The Shadow Dancer: An interactive performance system with a foot interface

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Abstract

In this paper, we have designed novel shoes to provide active performance which enables a dancer to interact with sounds and images. Our system which we named 'the Shadow Dancer' suggests a new physical interface consists of two main parts. A wearable physical interface is utilizing for the input part that allows procedural user inputs for the dancer to create a bunch of rhythmic patterns. The output part of our system is in charge of generating sound and image using speakers and display devices in relation to the performance of the dancer. The combined system of two main parts finally provides a communication medium of the interactive dancer. We have used rhythm of step dance as outline application for the rising field of the interactive dance.

1. Introduction

As the field of new music interfaces grows, diverse types of musical interfaces have been developed. The earliest attempt was maybe Theremin's Terpsitone [2], which has been demonstrated to have virtuosic capabilities. Though many previous works were made and accomplished great achievements, mostly they were inspired by traditional acoustic instruments, such as Young's Hyperbow Controller [3]. Many interfaces show different ways to sensor design, mapping, and performance in order to accomplish their goal. However, it is quite difficult to find cases for non-professional performers because new interfaces are often designed for the use of the designer itself or professional performers.

Our system, the Shadow Dancer, is a foot interface that people can perform easily by interacting with a computer. The Shadow Dancer is built for use in real-time interaction and based on the footwork of tap-dance. The technique of tap-dance requires a sophisticated foot coordination, most of which is easily understood by non-players.

In our system, once the computer gets a bunch of rhythmic patterns, the computer plays a new combined pattern with the sound from tap shoes and the image from the tap dancer. The dancer would make interactive performance with repetition and application of this process.

To explain this work more intuitively, we used the frame-work of Interaction Design Sketchbook by Bill Verplank [7].

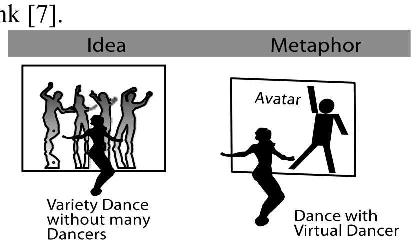

Figure 1-1: First, we got the idea of an interactive virtual dancer can generate creative rhythms and choreographies.

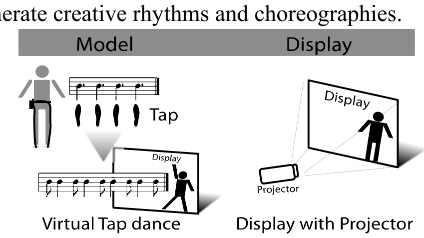

Figure 1-2: The interface transmits information on your dance. A virtual dancer can be seen performing on the projected screen.

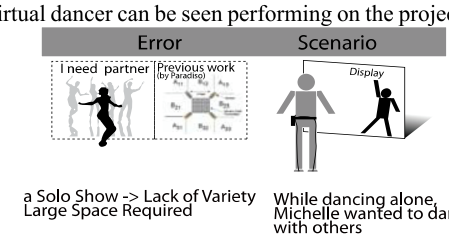

Figure 1-3 The used space can be minimized by using only interactive footwear and display.

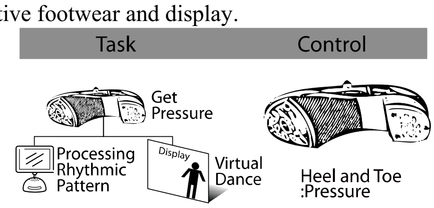

Figure 1-4: The key point of the system is to get information of shoes. The information is transmitted and then applied to the image of the virtual dance.

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2. Related Work

Several related work have been done in the field of designing the interface for interactive shoes. From 1997 to 2000, Joseph A. Paradiso developed instrumented dance shoes which could be used in a music environment. Since 1997, he started to study in the field of music interfaces [3] and developed the idea of dance shoes. Our work is quite similar to his basic concept of human-computer interaction in terms of using a foot interface as an interaction medium. His basic concept of human-computer interaction and using a foot interface is the same as our work. However, as he focused on the professional music environment, his work needed a stage that included field-sensing transmitter and a 40 KHz sonar transmitter. We focused on simpler environments such as streets or any stages with a computer and a screen.

3. System Overview

3.1. Concept

In deciding the form of the Shadow Dancer, the inspiration concept was an interactive partner that could dance with humans. Like a real dance partner, we used moving images of a dancer as the interactive partner. The images were selected by rhythmic computer-generated patterns. The computer received rhythmic patterns from a dancer who wore the interactive shoes we made, and changed its own rhythmic patterns. The computer obtained information from the interactive shoes and displayed the images along with the sound.

The Shadow Dancer is composed of two parts. One is the wearable footwear interface and the other is the speaker and screen equipment.

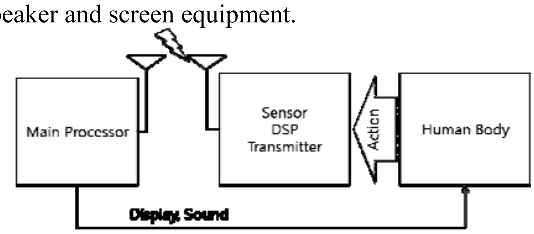

Figure 2: The Basic Diagram of the Shadow Dancer.

Fig.2. shows a basic diagram of a two-part system. This system is composed of a wearable footwear interface using a sensor DSP transmitter and a computer as a main processor. The reason for dividing the system into two parts is to increase the efficiency of various attempts.

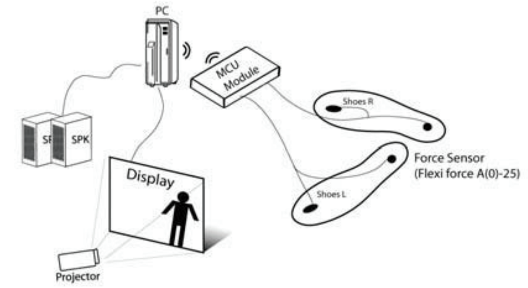

Figure 3: Detail Concept of the Shadow Dancer.

Fig.3. shows the detailed concept of the entire system. The sensor is located in the sole of the shoe and a dancer wears these shoes. When a dancer makes a move, a signal is generated from the sensor. This signal is processed by a module on the dancer's belt and transmitted to a computer. Once the computer gets a signal from the module, a virtual image of the dancer is created.

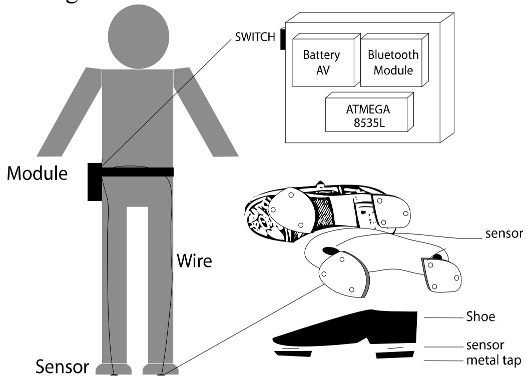

Figure 4: Detail Feature of Equipment.

Fig.4. shows the detailed features of the dancer's equipment. Large and heavy equipment are separated from the body. Only minimal equipment was used such as the sensor, signal, and communication equipment. In Paradiso's previous development [6], a circuit was on the shoes but it was too big to be carried around for large dance motions so we put a module on the waist. The sensors are connected with thin and strong electric wires.

In order to protect the sensor, we put it between the bottom of the shoe and the metal tap.

3.2. Hardware

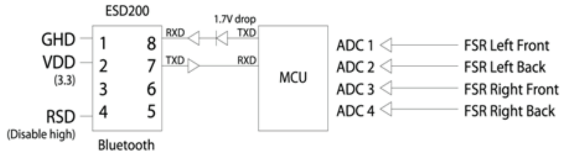

Figure 5: Wireless transmission circuit

The user's movements are converted into a signal so that the device is able to measure the movements. The signal from the FSR(Force Sensitive Resistor) is converted into a voltage signal after passing through a sensor circuit. The voltage signal changes to a digital signal after passing the ADC in the MCU. The digital signal is transmitted to the computer by the Bluetooth module.

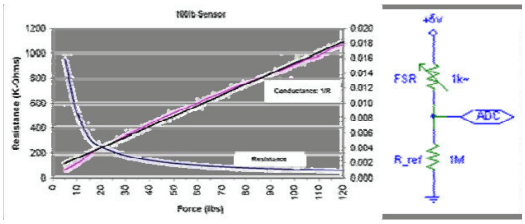

Figure 6: The Sensor Response

A large size of the general AVR board was used for prototyping. For future development, we will try to make a smaller AVR in depth.

Because of the limited communication bandwidth, we have reduced the amount of signals from the sensor to the main computer with a simple digital filter on MCU.

$$y[n]+a_2 \cdot y[n-1]=b_1 \cdot x[n]+b_2 \cdot x[n-1]$$

$$y[n]=b_1 \cdot x[n]+b_2 \cdot x[n-1]-a_2 \cdot y[n-1]$$

Equation 1: Equation of the digital filter

Our designed module will send only the peak data of each step with these digital filters, as you can find the pink lines in the Fig. 7.

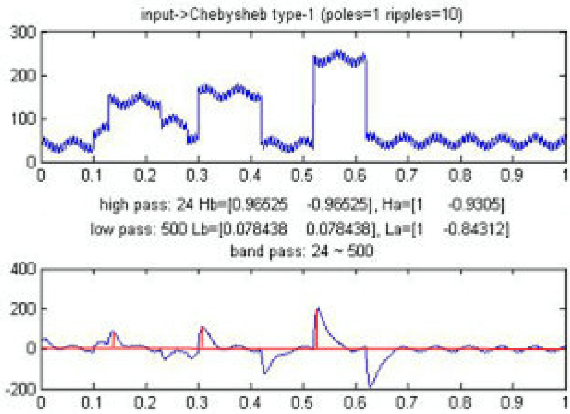

Figure 7: Filter simulation

3.3. Interaction

3.3.1Concept

The software is able to save movements of the dancer and converts original steps into new steps. When the dancer finishes an action, the avatar starts to dance on screen. If the dancer resumes dancing before the avatar is done with its dance, the dancer's input signals are appended to the previously stored data. This enables the avatar to continue dancing until the end of the data stream, despite an early action from the dancer.

There is a method to make new rhythm steps which are suitable for tap dancing and reflecting dancer's movement. The method is divided into two parts: making realistic steps and deciding the length of the pattern stream.

Video clips were created so that the same rhythm could have different motions and expressions. Each pattern has 8 different video clips. More video clips can be added easily for a further dynamic and diverse avatar motions.

3.3.2Software implementation

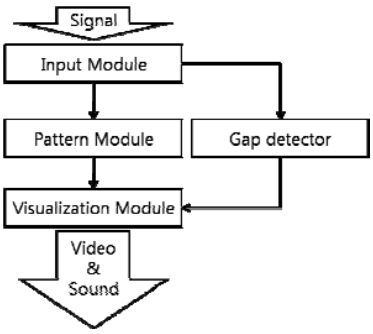

Figure 8: Program Structure

Software is built with MAXMSP and includes the following functions: analyzing signals, generating new data for interaction, and matching generated data with avatar video clips. Each function is implemented in the input module, pattern module, and visualization module.

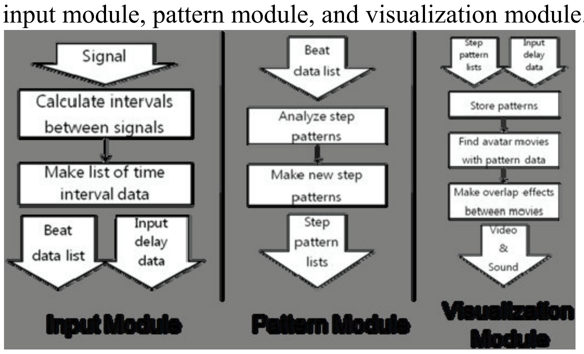

Figure 9: Input Module Structure

The Input Module arranges input signals, which are received through a serial port within a reliable range. After calculating the gap between signals, the program analyzes the rhythm of each step. The rhythm of each step analyzed in the Input Module is used to generate a step pattern for the avatar in the Pattern Module. It categorizes into four patterns, the fundamental patterns of tap dance, indexed from 1 to 4. Based on these results, the Pattern Module makes a new step pattern for interaction between the dancer and avatar on the screen. Visualization module finds the video clip that is suitable for the pattern from the database and outputs the video clips sequentially to the display equipment. The video clip stream becomes the dancing avatar that interacts with the dancer.

3.3.3 Visualization

We use Jitter only for playing clips which already have special effects because it is a big burden for Jitter to perform whole processes.

Figure 10: An edited clip

When Visualization Module receives a pattern from the Pattern Module, it chooses a clip in the movie clip list of each pattern. When there are not any new patterns generated, the Pattern module sends "standing by" patterns to the Visualization module, and then it plays a rest clip.

4. Conclusion and Future work

Figure 11: Shoes and the electronic device

We have described an interactive hardware and a software interface for interacting personal motion by foot and introduced the concept and the function of each part of the prototype interface, 'the Shadow Dancer'. Our system can facilitate the studies of the various interface area and may even be more useful for various potential performances. With the Shadow Dancer, the audience can experience rhythmic senses and interactive images from a computer-generated system.

Future work will include following developments; using new digital wireless tracing, networking standards in an unlimited environment, and allowing different types of sensors such as a gyroscope, 2D, or 3D accelerometer sensors. Miniaturization of this system may also need for putting the system on a pedagogical system. As we continue, we plan to develop various types of dances what we tried to invoke our project into them, B-boys' dances or rappers' dances can be good scenarios. The technology of detecting upper body motion might also be needed in the future version. We hope that through such works we may soon be able to show improved Shadow Dancers that will be more useful in both interactive performances and training procedures.

Figure 12: Performance with the Shadow dancer

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