Study on Interactive Dance Performance based on Wearable Sensor Technology

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Abstract. The study goal of this assessment is the primary research of development and production of the wearable object equipment, where sound and light is controlled from wireless through the movement of the dancer's joint. The right elbow's joint from the dancer's body is recognized to develop a sensing module with the substitution of 7 kinds of sound and light's sensitive theory based on Newton's light and waves theory along with Labanotation theory to materialize wearable interactive control technology. This assessment is a project to test the expanded sensitive experience of sight, hearing, and touch by attaching an equipment on the body of the dancer. The project is being pushed forward with the goal of creating on media performance with the wearable equipment after primary development. Through this study, how the wearable computing technology can be utilized is experimented, the possibility of combining the high technologies in performing arts field is suggested and the extended function of the technology is explored.

Keywords: wearable computer, media art, wearable performance, motion sensing

1 Introduction

Research and development of wearable device had started very long time ago. The first study on the wearable computing started 40 years ago [1] and the same study started in Korea since mid-2000. Recently, the wearable equipment is strongly recommended as a future-strategic business as smart devices are incredibly improved and an attempt for the new artistic communication is expected to be possible. Especially, in performing art where the performer is the most important factor, liveliness and the sense of being in the scene of the performance are important factors for artistic expression. Thus, wearable computing technology, if it is applied to performance, it maximizes the interactive effect and makes the performance more effective and extreme. According to Yu I ha and Yi Kyung Kim, if the wearable computer technology, which has characteristics such as liberal operation, extension of the human body through sensors, and ability to recognize the surrounding...
environments by itself, is applied on the performers' garments, its natural function of the performing garment will be strengthened and it will enable the performers to media the piece in a whole new way and to extend their physical expressions [2]. Thus, the necessity of trying a new type of performance by mixing the wearable technology and performing art, which the performers are the center, in various ways raises.

2 Usage of Wearable Technology in Performing Arts

Portability and mobility of wearable computer technology are greatly helping to exhibit various and new expression effects. The cases where wearable computer are applied to physical actions as an 'interface' are as follows

2.1 Research on Related Cases

QuantumSound (fig.1) is the piece which expresses the movement of the performances through sounds using wearable devices and establishes synesthesia experience that audiences feel like watching and listening to the colors [3]. ImogenHeap (fig.2) is an equipment that makes various sounds such as Vibrato by adjusting sounds using sensors and controllers located at body parts such as hands, arms and back. Performers can perform like they are playing the musical instrument on the stage using this equipment [4]. AUDFIT (fig.3) is the interactive performance piece which makes a real time sounds by gathering data on movements through the sensors. The audience can choose one out of three sound channels made from the performer's movement and can enjoy three kinds of sounds from one movement [5].

3 Interactive Dance Performance

This study creates a wearable interactive controlling technology, which is syntagmatically adjustable through application of Labanotation theory, seven sounds based on Newton's light and wavelengths theory and sensitivity of lights theory, by developing a module which is attachable on right elbow of the user.
This task is to experiment the extended sensory experiences of sight, hearing and touching by attaching the modules in the body of the performers. Not just developing the wearable technology, by applying the wearable technology, this study also suggests the method on how mechanical technology can be utilized artistically via physical arts. The wearable system developed in this study (fig.4) associates wirelessly with PC which creates visual and auditory contents by measuring the angle and direction of the moving arms of the user.

![Wearable Device System](image)

**Fig. 4. Wearable Device System**

Each system is composed of Bluetooth 4.0 wireless communication module, controlling section which includes the micro controller, sensory section which includes Flex sensor and IMU sensor in order to sense the movements of all joints, operating section which is composed of vibrating motors to give feedbacks to the sensed movements and power-supply section which is composed of lithium polymer battery and boosting module.

Controlling section and communication module act as an embedded controller which sends the raw data measured by the sensor wirelessly to PC and as a controller which adjusts every sensors and actuator through an 8-bit micro controller based on Arduino which includes Bluetooth 4.0 module. In order to measure the movements of the joints, two sensors, Flex sensor and IMU sensor have been used. Since IMU sensor is composed of acceleration sensor, gyro-sensor and geomagnetic filed sensor which can measure the inner inertia, it can be utilized to develop an application using direction, speed and gravity of an object. This system measured the movements of joints by using Flex sensor and IMU sensor which has 10 degree of freedom. Power-supply section which is composed of battery and boosting circuit is manufactured to operate with the electric power of 3.7~5.0V, so that it can operate in the low electric power board and an ordinary 5V system as well. Picture 5 describes the module.
The performer, who is equipped with this wearable equipment, combined seven movements of the effort movement of Labanotation theory (fig. 6) which is the movement recording method that analyzed the physical movements, defined movements of the feelings that are common to all people and applied the sound of light, color and sound to seven movements. As a result, seven contents (fig. 7), the videos and music that received the data value of the seven movements, are produced and the performance was conducted. Hyun Jin Kim analyzed sensitivity matching lighting display technique by matching the sensitivity of the color and frequency based on the music data on her study. In this study, the algorithm was created to maximize the delivery of sensitivity via LED sensitive lighting, which is transforming the characteristics of frequency range encoded in every single moment in music into the natural sensitivity flow [6]. Moreover, according to Robert Plutchik's studies which sought for the association of color and feeling, human's feeling has eight basic one-dimensional feelings which are similar to the three primary colors theory and other feelings aside from those one-dimensional feelings are created by combining the basic feelings [7][8]. Thus, the performing piece is created as it is shown in figure 8, by defining the Labanotation's movements, the color of the light, and hertz of the sound in seven.

<table>
<thead>
<tr>
<th>Labanotation</th>
<th>Effort / Movement</th>
<th>Light</th>
<th>Human Sensitivity</th>
<th>Sound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>Free</td>
<td></td>
<td>Passion, energetic, desire</td>
<td>131Hz (do)</td>
</tr>
<tr>
<td></td>
<td>Bound</td>
<td></td>
<td>soothness, sensitivity</td>
<td>195Hz (mi)</td>
</tr>
<tr>
<td>weight</td>
<td>light</td>
<td></td>
<td>joy, warmth</td>
<td>147Hz (mi)</td>
</tr>
<tr>
<td></td>
<td>heavy</td>
<td></td>
<td>Sadness, melancholy</td>
<td>220Hz (fa)</td>
</tr>
<tr>
<td>Time</td>
<td>sudden</td>
<td></td>
<td>cheerfulness, fact moving</td>
<td>106Hz (sol)</td>
</tr>
<tr>
<td></td>
<td>sustained</td>
<td></td>
<td>Powerlessness, dimmer</td>
<td>247Hz (la)</td>
</tr>
<tr>
<td>Space</td>
<td>direct / indirect</td>
<td></td>
<td>Activity, trust</td>
<td>175Hz (fa)</td>
</tr>
</tbody>
</table>
5 Conclusion

This study suggested for a creative application of the technology by exhibiting how the wearable technology is utilized in performing arts, especially in stage art and how the art extends the imagination in technology and vice versa. As a result, it showed the possibility of utilization of wearable device for synesthesia expressions of image through performance production by creating wearable equipment which controls the light and sound, gained through sensing the performer's movement, in a real time. Wearable mechanical technology, exhibition and performing arts have been combined through this study and showed an experimental and initiative trial for a new type of media performance. In the future, more detailed and stable technology, considering the nature of the performing arts, which is the necessity of quick response towards sensitive environment, should be attained through more advanced studies.

References

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