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RESEARCH ARTICLE

Restoration of traditional Chinese shadow play-Piying art from tangible interaction

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ABSTRACT

Piying, the world's intangible culture heritage, is a characteristic Chinese folk shadow play and one of the origins of modern movie. The spirit of traditional Piying is to express rich emotion and stories through impromptu action change by professional artists. Now Piying gradually fades away in people's lives, encountering the risk of extinction. We focus on transforming the traditional Piying play into an interactive system, which can be seamlessly performed by ordinary people and bring a strong sense of immersion to the users. Two interactive systems were developed, with Kinect-based interaction or sensors, users can create own digital Piying animations by employing their body movement as input. A field study was presented with 20 students in a primary school. The result showed that our system was far more effective in emotion induction and Piying understanding than traditional one. We demonstrated this system in a charitable foundation and a workshop of a tangible conference. It is also honored to be collected by China's intangible cultural heritage network.

KEYWORDS
culture preservation; shadow play; tangible interaction; kinect; bodily movement; field studies

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1. INTRODUCTION

With a history of 2000 years, Chinese traditional shadow play-Piying is a splendid art, combining delicate hand craftsmanship and folk drama. Piying is recognized as "the ancestor of the movie" in the international film history [1]. In Piying, semitransparent leather silhouette with decorative patterns, including puppet-like characters and scenes, are projected onto a white screen. Motions of a character are realized by transforming various parts of a character via a few sticks on the hands of the performer. Audience on the other side watch the performance of these colored shadows of characters, which are manipulated by performers who are behind the curtain and forges soul for Piying figures. Piying are performed impromptu according to the mood, idea of the performers and the interaction with audience (Figure 1).

When performing Piying, the movement of different pieces must be well coordinated; thus playing Piying is helpful not only for intelligent training, but also for health. The great Chinese educationist Confucius once said:

> *Piying is a good form of edutainment, catering to the demand of prevalent stories and jokes with meaningful philosophy as well as ones with facetious expressions, which means integrating animation, performance and teaching functions together.*

However, with the development of film, television, and PC games, Piying gradually fades away in people's lives, encountering the risk of extinction. Thus, questions about how to reform and recreate Piying art form, how to use modern technology reasonably to inherit and develop this cultural work, and how to reserve a foothold of Piying among the fierce art performance market are supposed to be considered. The spirit of traditional Piying performance is to express rich stories and emotion through improvising actions controlled by the artists. The digitalized form of Piying characters can be expected as a way of retaining cultural legacy, in which people could interact with the digital characters and create stories by themselves [2].

(a) Artists control the actions of shadow by using sticks fastened to the characters

(b) The shadow of characters with delicate carving could be seen by audience

Figure 1. Performance of Piying.

In this paper, we propose two systems that mix the digital and physical interaction to let users obtain immersed in the traditional treasure of Piying. Specifically, one system concentrates on kinesthetic interaction where digital Piying movement is driven by human skeleton data captured by Kinect; another focuses on wearable computing where digital stories can be created by the user's body movements through real-time image processing.

Our aim is to freely support emotional expression and idea creation in Piying, and to avoid professional playing skills required in the traditional Piying. Our systems impose no constraints on body movement of users and still preserve spirit of traditional Piying performance: free control of movement, impromptu interaction between performers and audience, and spontaneous expression of the emotion.

2. RELATED WORK

Relevant prior work includes contemporary methods of protecting Piying culture and relative culture heritage, as well as research on tangible interaction.

2.1. Contemporary Methods of Protecting Piying Culture

The Chinese government establishes culture protective associations to protect Piying, such as Piying museums and research groups. Some researchers present a set of techniques developed for digital simulation of Piying [3] or make Piying animation system. [4–6] New computer software has been designed to animate Piying characters [7]. A few programs focused on interactive Piying performance, generating unconventional performance between human and digital Piying characters [2]. In foreign countries, there are associations and curriculums focusing on Piying on campuses, and a gallery in Bursa of Turkey shows many kinds of Piying props and production supplies in different periods. People there have applied Piying to TV drama and published many books about Piying [8].

Although via these methods, people could receive a partial feeling and information about Piying, the vivid performance experience of Piying show, and the improvised emotional expression presented during the performance cannot be well delivered to people.

2.2. Contemporary Methods of Protecting Culture Heritage

Wetpaint is a tangible interface focusing on art restoration. [9] Authors intend to offer people experience in the same way as a restorer does. Brick and stone relief is a form of sculpting, which was used in ancestral halls and tombs as architectural decorations in the ancient time of China. A system is to plausibly restore the relief surface of brick and stone relief from their rubbings [10]. Some Chinese researchers focus on restoring historical documents of Chinese calligraphy [11,12]. Animations, computer games, and virtual reality are applied to China's famous Jing-Hang Grand Canal and Ancient Chinese Painting for the purpose of cultural heritage preservation [13–16].

In the context of martial arts and computers, Perttu Hämäläinen *et al*. explore a system named Kick Ass Kung-Fu, which is an immersive game installation that transforms computer game into a visual, physical performance like dance or sports [17]. Chua *et al*. present a wireless virtual reality system with a video receiver and head-mounted display for full body tai chi training [18]. Chi *et al*. describe a wearable sensor system that has impacts on the sparring ring of a martial art competition [19].

2.3. Tangible Interaction

The goal of tangible interaction is to empower collaboration, learning, and design by using digital technology and at the same time takes advantage of human abilities to grasp and manipulate physical objects and materials [20]. Some educational toys used to materialize record and play concepts have been explored as well in this field. There are toys, which distill ideas and inspirations from gestures and from the form of dynamic movement. [21–23] PageCraft [24], augmented Knight's Castle [25] and authorable virtual peer [26] are three interactive platforms, which lets users manipulate familiar things around like toys to construct their own story. Instead of using predefined discrete objects with fixed forms, Illuminating Clay [27] and Sandscape [28] utilize continuous tangible material such as clay and sand to form giving and sculpting for landscape design rapidly.

From a broader perspective, human–computer interaction requires physical effort, by using body movement to control the character, scene, animation and so on. In particular, "Sports over a Distance" [29], Table Tennis Three [30], and Shadow boxing [31] are exertion interfaces that deliberately require intense physical effort to offer rich opportunities for connecting people socially by using a game device with a regular soccer ball, ping-pong ball, boxing glove, and a video conference screen. Ishii *et al*. presents a "motional-tangible interface", which is a digital technology expanding interaction game design for a traditional ping-pong table that augments the sport with dynamic graphics and sound [32]. The Microsoft Xbox [33] presents a significant approach of one more sophisticated, 3D interactive game device that the user can interact with visual scenes and game plots with a variety of physical movements. Kinects were used for 3D human animation and virtual try on to facilitate a range of home-oriented virtual reality applications. [34] Distributed VR technology is employed to construct a virtual Olympics museum, which is a large-scale distributed 3D virtual environment for demonstrating the Olympics' history, culture and highlights. [35] Vision-based gesture interaction technique are used for tracking both hands in real-time [36], and research focus on depth sensing that is one of the fundamental challenges of computer vision [37].

3. SYSTEM DESIGN

3.1. Design Guidelines

We design two systems to stimulate creativity and movement by creating relevant design affordance. During the process of designing the functionalities and devices, we follow the guidelines in the later text.

Inheriting the essence of traditional Piying culture: We focus on trials to reserve the spirit of Piying culture, which enables the unique primitiveness of Piying image to impress the audiences. Thus, when animating digital characters on the screen, we preserve traditional Piying characteristics, such as: (1) all actions are animated on 2D; (2) special effects are used to provide users with real feeling of Piying, for example, feint effect are used for fast action; and (3) the animation of activities between joints of a Piying character are based on the real Piying movement.

Sharing and improving the interest of shadow show: We hope to design a system that would encourage ordinary people to get involved in Piying by interactive performances and allow users to immediately create stories without sophisticated planning or construction.

3.2. System Construction of Digital Piying Controlled by Kinesthetic Interaction

The interaction system captures human skeleton data by using Kinect to control the digital Piying movement. The overall architecture of our system is presented in Figure 2. Specifically, (1) the data of body movement is captured by Kinect; (2) calculate the joints relationship of human body, then use it to draw Piying; and (3) generate Piying animation.

3.2.1. Acquisition and Processing of Depth Information

Kinect is a somatosensory peripheral of the home video game console XBOX360 developed by Microsoft. It is a 3D camera, which boasts of real-time dynamic capture, image recognition, microphone input, voice recognition, and community interaction. The OpenNI framework is an open source SDK (Software Development Kit) used for the development of 3D sensing middleware libraries and applications on the Kinect. And the NITE is a kind of Natural Interaction Middleware Libraries under the OpenNI framework. Both of them are developed by PrimeSense, which was founded in 2005 by a group of talented visionaries. We can get the released softwares from the web. In

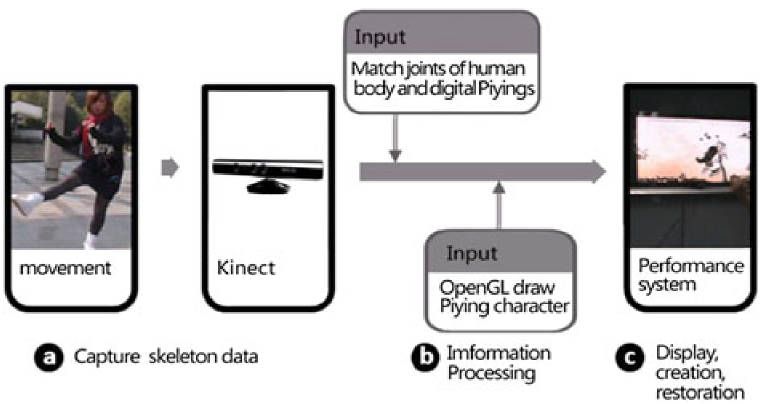

Figure 2. System workflow overview of digital Piying controlled by kinesthetic interaction.

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the system, the algorithm first acquires depth information of the scene, then through processing and analyzing, can stably trace human skeleton so as to acquire skeleton joint data. In the process, there are mainly 15 skeleton joints being tracked, shown in the Figure 3.

3.2.2. Analysis of Piying Joint

The traditional Piying character consists of six parts, including the following: head, body, thigh, legs and feet, and upper arm and lower arm. According to the control structures of Piying and kinematics, we take the connection between body and head (neck) as the root joint of all joints, in other words the 'neck' is the starting point for drawing the whole Piying. It is because the strut of the neck in Piying character is the supporting point of the entire Piying character and decides the position of Piying character on screen as well.

Figure 4 shows the process of drawing the skeleton of a Piying character. The outline border in the figure is the screen size of Piying performance. It is assumed that the neck coordinate is (x_0, y_0) (red coordinate is the local coordinate system of the neck). The left lower arm coordinate (blue coordinate system) is (x_1, y_1).

To rotate all parts of the body, it needs to separately draw the textures of each part. Therefore, if it wants to draw the overall Piying, it should first know the coordinate of neck (red coordinate) coordinate system in the entire screen coordinate system, namely (x_0, y_0). Then, it draws the head upward from the point. When it needs to draw the arm after the head, the upper arm is below the neck coordinate system and forms α angle in a vertical downward direction, and the lower arm has to move to the position of blue coordinate system. To move to the target position, it needs to move (lx, ly) first as per the OpenGL principle and then rotate for corresponding angle.

It can only draw the next part when it moves to the target position by using this way to draw each part one by one till finish the whole character of Piying.

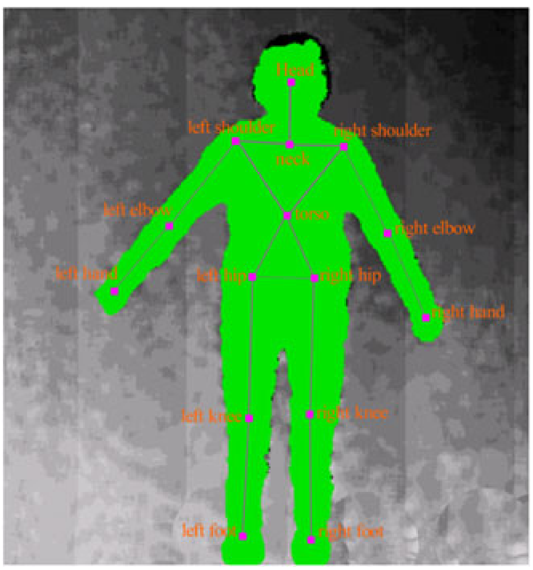

Figure 3. Fifteen skeleton joints of the human body.

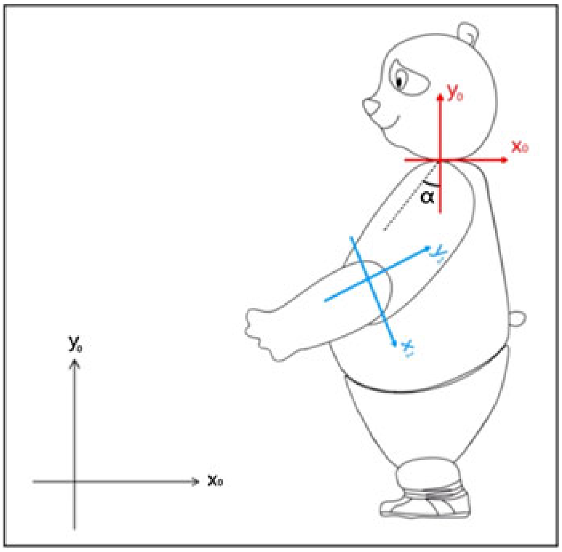

Figure 4. Process of drawing the skeleton of a Piying character.

3.2.3. Draw Piying Texture

To vividly display, it needs to add texture to each part of Piying character. However, because of the irregular shape of the parts, simple chartlet cannot be applied; for a more vivid display, it adopts a Truevision Graphics Adapter file format to store Piying file and by drawing Piying texture with the method of OpenGL.

3.2.4. Binding Piying Human Joints

The binding between human skeleton data and Piying character means to combine positions between human skeletons, rotary features, and digital Piying characters. The article has defined the data structure of joint relationship. According to the movement features of a Piying character, 12 joint relationships have been defined (Table 1), which have supported various actions of Piying, such as raising hands, bending the body forward, respect, and the raising legs and feet. First, we capture human skeleton information by Kinect and NiTE2, then smoothen and denoise such information so as to acquire accurate information of 15 joints. Secondly, on the basis of such information, we calculate the defined 12 joint relationships, which means that the angles between vector quantity is composed of two joints and vertical direction. Then apply the angles into the Piying drawing and rotate the relevant body part formed by two joints to shape the action of each frame of Piying.

The data obtained by Kinect is sequential frames. Thus, we need to bind each frame to obtain a smooth Piying animation. (Figure 5)

3.3. System Construction of Digital Piying Controlled by Wearable Sensor

This interactive system uses embedded sensors and computing chips to control digital images on the screen to

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Table 1. Twelve joint relationships of a digital Piying character.

Joint relationships			Joint relationships			Joint relationships		
0	Head	Neck	4	Elbow right	Hand right	8	Knee left	Foot left
1	Neck	Elbow left	5	Neck	Torso	9	Knee right	Foot right
2	Elbow left	Hand left	6	Hip left	Knee left	10	Neck	Hip left
3	Neck	Elbow right	7	Hip right	Knee right	11	Neck	Hip right

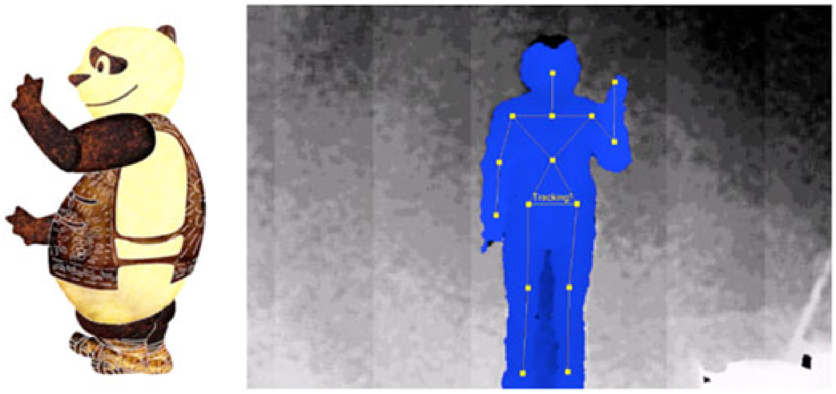

Figure 5. Piying system based on Kinect.

perform corresponding Piying actions. The overall architecture of our system is presented in Figure 6. In particular as follows: (1) the data of body movement are captured by sensors: (2) data information are processed by using a computer; and (3) the information processed by the computer is transferred to the corresponding exaggerated digital actions that are then displayed on the screen as Piying movement.

Sensors and chip microcomputers used in the tangible period could be attached to the user's arms, legs, waists, and so on. With multiple sensors on different parts of the body, we can create more live motion effects.

To highlight the unique and vivid effects of Piying show, we generate exaggerated Piying movements on the basis of input. For instance, a digital character could easily jump 3 m in the air or dash a long run. Also, to achieve a reasonable interaction, we have designed a paper hat containing sensors with which we can do the following: (1) minimize the restriction of physical device design; (2) allow users to move around a certain range so that sensors are sensitive to the location changes; and (3) install the sound sensor close to mouth.

In this prototype, we preset six digital characters, three default scenes and three traditional Chinese songs with which both Chinese and foreign friends are familiar with. In the following part of this section, one of the characters, kung fu panda, is chosen to demonstrate the technical construction.

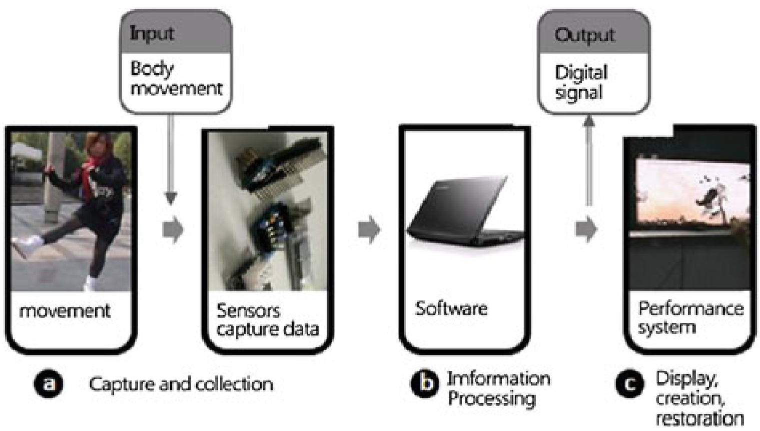

Figure 6. System workflow overview of digital Piying controlled by using a wearable sensor.

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3.3.1. Arduino Program

The hardware embedded in the hat is built on Arduino board consisting of a chip microcomputer, an acceleration sensor, a sound sensor, and bluetooth. Firstly, acceleration sensors detect changes of actions. Then the corresponding data are sent to the Arduino board and computer through the wireless Bluetooth. Finally, Flash program on the computer receives data and calls on appropriate digital character's movement. Serproxy is used to build a connection between Arduino and Flash program.

The Arduino program controls the action mode of the virtual image by defining the different dimensions through the parameters of the acceleration sensor and sending the corresponding instructions to the Flash files by using bluetooth. The action elements abstracted from this interactive system include direction, frequency, and combination pattern, excluding intensity.

Our system detects the acceleration in one direction by comparing the difference between the obtained acceleration and the initial one from each axis, and judges the direction in each axis by checking whether the value is positive or negative. We divide a user's movement into two styles: combination action and single action. The former one means digital character's action generated by a user's multiple movements, whereas the latter one means digital character's action generated by a user's single movement. To judge whether an action is a combination action or a single, one is performed by counting the frequency of the acceleration value appearing in one direction, in 1300 ms. If it appears once, it is regarded as a single action; otherwise, it is a combination action. In total, three axes can define six kinds of action modes. After all, the program is executed once there is a 400-ms delay. Such delay guarantees acceleration will not be counted repeatedly.

3.3.2. Digital Information-Processing Device

Based on Flash program, this is a digital information-processing device, mainly containing action database, and animation-running interface.

Our interface has three options including start, setting, and exit (Figure 7(a)). Once the setting is pressed, a setting page pops up with a complete set of the character's Kung Fu action icons displayed (Figure 7(b)). A player can preview actions of the digital character on this page.

Characteristic and key action components in Figure 7(b) are selected from actions based on traditional kung fu performances. In our currently implemented system there are action components such as respect, quick fist, and so on. Table 2 shows the action code in Flash, user's action request, and definition in Arduino program and Flash program.

(a) Start-up interface (b) Action database (c) Animation running interface

Figure 7. Interface of Piying play system.

Table 2. Action definition.

Action code in Flash	User's action request	Definition in Arduino program	Definition in Flash
"1 respect"	Initial action		
"2 palm"	Forward	(X+)	
"3 quick fist"	Forward, forward again	(X+; X+)	
"4 hands down"	Down and forward together	(X + Z−)	
"5 leg bounce"	back	(X−)	
"6 jump up"	Up, then down	(Z+; Z−)	Random setting,
"7 roll up ward"	Up, then down	(Z+; Z−)	Action combination
"8 jump forward"	Up and forward together(like jump forward)	(X + Z+)	Background change
"9 loop"	Rotate 360 degree	Y+, Y−,Y+	
"10 roll"	Down, then up	(Z−; Z+)	
"11 respect"	up	(X+; X + Z−)	
"12 upside down"	Down, without other action in 1 s	(Z−)	
"13 fly"	Fast shake	(Y+; Y−)	Background change
"14 dash"	Fast left or right	(Y+) or (Y−)	Background change
"15 fast run"	Shout in loud voice	Z+, Z−, Z+	Background change

In Figure 7(c), we show the animation-running interface. Panda's movements are displayed in real time corresponding to user's movements. With Flash program we can record the whole process of movements, which can be played back afterward.

4. EXPERIMENT

We designed a between-subjects storytelling experiment on the basis of the second system. In this experiment participators are invited to watch a classical emotive Piying show performed by a professional Piying artist. Emotional state of subjects is measured before and after the experiment session as well as the degree they understand story. The experiment includes two conditions. In condition 1, participators watch the story played by professional artist without interaction. In condition 2, participators will do some interactions at several points of the story when the artist is telling the same story at the same time. In the experiment, we choose a story from classic Piying art, then transform this story into digital mode by making similar digital images and plots on the basis of the traditional performance to make sure the interaction between the participants and the digital characters will put the plots forward, such as the digital character cross a stream by users' jumping and digital characters greeting by participators' loud voices. We are interested in whether this system can make any difference to participators in emotional state as well as their understanding of Piying art. During the process, a video camera was set up to record activities around this system.

We use pre-Positive and post-Positive Affective Negative Affective Schedules (pre-PANAS and post-PANAS) to measure the changes in current feelings and emotions of the participators. This form is extracted from the Positive Affective Negative Affective Schedules–Expanded form (PANAS-X) [38]. The scale consists of 60 words, and participants are asked to mark each word, by using a scale, according to how they are feeling right now. The scale ranges from 1 (not at all) to 7 (extremely).

4.1. Decision of Story, Professional Artist, and Interactive Points

A suitable story used in this experiment should be as follows: (1) emotive so it has the power to affect people's emotion state; (2). participators have not heard the story before; (3) attractive to a wide range of people with different backgrounds. We decided to avoid stories dealing with sensitive topics such as religions and politics. We chose and edited a story named Kung fu Panda. This story is emotion-laden and is one of the classical stories passed down from ancient time with a well-known role (panda) in it.

Piying art is a professional integrative performance with music, vision, storytelling, and teaching, and our exploration is also a research process. We invited a professor in Fine Arts Institute who focuses on studying Chinese traditional culture and plays a role as the Piying performer in this experiment.

One more purpose is trying to potentially guide people to do movement. Thus, how we embed proper interactive points with story content is important to the success of this experiment. Interactive "episodes" must be situated within watcher's experience of the story so it can be contextual. Only when the watcher is able to feel the mood of the Piying character and does the expected movement, then the interaction becomes an "episode" could be realized.

The story lasts 5 mins, and the experiment proposed 24 possible interactive points which last 3–8 s in the story. We invited 10 people to evaluate these interactive points by rating the question "Is this a suitable emotional interactive time in this story?" in a scale of 1–5. Fifteen interactive times were chosen which had equal scores or higher than 25.

4.2. Participants

We recruited participants in a primary school. Participators recruited from this school should have no idea of Piying performance before, and students in grade 5 and grade 6 were our target group. We assumed that they had no understanding problem in listening story and doing questionnaire. Every participator would obtain leather made Piying character as a gift after the experiment. Participators in our experiment included 10 females and 10 males. The average age was 12.9.

4.3. Procedure

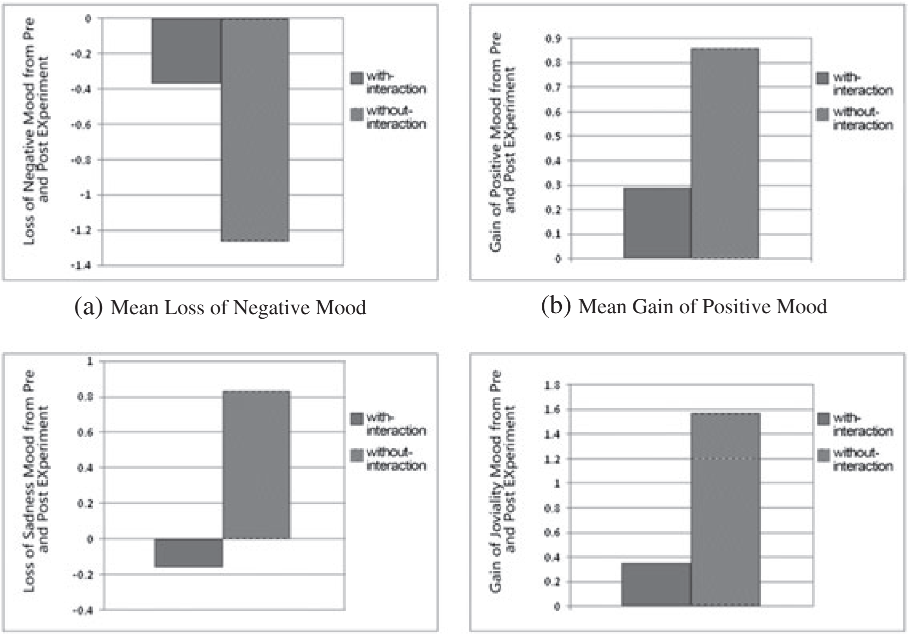
Participators were randomly assigned into one of two experimental conditions. Before they watched Piying, they were asked to fill a background information form, a pre-PANAS form. For participators in with-interaction condition, brown paper made hat with sensors in it would be worn. The experimenter made sure the character on the screen could follow participators' movement and participators were used to it. Then participators in both conditions will watch a Piying show.

After the story-telling session, participators were asked to fill a post-PANAS form [38] and a 10-question quiz about the content of the story. We interviewed these two groups of participators with a number of semi-structured questions including how the children felt about this shadowgraph kind of performance and what did they feel after watching this. Also there was a brief interview about how subjects in with-interaction condition felt about the interaction of the system.

4.4. Mood Change and Story Understanding

Mood change is measured by the PANAS in four subscales: negative effect, positive effect, sadness, and joviality. Each subscale contains approximately 10 words. Two-sample *t*-tests are run to determine the statistical significance of mood change across conditions.

On average, subjects in both conditions experience negative mood reduction, a gain in positive mood condition, and joviality condition (Figures 8(a) and 8(b)). Although the



(a) Mean Loss of Negative Mood (b) Mean Gain of Positive Mood

(c) Mean Loss of Sadness Mood (d) Mean Gain of Joviality Mood

Figure 8. Results of the experiment.

trends showing positive mood increases in both conditions, our experiment does not show a significant difference between the two conditions. Whereas *T*-test shows significant difference in Joviality between two conditions ($T(18) = -4.48$, $p = 0.000$).

Participators in the with-interaction condition experience a loss in sadness, whereas subjects in the other condition experience a gain in sadness. The *T*-test shows there is a significant difference in change in sadness emotion between the two conditions. (Loss in Sadness: $T(18) = -3.005$, $p = 0.008$). See Figure 8(c).

4.5. User Feedback

We performed a semi-structured interview at the end of the experiment to gain further insights into their experience.

The general impression of Piying was overwhelmingly positive, with all of the subjects reporting that they had enjoyed watching this performance. All the participants said when hearing the music and seeing characters appearing, they could realize this was related to Chinese traditional art. The 12 participants mentioned that the background music made them feel exciting in the Chinese traditional folk performances. The 16 participants said this interactive way of telling a story was fascinating. In addition, their involvement often continued after their session. We observed the situation when they came back to classroom. Words seemed to quickly spread from the children who took part in the study. Consequently, there was a great deal of enthusiasm about Piying surrounding the participators.

After concluding the interview about how they feel about the interaction with Piying art, two points shall be mentioned.

A feature of the experiment worth mentioning is that when in the experiment under condition 2, children took on roles as the character in Piying. The possibility of becoming roles to reflect themselves was appealing.

> *As much as I love creating . . . stories, I love to be the role in the performance, it is like my own story and I am the Kung fu Panda*. (by a Grade 6 boy)

Fourteen participators mentioned they would like using this interactive system with their friends. Two children even said they wanted this system at home.

> *I can share fun with my friends. The best thing is I can create my own Piying performance and we can replay them to discuss what we can make together later*. (by a Grade 5 Girl)

4.6. Discussion of Experiment

Our results show that with-interaction system gains negative, significantly. This is important because this result could be evidence related to our purpose to induce movement potentially so that user's emotion will be adjusted. Besides, the interaction based on our system amplifies the effect of

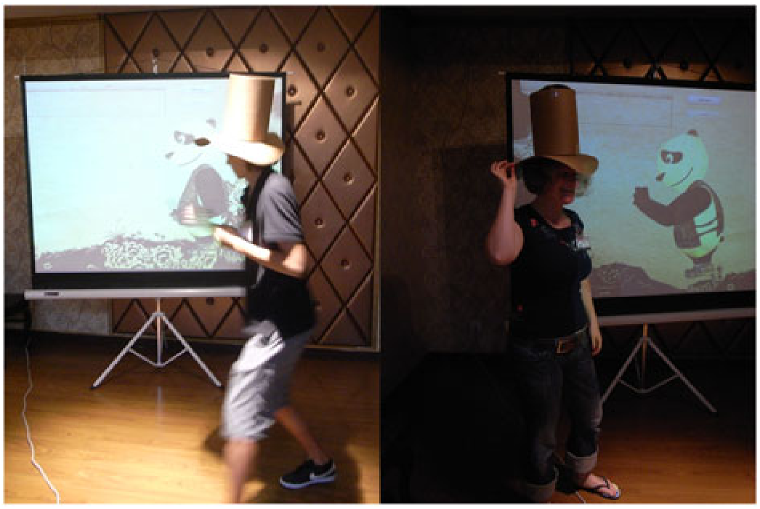


Figure 9. Our system shown in TED*MFZU

the story over the without-interaction condition. Our results reveal significance in the joviality measure; it shows a trend in the positive direction with interaction. Likewise, the sadness effect measure shows gain in the with-interaction condition as opposed to almost no change in the without-touch condition. In summary, our study reinforces our interpretation that there is effect of emotion on the with-interaction condition.

4.7. Activities

4.7.1. Performs at TEDxMFZU

Our second interactive system of Piying performance was showed at TEDxMFZU (MFZU; Melton Foundation, Zhejiang University). The theme of this activity is Idea, Impaction, and China, which means that we hope to let people feel how contemporary wisdom promotes the development of China through speaker's thoughts, feelings, and practice. Our system was invited to attend this meeting for the purpose of spreading Chinese culture. (Figure 9)

4.7.2. Performs at TEI2010

Tangible, embedded, and embodied interaction, 2010 accepted our concept of exploring innovative ways to preserve traditional culture as one of the eight workshop themes. Every workshop lasts for 4 h. Our specific purpose at this workshop is to find a way of integrating Chinese old Piying into daily life, thus to preserve the culture treasure in a natural and novel manner.

5. CONCLUSION

We can draw three conclusions from the research work presented in this paper. Firstly, the essence of Piying is to preserve the precious spark of Chinese traditional culture through an innovative way, including the free control of movement, impromptu interaction between artists and audiences, and spontaneous expression of emotion. Therefore, the way of building digital Piying art on the basis of tangible interaction has a significant practical value. Secondly, through our experiments of international events and shows, our approach is able to lead people to be immersed in Chinese Piying culture. Furthermore this project extends our previous work to motivate acrobatic moves and interaction through playful entertainment, which means our approach does not isolate the users from their environment.

However, some limitations of the present study must be mentioned. First, Piying system based on Kinect design is not flexible in foot action. It only uses knee and feet rotation to simulate the action of feet. Movement on the feet is not precisely treated because of the lack of more detailed articulation points. Meanwhile, at present, single a Piying character is control by a single person. Only one person could appear in the scene. It would be interfered if there is more than one person. We hope to track the skeleton of several people, to control several Piying characters, or to attempt to use gesture to control Piying. In terms of Piying system based on sensors, the action amount in the digital Piying action database that matches with people's actions is limited. It needs to expand the action database and also try to use more diverse sensor. Third, the number of subjects used in experiment was relatively low, we need enlarge the scope and difference of the subjects.

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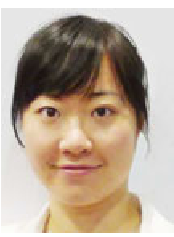

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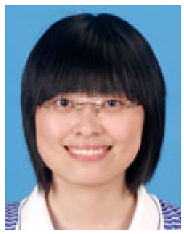

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