Non-conventional interfaces using Stamp controllers

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Abstract

Artists continue to search for new methods of creation of artworks. The trend to interactive multimedia installation work requires systems that allow participants to interact in subtle ways. The paper describes a number of non-conventional interfaces to computer mediated art works achieved using small Programmable Logic Controllers (PLC) called ‘Stamps’. These are programmed in BASIC and can be interfaced to personal computers or used as stand alone devices. They are cheap and extremely versatile in their use for non-conventional interfaces.

Key words: Human Computer Interaction, Installation

1 Introduction

This paper deals with one particular type of interface method that has been widely used in the Lansdown Centre for Electronic Arts (LCEA) at Middlesex University. It is an example of the non-conventional interface methods developed in LCEA over the last ten years in the creation of computer mediated art works.

It is easier to clarify the concept of a non conventional interface (NCI) by identifying what it is not. For example, it is not controlled by:

- the kind of conventional input device normally supplied with a standard computer, such as a keyboard or a mouse;
- other input devices such as microphones, graphic tablets or touch screens that are commercially available and supplied with interface software.

Hence a non conventional interface involves the custom building of electronic hardware, as well as, normally, the writing of interface software.

Over a period of fifteen years [Jones 1998], the Lansdown Centre for Electronic Arts [LCEA 1999] has explored new methods within the areas of art and design, from early work in computer animations [Jones and Siffert 1995] to the more recent interest in interactive work [Poletti *et al.* 1995] and the sonic arts [Robinson 1996]. Recent creations have tended to include not only conventional modes of display and interaction, but installations populated by ‘users’, where the interaction affects the work but is not evidently apparent [Elliott 1995]. This is categorised by Tannenbaum [1998, p 397] as an ‘unobtrusive function ... when a computer is present in the interaction but not noticed’. The emphasis is to develop innovative methods that may fall outside the standard concepts embedded within conventional software and hardware. Users of such systems are engaged to participate in a ‘puzzle’ like manner to explore the variety of effects created by their physical location, posture or movement. This extends the richness of opportunity for artists and designers to explore innovative work. It has also been necessary in an educational environment to do this relatively cheaply, achieved with some ingenuity by the use of low cost commercially available components widely used in other contexts.

2 Component parts of a non-conventional interface

A non conventional interface can be considered to be made up of the following three parts:

- Transducers: these convert a physical property into an electrical signal. For example, mechanical motion can turn a switch on or off or the intensity of light falling on a photosensitive cell can produce a corresponding electrical signal.
- Signal conditioning hardware: this conditions the signal by amplification or other modification into a form suitable for feeding into a computer’s interface ports, such as printer, modem and microphone ports.
- Driver software: this accesses data from the port into the user program.

This paper is concerned with the signal conditioning hardware part of such an interface, particularly describing the use of a cheap but versatile interface control computer. Other examples of signal conditioning hardware that have been used in NCIs include

- modified keyboards (Mallinder and Jones 1999),
- transducer controlled oscillators that connect with Macintosh computer microphone ports.

3 Signal conditioning hardware (SCH)

3.1 Hard wired versus programmable devices.

In many cases student projects require a considerable number of input transducers but the signal conditioning hardware (SCH) has to input these to a computer via a single port. In most Macintosh computers used by artists, printer as well as modem ports can be used as serial ports and many now have USB capability. Some form of sequencing of the transducer inputs is required, plus the generation of the correct protocol serial signal.

It would be possible to use various logic integrated circuits (IC) to achieve this, but for each new interface a considerable amount of redesign would be required. However these disadvantages can be overcome by using a Programmable Logic Controller (PLC). This is an electronic device that uses programmable memory to store instructions that implement specific functions such as sequencing, timing, counting, logic and arithmetic to control external devices.

Many of PLCs are programmed in assembly language, but a family of devices made by Parallax Inc, use the BASIC language. This simple but powerful dialect, besides having all the familiar language instructions, such as FOR...NEXT, IF ... THEN, GOTO, GOSUB, also has many instructions for common control tasks, such as serial input/output of data, debouncing pushbuttons, generating and measuring pulses, and generating sound. Thus interface software development time is reduced, but with the disadvantage that running BASIC is slower than running assembly routines. This leads to relatively easy design and construction of NCIs, but can impose limitations on the tasks performed in relatively ‘real time’. This has not proved to be over constrictive in the wide range of interfaces created in LCEA.

3.2 Stamp interface control computers

There are two types of Parallax interface control computers [Parallax 1995a, 1995b].

- Stamp I with a variant known as a School Stamp
- Stamp II with a high speed variant.

The salient features of the Stamps are:

- They are programmed in BASIC language from a PC or Macintosh.
- The program is stored in Electrically Erasable Programmable Read Only Memory (EEPROM), and is retained when power is disconnected.
- They have 8 or 16 non dedicated input, output (I/O) lines, each of which is capable of serial I/O.
- They are compact and unobtrusive (their name indicates that they are approximately the size of a postage stamp), and cheap.

3.3 Comparison of the four Stamp variants

The Stamp I comes in two forms which are functionally the same, but physically different. The School Stamp is a more robust version of the BS1-IC, using discrete components that can be replaced.

The Stamp II comes in two forms which are functionally different but physically the same, namely BS2-IC and BS2SX. Table 1 compares some of the features of the three functionally distinct versions.

The following also help in deciding which is the most appropriate type of Stamp to use in different circumstances.

- All 4 variants can be used either freestanding or via a serial port to a Macintosh or PC.
- All 4 variants have a voltage regulator on board and can be powered from batteries, such as a PP3 (9 volt), or from DC power supplies of 5 to 15 volt.
- The BS1-IC, BS2-IC and BS2SX can be mounted on small Project Boards with the following features:
  - Programming header (3 pin for BS1-IC, 9 way D type socket for the others),

- PP3 battery clips,
- Prototyping area,
- Size is 105 mm by 38 mm for a Stamp II project board,
- Cost is £6 excluding taxes.

Development kits include programming software, printed manual, programming lead, project board and relevant Stamp. They cost (excluding taxes) £59, £79, & £99 for School Stamp, Stamp I (BS1-IC), and Stamp II BS2-IC respectively.

Table 1: Comparison of essential features of Stamps

Name	Stamp I (BS1-IC or School Stamp	Stamp II (BS2-IC)	Stamp II (BS2SX)
Programming	PC via parallel port	PC/Mac(Soft PC) via serial port	PC/Mac(Soft PC) via serial port
Prog retained on switch off	yes EEPROM, 256 byte	yes EEPROM, 2 Kbyte	yes EEPROM, 16 Kbyte
Programming language	BASIC approx. 80 lines	BASIC approx. 500 lines	BASIC approx. 4000 lines
Program speed (instructions/sec)	2000	4000	10,000
Internal registers	16 byte	32 byte	32 byte
I/O channels (unconfigured)	8	16	16
Size and physical format	10 mm by 35 mm, 14 pin SIP (BS1-IC) 38 mm by 20 mm 14 pin DIP (Sch'l St.)	31 mm by 26 mm 24 pin DIP	31 mm by 26 mm 24 pin DIP
UK Cost (excluding taxes)	£25 (BS1-IC) £16 (School Stamp)	£39	£49

4 Transducers

The types of transducers that can be used with Stamps are those that give relatively slow output variations. The Stamps are not fast enough directly to process audio or video waveforms, where a sampling frequency of greater than 10K samples per second would be required. For use in installation work, there are normally several channels whose inputs need to be read sufficiently often to give users a sense of continuous control without noticeable delays. The Stamps are thus more suitable for those interfaces where the speed of sampling per channel is in the region of about 4 to 20 per second.

Some of the following examples of transducers that have been used with Stamps in LCEA are discussed in more detail in case studies below.

4.1 Input transducers

- Switches: microswitches, vibration and tilt switches and pressure mats [Mallinder and Jones 1999],
- resistors: potentiometers, thermistors, light dependent resistors, conductive foam, body resistance,
- variable capacitors,
- infra red receiver photodiodes and ICs.

4.2 Output transducer systems

- Light emitting diodes (LED),
- relay control of DC motors, and of heating elements,
- servo motors,
- stepper motors,
- pulse width modulation (PWM) control of DC motors,
- shape memory alloys (muscle wires).

Note that most of the above output transducers require additional signal conditioning hardware, for example current amplification, to give the output power required from the transducer.

4.3 On/off switches

Commercial pressure mats can be obtained from various sources for use in security applications, being normally laid on a floor under a carpet. The name pressure mat is slightly misleading as commercially available devices act only as on/off switches rather than translating continuously variable pressures into continuous analogue signals. Commercially sold mats frequently used in LCEA have dimensions of approximately 0.7 by 0.4 metres, with a thickness of 0.3 mm, and cost no more than £5 each. The currently available mats consist of 2 pieces of aluminised thick paper connected to output wires, with the aluminised sides facing inwards. They are separated by a 2 mm layer of plastic foam with holes of 10 mm diameter on a 40 mm hexagonal lattice. These parts are contained in an envelope of thin plastic, which holds them in place and keeps out contaminants such as dirt, grit and liquids. An adult's foot standing on a mat will compress the foam sufficiently for the two aluminised surfaces to contact through the holes, so a mat acts electrically as a normally open switch.

5 Use of NCIs in LCEA student projects

Students in two postgraduate and one undergraduate course have used NCIs in their project work. The one year MA Digital Arts and MA Design for Interactive Media courses accept students from a wide range of backgrounds, but have a Fine Art and Design bias respectively. Each course involves considerable project work, comprising a three month individual or group project as the final assessable stage. Students use scripting or programming languages such as Lingo for Director, C and Java. Projects are displayed in annual shows in central London and several have been described in published papers [Poletti *et al.* 1995, Jones and Siffert 1995, Jones 1998]. In order to be effective and usable in such student projects, an interface should be:

a) non intrusive, so users should not have to wear or carry special devices to enable the system to work;
b) not apparent to the users in the sense that they should be unaware of the devices that make the system work;
c) cheap, costing no more than a few hundred pounds — students may want to develop their projects or show them again after completion of the course, so they will have to rebuild or pay for necessary components of the interface;
d) gallery independent, so that they can easily be set up in different spaces.
e) simple, as students need to spend more time on developing conceptual issues of their art works rather than on complex interfaces;
f) sufficiently precise to accomplish the required work.

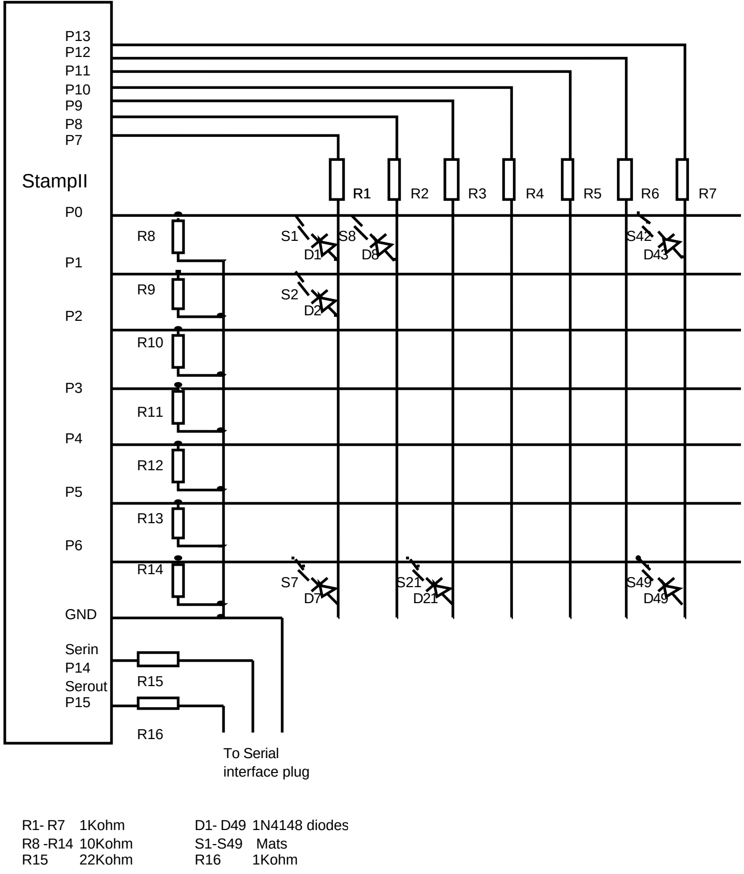

Figure 1 The circuit diagram for a 49 mat interface using a Stamp II. Only a few of the mat connections at junctions are shown for simplicity.

As an example, one of the largest installations in LCEA used 49 pressure mats, with the inputs arranged on a lattice of seven rows by seven columns as shown in the circuit diagram (fig 1). Each mat is connected to a 'row on' and 'column on' wire, so occupancy of a single mat can be identified from the row and column for which a switch is closed.

This achieves identification using only fourteen input wires to the stamp rather than the 49 required if each individual mat were directly connected. The stamp program is very simple. In essence,

- each column P7 to P13 is set high, the others being low,
- the state of pins P0 to P6 (high/low) caused by mats being on or off is read and stored in an array,
- the 7 bytes of data (1 bit per map) is sent to a Macintosh computer in serial form.

Shown in the circuit diagram are diodes, which allow current only to flow in one direction, here from column to row. The diodes prevent mats that are 'on' in other columns than the 'high set' column from giving spurious results.

Consider the following example:

- Mats S1, S8, and S13 are on, all others are off.
- Column P7 (left most one) is set high, others low.
- The input on pins P0 to P6 should be 0000001 binary.

If there were no diodes, column P8 would also be set high as current would flow through S1 and S8, and hence on through S13 to pin P5. The input on pins P0 to P6 would then be 0100001 binary, not what is required. The diode D8 prevents column P8 from 'going high' and so prevents pin P5 from going high.

6 Examples of work using Stamp interfaces.

This section describes uses of Stamps as components of unobtrusive interaction in a number of projects developed in LCEA. The case studies are listed chronologically within a number of main categories. Due to the complexity of some of the interfaces, several projects could have fallen into more than one category, but they are identified according to major features.

6.1 Resistance detection

6.1.1 Michael Flaherty, MA Digital Arts (1994-5)

This was the first project to use a Stamp, a BS1-IC. A sound space was controlled using a 6 channel input responding to the strength of gripping solid metal objects (2 cones, a hemisphere, plate, ring and tap mounted on a table). If a person, or a ring of people touching each other, simultaneously held more than one of these, they closed an electrical circuit. Changes of contact resistance as these objects were gripped more or less tightly were identified using the charging time of a Resistive Capacitance (RC) circuit. This time was measured, and saved in a register using one of the inbuilt Stamp Basic routines. The register value was thus related to the resistance value, which was used to control sound sources via a Macintosh computer.

6.1.2 Anya Langmead, MA Digital Arts (1995-6)

This used a Stamp II. A wooden egg, about the same size as a chicken's egg, was held in the hand [Langmead 1995]. Mounted on it were three types of detector,

- conductive foam for hand pressure detection,
- thermistors for hand heat,
- copper foil for skin resistance.

The three worked by changing their resistances, and were combined with suitably valued capacitors to make RC circuits as above. The Stamp measured charging time and enabled the sensors partly to control an abstract swirling image displayed on a monitor at eye level.

6.1.3 Emma Posey, MA Digital Arts (1995-6).

This work used two Stamp IIs, as more than 16 channels were required. Two or more Stamps can be linked together via any of their 16 I/O pins using serial communications with a particular serial output mode known as 'Open drain'. Multiple Stamp configurations can use Stamp Is or Stamp IIs. Sensors were stuck to a rounded sculpture shaped like a small seal [Posey 1996]. A wire frame image of its surface was projected on a screen (fig 2). As a particular sensor was pressed the image rotated to be viewed from where it was pressed. On continuation of pressure on the pad, the image enlarged to reveal abstract shapes within, zoom in and out controlled by varying finger pressure. To detect this pressure, 29 conductive foam pads of 5 mm thickness were stuck between square copper plates of 2.5 cm edge length. They were combined with suitable value capacitors to give an RC circuit as above. Again, the Stamp measured the charging times for transmission to an image generating Macintosh computer.

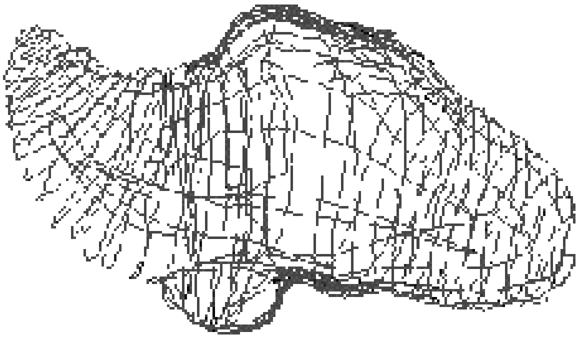

Figure 2 Posey's sculpted shape was covered with sensors

6.1.4 Martin Robinson, Staff member in Sonic Arts (1996)

An input device similar to the handlebars and front shaft of a motor scooter was jointly developed by Robinson and Mallinder using a Stamp II. This was used to control sonic outputs, with different forms of motion controlling timbre, pitch and repetitive percussive sounds [Robinson 1996]. The handle bars and front shaft each had 3 degrees of freedom, there were also switches, brake-like and twist grip controls on the handlebars. Nine potentiometers were used in RC circuits. Output was in MIDI format at 31250 Baud. Robinson gave a live demonstration of the 'MIDI scooter' at the Control-Shift-Escape show, The Tannery, London SE1, September 1996. Robinson's dance like movements control the improvised sounds created, a reverse of cause and effect from the normal dancer/music scenario.

6.2 Light detection

6.2.1 Fiddian Warman, MA Digital Arts (1995-6).

Hardware infra-red (IR) area transmission of serial control information from a Macintosh computer controlled six small earth moving robots [Warman 1996]. A School Stamp on each robot received input from the IR receiver/demodulator integrated circuit and from microswitches on the robot plough mechanism. Stamps controlled the on/off switches and direction control of two DC motors driving caterpillar tracks, the plough actuating servo, and small 'grain of wheat' (gow) light. A video camera detected this light to determine the robot's position, giving a closed loop robot positional control system, which was intended to create a pre-planned terrain layout in the controlled environment by moving earth from high intensity regions of a mapped image towards low intensity regions (fig 3).

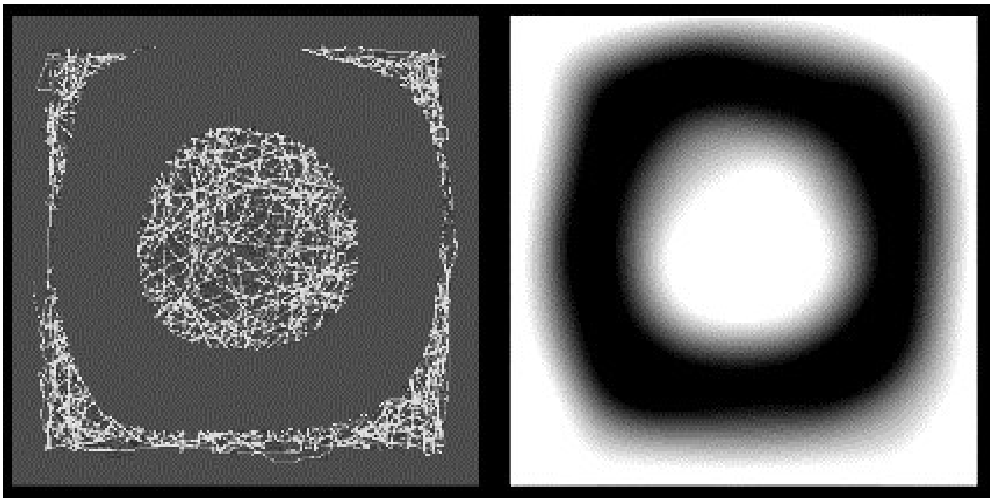

Figure 3 The left image shows tracks of Warman's robots with bulldozers down, moving earth away from the lighter areas of the index image on the right

6.2.2 Melissa Bliss, MA Digital Arts (1997-8).

Entry or exit to or from a small room were identified by the sequential breaking of two infra-red (IR) beams across the door [Bliss 1998]. The IR beams were modulated with 30 kHz and 300 Hz square waves. The receiver integrated circuit (IC) demodulated the 30 kHz signal to give a 300 Hz square wave if the beam was clear or logic high when it was obstructed. This 30 kHz modulation made the system insensitive to other lights. Outputs from the IR receiver ICs were input to the School Stamp, where custom software processed the two inputs. This software could discriminate between a person's body passing completely or only partly through the door in either direction, and also could identify a hand waved in the beams. The output to the serial port of a Macintosh was a single byte which showed if the room had been entered or exited. Within the room two plastic basins representing heads, each containing a small loudspeaker, were mounted on vertical axes about 50 cm apart. Sounds emanated from the basins, apparently conversing with each other, whose motions were controlled by small servo motors from the Stamp. Entry to the room triggered other interactive actions not described here.

A similar set up was used by Matt Grey, another student in the same group, to identify entrance and exit from a small room [Grey 1998]. Also in this piece, LEDs were controlled to flash red to signify entrance, green for exit.

6.2.3 Suzete Herrmann, MA Digital Arts (1997-8).

A static mounted bicycle was modified to give users control of backprojected Quicktime™ movies which they faced as they pedalled [Herrmann 1998]. Speed of pedalling was determined by counting the numbers of rear wheel spokes to pass through an IR beam. The direction of the handlebars was sensed by a potentiometer in an RC circuit. Actuation of each brake was identified by microswitches near the brake pads (fig 4). Control of images was achieved by feeding this information to a Macintosh computer via a Stamp II, enabling participants to navigate their way through the labyrinthine landscape displayed.

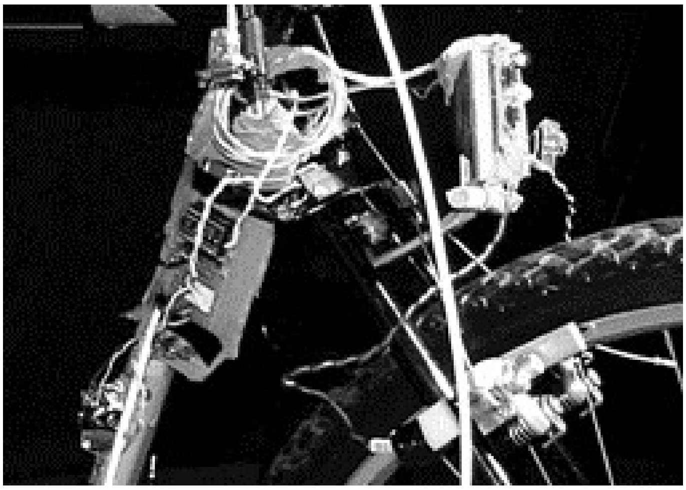

Figure 4 The rear wheel mounting of the static bicycle shows brake sensors

6.3 Capacitance detection

6.3.1 Chris Rule, MA Digital Arts (1998-9)

The subtitle of Rule's MA dissertation was, 'Perception, Synaesthesia and Synaesthetic Effect' [Rule 1999], and the project was concerned with the perception of an invisible 3D sculpture, made manifest by changes of aural stimulus. A single user wearing cordless headphones entered a nearly dark cube of side 3m, painted black on the inside. Sound changes were caused by the position of the user relative to a large metal plate sensor in the roof of the cube. This operated on the same principle as one of the earliest electronic instruments, the 1917 designed Theremin [1999]. The sensor's capacitance was changed by the presence of a body nearby. This variable capacitance, together with a fixed resistance, form the elements of an RC oscillator, here realised using a commercially bought 7555 oscillator IC. The variable frequency square wave output from the 7555 is input to a Stamp II, and the number of cycles in a given time is measured using the 'count' Stamp BASIC instruction. Thus the numbers recorded varied as the user moved relative to the sensor plate. These values were sent via a MIDI interface to the Super Collider program running on a Macintosh 7600 to generate the sound output. Each single user could be observed through two small windows, making the installation intriguing both for participants and observers.

6.4 Motion control

6.4.1 Lucy Kimbell, Soda group show at the London Electronic Arts Gallery, Jan-Feb 1998.

Soda is a group comprised mainly of LCEA alumni. Lucy Kimbell's piece comprised a wall of 72 Musical Greetings Cards [Kimbell 1998]. The cards were opened (so that their sounds would play) and closed using a low cost sculptural construction of levers, wires and weights on pulleys. The motive force was supplied by a thin wire of shape memory alloy, commonly known as muscle wire. This contracts by about 5% of its length with considerable force when a low voltage current is passed through it. Current, and hence the opening and closing of cards, was controlled by a Stamp II. The driver hardware to interface the Stamp to the cards was also custom built.

6.4.2 David Muth, MA Digital Arts (1998-9) Distorting Mirrors.

Two mirrors, each one metre square, made of aluminised perspex were mounted vertically in wooden frames facing each other about 1.5 metres apart. The mirrors were mounted so that their vertical left and right edges, could be moved up to ten centimetres forwards or backwards from the mirror's normal planar position [Muth 1999]. This was achieved by four vertical axis geared DC motors, two for each mirror. Motors were driven at eight different speeds using a pulse width modulated waveform. A Stamp II was used to input data from a Macintosh serial port and condition it so it could be output to four sets of custom designed driver hardware. These also included current limiting, to avoid damaging the driver ICs. At the limits of motion of each motor, a greater torque was required to turn the mirror and the current drawn by the motor increased. At an initial developmental phase, current limits were controlled by microswitches mounted on the mirror frame, which would be switched on by the frame's position at the limits of motion. These were connected to the Stamp II, which was programmed to reverse the motor direction on receiving the switch signal. In the time available to develop the Macintosh and Stamp II programs it was found impossible to control the motors with sufficient precision to stop them damaging the microswitches. The microswitches were removed, it was found that if the motors were reversed by data transmitted from the Macintosh within a short time of their stalling at the end of the flexing motion, the driver ICs survived. Four floor mats were also used to trigger the motors into action when a participant entered the mirror space, giving interesting distorted views of multiple reflections in the two mirrors.

6.5 Multiple position detection within an area

6.5.1 Pause for Breath, MA Digital Arts (1997-8)

Pause for Breath, a collaboration by a group of 12 students led by staff tutors Andrew Deakin and Hugh Mallinder, was presented at the Lovebytes festival in Sheffield, UK, April 1998. The visual installation was located in a large darkened studio with a high ceiling. Two large projection screens faced each other at a distance of about 10 metres (fig 5). The forty nine-mat layout described in section 5 above was covered by a layer of grit to evoke an outdoor environment. Conceptually, this represented a spring loaded platform which responded to the centre of mass of those on it by tilting and oscillating. Although the 'platform' was static, the visual images presented gave the sense of motion. By sensing location and motion of users through mat occupancy, rotation and other distortions of the star field images were triggered. Slowing down and standing still gradually reduced motion, inducing a meditative mood and clustering the visible stars into recognisable patterns such as the shape of a hand. Location identification and its control of image generation using a Macintosh computer was enabled by custom built software on a Stamp II.

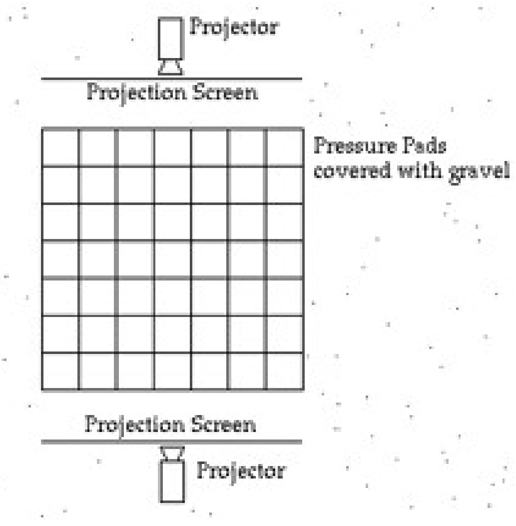

Figure 5 The layout of the 'Pause for Breath' installation

6.5.2 Phoebe Jenkins, Jackie Heron & Orit Zetouni, MA Design for Interactive Media and MA Digital Arts (1998-9)


Figure 6 Orit Zetouni and Phoebe Jenkins are watched as they demonstrate *Double Up*

'Double up', comprised a series of two player physical games. Sixteen mats were placed in a four by four square array below a large paddling pool, occupied by a custom made 'mattress', filled with small plastic beads, like a 1960s 'sag bag'. This was sufficiently thick and wobbly that retaining one's balance on it proved difficult. By jumping on the bag, various images displayed on a screen or sounds were selected (fig 6). One of the games was based on 'Pelmanism', both users had to select a matching pair in the correct order. For example, if a bounce in a particular location played the word, 'Houston', the correct response was to find, 'we have a problem'. The game proved engaging, with users bouncing vigorously to identify a variety of sounds and then closing in on identifiable pairs. The visual and sonic devices used, such as the bright pink mattress, specially composed jingles and games show style visual on screen flashes, were deliberately trashy, evoking American cable television game shows.

This project used the same mats and Stamp as used in the Lovebytes project (above), showing how the interface can be readily adapted. The modifications were simple as the mat set had been constructed in a modular manner. The mats were connected by multiway plugs and sockets, one plug for each set of 7 mats, and the terminals on the sockets were removable. Modifications for this project consisted of using just 4 rows of 4 mats, and reprogramming the Stamp accordingly.

7 Summary

This paper describes a number of artist created installations that have used Stamp interface controllers as components of non-conventional interfaces. These are genuinely multimedia objects allowing a variety of ways of interacting with image, sound and touch in a real-time context, with responses appearing immediate to participants. As artists come up with more and more interesting installation concepts, the technical ingenuity of the interface designer is tested. By extending the normally limited range of interface devices, relatively cheap but conceptually rich solutions to these design problems have been found. The various forms of Stamp used over a period of five years have enabled a series of innovative projects in a reliable, low cost and adaptable way.

These projects were presented in 'one-off' exhibitions, where installations were constructed for and dismantled after exhibitions. To this extent, the normal methods of assessment of interactive systems are inappropriate, as these usually relate to systems used repetitively by many regular users.

There are lessons from these examples for more mainstream forms of multimedia work, dominated by point-and-click and button pressing interfaces. The work illustrated shows how forms of interface that are natural and transparent to the user can be achieved at relatively low cost. There is considerable interest in such natural human interactions, for example the work of Justine Cassell [1999] and her group on gesture and narrative language at MIT Media Labs. The use of low cost non-conventional interfaces could make such advances affordable. Such methods are also being explored by Mallinder and colleagues to create innovative methods for interacting with sound production for the Sonic Arts [Robinson 1996].

8 Acknowledgements

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