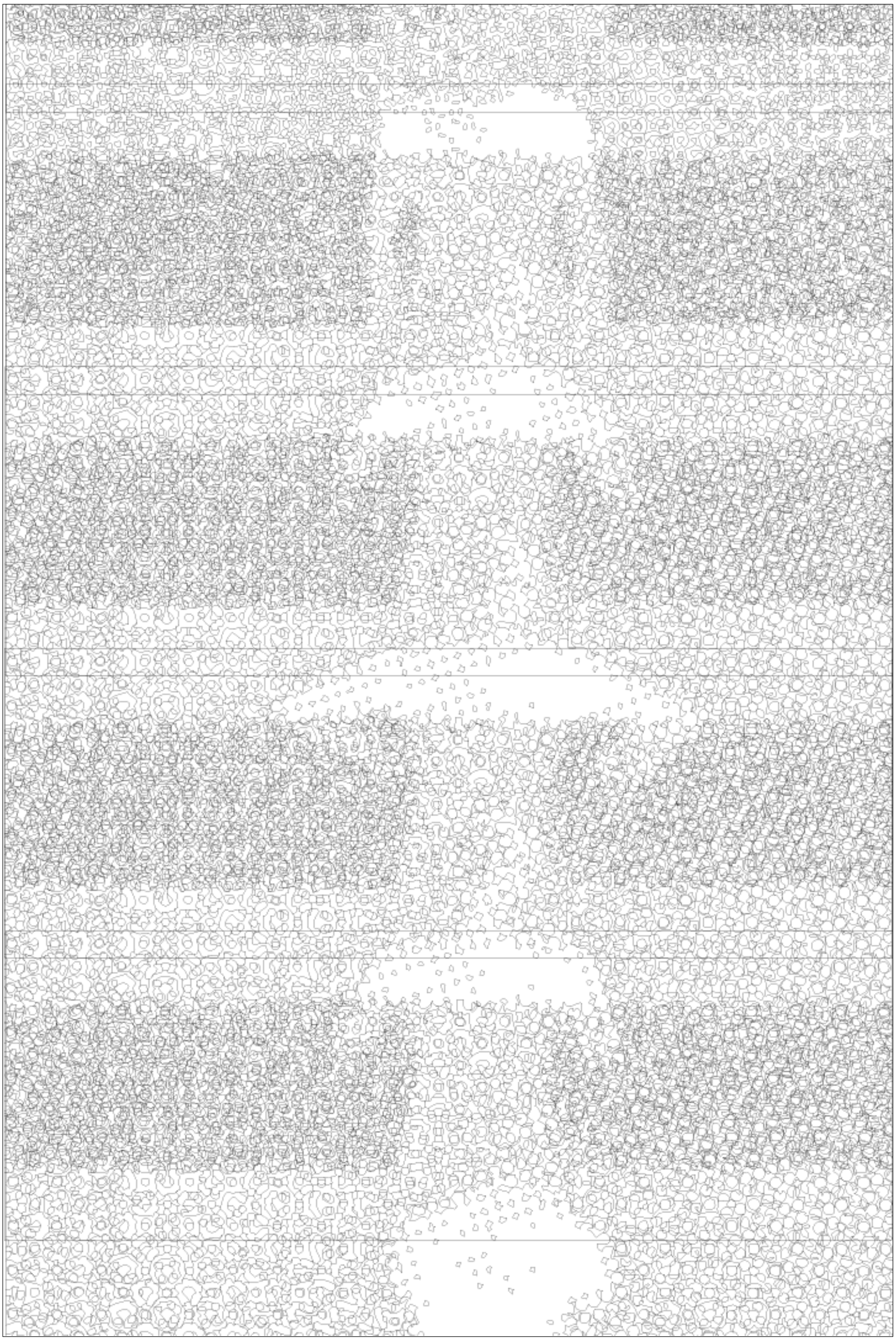

Fig. 4.8.3 Gestures in British Sign Language –I, construction of a textural pattern

4.8.2.3 Textile materialisation

Fig. 4.8.4 Gestures in British Sign Language –I, printed on 100% silk chiffon

Both the pattern and its colour variation were then printed on 100% silk chiffon and 100% silk twill (Fig. 4.8.4 & Fig. 4.8.5). The intention to print them on these fabrics was to assess the effect of the transparency and texture of the fabric on the printed pattern. The silk twill is textured and opaque in comparison with the 100% silk chiffon. The printed textural pattern appears slightly blurred on silk twill, which is caused due to ink bloating. Whereas although the silk chiffon is lightweight and transparent, the pattern appears distinct and sharp.

Fig. 4.8.5 Gestures in British Sign Language –I, printed on 100% silk twill

4.8.3 Reflection

The outcome of this process shows a visually complex pattern that was constructed from a series of vector textures. The movement in body form seems to alter the textural space and contribute to the pattern by inducing blank spaces amongst the dense texture. The tracing therefore justifies the BSL interpreters advice that BSL is not limited to hand movements but the whole body. This concluding experiment shows that the researcher has explored the method of motion tracing hand shapes, the movement of the fingers and finally the whole body.

4.9 Conclusion

The method of motion tracing was used to trace hand shapes; finger movements and bodily movements to create new surface patterns.

The method of combining a rotoscoping technique with digital imaging software is identified as a hybrid approach to create surface patterns, which explores and combines established methods with new digital media.

The outcome of experiments Simple Gestures – I, II and III are continuous surface patterns that represent gestural hand movements in transition. When the vector shapes are filled with colour the resulting patterns depicted 3D, kinetic and sculpturally rendered forms. In which, gestures representing actions such as 'stop, close and tight-fist' seemed to create a form of disturbance in the continuity of the pattern, which attributed to the 3D form. This technique shows a great deal of potential for the construction of continuous patterns through the combination of various media. The relationship between the gesture and the resultant pattern is significant in the sense that it's meaning could be understood as a symbol or a sign representing a gesture. The process of creating surface pattern is new and through automation improved the overall appearance of the surface pattern by inducing new visual characteristics such as organic, vegetal and less algorithmic. The automation technique shows a new method of creating such realistic transitional shapes.

The research generated new transitional shapes by tracing finger movements to create a surface pattern. Finger movements show more detailed aspects of hand movements in a gesture. The shape-blending tool was found to be effective for creating transitional shapes from traced finger movements especially in a curvilinear path. The outcome of this process shows a visually complex pattern that is constructed from a series of vector textures. The movement of the body form seems to alter the textural space and contribute to the pattern by inducing blank spaces amongst the dense texture.

The final outcome of the motion tracing method is a nonrepresentational, or abstract pattern form. The form did not convey the meaningful expression used either in the poem, 'The Tyger', or in the BSL interpretation but presents a new form of expression, which can be assessed for its own merits. It represents the possibility that a poem could be translated into a visual form and analysed using semiotics, based on the signification and communication of signs and symbols, both individually and grouped into sign systems.

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Chapter 5

MOTION SENSING

5.1 Introduction

This chapter deals with the second practical method of HPS described in section 4.2 which is Motion sensing – a combination of computer vision (external webcam) and programming language such as *Processing*.

During the practical research, capturing and representing the hand movements of a participant became the key focus. One of the key aims of the HPS is audience participation at the generative stage of pattern design. Audience participation has been established in Experiments 1,2,3,4 and 5 in Chapter 4 (section 4.4) by using digital photography and video filming participants hand gestures. The intention at this stage of the research was to create an interactive platform to establish audience participation. It was found that automation of the key steps in the process of motion tracing could reduce manual work. However, it cannot create a real-time processed design, in which a participant's hand gesture and the resulting motif and pattern could be viewed simultaneously, which is what is required to create an interactive platform.

Hilary Carlisle's explanation about logic and software prototypes to create non-repeating surface patterns further inspired the direction of the research.

"(…) need for a less laborious construction method for the patterns, and, as the project is particularly concerned with demonstrating digital possibilities, it seemed logical to consider writing a software application capable of assisting in the production of non-repeating patterns" (Carlisle, 2002: 181).

Therefore, motion sensing is a method, which combines programming language and computer vision to capture hand movements and create surface patterns simultaneously. This combination is used to create software, a working prototype, and an interactive platform through which audience participation will be established.

Pavlovic et.al (1997) classifies hand gestures in human-computer interaction (HCI) in two modalities as: ‘communicative’ and ‘manipulative’; of which, manipulative gestures are the ones used to act on objects in an environment (object movement, rotation, etc.). Karam & M.C. Schraefel (2005: 5) have stated: “Manipulations can occur both on the desktop in a 2D interaction using a direct manipulation device such as a mouse or stylus, or as a 3D interaction involving empty handed movements to mimic manipulations of physical objects”.

The research found that open source programming language such as *Processing* could be used to design patterns through the real-time processing of manipulative hand gestures.

This led to the experimentation with *Processing*; a Java based Open Source Programming Language. The choice of such programming language was based on reasoning such as: it was freely available; easy to learn; an open source alternative to proprietary software tools with expensive licenses; is accessible online, and has been widely used in the field of digital art & design practice (2.6 & 2.8). For example, in the context of fashion and textiles ‘*The Tissue Collection*’, 2008, collaboration between a digital artist Cassey Reas and fashion designer Cait Reas, showed that imagery generated by processing could be tangibly printed on textiles (Fig.2.6.4).

It was envisaged that the method of motion sensing could be used to explore a digital crafting approach using the concept of direct manipulation (section 2.4).

Using the method of motion sensing developed through the research; four design examples were created that demonstrate gestural hand movements in 2D and 3D space to generate surface patterns. The design examples were Hybrid Bubbles, Hybrid Ikat, Hybrid Duree and Hybrid Kolam.

5.2 Experiment 6: Hybrid Bubbles

As acknowledged earlier in the Chapter Four, the new knowledge gained through the creative, experimental research could be applied to disciplines within the wider field of Art & Design, where practitioners may or may not be well versed with computing language. Therefore in the forthcoming sections, which focus on computation; the researcher has adopted Carlisle's (2002) program procedure method to write the program in simple language rather than 'real code.'

5.2.1 Intention

The intention in this experiment was to create a software program that would record the hand movements of a participant as they moved through a 2D plane surface and generated a surface pattern. Such hand movements are typically used to operate a computer using a graphical user interface (GUI). The pattern would be composed of randomly placed, overlapped variable sized circles. A circle was selected as it was seen as a universal form that encompasses all the other polygonal shapes within its circumference. Therefore, the choice of a circle was appropriate in this experiment. During the initial stages of learning the programming language, it was found that basic shapes such as a dot, line, circle and polygons could be drawn by defining their parameters in the sketch code through their x and y coordinates, and the stroke strength of the outline and colour. These parameters can be either fixed values or variable inputs, such as input from the 'position of the mouse' (Fig. 5.2.1). This means, the placement and the size of the circle in the image are informed by the position of the mouse. However, the constraint is the size of the generated image, which is defined at the beginning in terms of pixels.

The research question was: how to create a surface pattern that integrates features such as predefined image size and variable sized shapes available in the programming language? It was found that a *saveFrame ( )* command at the end of the program, saves a numbered sequence of the image that is identical to the display window, each time the program is run. By using the *saveFrame ( )* command the program would generate and save a number of regular sized images within a given period of time in a pre-destined folder. The generated sequence of images was then arranged in a regular grid to create a surface pattern (Fig. 5.2.3). With this resolved intention, the program procedure was created.

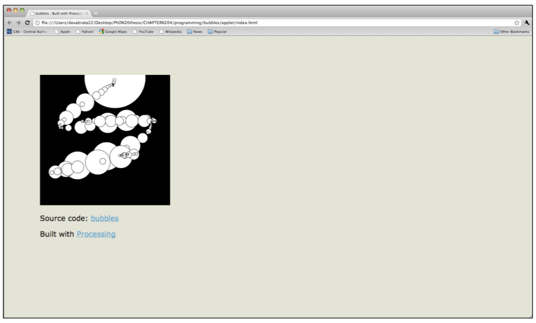

Fig. 5.2.1 Hybrid bubbles applet in a web page

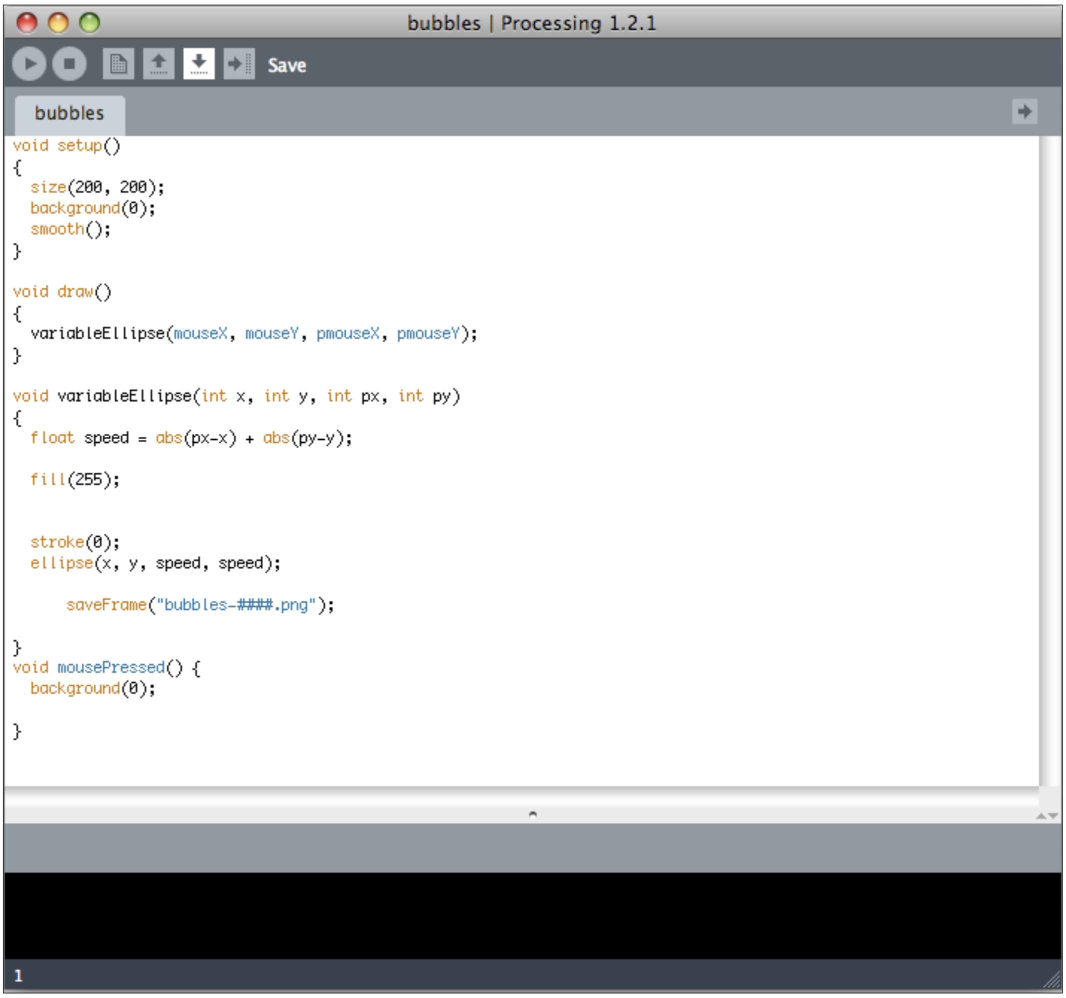

Fig. 5.2.2 Hybrid bubbles program in a programming sketch pad

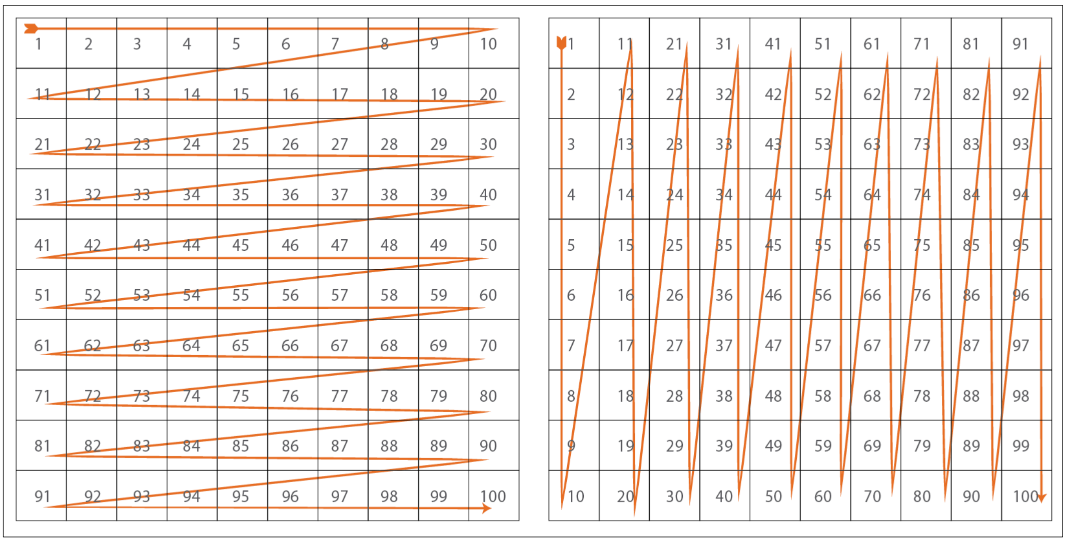

Fig. 5.2.3 A regular square grid of 10 x 10 in two arrangements, across and down

5.2.2 Program procedure

1. Set size of the artwork as 800 X 800 pixels

2. Set background colour as black

3. Create variable input for ellipses- parameters for the current mouse position and the previous mouse position

4. Calculate the speed of the mouse through measuring the change in the current mouse position and the previous mouse position

5. Condition: draw a small ellipse if the mouse is moving slowly

6. Or draw a large ellipse if the mouse is moving quickly

7. Set ellipse fill colour as white

8. Set outline colour in black

9. Save frames as bubble sequence - bubbles - ####. tiff

10. Clear screen – set background colour as black if mouse pressed.

5.2.3 Process

5.2.3.1 Motif Generation

In the program, the participant is directed to move the mouse to draw variable sized circles in the sketch area (Fig. 5.2.1). The participant has a choice, if required he could clear the screen at any time by right clicking the mouse and restart the drawing.

These drawings are recorded in stages as image files and saved simultaneously in a specific folder as motifs (Fig. 5.2.4). Pattern Design

The files are then sorted out in two ways that is according to the file size and the time of creation. In Adobe Bridge a contact sheet of the image files in sequence creates the surface pattern (Fig. 5.2.5).

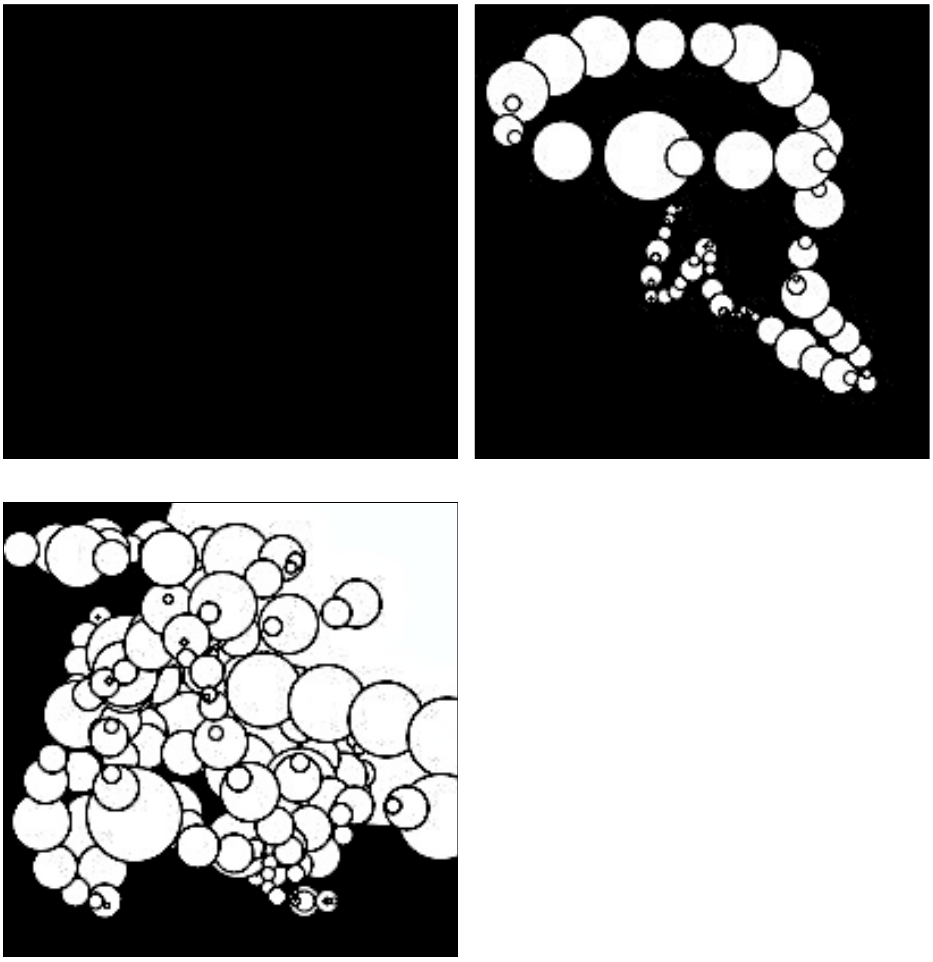

Fig. 5.2.4 Selection of three saved images representing three stages in Hybrid Bubbles

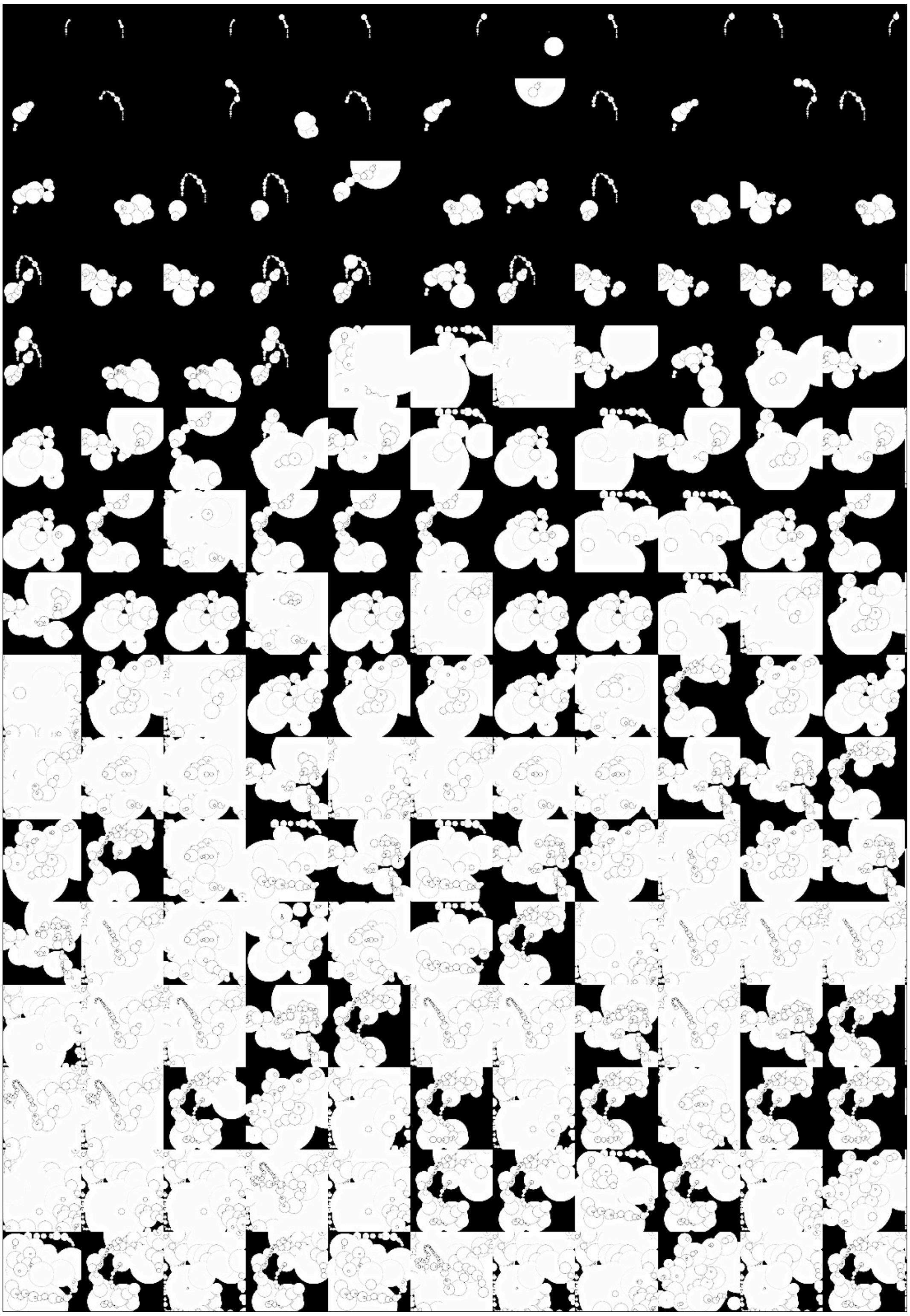

Fig. 5.2.5 Designed Pattern: Hybrid Bubbles

5.2.3.2 Textile Materialisation

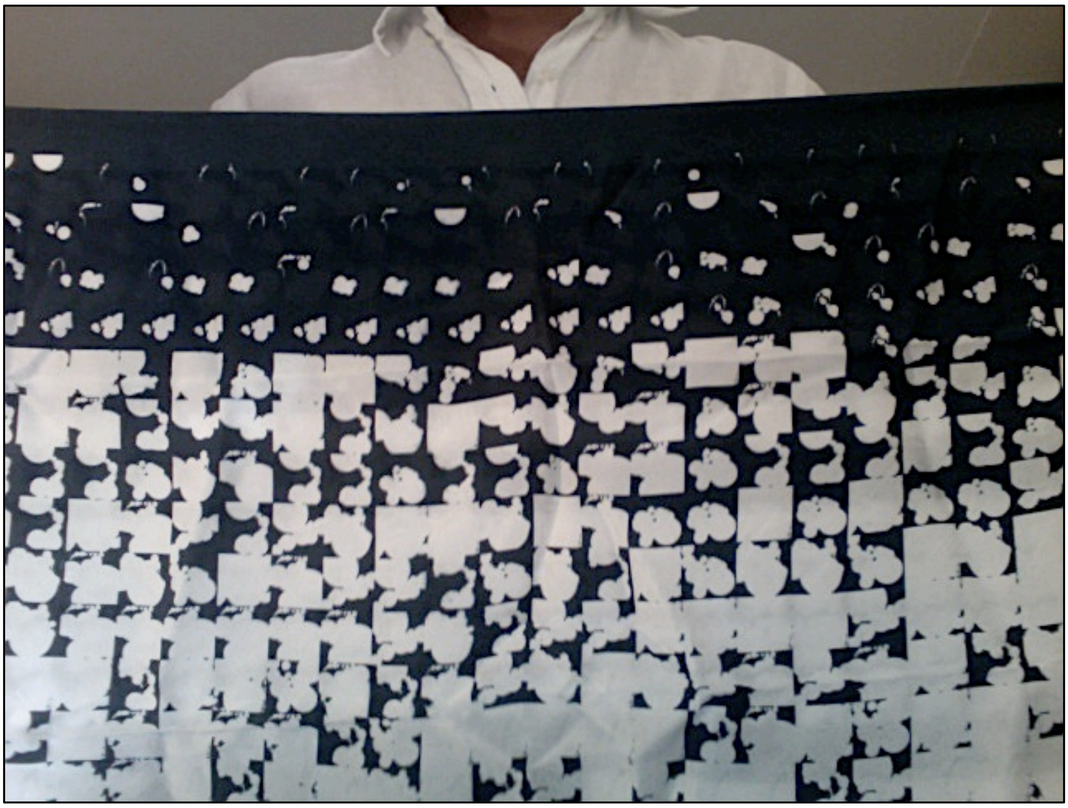

Fig. 5.2.6 Hybrid Bubbles printed on 100% Silk Habotai

Prior to printing on a textile, the generated pattern was printed on paper using a Desktop laser printer. The quality of outlines was crisp and the distinction between the overlapped circle shapes was visible. The designed pattern was then printed on 100% Silk Habotai using DTPT (Fig. 5.2.6). It was found that the some of the fine details within the pattern were lost due to thin lines. This was recorded for future experiments.

5.2.4 Reflection

This experiment demonstrates that the process of motif generation could be made interactive. The interaction that would occur between the hands of the participant while moving the mouse on a 2D surface could inform, shape and create the artwork. Later if appropriate, other devices such as a stylus, track ball or a touch sensitive screen could replace the mouse.

In *Processing*, the sketchpad or the art board needs to be defined at the beginning of the program. The sketchpad could be either a square or a rectangle. Therefore, the generated motif will be based on a square or a rectangular shape. This constraint will be considered in further explorations in the chapter. The Hybrid Bubbles pattern shows an interesting formation in which the areas of dark and light are randomly distributed. It was found that the saved image files could be sorted out in two ways such as, time of creation and size of the file. The files sorted by their file sizes resulted in the random disruptive pattern of variable sized circles in a square (Fig. 5.2.5). This could be improvised by replacing the circles with basic shapes such as a line or a dot in the next experiment.

5.3 **Experiment 7: Hybrid Kolam**

5.3.1 Intention

The Hybrid Kolam design example is influenced by research on Alfred Gell's "*Art and Agency: An Anthropological Theory*", 1998, in which he has discussed extensively about free-hand line, rice powder drawings widely practiced by Indian woman known as *Kolam*. They are created on the ground using various hand movements, which result in interesting patterns. Although connecting computation with *Kolam* seems to be an idiosyncratic idea it was pursued to see if similar patterns could be drawn. The intention in this experiment was to extend the participants hand movement into 3D space by using a light glove (Fig. 5.3.1). The light source on the user's hand informed the research into the participant's hand movements. This information was recorded and recognized by the computer to create the surface pattern. It was found that the computer's vision could analyze light intensity from a live video stream, by detecting the brightest spot in terms of X, Y co-ordinate positions (Fig. 5.3.2). These variable co-ordinate positions could then be defined as a drawing point. The fluctuations of light caused due to the participant's hand movements became a key point in creating the surface pattern. Reflecting upon the previous design example of Hybrid Bubbles, it was decided to use lines to suggest basic shapes instead of a circle in this example. These lines were drawn outwards to the four corners from a defined starting point (brightest spot–X, Y). With this resolved intention, the program procedure is created.

5.3.2 Program procedure

1. Set size of the artwork as 900 X 900 pixels

2. Set background colour as white

3. Capture video to the size of the artwork

4. Then find brightness of the brightest video pixel

5. Search for the brightest pixel: For each row of pixels in the video image and

6. For each pixel in the y row, compute each pixel's index in the video

7. Get the colour stored in the pixel

8. Determine the brightness of the pixel

9. If that value is brighter than any previous, then store the

10. Brightness of that pixel, as well as its (x,y) location

11. Draw lines from four corners of the artwork by tracking brightest pixel

12. Line 1 (0, 0,brightestX,brightestY)

13. Line 2 (height, width, brightest X, brightest Y)

14. Line 3 (0, width, brightest X, brightes tY)

15. Line 4 (height, 0,brightestX,brightestY)

16. Save frames as hybrid_kolam -####. Png

17. Clear screen – set background colour as black if mouse pressed.

Fig. 5.3.1 Light glove

Fig. 5.3.2 Detection of brightest pixel in a live video

5.3.3 Process

5.3.3.1 Motif Generation

In the program, a participant wearing the light glove makes gestural hand movements with their hand pointed towards the webcam (Fig. 5.3.2). This creates a composition of interconnected lines. The hand movements control the central meeting point of the lines. These drawings or motifs are recorded in stages as image files and saved simultaneously in a specified folder (Fig.5.3.3).

5.3.3.2 Pattern Design

These files are then ordered by their time of creation. In Adobe Bridge a contact sheet of the image files in sequence constitutes the designed pattern (Fig. 5.3.4).

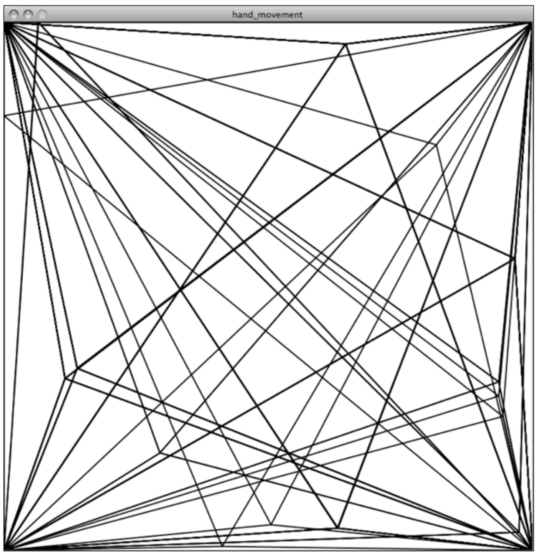

Fig. 5.3.3 Motif, Hybrid Kolam saved image

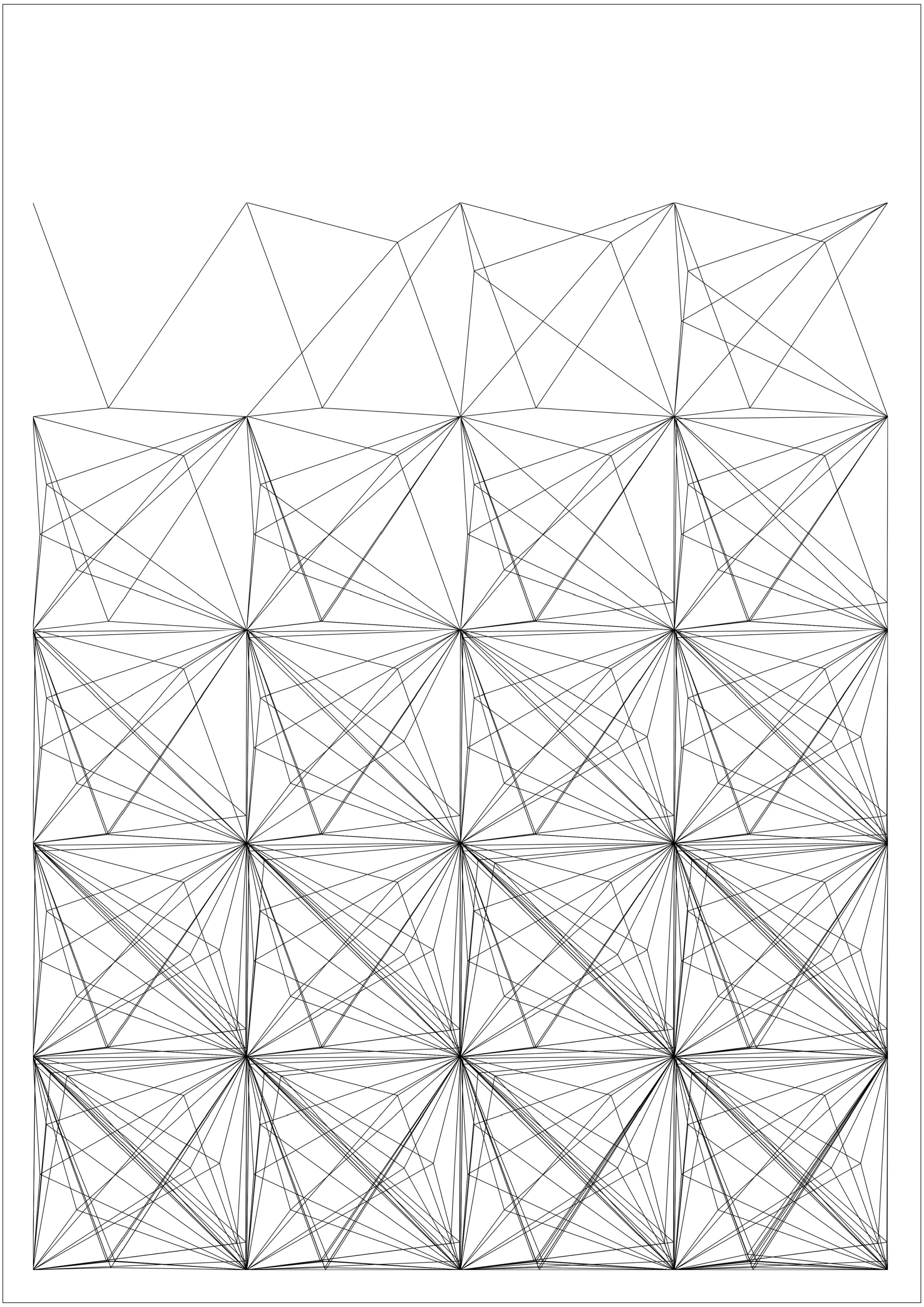

Fig. 5.3.4 Designed Pattern, Hybrid Kolam

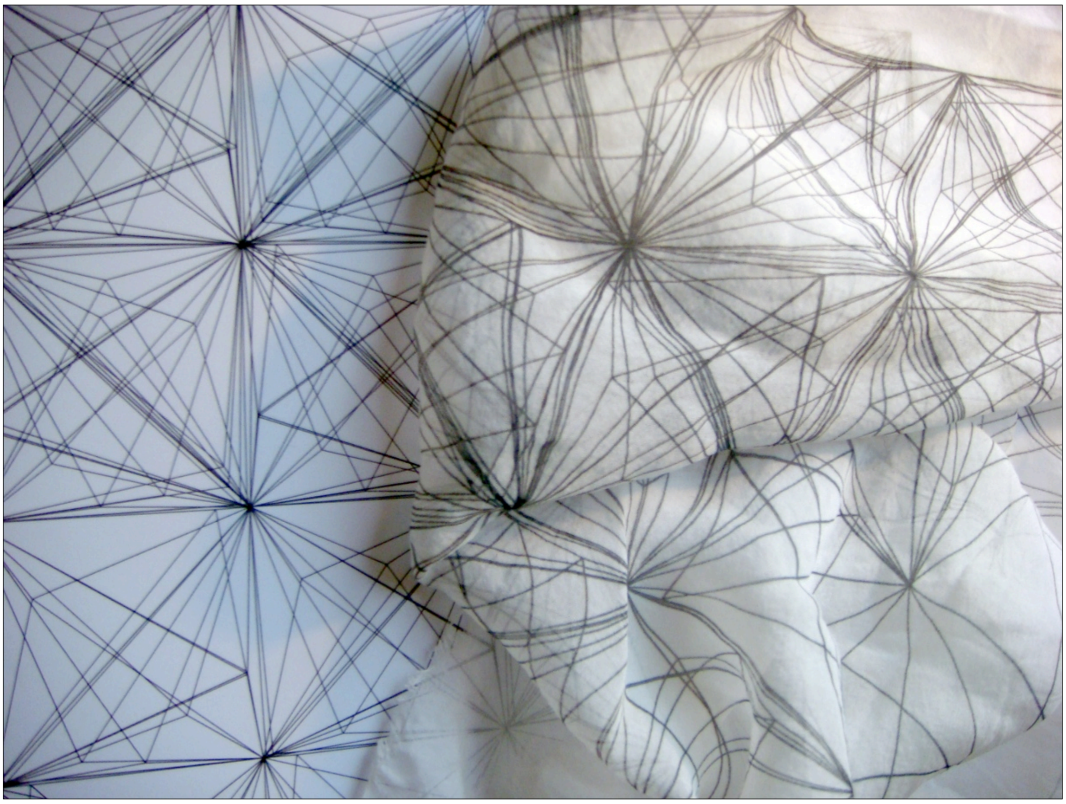

Fig. 5.3.5 Hybrid Kolam, printed on paper and 100% Silk Chiffon Mouseline

5.3.3.3 Textile Materialisation

Reflecting on the previous printing error described in section 5.2.4., the designed pattern was first printed on paper to check the thickness and consistency of lines. The pattern was then printed on a lightweight transparent fabric, 100% Silk Chiffon Muslin using DTPT. It was found that by defining line thickness in the programming stage prevented error. The figure below shows a comparison of print on paper and textile (Fig. 5.3.5).

5.3.4 Reflection

Following the reflections in section 5.2.4, the circles were replaced by lines, which resolved the issue of a disruptive pattern. The rigidity of the square was resolved by programming to generate lines to form a trapezoid motif. Each motif contains its previous motifs, resulting in a superimposed motif. This is illustrated in the Fig. 5.3.4, in which the first motif occurs on the top-left corner, consecutive motifs are then generated and placed adjacent to each other. The last motif placed in the bottom-right corner reflects a superimposed motif. Therefore, when such a sequence of generated images are arranged to create a pattern, there are spaces, which are light, optically regular and haphazardly placed. This creates an interesting rhythmic pattern.

It was found that the user could clear the screen at any time by right clicking the mouse. This would result in a clear frame (no lines), disrupting the patterns creation. This should therefore be avoided and applicable solutions were explored in the next experiment.

5.4 **Experiment 8: Hybrid Duree**

5.4.1 Intention

The intention for this experiment arose from the amalgamation motion tracing with computation to create new surface patterns. The research identified that an algorithm developed by Ben Fry (2007) can show subsequent frames from video input as a grid. The algorithm is developed to deconstruct a live film into frames, distribute them on a grid for display. The algorithm was applied to the method of motion tracing using video input of hand gestures to find if hand gestures in a live sequence could create patterns. The research found that such algorithms are able to generate sequences of images; therefore the idea was applied to create a pattern, which would be ready to print.

The main research question that arises within this process is: how to transpose a screen visualisation onto cloth to create a printed fabric? ‘Ready to print’ pattern also means that it is required to define a height and width of the pattern at the coding stage. The outcomes were visualised firstly on the computer’s monitor based on pixel ratio of 1:1.6 and resolution of 1680 X 1050 pixels, therefore they could not be compared to the width or height of the cloth. A set of experiments was carried out to identify the relationship between the monitor’s pixel ratio and conversion to printed media. This ranged from converting an image into its pixels and printing various pixels onto paper to see what the dimensions of the actual image were. It was found that an image size of 1 x 1 pixel generates a print size 25.4X 25.4 mm. This finding was employed in this experiment, where an artwork size based on pixels needs to be specified at the beginning of the program.

5.4.2 Program procedure

1. Capture video
2. Set size of the artwork as 1600 X 1000 pixels
3. Calculate ratio of width to height
4. Use ratio to generate number of frames in a row
5. Set video frame size using ratio of width to height multiplied by number of frames, frame speed
6. Calculate column, column count and row count
7. Initial column value is 0
8. Column count is the ratio width of the artwork to width of the video.
9. Row count is the ratio of the height of the artwork to the height of the video frame.
10. Calculate scoot value: last row of the video frames
11. Conditional: if video available read video
12. Set video frame rate
13. Once a column of frames is captured scoot all the frames by one row.
14. Set the moved row as black

15. Update pixels

16. Set up condition: if mouse pressed save entire image as “duree-####.tiff”

17. Clear screen and start again

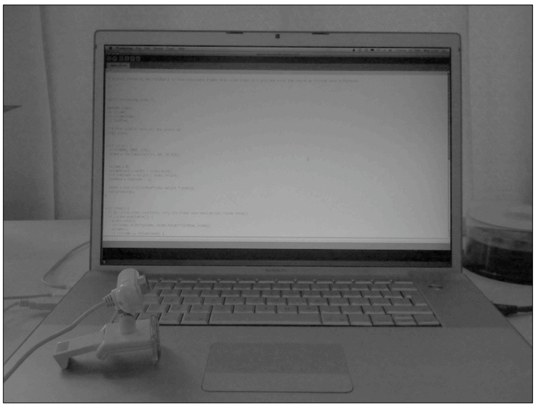

Fig. 5.4.1 External webcam, to produce Hybrid Duree

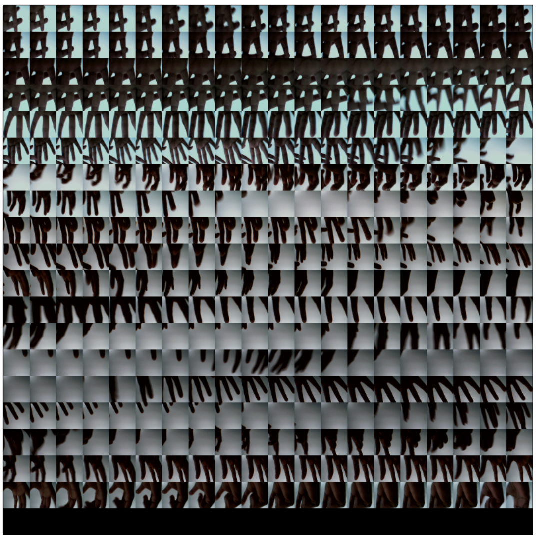

Fig. 5.4.2 Generated Pattern, Hybrid Duree

5.4.3 Process

5.4.3.1 Pattern Design

In the program, a participant makes gestural hand movements with their hand pointed towards the webcam (Fig. 5.4.1). This creates a composition of hand silhouettes, which is then saved as an image in a specific folder (Fig. 5.4.2). This image is then live traced in Adobe Illustrator to create a surface pattern (Fig. 5.4.3). The surface pattern is then rendered in reverse colours. During this process it was found that this application could be

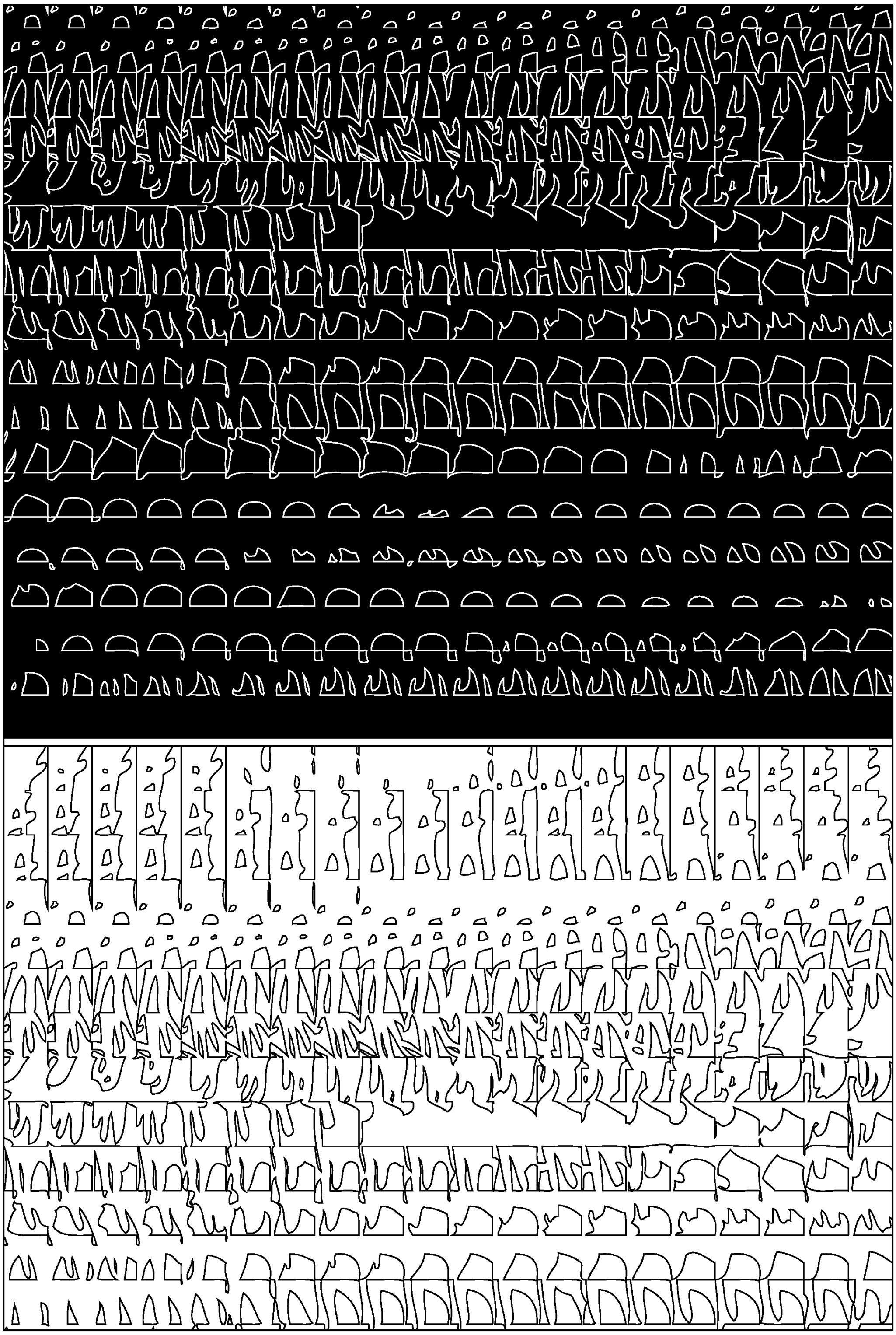

Fig. 5.4.3 Live tracing on Hybrid Duree image to construct a pattern

explored in a different way to capture alternative hand movements. For example, a webcam attached to the participant's hands while they explored their environment will create a surface pattern of images that reflects the hand movements. The resulting technique became a new method of motion sensing (Fig. 5.4.4).

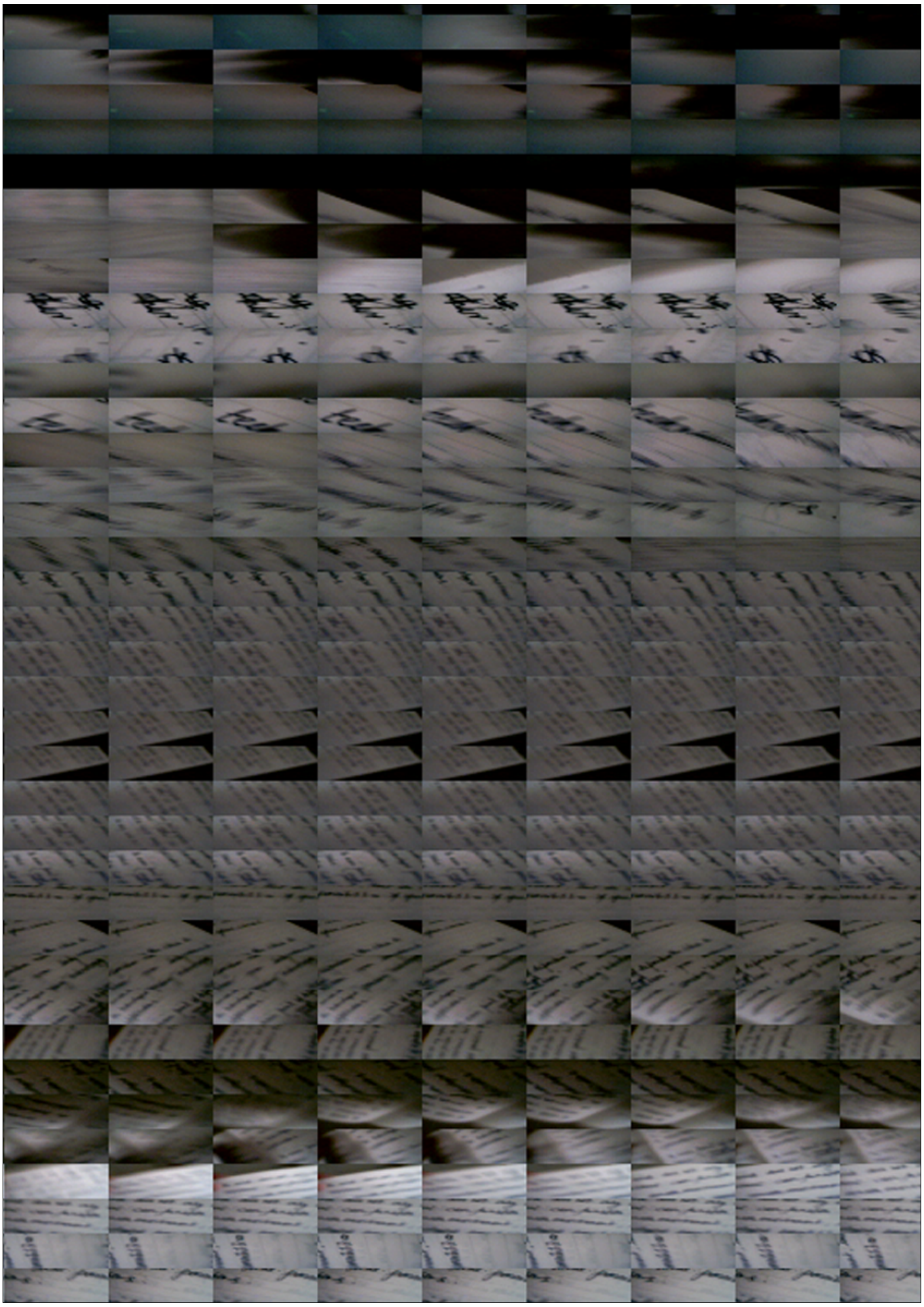

Fig. 5.4.4 Pattern, Hybrid Duree

5.4.3.2 Textile Materialisation

The Hybrid Duree pattern was then printed on 100% Silk twill using DTPT (Fig. 5.4.4).

5.4.4 Reflection

The idea to combine the concept of motion tracing with computation resulted in a unique pattern, which represents the hand's silhouettes as a new temporal shape, which appear as a set of symbols. The use of computation meant that this pattern could be generated continuously and in principle printed simultaneously as it was created. This process reflects the initial focus of the research and specifically on Karim Rashid's '*Mutablob*' series 2004, in which he explored digital craft to create new sculptural shapes.

In a variation, the program was explored by placing a web cam on a participant's hands. As their hands moved to explore the environment around them, continuous images of video frames created a sense of a moving pattern. Such patterns could not convey the direct meaning of a hand gesture but as discussed previously reflect the overall manipulative gestures involved.

5.5 Experiment 9: Hybrid Ikat

5.5.1 Intention

Similar to the previous experiment in this section, the intention for Hybrid Ikat arose from the amalgamation of motion tracing with computation to create new surface patterns.

The concept of tracing was explored as a scanned image, which was informed by the participant's hand movements in a manipulative gesture. The research found that an algorithm such as Simple Real-Time Slit-Scan Program developed by Golan Levin

(2006), could be effectively used to create the program. With this idea the program procedure was created.

5.5.2 Program procedure

1. Capture video
2. Set size of the artwork as 4000X1000 pixels
3. Initiate the video slice position as half of the width; this is the row of pixel capture, which will be captured
4. Initiate the drawing position as 1 pixel less than width
5. Set background colour as black
6. Capture video to the size of the artwork
7. Conditional: if video available read video
8. Set pixel index with a value ‘y’ which ranges from 0-width of the artwork with incremental value less than the width
9. Get pixel index of size as height of the artwork from the video slice position initiated earlier.
10. Update pixels
11. Draw position as width of the video with a decreasing value
12. If the draw position is less than 0 then loop process
13. Save entire image as ikat-####.tiff

5.5.3 Process

5.5.3.1 Pattern Design

In the programme, the participant makes gestural hand movements with a webcam attached to their index finger to generate a pattern. The program is designed to generate a ready to print pattern as opposed to the outcomes of previous experiments. The file is simultaneously saved in a defined folder.

In a variation of the experiment, the participant makes gestural hand movements to scan his surroundings. The hand movements could inform variations such as colour, light intensity and formations in the pattern (Fig. 5.5.1Fig. 5.5.2).

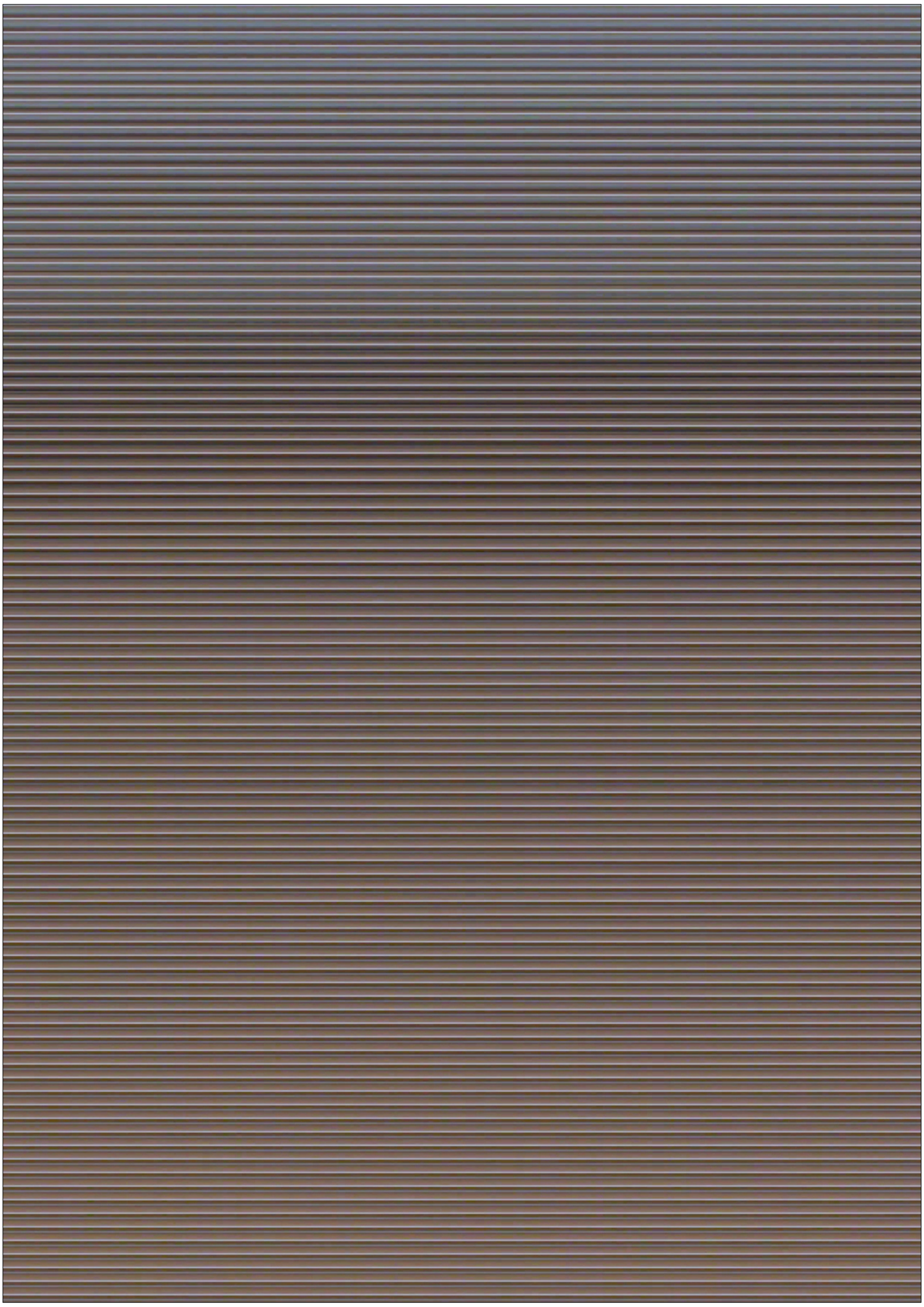

Fig. 5.5.1 Pattern, Hybrid Ikat

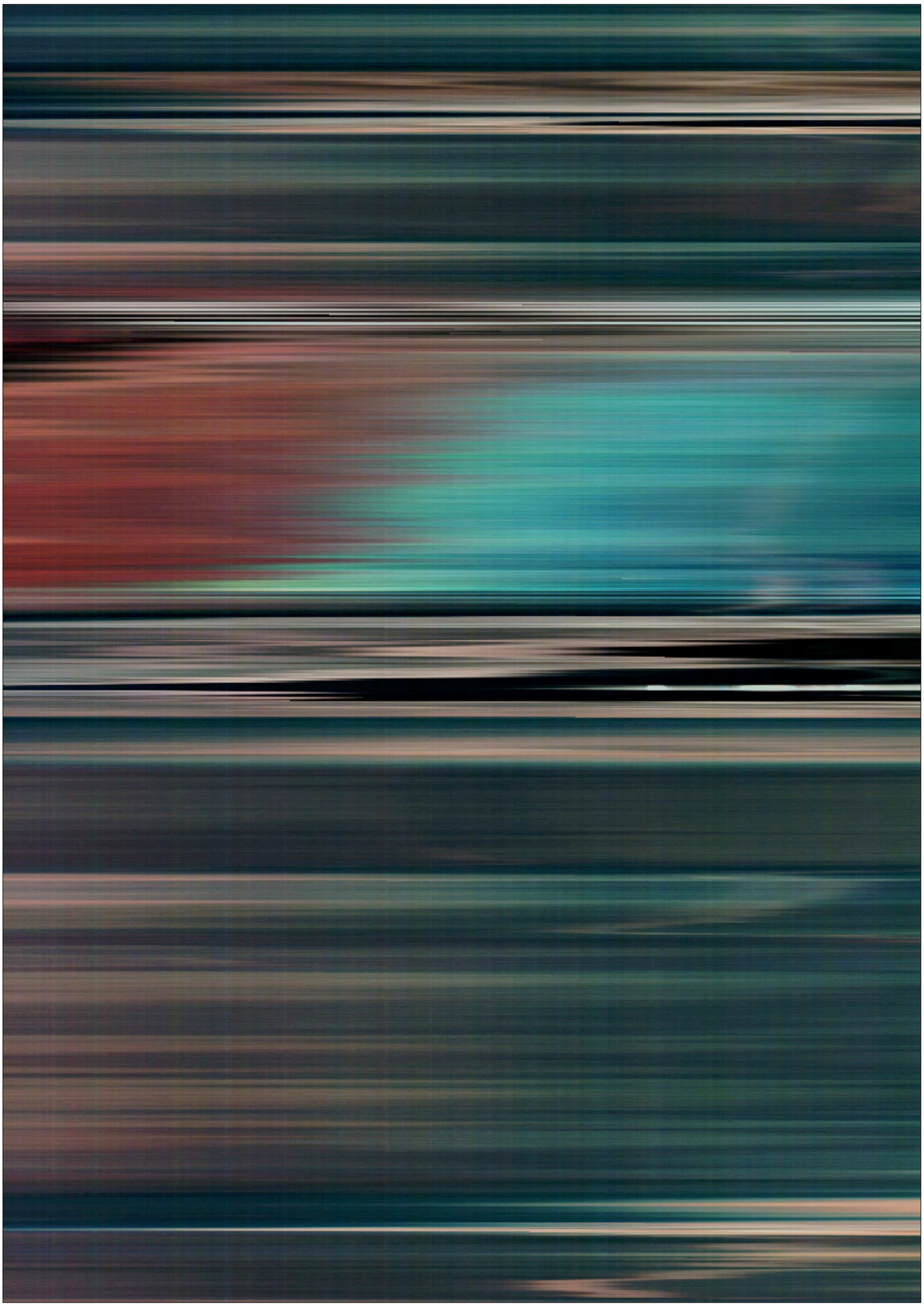

Fig. 5.5.2 Pattern, Hybrid Ikat

5.5.3.2 Textile Materialisation

The Hybrid Ikat pattern was printed on two fabrics, 100% Viscose Lining and 82% Viscose 18% Silk Velvet. The intention to use a textural and shiny fabric in compared to a plain and shiny fabric was to find out the role of texture and light reflection. It was found that both the fabrics added to the visual complexity of the printed pattern (Fig. 5.5.3). The pattern appeared much darker when printed on silk viscose velvet.

5.5.4 Reflection

The outcome of this experiment showed two different kinds of surface patterns based on scan methods. The two different kinds are: *striped* pattern and colour *wave* pattern. The stripe pattern is created when a participant makes rhythmic hand movements. Therefore, it reflects the rhythm of gesture such as clapping hands etc. This kind of gesture has been classified as a manipulative gesture in the previous section. The second pattern represents the hand movements, which are associated with holding a colored object. The objects colour is imparted in the pattern, the fluctuations of colour are due to the specific hand movements. Therefore, these patterns reflect hand movements undertaking a manipulative gesture and their association in creating new surface patterns.

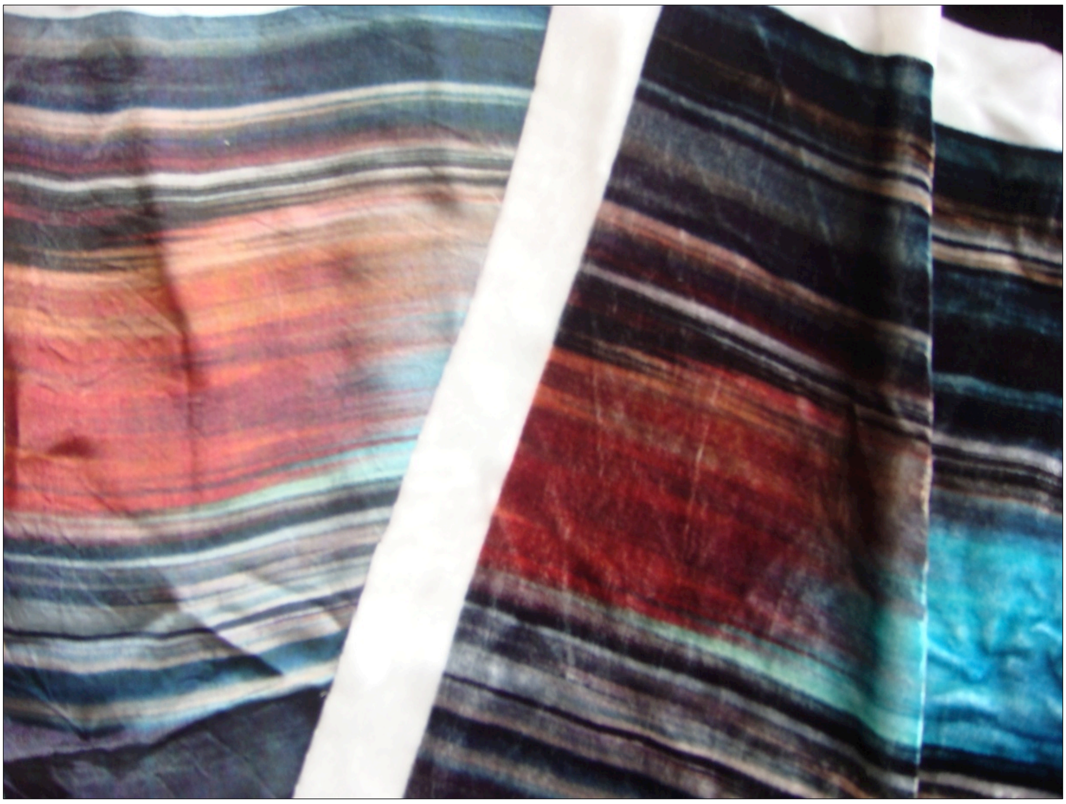

Fig. 5.5.3 Hybrid Ikat printed on 100% Viscose Lining and 82% Viscose 18% silk Velvet

5.6 **Conclusion**

In this chapter the method of motion sensing is explored by creating set of software, working prototypes. The prototypes are created by combining programming language such as *Processing* with computer vision to capture hand gestures especially manipulative gestures. The four working prototypes: Hybrid Bubbles; Hybrid Kolam; Hybrid Duree and Hybrid Ikat. The prototypes were used to create an interactive platform to establish audience participation. The working prototypes show that the process of motif generation could be made interactive.

The first prototype, Hybrid Bubbles, informs the research of the constraints of the programming language such as shape of the sketchpad, shape of the basic elements and the distribution of images in the generated pattern. It also pointed out the need to search for alternatives other than using a mouse, which was restricted to capture hand movements on a 2D plane. These constraints were then considered in consecutive experiments.

In the second prototype Hybrid Kolam, the mouse was replaced by a light glove. The prototype was designed to read the brightest pixel in a live video frame and generate motifs composed with intersecting lines. The light glove removed the constraint imposed by a mouse. It can be used in a 3D space rather than on a 2D plane. A key feature of the Hybrid Kolam's motif style is that they contain each other, meaning that each motif contains the previous motif, resulting in a superimposed motif. The motifs are arranged in a regular grid, based on their time of creation, to create the pattern.

The third prototype, Hybrid Duree is based on the concept of live video film deconstruction into frames to create a 'ready to print' pattern as compared to the previous two prototypes. Firstly, the prototype was used to capture live video of hand gestures, then deconstruct the frames and arrange them in a regular grid. In a variation of use, the web cam is clipped to the participant's index finger exploring their surroundings, objects, things etc. the resulting patterns created a sense of movement informed by hand gestures.

The fourth prototype, Hybrid Ikat, is based on video scanning generated two different kinds of surface patterns such as, striped pattern and colour wave pattern. The stripe pattern reflects the rhythm of a manipulative hand gesture such as a clap. The colour wave pattern represents the hand movements, which are associated in the exploration of the surface of a colored object. The object's colour is imparted in the pattern, the fluctuations of colour are due to the hand movement. Therefore, Hybrid Ikat patterns reflect hand movements in a manipulative gesture.

Materialization of the print patterns required meticulous calculation of the number of motifs, placement, and consideration of the constraints of the digital inkjet printer.

The designed patterns were materialized on various materials such as viscose lining , silk twill, silk chiffon etc to see how the pattern appeared on various textures with reflection of light. The fluidity of the pattern is extended with the soft handle of the textile fabric. In some fabrics the same print pattern appeared darker or brighter in colour than on screen.

The set of eight design examples generated using motion sensing were presented in a group exhibition (Capturing rhythm and space, In: Hong Kong Polytechnic and University, 1-31 December, 2009) as a part of public dissemination. The Hybrid Ikat prototype has been used to design patterns to cover the acoustic panels for Student Counselling rooms in the Newton building, Nottingham Trent University (See Appendix III).

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Chapter 6

MOTION TRACKING

6.1 Introduction

In the experiments discussed in Chapter Four, the shape of the hand informed the construction of surface patterns, which were further developed by tracing the details of finger movements in a gesture (section 4.4 - 4.8). Similarly, the research aimed to capture such details using motion capture but a limitation of the optical MOCAP system is that it cannot assimilate more than two markers placed on a hand simultaneously. This is due to occlusion, which can result in errors, because the cameras are not able to triangulate reflections from the markers if they are very close to each other (section 3.4).

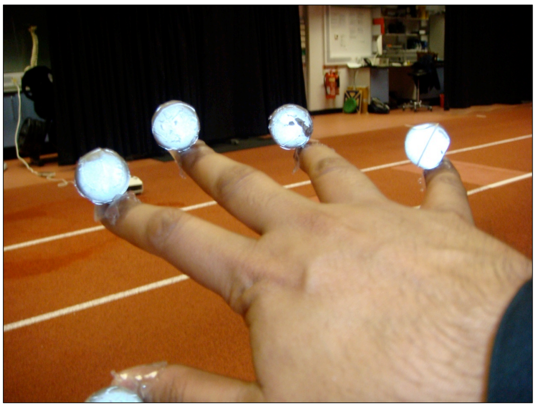

Fig. 6.1.1 The Researcher exploring markers placement on hand

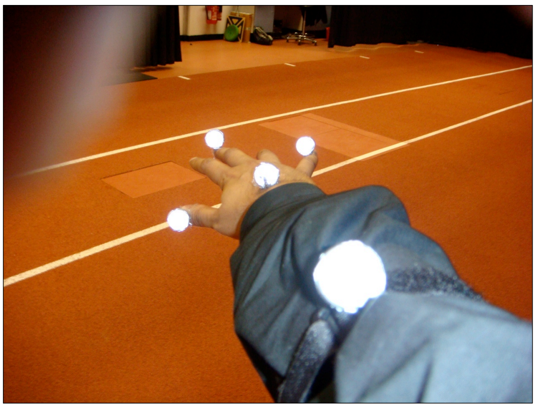

Fig. 6.1.2 The Researcher exploring markers placement on hand

Therefore, the number of markers had to be optimized so that even the slightest movement of the participant's hand could be recorded. The solution to this problem was inspired by Leonardo da Vinci, "*Vitruvian Man*" 1492 in which the extended arms show the maximum width covered by a man's body in space. The tip of the middle finger of a participant's hand was therefore selected as the appropriate position to place a marker. This was tested and found to be effective in the experiments.

6.2 Accessing Motion capture Facility

It was found that the Performance Analysis Laboratory in the School of Science and Technology, located within the university uses MOCAP for sports performance and gait analysis. Therefore, access to the MOCAP equipment and facility was negotiated with the department. Prior to the experiments an induction program was conducted for the researcher to use the MOCAP equipment, which included the basic training in operating the software and utilization of the space (Fig. 6.2.1). Following the basic training in the MOCAP system, the researcher began to consider some of the options that the 3D visualization software offered to construct real life scenarios to capture gestural hand movements such as a formal group discussion, performance etc.

Fig. 6.2.1 Ian Varley, Senior Technician, calibrating the MOCAP system

6.2.1 Qualisys Track Manager

Qualisys Track Manager (QTM), is the main software that processes the MOCAP data. QTM collects 2D marker position data and calculates 3D and 6DOF data. This can be done in real-time or in post-processing. The tracker in QTM is completely scalable: one can start with a single camera (only doing 2D-tracking) and then add further cameras in order to expand the measurement volume (Qualisys 2006: 7- 23).

QTM also allows the exporting of MOCAP data for further analysis in other software. For example, data can be exported to Matlab (.mat), Visual3D (.c3d) or to plain tab separated value files (.tsv), which can be read by Microsoft Excel.

Calibration - For 3D and 6DOF measurement, the MOCAP system needs to be calibrated. QTM uses a dynamic calibration method. A wand is simply moved around in the volume while a stationary reference object in the volume defines the coordinate system for the motion capture (Fig. 6.2.1). All settings for the calibration are controlled by QTM and the result of the calibration is visualized in a quick and intuitive way. The calibration is done within 15-30 seconds.

2D and 3D tracking - When the data (x, y) from the cameras are collected in 2D, QTM calculates the 3D (x, y, z) positions for visualization of body displacement.

6 Degree of Freedom (6DOF) - The 6DOF tracking function provides 6-degrees-of-freedom (pitch, roll, yaw, x, y, z) data from user defined rigid bodies. The 6DOF data gives information about the position and rotation of a moving body.

6.3 Experiment 10: Hand gestures in a group discussion

6.3.1 Intention

The intention in this experiment was to use MOCAP to illustrate that hand movements in gestures draw patterns. Based on theory (section 3.5), it was envisioned that such patterns could reveal the content of the conversation. The research question was: how would gestures appear in MOCAP? Would they resemble any shape? Can such shapes be generated as motifs to be used in the design of patterns for printed textiles?

The gestures made in a live event means, that they would be subconsciously attached to the spoken word or verses that were used in the communication process rather than choreographed. The speech related hand movements such as *illustrators* when visualised using MOCAP, could reveal a motif or a pattern. According to the model of HPS such motifs or patterns could represent a participant's role in a live event that could then be used to design novel surface prints or textiles.

6.3.2 Process

The Director of Studies and the First Supervisor agreed to participate with the researcher in this initial experiment. They agreed to carry out a supervisory tutorial meeting in the MOCAP suite (Fig. 6.3.1). They also, agreed to wear dark clothing and avoid wearing any shiny jewelry, to prevent *occlusion*. The meeting was recorded in two ways; video film and MOCAP. The video film would provide the audio-visual data, which would be used later to analyze the MOCAP generated pattern (Fig. 6.3.2).

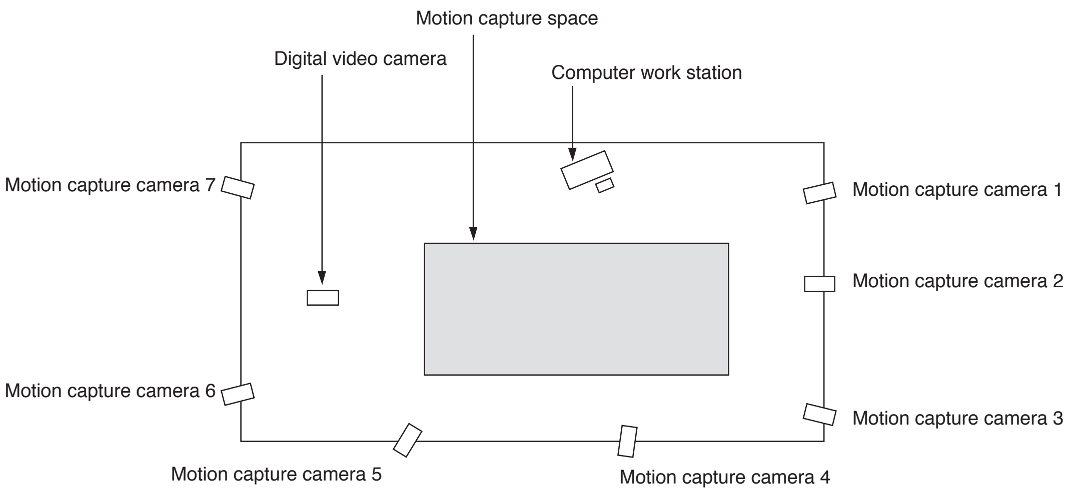

Fig. 6.3.1 Schematic diagram of MOCAP suite in Performance Analysis Laboratory, NTU

Fig. 6.3.2 Still image from the supervisory tutorial meeting in MOCAP suite, NTU

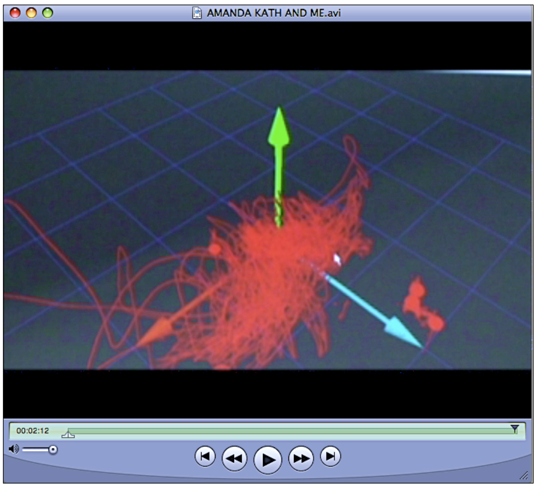

Fig. 6.3.3 Video screen grabs of motion capture visualization of hand gestures in QTM

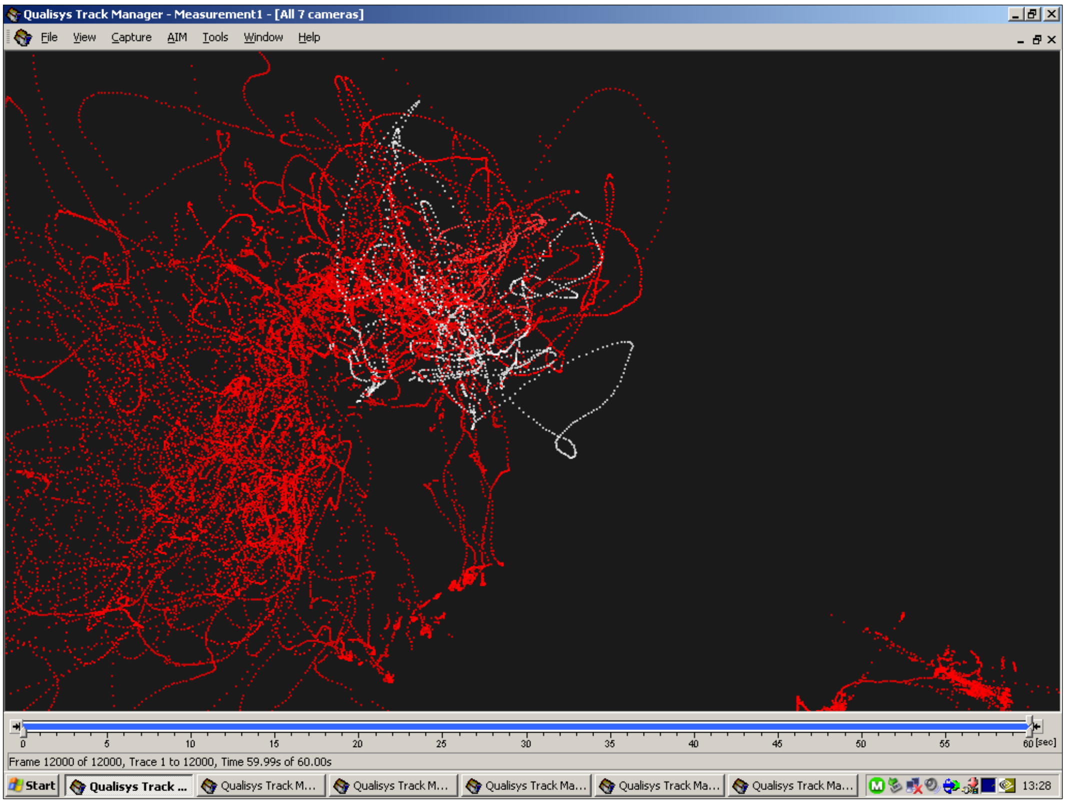

Fig. 6.3.4 Screen grab of motion capture visualization of hand gestures in QTM

6.3.2.1 Motif Generation

In the MOCAP suite a formal seating arrangement was laid out with a table and three chairs around it. We then attached small sized reflective markers to the tips of our middle fingers. The topic of the tutorial was a discussion on drawing in 3D space, how it differs from conventional 2D drawing on paper.

When we draw on paper we can see the results immediately. However, drawing in 3D space would change such behavior because such drawing cannot be seen while being drawn. The drawing can only be seen after the motion capture data is processed in QTM. This meant we do not know the exact points of departure of the hand, where has it moved on and where will it end. This new medium required various explorations in order to be able to draw effectively. We also discussed how basic shapes could be drawn in 3D space.

Hand movements made during the discussion were captured by MOCAP. The duration of discussions were short and ranged from about 3 to 5 minutes. The discussions were repeated twice so as to find out any difference in the outcomes. The MOCAP data was then visualized in QTM. The visualization of the discussion revealed a complex pattern of lines and dots representing hand gestures of the participants (Fig. 6.3.3). The QTM's visualization was then obtained by a simple method of *screen capture* (print screen) as a bitmap file.

6.3.2.2 Pattern Design

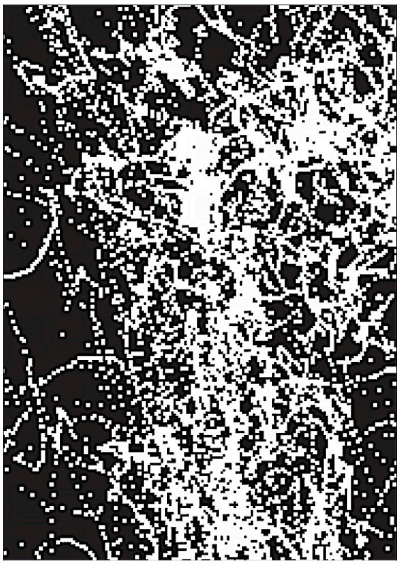

Fig. 6.3.5 Details of vector paths in Adobe Illustrator

The screen captured image included unwanted visual elements such as menu bars, which were first removed in Adobe Photoshop by using the *cropping* tool. The saved image was then traced using *live trace* tool to create vector paths in Adobe Illustrator (Fig. 6.3.5). The resulting vector paths were then *simplified* to obtain a distinct outline with edges. This step is also required to remove unwanted vector paths, which could hinder image manipulation such as scale and transformation.

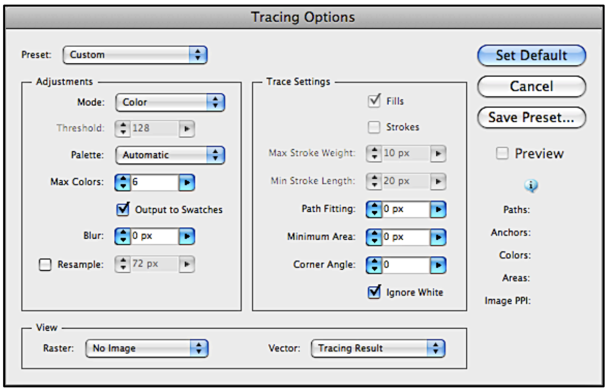

Fig. 6.3.6 Parameters that were defined for *live trace* tool

The vector paths were then filled with colour to create a pattern (Fig. 6.3.7). The colours in the pattern were kept similar to the image obtained from QTM. The intention was to retain the visual characteristics of the image generated by QTM.

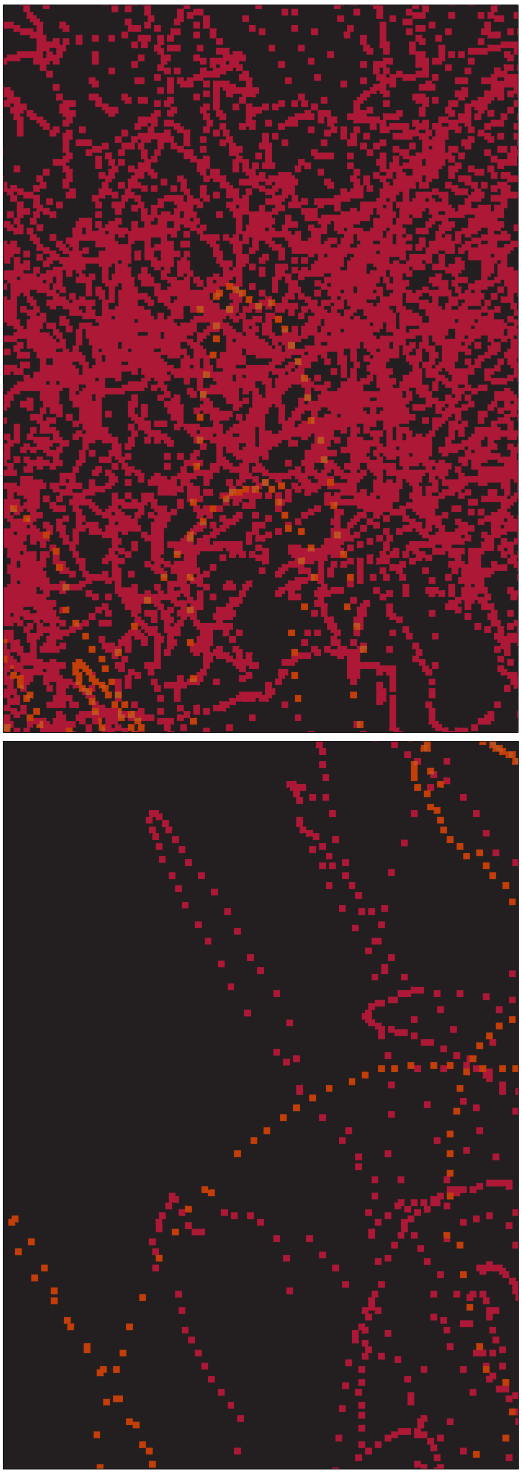

Fig. 6.3.7 Details of the pattern filled with colour

6.3.2.3 Textile Materialisation

The designed patterns were then printed on two different fabrics, 100% Silk Crepe Satin and 100% Bamboo using DTPT. The intention of using two different fabrics was to see if the fibre composition and texture of the fabric produced any comparative differences. It was found that the pattern printed on 100% Bamboo was more distinct and the colours appeared much darker in comparison to the 100% Silk Crepe Satin (Fig. 6.3.8).

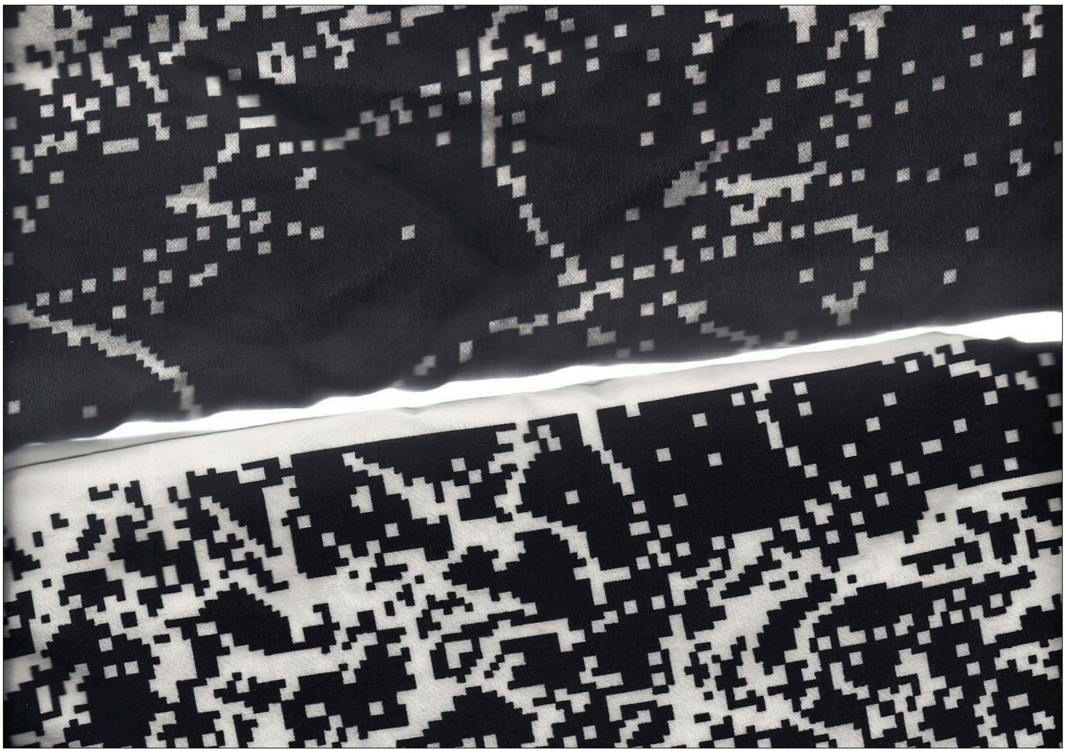

Fig. 6.3.8 Comparative image of the pattern printed on two different fabrics, top (100% Silk Crepe Satin and bottom (100% Bamboo)

6.3.3 Reflection

The only way we could get any visual data from the motion capture system was to get a screen capture of the visualization. However, the motion capture system also generated a numerical data file, which comprised of the positions of the markers frame by frame. It was found that such numerical data could be imported into other software such as Maya and Autodesk to visualize them. The current entertainment and media industry is using this software to create complex animations. This was not a requirement in this research.

Through this process we also understood that there was a shift of consciousness, linked to the markers being placed on the participant's fingers, which affected their natural speech (and associated gestural) patterns.

The visualization of the MOCAP represents the position of the markers in a 3D space. The 3D visualization is based on an X, Y and Z-axis which means that the visualization could be rotated at an angle of 360° on each axis which is not required from this research's point of view (Fig. 6.3.2). Therefore the visualization needs to be simplified and be coherent in relation to the theoretical discussions presented prior to the experiments. Samples of two screen grabs were then processed to create surface patterns. On analysis the image appears, as vividly drawn lines, entangled with each other, like a wire mesh. Therefore the image was magnified to examine how it appeared on a larger scale. When enlarged the image appeared as dots, which represented the position of the markers on the participants hands and illustrated vigorous, dynamic activity. Therefore it seemed appropriate to create a magnified version of a single image (screen grab) as a surface pattern, which in the context of MOCAP and non-verbal communication are connected with each other. A common approach to increase the image size would be to enlarge it, creating a pixelated image. Pixelated (distortion) is avoided by creating a vector shape of the surface pattern.

6.4 Experiment 11: Sports Actions- Golf, Rowing, Tennis

6.4.1 Intention

Reflecting on the experiment with hand gestures in a group discussion, which resulted in a complex pattern, the research now sought simplicity. During the induction to the MOCAP system, examples of sporting events were shown. These occurred to the researcher as a simplified version of a complex gestural pattern. Therefore, the intention in this experiment was to create surface patterns by using motion capture data of sporting events such as golf, rowing and tennis. The outcomes would be then visually analyzed to see if there is a relationship between hand moments in a sporting event and gestures. The intention to use sports action such as golf shot were inspired by research into the history of motion capture such as Doctor Edgerton's photograph of a golfer shot (Fig. 2.7.2), in which movements of a golfer's shot as a single image represented a sculptured form.

6.4.2 Process

6.4.2.1 Motif Generation

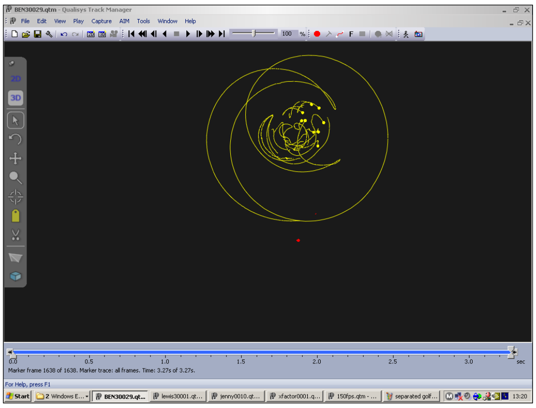

Fig. 6.4.1 MOCAP visualization of a golf shot

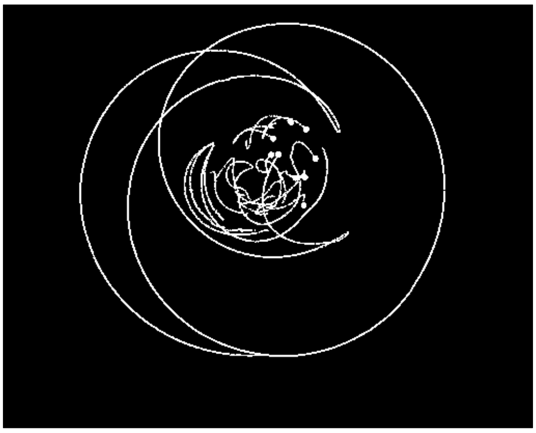

Fig. 6.4.2 Motif, Vector shape of MOCAP visualization of a golf shot

Golf - MOCAP data of a golf shot was visualized in QTM. The 3D visualization was then viewed from different angles. Of which one view was selected and screen captured. The next step was to remove unwanted visual elements from the screen capture image such as menu bars. The image is then traced using *live trace* tool to create a vector shape in Adobe Illustrator. The vector shape is then with defined with an outline colour as a motif.

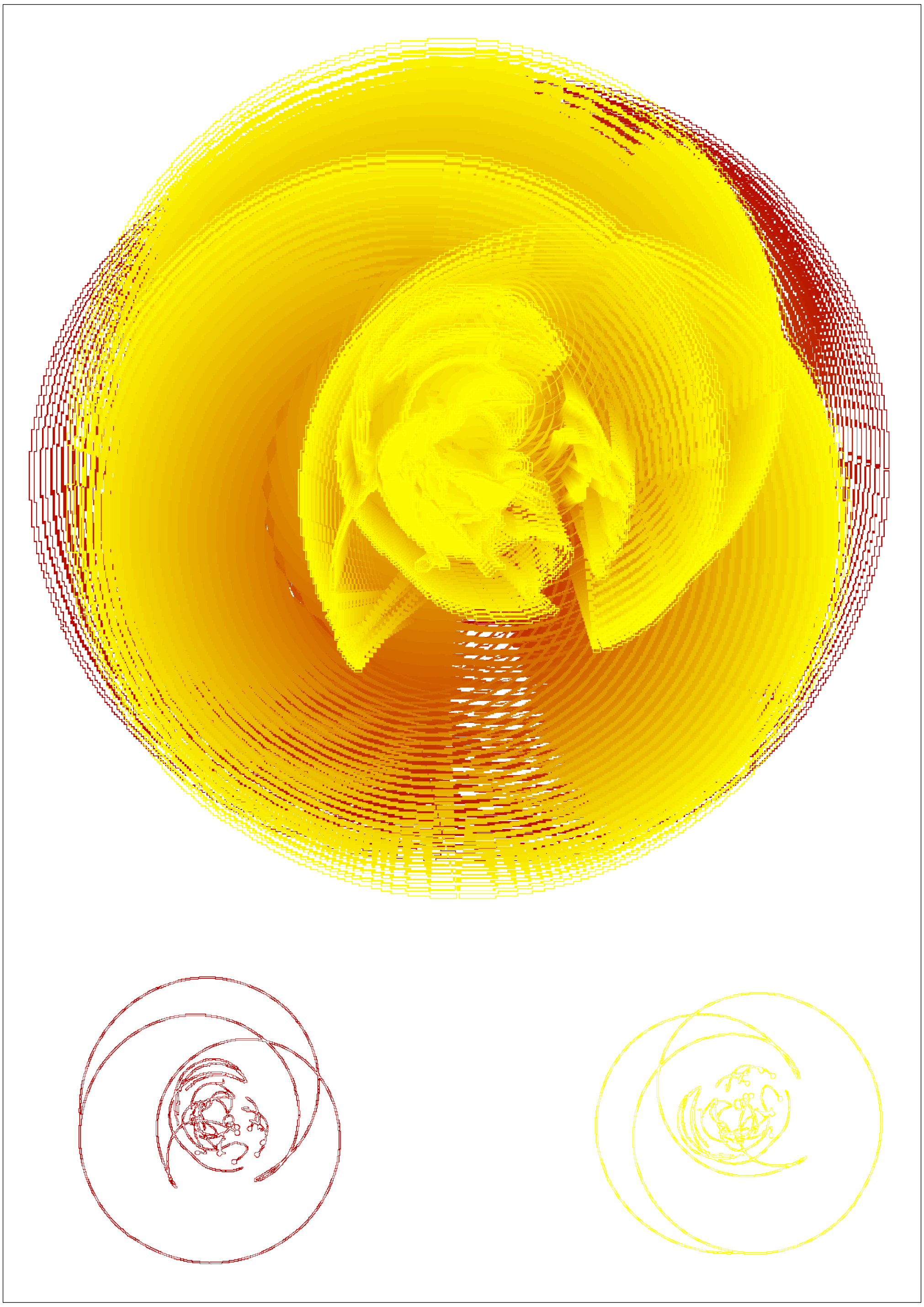

Fig. 6.4.3 Pattern, 3D transitional shapes of a golf shot

6.4.2.2 Pattern Design

In order to design the motif as pattern, two methods were explored such as creating a 3D transitional shape and motif placement in a repeat. To create a 3D transitional shape, two

Fig. 6.4.4 Pattern, golf shot motif in a half drop repeat

contrasting, coloured motifs were superimposed and blended to each other using the *blend* tool resulting in a pattern (Fig. 6.4.3).

In the second method, the motif is placed in a half-drop repeat to create a pattern. It was discovered while defining the motif's colour that due to the complex vector path, part of the motif would remain uncoloured. The partly coloured motif created an uneven distribution of colour in the pattern (Fig. 6.4.4).

6.4.2.3 Textile Materialisation

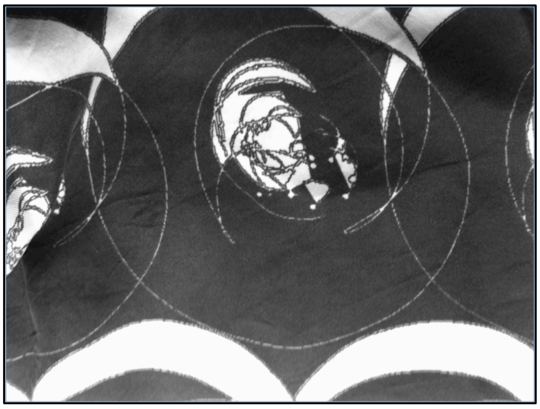

Fig. 6.4.5 Pattern half drop repeat printed on 100% Silk Twill

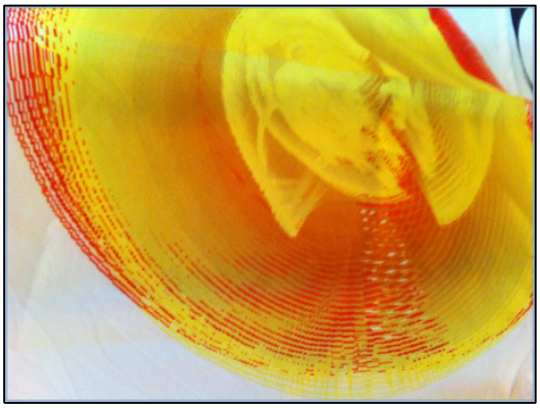

Fig. 6.4.6 Pattern 3D transitional shapes printed on 100% Silk Twill

The two designed patterns were then printed on 100% Silk twill using DTPT. It was found that woven texture of the fabric surface, enhanced the fine textural lines in the pattern (Fig. 6.4.5 & Fig. 6.4.6).

6.4.2.4 Motif Generation

Rowing -MOCAP data of a rowing action was visualized in QTM. The 3D visualization was then viewed from different angles. Of which one view was selected and screen captured (Fig. 6.4.7).

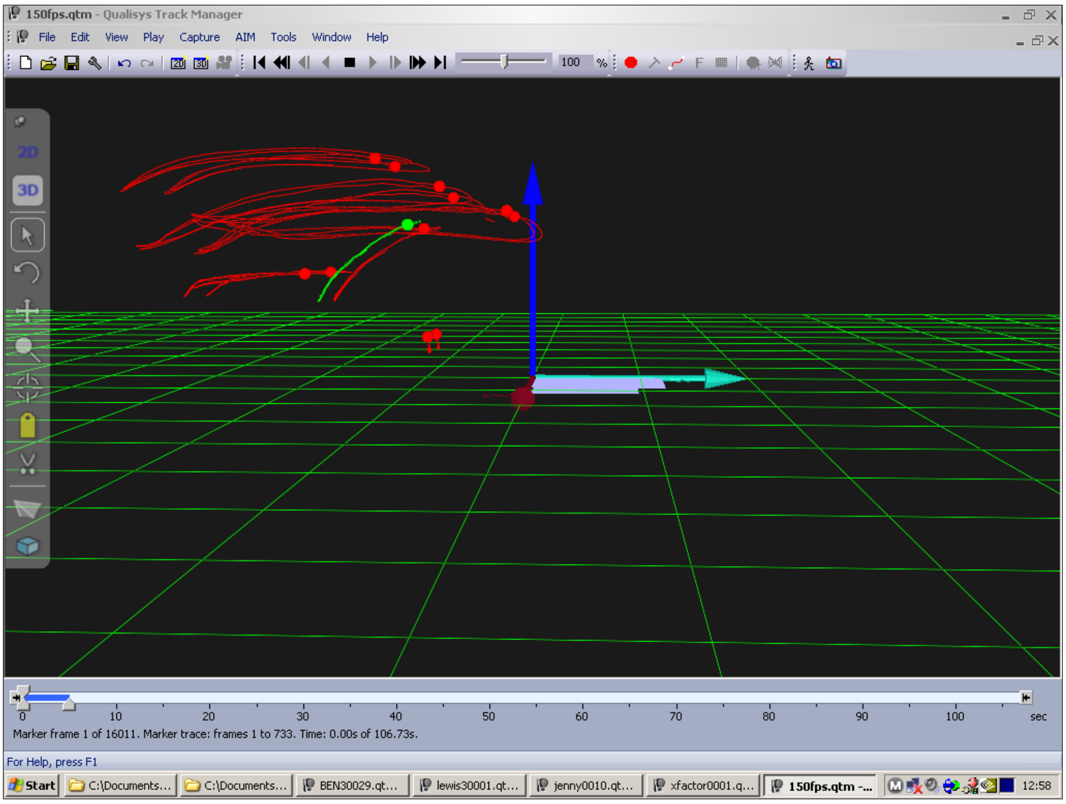

Fig. 6.4.7 MOCAP visualization of rowing

The next step was to remove unwanted visual elements from the screen capture image such as menu bars. The image is then traced using *live trace* tool to create a vector shape in Adobe Illustrator. The *live trace* tool settings are defined to include colour instead of black and white. The vector shape's path is then simplified to transform the pixelated outline into a mosaic like structure (Fig. 6.4.9). The resulting vector shape is then placed in a mirror repeat to create a single motif (Fig. 6.4.8).

Fig. 6.4.8 Motif, Vector shape of rowing in a mirror repeat

Fig. 6.4.9 Detailed view of the motif

6.4.2.5 Pattern Design

The designed motif would work as a placement print. If repeated, it would create a complex pattern and the motif would lose its dynamic appearance. Therefore further exploration to design a pattern was not required.

6.4.2.6 Motif Generation

Tennis - MOCAP data of a tennis serving action was visualized in QTM. The 3-D visualization was then viewed from different angles. Of which one view was selected and screen captured (Fig. 6.4.10). The next step was to remove unwanted visual elements from the screen capture image such as menu bars. The image is then traced using *live trace* tool to create a vector shape in Adobe Illustrator. The resultant vector shape's path is then simplified to create a motif (Fig. 6.4.11).

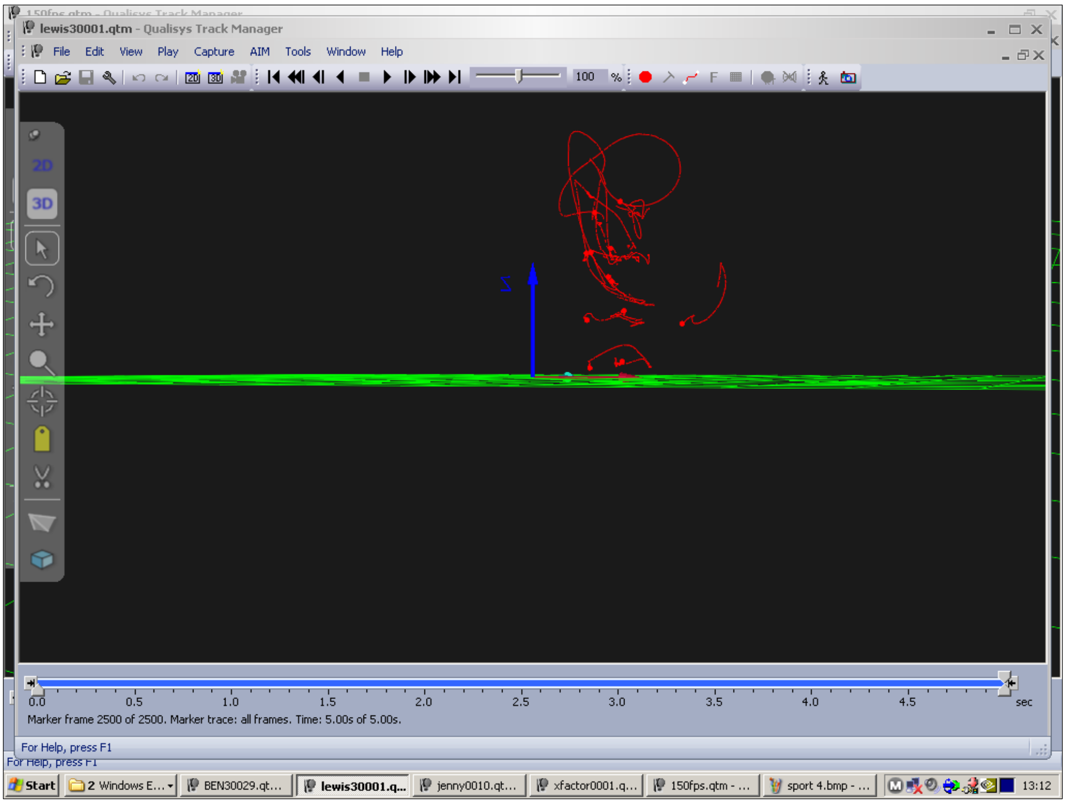

Fig. 6.4.10 MOCAP visualization of tennis shot

Fig. 6.4.11 Motif, Vector shape of tennis shot

6.4.2.7 Pattern Design

The designed motif would work as a placement print. In comparison to both golf and rowing action-generated motifs, the tennis shot motif appeared incomplete. If repeated, it could create a complex pattern, and the motif would loose its individual, signature appearance. Therefore further exploration to design a pattern was not required.

6.4.3 Reflection

The outcome of this experiment showed the potential for creating interesting surface patterns by using MOCAP visualisation of sports action such as golf shot, rowing action and tennis serve. This was required to show coherence in experimental research. Meaning, if sports actions could provide a means to portray hand gestures. Therefore, the pattern extraction processes for each action were approached differently. For example a comparison between Fig. 6.4.3, which represents a 3D visualization of a transitional shape created from a golf shot and Fig. 6.4.8, which represents a rowing action and its resultant pattern, appears organic. The textile design approach used in Fig. 6.4.4 highlights that the golf shot provides motifs, which can then be repeated. The pattern, which was the result of simplifying a path representing a tennis serve shows that patterns obtained from visualizations, can be transformed into several views, however the path would remain the same.

The surface patterns also show that if gestures were performed one at a time they can be more definitive drawing rather than a complex structure as it occurred in the first experiment with motion tracking. It also shows that, motion capture can be used as an alternative media to draw. The MOCAP visualizations of sports action appeared as drawings created by individual sports personnel through motion capture. This shows potential that performing one gesture at a time should be experimented.

6.5 Experiment 12: Hand gesture to greet (Namaste)

6.5.1 Intention

This experiment arises from the reflections from the previous experiments 10 and 11 in this section to perform one gesture and see what the resultant pattern is. The Indian gesture, *namaste* when spoken to another person, is commonly accompanied by a slight bow made with hands pressed together, palms touching and fingers pointed upwards, in front of the chest (Fig. 6.5.1).

Fig. 6.5.1 The researcher performing Indian hand gesture to greet, *namaste*

6.5.2 Process

6.5.2.1 Motif Generation

Motion capture data of 'Namaste' was visualised in QTM. The 3D visualization was then studied from different angles, from which one view was selected (Fig. 6.5.2). The image was then traced to create a vector shape in Adobe Illustrator. The *live trace* tool settings were defined to include six colour samples, instead of black and white. The next step was to remove unwanted visual elements from the screen capture image such as menu bars, the grid and the background. The resulting vector shape's was then used as a motif (Fig.6.5.3).

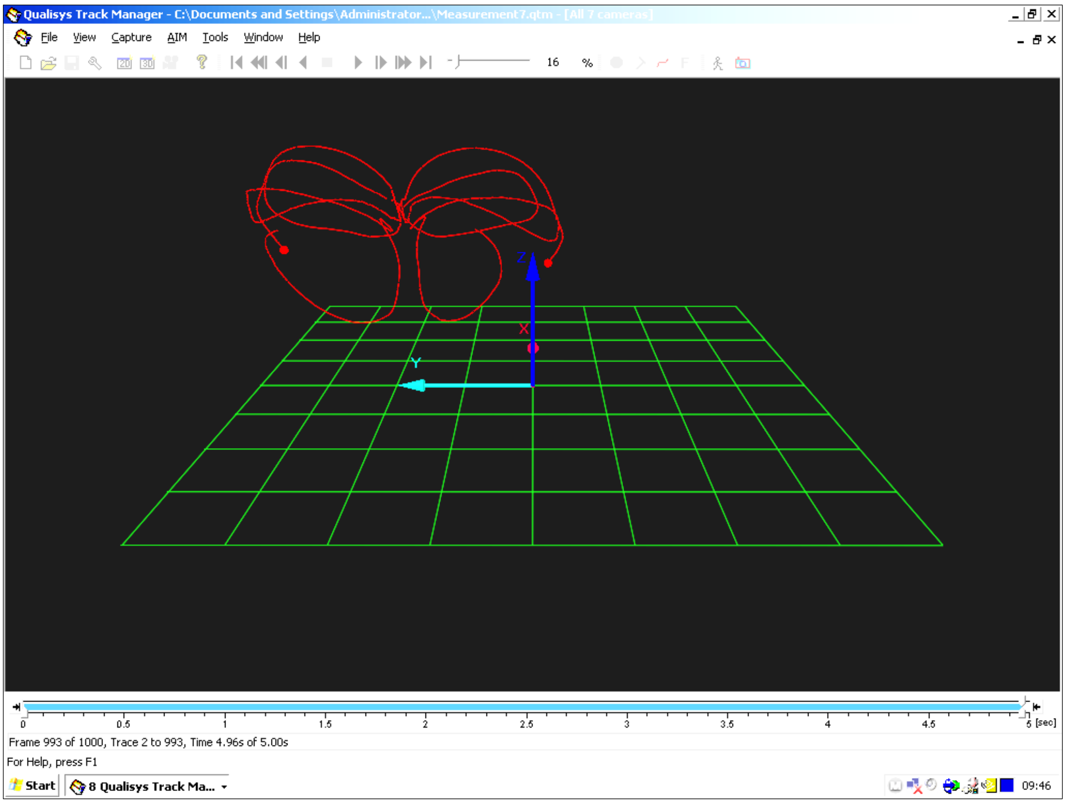

Fig. 6.5.2 Selected view of MOCAP visualization, *namaste*

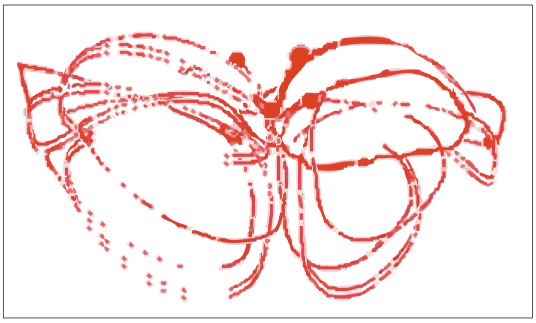

Fig. 6.5.3 Motif, Vector shape extracted from visualization, *namaste*

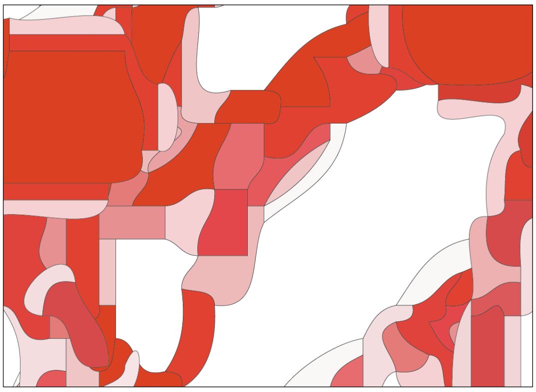

Fig. 6.5.4 Detail view of a section of motif, *namaste*

6.5.2.2 Pattern Design

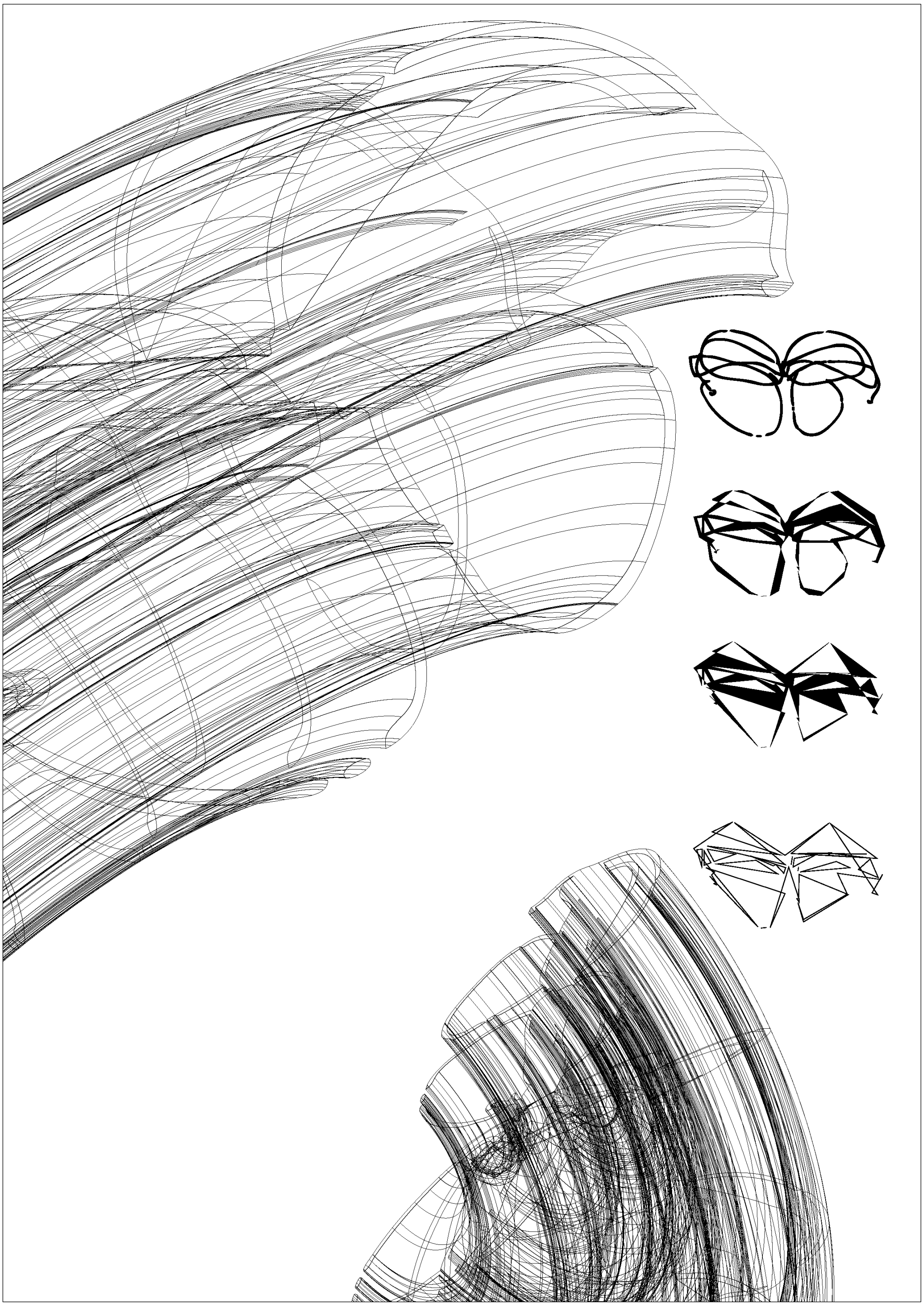

Fig. 6.5.5 *Namaste*, motif rendered using *3D revolve effect*

The exploratory process is based on two different concepts such as either the motif could be regularly repeated to create a surface pattern or it could be transformed into a three-dimensional rendering. Firstly, the motif (Fig. 6.5.3) was placed in a regular grid to create a pattern (Fig. 6.5.7).

In the second concept, to create a three-dimensional rendering of the motif, the vector paths are first simplified as outlines in Adobe Illustrator. Then vector effect such as *3D revolve* was applied to the motif (Fig. 6.5.5). The resulting shapes from the exploration appear as 3D objects, which could be applied as a placement print rather than creating a pattern.

6.5.2.3 Textile Materialisation

Fig. 6.5.6 *Namaste,* motif rendered using *3D revolve*, printed on 100% Silk Habotai Lining

The designed patterns were then printed on two different fabrics, 100% Silk Habotai Lining and 100% Viscose lining material using DTPT. The intentions of using two different fabrics were to see if the fibre composition and texture of the fabric create any comparative differences. Viscose based fabrics are shiny in appearance in comparison to silk-based fabrics. In commercial production, viscose is referred as *Art* *silk* due to its resemblance to silk but costs less to produce. It was found that the pattern printed on 100% Viscose lining material was more distinct and the colours appeared much darker in comparison to the 100% Silk Habotai Lining. But, Silk Habotai Lining offered subtleness to the 3D rendered pattern, which contains fine lines.

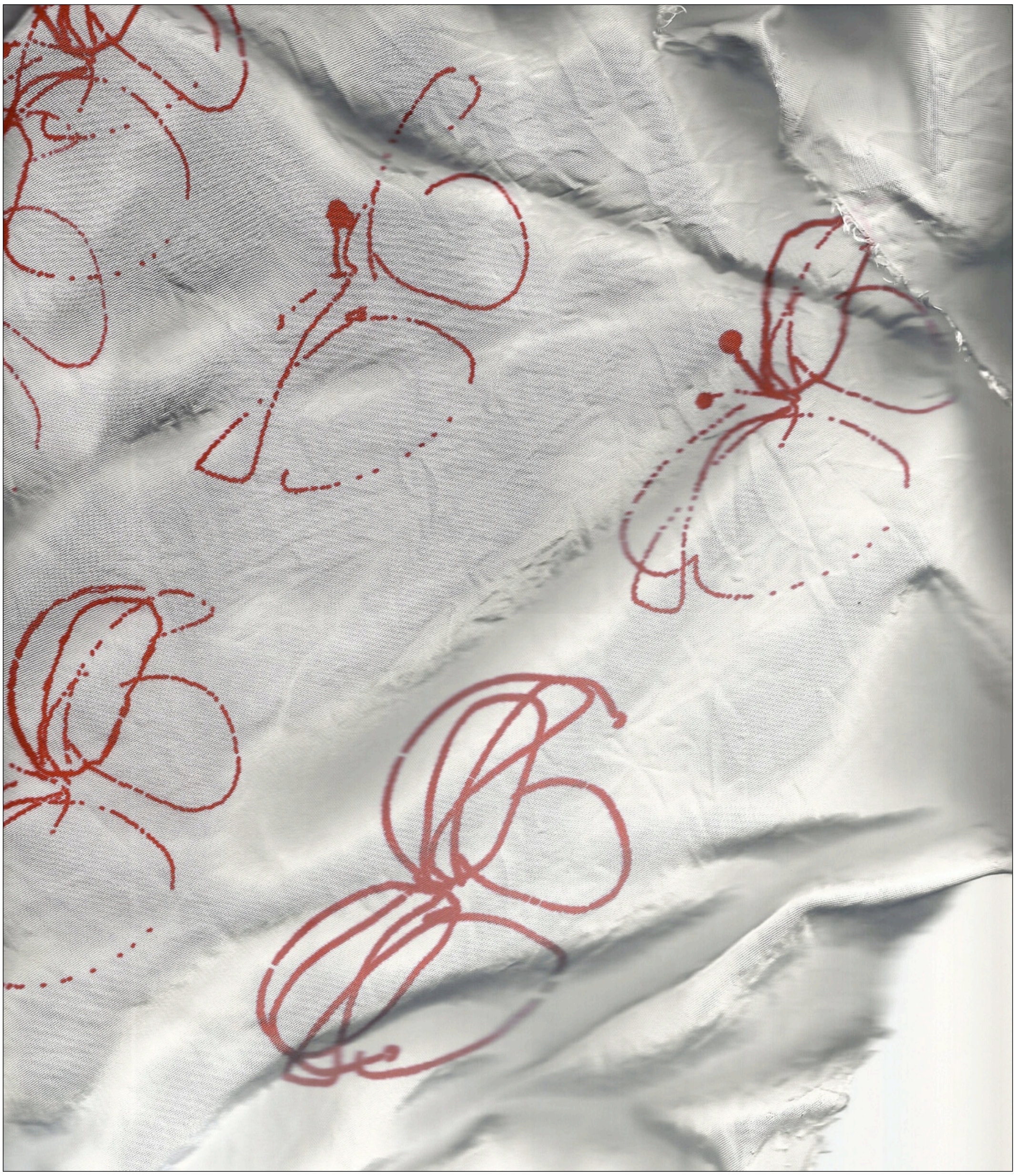

Fig. 6.5.7 *Namaste*, pattern printed on 100% viscose lining material

6.5.3 Reflection

The outcome of this experiment showed that MOCAP visualisation of rhythmic hand gesture generated a symmetrical motif. The motif showed a definitive drawing rather than a complex structure as it occurred in the first experiment with motion tracking (Fig. 6.3.4). It reflects that if the same gesture is repeated, the generated motif will be similar but not the same resulting in a unique motif. The concept of hand gesture, to draw a motif is similar to hand drawn motif. Therefore, it could be said that the motif is a hand drawn using technology. This concept could be further explored with a group of participants to create a performance and associated surface patterns.

6.6 Evaluation of practical research methods

So far in the thesis, the three practical research methods, motion tracing, motion sensing and motion tracking have been used to explore HPS. The methods have been employed to capture a participant's hand gestures to create a motif; the motif is then designed into a pattern to be printed on textiles. At this stage, it is required to evaluate the effectiveness of these practical methods to find out the most effective pattern generation method. The identified practical method will be then used in the concluding experiments of the thesis. The three practical research methods are evaluated using two main criteria: practical and aesthetic issues.

Practical issue: Using this criterion the three methods are compared with each other in terms of success and efficiency in application. Being a successful method means it solves the problem effectively. Which means, the method captures and visualises *illustrators* by meeting the constraints of digital inkjet printing technology of printed textile design and it is acceptable to the participants. By using the method the participants do not incur any discomfort or bodily harm. Being efficient means the cost of equipment and cost of production of the printed textile is comparable. The method is useful, simple and easy to apply. The method is reliable meaning; it will produce consistent results over time.

Aesthetic issue: Using this criterion the three methods are compared with each other in terms of new and coherent results in the context of printed textile design. Being new means the method creates, a pattern, which is innovative, breaking new ground, and is seminal; the pattern provides the foundation for further developments. Being coherent means the hand gestures of the participants and the resulting patterns are visually related. The quality of the pattern design is clear and visually stimulating, and reflects well-crafted execution.

It needs to be stated that this research focuses on qualitative rather than quantitative evaluation. However, in order to make comparison, this evaluation used a value rating system. The range of rating: 1 – 5 (1 is least effective and 5 represents the most effective). Using this system the three practical research methods are compared. The comparison is illustrated in a tabular form (Fig. 6.6.1).

	Criteria for evaluation				
Practical Method					
	Practical		**Aesthetic**		
	Successful	Efficient	New	Coherent	Total rating
Motion Tracing	3	3	3	2	11
Motion Sensing	3	2	4	2	11
Motion Tracking	3	3	4	4	14

Fig. 6.6.1 Table illustrating the evaluation of the three practical research methods

The evaluation found motion tracking to be the most effective method in terms of meeting both the practical and aesthetic criteria. Motion tracing is the least effective, whereas motion sensing is marginally effective in meeting the criteria.

6.6.1 Discussion

The three practical research methods meet most of the practical and aesthetic criteria. However, there is a certain degree of variation in meeting the criteria. This discussion will highlight them. The motif generation and pattern design sections in Chapters Four, Five and in this chapter demonstrate that the three methods can capture and visualise *illustrators.* Therefore, they are all equally rated as successful. In terms of efficiency motion tracking shows that it can produce consistent results whereas, both motion tracing and sensing produce variations. For example, the limited way the hand gestures can be captured by motion tracing and sensing.

All the three methods create new and original imagery. However, the methods of motion sensing and tracking offer seminal, or new possibilities. Therefore they have an advantage. In terms of coherence only motion tracking provides a relationship between hand gestures and the generated motifs. For example, the hand gesture *namaste* and its representation (section 6.5).

6.6.2 Implications for further experiments

Reflecting on the outcomes of the experiments, carried out in Chapter Four, Five and Six and their evaluation. The implications those were identified for final research experiments are:

5 Capturing hand movements and manipulation of the data resulted in variety of visually abstract forms, which may be designed as patterns to be printed on textiles but they would have no relationship to Non-verbal Communication as it was proposed.

6 Considering hand movements in relation to social interaction is a wide area of research and it would invite more complex studies to be undertaken, which were out of the scope of research. It would be challenging to underpin hand movements so that they can have a direct relationship to printed textile design.

7 The outcomes of some experiments which dealt with open source programming were distorted from my research point of view although the printed outcomes were aesthetically pleasing and could be seen as tangibles, they do not adhere to the original idea of translating gestures as print patterns and their recognition.

8 Re-visiting the rational of the proposed research found instead of revealing gestures made in a conversation, it should be directed to other means such as describing an object, describing a shape, gestural drawing of the object, representing emotions and drawing in 3D space.

6.7 Conclusion

The experiments to capture hand movements were formulated using contrasting methods. The research identified three contrasting methods such as motion tracing, motion tracking and motion sensing. Based on the concepts of manual, semi-automated and automated processes.

The method of motion tracking demonstrates, creation of motifs, designed as patterns for printed textiles. It contributes to the HPS, by capturing hand gestures in real-life scenarios. The contribution by participants to the HPS by their hand gestures needs to be further explored. The relation between hand gestures and resulting pattern needs to be established.

The research finds potential in sports performance actions such as golf shoot, rowing action and tennis serve to create new surface patterns. This has been explored in this chapter.

The research found that due to occlusion the number of markers require optimizing so that even the slightest movement of the participant's hand can be recorded. It was found that the tip of the middle finger of a participant's hand is the appropriate to place a marker, which is tested and found effective in the Experiment 12. These patterns show if gestures were performed one at a time they are definitive in appearance. This shows motion capture can be used as an alternative media to draw motifs.

The outcome of performed gesture “Namaste” showed that a rhythmic hand movement results in a rhythmic form. If the same gesture were repeated, the outcomes would not be same but similar, characterizing a hand drawn motif. This method should be further explored with a group of participants to create a performance resulting in surface patterns.

The three practical methods were evaluated by practical and aesthetic criteria to find motion tracking as the most appropriate method. The identified practical method, motion tracking will be used in the concluding experiments of the thesis in the next chapter.

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Chapter 7

FINAL EXPERIMENTS

7.1 Introduction

In this thesis, the chapters based on practical research; Chapters Four, Five and Six have explored motion capture using methods of motion tracing, motion sensing and motion tracking. The practical methods and their printed outcomes were then evaluated to find motion tracking as an appropriate method, which is stated in the conclusion to Chapter Six, along with a list of identified implications (section 6.6).

Of which specifically

1. Capturing hand gestures and manipulation of the visual data resulted in a variety of visually abstract forms, which may be designed as patterns to be printed on textiles but with no relationship to Non-verbal Communication (NVC) as it is proposed in the research. Therefore, specific hand gestures such as *illustrators* (section 3.5.1) batons, pointing and spatial movements could be explored with a group of participants, providing cohesion between NVC, generated motifs and designed patterns.

2. Considering hand gestures in social interaction is a wide area of research would invite more complex studies to be undertaken, which are beyond the scope of this research. The solution to this implication is to narrow down to a specific group activity amongst participants in which they use *illustrators* to generate motifs.

Informed by these implications, this chapter documents the final experiments, based on motion tracking as a method to find conclusions to the research.

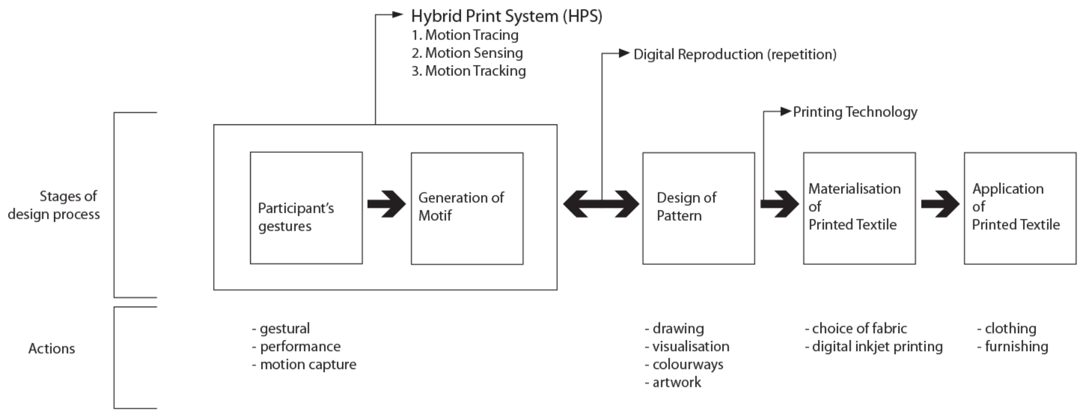

Fig. 7.1.1 The Model of Hybrid Print System

The model of hybrid print system (HPS) is recreated by combining (Fig 3.2.1 & Fig 4.2.1) to provide clarity in this chapter. In the HPS, the participant's gestures are used to generate motifs, which are then designed as patterns to be printed on textiles. This follows up on the method described in Section 6.5.3, in which a live event, or gesture of *namaste*, is performed to create a motif. If a gesture is repeated in a given time and space, the resulting motifs will be similar, not exactly the same. Similarly, if a group of participants make hand gestures it will result in a group of motifs, which are similar to each other. The formation of the motif will depend on the participant's placement within the group. Revisiting Chapter 2, where patterns have been defined as a group of similar (but not the same) motifs placed in a regular grid result in a pattern. This approach is further tested in this chapter through a set of experiments, dealing with live events in which participants make hand gestures to generate motifs to be designed as patterns for printed textiles. The experiments required at least two participants, so that that two individual's hand gestures would provide a basis for repetition and therefore could be designed into a pattern. Six postgraduate students assisted the researcher by participating in the experiments.

The experiments were carried out in two phases on two consecutive days (18^{th} & 19^{th} Feb, 2011). The first phase, on 18^{th} Feb 2011 was to familiarize individual participants with drawing using hand gestures in MOCAP. The second phase, on 19^{th} Feb 2011 was to facilitate the group of participants to create motifs using hand gestures in MOCAP. The motifs generated by the participants were then designed as gestural patterns for printed textiles. The experiment al sessions were digitally filmed on both days to provide evidence for analysis. The films are included in a DVD accompanying this thesis.

7.2 Experiment 13: Drawing using hand gestures in MOCAP

7.2.1 Intention

The intention of this experiment was to familiarize the participants with drawing by using hand gestures in MOCAP. The participants were required to draw different styles of lines, basic shapes and objects with hand gestures in 3D space.

- Styles of lines such as straight, curved, wavy, dotted, dashed and zigzagged.
- Basic shapes such as circle, square, rectangle, hexagon and spiral.
- Objects such as bottle, flower, vase, cup and wine glass

Prior to drawing in MOCAP, the participants were first required to draw on paper using a blackboard marker. Each drawing was timed at 30 seconds. The condition set for this task was that the drawing should be drawn spontaneously using a single stroke when prompted by either a vocal or a printed word. The intention of such a condition was, by drawing in a single stroke the participants would be creating a 2D representation of a line, shape and object. The 2D representation could be further drawn in 3D space as a hand gesture.

7.2.2 Process

Each participant drew different styles of lines, shapes and objects in a single stroke on individual sheets of paper using a marker pen (Fig. 7.2.1) & (Fig. 7.2.3). Once they completed drawing on paper they expressed their individual drawings using hand movements in MOCAP (

Fig. 7.2.2) & (Fig. 7.2.4). After they completed a set of drawings, they were shown the MOCAP visualization of their individual drawings, so that they could reflect on their own method of drawing in 3D space and improvise further.

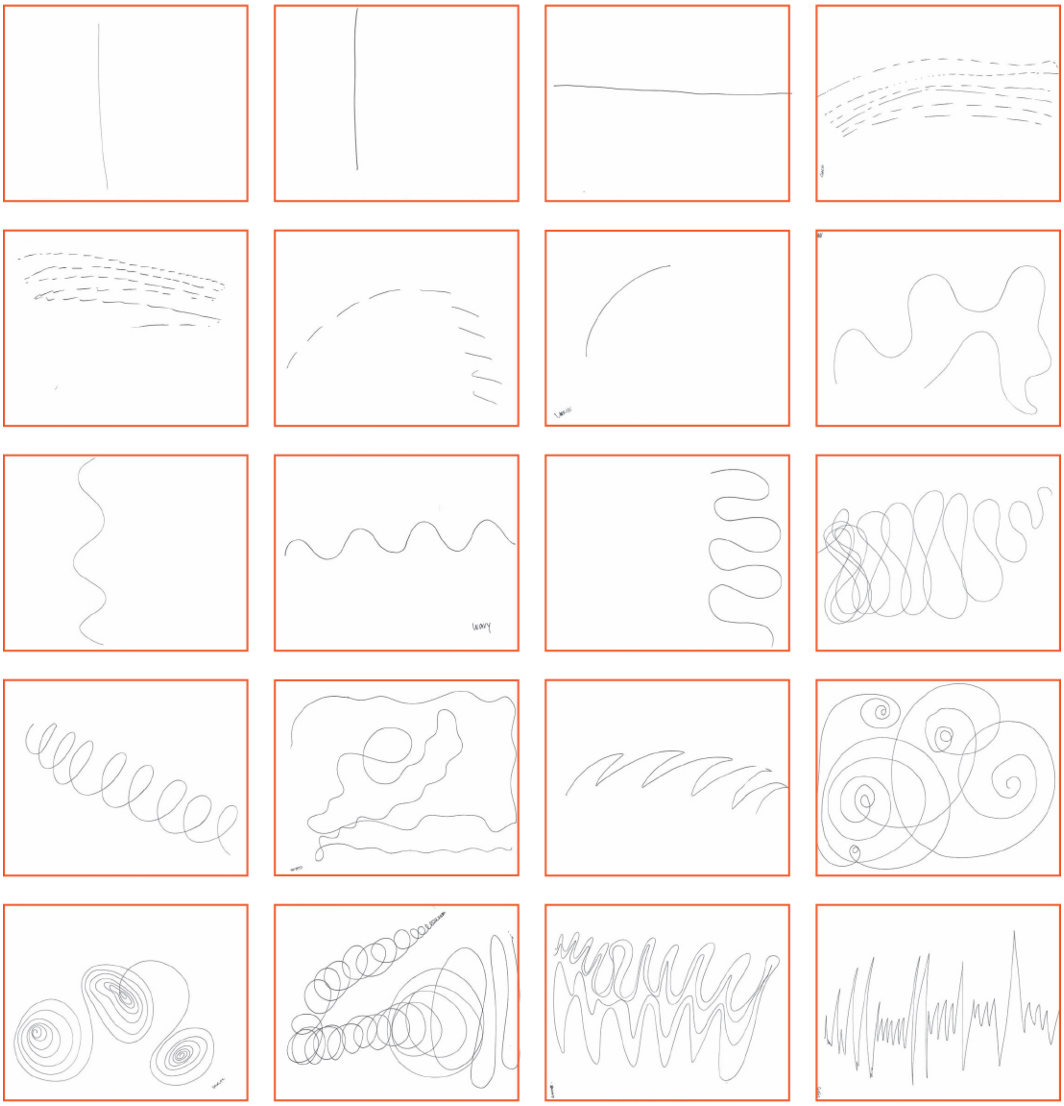

Fig. 7.2.1 Hand drawn lines by participants on paper

Fig. 7.2.2 Hand drawn lines by participants in MOCAP

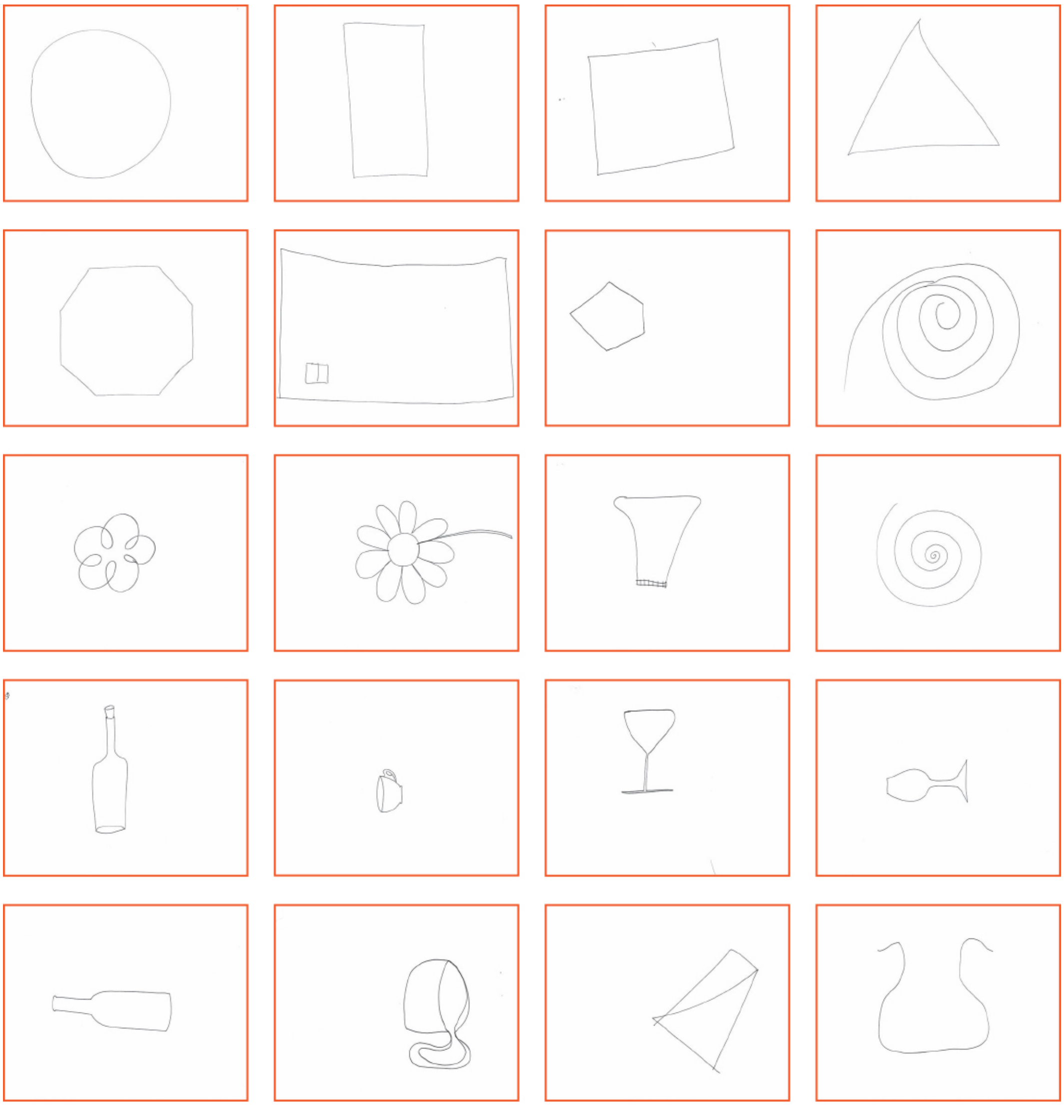

Fig. 7.2.3 Hand drawn basic shapes and objects by participants on paper

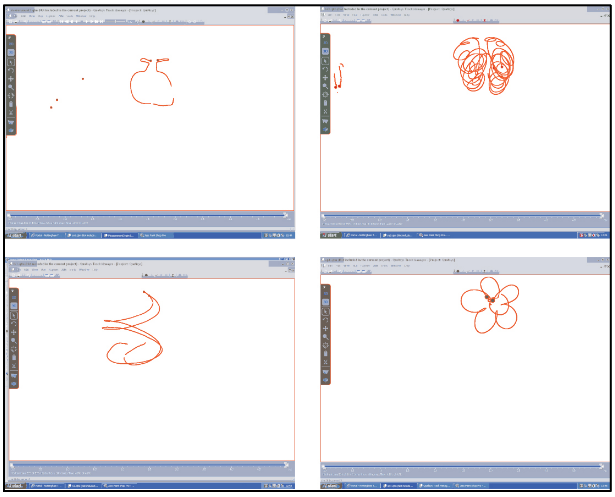

Fig. 7.2.4 Hand drawn basic shapes and objects by participants in MOCAP

7.2.3 Reflection

The main intention of this experiment to familiarize participants with the process of gestural drawing in MOCAP was met. The outcomes of this experiment were a set of hand drawn styles of lines, basic shapes and objects on paper (Fig. 7.2.1) & (Fig. 7.2.3). Their corresponding MOCAP visualizations (Fig. 7.2.2) & (Fig. 7.2.4).

The criteria for the analysis of the drawings and their MOCAP visualization are based on visual clues. From the drawings on paper it is evident that each of the individual participant's approach to drawing resulted in significantly different drawing styles illustrated through variations in motif shape and size. Similarly, individual participants drawing in MOCAP differed from each other. The participants found drawing lines and basic shapes in a single stroke easy in comparison to drawing simple objects. The participants had to try few times to create an object's basic outline in a single stroke. This shows that the participants were reflecting on their own methods of drawing to achieve better results.

The participants had no prior knowledge of drawing in a 3D space. When they drew on paper they were able to see the immediate result through the marker's stroke on the paper. Whereas, strokes made in 3D space were invisible. Therefore, their first attempt to draw was based on the 2D approach used in paper drawing. They used their index finger as a pointer to draw in 3D space.

The participants were shown the MOCAP visualizations of their drawings of lines, shapes and objects. This was followed by a brief discussion on how to use both the hands simultaneously to draw in 3D space. If the outline of a basic object is symmetrical as in a bottle or a vase, both the hands could follow the shape of the object and this would result in an outline representing the object. The participants then performed their individual object drawings in MOCAP (Fig. 7.2.4). The hand movement while drawing the outline represents the object as a gesture. In cases, where the participants had to draw spiral shapes, they tried a new method such as: making a circular hand gesture while moving downward resulting in a spiral shape. Similarly, while drawing zigzag lines, they moved forward and backward and while making hand gestures such as 'open' and 'close' (

Fig. 7.2.2). These insights provided the research with a new method of generating a motif using MOCAP by combining body movement with hand gestures. This method is explored with the participants in the following experiments, 14 & 15.

7.3 Experiment 14: Construction of a rectangular grid

7.3.1 Intention

Each individual participant was now familiarized with drawing using hand gestures in MOCAP. The main intention of this experiment was to explore generating motifs using hand gestures as a group activity rather than individual. The participants were required to stand in a formation and make hand gestures when prompted to generate a motif. Therefore, a rectangular grid was required to create a formation. The grid acted, as a reference in placing the participants, and informed the generation of hand gestured shapes within a motif.

7.3.2 Process

The group of participants stood in two rows at arm's length, so that their fingertips met each other's in two ways; both opposite, and side by side (Fig. 7.3.1).

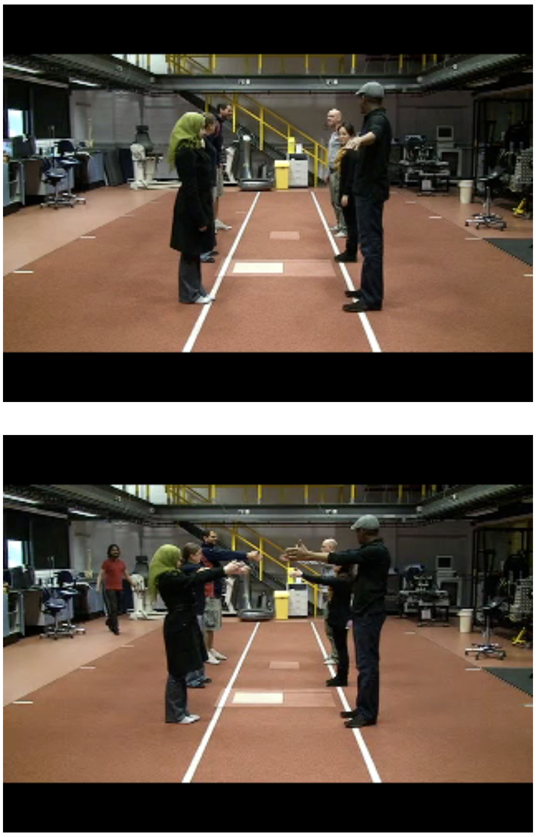

Fig. 7.3.1 Participants forming a grid to perform gestures

The participants standing positions were marked with a paper tape to form a rectangular grid (Fig. 7.3.2.).

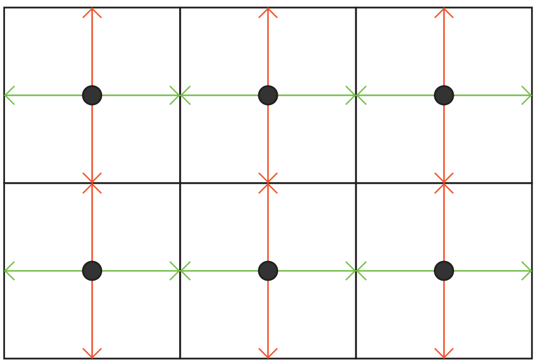

Fig. 7.3.1 Rectangular grid, with arrows representing the participants hands

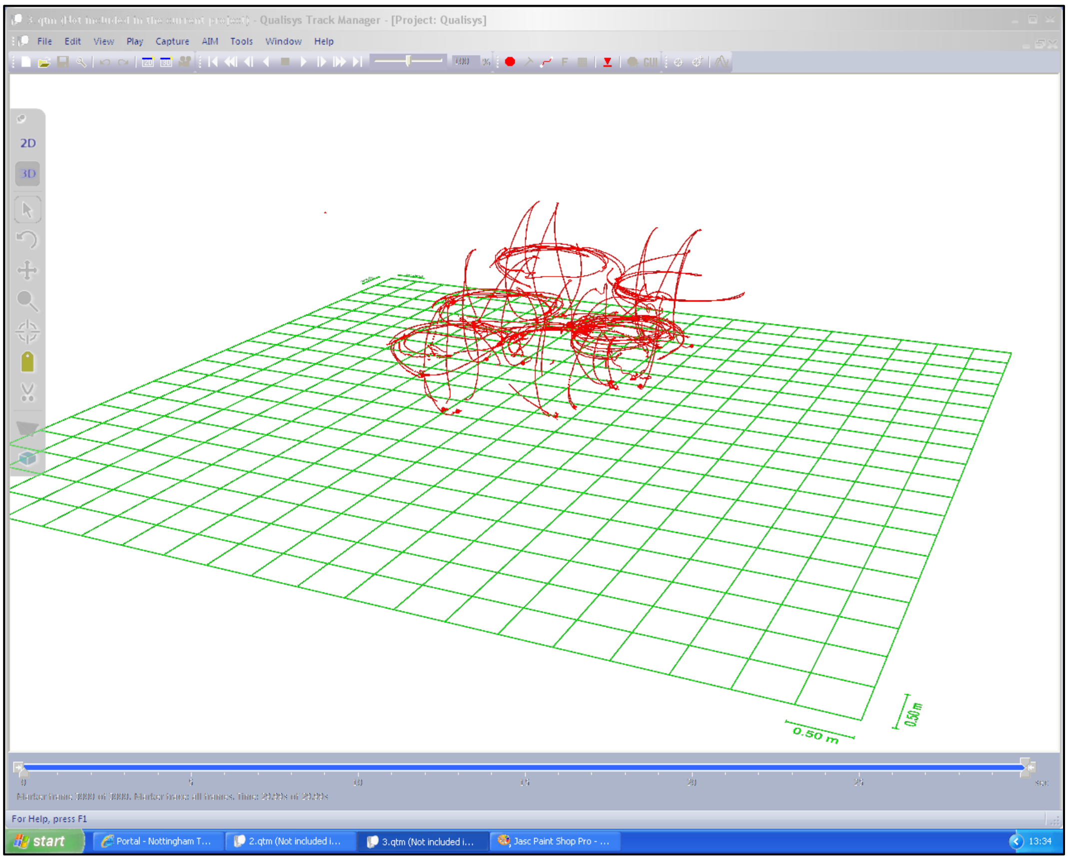

Fig. 7.3.2 MOCAP visualization of participants exploring hand gestures in the grid (three point perspective view)

The participants then performed a set of hand gestures, *illustrators* such as ‘up’, ‘down’ and ‘turn around’ on verbal prompting. The MOCAP visualization of the gestural performance was processed to visualize the resulting motif in three ways such as three-point perspective, top and side view (Fig. 7.3.2, Fig. 7.3.3, & Fig. 7.3.4).

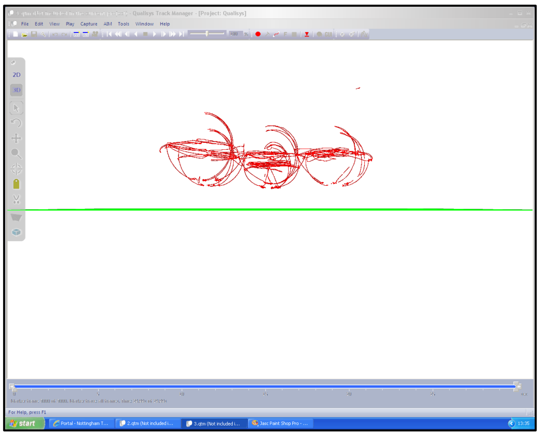

Fig. 7.3.3 MOCAP visualization of participants exploring hand gestures in the grid (side view)

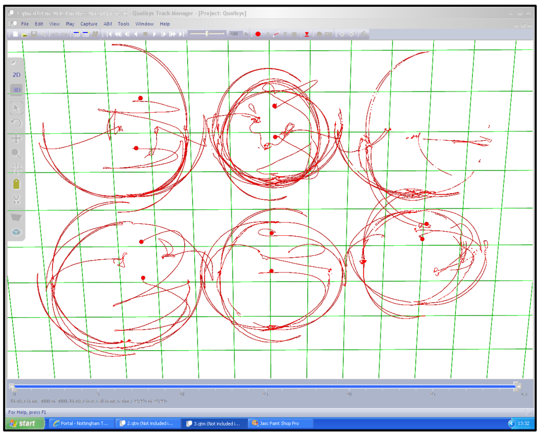

Fig. 7.3.4 MOCAP visualization of participants exploring hand gestures in the grid (top view)

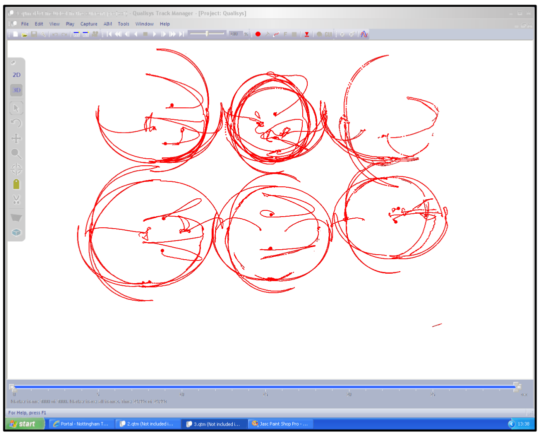

Fig. 7.3.5 MOCAP visualization of participants exploring hand gestures without the virtual grid

The research found that of the three views, the top view appears as a well-designed 2D motif. In which, the gestural contribution of each individual participant can be identified (

Fig. 7.3.5).

7.3.3 Reflection

The main intention of this experiment to explore generating a motif using hand gestures as a group activity rather than by an individual has been met. The outcomes of this experiment were, a gestural performance in a rectangular grid, and a corresponding set of MOCAP visualizations. The MOCAP visualization shows that participants hand gestures, *illustrators* such as 'up', 'down' and 'turn around' result in a motif composed of circular and semi-circular shapes in both horizontal and vertical directions (Fig. 7.3.2, Fig. 7.3.3, Fig. 7.3.4 &

Fig. 7.3.5). The MOCAP visualization shows gestures corresponding to particular shapes within the generated motif. Therefore, it establishes coherence with the implications laid down in the introduction to this chapter (section 7.1).

The research found that, the individual bodily forms of the participants such as their height and width resulted in a variation of the shapes in the motif. The errors committed by participants such as mistiming in performing hand gestures contributed to the imperfect and incomplete shape of the motif. The irregular lines in the motif represent the participant's flexibility to perform a hand gesture resulting in a 'handcrafted' appearance.

Although MOCAP offers 6DOF visualizations (section 6.2.1), to be consistent, the visualizations were studied in three views such as three-point perspective, top and side view. Out of these three views, the top view provided a well-composed motif, which could be further designed into a pattern by placing it in a simple repeat (Fig. 7.3.6). Therefore, the choice of a view in MOCAP visualizations is crucial to design the pattern. The decision to choose a view will become part of the design criteria, when selecting an appropriate gestural motif to design a gestural pattern in Experiment 15.

7.4 **Experiment 15: Gestural Patterns**

7.4.1 Intention

Following the outcomes of the first phase of experiments 13 & 14, Experiment 15 was designed to facilitate the participants' exploration of gestural performance to generate gestural motifs. The gestural motifs were then designed later as gestural patterns for printed textile design. The participants will explore hand gestures in combination with moving inside the grid, by exchanging positions, moving forward, backward, sideways etc. The method of combining hand gestures with body movements is based on the reflections on Experiment 13 (7.2.3). On the basis of the model of HPS (Fig. 7.1.1), the section describing the process is structured in two subsections such as motif generation and pattern design followed by a section on reflections.

7.4.2 Process

7.4.2.1 Motif Generation: Gestural Motif 1

The participants positioned themselves in the rectangular grid and performed hand gestures such as ‘open’, ‘close’ and ‘fold’ when prompted verbally. The duration of the gestural performance was 30 seconds.

The MOCAP data was visualized and viewed in three ways such as, three-point perspective, top and side view (Fig. 7.4.1).

Each of these views were screen captured and saved in *Portable Network Graphic (PNG)* file format into a specified folder. Based on the reflections in section 7.3.3, the top view is appropriate as a gestural motif as it shows the gestures performed by all six participants in a group.

The MOCAP visualization of the top view was then processed in Adobe Illustrator to extract the motif. The process of motif extraction is similar to six colour tracing method used in Chapter Six (section 6.5.2.1). However, in order to be consistent a change was made such as, the *live trace* tool was defined to trace sixteen colours with colour swatch output option (Fig. 7.4.2).

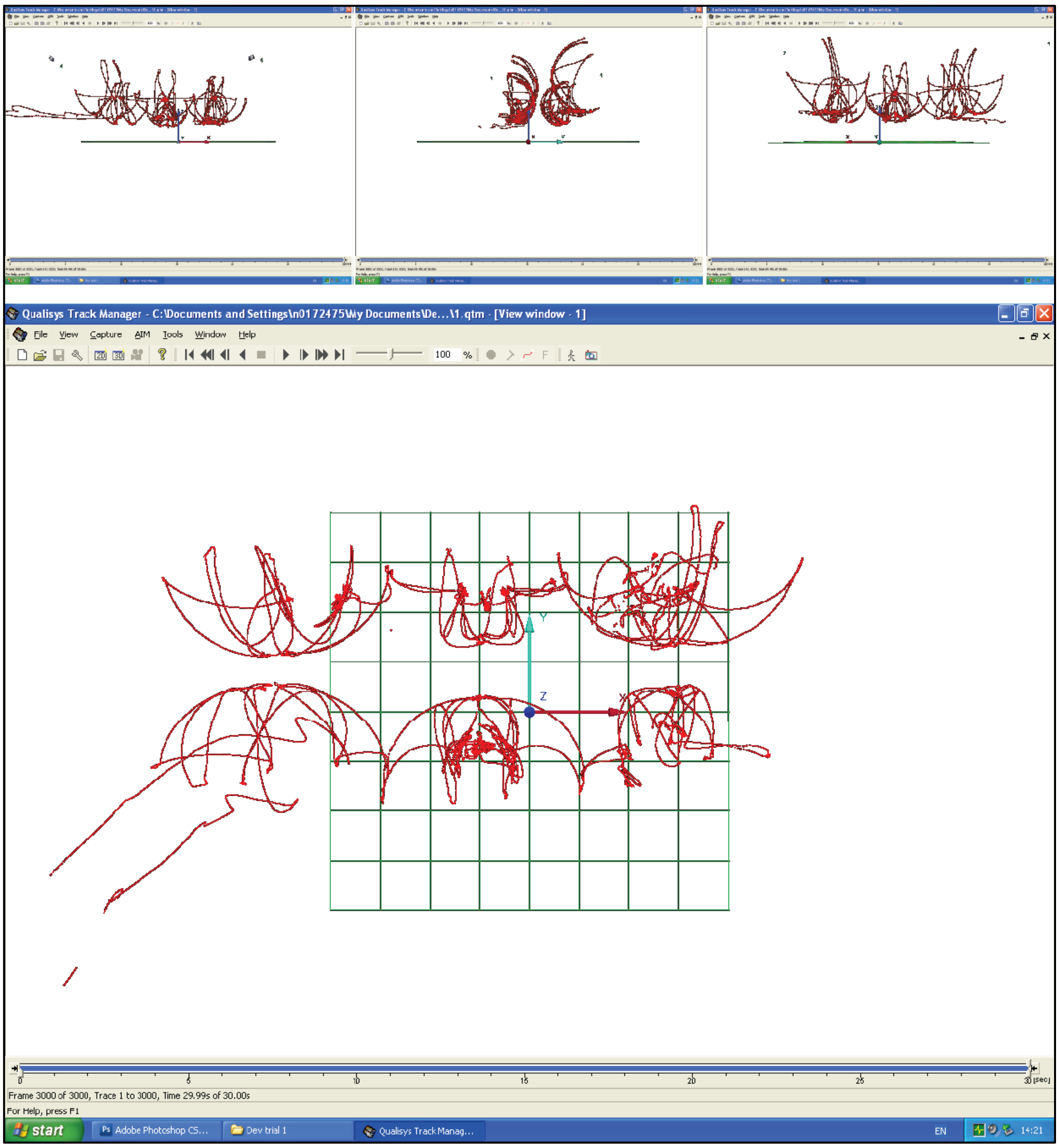

Fig. 7.4.1 MOCAP visualizations of Gestural Motif 1

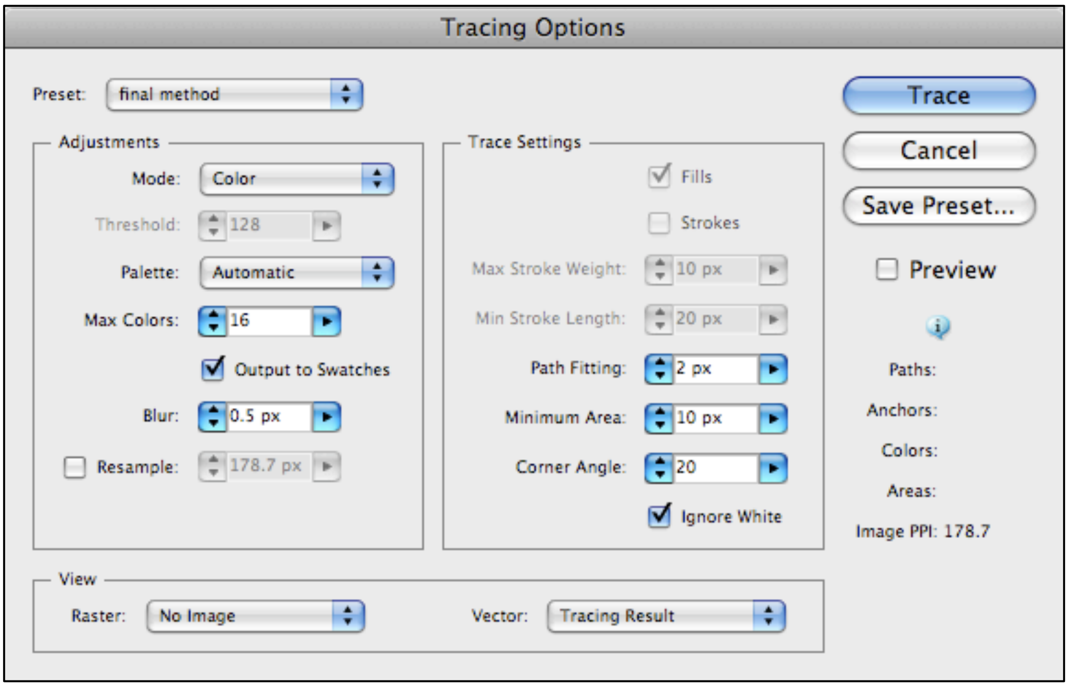

Fig. 7.4.2 Live tracing options

This method provided more accuracy and consistent results in comparison to the six colour tracing method (Fig. 7.4.3.).

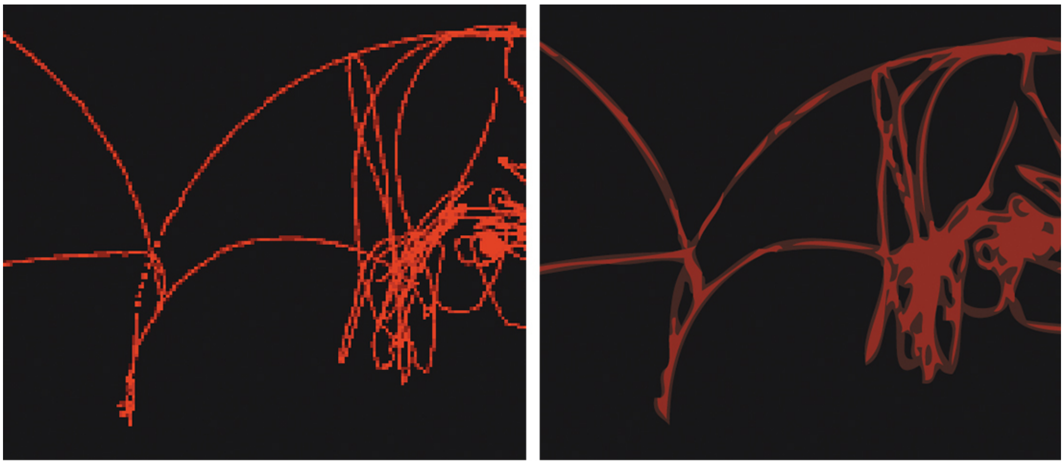

Fig. 7.4.3 Detail of the motif, before and after live trace is applied to create vector paths

Once the motif was traced, the unwanted visual elements such as menu bars, background were removed. The vector paths in the motif were *simplified* and the swatch selection was preserved (Fig. 7.4.5.).

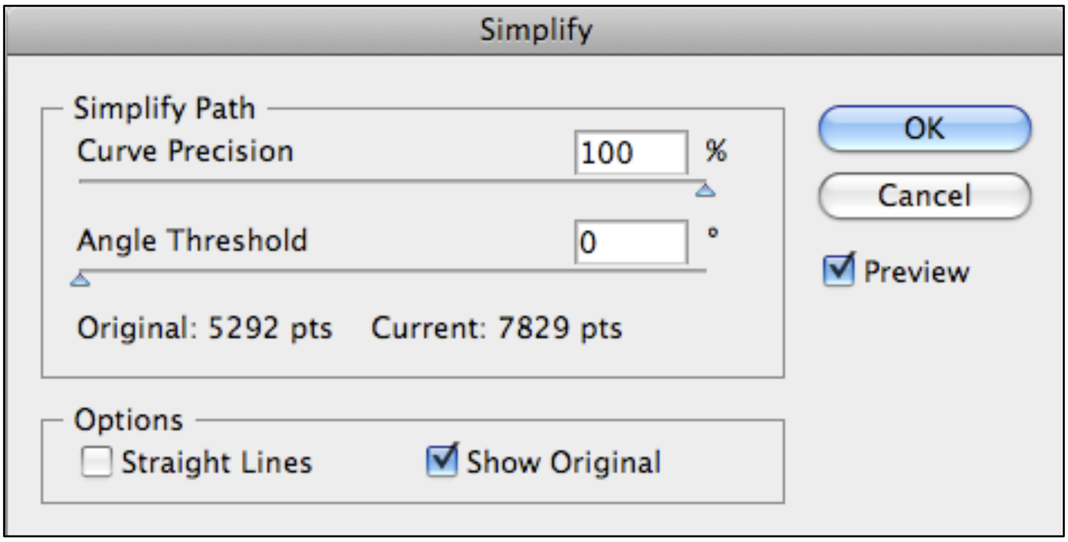

Fig. 7.4.4 Path simplify options

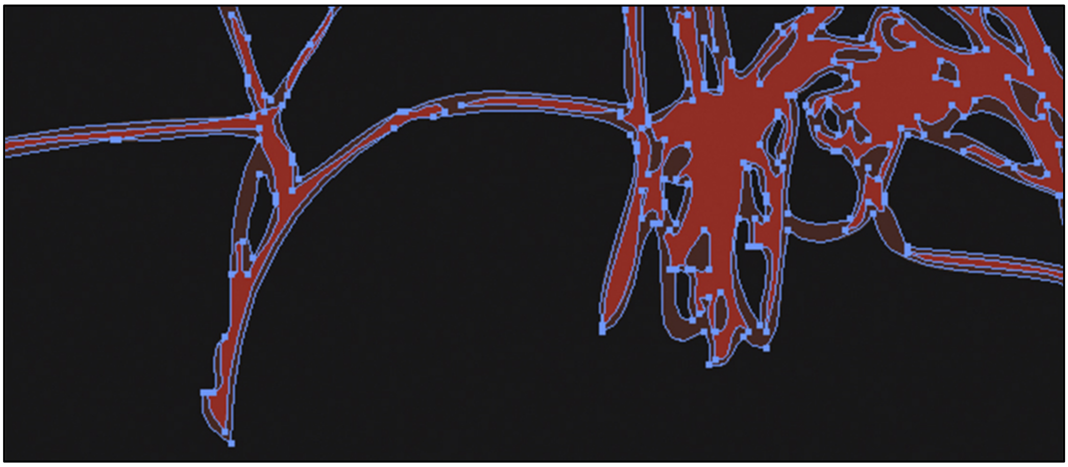

Fig. 7.4.5 Detail of the motif with simplified vector paths

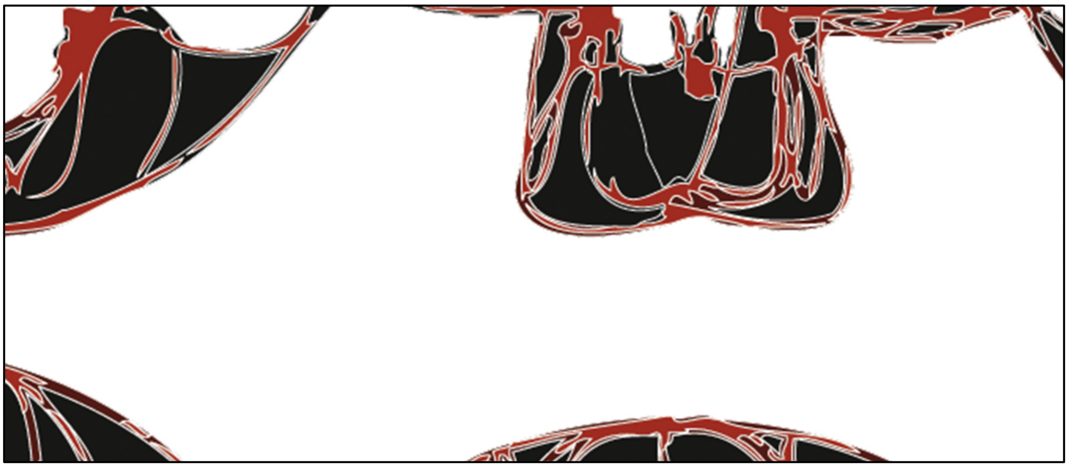

Fig. 7.4.6 Detailed view of the extracted motif

Based on the reflections (section 6.5.3), it was intentional to retain the motif's shape and colour and use them instead of transforming them into a new shape or a 3D form as explored in Chapter Six (Fig. 7.4.5.& Fig. 7.4.6).

To provide clarity in the rest of the sections dealing with motif generation, the process of motif extraction is illustrated as a step-to-step guide.

The steps to extract the motif from MOCAP visualization are:

1. Import the image (PNG file) in Adobe Illustrator.
2. Select the image.
3. Live trace the image with 16-colour preset with output to swatches.
4. Expand the live traced image into vector paths.
5. Simplify the vector paths to reduce the number of vector points while retaining the shape of the vector paths
6. Remove background elements manually.
7. In the swatch window, select all unused colour swatches and delete. The remaining swatches are the preserved colour swatches of the motif. This step is useful to create consistent colourways of the motif.
8. To create a raised effect the vector paths are stroked with white colour. This step is optional (Fig. 7.4.6.).

7.4.2.2 Pattern Design: Gestural Pattern 1

The Gestural Motif 1 is repeated by its horizontal reflection to create Gestural Pattern 1. The Gestural Pattern 1 is designed as an all over print on a black background (Fig. 7.4.7).

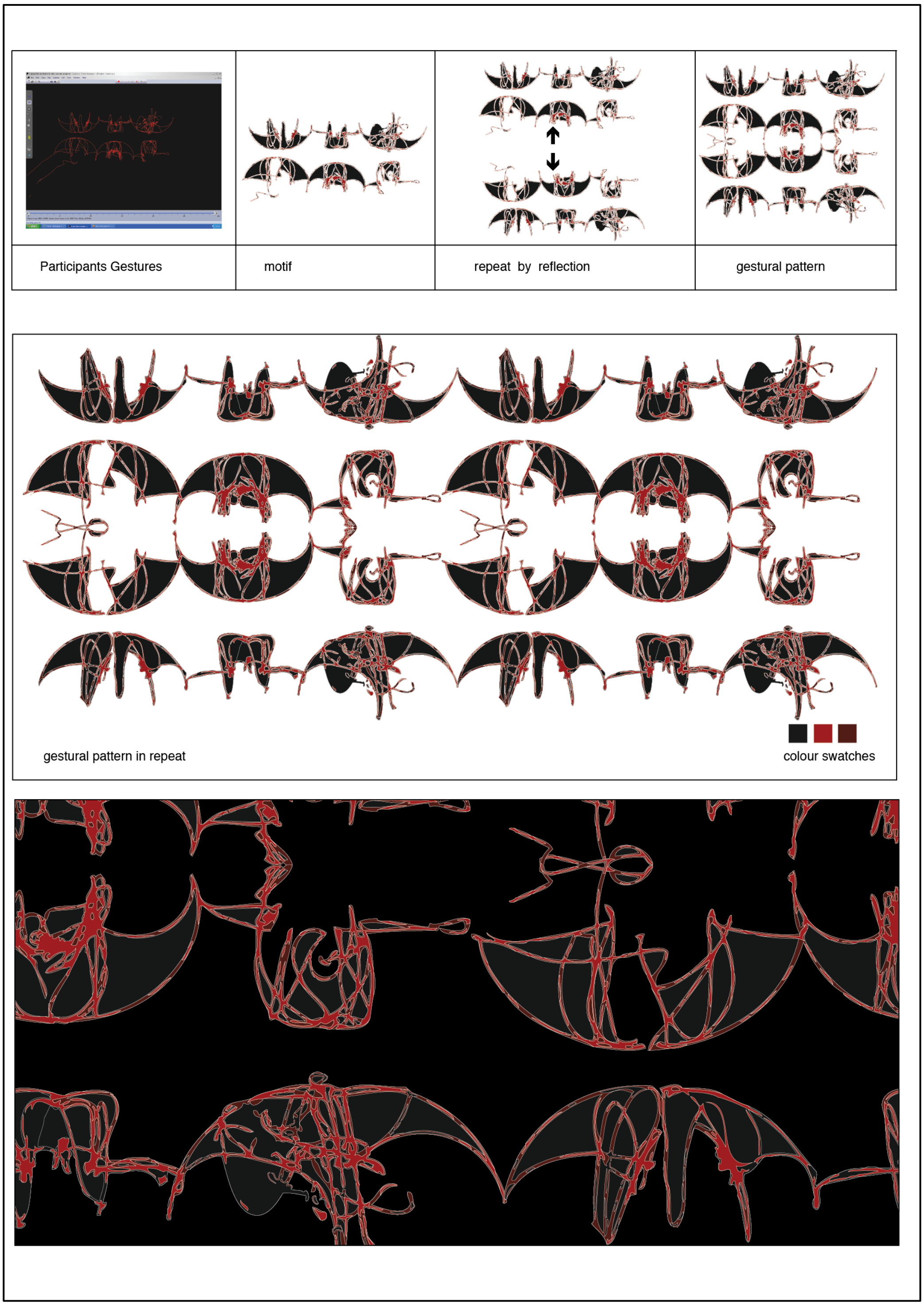

Fig. 7.4.7 Gestural Pattern 1

7.4.2.3 Reflections

The research identifies gestural performance by the group of participants is a new method of creating a motif. The MOCAP visualization of the gestural performance shows a motif composed of semi-circular shapes. In order to be consistent with the method of viewing a motif, the motif was studied in three ways such as three-point perspective, top view and side view. The top view of MOCAP visualization shows a 2D motif representing the coordinated hand gestures of each individual participant in the group. The group consisted of three male and three female students. The female students body dimensions such as, height and width were slighter than the male students. The variation in bodily dimensions of individual participants resulted in the variation of shapes in the motif. This reflects that the participants are required to be regrouped in the grid in next experiment.

The three possibilities of grouping are,

1. M M M / F F F

2. M F M / F M F

3. M M F/ F F M (M= Male & F=Female).

The gestural performance used to generate Gestural Motif 1 was repeated with regrouped participants to find out if it produced any differences.

The motif extraction process was well articulated, described as a step-by-step guide. This provides clarity to the rest of the experimental documentation in this chapter. The Gestural Pattern 1 was designed into by repeating the gestural motif’s horizontal, mirrored reflection. As a result semicircular shapes appear complete and the pattern appears symmetrically balanced. The research found that visually complex shapes, when arranged in a simple repeat created a pattern balanced in both chaos and order.

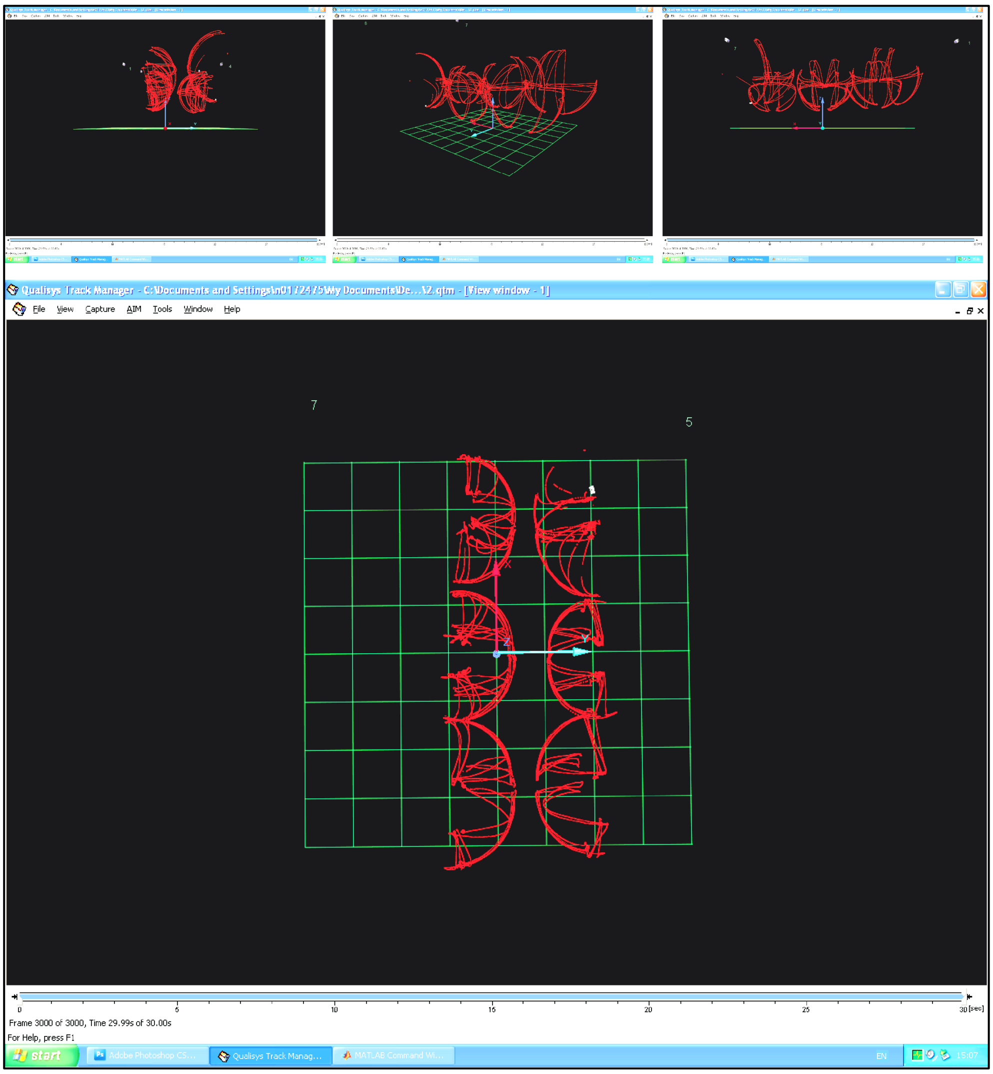

Fig. 7.4.8 MOCAP visualization of Gestural Motif 2 & 3

7.4.2.4 Motif Generation: Gestural Motif 2

Based on the reflection of Gestural Pattern 1, Gestural Motif 2 was created by repeating the gestural performance used for the creation of Gestural Motif 1. The participants were regrouped in the rectangular grid and performed the same set of hand gestures such as ‘open’, ‘close’ and ‘fold’ on verbal prompt. The duration of the gestural performance was 30 seconds. The MOCAP visualization was viewed in three ways such as side view, three-point perspective and top view (Fig. 7.4.8). Similar to the choice of view in Gestural Pattern 1 the top view is chosen to generate a Gestural Motif 2. The chosen view was then processed in Adobe Illustrator to extract the motif using process of motif extraction (section 7.4.2.1).

7.4.2.5 Pattern Design: Gestural Pattern 2

The Gestural Motif 2 was designed into Gestural Pattern 2 by repeating its vertical reflection. Gestural Pattern 2 was designed as an allover print on a black background (Fig. 7.4.9).

Fig. 7.4.9 Gestural Pattern 2

7.4.2.6 Textile Materialisation

Gestural Pattern 2 was printed on a 100% wool based fabric, branded as Tela Fina Wool (Fig. 7.4.10.). This fabric was new to the research (and the university's digital printing lab) so provided a new opportunity to digitally print on a new substrate and test how the print retained the fine detail of the pattern.

Fig. 7.4.10 Gestural Pattern 2 printed on a 100% wool fabric Tela Fina Wool

7.4.2.7 Reflections

Gestural Pattern 2 reflected an improvised gestural performance by the participants. The outcomes of the experiment further reflected that the participants were not only becoming familiarized with the whole process but they were improving their coordination. The motif appeared more well-composed motif than Gestural Motif 1.

Out of the three views of MOCAP visualizations, the three-point perspective view offered a 3D motif, which could be explored further to create a pattern.

The pattern was printed on to a 100% wool based fabric, and due to the fabric's texture and handle combined with the pattern's colourways appears primitive and tribal. The quality of line in the pattern was low as compared to fabrics composed of silk and rayon.

7.4.2.8 Motif Generation: Gestural Motif 3

Based on analysis of Gestural Pattern 2, the three-point perspective view of Gestural Motif 2 was used. The intention was to create a 2D pattern using the 3D motif while retaining its 3D attributes (Fig. 7.4.11). It was found that the 3D motif including the virtual grid could provide a solution. The virtual grid could be tiled to create a pattern.

The chosen view was processed in Adobe Illustrator to extract the motif including the virtual grid by using process of motif extraction (section 7.4.2.1).

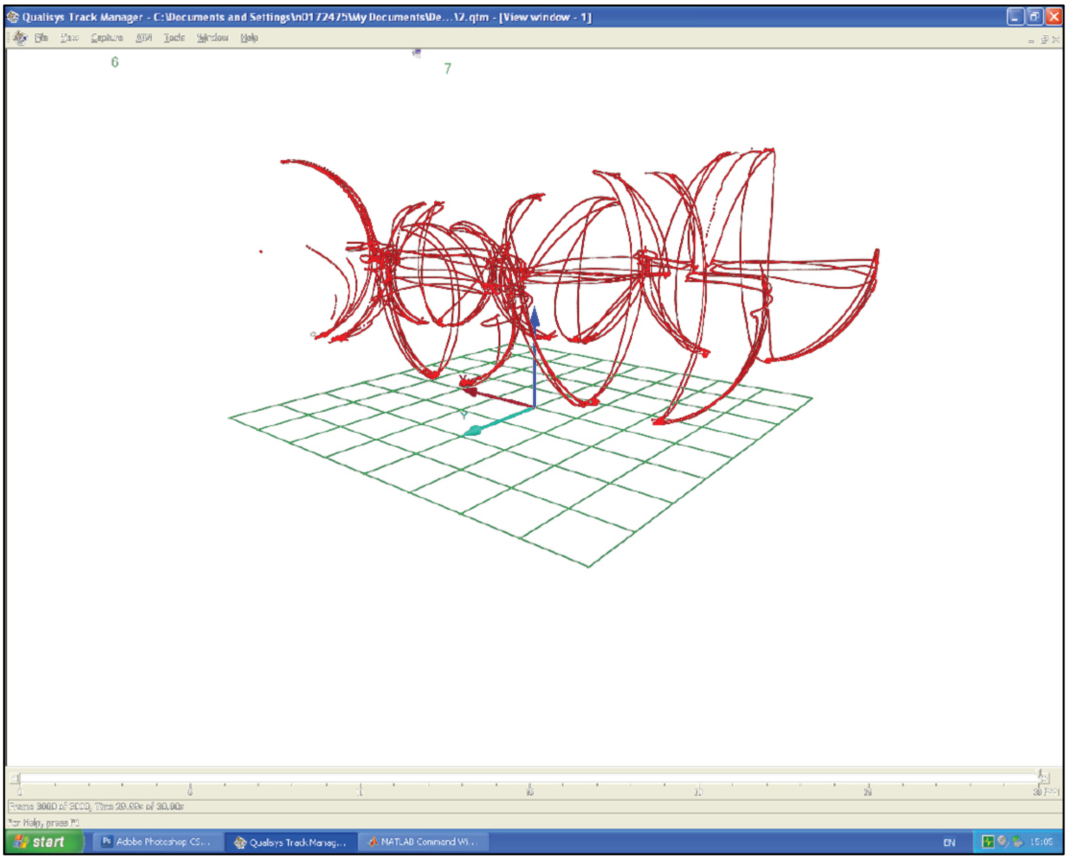

Fig. 7.4.11 Three point perspective view of Gestural Motif 2

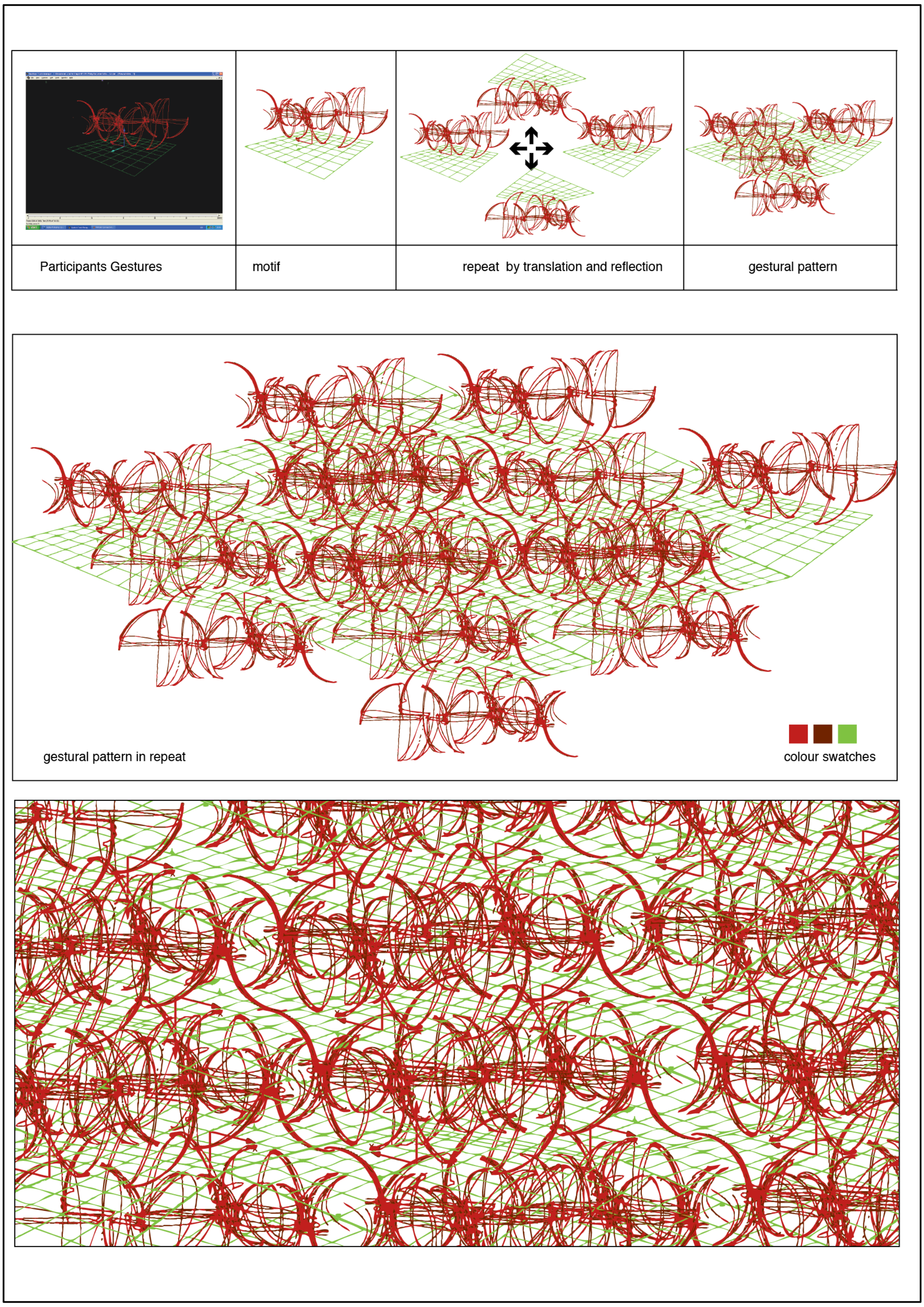

Fig. 7.4.12 Gestural Pattern 3

7.4.2.9 Pattern Design: Gestural Pattern 3

Gestural Motif 3 was designed into a pattern by repeating and mirroring its horizontal and vertical reflection (Fig. 7.4.12). Gestural Pattern 3 was designed as an allover print with a plain background so that the intricate details of the pattern formed by the virtual grid were distinct.

7.4.2.10 Reflections

Gestural Motif 2 in three-point perspective appeared significantly different in terms of its shape and size. The hand gestures such as, 'up' and 'down' contribute to the motifs 3-D shape. With the intention to retain the 3D shape in the pattern, the research found that the virtual grid in the MOCAP visualizations could be used as a reference and basis to create a pattern. By using such method the 3D attributes of the motif could be retained in the resulting pattern. Gestural Pattern 3 appears more geometrically complex than Gestural Pattern 2. This reflects the choice of MOCAP visualization's view and its effects on the resulting gestural pattern. Until now the gestural performances were based on participants standing in a grid. This could be extended to the participants moving in the grid such as, exchange of positions, moving forward and backward, etc.

7.4.2.11 Motif Generation: Gestural Motif 4

To create Gestural Motif 4, the participants were briefed to recollect their experience of drawing a spiral and zigzag in MOCAP in which, their hand gestures combined with body movement created shapes (Section 7.2.3). The participants discussed the use of similar gestures in a gestural performance to generate motif. They discussed and drew diagrams of grids and planned to explore movement within the grid as a group (Fig. 7.4.13). The participants then explored movement in the rectangular grid and found this difficult and unfeasible The participants recommended, a square grid which was constructed to allow free movement. The figure below shows the placement of nine reflective markers on the ground to create a square grid (Fig. 7.4.14). Reflective markers were used, so that the constructed grid appears in the MOCAP visualizations and it is useful in analyzing the motif, and the participants body movements. The participants also suggested a hexagonal grid, could be created as an alternative to both rectangular and square grids.

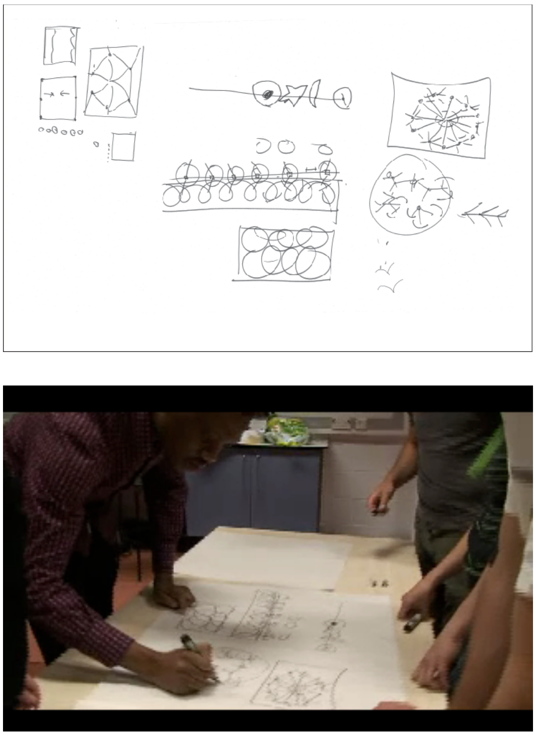

Fig. 7.4.13 Participants engaged in a discussion to create new grids to explore movement

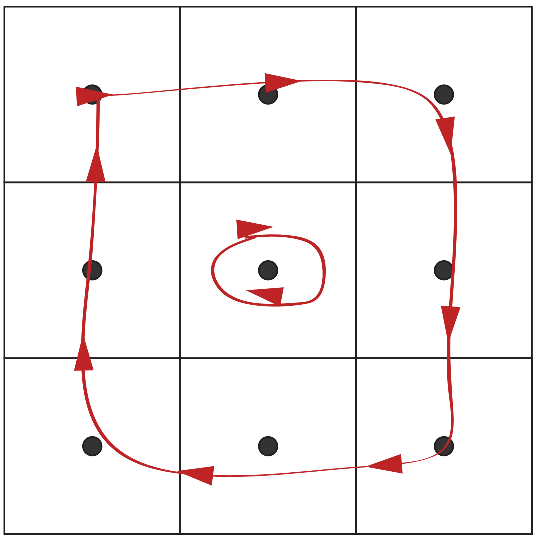

Fig. 7.4.14 Square grid showing participants movement

Using the square grid as a reference, the participants discussed formations for gestural performance. They finalised, to place four participants on the corners with one participant in the center. The participants placed in the corners exchanged positions with each other while, the participant in the center performed, remaining in the same position. In this formation, they made gestures representing ‘zigzag’ lines. The duration of the gestural performance was 60 seconds. The Fig. 7.4.14 shows the participants movement in the grid. The MOCAP visualization of the gestural performance is a composition of shapes (Fig. 7.4.15). In which, the hand gestures made by the participant in the center position resembled a floral shape. The participant in the center made hand gestures representing zigzag lines while turning clockwise resulted in the floral shape.

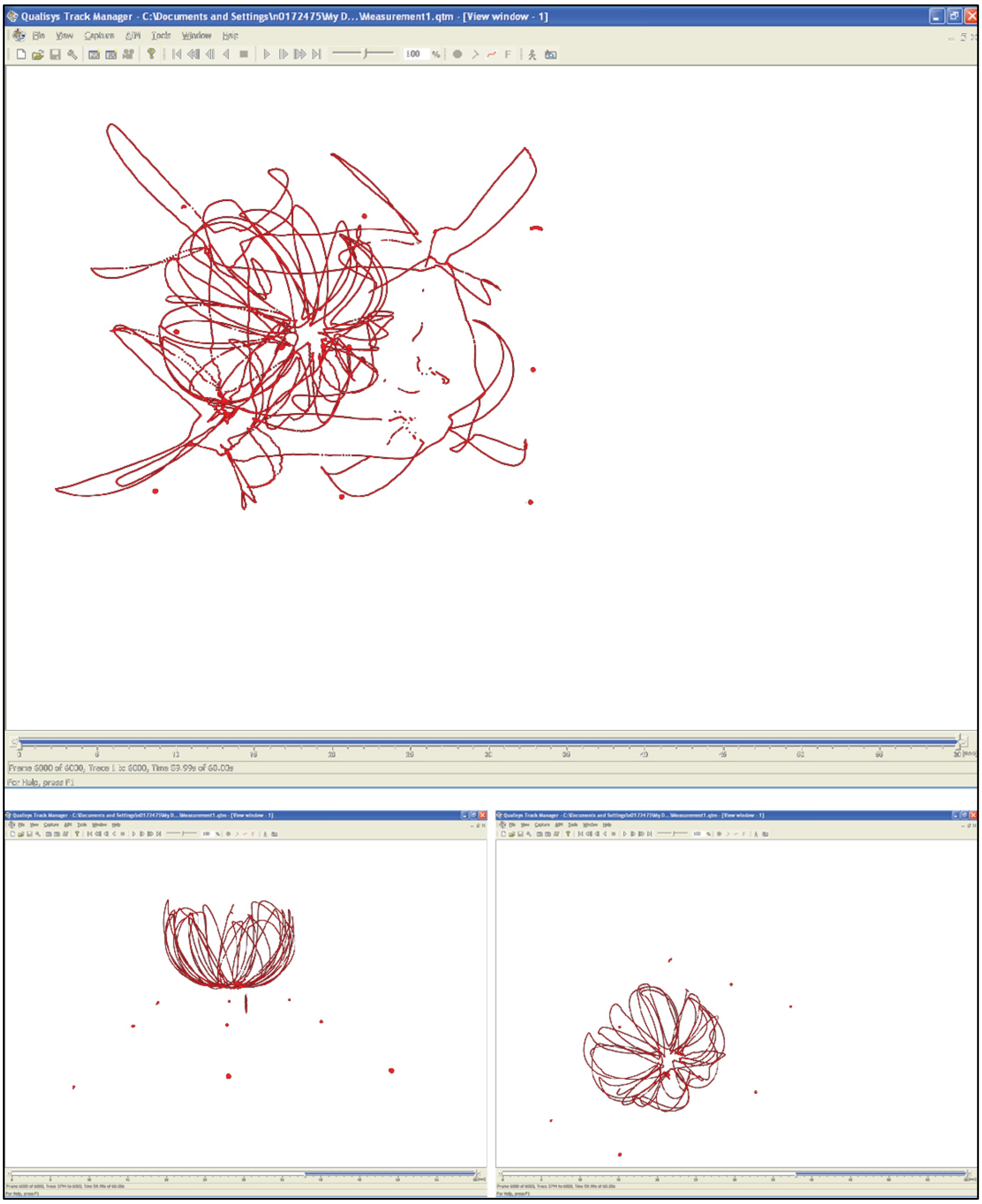

Fig. 7.4.15 MOCAP visualization of Gestural Motif 4

The participants exchanged their positions by creating lines and incomplete motifs in the corners. Therefore it was decided to visualize the floral motif separately, by altering the timeframe of the MOCAP visualization. The resulting motif was viewed in three ways such as, side view, three-point perspective and top view. Of which, the top view was then processed in Adobe Illustrator to extract the motif using process of motif extraction (section 7.4.2.1).

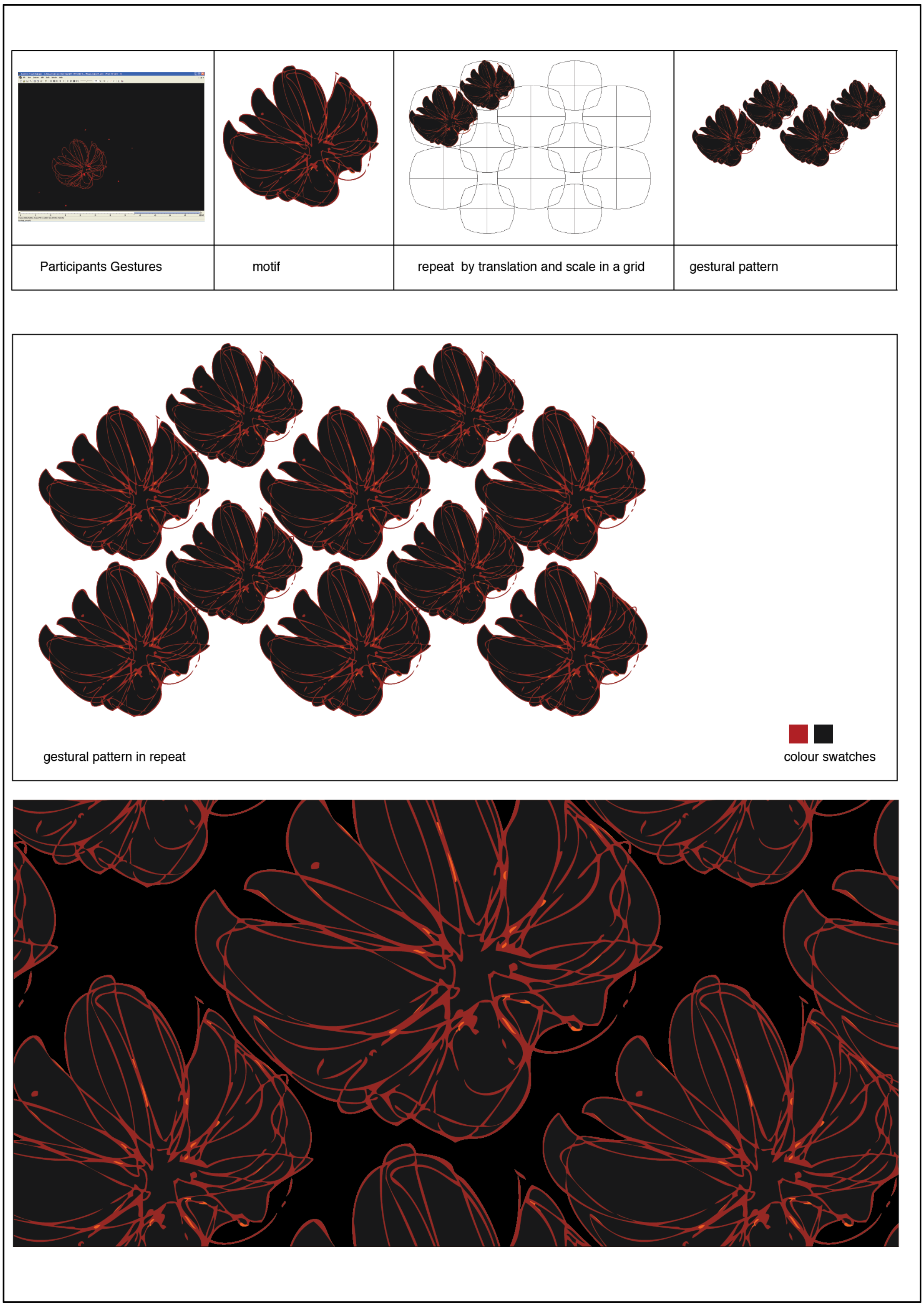

Fig. 7.4.16 Gestural Pattern 4

7.4.2.12 Pattern Design: Gestural Pattern 4

Gestural Motif 4 was designed into a pattern by scaled translation and repeated in a half-drop grid (Fig. 7.4.16). Gestural Pattern 4 was designed as an all over print with an optional coloured background.

7.4.2.13 Textile Materialisation

Following the printed outcomes in (7.4.2.6) the Gestural Pattern 4 was printed in three different colourways onto three separate fabrics; 100% wool fabric Tela Fina Wool, 100% Bamboo and 100% Silk Habotai to see the effect of base fabric on the quality of line (Fig. 7.4.17).

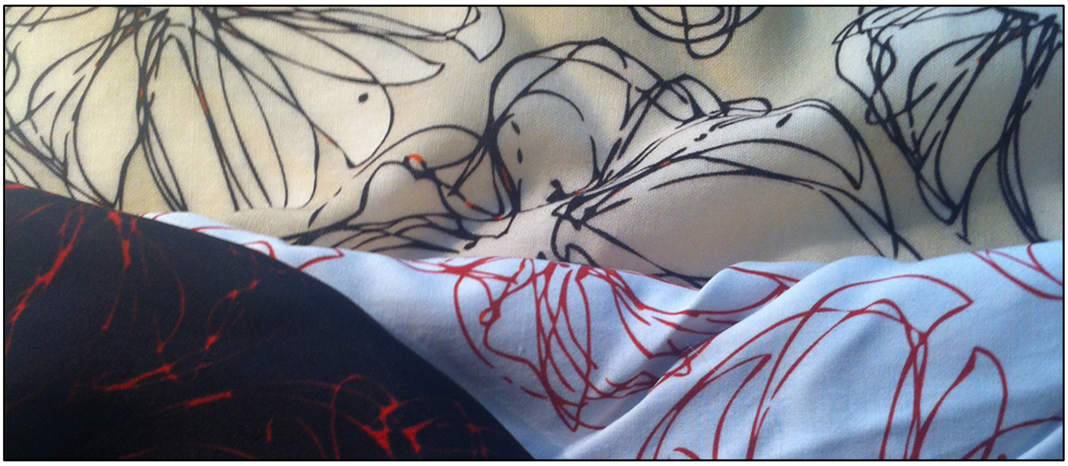

Fig. 7.4.17 Gestural Pattern 4 printed on three fabrics such as 100% wool fabric Tela Fina Wool, 100% Bamboo and 100% Silk Habotai

7.4.2.14 Reflections

Combining body movement with hand gestures generated Gestural Motif 4. The resulting motif resembled a floral shape. The research found this method of generating a motif was an alternative way of drawing a shaped object. The hand drawn objects by FRONT Design (Fig. 2.7.3) illustrated drawing an object in 3D space, their intention was to draw an object whereas, the main intention of the participant performing Gestural Motif 4, was to make hand gesture.

A discussion amongst the participants followed and the collaborative drawing of diagrams showed the integrity in the group's social activity. The activity in this experiment was the movement plan they had to create. The act of creating a formation is closely linked to the process of composing a pattern design. In printed textile design, a textile designer creates a formation of design elements such as hand drawn motifs, images and therefore creates a composition.

The participant's suggestions of constructing a square and hexagonal grid showed their spatial thinking during the discussion. The hexagonal grid was be explored further in the forthcoming experiments. This method of creating the pattern is also similar to making a structure in textiles such as lace, knitting, weaving etc. Final printed outcomes show that certain colour combinations such as black and orange when printed on a lighter base such as 100% silk Habotai appear blurred. However, when the same design is printed in alternative colourways on 100% wool fabric Tela Fina Wool and 100% Bamboo, the quality of the line appeared more distinct and crisp.

7.4.2.15 Motif Generation: Gestural Pattern 5

The outcome of gestural performance to generate Gestural Motif 4, suggested exploring solo gestural performances by participants. The intention was to see if a solo performance could create motifs as compared to group performance. The participant was briefed to create a movement plan within the grid in which a participant will move and make hand gestures such as 'open' and 'close' at regular intervals (Fig. 7.4.18).

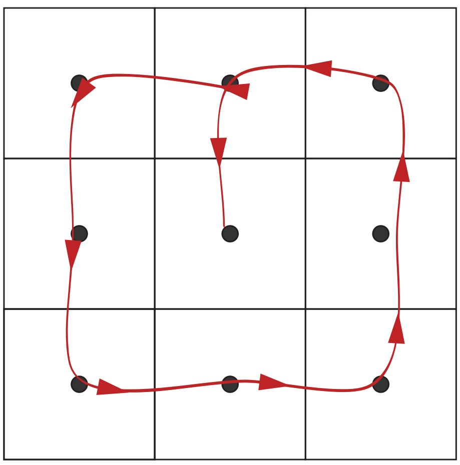

Fig. 7.4.18 Diagram showing the participant's movement in square grid

The MOCAP visualization of the gestural performance was viewed in two ways such as top and side view. The top view resembled a motif in which hand gestures such 'open' and 'close' create triangular shapes. The triangular shapes were connected by lines showing mark the participant's movement in the grid. The orientations of the triangular shapes with connecting lines in the motif show the animated movement of the participant in the grid (Fig. 7.4.19).

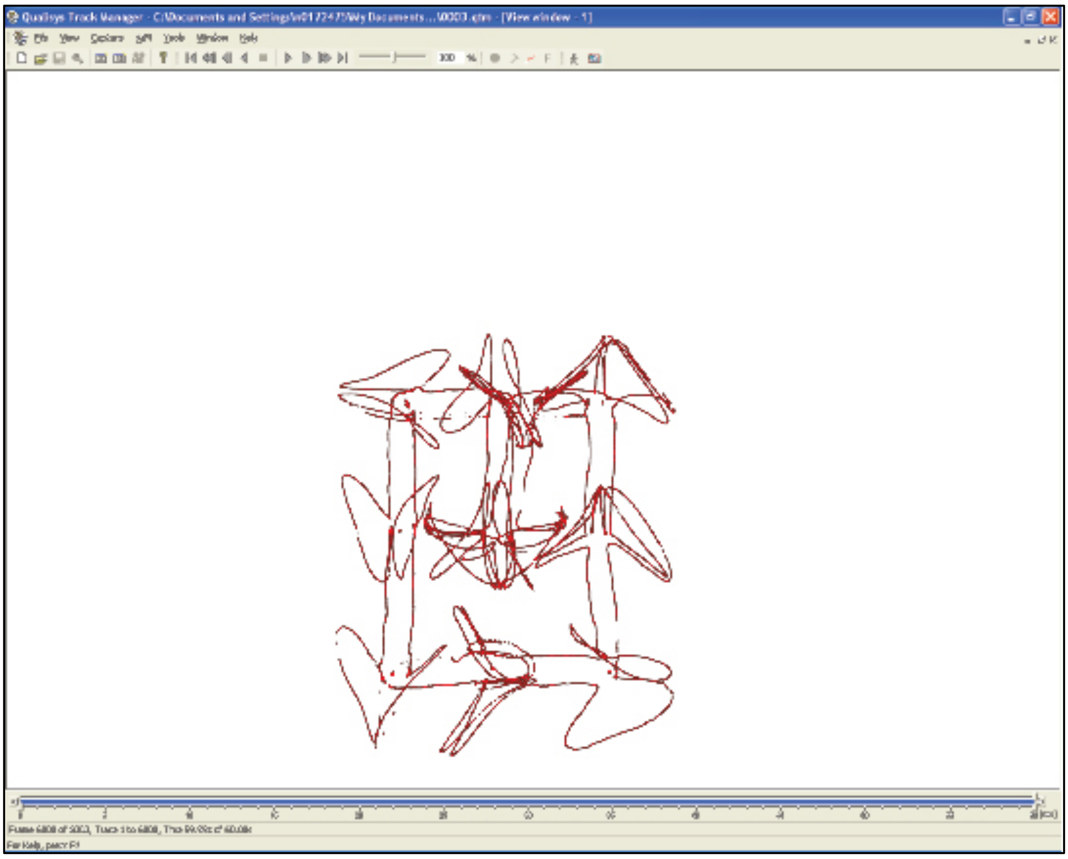

Fig. 7.4.19 MOCAP visualization of Gestural Pattern 5

7.4.2.16 Pattern Design: Gestural Pattern 5

The top view was then processed in Adobe Illustrator to extract the motif using process of motif extraction (section 7.4.2.1). Gestural Pattern 5 was designed to be a placement print with both coloured and plain backgrounds as options (Fig. 7.4.20).

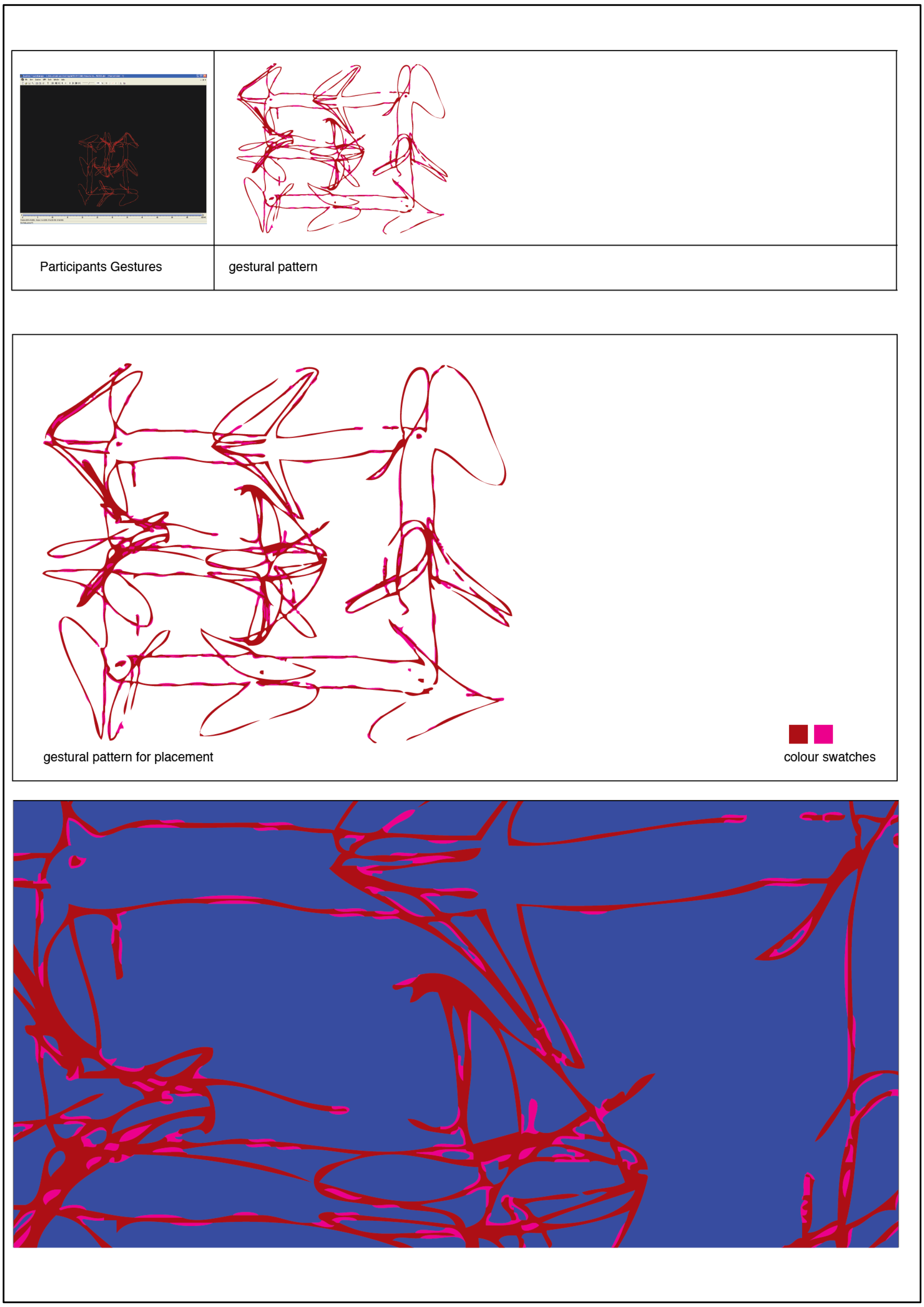

Fig. 7.4.20 Gestural Pattern 5

7.4.2.17 Textile Materialisation

Fig. 7.4.21 Gestural Pattern 5 printed on 100% wool fabric Tela Fina Wool

Gestural Pattern 5 was printed on a 100% wool based fabric, Tela Fina Wool (Fig. 7.4.21).

7.4.2.18 Reflections

The solo gestural performance of a participant combining hand gestures with movement resulted in a motif created a motif that was composed of triangular shapes and straight lines. The motif could be designed further into a pattern by placing it in a repeat. However, it was considered to use it as a placement motif, so that the individual participant's gestural performance was highlighted. The top view of the MOCAP visualization provided the complete gestural performance including the animated movement of the participants in the grid whereas the side view showed circular shapes corresponding to the hand movement in making the gesture.

7.4.2.19 Motif Generation: Gestural Pattern 6

Following the MOCAP visualization of Gestural Pattern 5, which showed the participant's movement in the grid combined with hand gestures to create a motif. This outcome was then followed by a similar gestural performance to create a motif.

The participants were briefed to create a solo performance, to explore movement within the grid while making hand gestures to represent 'curved' lines. The participants came up with a movement plan in which, the participant would move following the marked points in a grid while making hand gestures.

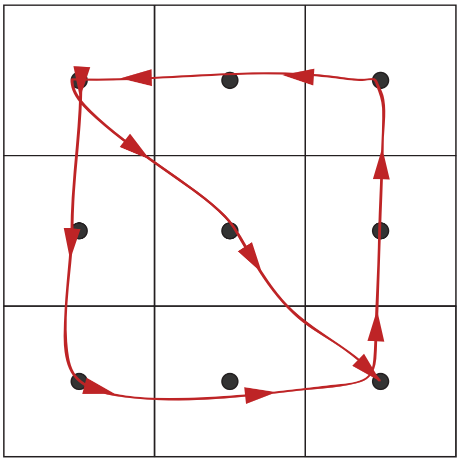

Fig. 7.4.22 Diagram showing the participant's movement plan in the grid

The intention of the movement plan was to cover all the points in the grid in a single path as an alternative way to the path covered in Gestural Motif 5 (Fig. 7.4.22).

The MOCAP visualization of the gestural performance was viewed in three ways such as three-point perspective, top and side view. Of these, the three-point perspective view resembled a diamond shaped motif (Fig. 7.4.23).

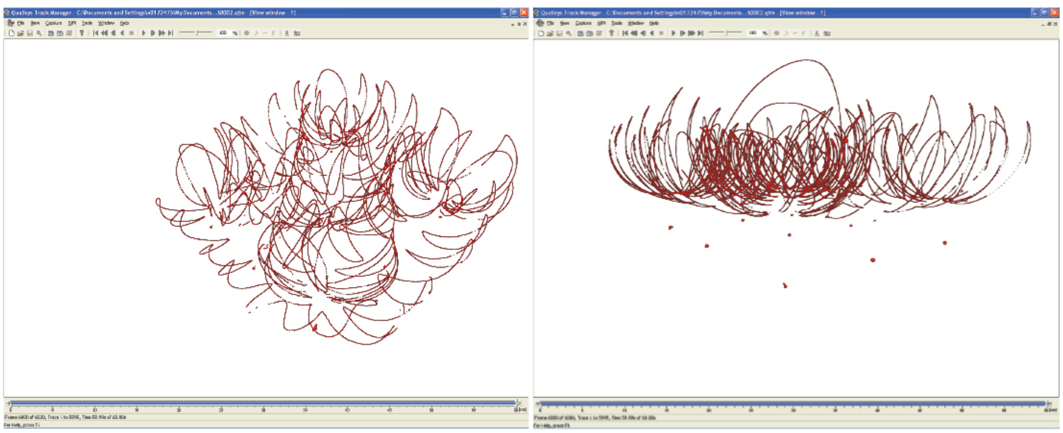

Fig. 7.4.23 Gestural Motif 6

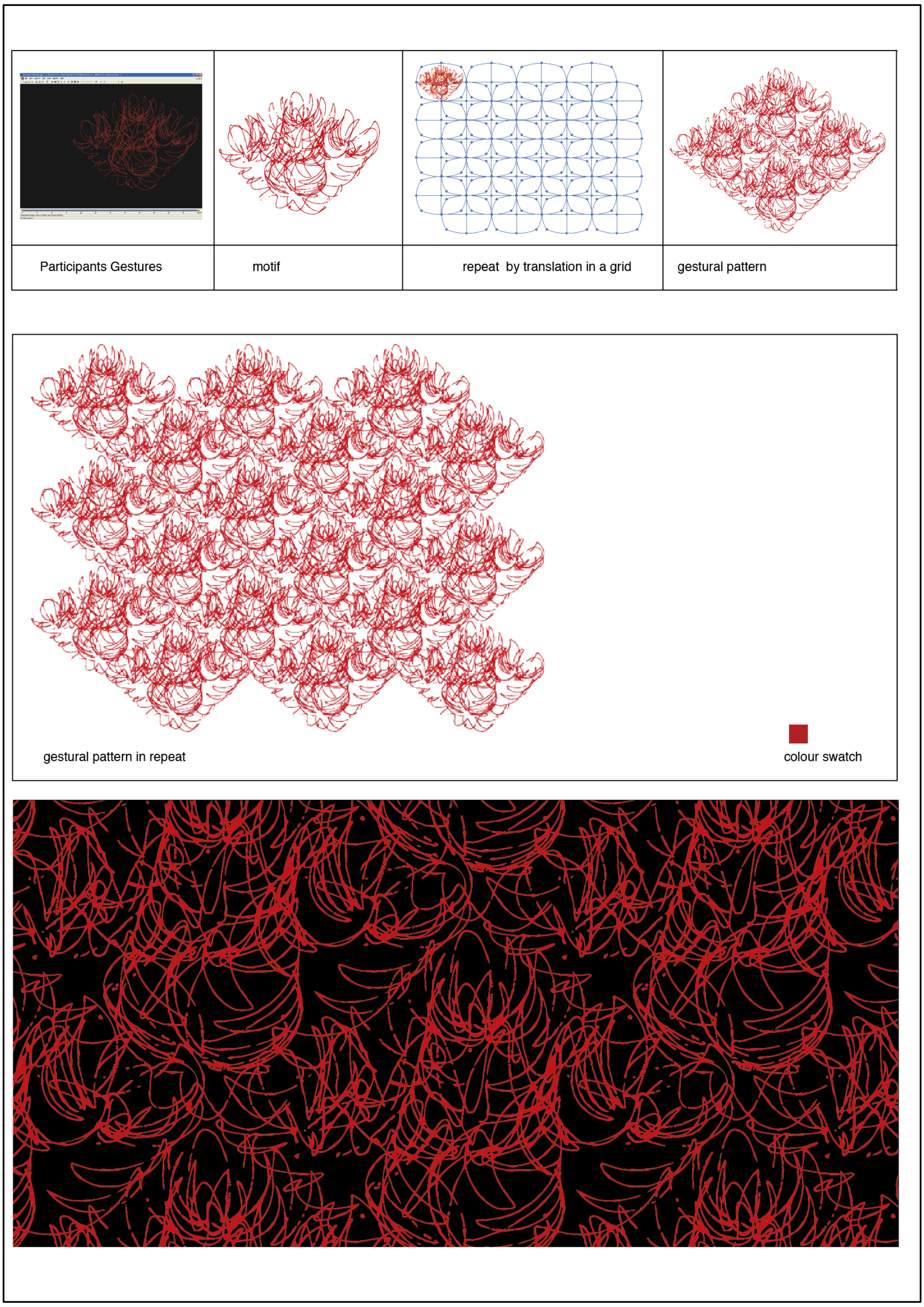

Fig. 7.4.24 Gestural Pattern 6

Although the three-point perspective view appeared complex and textural in comparison to the side view, the diamond shape provided the basis for repetition.

Therefore, this view was processed in Adobe Illustrator to extract the motif using the process of motif extraction (section 7.4.2.1).

7.4.2.20 Pattern Design: Gestural Pattern 6

The textural composition and the diamond shape of Gestural Motif 6 suggested that it could be designed as a pattern by repeating its translation in a grid. Gestural Pattern 6 was designed as an all over print on a plain and coloured background (Fig. 7.4.24).

7.4.2.21 Textile Materialisation

Gestural Pattern 6 was printed on 100% Silk Chiffon Mouseline (Fig. 7.4.25).

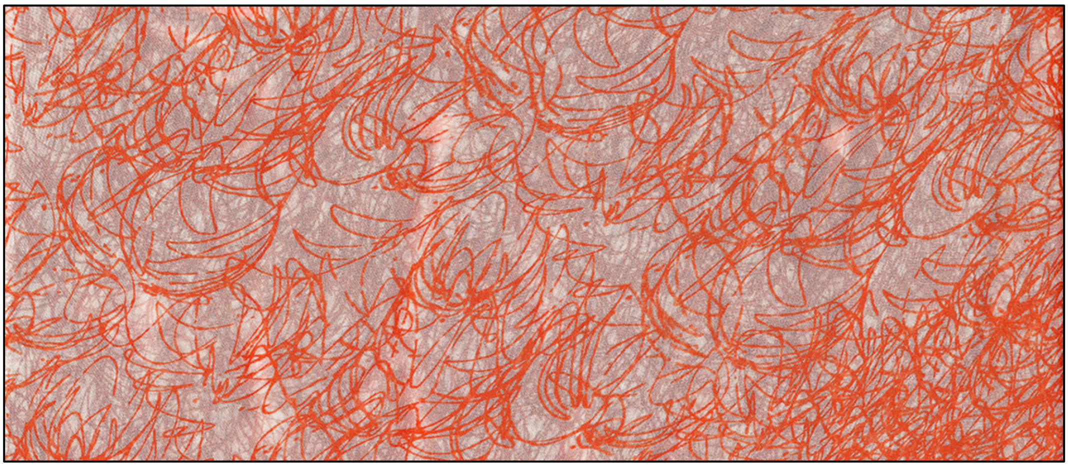

Fig. 7.4.25 Gestural Pattern 6 printed on 100% Silk Chiffon Mouseline

7.4.2.22 Reflections

By following the previous method used in Gestural Pattern 5, a similar gestural performance was devised to create Gestural Pattern 6. The participant had to move following the marked points in the grid in a single path, while making hand gestures representing 'curved' lines. The gestural performance resulted in a diamond shaped texture-filled motif. In the previous pattern it was decided that the motif generated by a solo gestural performance should be used as placement motif, which in this case was iterated on the basis of the motif's appearance. This reflects that the shape of the motif can inform the pattern's repeat structure. Gestural Pattern 6 suggests that a solo gestural performance can create a motif, which could be either designed as a placement design or repeated to form an allover pattern.

The research found that, on the basis of three Gestural Patterns 4,5 and 6 that HPS is not dependent on the number of participants but requires a variety of gestural contributions from the participants, to create interesting and dynamic surface patterns.

7.4.2.23 Motif Generation: Gestural Pattern 7

Through reflection and discussions about the process, the participants suggested creating a hexagonal grid as an alternative to both the rectangular, and square grids (Fig. 7.4.13). Following their suggestion a hexagonal grid was constructed by participants standing in a circular form at equal distance from each other (Fig. 7.4.26).

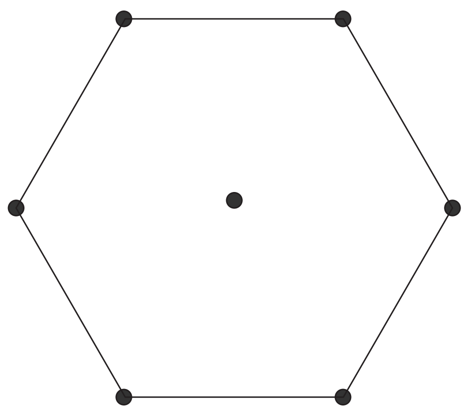

Fig. 7.4.26 Hexagonal grid

Once the hexagonal grid was formed, the participants explored a few gestural performances such as ‘zigzag’ and ‘curved’ lines combined with body movements to inform the resulting MOCAP visualizations (Fig. 7.4.27).

The MOCAP visualizations showed that gestural performance in a hexagonal grid generates alternative motifs. The participants performed simple hand gestures such as ‘turn around’ on verbal prompt. The duration of the gestural performance was 5 seconds. The MOCAP visualization of the gestural performance shows a motif composed of six circular shapes, each corresponding to the individual participant's gesture.

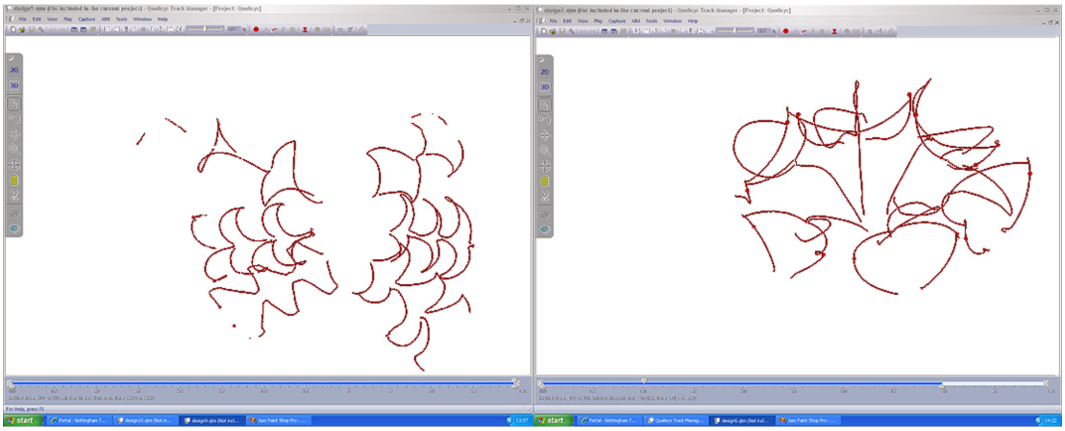

Fig. 7.4.27 Explorations of gestures in a hexagonal grid

Both the top view and the three-point perspective view of the motif were processed to create Gestural Motif 7 and its variation (

Fig. 7.4.28). The top view represents a 2D motif and the three-point perspective view represents its 3D variation. In order to construct gestural patterns of both motifs, the virtual grid in the MOCAP visualization is included. The intention is to study the effects on a pattern designed by tiling a 2D motif and its 3D variation.

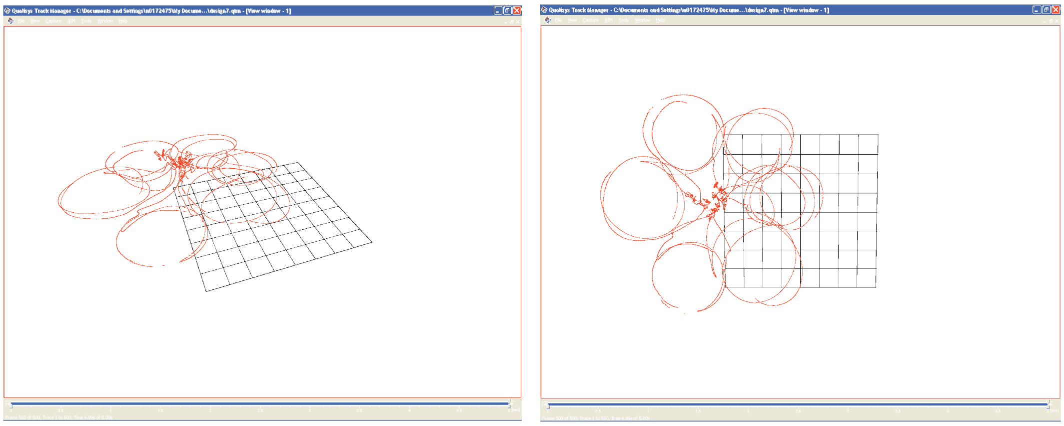

Fig. 7.4.28 MOCAP visualization of Gestural Motif 7

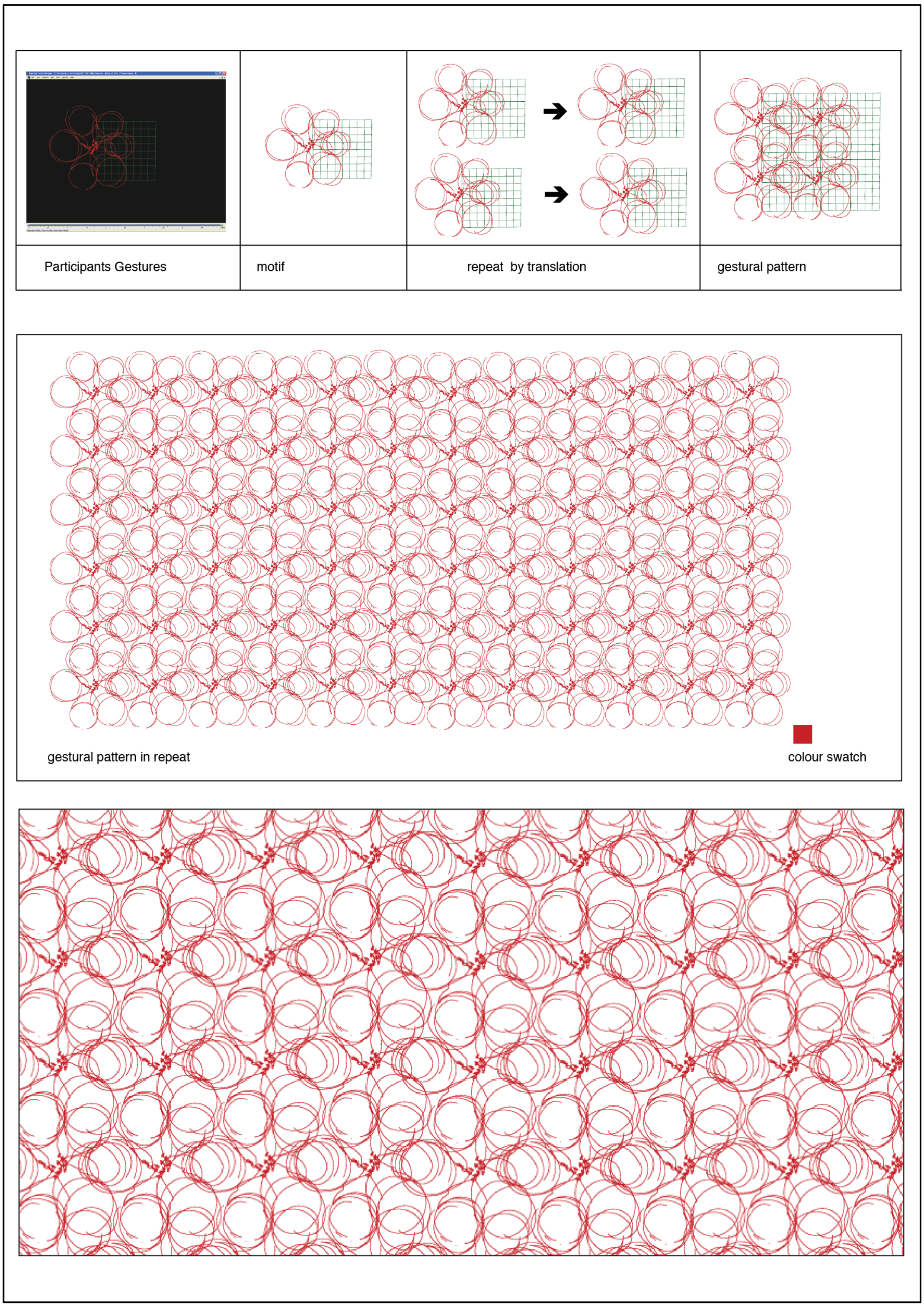

Fig. 7.4.29 Gestural Pattern 7

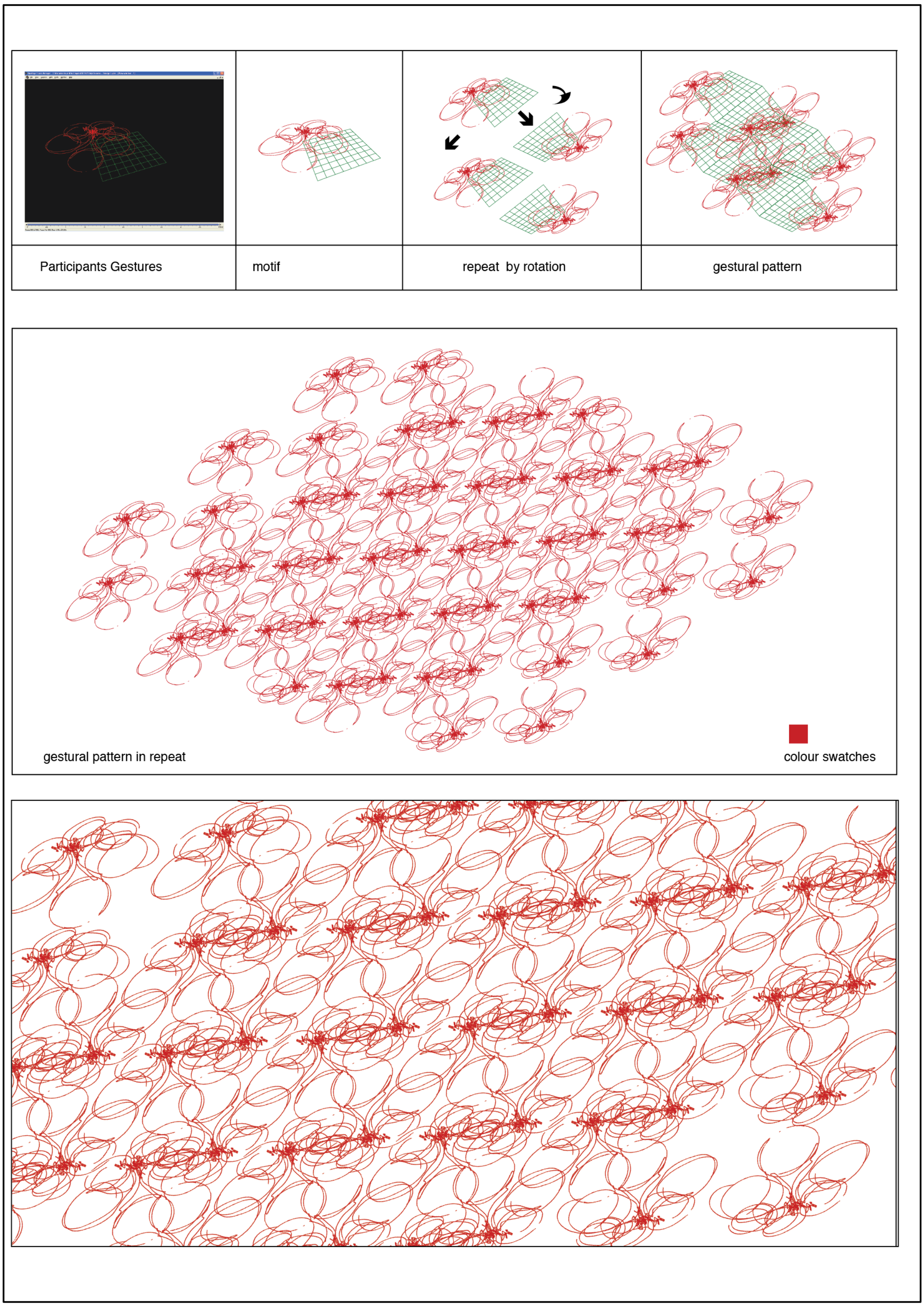

Fig. 7.4.30 Variation of Gestural Pattern 7

7.4.2.24 Pattern Design: Gestural Pattern 7

The MOCAP visualization representing the top view of the motif was then processed in Adobe Illustrator to extract the motif using process of motif extraction (section 7.4.2.1). Gestural Motif 7 is designed into a pattern by tiling the virtual grid. After the pattern is designed, the virtual grid is removed from the pattern's background. Gestural Pattern 7 was designed as an all over print on a plain ground (Fig. 7.4.29).

7.4.2.25 Pattern Design: Variation of Gestural Pattern 7

The MOCAP visualization representing the three-point perspective of the motif was then processed in Adobe Illustrator to extract Gestural Motif 7's variation using process of motif extraction (section 7.4.2.1). Gestural Motif 7's variation was designed into a pattern by tiling the virtual grid. After the pattern was designed, the virtual grid was removed from the pattern's background. Gestural Pattern 7's variation was designed as an allover print on a plain ground (Fig. 7.4.30).

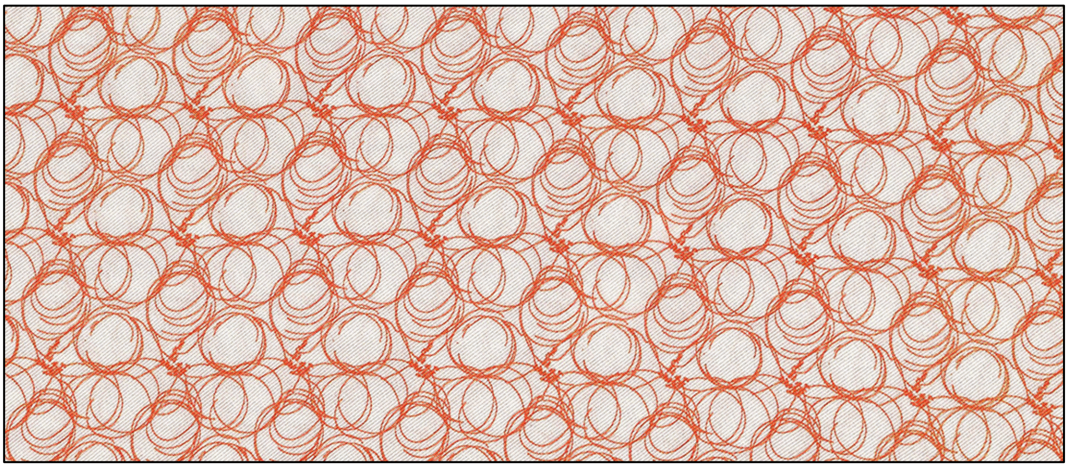

Fig. 7.4.31 Gestural Pattern 7 printed on a 100% Silk Twill

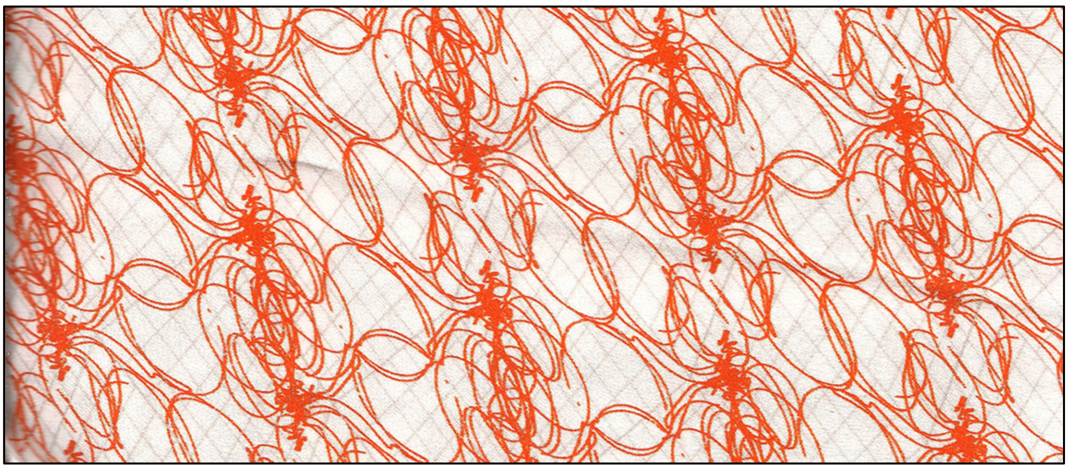

Fig. 7.4.32 Variation of Gestural Pattern 7 printed on a 100% Silk Satin

7.4.2.26 Textile Materialisation

Gestural Pattern 7 and the variation were printed on 100% Silk Twill (Fig. 7.4.31) and 100% Silk Satin respectively (Fig. 7.4.32).

7.4.2.27 Reflections

The construction of the hexagonal grid, followed by a gestural performance in the grid by participants showed a new way of creating a Gestural Motif. The participants explored different gestural performances in a hexagonal grid to create a variety of motifs (Fig. 7.4.27).However, due to the lack of coordination in the gestural performances, the motifs appeared incomplete. Therefore, the participants chose to perform a simple hand gesture to create a circular motif. The gestural performance was similar to the one performed in Experiment 14, except the grid formation was changed from rectangular to hexagonal.

In the MOCAP visualizations, both 2D and the 3D variations of the motif occurred on the edge of the virtual grid rather than in the center. Therefore, the tiling of the virtual grid results in the overlapping of motifs within the pattern. Due to the overlap, Gestural Pattern 7 appears dense whereas its variation using the 3D motif appears scattered. After the patterns were designed, the virtual grid was removed from the background in order to simplify the patterns appearance.

7.4.2.28 Motif generation: Gestural Motif 8

So far in the experiments, the participant's gestural performance in various grids such as rectangular, square and hexagonal have been explored. Similarly, group and solo gestural performances have resulted in generating a variety of gestural motifs. The participants at this stage seemed to be confident to perform hand gestures compared to in the earlier stages of the experiments. Therefore, in the following gestural performance, the participants were briefed to stand in a back-to-back position in the rectangular grid.

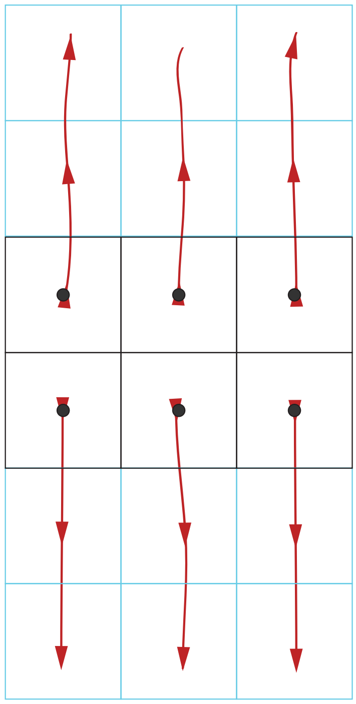

Fig. 7.4.33 Movement plan for the participants to extend the rectangular grid

The intention to place the participants back-to-back was because in such a placement they could move forward in opposite directions, extending the rectangular grid (Fig. 7.4.33). The participants were verbally prompted by random words, such as; ‘wide’, ‘open’, ‘move’, ‘up’, ‘close’ and ‘down’. The intention of using this method to generate a motif was to find out the effect of random words and their associated gestures could be combined with body movements in the grid.

When prompted they made hand gestures related to the prompt word and moved one-step forward in the grid. The duration of the gestural performance was 40 seconds.

The MOCAP visualization of the gestural performance was viewed in three ways such as, side view, three-point perspective and top view (Fig. 7.4.34). The top view was then processed in Adobe Illustrator to extract the motif using process of motif extraction (section 7.4.2.1).

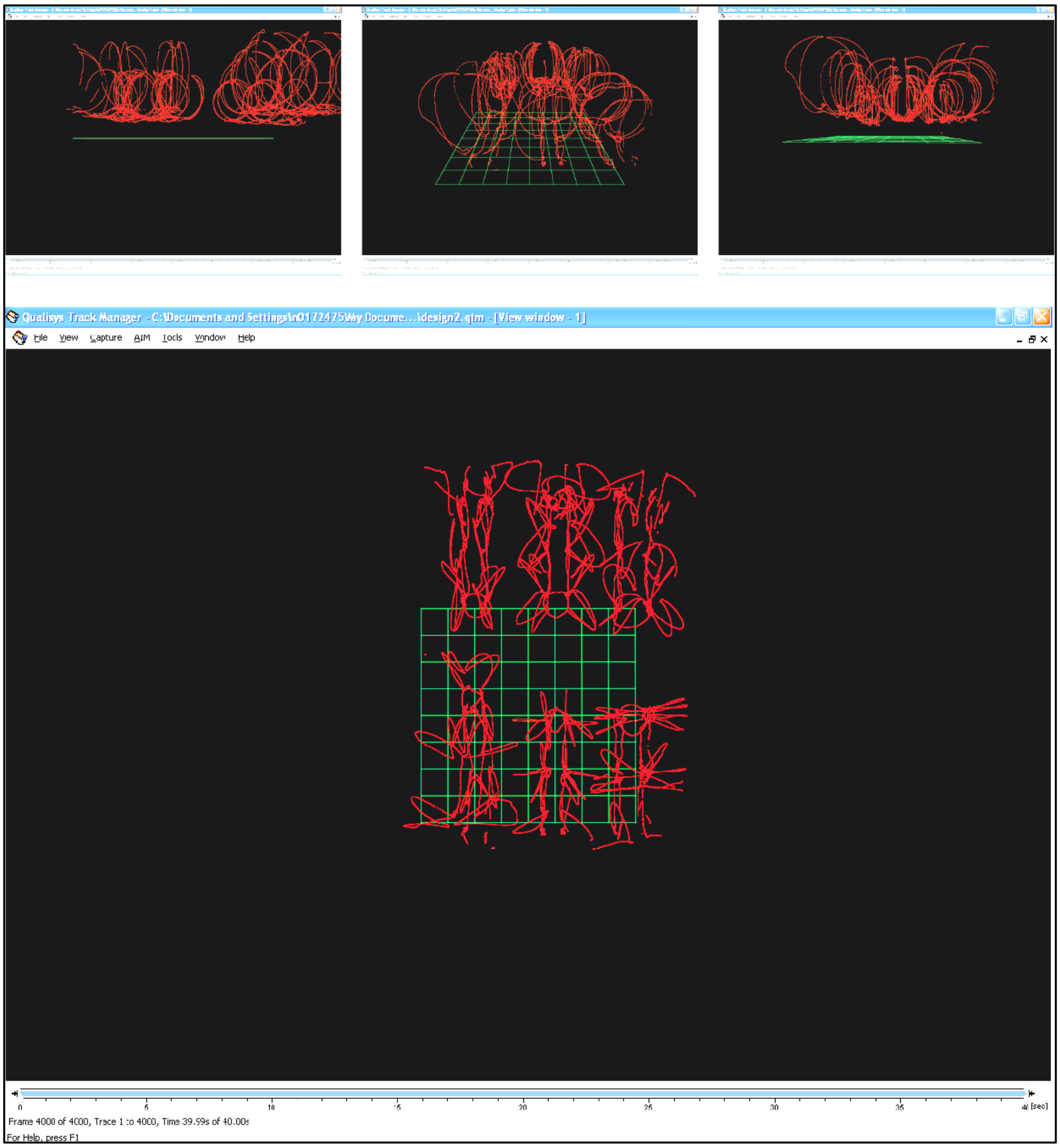

Fig. 7.4.34 MOCAP visualization of Gestural Motif 8

7.4.2.29 Pattern Design: Gestural Pattern 8

The Gestural Motif 8 is designed into a pattern by repeating its translation. The Gestural Pattern 8 is designed as an all over print with a coloured or plain background (Fig. 7.4.35).

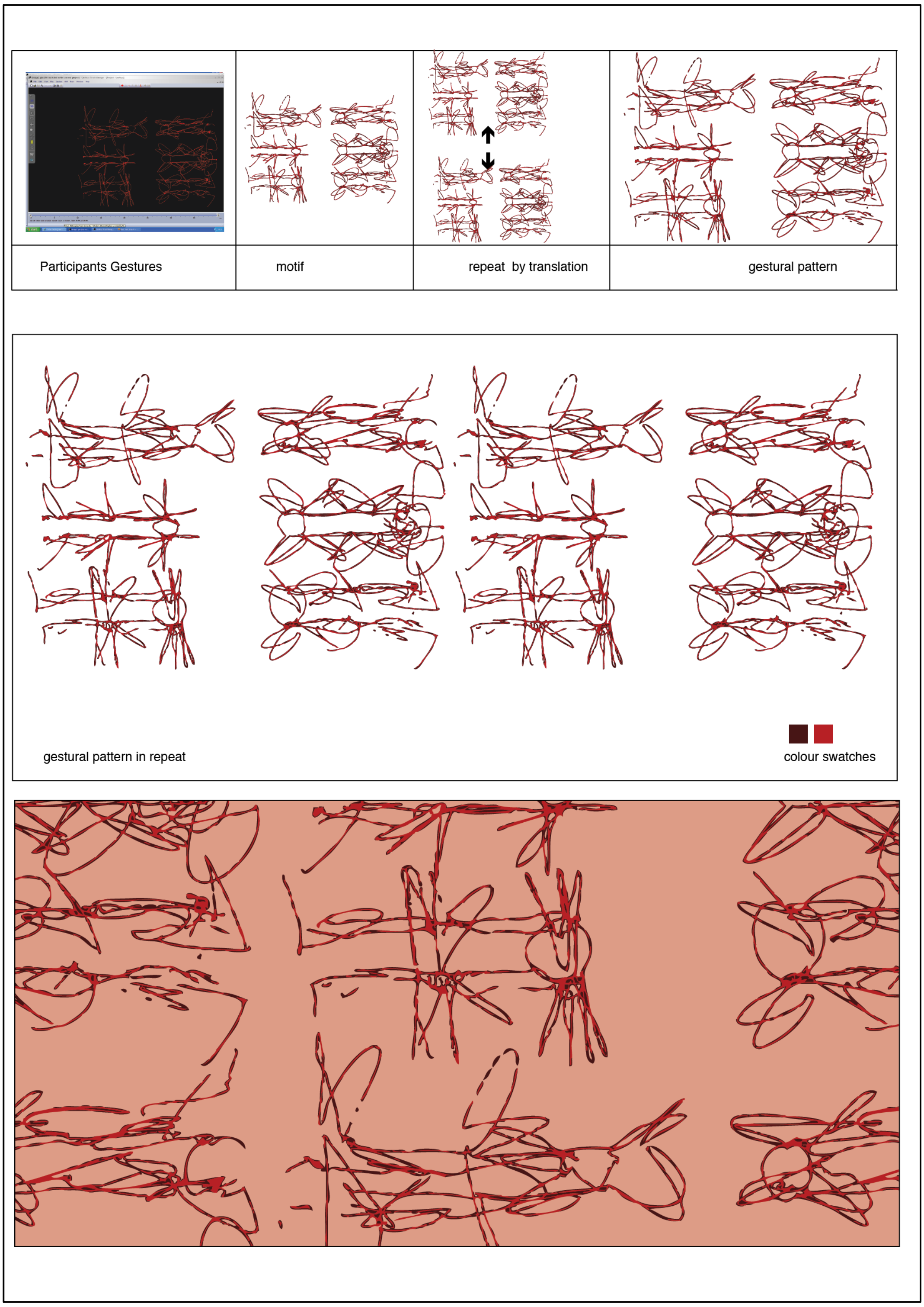

Fig. 7.4.35 Gestural Pattern 8

7.4.2.30 Reflections

The use of random words as verbal prompts was intended to see if after performing in at least 6 to 7 gestural performances the participants had become acquainted to a word and its related gesture. It was found that, individual participants had their own gestural interpretation of a word, resulting in the variation of shapes in the motif. The variation is particularly escalated in the top view, whereas the actual rhythmic hand movements can be seen in the side and three-point perspective views. The motif is composed of hand drawn scribbled shapes, each shape drawn by an individual participant in the group.

The movement plan to create Gestural Motif 8 reflects the possibility of transforming the rectangular grid into two square grids. This plan allowed the participants to move at least two steps ahead, as compared to the other plans described earlier in the experiment. They could move a few more steps ahead in a similar way, but the area covered by the MOCAP cameras is limited. Therefore, it was not explored further. However, this idea could be reformulated to combine separate performances into one, as is explored in the next gestural pattern.

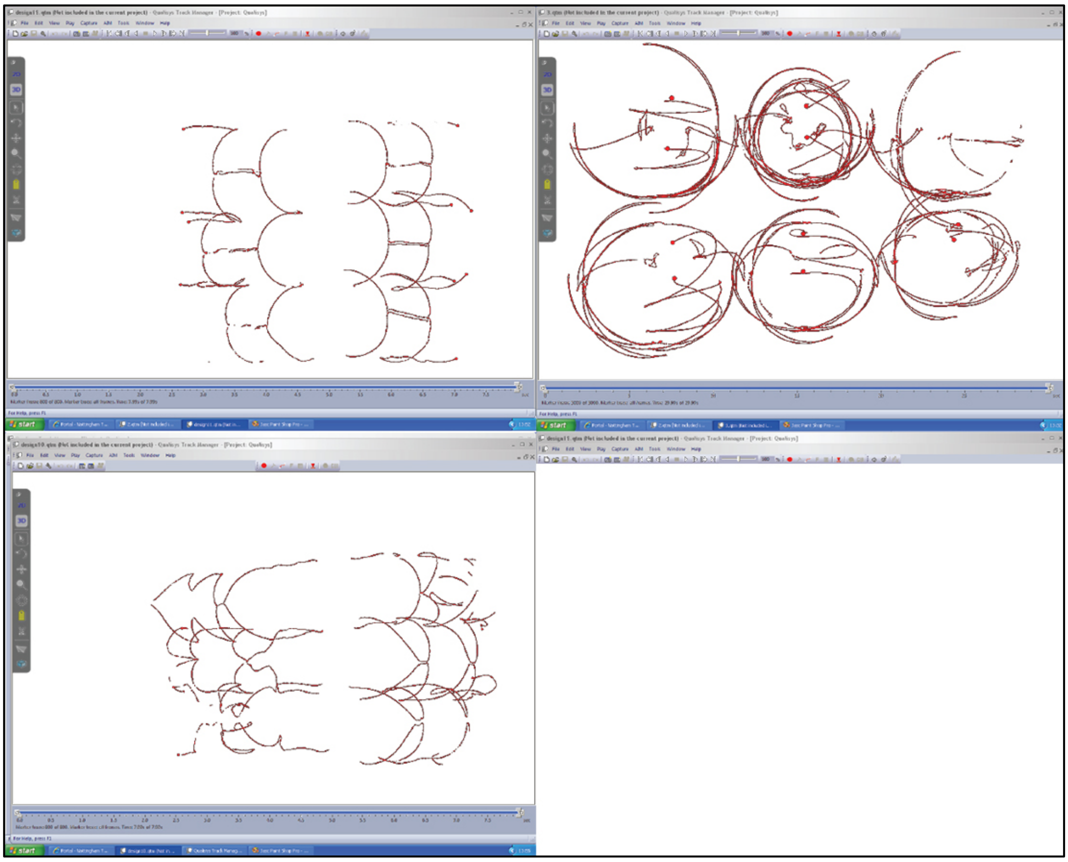

Fig. 7.4.36 MOCAP visualization of Gestural Motif 9

7.4.2.31 Motif Generation: Gestural Pattern 9

Based on the reflections of the method to create Gestural Pattern 8, MOCAP visualizations of three separate gestural performances are selected from Experiments 14 and15 to create Gestural Pattern 9. The intention was to use separate gestural performances to find out if the resulting motifs could be composed into a single motif. The gestural performances of participants in a rectangular grid were selected on the basis of their anticipated outcomes as motifs (Fig. 7.4.36).

1. The participant's hand gestures such as 'up, 'down' and 'turn around', created a motif of circular shapes. This could form the central element of the motif.

2. The participant's hand gestures such as 'open' and 'close' combined with moving forward and backward created semi-circular, open-ended motif. This motif could form the outer case in which the central elements are placed.

3. The participant's hand gesture such as 'zigzag' combined with moving forward and backward creates a motif of open-ended arcs and curves. This motif could also form the outer case in which the central elements are placed.

The top views of the selected MOCAP visualizations were then processed in Adobe Illustrator to extract the motif using process of motif extraction (section 7.4.2.1).

7.4.2.32 Pattern Design: Gestural Pattern 9

The three separate gestural motifs were then composed to create a single motif, which could be either used as a placement motif or repeated as an allover pattern (Fig. 7.4.37).

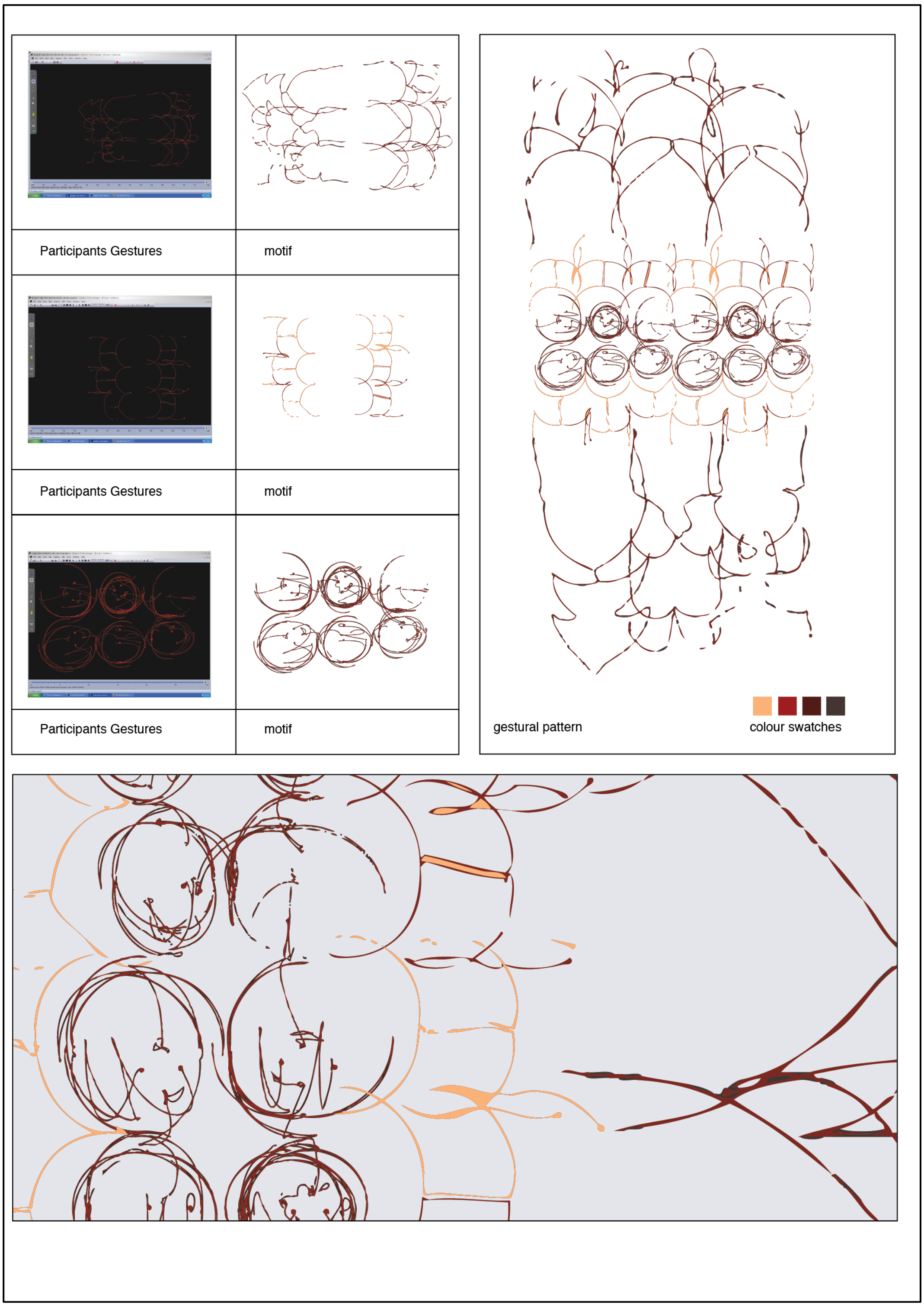

Fig. 7.4.37 Gestural Pattern 9

7.4.2.33 Textile Materialisation

Gestural Pattern 9 was printed on 100% silk habotai (Fig. 7.4.38)

Fig. 7.4.38 Gestural Pattern 9 printed on 100% Silk Habotai

7.4.2.34 Reflections

The intention to use separate gestural performances resulted in a new method of designing gestural patterns. Gestural Pattern 9 reflects that the group of participant's gestural performance can be composed prior to the design of a pattern. As compared to Gestural Patterns 1-8 in which the gestural motifs dictated the pattern design process.

The choice of the motif and the order of the motif in the pattern reflect the decisions made by the designer. The circular shapes where more complete and recognizable, and therefore formed the central focal element, followed by border-like details and motifs.

The method of creating Gestural Pattern 9 projects that in future, gestural performances and their resulting motifs could be stored in a form of database. The database could be used to create variety of gestural patterns based on different permutations and combinations of gestural motifs.

7.5 Evaluation of the Hybrid Print System

Similar to the evaluation of all the practical research methods, the HPS is evaluated using two main criteria: practical and aesthetic issues.

Practical issue: HPS is a successful system. By using the HPS, the research has identified answers to the main research questions, how to use MOCAP to create printed textile designs. HPS has demonstrated in Experiment 15 (section 7.4) that gestural performance by a group of participants generates gestural motifs, which can then be then designed into gestural patterns. Both the generation of the motif and the pattern design meet the constraints of digitally printed textile design.

HPS is user friendly. The group of participants had only a few sessions to become familiarized with the process of gestural performance and motif generation. It was fairly easy for them to grasp the whole concept. This was demonstrated in the group activities, in which the participants discussed, how to and what to perform keeping in mind the use of the gestural motif. They performed gestural performances in both solo and group contexts. The participants found the gestural performances invigorating, in which the body performs rhythmic hand gestures combined with body movements.

HPS is efficient meaning the cost of equipment and costs of production of the printed textile are comparable. It could be argued in general that the cost of the MOCAP equipment, rent of studio space and digital inkjet printer together is too high in comparison with the cost of equipment used is too high in comparison to any other traditional method of creating printed textile design. However, this research is not concerned with this issue as all the facilities were found and accessed within the university. But, this issue could be dealt in future research work.

HPS provided a tangible solution of creating patterns from participant's hand gestures, which is logical, useful, systematic and moreover repeatable.

HPS is reliable meaning; it will produce consistent results over time through following the practical steps as they are documented in procedures.

Aesthetic issue: Using this criterion the HPS is evaluated in terms of new and coherent results. In this case they are the set of generated gestural motifs, designed gestural patterns and printed textile designs.

HPS facilitates a new concept in which, participants perform rhythmic hand gestures combined with body movement to generate a gestural motif. This is identified as innovative, breaking new ground, and is seminal; the concept of gestural pattern provides the foundation for further developments.

HPS is coherent meaning the hand gestures of the participants and the resulting patterns are well related. Each kind of hand gesture produces a particular shape. The quality of the gestural motif is clear, and gestural pattern reiterates the idea of 'hand crafting.'

7.5.1 Emergent properties of the HPS

The emergent properties of the HPS and its outcomes are identified as:

The HPS realizes the importance of the hand's role in the generation of handmade and handcrafted motifs.

The HPS recognizes the participant's gestural contribution as a method of motif generation.

The HPS bridges the gap between digital and analogue, through creating concepts that promote 'humanizing technology', 'social activity' and 'performativity'.

The HPS allows a degree of freedom for participants in the design process by introducing the concept of 'active participation' as a deciding factor for 'progression' in design.

The HPS subverts the current, traditional mode of textile design by reversing the roles of the textile designer and the consumer.

Within the HPS the role of the textile designer transcends to a new level of expertise such as choreographer, scriptwriter and art-director.

The HPS introduces new concepts of gestural performance, symbolic activities and notational representation.

7.5.2 Emergent properties of a hybrid print

The emergent properties of a hybrid print are identified as:

- A hybrid print is created through the integration of traditional methods and digital tools.

- A hybrid print reflects the use of both traditional method and digital tools.
- A hybrid print is a 'handmade' print developed through digital technology, and is not computer-generated imagery.
- A hybrid print is a pattern, visualization of numerical data obtained from a participant's hand gestures.

7.6 Conclusion

This chapter has documents the final experiments undertaken by the researcher and presents an explicit documentation of the outcomes of the experiments so that the gestural performances discussed can be recreated. Prior to conducting the experiments it considered the set of implications defined in Chapter 6 to find specific solutions. Such as, to use specific hand gestures using both hands and rhythmic hand movements to provide cohesion between NVC generated motifs and designed patterns.

The experiments were carried out in two phases on consecutive days and dealt with familiarization and facilitation of hand gestural drawing by a group of participants.

In Experiment 13, the participants drew on two separate media such as paper and 3D space, which informed the research about the relationship between drawing and making hand gestures. A drawing representing a shape or object is a pictorial representation whereas performing a drawing to represent a shape or object is a gestural representation. It was found that in the process of drawing individual participants had a personal approach to drawing on paper and in MOCAP.

The research found a new method of generating a motif by combining body movements with hand gestures to draw in MOCAP. This method was then implemented successfully in Experiments 14 and 15.

Experiment 14 explored a group performance of the participants by creating a rectangular grid in which the group of participants performed hand gestures to generate Gestural Motif. In the process it was found that body dimensions of individual participants play an important role, informing the variation of shapes in a motif. The imperfect and incomplete nature of spontaneous drawings is evident in the outcomes of the experiment. Such drawings reflect the qualities of ‘handmade and handcrafted’ rather than ‘precise and algorithmic’.

The construction of various grids explored in the chapter could be mapped as; first, the rectangular grid was created with the intention to link gestural performance of the participants with the method of creating a simple repeat in printed textile design. Extending the rectangular grid into a square grid, which allowed individual participants to move freely, and finally the hexagonal grid as an alternative.

Experiment 15 explores group and solo gestural performances to generate a gestural motif, which were designed, into a collection of gestural patterns.

It was the researcher’s intention to only minimally transform the motifs to retain their MOCAP generated appearance. The top view was seen as an appropriate view, resulting in 2D motifs, and when 3D motifs were considered they required complex methods of tiling. It was found that although the top view presents a 2D motif it also represents hand gestures performed by individual participants in a group. The choice of view of MOCAP visualization becomes a design criterion.

The next and final chapter is the concluding chapter of the thesis and deals with overall conclusions to the research, contributions to knowledge and future research implications and propositions.

Table of Contents

Chapter 8

CONCLUSION

8.1 Overall summary

This thesis has documented a research journey through which a novel method, the hybrid print system (HPS) and innovative design examples have been created. The journey began with four key inspirations: pattern design, natural body movements, motion capture technology (MOCAP) and digital craft in printed textile design. The four inspirations then developed into a hypothesis stated in the introduction: *Motion capture technology can be harnessed to provide imagery for the use in the design of printed textiles, and connected to inkjet technologies to create a hybrid printing system.*

On the basis of the hypothesis, the aims of the research were stated which are:

- To create a Hybrid Print System (HPS) for printed textile design that incorporates integration of two diverse technologies motion-capture technology and digital inkjet printing of textiles.
- To use the HPS to demonstrate that hand gestures of a participant will generate a motif, which is then designed as patterns for printed textile design.
- To evaluate the HPS by qualitative analysis of the technical process and aesthetic qualities of the printed textile outcomes.

By describing how these aims have been met, the thesis has shown that this hypothesis has not been falsified. This final chapter re-examines each stage of the research, highlights the conclusions and recommendations for further research and discusses the new contributions to knowledge. Finally, I propose ways of developing this practice further by future research.

Chapter 1 identified the appropriate research methodology in practice-led research in Art & Design, based on Christopher Frayling's proposition of research *through* art & design and Donald Schön's reflective practitioner, in the context of the doctoral research. The inclusion of diagrams showing how the practical and theoretical research was undertaken strengthens the case for this practice-based research in printed textile design.

The research into the use of MOCAP found that it has been previously employed in the fields of music, fine art, dance, performance, sign language, gesture recognition, rehabilitation, biomechanics, special effects for live action films, and computer animation of all types, as well as in defence and athletic training. However, MOCAP has not been explored in printed textile design and this project is the first time it has been used extensively to create a novel method of design.

Chapter 2 showed that digital craft in printed textile design is linked with the development of inkjet printing in textile design and the development of imaging software. The development of digital inkjet printing for textiles is not only revolutionary in terms of removing traditional constraints imposed on the design of repeats but is adding new dimensions to the field of printed textile design. Designers are now looking into stories through illustrations and creating highly conceptual pieces, which blur the boundaries between Textile Design and Art.

The chapter found the roots of digital craft in the period Post-World War- II when computers were introduced and were used by artists to produce art. This bridged the gap between the computers and art, which resulted in a computer-art movement. This research has been inspired by art movements such as Fluxus and Conceptual art, where a participant becomes an artist, using such concepts to create a Hybrid Printing System in which the participant becomes an artist. Also, digital art brought to the research project the aesthetics of digitally generated form, shape, color etc. This informed the design of motifs and patterns in the experimental Chapters 4 - 7.

Research into the history of motion capture culminated in explorations of hybrid digital craft. The concept of digital craft that guided this research was divided into three strands, digital imaging, manipulation and production. A review of current practice showed that contemporary designers employ contrasting methods, mixing traditional hand drawn imagery with vector graphics to create new effects. Hybrid thinking and hybrid approaches inform practice-based research about the implications, the outcomes and materialisation of data. This review demonstrated that opportunities exist in the interdisciplinary spaces of digital practices.

This review also found that there is an opportunity to create a concept that allows consumers or participants to become more actively involved in design, offering them freedom and enjoyment in the act of creating a new product, which could have a commemorative value. The ownership of this design would be shared rather than being exclusively the property of the designer.

Chapter 3 identified the opportunity to develop a new method of printed textile design that involves the study of hand movements, drawing from theory from psychology and sociology to put this into a wider context of art and design as communication. The chapter identified a new model for digital printed textile design, consisting of successive stages – generation, design, materialization and application, the first three stages being iterative. In so doing, it established that optical marker-based motion capture technology can be used in printed textile design, showing that hand movements in non-verbal communication can be translated into 'hand crafted' digital prints. This convergence between everyday human actions and digital technology creates a new space - a medium and a tool - which the thesis proposes as a Hybrid Print System (HPS).

The HPS depends on consumer participation and implies changes in the field of printed textile design in parallel with the changing role of the designer and consumer through a gestural mode of drawing.

The focus of Chapter 4 was to formulate research questions which a design process could address and which could be assessed for their practicality and aesthetic effect. This required the identification of three distinct methods of motion capture for design examples (4.2.1). The practical research questions were formulated as:

1. How can *illustrators* (section 3.5.1) be captured and visualised?

2. How can *illustrators* be used to generate motif for printed textiles?

3. How can HPS generated motifs be used to design patterns?

The three methods identified were: motion tracing, motion tracking and motion sensing, based on the concepts of manual, semi-automated and automated processes.

Motion tracing was used to trace hand shapes, finger and body movements to generate motifs and patterns, combining the rotoscoping technique with digital imaging software to create surface patterns. This combined and explored old and established methods through new digital media. The outcome of the experiments 'Simple Gestures – I, II, III' were patterns that represent a gestural hand movement in transition. This technique showed a great deal of potential for the construction of patterns through the combination of various media. This process of creating surface pattern is new and its use of partial automation improved the overall appearance of the surface pattern by inducing new visual characteristics and developing a new method of creating transitional shapes.

Chapter 5 described how motion sensing can be combined with programming language and computer vision to capture gestural hand movements. This method created three software, prototypes through which audience participation was established and showed that HPS could be developed as an interactive platform. The outcome of these experiments showed two different kinds of surface patterns based on scan methods (5.3- 5.5), which demonstrate hand movement in manipulative gesture used to create new surface patterns. Combining the concept of motion tracing with computation resulted in unique patterns, which represent the hand's silhouettes as a new ‘temporal shape’. Use of computation meant that this pattern could be generated and printed simultaneously.

Chapter 6, presented the use of motion tracking to produce surface patterns by capturing real-life situations, giving results where there is a strong relation between hand gestures and the surface pattern. Optical motion capture technology was explored to create surface patterns from hand movements in a gesture. This method of motion tracking contributes to the HPS, by capturing hand gestures in three live events.

Firstly, a group discussion showed complex pattern of lines and dots representing hand gestures of the participants (6.3). Then, the sports performance actions such as golf shoot, showed a circular motif representing the swinging action of the golfer (6.4). This focused the research on rhythmic hand movements. With this focus, motion tracking of the gesture “Namaste” showed that a rhythmic hand movement results in a rhythmic form (6.5). If the same gesture were repeated, the outcomes would not be same but similar, maintaining the character of a hand drawn motif.

This chapter showed that due to occlusion the number of markers required optimizing so that the slightest movement of the participant’s hand could be recorded. Tests showed that the tip of the middle finger of a participant’s hand is the appropriate place for a marker. These patterns show if gestures were performed one at a time they are definitive in appearance and can be used to draw motifs.

Chapter 7 evaluated the three methods of motion capture and found motion tracking to be the most effective method in terms of meeting both the practical and aesthetic criteria. Motion tracing is the least effective, whereas motion sensing is marginally effective in meeting the criteria. Following the evaluation of the three methods, motion tacking was identified as the appropriate method to conduct the final set of experiments. The intentions were a specific group activity amongst participants in which they use hand gestures such as *illustrators* (section 3.6.1) batons, pointing and spatial movements to generate motifs, which provides cohesion between non-verbal communication, generated motifs and designed patterns.

The experiments were carried out on two phases on consecutive days and dealt with familiarization and facilitation of hand gestural drawing by a group of participants. In the familiarization stage, the participants produced drawings in two separate media: paper (2D) and in MOCAP space (3D). This made it possible to explore the relationship between drawing and making hand gestures. A drawing representing a shape or object is a pictorial representation whereas performing a drawing in space to represent a shape or object is a gestural representation. The process showed that each participants had a personal approach to drawing on both paper and in MOCAP space. By analysing the performed hand gestures and their effects on the generated shapes, the research found a new method of generating a motif - combining body movement with hand gestures to draw in MOCAP.

The method was then explored further through group and solo gestural performances using rectangular, square and hexagonal grids to generate a collection of gestural motifs. In the process it was found that the body dimensions of individual participants play an important role, influencing the variation of shapes in a motif. The imperfect and incomplete nature of spontaneous drawings gave the results a handmade and handcrafted character rather than a precise and algorithmic one.

With the intention of minimising the transformation of the motifs to retain the 'MOCAP-generated' appearance, the gestural motifs were then designed into gestural patterns by repeating them in regular grids. The MOCAP visualization of the gestural performance was processed to visualize the resulting motif in three ways such as three-point perspective, top and side view The top view was selected as the appropriate view, resulting in 2D motifs, when three-point perspective view were considered, and they required complex methods of tiling. It was found that although the top view presents a 2D motif it represents hand gestures performed by individual participants in a group. The choice of view of MOCAP visualisation became a design criterion.

Evaluation of the HPS against practical and aesthetic criteria, found that it is a systematic, repeatable, user friendly and efficient system that has demonstrated the use MOCAP to capture gestural performance of participants to create printed textile design, meeting the constraints of digitally printed textiles. In terms of its aesthetics, the outcomes of the HPS are identified as coherent and innovative. In its combination of techniques, HPS breaks new ground - the concept of gestural pattern provides the foundation for further developments.

To summarise, the properties of the HPS and its outcomes are:

- The HPS realises the importance of the hand's role in the handmade and handcrafted motifs. The HPS recognises the participant's gestural contribution as a method of motif generation.
- The HPS bridges the gap between digital and human (through creating concepts that promote 'humanising technology', 'social activity' and 'performativity'.

- The HPS allows a degree of freedom to participants in the design process by introducing the concept of 'active participation' as a deciding factor for 'progression' in design.

- The HPS subverts the current, traditional mode of textile design by changing the roles of the textile designer and consumer.

- Within the HPS the role of the textile designer transcends to a new level of expertise such as choreographer, scriptwriter and art-director.

- The HPS introduces new concepts of gestural performance, symbolic activities and notational representation.

- Further, the research has shown that the hybrid print that results from the HPS has the following properties; A hybrid print is created through the integration of traditional method and digital tools.

- A hybrid print will have resonance of both the traditional method and digital tools.

- A hybrid print is a 'handmade' print facilitated by technology, not 'computer-generated' imagery.

- A hybrid print is a visualisation of numerical data obtained from participant's hand gestures.

In summary then, this research has developed a novel method of HPS for printed textile design, which incorporates the investigation of historical and current developments in contemporary printed textile design. This pioneering process of integrating diverse and emerging technologies such as motion capture and digital inkjet printing provides one particular signposted route by which printed textile design can continue as viable and desirable in the twenty-first century mainstream commercial marketplace. The research demonstrates that HPS culminates in developing new aesthetics through a new mode of creation in a new medium, which will have impact on the user, the designer and the product as a part of the cyclical process.

HPS is an advancement of printed textile design, centred on the active participation of its audience at the generative stage of design. This shifts the role of a designer and subverts the current model of printed textile design practice. The HPS offers a democratic design process where the participants design for themselves, have their own voice, which induces a sense of community, togetherness and harmony in the creative process.

Through this research, then, HPS has been developed which supports the hypothesis stated as: Motion capture technology can be harnessed to provide imagery for the use in the design of printed textiles, and connected to inkjet technologies to create a hybrid printing system.

8.2 Contributions to new knowledge

This research focused adds to knowledge in the field of printed textile design, primarily through the development of a Hybrid Printing System. Knowledge of the opportunities this system offers, and its limitations, was gained through thoroughly investigating motion capture technology's ability to generate motifs by using participant's hand gestures.

HPS offers novelty in the following areas:

- The HPS offers new practical knowledge to the field of printed textile design by showing the potential of audience participation at the generative stage of design to result in novel motifs and the motifs that can be further designed as non-repeating patterns for digital print. Textile designers could adopt this model, especially those who practice in community and shared groups.

- The HPS offers three novel methods of motion capture technology, motion tracing, motion sensing and motion tracking. These methods are based on manual, semi-automated and automated process. The research has shown that each of these methods is capable of generating novel motifs.

The HPS contributes new practical knowledge to the field of printed textile design by demonstrating three methods to capture gestural motifs and patterns through working prototypes. These are motion tracing, motion sensing and motion tracking. Motion tracing is a semi-automates manual rotoscoping technique to capture hand gestures and generate gestural motifs, Motion sensing automates imagery from a live video stream to capture hand gestures and generate gestural patterns. Motion tracking is based on traditional hand drawing in 3D space. While motion tracing and motion tracking capture and generate the hand gestures as a series of linear motifs composed of lines and dots, motion sensing generates timed frames of photographic imagery as a composed pattern. ***Theoretical contributions***

The research shows that Frayling's proposition of research *through* design is a potential model of investigation to support developmental research in art and design. The research dealt with three fields, printed textile design, motion capture technology and nonverbal communication, using research *through* design to find connections between them. The research further shows that rigor can be achieved by combining creative and reflective practice. Thoroughly documented experimental procedures and their results can make tacit knowledge more explicit. This has been achieved in the research and forms the structure of the thesis. The research finds a new perspective of creating non-repeating patterns resulting by combining the traditional repeat system with individual mark making process. This is useful and informs the field of art and design, where practitioners are striving to achieve cutting edge design on a regular basis.

8.3 Future work

The research has identified ways of developing HPS further by using the three novel methods: motion tracing, motion sensing and motion tracking to capture whole body movements to generate new patterns. This could be further explored in collaboration with dance and performance researchers. It would be possible to develop HPS by incorporating democratic design as a new approach through research and development in participatory and co-design projects in printed textile design. Working with and for communities in developmental works dealing with gestural performance, creative workshops resulting in customised digital prints.

The implications of the work described in Chapter 6 for future research are:

Capturing hand movements and manipulation of the data resulted in variety of visually abstract forms, which may be designed as printed textiles that do not have a relationship to Non-verbal Communication. Considering hand movements in relation to social interaction is a wide area of research and it would invite more complex studies to be undertaken, which were beyond the scope of this study. The outcomes of experiments with open source programming were focused on the objectives of this research to translate gestures as print patterns - these were not pursued in this study but were aesthetically pleasing and could be further explored. Re-visiting the rationale of this study suggests that as well as revealing gestures made in a conversation, attention could be directed to other instances of physical aspects of communication, such as those involved in describing an object or a shape, the gestural drawing of an object or representing emotions and drawing in space.

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Glossary of terms

Rotoscoping

The process of creating individual drawn or animated images from photographic ones using a rotoscope.

Rotoscope

A device which projects an enlarged image of a single frame of filmed live action on to a frosted glass screen, so that it can be traced over to create a cartoon drawing. In later use also: a computer application which enables an animated sequence to be created from live action. The original technique was devised by M. Fleischer *c*1915, but the word *rotoscope* does not occur in his patent (*U.S. Patent 1,242,674* (1917))

Automatically trace artwork using Live Trace

1. Open or place a file to use as the source image for the tracing.
2. With the source image selected, do one of the following:
    - To trace the image using a tracing preset, click the Tracing Presets and Options button ▼ in the Control panel, and select a preset.
    - To trace the image using the default tracing options, click Live Trace in the Control panel, or choose Object > Live Trace > Make.
    - To set tracing options before you trace the image, click the Tracing Presets and Options button ▼ in the Control panel, and choose Tracing Options. Alternatively, choose Object > Live Trace > Tracing Options. Set tracing options, and then click Trace.
3. (Optional) Adjust the results of the tracing.
4. (Optional) Convert the tracing to paths or to a Live Paint object.

Tracing options

Preset
- Specifies a tracing preset.

Mode
- Specifies a color mode for the tracing result.

Threshold
- Specifies a value for generating a black and white tracing result from the original image. All pixels lighter than the Threshold value are converted to white, all pixels darker than the Threshold value are converted to black. (This option is available only when Mode is set to Black and White.)

Palette

- Specifies a palette for generating a color or grayscale tracing from the original image. (This option is available only when Mode is set to Color or Grayscale.)
- To let Illustrator determine the colors in the tracing, select Automatic. To use a custom palette for the tracing, select a swatch library name. (The swatch library must be open in order for it to appear in the Palette menu.)

Max Colors

- Specifies a maximum number of colors to use in a color or grayscale tracing result. (This option is available only when Mode is set to Color or Grayscale and when panel is set to Automatic.)

Output To Swatches

- Creates a new swatch in the Swatches panel for each color in the tracing result.

Blur

- Blurs the original image before generating the tracing result. Select this option to reduce small artifacts and smooth jagged edges in the tracing result.

Resample

- Resamples the original image to the specified resolution before generating the tracing result. This option is useful for speeding up the tracing process for large images but can yield degraded results.
- Note: The resample resolution is not saved when you create a preset.

Fills

- Creates filled regions in the tracing result.

Strokes

- Creates stroked paths in the tracing result.

Max Stroke Weight

- Specifies the maximum width of features in the original image that can be stroked. Features larger than the maximum width become outlined areas in the tracing result.

Min Stroke Length

- Specifies the minimum length of features in the original image that can be stroked. Features smaller than the minimum length are omitted from the tracing result.

Path Fitting

- Controls the distance between the traced shape and the original pixel shape. Lower values create a tighter path fitting; higher values create a looser path fitting.

Minimum Area

- Specifies the smallest feature in the original image that will be traced. For example, a value of 4 specifies that features smaller than 2 pixels wide by 2 pixels high will be omitted from the tracing result.

Corner Angle

- Specifies the sharpness of a turn in the original image that is considered a corner anchor point in the tracing result. For more information on the difference between a corner anchor point and a smooth anchor point.

Raster

- Specifies how to display the bitmap component of the tracing object. This view setting is not saved as part of the tracing preset.
Vector
- Specifies how to display the tracing result. This view setting is not saved as part of the tracing preset.

Convert a tracing object to a Live Paint object

When you are satisfied with the results of a tracing, you can convert the tracing object to paths or to a Live Paint object. This final step allows you to work with the tracing as you do other vector artwork. Once you convert the tracing object, you can no longer adjust the tracing options.

1. Select the tracing object.
2. Do one of the following:
    - To convert the tracing to paths, click Expand in the Control panel or choose Object > Live Trace > Expand. Use this method if you want to work with the components of the traced artwork as individual objects. The resulting paths are grouped together.
    - To convert the tracing to paths while preserving the current display options, choose Object > Live Trace > Expand As Viewed. For example, if the display options are set to Outlines for the tracing result, then the expanded paths will be outlines only (rather than filled and stroked). In addition, a snapshot of the tracing with its current display options is preserved and grouped with the expanded paths. Use this method if you want to preserve the tracing image as a guide for the expanded paths.
    - To convert the tracing to a Live Paint object, click Live Paint in the Control panel or choose Object > Live Trace > Convert To Live Paint. Use this method if you want to apply fills and strokes to the traced artwork using the Live Paint Bucket tool.

Simplify paths

Simplifying a path removes extra anchor points without changing the shape of the path. Removing unnecessary anchor points simplifies your artwork, reducing the file size, and making it display and print faster.

1. Select the object.
2. Choose Object > Path > Simplify.
3. Set the Curve Precision to control how closely the simplified path follows the original path.
4. Select additional options, and click OK:

Curve Precision

Enter a value between 0% and 100% to set how closely the simplified path should follow the original path. A higher percentage creates more points and a closer fit.

Any existing anchor points are ignored except for endpoints of a curve and corner points (unless you enter a value for Angle Threshold).

Angle Threshold

Enter a value between 0 and 180° to control the smoothness of corners. If the angle of a corner point is less than the angle threshold, the corner point is not changed. This option helps keep corners sharp, even if the value for Curve Precision is low.

Straight Lines

Creates straight lines between the object’s original anchor points. Corner points are removed if they have an angle greater than the value set in Angle Threshold.

Show Original

Shows the original path behind the simplified path.

Patterns

all-over and tossed designs, spot (sateen) repeats, irregular (step or sliding) repeats, composite repeats, counterchanged repeats, gradations and optical patterns

Table of Contents

Appendix - I : Tables

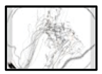
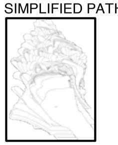
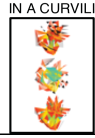
MOTION TRACING					
EXPERIMENT	**SIMPLE GESTURES - I**	**SIMPLE GESTURES - II**	**SIMPLE GESTURES - III**	**GESTURES IN BRITISH SIGN LANGUAGE-I**	**GESTURES IN BRITISH SIGN LANGUAGE-II**
METHOD OF CAPTURE	DIGITAL PHOTOGRAPHY	DIGITAL PHOTOGRAPHY	DIGITAL VIDEO FILM	DIGITAL VIDEO FILM	DIGITAL VIDEO FILM
MODEL	SONY DSC-T 100	SONY DSC-T 100	SONY DSC-T 100	SONY CAMCORDER (DCR-SR15E)	SONY CAMCORDER (DCR-SR15E)
MODE OF CAPTURE	BURST MODE	BURST MODE	NORMAL FILM MODE	NORMAL FILM MODE	NORMAL FILM MODE
RATE OF IMAGES GENERATED PER MINUTE	28-35	28-35	**1500** Movie length= 0.55 sec Total frames = 1375	Movie length= 1.51 sec Total frames = 2775	Movie length= 1.51 sec Total frames = 2775
NUMBER OF IMAGES USED	28	30	155	5	5
PRINT SIZE OF IMAGE	1151.47 X 836.6 mm	1151.47 X 836.6 mm	225.78 X 169.33 mm	254 X169.33 mm	254 X169.33 mm
PIXEL SIZE OF IMAGES	3264 X 2448 PIXELS	3264 X 2448 PIXELS	640 X 480 PIXELS	720 X 480 PIXELS	720 X 480 PIXELS
RESOLUTION	**72 PIXELS PER INCH**				
FILE SIZE	2.1 MB PER IMAGE	2.1 MB PER IMAGE	16-24 KB PER IMAGE	1.1 MB PER IMAGE	1.1 MB PER IMAGE
FILE TYPES	JPEG IMAGE	JPEG IMAGE	JPEG IMAGE	TIFF IMAGE	TIFF IMAGE
VISUAL QUALITIES	WELL FOCUSSED	BLURRED	MIXED	MIXED	MIXED
POST CAPTURE MANIPULATION	CREATE VECTOR SHAPES	CREATE VECTOR SHAPES	• DECONSTRUCT MOVIE INTO IMAGE FRAMES • CREATE VECTOR SHAPES	• DECONSTRUCT MOVIE INTO IMAGE FRAMES • CREATE VECTOR SHAPES	• DECONSTRUCT MOVIE INTO IMAGE FRAMES • CREATE VECTOR TEXTURES
SOFTWARE	**ADOBE CREATIVE SUITE 3 (PHOTOSHOP, ILLUSTRATOR, PREMIER PRO,BRIDGE)**				
DESIGN PROCESS	• IMAGE ADJUSTMENT BY **THRESHOLD** VALUE • COLOUR SELECTION • CONVERT SELECTION TO WORKPATH • EXPORT WORK PATH TO ILLUSTRATOR • LINEAR ARRANGEMENT • BLEND VECTOR SHAPES TO CREATE **TRANSITIONAL SHAPES**	• **LIVE TRACE** IMAGE TO CREATE VECTOR SHAPES • ALIGN AND DISTRIBUTE	• DECONSTRUCT VIDEO FILM INTO IMAGE FRAMES • **BATCH PROCESS** - LIVE TRACE IMAGE TO CREATE VECTOR SHAPES • SIMPLIFY VECTOR PATH • ALIGN AND DISTRIBUTE	• DECONSTRUCT VIDEO FILM INTO IMAGE FRAMES • **TRACE FINGER POSITIONS** AS LINES ON EACH IMAGE • STROKE EACH SET OF LINES WITH A SEPARATE COLOUR IN CMYK MODE. • LINEAR ARRANGEMENT OF THE CREATED SET OF LINES • BLEND TO CREATE TRANSITIONAL SHAPES	• DECONSTRUCT VIDEO FILM INTO IMAGE FRAMES • **BATCH PROCESS** - LIVE TRACE ENTIRE IMAGE TO CREATE VECTOR TEXTURES • **RE –COLOR ART WORK AS LINE AND FILL** • SIMPLIFY VECTOR PATH • ALIGN AND DISTRIBUTE •
COLOURS USED IN THE PATTERN	• BLACK AND WHITE	• BLACK AND WHITE	• BLACK AND WHITE	• COLOUR IN CMYK MODE	• BLACK AND WHITE
VARIATION OF PATTERN	• HORIZONTAL • VERTICAL • CENTRAL • OUTLINED • OUTLINED & FILLED • OPACITY 	• VERTICAL • CENTRAL • OUTLINED 	• SIMPLIFIED PATH 	• HORIZONTAL • VERTICAL • CENTRAL • IN A CURVILINEAR PATH 	• NEGATIVE • POSITIVE 

Table I : MOTION TRACING, Table of comparison of experiments (technical process and results

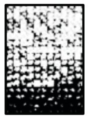
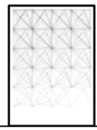
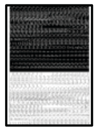
MOTION SENSING						
EXPERIMENT	**HYBRID BUBBLES**	**HYBRID KOLAM**	**HYBRID DUREE - I**	**HYBRID DUREE - II**	**HYBRID IKAT**	**HYBRID IKAT -II**
SPACE	**2D**	**3D**	**3D**	**3D**	**3D**	**3D**
METHOD OF CAPTURE	GUIDED USER INTERFACE	COMPUTER VISION / LIGHT GLOVE	COMPUTER VISION / WEBCAM	COMPUTER VISION / WEBCAM	COMPUTER VISION / WEBCAM	COMPUTER VISION / WEBCAM
PROGRAMMING LANGUAGE	**PROCESSING**					
NUMBER OF IMAGES GENERATED PER MINUTE	670	62	2 (32 X 24 FRAMES)	2 (32 X 24 FRAMES)	2	2
DURATION OF CAPTURE (MINUTES)	2	3	1	1	1	1
NUMBER OF IMAGES USED	800	20	1	1	1	1
PRINT SIZE OF IMAGE	70.56 X 70.56 mm	282.22 X 282.22 mm	361.24 X 270.93 mm	361.24 X 270.93 mm	282.22 X 282.22 mm	282.22 X 282.22 mm
PIXEL SIZE OF IMAGES	200 X 200 PIXELS	800 X 800 PIXELS	1024 X 768 PIXELS	1024 X 768 PIXELS	800 X 800 PIXELS	800 X 800 PIXELS
RESOLUTION	72 PIXELS PER INCH	72 PIXELS PER INCH	72 PIXELS PER INCH	72 PIXELS PER INCH	72 PIXELS PER INCH	72 PIXELS PER INCH
FILE SIZE PER IMAGE	4 -20 KB	4 - 400 KB	492 KB	492 KB	600 KB - 1 MB	600 KB - 1 MB
FILE TYPE	**PORTABLE NETWORK GRAPHICS**					
VISUAL QUALITIES	PRECISE, SHARP	PRECISE, SHARP	LOW RESOLUTION PHOTOGRAPH	LOW RESOLUTION PHOTOGRAPH	BLURRED	STRIPE
POST CAPTURE MANIPULATION	FILE SORTING, RENAME ARRANGEMENT / LAYOUT ON ART BOARD	FILE SORTING, RENAME ARRANGEMENT / LAYOUT ON ART BOARD	NONE	CREATE VECTOR OUTLINES	NONE	NONE
SOFTWARE	**ADOBE CREATIVE SUITE 3 (PHOTOSHOP, ILLUSTRATOR, BRIDGE)**					
PROCESS	• OPEN SKETCH FOLDER **TO SORT FILES** ACCORDING TO • TIME OF CREATION, • NAME • FILE SIZE • **RENAME THE BATCH** • **ARRANGE** THE IMAGES IN A REGULAR GRID	• OPEN SKETCH FOLDER TO **SORT FILES ACCORDING TO TIME OF CREATION**, • **ARRANGE** THE IMAGES IN A REGULAR GRID	• **READY** TO PRINT	• **LIVE TRACE** IMAGE TO CREATE VECTOR SHAPES	• **READY** TO PRINT	• **READY** TO PRINT
COLOURS USED IN THE PATTERN	• BLACK AND WHITE	• BLACK AND WHITE	• COLOUR IN CMYK MODE	• BLACK AND WHITE	• COLOUR IN CMYK MODE	• COLOUR IN CMYK MODE
VARIATION OF PATTERN	• HORIZONTAL • VERTICAL • RANDOM 	• HORIZONTAL • VERTICAL • RANDOM 		• NEGATIVE • POSITIVE 		

Table II: MOTION SENSING, Table of comparison of experiments (technical process and results)

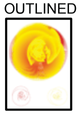
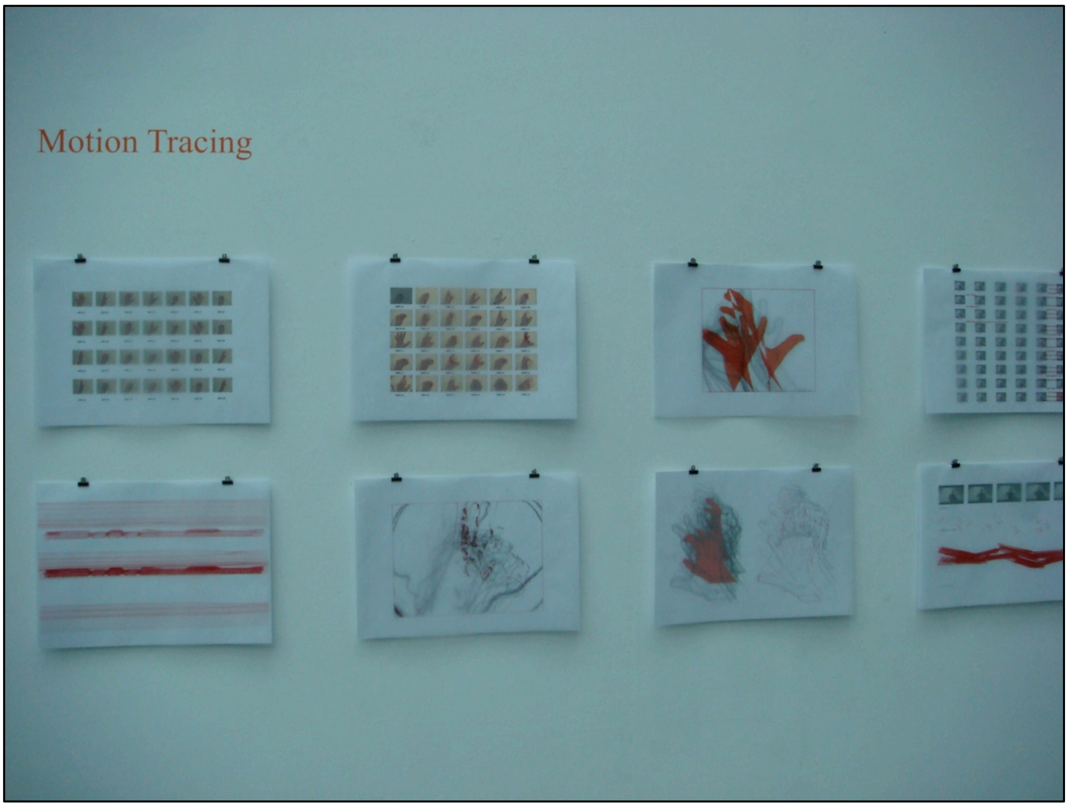
MOTION TRACKING					
EXPERIMENT	HAND GESTURES IN A GROUP DISCUSSION	SPORTS PERFORMANCE			HAND GESTURE TO GREET (NAMASTE)
METHOD OF CAPTURE	OPTICAL MOTION CAPTURE				
MODEL	QUALYSIS – PRO-REFLEX MCU				
NUMBER OF PARTICIPANTS	3	3			1
NUMBER OF FRAMES GENERATED	12000	GOLF 1638	ROWING 16011	TENNIS 2500	1000
TIME (IN SECONDS)	60	3.27	106.73	5	
FRAME USED	FINAL FRAME	FINAL FRAME	733	FINAL FRAME	201, 309, 602, 799, FINAL FRAME
3D DATA VISUALISATION	QUALYSIS TRACK MANAGER				
METHOD OF IMAGE CAPTURE	PRINT SCREEN (copy a bitmap image of the current screen)				
VISUAL QUALITIES	PIXELLETED LINES AND SHAPES ON A BLACK BACKGROUND				
PIXEL SIZE OF IMAGE	1024 X 768 PIXELS				
RESOLUTION	72 PIXELS PER INCH				
FILE SIZE/ TYPE	2.3 MB IN BITMAP				
POST CAPTURE MANIPULATION	CREATE VECTOR SHAPE OF THE ENTIRE IMAGE	CREATE VECTOR SHAPE OF THE ACTION TRACE			CREATE VECTOR SHAPE OF THE ACTION TRACE
SOFTWARE	CREATIVE SUITE 3 (ADOBE, PHOTOSHOP, ILLUSTRATOR, BRIDGE)				
PROCESS	• REMOVE VISUAL ELEMENTS SUCH AS MENU BARS FROM THE PRINT SCREEN IMAGE • IMAGE ADJUSTMENT BY THRESHOLD VALUE(62) • SAVE IMAGE AS BITMAP • OPEN IMAGE IN ILLUSTRATOR • LIVE TRACE IMAGE TO CREATE VECTOR SHAPES • SIMPLIFY VECTOR PATH • EXPAND VECTOR PATH	• REMOVE VISUAL ELEMENTS SUCH AS MENU BARS FROM THE PRINT SCREEN IMAGE • SAVE IMAGE AS BITMAP • OPEN IMAGE IN ILLUSTRATOR • LIVE TRACE IMAGE TO CREATE VECTOR SHAPE • SIMPLIFY VECTOR PATH • EXPAND VECTOR PATH • BLEND VECTOR SHAPES TO CREATE TRANSITIONAL SHAPES	• REMOVE VISUAL ELEMENTS SUCH AS MENU BARS FROM THE PRINT SCREEN IMAGE • SAVE IMAGE AS BITMAP • OPEN IMAGE IN ILLUSTRATOR • LIVE TRACE IMAGE IN COLOUR TO CREATE VECTOR SHAPE • SIMPLIFY VECTOR PATH • EXPAND VECTOR PATH	• REMOVE VISUAL ELEMENTS SUCH AS MENU BARS FROM THE PRINT SCREEN IMAGE • SAVE IMAGE AS BITMAP • OPEN IMAGE IN ILLUSTRATOR • LIVE TRACE IMAGE TO CREATE VECTOR SHAPE • SIMPLIFY VECTOR PATH • EXPAND VECTOR PATH	• REMOVE VISUAL ELEMENTS SUCH AS MENU BARS FROM THE PRINT SCREEN IMAGE • SAVE IMAGE AS BITMAP • OPEN IMAGE IN ILLUSTRATOR • LIVE TRACE IMAGE TO CREATE VECTOR SHAPE • SIMPLIFY VECTOR PATH • EXPAND VECTOR PATH • EXECUTE 3D EFFECT- REVOLVE TO GENERATE WIRE FRAME SHAPE.
COLOURS USED IN THE PATTERN	BLACK, WHITE, RED	• BLACK AND WHITE • COLOUR IN CMYK MODE	COLOUR IN CMYK MODE	COLOUR IN CMYK MODE	BLACK, WHITE, RED
VARIATION OF PATTERN	• BLACK OUTLINE • BLACK FILLED • COLOURWAY IN GREY 	• VERTICAL • CENTRAL • OUTLINED 			

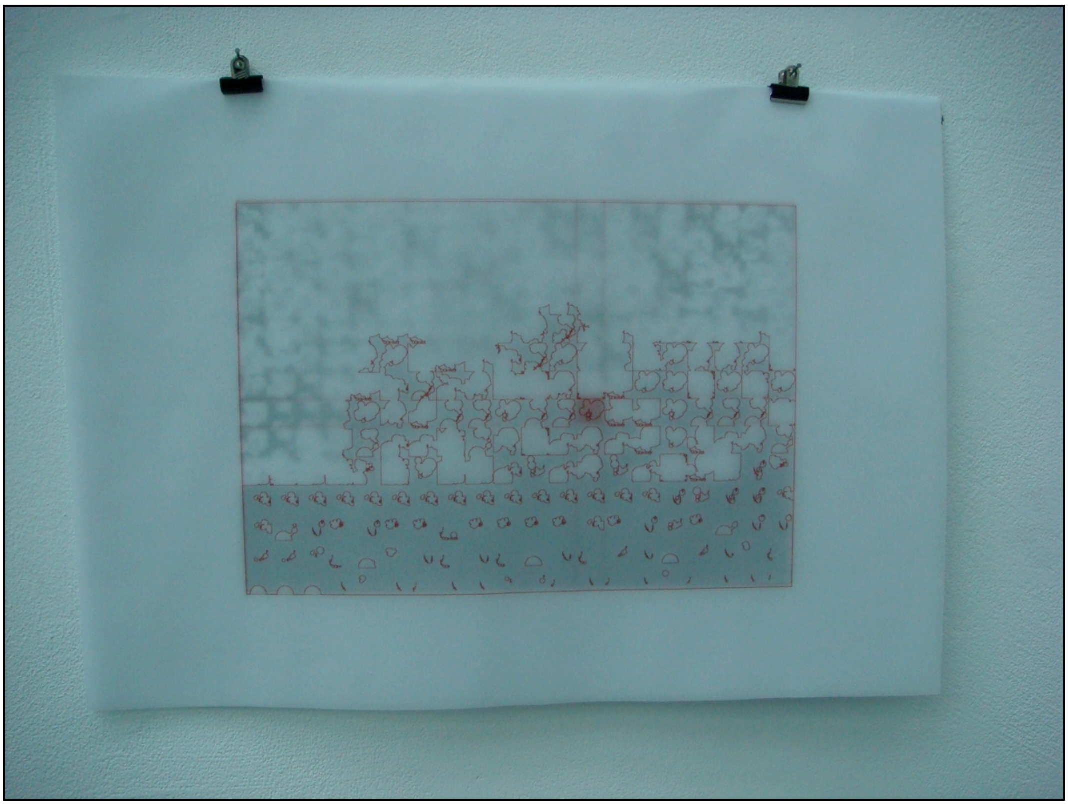
Table III : MOTION TRACKING, Table of comparison of experiments (technical process and results)

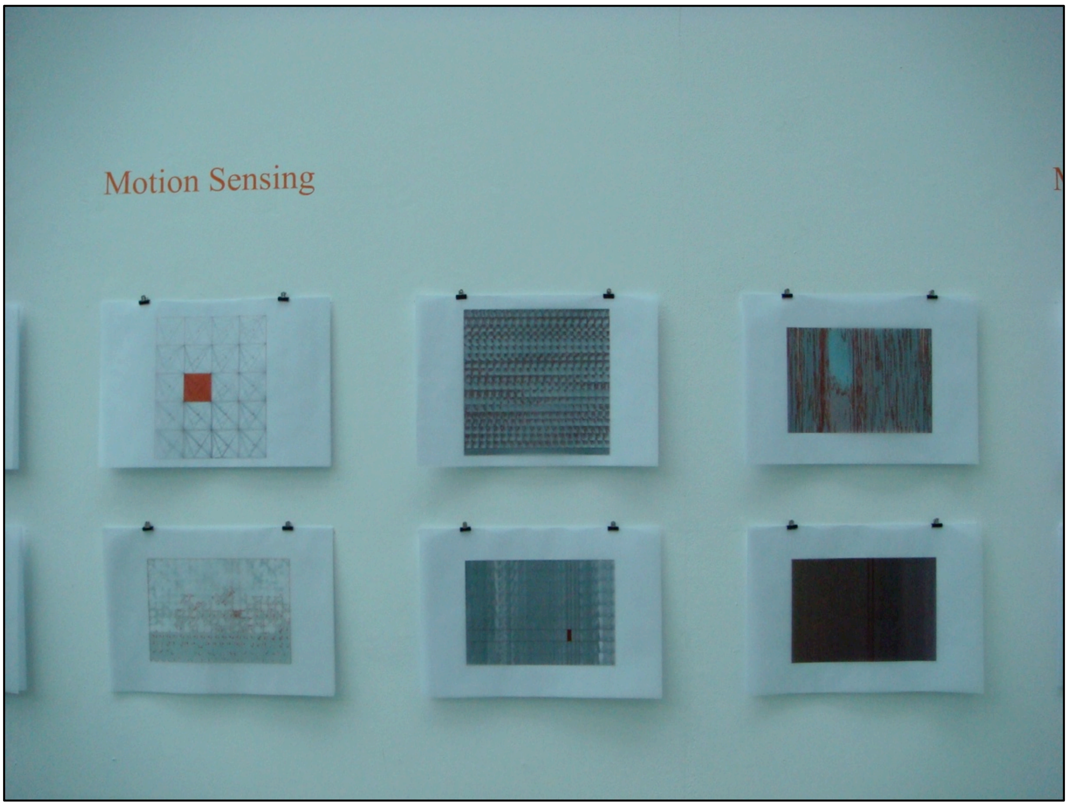
Appendix - II: Exhibition and Installation

Exposition of practical outcomes of the doctoral research titled,

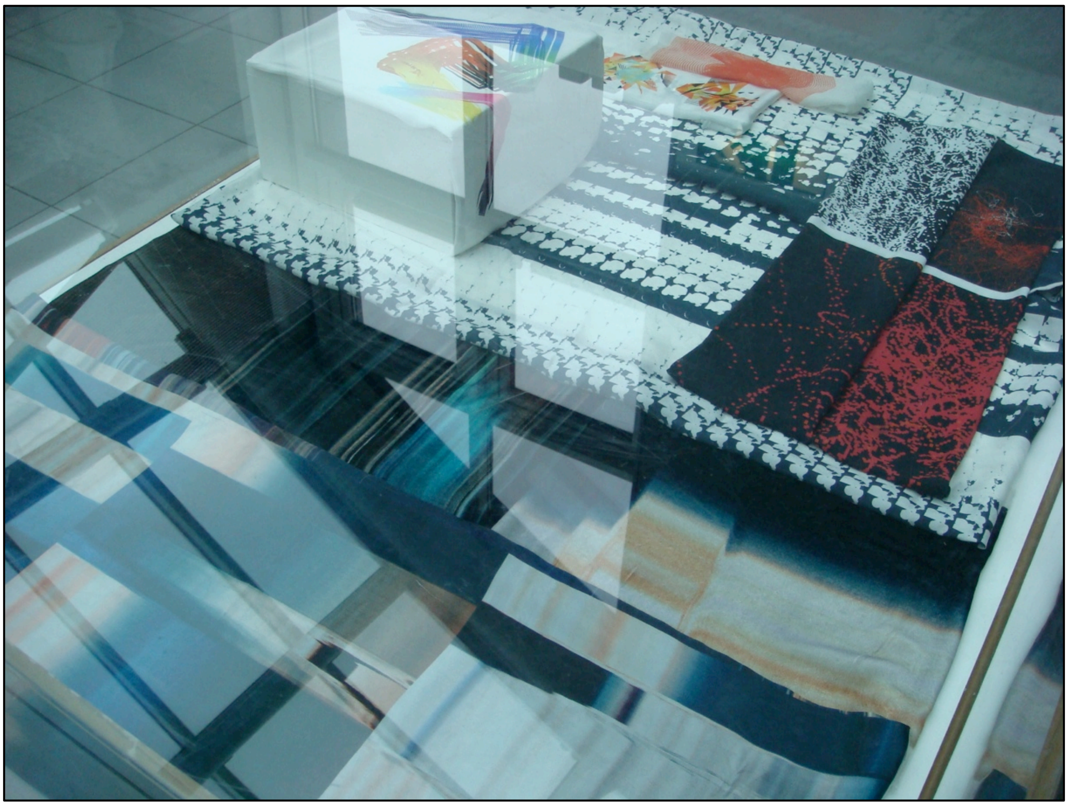
"Hybrid Print Patterns", 2nd – 8th July 2012, Nottingham Trent University, U.K.

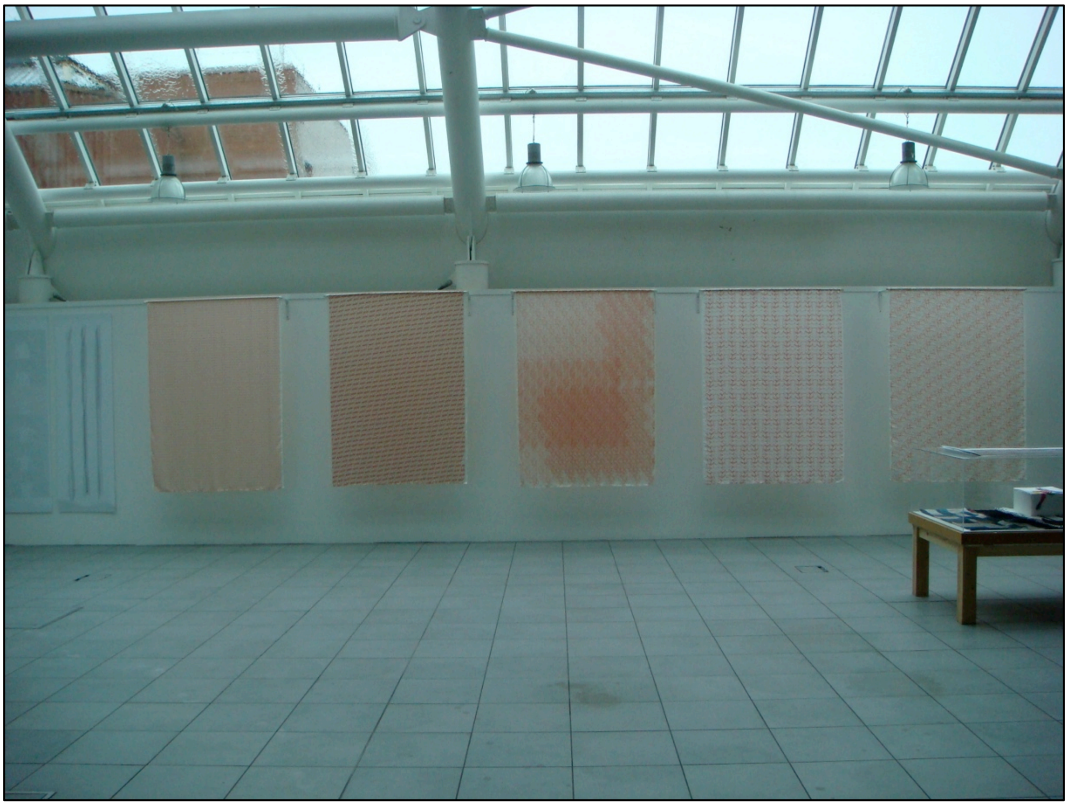

Motion Tracing



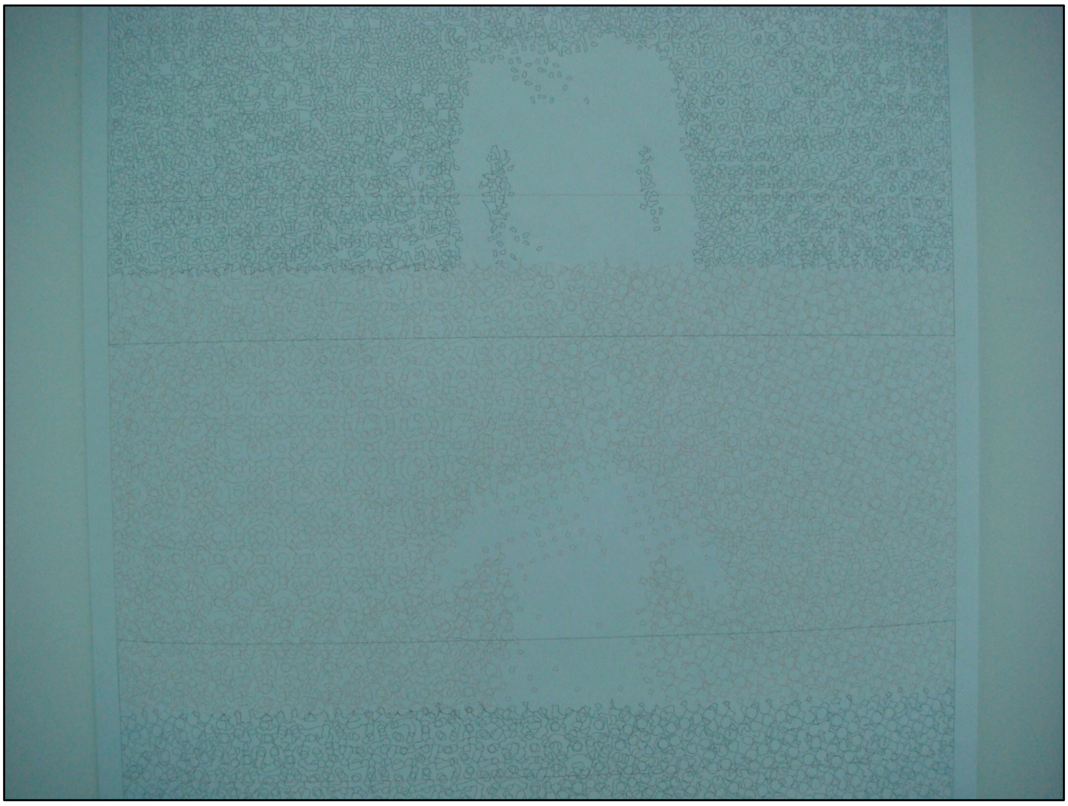

Motion Sensing


Motion Tracking






Automatic door
Automatic door



Capturing rhythm and space, EXHIBITION . In: Hong Kong Polytechnic and University, 1-31 December 2009

Capturing Rhythm and Space

1 – 28 December 2009

Devabrata Paramanik, Dr Amanda Briggs-Goode
Dr Katherine Townsend, Joy Buttress, Rosemarie Goulding

This group exhibition explores PhD and post-doctoral practice-led research by five textile artist / designers based in the School of Art and Design. Dr Amanda Briggs-Goode, Dr Katherine Townsend and Rosemarie Goulding are principal lecturers and members of the School's 2D to 3D Research Group. Devabrata Paramanik and Joy Buttress are both PhD students at the University.

The title of the exhibition reflects the shared aesthetic of this group which is underpinned by a hybrid design philosophy and the desire to capture the metaphorical and illusory qualities of movement and space, through the creation of experimental, expressive textiles.

The textiles convey contrasting notions of rhythm and space through printed and embroidered pieces. These simulate the spatiality of drapery and the notion of flux between manipulated fabric and the underlying form: capturing abstract concepts of movement and fluidity, interpreting metaphorical and illusionary qualities and replicating patterns originated from hand movements used in conversation.

Capturing Rhythm and Space is part of an exhibition exchange between The Hong Kong Polytechnic University and Nottingham Trent University. *Metallic Sound*, by Junichi Arai and Kinor Jiang, will be exhibited at The Bonington Gallery, Nottingham Trent University (18 January – 17 February 2010), reflecting the strong educational links between both universities through established fashion and textile research.

Acknowledgements

Digital Print: Paula Love and Sue Pike
Digital Embroidery: Sue Beckett and Donna Carr
Laser Cutting: Jason Holroyd and Sue Turton
Lace Archive images: Catherine Northall

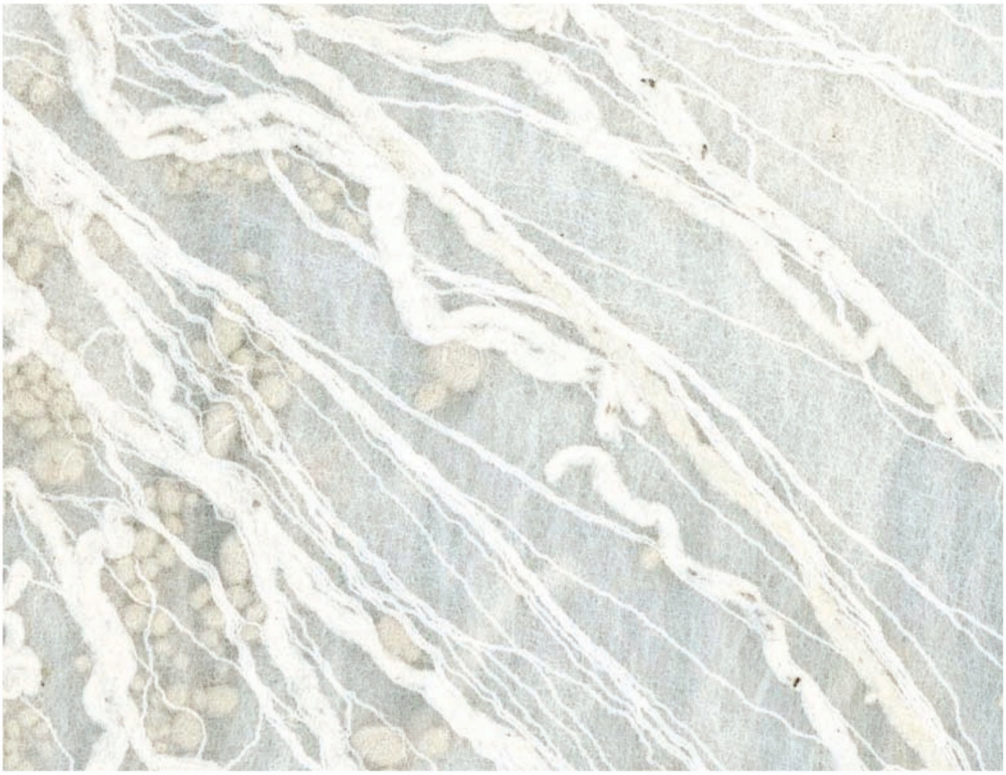
The School of Art & Design

Research in the School of Art and Design at Nottingham Trent University is dynamic and imaginative, acting as a vital cornerstone in the activities and life of the School. We have an outward looking research culture, with a strong focus on art and design practice as a significant contributor to cultural enrichment, social dynamics and economic vitality.

Staff and postgraduate researchers undertake original investigations to discover fresh ideas, designs, performances and works of art that lead to new perceptions, products and processes.

More theoretically-based projects engage with a range of perspectives on art and design practice, drawing from cultural, perceptual, pedagogic and systems theory. In addition, a significant strand of activity is focused on the exploration of new technologies, innovating methods, materials and procedures.

Our work is of direct relevance to the needs and developments in the cultural sector and industry and commerce. It is supported by income from a range of bodies, including the Arts and Humanities Research Council (AHRC), the Drapers Company, the EU and other national charities and public services in the UK.



Dr Amanda Briggs-Goode
Movement: Flower

amanda.briggs-goode@ntu.ac.uk

Dr Briggs-Goode is the BA (Hons) Textile Design programme leader, and research leader for fashion, knitwear and textiles in the School of Art and Design. Her research interests are digital printed textiles; the relationship between 2D and 3D, and she is currently working on a smart textiles project with colleagues across the University on the design integration of stretch sensors into garment forms. Dr Briggs-Goode recently completed an AHRC project as Principle Investigator working with the Nottingham Trent University Lace Collection and is developing research agendas, raising funds and supervising PhDs in this area.

Research Focus

Dr Briggs-Goode's research has developed from imperatives first explored during her PhD studies, completed in 1997. She is fascinated by the relationship between photographic imagery, digital input media and printed textiles. Photographs are perceptually complex having a rich fidelity, becoming even more intense when placed on a 3 dimensional form; the drape, folds and cut of a garment fracturing the imagery further. Designers who use photographic images for textiles have developed strategies to offset this complexity, through motif isolation, explorations with scale, simplifying the image through darkroom or digital techniques, abstraction.

Barthes (1977:44) describes the 'diminished projective power' of the photograph image. He argues that the photographic image has its own space-time category of 'there then' and that this 'diminishes the projective power of the image.'

This collection of work explores the relationship between the digital and hand in the creation of images which both literally and metaphorically convey movement and rhythm.

References

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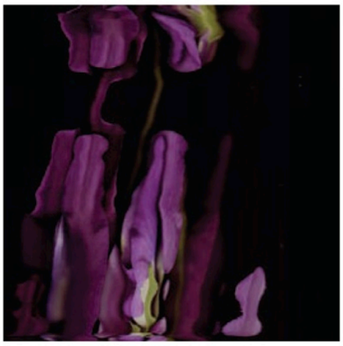

5.

Devabrata Paramanik
action_capture_print

devabrata.paramanik@ntu.ac.uk

Dev Paramanik is an Indian textile designer, who began his professional practice with the prestigious Pearl Academy of Fashion, New Delhi, India (1998). His work has been showcased nationally in association with Pearl Academy of Fashion (Art Direction for '*Continuum 2003*', Portfolio - 2001, 2002, 2003) and internationally in '*In–Stitches*' (2003), *MA Exposition* (2005) Nottingham Trent University, '*Futurotextiles 08*', Belgium, '*Generative Art 2008*' in Italy and *ISEA* 2009 in Belfast, Northern Ireland. In 2005, Dev received the Charles Wallace Trust Scholarship in support of his Masters studies in printed textiles at NTU, in which he gained a distinction. In 2007, Nottingham Trent University funded his PhD research, focused on creating a hybrid printing system for printed textile design.

Research Focus

Question – 'New Rhythms of Pattern: an exploration of digital craft for printed textile design using motion capture technology'.

Towards creating a hybrid print practice in printed textile design, this practice-based research explores the 'fusion' of media, such as motion-capture technology, visual programming language and digital textile printing technology, to capture, visualise and materialise hand movements into print patterns. It emerges within the context of 'broad-based technological infiltrations in all areas of human experience' and in a variety of digital practices in Art and Design (Broadhurst, 2006).

This research will contribute to the advancement of printed textile design, centred on the interactive, behaviourist and telematic participation of its audience, resulting in a shifting role for the designer, creating interactive participants as new users and subverting the current mode of printed textile design.

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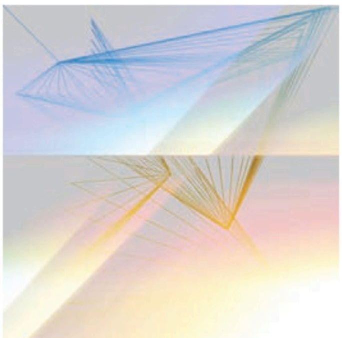
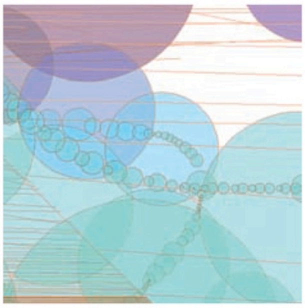
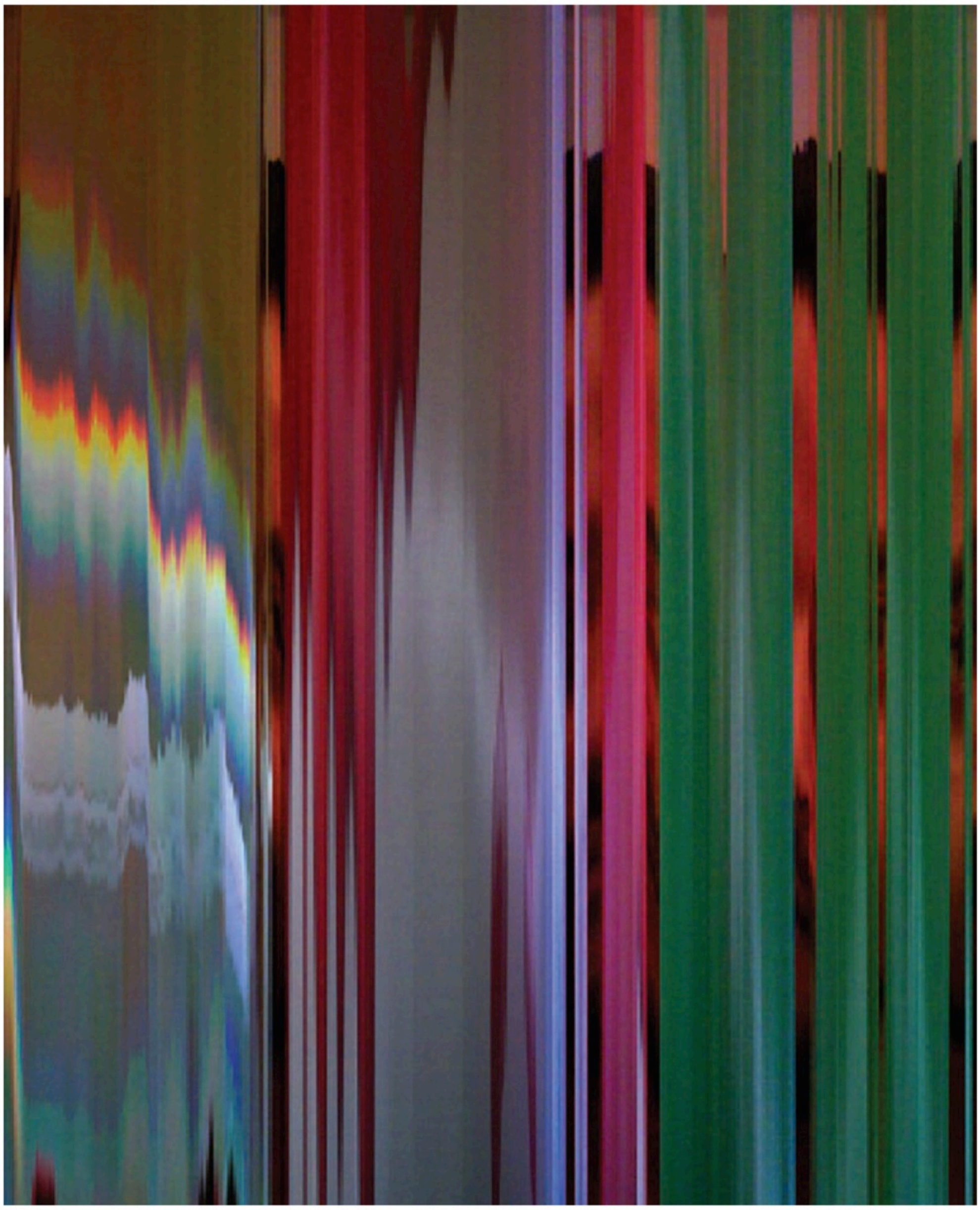
Broadhurst, S. (2006) Performance and technology: practices of embodiment and interactivity, Palgrave MacMillan, Basingstoke.







Katherine Townsend
High Falls: Water, lace and the body

katherine.townsend@ntu.ac.uk

Dr Katherine Townsend is the MA Fashion, Knitwear and Textile Design programme leader in the School of Art and Design at Nottingham Trent University. Her past practice as a printed fashion designer has informed both her teaching and research interests. Since achieving her PhD, Katherine has continued to explore the relationship between cloth, printed and the 3D form, specifically how each element visually informs the physical manifestation of the body. She has presented papers and shown her work at various international conferences and exhibitions, and is co-editor of the forthcoming Journal of Craft Research, published by Intellect in 2010.

Current work continues the interrogation of textiles and garments as spatial forms by reversing this 3D to 2D approach. Photographic images of a flowing river have inspired a series of digitally printed lengths, which are finally aligned with the 3D body form. The images are manipulated to suggest material qualities, through the strategic placement of lace patterns, insinuated by the formations of flotsam on the water's surface. Instead of creating the illusion of fluidity, images of moving water are interpreted into the recognisable textile rhythms of repetition, pattern and texture.

Research Focus

Townsend's practice-led PhD (2003) explored integrated CAD / CAM as a platform for creating new printed garment concepts. The research was facilitated through the development of a Simultaneous Design Method, inspired by the practice of Sonia Delaunay. Taking the female form as a starting point, a 3D modelled method of image capture was used to generate blueprinted toiles. The deconstructed pieces formed the basis of a series of engineer-printed prototypes that were digitally crafted to emulate the visual relationship between the moving form and a 'sculptural architectonic garment…constructed on the motif of soft, draping, figure enveloping fabric' (Adaskina 1990: 303).

References

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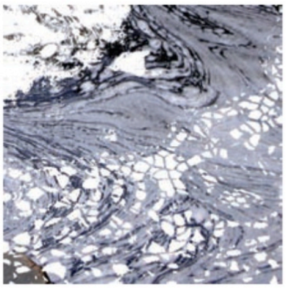

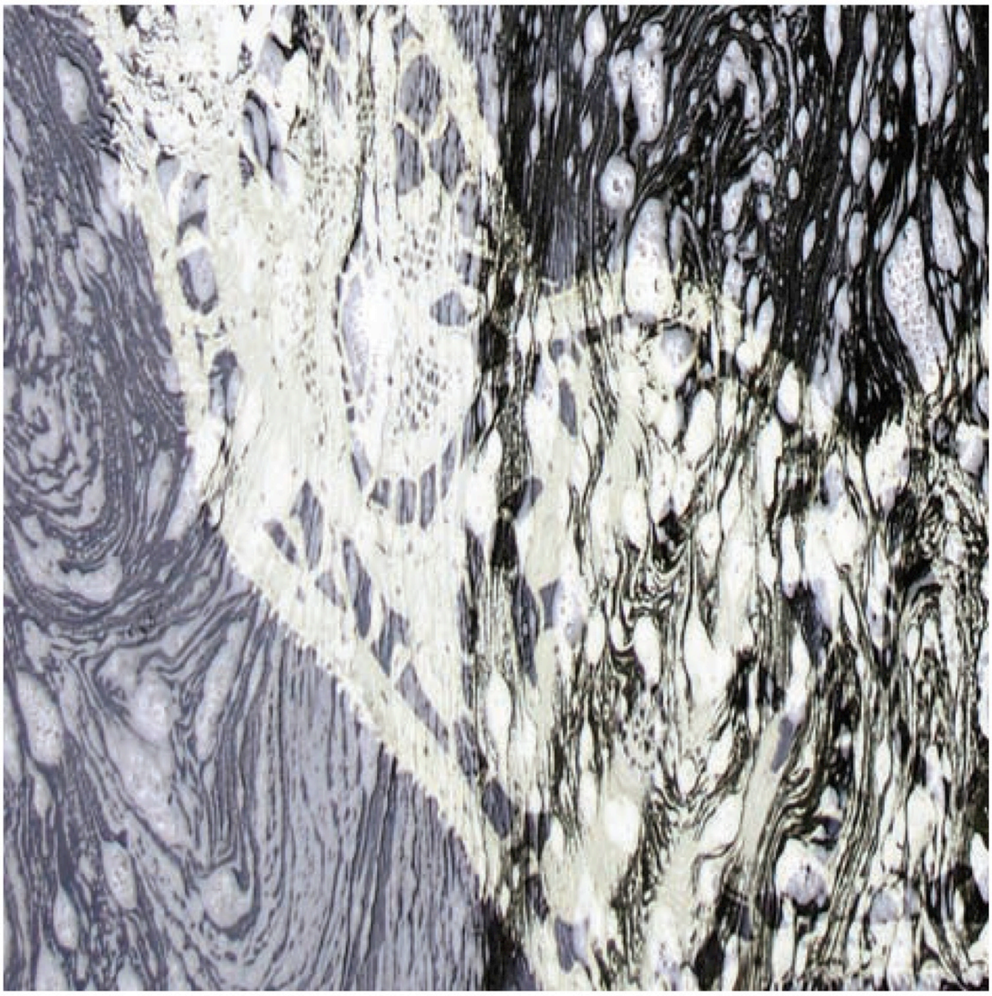

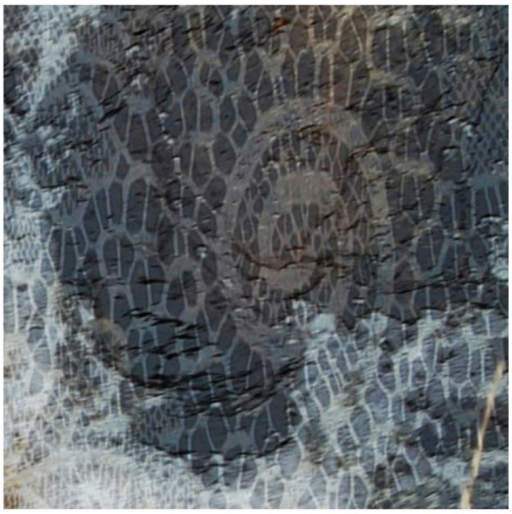

14.

Printed acoustic panels for student counseling rooms, Newton Building, Nottingham Trent University


R8
In Use
The Stevenson Room


The Barnes Room
This room is named in thanks for the financial support to the University of Mr Eric Barnes OBE DL

Appendix - III: Publications

PARAMANIK, D., 2008. E_MOTIONAL PRINTS: exploring 'digital craft' for printed textile design through motion capture technology . In: Futurotextiel Conference 08: 2nd International Scientific Conference 'Textiles of the Future', Kortrijk, Belgium, 13-15 November 2008 .

PARAMANIK, D., 2008. New rhythms of pattern: generating textile print patterns through motion-sensing technology . In: 11th Generative Art 2008 Conference, Polytechnico di Milano, Milan, Italy, 16-18 December 2008.

PARAMANIK, D., 2008. Time|motion: a book review. Leonardo Journals. vol 41/2008 . (3, June)

BRIGGS-GOODE, A., TOWNSEND, K., BUTTRESS, J. and PARAMANIK, D., 2009. Capturing rhythm and space, EXHIBITION . In: Hong Kong Polytechnic and University, 1-31 December 2009

PARAMANIK, D., 2009.E-Motional Textile: Creating Electronic Patterns for Printed Textile Design by Integrating Motion Capture Technology. In: 15th International Symposium of Electronic Arts (ISEA), Belfast, Northern Ireland, 23 August-3rd September 2009.

PARAMANIK, D., 2009.Hybrid Print Patterns: Generating textile print patterns through open source programming languages and hand movements. In: Futurescan:Mapping theTerritory,Association of Fashion and Textiles Courses Conference, University of Liverpool, 17–18 November 2009..

PARAMANIK, D., 2010. Hybrid Print Systems: Creating printed textile designs through Motion capture, Visual programming language and Digital inkject printing technology.In: Create10 - The interaction design conference, Edinburgh Napier University, UK, 30 June - 2 July 2010

E-Motional Textile: Creating Electronic Patterns for Printed Textile Design by Integrating Motion Capture Technology

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Submission: 499

Abstract

In search of creating new visual imagery for printed textiles and finding an exploratory method of creating interesting print patterns, this research is inspired by pattern formation in natural sciences. Previous research investigating the use of digital technology in Textile Design by Bunce (1993), Briggs-Goode (1997), Townsend (2003), Carlisle (2005) indicate that it is able to support the creative process at the generative stage of idea development through to the production of the final artifact. In the context of such 'hybrid practice' in printed textile design this research introduces motion capture of hand movements as a generative method of producing spontaneous print patterns (Boden & Edmonds, 2009).

The focus of the study concerns how body movements such as; gestures in Non-verbal Communication (NVC) can be captured and expressed visually as print patterns. This investigation reviews motion-capture in the period before and after the invention of computers – the Pre and Post Computational period – and applies the ideas involved within those techniques. Thereby contextualizing futuristic textile print development by digitally translating invisible body movement data into a visible form. The central contribution of this research is it insights into a new sort of creative process, and a discussion about useful theoretical frameworks through which to understand this process. It contributes to future research of creating a 'real-time printed textile' where a performance could be translated and printed in real time although the participant and the printing system are based in two different geographical locations (Ascott, 1978).

Key words

hybrid textile prints, generative design, motion capture, gestures, interactive performance

Introduction

"The hybrid or the meeting of two media is a moment of truth and revelation from which new form is born. For the parallel between two media holds us on the frontiers between forms that snap us out of the Narcissus-narcosis. The moment of the meeting of media is a moment of freedom and release from the ordinary trance and numbness imposed by them on our senses."(McLuhan, 1964)

In the context of hybrid practice in printed textile design this project integrates two diversely emerging technologies such as motion-capture technology and computational programming, to generate textile print patterns from hand movements made in a conversation.

Although this paper aims purely towards printed textile patterns, it was found that patterns these days are not just limited to textile surfaces (Wollheim, Tietenberg & Schmidt, 2007), but they are being adapted in other design fields such as Architecture, Product design and Visual communication. It has also been incorporated in Dance & performance art to impregnate the visual properties of a performing body towards creating a spectacle. So in a broader sense the research contextualises motion capture and its integration to produce an artifact in Art & Design.

In 'Pre-Computational period' photography as a method was used to capture performed movement (Marey, 1914 & Muybridge, 1887); therefore the outcomes were often two-dimensional photographs, which inspired artists to create futuristic paintings (Duchamp & Balla, 1912). With the introduction of electronic stroboscope it was possible to capture body movement that could be visualised as a three dimensional form (Edgerton, 1950).

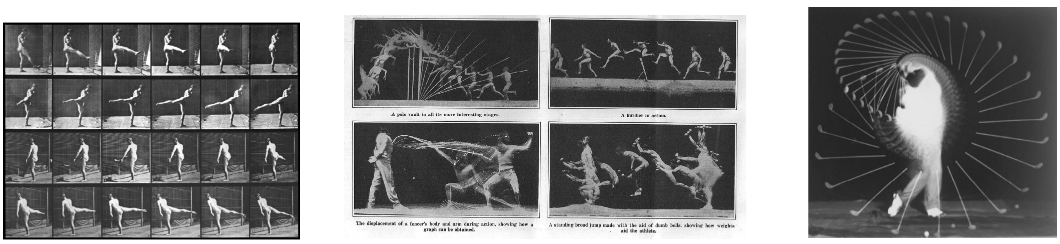


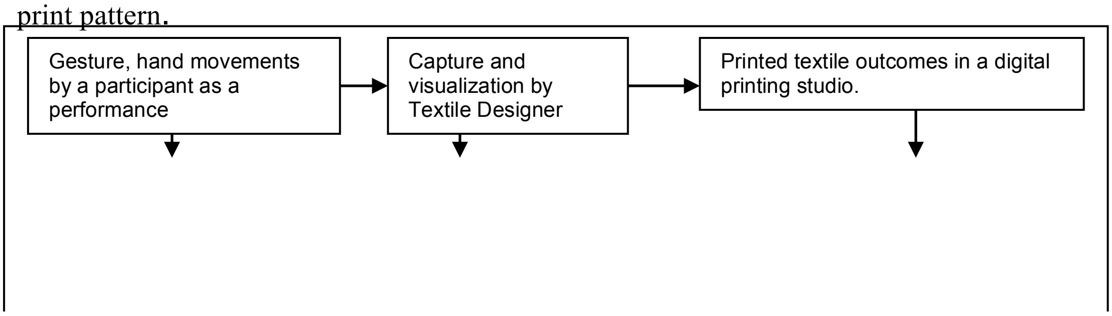
Figure 1. (a) Eadweard Muybridge "Animal Locomotion. Plate 99. First Ballet Action. [M.370] Copyright, 1887. (b) Etienne Jules Marey, Chronophotographs from "The Human Body in Action," Published in Scientific American, 1914. (c) Dr Harold Edgerton, Densmore Shute Bends the Shaft, 1938

With the introduction of the computer (ENIAC) in 1914, in 'Post-Computational period' movement patterns captured and created by computational programming could be plotted in two dimensions (Henry, 1960 & Noll, 1966), or by integrating rapid prototyping methods with motion capture using sensors it could be produced as a three-dimensional form (Rashid, 2004, Wanders, 2001 & FRONT Design, 2006). In Dance & performance art, motion capture integrated with digital projection of body movement patterns gave the audience a visual effect of a direct interface between physical and virtual bodies (Cunningham, 1999 & Troika Ranch, 2005). In fashion and textiles, integration of motion capture techniques and computation resulted in creation of virtual print (Morrow, 2004), virtually interactive dresses (Birringer & Danjoux, 2005), virtually animated dress forms (Harris, 2003), scanned movement incorporated photographic textile prints (Briggs-Goode, 1997), virtually transformed shapes as prints (Townsend, 2003) and algorithmically organic prints (Carlisle, 2005 & Reas, 2008).

In this paper motion capture and its integration to design printed textiles draws upon Roy Ascott's *Behaviourist Art and the Cybernetic Vision*, that states 'the role of the artist could be to provide 'a more or less empty receptacle (the canvas) into which the spectator can project his own imaginative world' (2003, p.128), and creates a passive designer whose role is to create an interactive space to enable the participant to perform and create print patterns by his gestures. The changing role of a textile designer demands a methodology to explore and understand the variables on which the final outcomes of the design are dependent and their implications.

Design method

With an aim to create a hybrid print, this design method comprises of three core stages that are Action, Process and Printing to capture gestures as data and transform it into textile print pattern.



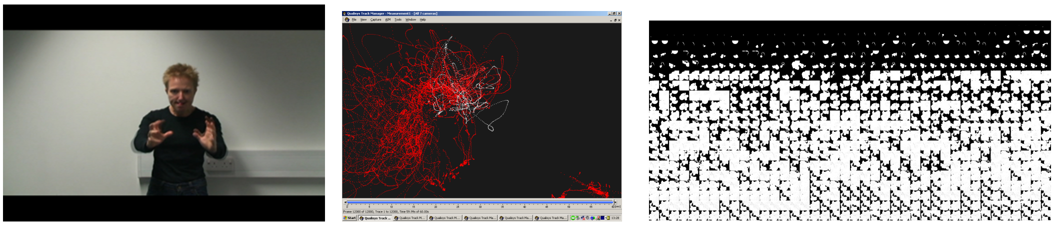


Figure 2. Hybrid print pattern generated by motion capture and processing

From an initial experiment that aimed to capture British Sign Language to translate ‘ The Tiger’ (Blake, 1794) as print pattern, it was found that the final print pattern is not entirely dependent on the hand movements by participant but also depends on post processing of the data into a vector form (Paramanik, 2008). So the design process was focused on to translate the captured marker positions to generate imagery. By writing a code in an open source programming language such as *Processing*, it was possible to translate the vector positions of the attached body markers into a form. The translated patterns were stored as individual image frames within a specified folder, which were later, sorted out by their file sizes and reorganised to print digitally on to textile base.

Analysis of the Outcomes

The final outcome of this translation, a hybrid print, is a non-representational form (abstract) in itself, but it represents that gestures could be translated to a visual form. Even if the same gestures were repeated, they would not produce same identical set of data resulting in a variation. Each variation would thus generate an individual print pattern. Digitally produced textile prints were always associated with mass-produced and precisely identical products but by using the above generative process we can produce hybrid prints that are individual.

In his seminal work *The Work of Art in the Age of Mechanical Reproduction* (1968), Walter Benjamin made an assumption that the very nature of art is defined by (among other things) the way in which it has been produced and materialized. By revisiting Benjamin’s notion, the project establishes that ‘digital craft’ is manifested in this work as a design method, which promotes the creation of hybrid print patterns through the process of motion capture and visualization of the captured data.

Conclusion and Future Research Direction

The hybrid design process explored within this paper supports the statement that digital medium facilitates the Textile Designer to create a generative method, an empty receptacle which will allow active interaction from audience to design. The computer and its peripherals including the software's used in the process dictate the print pattern outcome. In the process the final form does not retain the meaningful linguistic expression used in the conversation but it establishes that Digital translation can produce unpredictable forms, beyond our imagination. The project creates a base for playful human & computer interaction in producing textile prints.

The central contribution of this research is it insights into a new creative process, a discussion through theoretical frameworks through which to understand this process. It lays foundation for future research direction, which is textile print design in "real time process". It will look into the possibility of creating prints in future to translate Non-verbal Communication (NVC)(Argyle, 1988) visually as print patterns as a method of exploring 'digital craft'.

Acknowledgement

The research work is dedicated to my belated father Dr. S.C. Paramanik, and wishes to seek his eternal blessings. I am highly grateful of my Gurus, Dr Amanda Briggs-Goode, Dr Tom Fisher and Dr Katherine Townsend for their professional advice and guidance through my Doctoral Research in Nottingham Trent University.

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New Rhythms of Pattern: Generating textile print patterns through motion-sensing technology

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Abstract

In search of creating new visual imagery for printed textiles and finding an exploratory method of creating interesting print patterns, my interest in pattern formation in natural sciences has been a great stimulus. Previous studies investigating the use of digital technology in Textile Design by Bunce (1993), Briggs-Goode(1997), Treadaway(2006), Townsend(2003), Carlyle(2005) indicate that it is able to support the creative process at the generative stage of idea development through to the production of the final artifact. In the context of such "hybrid practice" in printed textile design this poster explores motion-sensing technology, to develop print patterns from hand movements used in conversation.

The focus of the study concerns how body movements such as; gestures in Non-verbal Communication (NVC) can be captured and expressed visually as print patterns. What kind of patterns can be generated out of these body movements? Can the patterns be transformed as printed textile patterns?

Introduction

1.1Context of Motion Capture in Art & Design

This investigation reviews motion-capture in the period before and after the invention of computers – the Pre and Post Computational period[9] – and applies the ideas involved within those techniques. The history of movement capture can be traced back to the late 1800's when Etienne Jules Marey[10] and Eadweard J. Muybridge[11] first performed motion studies of various animals and humans. Inspired by Marey's study of movement, Marcel Duchamp[13] and Giacomo Balla[14] produced their futurist[24] work, which depicted motion as painted on to a single frame. Dr Harold Edgerton[11], in the late 50's recorded movement that the unaided eye could not see with his development of the electronic stroboscope, Edgerton set into motion a course of innovation centered on a single idea making the invisible visible.

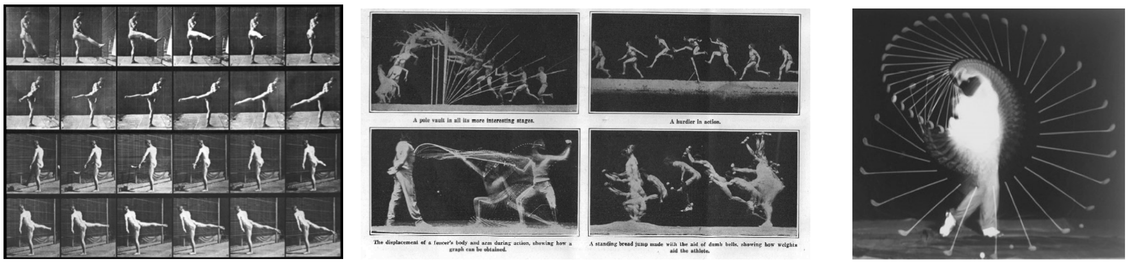

Fig 1: (a) Eadweard Muybridge "Animal Locomotion. Plate 99. First Ballet Action. [M.370] Copyright, 1887. (b) Etienne Jules Marey, Chronophotographs from "The Human Body in Action," Published in Scientific American, 1914. (c) Dr Harold Edgerton, Densmore Shute Bends the Shaft, 1938

The “Post-Computational period” captured movement as data using computer technology. The use of sensors added a new dimension to the process. Data could be captured from invisible sources and transformed to a visible and tactile form almost instantly.

For instance Karim Rashid’s “Mutablob”[15],Marcel Wander’s[16] and FRONT Design’s[17] products are a result of capturing invisible movement and its translation into a three dimensional tactile form which is later produced by rapid prototyping methods[26].

Then there are some recent notable commercial applications of movement technology, the Nintendo Wii and Apple’s iphone. By employing gesture-sensing controls they have changed the way we operated mobile phone and played video games.

In the field of Fashion & Textiles, Hamish Morrow’s S/S 2004[18] catwalk show and the ‘telematic dress’ by Johannes Birringer and Michele Danjoux[19] embrace these new movement capture technologies and explored them to represent their new ideas. While Morrow captured digital light reflections from a model’s body movements and projected them on to garments as virtual prints, the ‘telematic dress’ captured body movements of a performer to interact with another in far away location. Similarly 1 of 1 design studio creates one-of-a-kind, made to order apparel, “The Tissue Collection”, designer Cait Reas worked together with C.E.B. Reas to generate the Tissue images by defining algorithm and translating them into images with code and software which was later printed digitally to fabrics. The outcomes of all these projects are interlinked by the context of body movement capture and application in Fashion & Textiles.

These studies show that a range of types of movement can be captured and transformed with digital technology into various two-dimensional and three-dimensional forms expanded into their applications i.e. Phones, games etc. As Gen Doy says in the context of Interdisciplinary Research:

"Should the outcomes (product) be functional…they would start 'conversations' for sure …isn't it a new function."[20].

The above context creates a space for a futuristic textile print development by digitally translating invisible body movement data into a visible form. It also lays foundation for a "real-time print process" where a performance could be translated and printed simultaneously although they are based in different geographical locations.

1.2 Generative Textile Print Design System

The proposed print design system uses computer vision to capture body movements in a conversation as binary data and translates it into a vector path. By using available assorted brushes such as line, dot, etc. in a vector software (Adobe Illustrator) the vector path could then be transformed to a continuous pattern.

The system introduces movement capture and transformation of hand movements as a generative [21] method of drawing print pattern. This system allows a "self" to interact with a computer through their body movements to create spontaneous print patterns.

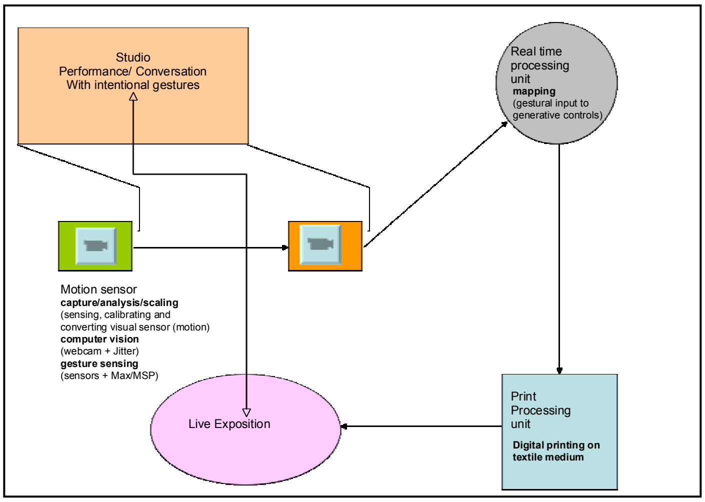

Fig 2: Diagram representing Generative Textile Print Design System as an exposition

The above diagram proposes to a stage of performance where the performer uses his body movements to create a textile print pattern. Even if the performance were repeated again it would not produce same identical set of patterns. Digitally produced textile prints were always associated with mass-produced and precisely identical products but by using the above generative process we can produce "one-off" textile prints that are never repeated.

In his seminal work "The Work of Art in the Age of Mechanical Reproduction" [22], Walter Benjamin made an assumption that the very nature of art is defined by (among other things) the way in which it has been produced and materialized. By revisiting Benjamin's notion, the project establishes that "digital craft" is manifested in this work as a design method, which promotes the creation of print patterns through processes of digital data capture and its transformation to a visual form.

Design Process

2.1 Capturing hand movements used in British Sign Language

The design process initiates with the translation of a poem in British Sign Language (BSL). Etymologically, "translation" means, "carrying across" or "bringing across." In this experiment the poem is 'carried' from one convention (English literature) to another (BSL) to then be further 'carried' to a machine language to make a print pattern. The final outcome of this translation is non-representational form (abstract) in itself. The form (Fig 4) does not convey the meaningful expression used either in the poem or in the BSL interpretation but creates an expression, which stands for itself. It represents a possibility that a poem could be translated to a visual form. If so does the form represent continuity in communication like the poem and the sign language intended to do. What does it communicate? Is it legible? Visually the form is a composition of fine curvaceous lines and it can be perceived as a silhouette in motion only in relation to the video film that represents BSL recitation. The BSL recitation can be understood in relation to the poem and the poem can only be understood in relation to its literature context. This relation puts forward an ontological enquiry if the form actually means or relates to something. Within the formal boundary of Textile Design "communication is not the explicit intention and that the decision is made purely upon aesthetic pleasure derived from them" (Briggs-Goode, Pg192) [2]. But in this project the patterns are a result of a continued communication and in order to make sense it should also continue communicating the translation.

2.2 Visual Capture, Transformation and Analysis of the pattern

The experiment used a HDD camcorder attached to the computer (computer vision) to capture the entire sign interpretation of the poem as a film, which is simultaneously divided into frames at the rate of 29F/ sec.1 (Fig 5). The generated frames are then saved individually in TIFF (Tagged Image File Format) in a single folder location so that they can be processed to trace finger movements as a vector path. The LiveTrace tool in Adobe Illustrator was found competitive to convert these TIFF images into editable vector paths.

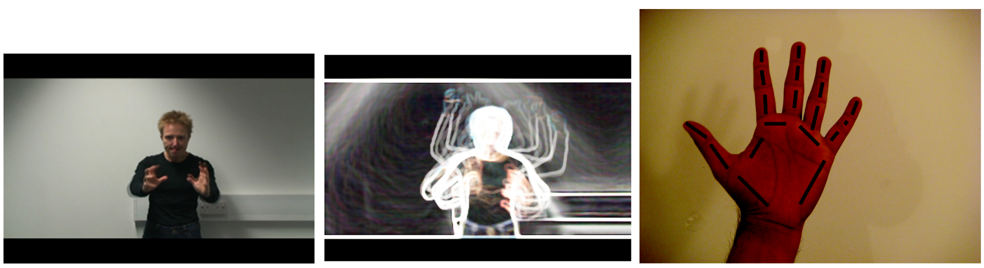

Fig 5: (a) Video film (b) Video movement tracking (c) Tracking movement

The above figure illustrates the process of tracking movement in a film. The set of tracked finger movements, which were generated as scattered lines, were then blended seamlessly by vector blending tool to generate an un-repeated pattern (Fig. 7). This particular pattern represents the first verse of the poem…

"Tyger! Tyger! Burning bright,

In the forests of the night,

What immortal hand or eye

Could frame thy fearful symmetry?"

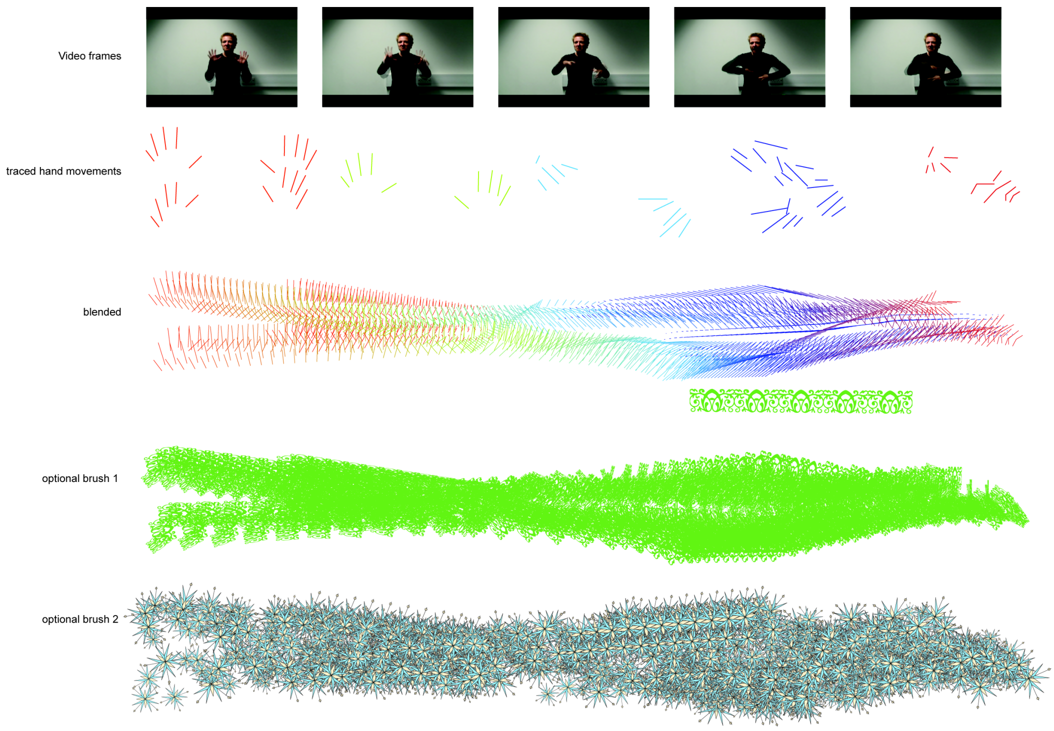

Figure 7: Pattern generated by Hand Movement Tracking

2.2.2 Visual Analysis of the pattern

Visual analysis (Semiotics is the study of sign processes (semiosis), or signification and communication, signs and symbols, both individually and grouped into sign systems. It includes the study of how meaning is constructed and understood.) by eminent semioticians such as Ferdinand de Saussure, Charles Sanders Pierce, Roland Barthes and Charles Morris, have explored images/ text, into categories, which relate to language, image and meaning. This project uses Pierce's triadic method of index, icon, symbol to enable the analysis of the printed pattern, for any semiotic significance they would have, to evaluate their communicative ability.

(a) Icon: As an Icon(… a sign that denotes its object by virtue of a quality which is shared by them but which the icon has irrespectively of the object) the form resembles closely to Boccioni's Fist (post modern futuristic sculpture) produced by Balla in 1914 (Fig:8). In this context the generated pattern represents a dynamic, energetic and ferocious subject (The Tiger) in digital media notation. It also signifies that digital translation can lead to visually unpredictable form.

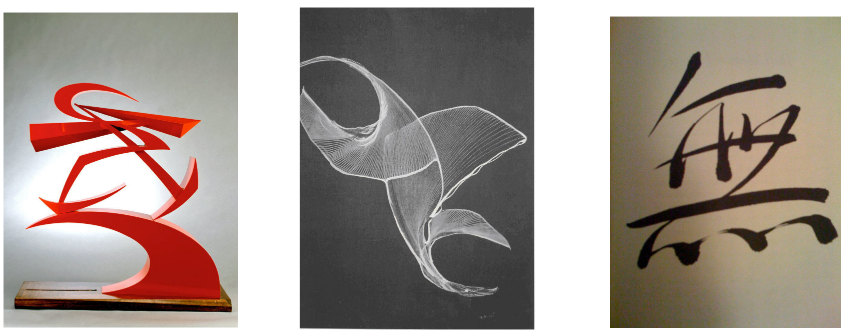

Figure 8: (a) Boccioni's Fist produced by Balla in 1914 (b) Dr. Desmond Paul Henry, Picture by Drawing Machine 2   (c) Mu, Emptiness in Japanese

(b) Index: As an Index (…a sign that denotes its object by virtue of an actual connection involving them, one that he also calls a real relation in virtue of its being irrespective of interpretation) the pattern represents digital expression. If compared to (Fig 8 bPaul Henry's Picture by Drawing Machine 2) the linear form resonates that the pattern is drawn by a compter. It communicates the poem in BSL interpretation as Art, whose meaning resides in the process of translation.

(c) Symbol: As a Symbol (… is a sign that denotes its object solely by virtue of the fact that it will be interpreted to do so.) Its close resemblance to Japanese script (Fig 8 c: Mu, meaning emptiness) explains that although the pattern is abstract in nature, it can possibly have a literal meaning that could represent "The Tiger" in a new visual sign language (digital media).This analysis finds the generated pattern as an art form that signifies digital translation can lead to visually unpredictable form, whose meaning resides in the process of translation and it can have a literal meaning that could represent the subject in a new visual sign language (digital media).

Conclusions & Future Research Directions

The unique design process explored within this poster supports the statement that digital medium allows the creative process from the generative stage to the final artefact. The generative stage in this case is the translation of the poem in BSL and its video film capture. The computer and its peripherals including the software's used in the process dictate the print pattern outcome. In the process the final form does not retain the meaningful expression used in the poem and its BSL interpretation but it establishes that Digital translation can produce unpredictable forms, beyond our imagination. The project creates a base for playful human & computer interaction in producing textile prints.

The central contribution of this poster is it insights into a new sort of creative process, a discussion about useful theoretical frameworks through which to understand this process. It lays foundation for future research direction, which is textile print design in "real time process". It will look into the possibility of creating prints in future to translate Non-verbal Communication (NVC)[8] visually as print patterns as a method of exploring "digital craft".

Acknowledgements

The research work is dedicated to my belated father Dr. S.C. Paramanik, and wishes to seek his eternal blessings. I am highly grateful of my Gurus, Dr Amanda Briggs-Goode, Dr Tom Fisher and Dr Katherine Townsend for their professional advice and guidance. I would also like to thank Elvira Roberts for her professional assistance in translating "The Tiger" in British Sign Language.

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[24] The Futurist Manifesto, written by the Italian poet Filippo Tommaso Marinetti, was published in French in Le Figaro on 20 February 1909. It launched an art movement, Futurism, that rejected the past; celebrated speed, machinery, and industry; and sought the modernisation and cultural rejuvenation of Italy. Influenced by it Giacommo Balla adopted a style creating pictorial depiction of light, movement and speed.

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E_MOTIONAL PRINTS: Exploring “digital craft” for printed textile design through motion capture technology

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ABSTRACT

Previous studies by Bunce[1], Briggs-Goode[2], Treadaway[3], Townsend[4] and Carlisle[12] investigating the use of “digital technology” in Textile Design indicate

that it is able to support the creative process at the generative[5] stage of idea development through to the production of the final artifact. In the context of such "hybrid practice" in printed textile design this ongoing research explores image capture method, to develop print patterns from hand movements used in translating William Blake's noted poem "The Tiger"[6] in British Sign Language (BSL)[7]. Will the generated print pattern reveal a "new form" that can represent "The Tiger" itself? If so can it be compared to the conventional form of "The Tiger". The project thus aims to bridge the gap between a digital transformation and its outcome.

Can such methods be used further to translate Non-verbal Communication (NVC)[8] visually as print patterns?

This method will formulate a new way of creating print patterns, empowering the print design process by introducing individuality into the final product as a method of exploring "digital craft".

1. INTRODUCTION

1.1 Context of Movement Capture in Art & Design

This investigation reviews movement captures in Pre and Post Computational period[9] and analyses the ideas involved within those techniques. The history of movement capture can be traced back to the late 1800's when Etienne Jules Marey[10] and Eadweard Muybridge[11] first performed motion studies of various animals and humans. Inspired by Marey's study of movement Marcel Duchamp[13] and Giacomo Balla[14] produced their futurist work, which depicted motion as painted on to a single frame. Dr Harold Edgerton[11], in late 50's recorded movement that the unaided eye could not see such as: a bullet seen the instant it explodes through an apple, a perfect coronet formed by a milk-drop splash.

The “Post-Computational period” captured movement as data using computer technology. The use of “sensors” added a new dimension to the creative process. Data could be captured from invisible sources and transformed to a visible, tactile form almost virtually.

For instance product designer, Karim Rashid’s “Mutablob”[15],Marcel Wander’s[16] and FRONT Design’s[17] products are a result of 3D movement capture as a phenomenon and translated into a tactile product using rapid prototyping technology.

Then there are some recent recognisable applications of movement technology, the Nintendo Wii and Apple’s iphone. They have changed the way user-interaction could be.

In the field of Fashion & Textiles, Hamish Morrow’s S/S 2004[18] catwalk show, Johannes Birringer and Michele Danjoux "telematic dress"[19] project embrace these new movement capture technologies and explored them to represent their “fururist” ideas.

As it is evident by the above studies that “movement” as a phenomena can be captured from different forms and now with the possibility of digital technology can be transformed to various forms such as 2D, 3D etc.

Should the outcomes (product) be functional…they would start “conversations” for sure …isn’t it a new function. – Gen Doy[20].

1.2 E_motional Print Design System

In the field of Textile Design “E_motional Prints” introduces movement capture and transformation of the traced movements into a print pattern. It translates body movements into virtual forms in any given time and space. Hence this system allows a "self" to interact with a computer through their body movements to create spontaneous patterns.

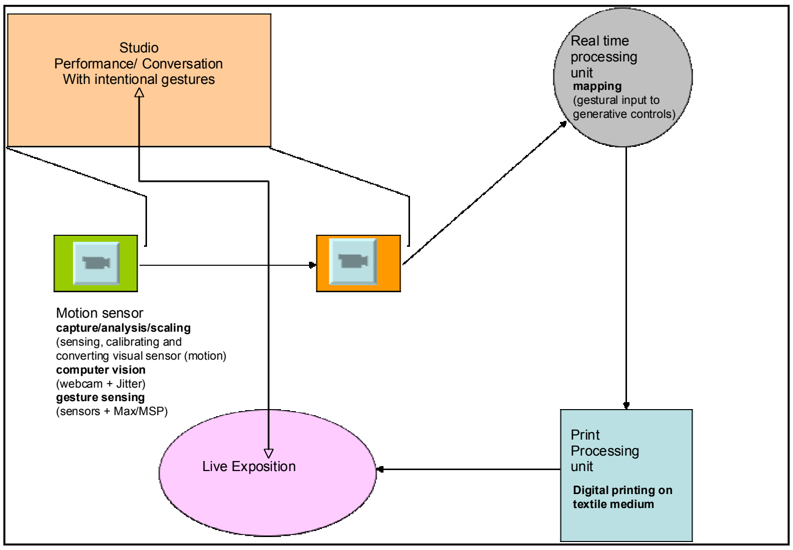

Figure 2: Diagram representing "E_Motional Print" Design Process

The program is generative[21], where the performer is not trained as a textile designer but their body movements constitute basic blocks of textile print patterns. Even if the performance were repeated it would not produce same identical set of patterns. The process thus empowers Textile Design by introducing individuality into the final product.

By revisiting Walter Benjamin's notion[22], the project establishes that "Digital Craft" is manifested in this work as a design method, which promotes the creation of print patterns through processes of digital data capture and transformation in a real time process.

It argues Benjamin's notion of "aura" that the emotional content of digitally produced artifacts reside in the process and concept of making it.

2. DESIGN PROCESS

2.1 Translation of "The Tiger" by British Sign Language Interpreter

The process begins with the translation of William Blake's noted poem "The Tiger" in British Sign Language(BSL). Etymologically, "translation" means "carrying across" or "bringing across." The translation of the poem in this experiment is "carrying across" over from one convention (English literature) to another (BSL) which would then be further "carried over" to machine language (print pattern). The final outcome of this translation is un-representable (abstract) in itself because it has been deconstructed and reconstructed in very different language platforms. The form does not retain the meaningful expression used neither in the poem nor in the BSL interpretation but presents a "neo virtual" form (Fig 4).

Can this process be classified as a " translation" then? Yes, it can be justified as a translation. Just as linguistic translation ranges over words, this digital translation gathers its meaning from its embedded cultural (Post Computational Period) use in the deeper sense of a Heideggerian *zuhanden*[23]. Heidegger (1971) perceived with great force that an ontology founded on phenomenological description cannot see objects merely as things but must call into presence the expanding circle of cultural and existential significance.

2.2 Capture and Transformation of the Image

2.2.1 Processing the output

The experiment uses a SONY-HDD camcorder attached to the computer to capture the entire “interpretation” as a film, which is simultaneously divided into frames at the rate of 29F/ sec. using Adobe Premier Pro CS4 edition (Fig 2). The generated frames are then saved individually in TIFF file format in a specific file/ folder location.

Figure 2: Video filming

Figure 3: Video movement tracking

The saved folder at a later stage is batch processed for Live Tracing option in Adobe Illustrator CS4 edition (Fig 5). The out come of the process is an outline tracing of the body movement in each individual frame layered on top of one another (Fig 4).

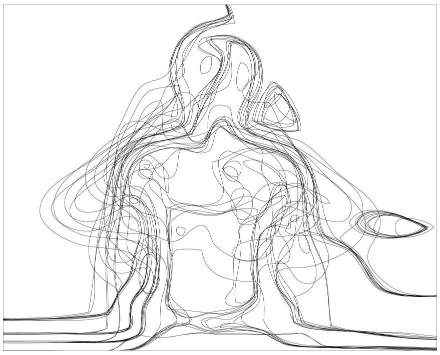

Figure 4: Out line tracing of the Body movement

Figure 5: Tracing Preset in Adobe Illustrator CS4

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/collection1 {
        /attributes {
                /collectionName [ 7
                        64656661756c74
                ]
                /adobe.tracing.mode 1
                /adobe.tracing.ip.blur 0.0
                /adobe.tracing.ip.threshold 128
                /adobe.tracing.ip.palette [ 0

                ]
                /adobe.tracing.ip.maxcolors 4
                /adobe.tracing.tracing.fills 1
                /adobe.tracing.tracing.strokes 0
                /adobe.tracing.tracing.maxstrokeweight 10.0
                /adobe.tracing.tracing.minstrokelength 20.0
                /adobe.tracing.tracing.pathtightness 2.0
                /adobe.tracing.tracing.cornerangle 20.0
                /adobe.tracing.tracing.minimumarea 10
                /adobe.tracing.output.livepaint 0
                /adobe.tracing.output.outputtoswatches 0
                /adobe.tracing.output.ignorewhite 0
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/Sketch {
        /Version 0
        /Description (Adobe Tracing Presets)
        /Owner ()
}
/NumberOfCollections 1
/CatalogName (AI12 Gallery Save Collections)
```

2.2.2 Transformation and manipulation of the vector output

The individual vector files, which were generated by capture process, are then manipulated to generate a continuous un-repeated pattern. The manipulation in this case is changing the file format and placement of the individual image in a single continuous chain.

Although using computer peripherals, such as the software (Adobe Illustrator) dictates the final outcome but contributes to the emerging visual language[2].

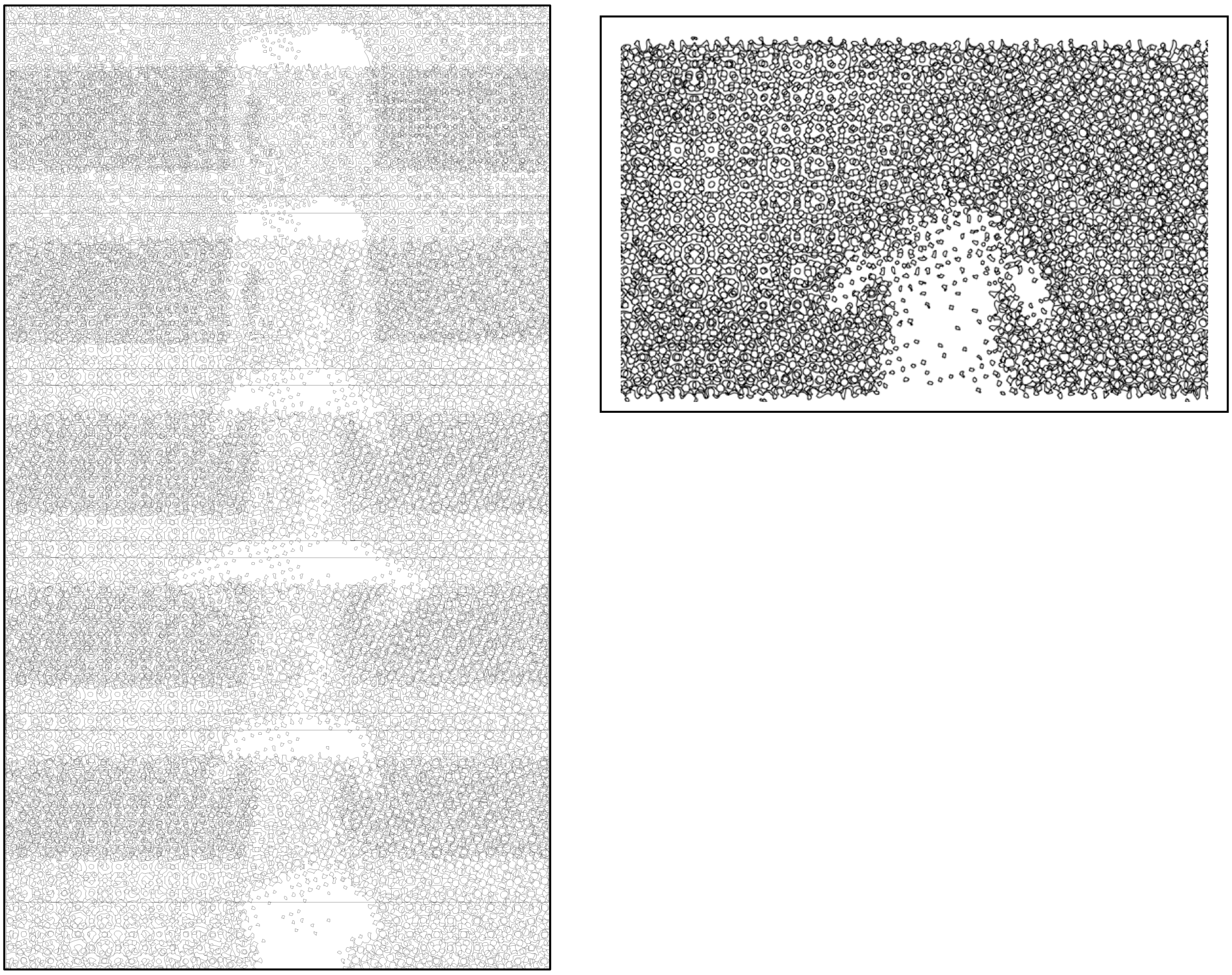

Figure 5: vector manipulation of the Body movement

3. CONCLUSIONS & FUTURE RESEARCH DIRECTIONS

The unique design process explored in this paper supports the statement that digital medium allows the creative process at the generative stage to the final artifact. The generative stage in this case is the translation of the poem in BSL and its video film capture. The computer and its peripherals including the software's used in the process dictate the print pattern outcome. In the process the final form does not retain the meaningful expression used in the poem and its BSL interpretation but amuses the audience with a surprise. It establishes that Digital translation can produce unpredictable forms, beyond our imagination. The project creates a base for playful human & computer interaction in textile design.

It lays foundation for future research direction which is textile print design in "real time process".

This method will be used further to translate Non-verbal Communication (NVC)[8] visually as print patterns as a method of exploring "digital craft".

ACKNOWLEDGEMENTS

The research work is dedicated to my belated father Dr. S.C. Paramanik, and wishes to seek his eternal blessings. I am highly grateful of my Gurus, Dr Amanda Briggs-Goode, Dr Tom Fisher and Dr Katherine Townsend without whose supervision and guidance this project would not have seen the daylight.

I would also like to thank Elvira Roberts for her professional assistance in translating "The Tiger" in British Sign Language.

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