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TITLE:

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This paper investigates whether or not virtual representations can support remote collaboration within the fashion industry using a **T**extual **V**irtual **T**angible **M**ulti-touch (TVTM) system. The software interface for the TVTM system was developed from the results and feedback from a previous study. Two different types of multi-touch technology were deployed for the case study. The paper then covers the nature of the user testing and how it addresses the hypothesis developed from our pilot study, and team expectations of the participants' selections of a variety of methods to complete their task. The paper presents the data we collected from the user testing including correlation between various different representations, time taken to finish the task and the difficulty ratings for the three levels of representation. The paper concludes by validating our hypothesis against our findings, and looks at some improvements to the current system and some potential features that might be considered for our next prototype.

AUTHOR KEYWORDS

Usability Testing and Evaluation, User-centred design, collaboration, tangible interface, multi-touch, gestural interface, natural user interface

ACM CLASSIFICATION KEYWORDS

H.5.2 User Interfaces (D.2.2, H.1.2, I.3.6): Evaluation/methodology, Graphical user interfaces, Input devices and strategies, Interaction styles, Prototyping, Screen design, User-centred design.

INTRODUCTION

In a distributed manufacturing process such as the fashion industry, designers have to give clear instructions and pass intermediate products back and forth between factories in order to make sure designers and manufacturers agree on expectations about aspects of the final product. Hence, it is vital that there is minimal error in communications. It may take up to nine months to design an entire new season's range of clothing before it appears on the retailer's shelves.

The fashion industry may have a glamorous and trendy look but, behind the scenes, the technology used in the clothing industry has not kept pace with recent trends in Information and Communication Technologies (ICT). Competition forces all firms to transform and as Sheehan pointed out, the new ICT and the processes of globalisation have already changed the face of manufacturing (Sheehan, 2000). The computing demands have increased dramatically and such demands have also given rise to new computing technologies. Users now have the option to utilize a variety of new tools such as tangible or gesture input to navigate, access and manipulate data presented by a computer. Designers often use physical manipulation of items to compare various design ideas, or try different fabrics and colours to suit a particular design. It is important to use these emerging technologies to enhance the current design practices, rather than significantly alter the design process.

Figure 1. Two fashion design students collaborate on a design exercise using the TVTM system.

The aim of this case study is to examine how current technology can assist distributed manufacturing processes with remotely located facilities to function as effectively and efficiently as if they are in the same location.

The concept of creating a combination of textual, visual and tangible interface, rather than the traditional Graphical User Interface (GUI), is making designers' work as natural as possible. This research will focus on, but not be limited to the fashion industry as the concepts could equally apply to any distributed processes.

TVTM SYSTEM

Previous work
Previously, we have identified issues regarding different modes of interaction, such as the manipulation of physical artefacts, as opposed to textual, visual or tangible encoded virtual representation of these artefacts. We also identified collaboration issues in the textile industry through interviews and observational studies, in terms of classification of context in a fashion design environment.

Software interface
Based on our pilot studies of collaboration, and the use of currently available technologies in a fashion design environment, we developed a prototype multi-touch interface which may prove helpful in the collaborative process. The early prototype multi-touch interface was developed to investigate the three modes of interaction; textual, visual and tangible, and to determine whether multi-touch interactions that better represent physical artefacts would be more beneficial within a clothing design environment than a traditional digital interface.

The multi-touch interface has the following three types of virtual representations for the case study:

Textual – the designers can add hand written notes and sizing specifications for particular parts of the garments. For example, the designers can add specific sewing order instructions for the more complex and difficult sewing task of the stripes associated with the pockets of the garment, a typical example shown in Figure 2. In a virtual representation at this level, the designer would be able to input textual and numeric data (measurements) to the design notes.

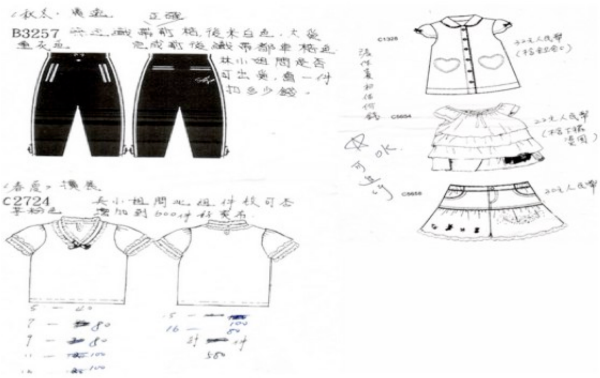

Figure 2. Design specification and notes.

Visual – In order to create a new colour pattern to suit a particular design, the designers will be able to scan actual fabric samples into a computer then manipulate the colours and produce a new pattern in a digital format as shown in figure 3. Additionally, designers may take a digital "snap-shot" of an item to illustrate a particular sewing instruction to the manufacturer. A typical example of this is the folding of the fabric shown in Figure 3. For the virtual representation at this level the designer would have access to databases of the available fabrics, patterns and textures, and illustrative tools to demonstrate folding or similar manufacturing instructions.

Figure 3. Digital photograph showing complex sewing procedure.

Tangible –During the design phase of a garment, designers may need to change the sizes or rotate logos for certain designs, and also perform numerous other prototyping tasks including cutting and taking measurements. Virtual representation at this level could reduce the need for prototyping the garment over and over again. It would also involve the use of virtual tools such as virtual scissors, or virtual measuring tools to perform these prototyping tasks.

Hardware
The TVTM system used for the case study was deployed in two different multi-touch tables using different multi-touch technologies. The first multi-touch technology that we have adopted is based on an optical multi-touch methodology called Frustrated Total Internal Reflection (FTIR) (Han, 2005) developed by Jeff Han. Our multi-touch technology uses revised and updated version of this technology known as Diffused Surface Illumination (DSI) (NUI, 2009), made possible by the development of new acrylic materials. The second type of multi-touch technology is called Laser Light Plane (LLP) which is developed by Alex Popovich; a NUI-community member. In order to link the two multi-touch tables, a java server; Flash Open Sound Control (FLOSC) extension (Chun 2002) was used to act as a gateway for Open Sound Control (OSC) (Wright 2002) and Flash, to pass finger touches/blob co-ordinates between 2 multi-touch tables via a LAN cable.

USER TESTING
The purpose of the user testing is to find out which type of representation; textual, visual or tangible should be used when, for what and for whom.

Our hypothesis stated that: "for a given problem, there may be many instances where simple textual encoded representation of the data may lead to a resolution of the problem. If insufficient digital data is presented in the first instance, and a problem persists, visual encoded representation may be sufficient to allow a resolution of the problem. If the problem persists and cannot be resolved the next step is to potentially show the solution, and this may well need the data to be presented at a higher level - either visual encoded or tangible encoded information".

The amount of time to compile the written data compared to the time required to visually present the solution may well mean that it is more time efficient to present the data at a higher level even if it were possible to solve it with simpler representation.

We conducted our user testing with a group of female students in their second and final years of their fashion design course at a local TAFE collage. There were twenty participants in total and each user testing session was conducted with two participants, giving ten groups in total.

The multi-touch interface was evaluated with a scenario based collaborative task. The estimated time to complete the task was set to 5 minutes. Both participants were given a same task to complete, which involved either locating three different shirt designs from the database, or creating three new designs, and deciding which design they like best and least. The participants were shown a short video clip detailing the functionality of the interface, and operating instructions prior to each user testing session. The participants were encouraged to "think out loud" during the entire session, and the interaction between the participants was studied during the testing session.

We discussed the various methods we expected the candidates to select to complete the task. Some possible examples of the selection of representations might be:

1. using text based chat to ask the other participant's preferences on the selected best and worst design.

2. using predefined shapes to either circle or put a cross to their selected best and worst design..

3. using textual based annotations indicating their selected best and worst design..

4. moving designs into groups indicating their selected best and worst design.

We evaluated the effectiveness of our interface through a short survey containing two kinds of questions; six questions with rating scale of 0 to 5 for our quantitative analysis, and six open ended questions for our qualitative analysis for our future design. Participants were asked to undertake this short survey immediately on completion of the user testing.

In this case study, the focus was on two aspects of the usability of the TVTM system; the efficiency of completing the task, and the effectiveness of the system which was graded by the participants on a 5-point Likert scale: (1 – Very Hard, 2 – Hard, 3 – Average, 4 – Easy, 5 – Very Easy).

Results and Evaluation

Table 1 shows the relationship between the total amount of time each group required to complete the task, and the rating scale measuring the difficulties for the overall communication between participants at any time while collaborating on the task.

Group	Time taken to complete the task	Average Grade	Difficulties
Group 1	0:05:28	3	Average
Group 2	0:04:15	5	Very Easy
Group 3	0:04:03	5	Very Easy
Group 4	0:04:58	5	Very Easy
Group 5	0:05:49	3.5	Average
Group 6	0:04:56	4.5	Easy
Group 7	0:04:48	3.5	Average
Group 8	0:05:14	3.5	Average
Group 9	0:04:47	5	Very Easy
Group 10	0:05:22	4	Easy

Table 1: Time taken for each group to complete the task and how participants rated the overall difficulties communicating while collaborating on the task.

According to our data in Figure 4, 60% of the participants finished the task in less than 5 minutes, and 40% of the participants found it very easy to communicate with other participants while collaborating on the same task. Conversely, 40% of the participants who took more than 5 minutes to complete the task found it neither easy nor hard to communicate with their allocated partner while collaborating on the task. Overall, 70% of the participants found it easy to use the system.

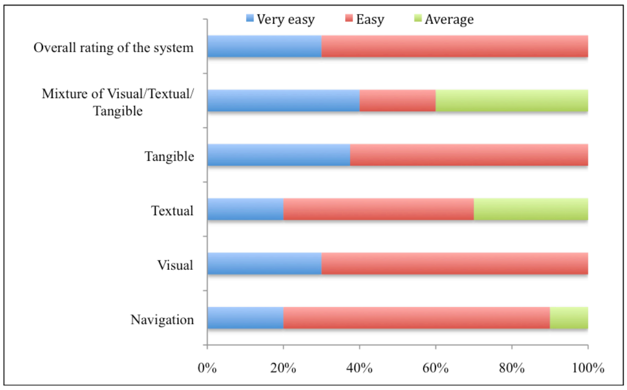

Figure 4: Difficulties ratings rated by the participants.

The correlation between the participants' choice of either textual, visual and tangible representation while collaborating on the task is somewhat significant. For 7.5 out of 10 pairs of participants, these differences did not occur by chance. The nature of the task required the participants to select either textual, visual or tangible representations, or a combination of any of the three representations to complete their task. Significantly, only a minority of the participants did not make the selection of textual, visual or tangible representations, or a combination of any of the three, based on suitability for the task, instead making only random selections.

From our survey results, 95% of the participants thought it might be a good idea to have a basic tutorial and help features on how to use the TVTM system. 95% of the participants felt that it was easy to understand how the system was interpreting their interaction with another participants while collaborating on the task.

We observed some interesting behaviour and interactions while the participants were working on the task. The task required both participants to decide which designs they like best and least. It was expected that the majority of the participants would use textual representation initially, then move on to visual and tangible representation. The results show that 90% of the participants used a combination of textual, visual and tangible interactions.

We observed a group use the system to complete the task in a manner which we had not anticipated. Participant A verbally mentioned to participant B that she liked a particular design. Participant B was uncertain which particular design participant A liked, so participant B put a question mark on each design. Participant A then selected the particular shirt design, and holding down their finger, 'wiggled' the design up and down to get the visual attention from participant B while saying "*I like this one best*". Participant B then immediately knew what participant A liked and agreed with that decision. This was unexpected, and showed the system allowed intuitive and natural interactions between the users, as this would reflect how the participants would potentially interact with physical garments.

CONCLUSIONS AND FUTURE WORK

Our results confirmed our hypothesis. We observed the users explore lower levels of representation first before choosing a higher level of representation, such as a combination of visual & tangible virtual representation to quickly acknowledge or respond to a task or problem. There is a strong correlation between the time taken to complete the task, the degree of difficulty users experienced for overall communications while collaborating on the task, and the selection of either textual, visual and tangible virtual representations. Some slight uncertainty may exist owing to the possibility that a small number of users may have randomly chosen any of those three levels of virtual representations for their task during our user testing. Our observations and the experimental data obtained suggest that textual, visual and tangible virtual representations could support and enhance remote collaboration.

The next step is to develop a second version of prototype incorporating additional features such as basic tutorial and help functions highlighted in the survey feedback. The system also requires the development of some form of token passing mechanism that allows a given machine to have priority while it is editing the content. We would also like to attach webcams to each machine so that the users can scan physical artefacts such as fabric, or accessory such as zips or buttons, and import them as 2D or 3D images. Additionally we would like to explore voice recognition with gesture input such as Gesture Pendant (Krum et al., 2002) and gesture based 3D inputs like POGEST (Yunde et al., 2007) to replace the traditional "point-and-click" interaction for our system.

In order to minimise the tendency to give very similar results from using the Likert scale for our survey, we will try out a desirability toolkit called Product Reaction Card developed by Benedek and Miner from Microsoft (Benedek et al., 2002) to evaluate our next prototype.

Our ultimate goal is to develop a new form of embodiment that utilises our senses as a smart interface that supports interactions in a real context using an iterative process of data collection from field studies, device design, prototyping and evaluation.

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