Wireless Dance Control: PAIR and WISEAR

David Topper
VCCM, McIntire Dept. of Music
University of Virginia
Charlottesville, VA 22903 USA
434-964-0179
topper@virginia.edu

Peter V. Swendsen
VCCM, McIntire Dept. of Music
University of Virginia
Charlottesville, VA 22903 USA
434-242-8691
swendsen@virginia.edu

ABSTRACT

WISEAR (Wireless Sensor Array) is a Linux based Embeddedx86 TS-5600 SBC (Single Board Computer) specifically configured for use with music, dance and video performance technologies. The device offers a general purpose solution to many sensor and gestural controller problems. Much like the general purpose CPU, which resolved many issues of its predecessor (ie., the special purpose DSP chip), the WISEAR box attempts to move beyond custom made BASIC stamp projects that are often created on a per-performance basis and rely heavily on MIDI. WISEAR is both lightweight and wireless. Unlike several commercial alternatives, it is also a completely open source project.

PAIR (Partnering Analysis in Real Time) exploits the power of WISEAR and revisits the potential of hardware-based systems for real-time measurement of bodily movement. Our goal was to create a robust yet adaptable system that could attend to both general and precise aspects of performer interaction. Though certain commonalities with existing hardware systems exist, our PAIR system takes a fundamentally different approach by focusing specifically on the interaction of two or more dancers.

Keywords

Interactive performance, dance, music and video controllers, Open Source

1. INTRODUCTION

Motivated by work such as Matthew Burtner's Metasax project[1] and its predecessors[2], the WISEAR box was inspired by a desire to create a general purpose interface to a wide variety of sensors and gestural controllers. Many recent gestural controllers have made use of sensors and chips (eg., the BASIC stamp) originally designed for use in robotics. Recent projects in robotics have been making heavy use of SBCs and related sensors. Our work with WISEAR follows that trend. The Embeddedx86 TS-5600 board is essentially a Pentium class computer measuring 4.3" in width and 5.6" in length. Newer models are a bit smaller, but remain untested in this environment.

It is essentially a fully functional Linux PC which accepts C/C++ binaries which can be precompiled and even tested to an extent on another machine (eg., a standard Linux computer) and then copied over via FTP, NFS mount or flash card reader.

Figure 1. TS-5600 SBC

Existing hardware systems such as the DIEM Digital Dance System[3] and Troika Ranch's MIDI Dancer[4] provide effective tools for measuring the movement of individual dancers in performance. Both systems use bend sensors mounted primarily at the knees and elbows, FM radio transmitters for wireless communication, and MIDI data as the final output to computer software. Developed in the 1990s and still in use[3], these systems and others like them have established an important technological foundation for linking movement with sound and video.

These hardware-based performance interfaces remain current long after much of the technology within them—MIDI, FM—has been surpassed by more versatile and powerful standards. This is due, in part, to the rapid improvements in video tracking technologies over the last decade. Video tracking systems such as Eyecon[6] and softVNS[7] provide capable and cost effective means of enabling performer interaction. They also allow performers to be completely free of wires on-stage. However, these systems are often limited in their ability to adapt to diverse performance environments and to differentiate between dancers, especially if those dancers are in close proximity to each other. Very recent developments in live motion capture take video-based systems even further toward freeing the performance space from the trappings and trippings of hardware while granting powerful data measurement. However, these systems require a large number of cameras, exceptional computer hardware, and still rely on dancer-mounted objects for tracking.

2. WISEAR

2.1 Hardware

The TS-5600 board is essentially a complete data acquisition system for dance and gestural based controllers. It is a full featured computer equipped with an AMD Elan 520 processor, very small motherboard, USB, VGA and other standard ports. It makes use of flash memory as large as two gigabytes, instead of a hard drive. Most importantly, the chip features an 8 channel, 12bit AtoD converter for reading data from voltage based devices such as bend sensors and FSRs as well as 23 digital IO lines for reading data from pulsed based sensors such as accelerometers. The specially configured Linux OS running on the board provides a very simple to use API for reading from both. Figure 2 illustrates the basic method for reading from a voltage controlled device.

```
int main () {
   unsigned char command = 0;
   int response;
   signed int datavalue;
   int fd = open ("/dev/AtoD/0", O_RDWR);
   if (fd < 0) {
      printf ("failed opening /dev/AtoD/0\n");
      return -1;
   }
   command = (A2D_BIPOLAR| A2D_RANGE2 );
   ioctl (fd, TSA2D_CONFIG, command);
   response = ioctl (fd, TSA2D_SHOWCONFIG);
   datavalue=0;
   while (1) {
      response = write(fd, "trigger", sizeof("trigger"));
      if (response < 0) {
         printf("write returned %d\n", response);
         perror("error:");
      }
      response = read (fd, &datavalue, sizeof(signed int));
      printf("Channel 0: %d\n", datavalue);
   }
}
```

Figure 2. Sample AtoD code.

WISEAR uses standard ribbon cable, which connects from the TS-5600 board to a daughter board, where specific links are made from the various A/D and DIO ports. Wires are soldered from this daughterboard to the specific sensors. High performance removable connectors are soldered in between all sensors and boards to facilitate swapping out faulty hardware as well as testing out experimental devices without having to extensively re-solder connections. Two 9volt batteries provide the TS-5600 board with about two to three hours of operation. Larger battery packs are available to provide as much as eight hours of battery life , but weigh several pound and are as a result ill suited for dance performance.

2.2 Data Communication

WISEAR requires no special purpose hardware to interface with the underlying performance engine. Our implementation uses basic and direct TCP read and writes. As a result, there is no limit to the number of WISEAR boxes which can communicate simultaneously with a running audio or graphics engine, as each WISEAR box has a unique IP address.. The TS-5600 board is equipped with a built in PCMCIA slot. This allows the board to support standard 802.11b PCMCIA wireless devices and communicate with any computer connected to the internet or a simple LAN via wireless hub or router.

Information is sent via standard TCP calls to the the audio synthesis / graphics engine of choice. There is no reason to avoid using the UDP protocol, but the majority of sample code for various applications makes heavy use of TCP, so we've kept that as the default. Data types are very simple: controller number and data value are sent in floating point pairs. The resolution of data acquisition is limited only to the given environment's wireless 802.11b data speed. Realistically, this translates into the 2.5 to 5.4 Mbps range. As a result, WISEAR moves orders of magnitude beyond the conventional MIDI communication rate. Data is sent using long integers. This limits data resolution to the underlying acquisition device. In the case of sensors requiring AtoD conversion, WISEAR offers 12 bit resolution. In the case of direct DIO based sensors, the resolution is limited by pulse width of the underlying sensor.

For applications such as GAIA (Graphical Audio Interface Application)[8] data is sent directly via TCP object built into the application. For Max/MSP, Norman Jaffe's TCP objects[9] provide the same functionality. By using TCP data communication in this way multiple agents are easily supported. Both GAIA's and Jaffe's TCP objects support multiple simultaneous connections. So the system easily supports multiple performers on stage communicating to the same audio / graphics processing engine.

4. THE PARTNERING ANALYSIS IN REAL-TIME (PAIR) SYSTEM

4.1 Context and Implementation

The primary intention of the PAIR system is to quantify three components of dancers' interactions with other dancers: touch, proximity, and focus. The choice of these three elements accounts for virtually all possible distances between performers on stage: Touch when dancers are in contact with each other, Proximity when they are near to each other, and Focus for all times including when they are separated by a large distance. By combining data from these three measurements, we can glean much insight into the relationship of two or more dancers on stage.

Instead of placing sensors at the knees and elbows to measure the large movements of an individual performer, we arrange the sensors (Figure 3) at locations of potential contact or interaction with other performers. Our rationale is to give up knowing things such as angle of knee bend in favor of knowing when two dancers are within close proximity or sharing weight with one another.

Touch is measured by small force sensing resistors (FSRs) mounted on the palm of each hand (see Figure 2). These FSRs yield variable resistance with pressure, allowing us to see whether two dancers are touching and how much weight is being transferred or shared between them. The FSRs are also useful in measuring hand contact during floor work. The parameter of Touch is further articulated by two other sensors worn on each hand: a bend sensor at the wrist and an accelerometer on top of the hand. The bend sensor measures the angle of wrist flexion and is particularly helpful is capturing “pushing off” and “catching” movements. The accelerometer measures XY tilt and is especially helpful is capturing gestural hand movements.

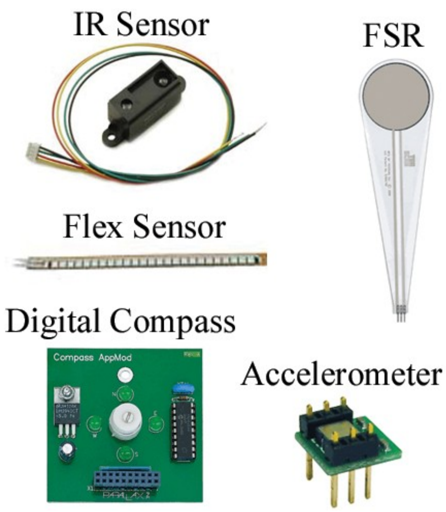

Figure 3: the sensors employed

Focus is handled by a tiny digital compass, mounted on the dancer's head. Though only precise to eight regions, these compasses are quite useful in determining whether two dancers are looking at each other. By comparing the directionality of two compasses, we can easily see whether gaze is shared or diverted.

No solution currently exists for proximity tracking over the range necessary for dance performance. Video tracking works well for general motion on stage but suffers when dancers are in close proximity or contact. Infrared and sonar sensors work well for mid-range tracking (ca. 8-60") but fail at both smaller and larger distances. We would like to create a generalized hardware-based proximity sensing system by combining exiting technology. For now, we employ IR sensors and accept an incomplete range of proximity detection. We feel that our Touch and Focus measurements effectively compensate in measuring interactions outside of the IR range. The location of the IR sensors is based on the choreography of the piece. They can be mounted on the hands, body, or head, facilitating proximity measurements in one or more directions outwards from each dancer.

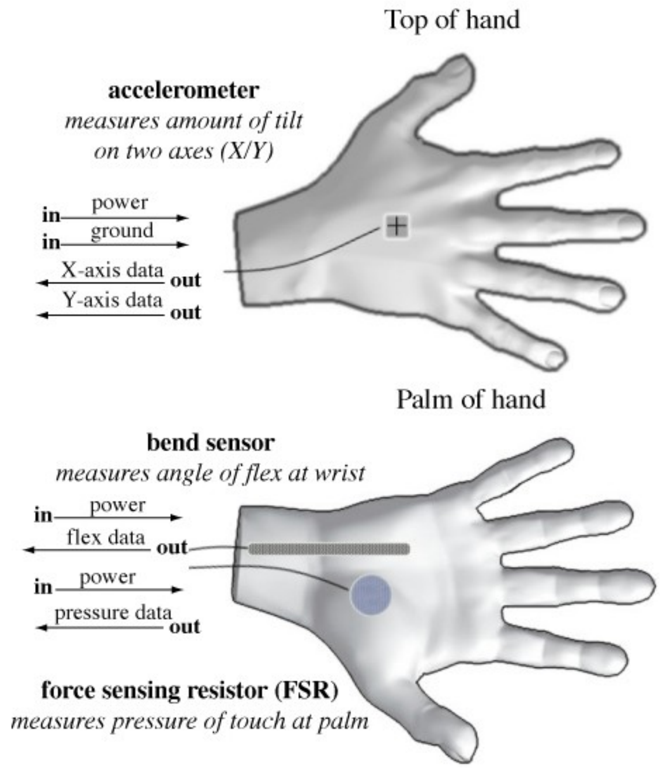

Figure 4: Layout of sensors placed on performers' hands

4.2 Software Mappings and Artistic Possibilities

One of the beauties of combing the PAIR and WISEAR systems is found in the flexibility of software mappings. Because data arrives wirelessly and because this data is of such high resolution, one can easily experiment with a variety of software and mapping strategies (see Figure 5). The two pieces of software we are currently using are Max/MSP and Isadora. Max/MSP handles audio and Isadora handles video. WISEAR also works with the GAIA program, but this combination has not yet been implemented with PAIR.

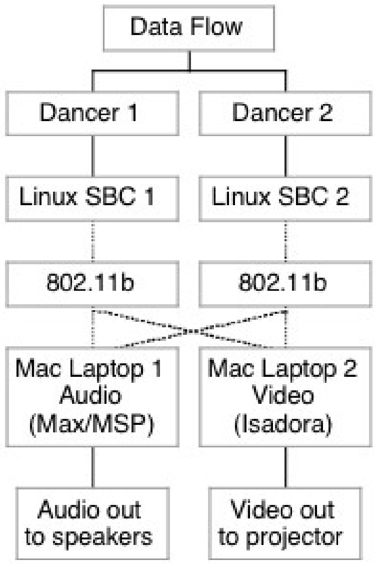

Figure 5: Data flow of the combined WISEAR/PAIR System

The presence of two or more dancers allows for even obvious mappings to generate engaging sound and image. Proximity and Focus, for instance, can be linked to the registral range and spatial location of sonic objects. While a single dancer controlling a single such object often seems trivial, multiple dancers and objects can challenge audience perception without needing to employ complex mappings.

These simple mappings can profoundly augment the dancers' ability to communicate through movement. Touch values, for instance, can be used to illuminate subtle but meaningful changes in weight sharing between dancers. Though often undetectable by the audience, the changing pressures of contact are vital to dancers' interactions. Using the PAIR system, these articulations are mapped into sound and video elements that can magnify these expressive but unseen elements of performance.

5. FUTURE DIRECTIONS

We have chosen to use TCP communication in our initial development for its ease, efficiency, and numerous code examples. As stated previously, using UDP is a logical next step. Similarly, adding support for Open Sound Control (OSC) would allow WISEAR and PAIR to work with an even wider base of programs.

It is likely that the most refined and immersive interactive performance environment will include both hardware and video systems. Combining the data output of WISEAR with video tracking data is an area we wish to explore. Currently, PAIR has been implemented only with Max/MSP and Isadora under Mac OS X. Testing is also under way to implement the system using GAIA.

6. ACKNOWLEDGEMENTS

Thanks to Dinah Gray and Ashley Thorndike of Prospect Dance Group for ongoing feedback and collaborative energy. Thanks also to the University of Virginia's Jefferson Scholars Foundation, Raven Society, and Independent Student Arts Project Fund for supporting this work. Thanks as well to the McIntire Department of Music and the Virginia Center for Computer Music at The University of Virginia, professor Matthew Burtner for his tireless efforts at pushing the boundaries of sensor controlled instruments and professor Judith Shatin for her constructive input and support.

7. REFERENCES

[1] Burtner, M. "The Metasaxophone: Concept, Implementation and Mapping Strategies for a New Computer Music Instrument," Organized Sound vol 7. n.2 (2002).

[2] Cook, P. "A Meta-Wind-Instrument Physical Model, and a Meta-Controller for Real Time Performance Control." International Computer Music Conference (1992).

[3] Siegel and Jacobsen. "Challenges of Interactive Dance." Computer Music Journal 22.4 (1998). Also see http://www.diem.dk/english/diem/research.php.

[4] Coniglio, Mark. http://www.troikaranch.org/

[5] mididancer.html (n.d.) Retrieved 1/28/05.

[6] Siegel, Wayne. "Sisters." Performance at the *Strategies.* International Computer Music Conference (ICMC '04) (Miami, 2004). Troika Rance current performance season: http://www.troikaranch.org/performances.html.

[7] Palindrome Performance Systems. http://eyecon.palindrome.de (n.d.) Retrieved 1/28/05.

[8] Rokeby,D. http://homepage.mac.com/

[9] davidrokeby/softVNS.html (n.d.) Retrieved 1/28/05.

[10] Topper, D. "GAIA: Graphical Audio Application" 2nd Linux Audio Developers Conference, Proceedings of the 2004 NIME Conference (2004).

[11] Jaffe, N. http://www.opendragon.com/

[12] Pages/MaxObjects.shtml (n.d.) Retrieved 2/1/05.