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.

1 Introduction

This paper deals with an interface method used in the Lansdown Centre for Electronic Arts (LCEA). Non-conventional interfaces have been developed in LCEA over 12 years to create computer mediated art works. They are popular in a range of artistic and musical works, such as in 'tangible user interfaces' for sound manipulation [1].

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:

- a conventional device supplied with a computer, such as a keyboard or mouse;
- other devices such as microphones or graphic tablets with interface software.

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

LCEA [2] has explored new methods in computer mediated art and design from early work in computer animation [3] to later interest in interaction [4] and sonic arts [5]. Recent creations include installations populated by users [6]. These have unobtrusive functionality, 'when a computer is present in the interaction but not noticed' [7, p 397]. The emphasis is to develop innovative methods outside the standard concepts embedded within conventional software and hardware. Users of such systems participate in a puzzle like manner to explore effects created by their physical location, posture or movement. This extends the richness of opportunity for creative artists and designers. It is also necessary in an educational environment to do this cheaply, achieved with 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 is 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 USB, printer, modem and microphone ports.
- Driver software: this accesses data from the port into the user program.

This paper describes signal conditioning hardware, particularly a cheap but versatile interface control computer. Modified keyboards [8] and transducer controlled oscillators have also been used as signal conditioning hardware.

3 Signal Conditioning Hardware (SCH)

3.1 Hard Wired Versus Programmable Devices

Installations may require several input transducers with signal conditioning hardware (SCH) inputting these to a computer via few ports. In Macintosh computers used by many artists, serial USB, printer and modem ports are used. Sequencing of the transducer inputs is required, plus generation of the correct protocol serial signal.

Various logic integrated circuits (IC) could be used, but for each new interface, considerable redesign would be needed. 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 PLCs are programmed in assembly language, but Stamp devices made by Parallax Inc. use BASIC. Besides having standard language instructions, they allow instructions for common control tasks, such as serial data input/output, debouncing pushbuttons, generating and measuring pulses and sound. This reduces software development time, but the disadvantage is that BASIC is slower than assembly routines. This leads to relatively easy design and construction of NCIs, but imposes 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

Parallax Inc. makes two types of interface control computers [9, 10], Stamp I with a variant known as a School Stamp and Stamp II with a high speed variant. BASIC programs are created from a PC or Macintosh. The program is stored in EEPROM and is retained when power is disconnected. Stamps have 8 or 16 serial input/output (I/O) lines. Stamps are small (postage stamp size), unobtrusive, and cheap.

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 (instr's/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 (exc. taxes)	£25 (BS1-IC) £16 (School Stamp)	£39	£49

3.3 Comparison of the Four Stamp Variants

The Stamp I comes in two functionally similar but physically different forms. The School Stamp is more robust than the BS1-IC, using discrete replaceable components. The Stamp II has two functionally different but physically similar forms, BS2-IC and BS2SX. Table 1 compares features of the three functionally distinct versions.

All 4 variants can be used either freestanding or via a serial port to a Macintosh or PC, have a voltage regulator on board and can be powered from PP3 (9 volt) batteries or DC power supplies of 5 to 15 volt. The BS1-IC, BS2-IC and BS2SX can be mounted on very cheap 105 mm by 38 mm Project Boards containing a programming header (3 pin for BS1-IC, 9 way D type socket for others), PP3 battery clips and a prototyping area.

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.

4 Transducers

Transducers used with Stamps are those that give relatively slow output variations. Stamps are not fast enough to process audio or video waveforms needing typical sampling frequencies of 10K per second. For installations, several input channels need to be read often enough to give a sense of continuous control without delay. Stamps are suitable where sampling is needed at up to 20 per second per channel.

4.1 Input Transducers

Transducers used with Stamps in LCEA work include

- Switches: microswitches, vibration and tilt switches and pressure mats [8].
- Resistors: potentiometers, thermistors, light dependent resistors, conductive foam, body resistance.
- Variable capacitors.
- Infra red receiver photodiodes and ICs.

4.2 Output Transducer Systems

To give the output power required for the transducer, extra signal conditioning hardware is needed, for example current amplification, to drive systems such as:

- Light emitting diodes (LED).
- DC, Servo and Stepper motors and heating elements.
- Shape memory alloys (muscle wires).

4.3 On/Off Switches

Commercial pressure mats are often used for security, being laid on a floor under a carpet, acting as on/off switches when depressed underfoot. Mats frequently used in LCEA have dimensions of about 0.7 by 0.4 metres, with thickness of 0.3 mm, and cost no more than £5 each. They consist of 2 pieces of aluminised thick paper connected to output wires, with 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 have a Fine Art and a Design bias respectively. Each course involves major projects; a three month individual or group project is the final assessment. Students use scripting or programming languages such as Lingo, C and Java. Projects are displayed in annual London shows and have been described in papers [2, 3, 4]. In order to be effective and usable in such 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;

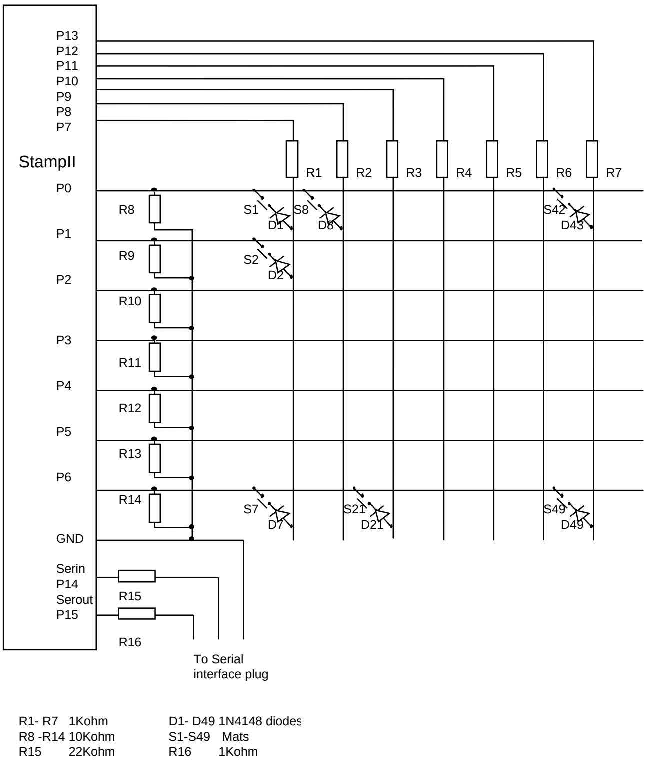

Fig. 1. The circuit diagram for a 49 mat interface using a Stamp II. Only a few mat connections at junctions are shown for simplicity

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.

As an example, a large installations used 49 pressure mats, with inputs arranged on a lattice of seven rows by seven columns as shown in fig. 1. Each mat in this circuit diagram 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 by connection to each individual mat. The stamp program is very simple. 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.

Diodes shown in the circuit diagram (fig. 1) allow current to flow only from column to row. This prevent mats that are ‘on’ in columns other than the ‘high set’ column from giving spurious results. Consider the following example: mats S1, S8, and S13 are on, all others are off; left-most column P7 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 in a number of projects developed in LCEA. 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

Michael Flaherty, MA Digital Arts (1994-5). This was the first LCEA project to use a Stamp, a BS1-IC. A sound space was controlled by a 6 channel input responding to the strength of gripping solid metal objects 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 a Stamp routine. The register value was thus related to the resistance value, which was used to control sound sources via a Macintosh computer.

Anya Langmead, MA Digital Arts (1995-6). This used a Stamp II. A wooden egg the size of a chicken’s egg was held in the hand [11]. It contained three types of detector, conductive foam for hand pressure detection, thermistors for hand heat and 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.

Emma Posey, MA Digital Arts (1995-6). This work used two Stamp IIs, as more than 16 channels were required. Stamps of any type can be linked via any of their I/O pins using serial communications with an ‘Open Drain’ serial output mode. Sensors were stuck to a rounded sculpture shaped like a small seal [12]. 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, the image enlarged to show abstract shapes, zoom in and out controlled by varying

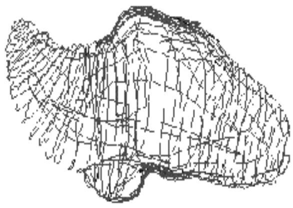

Fig. 2. Posey's sculpted shape was covered with sensors

finger 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.

Martin Robinson, Staff Member in Sonic Arts (1996). An input device like the handlebars and front shaft of a motor scooter was developed using a Stamp II by Robinson and Mallinder. This controlled sonic outputs, with different forms of motion controlling timbre, pitch and repetitive percussive sounds [5]. The handle bars and front shaft each had 3 degrees of freedom. Switches, brake-like and twist grip controls lay on the handlebars. Nine potentiometers were used in RC circuits. Output was of 31250 Baud MIDI. Robinson's dance like movements controlled the improvised sounds created, a reverse of cause and effect from the normal dancer/music scenario.

6.2 Light Detection

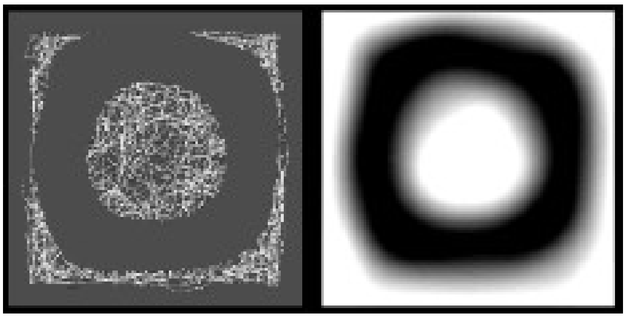

Fig. 3. The left image shows tracks of Warman's robots with bulldozers down, moving earth away from the lighter areas of the index image on the right

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 [13]. 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, 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).

Melissa Bliss, MA Digital Arts (1997-8). Entry or exit to or from a small room were identified by sequential breaking of two infra-red (IR) beams, modulated with 30 kHZ and 300 Hz square waves [14]. 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 discriminated 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 a Macintosh serial port was a single byte which showed if the room had been entered or exited. In the room, two plastic basins representing heads, each containing a loudspeaker, were mounted on vertical axes 50 cm apart. Sounds emanated from the basins, whose motions were controlled by small servo motors from the Stamp, so it appeared that they were in conversation. 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 [15]. Also in this piece, LEDs were controlled to flash red to signify entrance, green for exit.

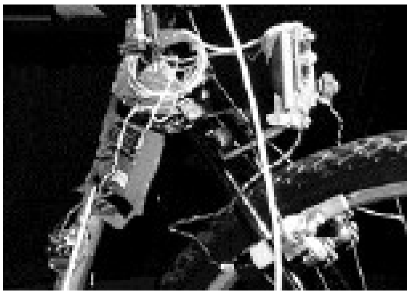

Fig. 4. The rear wheel mounting of the static bicycle shows brake sensors

Suzete Herrmann, MA Digital Arts (1997-8). A static mounted bicycle gave users control of backprojected Quicktime™ movies which they faced as they pedalled [16]. Speed of pedalling was determined by counting the rear wheel spokes to pass through an IR beam. Handlebar direction was sensed by a potentiometer in an RC circuit. Brake actuation was identified by microswitches near the brake pads (fig 4). This information was fed to a Macintosh computer via a Stamp II to control images, enabling participants to navigate through a labyrinthine landscape.

6.3 Capacitance Detection

Chris Rule, MA Digital Arts (1998-9). Rule's project [17] was concerned with 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 cube's roof. This operated on the principle of one of the earliest electronic instruments, the 1917 designed Theremin [18]. The sensor's capacitance, changed by the presence of a body nearby, with a fixed resistance formed the elements of an RC oscillator, realised using a commercially bought 7555 oscillator IC. The variable frequency square wave output was input to a Stamp II, and the number of cycles in a given time was measured using a 'count' Stamp instruction. The numbers recorded varied as the user moved relative to the sensor. These values were sent by a MIDI interface to the SuperCollider program on a Macintosh 7600 to generate sound output. Each user could be observed through two small windows, making the installation intriguing both for participants and observers.

6.4 Motion Control

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 [19]. Cards were opened (to play their tunes) and closed by a low cost sculptural construction of levers, wires and weights on pulleys. Motive force was supplied by a thin wire of shape memory alloy, known as muscle wire. This contracts by 5% of its length with considerable force when subjected to a low voltage. Current, and hence the opening and closing of cards, was controlled by a Stamp II.

David Muth, MA Digital Arts (1998-9) Distorting Mirrors. Two aluminised perspex mirrors of one metre square were mounted vertically in wooden frames to face each other about 1.5 metres apart. The mirrors were mounted so their vertical left and right edges could be moved up to 10 centimetres forwards or backwards from the normal planar position [20]. 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. Data was input from a Macintosh serial port to a Stamp II. This was conditioned for output to four sets of custom designed driver hardware. These included current limiting to avoid damaging driver ICs. At the limits of motion, a greater torque was required to turn the mirror and the current drawn by the motor increased. Current limits were controlled by microswitches mounted on the mirror frame 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. 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.

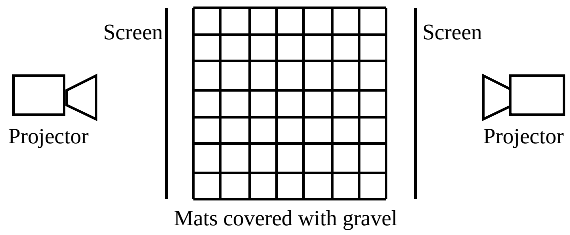

Fig. 5. The layout of the 'Pause for Breath' installation

6.5 Multiple Position Detection within an Area

Pause for Breath, MA Digital Arts (1997-8). This collaboration by 12 students with staff tutors Andrew Deakin and Hugh Mallinder, was presented at the Lovebytes Festival in Sheffield, UK, April 1998. The installation was located in a large darkened studio with a high ceiling. Two projection screens faced each other at a distance of 10 metres (fig 5). The forty nine-mat layout of 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, screen images gave a sense of motion. By sensing location and motion of users through mat occupancy, rotation and other distortions of star field images were triggered. Slowing down and standing still reduced motion, inducing a meditative mood and clustering the visible stars into patterns such as the shape of a hand. Location identification and control of images using a Macintosh computer was enabled by custom built software on a Stamp II.

Phoebe Jenkins, Jackie Heron & Orit Zetouni, MA Design for Interactive Media and MA Digital Arts (1998-9). 'Double up' comprised a series of two player physical games [21]. Sixteen mats were placed in a 4 by 4 square below a paddling pool filled by a custom made mattress containing plastic beads (fig. 6). This was sufficiently wobbly to make it difficult to keep one's balance. Jumping on the bag triggered image display and sound generation. One game was based on 'Pelmanism'; users had to seek a pair of sounds played in the correct sequence. After 'Houston', 'we have a problem' should follow. The game was engaging with users bouncing vigorously to play a variety of sounds and then closing in on identifiable pairs. Visual and sonic devices used, like the bright pink mattress, specially composed jingles and game show style on-screen flashes, were deliberately trashy, evoking American cable tv game shows.

This project used the same mats and Stamp as the Lovebytes project, showing how the interface is robust and can be readily adapted. Modifications were simple as the mat set was constructed in a modular manner. Mats were connected by multiway plugs and sockets, one plug for each row, the terminals on the sockets being removable. Modifications for this project consisted of using just 4 rows of 4 mats, and reprogramming the Stamp accordingly.

Fig. 6. Orit Zetouni and Pheobe Jenkins are watched as they demonstrate 'Double Up'

7 Summary

This paper describes a number of artist created installations using Stamp interface controllers as components of non-conventional interfaces. These genuine multimedia objects allow a variety of ways of interacting with image, sound and touch in real-time, with responses appearing immediate to participants. As artists devise more interesting installation concepts, the interface designer's technical ingenuity is tested. By extending the normally limited range of interface devices, relatively cheap but conceptually rich solutions to these design problems have been found. Various forms of Stamp have enabled a series of innovative projects in a reliable, low cost and adaptable way.

These were presented in 'one-off' exhibitions, with installations specially built and dismantled. To this extent, normal methods of assessment of interactive systems are inappropriate, as these usually relate to systems used repetitively by many regular users. Interfaces proved robust enough to survive complete shows, usually lasting about one week, and components were reused for subsequent projects.

There are lessons from these examples for more mainstream forms of multimedia, 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 the Gesture and Narrative Language Group at MIT Media Lab [22]. Innovative methods for interacting with sound production for the Sonic Arts are sought in LCEA [5] and elsewhere [1]. The use of low cost non-conventional interfaces could make such advances more reasonably affordable.

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