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A wireless-networked wearable musical instrument with which we can go to town

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Abstract

Contributions of electronic media technology to learning or education have become more necessary. Especially, VR or multimedia technology could be utilized effectively for education of the artistic fields such as music. we developed a CosTune-prototype as the first step of the system with which we could create and play musical pieces anywhere, at anytime, and with anybody as previously reported. However, CosTune-prototype needed a supporting server, and so a user could not go to town wearing it and play a song. Therefore, in this study, we developed a truly wearable system based on the CosTune-prototype. It is expected that the developed system would be useful for making an active virtual direction of our daily life space and us through music play and communication.

Key words: wireless network, wearable, electronic musical instrument, learning, education

1. Introduction

Contributions of telecommunications technology to education and learning are becoming increasingly necessary. VR and Multimedia technology, in particular, can be effectively used for teaching artistic pursuits such as music. Music-related technology has already added a variety of new effects to musical education. For example, music was originally only available to those who were present at the time it was performed. Once Thomas Edison invented the phonograph, the technology of recording and reproducing sound enabled us to experience virtual musical performances whenever we wanted. Portable music players like the Sony Walkman also went on to create entirely new musical environments. They let us take our music to the streets, literally filling our lives with music. However, these are all passive experiences. To support the learning of music more effectively, we believe that a new system is necessary, one with which we can create and play songs all by ourselves as well as listen to prepared songs.

On the other hand, several wearable musical instruments, such as the YAMAHA MIBURI and the BODYCODER, [1] have been developed, although they are still restricted to use on a stage. The Musical Jacket [2] developed at Media Lab., MIT, achieves true portability. However, the Musical Jacket was developed as a practical sample application of “washable computing” [3] and we think that its design lacks the elements required to make it a new musical instrument for daily musical activities, although it has been implemented as a form of daily wear. These examples are also limited in their ability to build relationships with other performers as a communications tool, even though this is such a significant element of music.

For use as communications tools, inter-network systems have been proposed that enable users to communicate and collaborate with each other in composing music [4, 5]. However, they lack real-time response and face-to-face communication, even though these are also important elements of musical fun.

To solve the above problems, we are developing and studying a wearable musical instrument system that (1) enables individual, everyday portability for both playing and listening to songs, (2) supports communication among users, and (3) enables ad hoc musical sessions and collaborative musical composition. This system can provide a useful environment for learning music.

We already developed a CosTune (costume + tune)

prototype as the first step in a system that allows us to create and play musical pieces anywhere, anytime, and with anybody, as previously reported [6,7]. The CosTune prototype was a wearable, wireless, networked MIDI instrument and enabled a user or users to enjoy single-session playing. However, since the CosTune prototype needed a supporting server in the neighborhood, its users had to be in an experimental room. Therefore, in this study, we developed CosTune-v2, a truly wearable system based on the CosTune prototype.

2. Musical instruments with easy portability

Easy portability is an important characteristic in a musical instrument for enhancing the learning of music. Easy portability was developed in the CosTune as described below.

2.1 Requirements

People naturally want to be able to play songs anywhere, at anytime. To make this possible, it is necessary to release musical instruments from their own physical restrictions. Musical instruments are essentially mechanisms for generating sounds by utilizing the physical characteristics of certain objects. Investigations have determined how effectively a string, a pipe, a mass, etc., could be vibrated. The ease of playing a song has been second in priority, following the physical requirements for effective vibration. This is one of the reasons for the undeniably high barrier that exists for anyone starting to learn how to play a musical instrument. Moreover, large, heavy instruments are required to produce a broad range of tones and various kinds of timbres. Thus, we often cannot carry them and play them at the same time.

Considering the above, it seems strange that almost all electronic musical instruments, which are able to generate sounds free from their own physical restrictions, still have shapes and forms that are similar to ordinary, acoustic musical instruments. We think it is important for a new musical instrument to (1) be easily manipulated and played, (2) have a weight and size that allow it to be carried, and (3) have a suitable shape for playing without requiring an unnatural posture.

2.2 Design

Clothing was adopted as a performing interface for the CosTune prototype because we thought that it offered two advantages over ordinary musical instruments. The first is that clothing is a familiar, daily object for us. It was expected that anyone could handle controls installed onto clothing without difficulty. The second is that we do not need to carry or support clothing when we wear it. This allows us to use both hands for playing a song.

CosTune basically consist of a performing interface, an A/D converter, a PC, a tone generator, and a headphone (see Fig.1). All equipment was selected to enable the use of long-life batteries and to be as small and light as possible, so it could be packaged in a small bag.

2.3 Improvements for CosTune-v2

We rearranged the functions and roles of the equipment in CosTune-v2. For example, players do not need a tone generator when they are not listening to music with headphones. We also selected a lighter PC for CosTune-v2.

3. Ease of playing songs

Ease of playing is also an important characteristic to enhance the learning of music. The ease of playing CosTune was increased as described below.

3.1 Requirements

Of course, some ordinary musical instruments, for example the harmonica and accordion, offer easy portability. The accordion, in particular, is able to generate not only melodies but also harmonious chords all by itself. However, many ordinary musical instruments, including the harmonica and accordion, are difficult to play and they take a long time to master. This is one of the reasons why people tend not to think lightly about playing a musical instrument.

It was therefore necessary to solve the difficulties of musical theory and playing technique. We thought it would be effective to make several systematic arrangements in CosTune. That is, to distribute the musical roles of the players, reduce the number of controls, and systematically arrange the controls according to musical theory and human factors, to achieve a rational and easy-to-understand layout. A “function-based note mapping method” [8] also serves as a user-support function. That is, the specific function of a note is constantly mapped to a certain touch sensor based on the analytical results of a chord progression in the piece of music being performed.

3.2 Design

We investigated ways to reduce the number of controls on the performing interface, and studied their layout and systematic usage.

Three types of performing interfaces were prepared: a jacket-type, a pants-type, and a glove-type. Each of them took charge over the melody, rhythm, and decoration, respectively.

The number of controls should ideally be less than ten, or about ten, because we have ten fingers. Therefore, we put three controls each onto the right and left sides of the pants-type interface, so that a player can touch them with the thumb, the forefinger, and the other fingers. We put four controls each onto the right and left sides of the

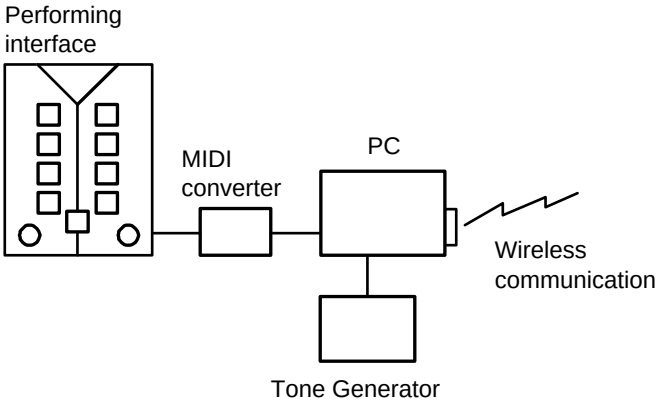

Fig.1 Composition of CosTune-v2 system

jacket-type interface for the four fingers from the thumb to the ring finger. We mapped the eight tones of an octave to the eight controls. Then, we implemented pseudo-function-based note mapping for these controls. The little finger was given the role of changing the height of the tones (raising and lowering octaves) with another control. This allowed the performing interface to generate broad bands of tones that are equivalent to all of the white keys on a piano. We also designed a timbre change control. Consequently, the systematic arrangement of only eleven controls enabled us to create various kinds of expression comparable to a small electric piano.

Minor adjustments to the layout of the controls are also made for each player according to his or her personal preferences.

3.3 Improvements for CosTune-v2

We also added a timbre change function to the pants-type interface. Each of the controls can be used to independently select the timbre from among fifty varieties. The timbre list can be edited by a text editor on a PC.

4. Communication between musical instruments

Communication is an essential characteristic of music. We designed a non-sound communication between the musical instruments to support communication between players in the CosTune prototype. However, since it required a server, we were not able to carry the CosTune prototype onto the street. So, we newly developed a peer-to-peer communications system without a server.

The portable control unit of the newly developed CosTune-v2 is equipped with an A/D converter, PC sequencer software, a wireless communication unit on a PC, and a tone generator (Fig.1). The output signals from the sensors on the wearable input device are input to the A/D converter, which converts the input analog signals into MIDI (Musical Instrument Digital Interface) data according to mapping rules designated in advance. The generated MIDI data are encapsulated into UDP packets in a PC and broadcast through its wireless communication interface.

On the other hand, all broadcast MIDI data are received by the PC through its wireless communication interface and sent to a tone generator. The tone generator reproduces sounds according to the received MIDI data. Therefore, every player can listen to the performance of all of the players with either headphones or a speaker system, as they choose. If a new CosTune user enters the communication area, the new user becomes able to listen to the other performers' performance. At the same time, the other performers also become able to listen to the new user's performance.

Microsoft Windows XP was adopted as the OS and the wireless LAN service (IEEE802.11b/11Mbps) on Windows XP was used in the ad hoc communication mode.

5. Evaluation

Tests and experiments were conducted to evaluate CosTune-v2 system developed as mentioned above. Following three points were mainly examined. (1) Portability. (2) Ease of playing a song. (3) Wireless transmission function.

5.1 Easy portability

We succeeded in packing all equipment of CosTune-v2 system without performing interface in a small bag. The whole weight of CosTune-v2 system was about 3 kg and a woman could wear and play it. Wearable fashion of the performing interface was effective. The player could move his / her arms and legs freely. While standing, sitting, walking, and dancing, he / she could play songs simultaneously. For more than three or four hours, CosTune-v2 worked due to batteries capacity. These results suggest that CosTune-v2 has everyday portability and we can wear and play it in daily life from the viewpoint of hardware aspect.

5.2 Ease of playing songs

The systematic layout and arrangement of controls on the jacket-type performing interface enabled a step-by-step learning of playing technique of CosTune. Novice subjects understood and learned the layout and role of the eight controls at first. They learned using some or all controls to play a song in one octave range. There was a tendency that they learned next the role of the timbre change control and became to play changing timbres. The next step of learning was the changing the height of the tones. In this step, they became able to use several octave of tones and several kinds of timbres freely to play more complicated and difficult songs. These learning processes were achieved in a few days. It would

Fig.2 Outdoor Jam session by CosTune-v2 players

be rather short compared with that for the ordinary musical instrument.

5.3 Wireless transmission

We also succeeded in the implement of wireless communication of MIDI data encapsulated in UDP packets. Few packets-loss were observed within 30m of distance. The delay of information processing and transmission was reduced to less than 10 ms. This is short enough for most amateur players to play without confusion. CosTune-v2s enabled us to make a jam session by plural players out of doors (Fig.2).

6. Conclusion

We developed a truly wearable system CosTune-v2 based on the CosTune-prototype. It is expected that the developed system would be useful for making an active virtual direction of our daily life space and us through music play and communication.

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