Music Ball: An Adaptive, Gesture-based Musical Instrument

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ABSTRACT

We describe a new approach for applying an adaptive, gesture-based interface to create a novel musical instrument. We present the design of a prototype "Music Ball" system which learns its user's model of how a musical interface should work, and modifies itself to meet those expectations.

Keywords: Gesture recognition, heuristic learning, user modeling, implicit communication

1. INTRODUCTION

Position is used in virtually all computer interfaces as the graphical interface input. Performance in pointing has been investigated thoroughly and is satisfactorily modeled by Fitt's law [1]. Path of motion is a more sophisticated motion based control that has not yet been widely utilized in computer-human interfaces [2]. Detection of the dynamics of human motion, or gesture, is even less understood but is employed in many areas of computing including handwriting recognition [7]. Of course, the importance of gesture as a medium for non-verbal communication of human thought and emotion has been well established [3].

Musical performance, in particular, is uniquely dependent upon the use of gesture to convey performers' emotional and intellectual intent. Indeed, in its most fundamental form, the musical instrument can be considered a converter from motion to emotional expression. Consequently, many researchers have focused on the development of gesture-based instruments and conducting devices. As a result of these efforts, considerable advances have been made in the accuracy and efficiency of gesture sensing and recognition techniques [3,4].

The emulation of musical instruments using gesture-based interfaces has been achieved [3]. However, devices of this nature are usually limited by their adherence to conventional forms of human-instrument interaction. Much like a real instrument, typical gesture-based devices require training in performance techniques particular to the designer's implementation. In this paper, we describe an approach for applying an adaptive, gesture-based interface to create a novel musical instrument. The aim is to create a smart relationship in which the computer and user work together to accomplish something outside the skill set of the user alone.

2. MUSIC BALL

The idea behind the Music Ball is to provide a unique shared experience in which a computer can facilitate its users' musical expression. The Music Ball system interprets a user's gestures and uses a dynamic language to translate them into music. Unlike typical implementations of gesture-based instruments, however, the Music Ball actively learns and adapts itself to the user's expectations of how its musical interpretation should behave. In this manner, the onus of learning a gesture-language is effectively shifted from man to machine.

2.1. The Design

To achieve this goal, the Music Ball system takes the approach of proposing ideas to the user and subsequently adapting its model to his/her feedback [6]. To begin, the user starts with a fresh, untrained Music Ball system.

When s/he makes an initial gesture with the system's six degree of freedom input device, the Music Ball responds with a subtle vocalization consisting of a few notes of arbitrarily assigned pitch, tempo, and dynamics. Repeating the gesture prompts the Music Ball to record the gesture and associate it with the presented vocalization. If the user

is displeased with the vocalization, s/he can elicit an entirely new response by making a different gesture. Conversely, repetition of a particular gesture pattern will result in a slightly modified recurrence of the original vocalization. Using this feedback loop, the Music Ball draws on its user model and feedback to hypothesize sounds that the user will appreciate. The system-user collaboration thereby creates a dynamic language of sounds and associated motions. During future sessions, the user can evoke known sounds by drawing from the nascent gesture-language. Otherwise, the user and system can significantly expand their repertoire with new gestures. The system utilizes basic heuristic learning to test its new theories about what the user likes and thereby expands the gesture-language.

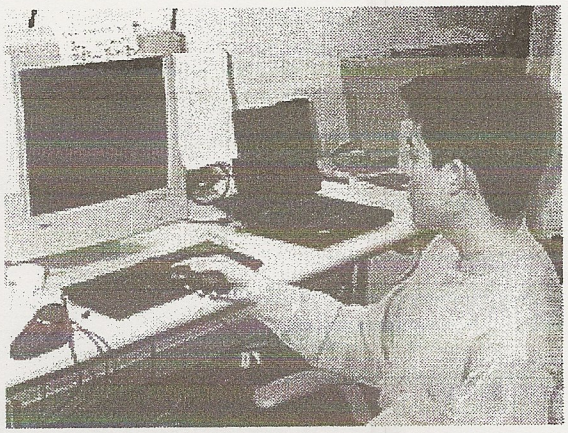

Figure 1. The Music Ball prototype

2.2. The Prototype

The initial prototype of the Music Ball system was implemented on a personal computer using a Polhemus IsoTrak II device for gesture input in two dimensions. Separate audio handling, gesture handling, reasoning and display modules work together to create the instrument. Furthermore, the program was designed as a multithreaded system which allows multiple gesture/sound pairs to be processed concurrently. In this way, the system becomes increasingly multiphonic as the user becomes more adept at using his/her gesture-language. We have yet to conduct formal user testing with this prototype. However, initial observations of user's interactions with the system have been encouraging.

3. FUTURE WORK

Experimentation with the current Music Ball system prototype has revealed several potential avenues for further investigation. In particular, we have discovered that the serial nature of sound poses significant difficulties in obtaining real-time feedback from the user. The initial challenge of eliminating the feeling of handshaking when reacting to a serial output has been particularly challenging. Built-in syncopation in the gesture input and temporal constraints are being explored as ways to hide undesirable delays in user interaction. Additionally, future work will continue to concentrate on increasing the responsiveness and fidelity of the instrument. Specifically, the choice of associations that are expected to be musically appropriate at any moment presents a fascinating modeling challenge.

4. CONCLUSION

This paper has presented the philosophy and design of the Music Ball. The Music Ball system utilizes an adaptive gesture-based interface to create a unique musical partnership between man and machine. We believe that our work suggests a new pathway for the development of adaptive gesture-based interfaces. Indeed, the lessons learned in the development of the Music Ball system are cogent to numerous real-world applications ranging from improved handheld PC interfaces to the intelligent training of industrial machines.

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