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Enhanced gesture capture in virtual interactive space (VIS)

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Abstract

This article reports on the capture of human movement information which is made possible from a commercially affordable and readily available technology complimented by a simple enhancement which results in an extended *virtual* volume of 3D high resolution activated air being created and available for intervention as a basic computer interface. Through examples presenting the use of the methodology in performance art, education and human performance projects, this article hints at the opportunities from such a methodology so as to inspire others to explore the potential use in human computer interaction (HCI).

Keywords: embodied interaction, presence, sensors

1 Introduction

SoundScapes is a body of research which includes the creation of an intuitive natural interaction to digital technologies which gives opportunity of expressive freedom through the arts. This is through gesture and body function which inputs 'change' data to a system that is immediately responsive through causal interaction.

This article informs on just one element of the body of research titled *SoundScapes* which the author has been developing since the early 1990s. The holistic body of work has parallel connotations in contemporary performance art, installations, and human performance (therapy and rehabilitation) which are briefly overviewed in the closing sections. Further details are available on the *SoundScapes* website.

1.1 History 1920

The creation of electronic music through gesture has been around since the days of the Russian pioneer and physicist Leon Theremin. His main creations, the Theremin and the Terpsitone, are based on the principle of movement within an electromagnetic field producing a monophonic tone with pitch and amplitude being determined by body conductance proximity. His best known creation that he named after himself has been used in hit music recordings and film sound effects where a small hand movement creates a unique analogue tone manipulation in immediate response.

The lesser known Terpsitone system which Leon Theremin created for his dancer

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to control sounds and visuals by whole body gesture is more specific to this article and the recent *SoundScapes* body of research (Brooks 2003) which utilize modern day equivalent systems to that implemented by Theremin.

1.2 The technology 2004

Commercially available volumetric 3D infrared sensors are used which are stand alone units or inbuilt to equipment created for use by performing artists, disk jockeys (DJs) and video jockeys (VJs). These were originally created by DeFranco in the early 1990s for Interactive Light Corporation and called ‘D Beam’ (or Dimension Beam) sensors. The sensors are available as single or double emitter heads on standard music equipment made by the Roland ® Corporation who license the technology. A new generation of sensors are available from the original creator at www.synesthesiacorp.com.The original programmability is that interference in the beam space enables control and manipulate of digital sound. Units were enhanced in *SoundScapes* by the author so as to additionally control and manipulate image through gesture (Brooks 1999).

The sensor is emitting an infrared beam in the shape of an apple or an onion skin with a ‘virtual’ core and a multi-skin layer (Figure 1). The beam, existing in the electromagnetic spectrum at a wavelength longer than visible light infrared radiation can be detected but cannot be seen.

The sensor system used is a passive infrared (PIR) system. This infrared sensor technology is sensitive only to reflections of the exact wavelength of IR photons which it is emitting. Any reflective object which enters the volume of space which is an overlap of the emission and detection zones will cause the output signal of the receiver to change by way of reflected photon energy. Movement is not necessary for a signal to be present (thus the enhanced space opportune), but movement results in altering the signal. Human skin has a certain IR reflectivity so it is effective in reflecting photons back to the receiver. Most

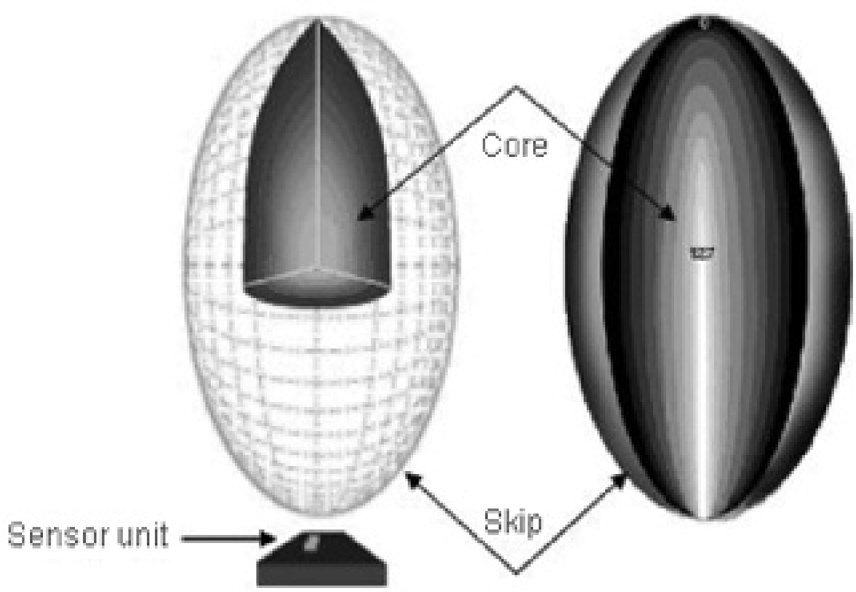

Figure 1. Two diagrammatic views of 3D infraredsensor cross section.

matter has at least some ability to reflect IR, although certain materials can absorb all of it. The system does not see IR emitted from skin surface (heat) because the wavelength of those photons is too long.

The sensor sends, via an emitter, infrared light electrons which reflect off a substrate and can be detected by a receiver located adjacent to the emitter in the sensor head assembly (see Figure 2).

The received interference information is converted into a digital signal for processing and subsequent routing through the unit to exit as a MIDI (Musical Instrument Digital Interface) protocol signal at the sensor unit output.

The sensor, as a motion detector, is looking for rapid change in the amount of reflected photon energy – a variation on the Theremin technique mentioned above based on body conductance – and at high resolution settings it can even detect breathing movement.

The sensor has a lens assembly which focuses and bends the light and gives a pseudo-3D shape to the beam which is experienced in interaction as a volumetric active air space.

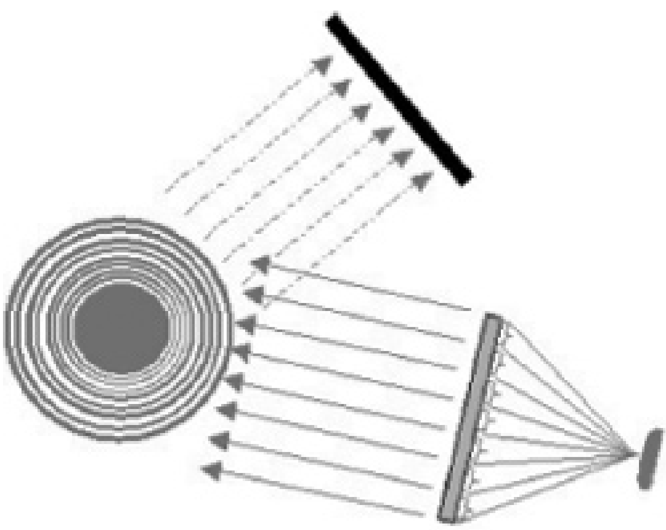

Figure 2. Sensor (emitter lens grey, receiver black).

2 Programming and enhancing the space

The skin of the ‘onion shaped beam’ (Figure 1) is programmable for 1) distance from centre and 2) for core size. The data can be event trigger or controller data. This movement change information stream can also be frozen through a footswitch with release on *match of data* or *second switch activation*. Sensitivity can be adjusted for the space to represent between 0 and 127 events (initial trigger at skin); or control information at varying sensitivity, or combinations of these.

Movement of any object capable of reflecting infrared photons entering and traversing the onion shape beam triggers a response as MIDI data. The beam has a skin value and a core value and all values in between. These are programmable so that a MIDI value (0– 127) can be assigned to the outer skin and similarly a MIDI value (0–127) can be assigned for the core. Options are to program at source sensor unit (limited to sensor data) or in computer software (sensor data filtered, interpreted and routed).

In the enhance method as described in this article an optimal programming of skin 127 and core 0 (a reversal of usual programming) compensates for the ‘reverse polarity’ of information which is a factor through use of the reflective material changing the extended air space from passive to active.

To extend the space from the original regulated constraints of approximately half a meter above the inbuilt sensor module on the equipment (usually a sound module box) to approximately 12 meters of free volumetric Virtual Interactive Space (VIS) one only needs to use a material called ‘retroreflective microprism’ which is a high reflective paper/ cloth used for example in safety apparel. This material is described in the subsequent sections in more detail with considerations for optimal selection.

The enhanced VIS with specific

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alternative mapping strategies has been enabled to capture gesture so as to control, for example, robotic interaction (Brooks 2004), navigation in virtual environments (Brooks 2002), and be utilized in telehealth design (Brooks 2004a) and quality of life applications considering people who are handicapped, elderly, and in rehabilitation (Brooks and Hasselblad 2004).

The material can be used in a variety of ways. It can be mounted on a limb whereby if directed to face the sensor emitter/receiver data is captured depending on the movement & mapping. In *SoundScapes* this has been used to emulate a mouse control and Quick Time Virtual Reality (QTVR) navigation, as well as in the creation of a "smart jacket" where half of the jacket was covered with the material so as to enable interactive painting (Brooks 2004b)—however it has a limitation in these modes and necessitates the user 'wearing' the material which is against the mission statement of *SoundScapes*.

This use of worn reflective material is also to some degree similar to a method used in high end (cost, training, etc.) body tracking systems where multiple infrared cameras track and plot the information for post session analysis for rehabilitation[1]. However, differing to these referenced systems, the focus with the *SoundScapes* system is to achieve an immediate and direct feedback to the captured movement in real-time which will subsequently motivate and inspire further movements. This occurs in an immersive environment so that the user is directed towards that state which is similar as witnessed in game psychology where a teenager is engrossed beyond anything outside of the virtual world where the interaction is taking place (the monitor). For this an intuitive interaction from body movement to computer feedback is targeted and a corresponding volume of interactive free air is created that enhances and optimises this state.

An ongoing aspect of the research is in fact to quantify aspects of this state so as to further optimize and use across the disciplines where SoundScapes is implemented. As such algorithms have been created which enable analysis of movement in real time and post session. Latest news on these issues are through a visit to the research website www.soundscapes.dk.

3 Method

A piece of retroreflective microprism material of suitable dimension is mounted onto a wall that faces the sensor head (Figure 3). This is an experimental space as the size and distance of the material from the sensor determines the interaction dimension and sensitivity. The space can be further enhanced with more sensor/material configurations that cross reference (e.g. Figure 4). Such configurations enable a higher resolution of gesture capture. There is no limit on the number of cross referencing units employed which is restrictive when using ultrasound sensors due to cross-noise.

The interaction within the enhanced spaces is through the blocking of the reflected light from the Retroreflective Microprism material by the human body, thus triggering events to be generated in real-time relative to any change in movement.

In other words free air is made to be active in various dimensions so as to control digital multimedia through movement.

Figure 3: VIS enhancement technique (a) sensor head (b) beam dimension without enhancement (c) enhancement retroreflective material (d) approximately 1 meter (e) additional reversed polarity active space of around 12 meters plus.

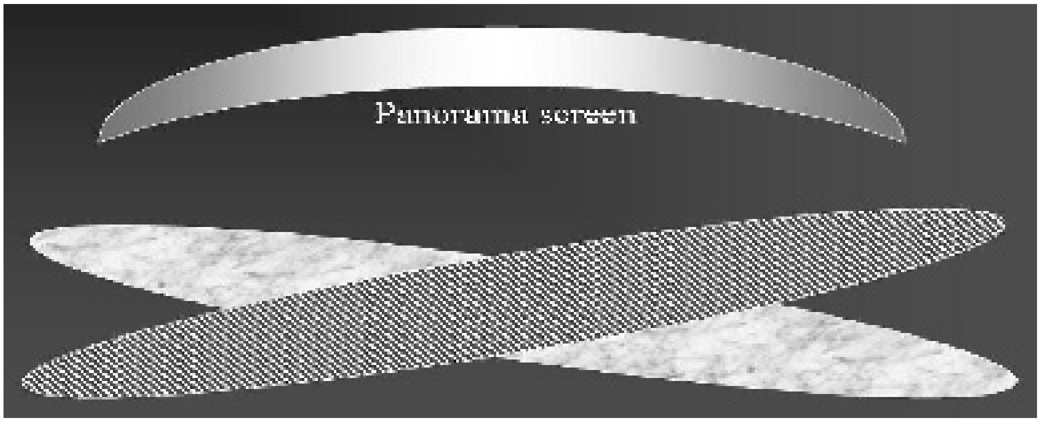

Figure 4: Cross referencing enhanced beam zones (lower elongated ovals) used in this case as a navigational interface for virtual reality from human movement in front of a panorama screen.

Through creative programming the enhanced system can be utilized for other forms of computer interaction such as mouse emulation, game control, and VR navigation. The system is further enhanced through the development and use of complimentary camera sensor systems and these are included in later sections exemplifying use in public installations, education, public events, and art performance as well as in rehabilitation and therapy.

Figure 5. Human performance training through traversing across working areas of enhanced beam: left = approach from outer left perimeter; right = approach from outer right perimeter; and centre working from the start of blocking of the complete beam.

4 Interaction training

In human performance training (e.g. dance, therapy, rehabilitation, etc.) a user is advised to interact by approaching the space (at highest sensitivity initially) traversing across both perimeters of the long axis so that interference is heard (via the programmed sounds) as the reflected IR photons are blocked (Figure 5).

Subsequent training is in the finding of hot spots so that total blocking of the reflected IR photons is achieved and then a controlled dynamic movement (tilt, rotation, raise, etc.) allows a corresponding number of reflected IR photons to pass the body. Much experimentation is required according to the desires from the interaction.

4.1 The public create the art

In performance art a similar technique is employed as in human performance training.

In installations the spaces are created as dynamic to the public in the space so that ‘the public create the art’. Other uses could be in club events where DJ and VJ decide to capture the movement of dancers which affect the sounds and images that they are dancing to.

This multi-disciplinary approach of performance art supplementing human performance in therapy and rehabilitation at first may seem strange, however if one considers the *Verstehen* (German for ‘empathy’) tradition in realization of the requirement to employ different methods of research, and specific to the *SoundScapes* concept where through utilizing performance art and public interactive installations opportunities are created to study behavioural patterns and subjective aspects of human experience. Furthermore, this research technique in *SoundScapes* is mindful of the arguments from the German sociologist Max Weber (1864-1930) who argued that “if social scientists are to understand the behaviour of individuals and groups, they must learn to “put themselves into the place of the subject of inquiry”. They must gain an understanding of the other’s view of reality, of his or her symbols, values and attitudes.” (Frankfort-Nachmias & Nachmias 1996). This the author attempts through performance

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4.2 Retro-reflective technologies

This section details the material used for enhancement and extension of the VIS. Retro-reflective systems are high light reflective surfaces used for example for road safety vehicle marking. There are two major types of retroreflective materials available on the market today—glass bead and microprism. In a glass bead system (Figure 6), light strikes the back surface of the bead and is returned directly to its source. In contrast, light strikes each of the three surfaces of the reflexite microprism (Figure 7) in turn, before returning to its source. Because the microprism provides more reflective surface area than a glass bead, microprisms reflect up to 250 percent more light than glass beads.

Retroreflective efficiency is enhanced by comparing the random size and placement of the glass beads (6a) with the precise uniformity of the reflexite microprism array

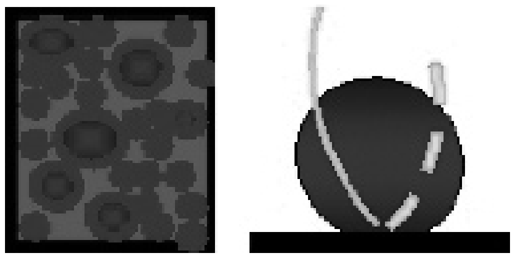

Figure 6 Glass bead retroreflective system (a: left, b: right).

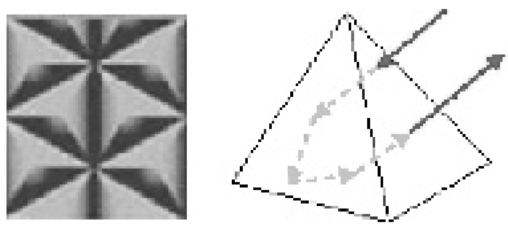

Figure 7. Reflexite microprism retroreflective system (a: left, b: right).

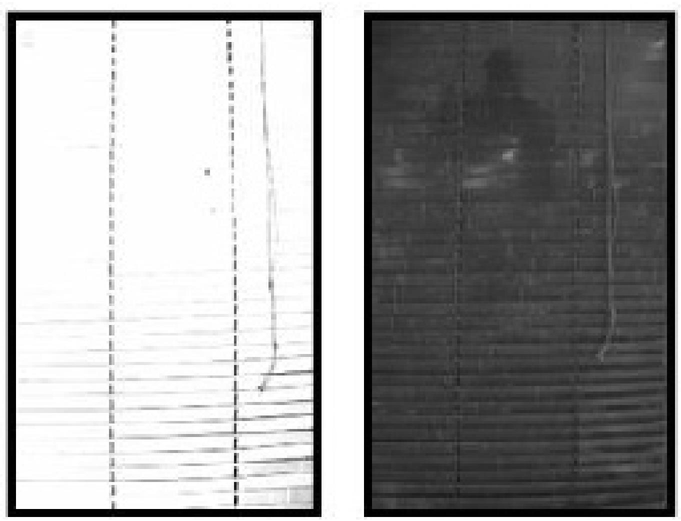

Figure 8. Retroreflective microprism window blind with reflection material stuck onto horizontal slats: As seen by (left) the sensor—(right) the naked eye: Where angle adjustments of the horizontal slats control the amount of reflected protons.

(7a).

The retroreflective microprism material that was found to be optimal in the study is Reflexite GP 800 silver which is high performance retro-reflective material of ‘extra class’ offering an extremely high specific retro-reflection of 1.000 cd/lux/m measured at 0,2 degree observation angle and + 5 degree entrance angle. This can be used in sheets, dots (wearable) or strips as in Figure 8 stuck onto the horizontal slats of a window blind.

The use of the retroreflective microprism material ‘activates’ the infrared sensor due to the high reflection surface reflecting the IR photons. A window blind is optimal as through adjusting the angle of the horizontal slats that the reflective material is adhered to one can adjust the parameters.

As mentioned previously this enhancement method to the use of infrared sensor technology has been implemented in various projects and these are briefly overviewed here to give an example of the broad potential applications so as to inspire others to experiment along similar lines.

4.3 Contemporary performance art

Performance art is viewed as a perfect vehicle for exploring new research methods as outlined above under the Verstehen tradition. The potential to understand the behaviour of individuals and groups through observation within public interactive installations gives many inspiring insights (see Figure 9). In a similar fashion to this ‘observational mode’ on-stage-performances that are utilising the same techniques can enable the artist to ‘put himself into the space of the perceived

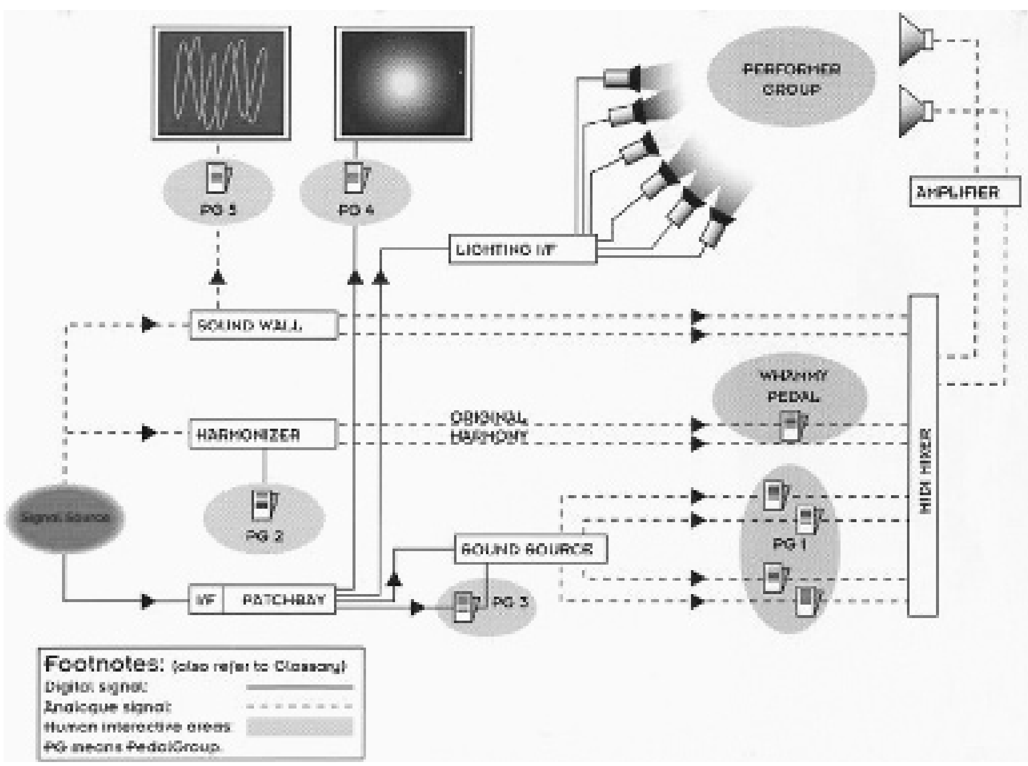

Figure 9: *SoundScapes* early interactive local area

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inquiry' i.e. human performance; whereby a form of subliminal physiological immediate self-reflection is suggested—maybe as a subjective responsive cognitive learning?—via the afferent efferent 'body function to multimedia feedback' relationships that are inherently embedded within the interaction. Subsequently, through a form of inductive processing and reflection this modality, in combination with the observational, can be applied within the therapeutic field. This gives opportunities for a new breed of therapist (virtual and real-world) to emerge through artistic intervention whereby gaining an insight at "understanding of the other's view of reality, of his or her symbols, values and attitudes" (Frankfort-Nachmias & Nachmias 1996) so as to improve upon the traditional form.

The history of performance art from the Futurism movement at the turn of the 1900s through to contemporary "Body Art" in the 1960s and beyond hold a fascination freedom of expression that is intrinsic to any artist. Within *SoundScapes* such freedom is positively exemplified through inductive hypothesis which are continuously manifested. As such the scenario where the author places himself into a role of 'performing subject' becomes a learning space for reflection of the grounding of theories that are built within the research process. Weaknesses and strengths become apparent and due to the nature of the experimental form of performance many new layers can be built upon the original design.

On-body biofeedback sensors which captured biological signals (brain waves, muscle tension, galvanic skin response (GSR), heartbeat) and the voice was explored as a layer upon the original design above. Non-tangible sensor technologies were a subsequent additional layer as illustrated in Figure 10.

As camera and computer technologies improved and became more complimentary integrated together a system that focused

Figure 10: Author experimenting with biofeedback sensors and invisible sensor technologies that manipulate sounds, images and physical robotic light effects. Danish TV circa 1995.

Figure 11. Escalator at the Copenhagen Metro

Figure 12. (Left) Enhanced gesture VIS in balance exercise with stroke patient—the white line shows approach to the active sensor space. (Right) Small enhanced space (white oval) for exercise of leg travel (dotted line) and subsequent sonic feedback relative to travel.

on non-wearable VIS interface technologies inductively became the grounded theory of the *SoundScapes* body of research and work.

Installations at Museums of Modern Art (Scandinavia 1998, 1999), the Olympics/ Paralympics (Atlanta 1996, Sydney 2000), Danish NeWave (New York 1998), Exit (Sweden 1999) and others, attested to the potential utilization of the model.

4.4 Education

The author is involved in the recently created Medialogy and Digital Design educations in Aalborg University Esbjerg (Denmark) where he is employed as an Associate Professor. Within the education students are encouraged to explore creativity integrated with technology and to design and realise in real-world scenarios (with teachers). One of the many interesting projects is one that was designed for the new Metro underground system in Copenhagen, Denmark. This is a work in progress with the Metro owners' positive as to the realization of the proposal. The design utilizes camera technologies which capture human movement on the down travelling escalators. A screen is facing the escalator and message balloons are shown that are sourced from any selected individual in an attempt to get them to react and communicate together following the escalator travel when they are together on the same lower platform awaiting the subway train to arrive. The illustration in figure 11 shows the concept, which as of writing still awaits a feasibility testing.

Figure 13. Performance group in enhanced VIS, Auckland New Zealand 2002.

4.5 Therapy/rehabilitation

The enhanced VIS under *SoundScapes* has been involved in major funded projects in the field of therapy and rehabilitation, one nationally funded by the Danish government (Brooks and Petersson 2005) illustrated in figure 12 with acquired brain injured patients and one funded by the European Commission under the 6th framework IST[2] (Brooks and Hasselblad 2004) with people who are handicapped, elderly and in rehabilitation. As a result of these projects algorithms for quantifying and analysing movement (velocity, duration, phase, quantity, etc.) have been created where camera sensors further enhanced the gesture capture in the VIS. Such analysis is important for progress mapping and system and content design.

4.6 Performance, education and therapy

The final example of implementation of *SoundScapes* is an event illustrating the potential in an all-encompassing assignment where the author was invited to work with a symphony orchestra, various groups of physically disabled, and two groups of University students, one from an art and design education, and the others from a dance and performance education. This was in Auckland, New Zealand and took place in 2002. It is documented in publication (Brooks 2004b) and online at the MARS (Media Arts and Research studies) Exploratory Media Lab[3] where a search for Four Senses gives access.

5 Conclusion

Through the implementation of the described simple system the opportunities of exploration within the arts, design education and social sciences are multiple. The system has attracted much interest from interdisciplinary researchers and is ongoing. Workshops, lectures and presentations are continuous and a new author led and designed complex (The Sensorama) that will host the research is currently (Fall 2004) being built at the Esbjerg campus on the beautiful south west coast of Denmark.

Applied real-world digital creativity offers much potential in human experiences and subsequent quality of life issues for the future across disciplines. What is offered in this article is the author's humble contribution relative to his creative digital vision where art is applied to help people.

The author states that communications in respect of the article are welcome as are proposals for collaborative research. Anyone interested in workshops, presentations or lectures are also welcome to contact the author at the email address given at the title of the paper.

Acknowledgements

DeFranco, V. Infrared sensor Images (and sensor detail) used with permission. Reflexite Europe, Denmark. Images and information used with permission.

Notes

[1]Three links to examples of such systems
http://www.vicon.com/
http://www.simi.com/en/
http://www.qualisys.com/

[2]www.bris.ac.uk/carehere

[3]http://netzspannung.org

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