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Enhanced Gesture Capture in Virtual Interactive Space (VIS)

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ABSTRACT: This paper overviews the research of a new extended sensor system enhancement for non-tangible gesture capture with minimized fixation. It describes how the enhancement is utilized in art and design and is implemented in an open computer based concept and methodology which has been utilized for applied research and education. The art is tailor made audio visual (optionally independent) real-time manipulated content. The design is the system threaded interaction loop from source to mapping to feedback to source. The use in education is for (but not limited to): - special needs related education (therapy, helpers, families); IT (content makers, human science and interface designers), and performance & installation art.

KEYWORDS: Interactive, Sensors, Space, Gesture.

INTRODUCTION

Art in the form of music and painting (or more specifically sonic and visual events) are targeted in the author's work as interactive feedback to a participant whereby aesthetic resonance is targeted. This space was titled in its inaugural form by the author as Virtual Interactive Space or VIS – [1] [2]. Subsequent later enhancement enabled the more stable capture of gesture in varying light conditions and with extended multi-dimensional attributes. The space enhanced as such, exhibits a 'pseudo reversed polarity of information' – related to the original polarity of sensor data - detailed in body text - which can be applied in various formats accordingly. It can be programmed for dynamic aspects of real-time interaction (e.g. velocity, sensitivity) which make it a tool of interest for future art, performance, design and education. This paper details in depth the materials and technique that enable the creation of the enhanced and extended VIS. The set up involves hardware (sensors and cameras) so as to create an active space. A participant enters with no wearable equipment so as to enable free movement and expression. The gesture (intent) from the participant is captured by the hardware and routed to a computer where mapping to the appropriate feedback content (manipulated art form) is achieved.

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The term Aesthetic Resonance* is used in this scenario referring to a situation where the response to intent is so immediate and aesthetically pleasing as to make one forget the physical movement (and often effort) involved in the conveying of the intention [3]. Computer Game psychology is a related mindset. The naturalistic inquiry of an enhanced capture of information in an extended active zone also resulted in a 'non fixation of gesture capture source location for user' environment which resulted in an observed higher presence state for the participant – suggested relating to Aesthetic resonance.

TECHNOLOGY

Creating musical events through proximity hand gestures has been around since the days of Leon Theremin [5]. His creation, the Theremin, is based on the principle of movement within an electromagnetic field producing a monophonic tone with pitch and amplitude being determined by proximity. The sensors used for the SoundScapes study are modern day equivalents of the early invention.

The sensor is emitting an infrared beam in the shape of an apple or an onion skin with a 'virtual' core zone and a 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 for the test is a passive infrared (PIR) system that detects infrared energy and is sensitive to the temperature of the human body. Humans have a normal skin temperature of around 93 degrees Fahrenheit and radiate infrared energy with a wavelength between 9 and 10 micrometers (strongest at 9.4 um). Therefore the sensors are typically sensitive in the 8 to 12 micrometers range.

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

The sensor, as a motion detector, is looking for rapid change in the amount of infrared energy being sensed in the space and thus does not detect a person standing still – a variation on the Theremin technique - yet at high resolution settings it can detect even breathing movement.

The sensor has a lens assembly which focuses and bends the light. This is shown diagrammatically on the sensor section and gives a pseudo-3D shape to the beam.

CONTROL AND INTERACTION

The virtual interactive space offers control of the feedback and through the use of additional sensors the space can be programmed so as to give a higher resolution capture. When such enhanced gesture capture is implemented and thus the participant is a greater distance away, it is possible to remove fixation from the source of the capture (in this case the sensor LED read out) to a more focused concentration solely on the proprioceptive feedback, the environment multimedia feedback and the causal interaction. It is suggested as this attribute is heightening the sense of ‘presence’ for the user during the interaction.

The catalyst of the created interactive space is thus the human and knowledge of the user (preferably a verbal dialogue if possible) defines the content of the artistic feedback so that a tailoring of the parameters is optimal for user immersion. In this way the opportunity for creative motivation through gesture is enabled.

METHODOLOGY

Referring to figure 3 - whole body gesture is tracked through positioning the user alongside the active extended sensor space. Guidance through physical contact (for example guide’s hands on user’s shoulders for the initial navigation of the space) on their first entry across a single plane of the space. As the user gets a feel of the space and it is detected through the physical contact a second plane perpendicular to the first can be investigated.

Subsequently the user is asked to explore the space themselves.

Individual body part tracking and training is facilitated through refining the parameters of the system relative to the body part size and exercise. This is for example by adjusting the size, position or angle of the microprisms material and/or programming the sensor for sensitivity etc. Each case is individual to each user.

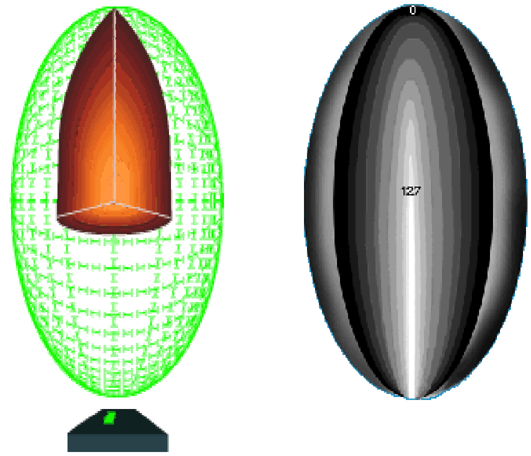

Figure 1. 3D infrared sensor cross section

THE SENSOR BEAM

The sensor is a small stand-alone unit with a screw in connection suitable for a microphone stand or a camera tripod (with adaptor). As suggested above the shape of the beam is like a big invisible virtual onion floating above the unit when laid on a horizontal surface.

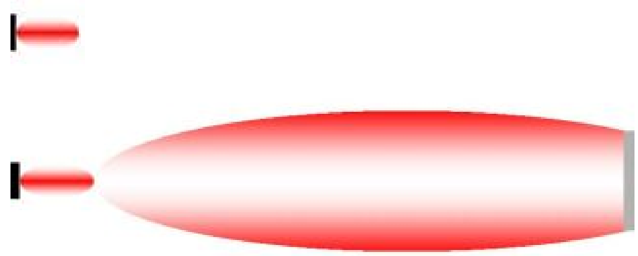

Figure 2. Top - PIR (without Retroreflective microprisms) Bottom – activated by Retroreflective microprisms material on right edge of beam (gray) range up to around 12 meters.

PROGRAMMING THE SPACE

The skin of the onion is programmable for (1) distance from center and (2) for core size. Movement of any object emitting infrared electrons in entering and traversing the onion shape triggers MIDI data event(s). The onion has a skin value and a core value and all values in between. These are programmable so that a MIDI value (between 0 – 127) can be assigned to the outer skin of the imagined onion and similarly the desired MIDI value (between 0 – 127) can be assigned for the core.

RETROREFLECTIVE MICROPRISM MATERIAL

There is the standard programming to set up the active zone of the PIR unit. However when the Retroreflective microprisms material is used in front of the infrared sensor a direct feedback of the electrons in an amplified manner occurs. This is utilized in State of the Art (SOA) rehabilitation clinics in a different system where small reflection locators (balls/dots) are positioned on a user's body part as a source tracking for the system software via cameras. For example reference "Vicon [6]", "SIMI [7]", "Qualisys [8]". The system is expensive and for a full implementation requires a designated room with installed hardware (IR cameras, force plates, workstation etc.) and extensive training for personnel.

The system detailed in this paper does not in any way suggest at even approaching the high detail for tracking as these SOA systems. However it has been shown that there is an interesting causal space to be explored with potential in many areas. Figure 1 shows on the left the sensor head with LED readout, a visualization of the sensor space with the programmable skin (outer perimeter) of the "onion" shape, the inner core with axis on the perpendicular and horizontal and the matrix of information data obtainable from the space. The right hand diagram in the same figure gives a representation of the MIDI data information which has a maximum resolution of 0 – 127. This is the standard definition of the dimension beam interactive space. However when a Retroreflective microprisms screen material is positioned as in figure 2 a new active area is apparent with reversed polarity data attributes.

POLARITY REVERSAL

The standard initial active zone to work with is the upper sensor head diagram (figure 2). In the lower diagram it can be seen that the initial active zone is still available however the Retroreflective microprisms screen (at right of lower image) enables a secondary zone which depending upon the parameters can be up to approximately 12 meters. The parameters are in relation to the screen and the sensor programming.

The infrared beam undergoes a change of its polarity in so much that the information is now reversed. This means that the beam is active without a person in the space as the infrared radiation feeding back to the receiver on the sensor head is receiving a large proportion (depending on screen dimension) of the emitted signal. This means that for example when the sensor is sending MIDI information to a sound module or music synthesizer and the patch (selected sound) is having the release parameter of its amplitude envelope extended beyond a parameter of the sensor it will result in a continuously sounding tone. This is like keeping your finger on a synthesizer key.

The sensor data can be programmed in two ways so as to take advantage of the reverse polarity (passive to active) of the sensor space – at source by programming the core to have a MIDI value of zero and the skin to having a MIDI value of 127. In this way the enhanced extended sensor space will respond as the standard 1 meter sensing space. Or in the software program [5] (this programming patch is shown in the appendix).

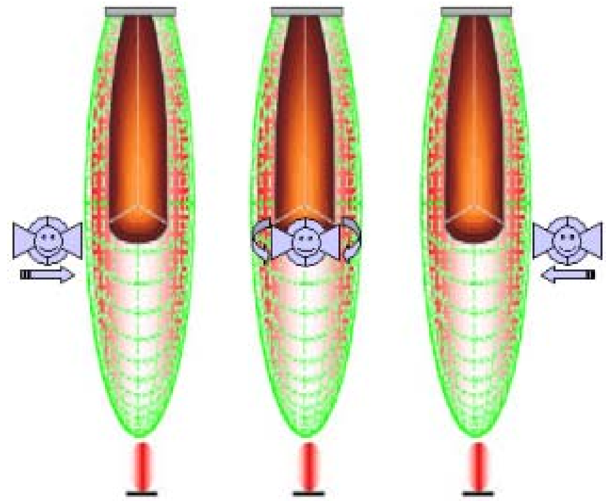

Figure 3. Lateral working areas of beam zone.

In figure 3 the enhanced extended data space has been superimposed over the two infrared sensor spaces shown previously in figure 2. The plan view of a user who is to work across the beam is shown with arrow indication for the directional gesture. The initial start position is just at the perimeter of the "skin" of the beam. Ingress towards the core will give feedback for a sonic feedback to body awareness.

ENHANCED INTERACTIVE SPACE

The three images in figure 3 are an example of the different ways to explore the beam utilizing the Retroreflective microprisms screen. The left image (a) shows left arm/side of the body ingress training, (c) shows right arm/side of the body ingress training. The middle image is where the body of the user totally blocks the core of the infrared light such that no electrons are able to be received by the sensor head to initiate a trigger of a MIDI event. The human body is outside of the 1 meter range sensor so subsequently this is a "no signal zone". As such it is workable for example with torso rotation, balance, and other double body exercises. In this position a rising of an arm (allowing reflected light electrons from the microprisms material to be received by the sensor) triggers the MIDI events.

The sensitivity of the interactions can be programmed so that a comfortable level is worked with. It is also possible to make the space dynamic so that velocity of movement has corresponding amplitude of MIDI event. This aspect is detailed more fully in a separate paper. The distance from the sensor head is such that the user cannot see the LED readout information as is possible at the 1 meter range. A reduction of fixation is achieved so that the user focuses on the feedback relative the body movement that achieves the event triggering. Thus a suggested closing of the afferent efferent neural loop is achieved through the sensorimotor stimulation.

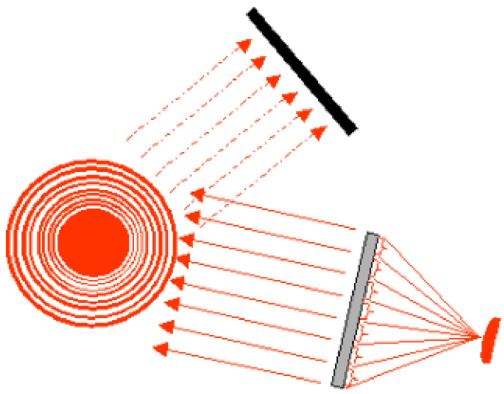

Figure 4. Sensor (emitter lens gray- receiver black)

RETRO-REFLECTIVE TECHNOLOGIES

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 microprisms.

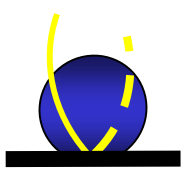

Figure 5. Glass bead system

In a glass bead system (Figure 5), light strikes the back surface of the bead and is returned to its source. In contrast, light strikes each of the three surfaces of the Reflexite microprisms (Figure 6) in turn, before returning to its source. Because the microprisms provides more reflective surface area than a glass bead, microprisms reflect up to 250 percent more light than glass beads.

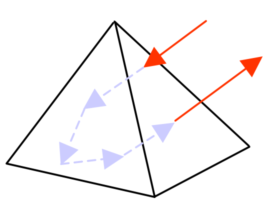

Figure 6. Retroreflective microprisms system

Retroreflective efficiency is enhanced by the precise arrangement of the microprisms, as seen in a microscopic view below. Compare random size and placement of the glass beads (Figure 7 left) with the precise uniformity of the Reflexite microprisms array (Figure 7 right).

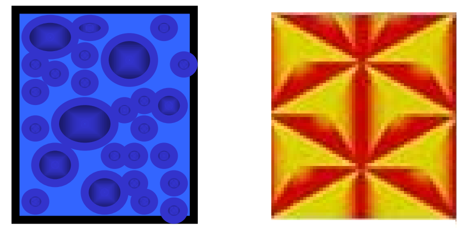

Figure 7. (L) Glass Bead

The microprisms economical use of surface area delivers the highest standard of reflection.

The plan view (figure 8) of the microprisms system gives further detail as to the light management attributes.

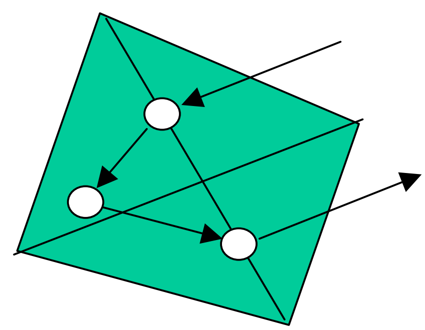

Figure 8. Microprisms system

The Retroreflective microprisms material used in the study is 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.

PASSIVE TO ACTIVE

The use of the Retroreflective microprisms material activates the infrared sensor due to the high reflection causing a controllable feedback. The infrared sensor technology looks for the reflected electrons and as can be seen in figure 9 to the naked eye on the right it looks like a standard window blind whereas what the sensor receiver is seeing is shown on left. Thus the polarity change from passive to active.

Figure 9. Retroreflective microprisms window blind

CONCLUSION

Promising outcomes reported by experts (including therapists, carers, families and participants) from early research of use in the field of disability led to SoundScapes [10] being implemented in a Danish government [11] funded project and a European Commission funded project [12].

The unique system enhancement added increased opportunities to the SoundScapes research and it has attracted interest from a number of interdisciplinary researchers.

The (no limit) high resolution enhancement and reduced fixation on capture source offers added potential as an alternative non-formal training system - for example in physical rehabilitation [11] or entertainment. Empowered creative expression and/or playful interaction is targeted through a digital mirroring technique where an individual controls his/her (responsive) environment via movement. The system has been used as a noninvasive input control device to video games and Virtual Reality (VR) navigation. The system was most recently used as an integral element of the Four Senses series of performances in Auckland, New Zealand [13].

APPENDIX: Sensor data capture from movement

MAX software environment used to process & map - max v2;

```
#N vpatcher 608 116 1436 814;
#P window setfont "Sans Serif" 9.;
#P number 131 318 35 9 0 0 0 139 0 0 0 221 221 221 222 222 222 0 0 0;
#P number 111 277 35 9 0 0 0 139 0 0 0 221 221 221 222 222 222 0 0 0;
#P newex 130 297 64 9109513 makenote 500;
#P number 95 257 35 9 0 127 3 139 0 0 0 221 221 221 222 222 222 0 0 0;
#P number 133 257 35 9 0 127 3 139 0 0 0 221 221 221 222 222 222 0 0 0;
#P number 133 217 35 9 0 127 3 139 0 0 0 221 221 221 222 222 222 0 0 0;
#P newex 133 235 31 9109513 !- 127;
#B color 14;
#P user gswitch2 104 181 39 32 0 0;
#P button 104 163 15 0;
#P newex 131 342 40 9109513 noteout;
#P number 134 161 35 9 0 127 3 139 0 0 0 221 221 221 222 222 222 0 0 0;
#P newex 134 138 40 9109513 notein;
#P comment 32 119 100 9109513 Switch to right for reverse polarity of data;
```


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De Franco, V. Infrared sensor profile images
Reflexite Europe, material concept images

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12. http://www.bris.ac.uk/carehere
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END NOTES

Aesthetic Resonance* original reference to investigation of solely auditory stimulus acknowledged to Ellis, P. The music of sound: a new approach for children with severe and profound and multiple learning difficulties. The British Journal of Music Education, 1997, 14(2), pp. 173-186.

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