AN INTERACTIVE RESPONSIVE SKIN FOR MUSIC PERFORMERS, AIDA

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ABSTRACT
With the decreasing audience of classical music performance, this research aims to develop a performance-enhancement system, called AIDA, to help classical performers better communicating with their audiences. With three procedures Input-Processing-Output, AIDA system can sense and analyze the body information of performers and further reflect it onto the responsive skin. Thus abstract and intangible emotional expressions of performers are transformed into tangible and concrete visual elements, which clearly facilitating the audiences' threshold for music appreciation.

Keywords
Interactive Performance, Ambient Environment, Responsive Skin, Music performance.

1. INTRODUCTION
The audience of classical music is decreasing rapidly especially in contrast with pop music. Conventional classical music performance thoroughly depends on audio transmission, such as timbres, tempi, dynamic, ambient sound, melodies, and chords a performance may evolve. It is the above-mentioned audio factors that create different emotion in listeners and all of them decide listeners' perception for music. Usually, a successful live performance is reflected by listeners' reaction, i.e., whether listeners are satisfied with the effect performers present onstage. Although music is conceived of universal language, many people still have difficulty understand it and further appreciate it due to its intangibility. Thus, this research aims to develop a performance-enhancement system, helping classical performers better illustrate their concerts in the live show.

Unlike traditional classical performance, which purely relies on audio effect to communicate with the audiences, this performance-enhancement system adds some visual elements into the performance and makes it a lively and enthusiastic visual-audio live show. This visualization-aided enhancement system (called AIDA) not only deliver messages between performers and listeners better but also bring more enjoyment for the listeners when attending a classical concert.

The concept of the AIDA system is to change the wall of the concert hall from fixed one to an elastic and flexible skin. Any stimuli caused or produced by performance will be recorded and reflected on the skin. In other words, the IDEA system visualizes the audio information, transforms the audio effect from intangible to tangible, from invisible to visible, so that audiences who lack of music training may catch each subtle alteration made by performers even if they overhear the music.

Interaction is the key point for AIDA system. Usually, people perceive the space (ambient environment) surrounds our bodies as a separation of the personal space from outside to inside. Through "the involvement of the body", behaviors are conducted, and participated in so called "field" or "existence" of interaction. Following this concept, AIDA will provide an ambient environment that embeds the power of performance into the space itself. Thus, audiences not only listen and visualize the performance, but also perceive the meaning of music within the atmosphere.

1.1 Motivation: Interaction on stage
How can performers interact with the skin AIDA supported? Here we believe that performers' physical changes will reflect onto their behaviors, such as facial expression, skin temperature, heart beats, postures, body movements, eyeballs' sizes, etc. Since these onstage behavior changes can be measured and analyzed, we can utilize this body information to interact with the skin.

Bernhardt and Robinson implements an interactive control of music using emotional body expressions [1]. Once the performer moves the body, the movement will be measured, recorded, and analyzed. This analysis information may contain the action's direction, weight, its position, and possible route. The analysis information then is divided into two sections: one is assigned to a machine which is responsible for finding the pattern of the body motion and starting the self-taught process. Its purpose is for better recognizing the behavior or imitating and representing it when it appears for the next time. Another direction is that the body information will be decoded to emotion code, so that the corresponding default music library may produce appropriate music excerpt which bounces back to performers. This result is a musical performance cyclical pattern. Detailed is shown in figure 1.

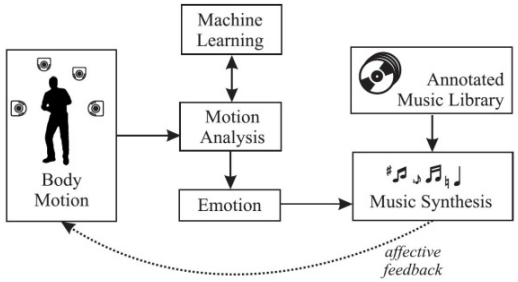

Figure 1. Design of the emotional music mixing interface [1]

Another case from music therapy is SiMS [2]. Built for detect the relationship between brain activity, physiology, emotion and musical features, SiMS has three parts: 1) physiological input (sensor organ) to detect electroencephalogram (EEG) and heart-rate (HR) signal which may trigger human's behavior, 2) processing model, the processing and decision-making (central nervous system) part, and 3) motor output (muscle system and glands). With the translation of some emotional properties from the brain activity and HR signal into the musical domain, the system tries to influence the physiological response with corresponding music.

1.2 Our Approach

With these two cases above, we adapt the process from Figure 1 and add the concept of SiMS to form the basic sensing framework of AIDA.

Three steps are used in this research. Firstly, we analyze the informative output from the performer, including body motions, facial expression, and biological information. Secondly, following the input-process-output paradigm, the responsive skin is implemented as a computational reification of concept. Thirdly, a test case is conducted for understanding the details of interaction behaviors.

2. FINDING INTERACTIVE BEHAVIORS

Following the case described above, we adapt the methodology of motion analysis for finding the interactive behaviors on stage. Starting with posture and behavior analysis, we narrow down the behaviors that are then verified by interviewing with performers.

2.1 Posture and Behavior Analysis

From the system point of views, the system can only gain the input as the postures or motion by the performers other than the music performed. The purpose of posture analysis is to find out the posture profile and identify the postures. The process of posture analysis must be clear and reflecting the concurrent emotion of performers. In addition, such analysis has to be in real-time. This might be a problem without invoking advance technology such as machine learning or artificial neural network. Addition to the posture analysis is bio-sensors. Bio-sensor can be used for explicating the inner emotion. With aid of bio-sensors and posture analysis, the behaviors of performers can be defined and adapted as the interaction trigger.

The analysis will be conducted in a sequence of lab experiments that will generate the data for the verification.

2.2 Interview with Performers

For reifying the analysis outcome from analysis conducted, a professional pianist is brought in for the in-depth interview for validating (1) the approach of using interaction design to support performers and (2) the analyzed data and corresponded emotion.

Before verifying the data, the interview conducted focus on the substantiation on using interaction design to support performers on stage. One thing mentioned by the pianist is that the introverted emotion of performers has to be performed explicitly through the gesture and acoustic cues for the purpose of persuading listeners to have the same mood as performers. In other words, the introverted emotions of performers have to be transformed into external emotions.

By going through the mapping of posture analysis with bio-sensors and the mapping to the emotions, the behaviors are approved are the temperature and heartbeats. The gestures are also part of valid sources for revealing the inner emotion of performers.

2.3 Test Case

A video-clip of Bridge's Fantasy is chosen for the purpose of analysis. The subtle differences of performers' (pianist in this clip) behaviors and postures, such as facial expressions, body motions, humidity, etc., are notated and mapped to appropriate visual expression. The outcome is then reified by the interview described above.

3. RESPONSIVE SKIN

3.1 The Concept

The concept of responsive skin comes from architecture domains. In architecture, a skin provides a sheltered place that defines the relationship between internal and external spaces. Further with concurrent researches in parametric designs and responsive technologies, architectural skin has been designed with light-weight structure and provides a set of responsive behaviors according to the habitants under the skin.

3.2 Responsive Technology

The key issue for responsive technology is the environment will be changed according to sensed behaviors conducted by the users. Consequently, the environment will be changed automatically based on user behavior, this concept also describes the information-intensive [3].

The responsive technology can be divided into sensing and actuators. The sensing technology transforms the space into a sensible space. Such spaces can then covey physical information such as chemical, biomass and so on into the possibility of re-usable electronic devices and output signals. Sensing technology blurs the relationship between the physical and virtual information, and led us into an irregular, but the rich concept of innovative interface. By developing of sensing technology, space interface should be with (1) perceiving internal and external environmental conditions; (2) detecting user activities; (3) trigging a response from the skin.

Further with actuator, the skin can then response with motion or transformation based on input from sensing technology. Combined with interactive mechanism of digital technology (sensing → computing → actuator→ response), we can then explore a new type of space and its significance.

3.3 Case Studies

For finding the solution suitable for our purpose, two cases are studied: Son-O House and Hylozoic Soil.

3.3.1 Son-O House

Son-O House [4] is a mixing chamber of instruments, musical notes, a combination, human exposure in it can hear the wonderful music, and can also participate in the creation of music. Breaking the shackles of traditional architecture and tools, this project creates new digital-based hardware and software to the architectural facade design and its computer design potentials. In the input and output of system, this project creates a reaction mechanism with responsive perceived interaction.

Figure 2. Son-O House.

3.3.2 Hylozoic Soil

Hylozoic Soil **[5]** is an interactive installation and power art work which is similar with artificial forest done by Philip Beesley. It uses shape memory alloy as drive, with feather-like veins and the capacitance sensor, feather-like veins will squirm their interactions produce similar respiratory, and building the mutual influence environment between artificial and natural systems when roaming the forest. Feather-like veins produce respiratory fretting behavior is from the distributed sensor network controlling the dozens of micro-sensors; however, other dozens of panel controls the overall interactive environment. The whole work presents interaction between virtual and physical environment.

Figure 3. Hylozoic Soil.

4. AIDA SYSTEM

4.1 System Design Concept

The Concept of AIDA system is reflecting the emotional expression of performer without affecting the performers on stage. AIDA emphasizes on harmonious combination among the audience, performers and music atmosphere of all three (figure 4).

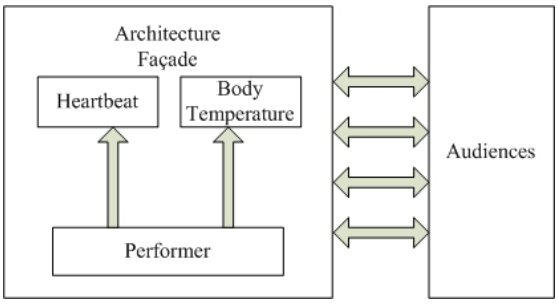

Figure 4. AIDA System diagram.

4.2 The Operations

The operations of AIDA are described in three parts: input-processing-output as below.

4.2.1 Input

The system detects the physiological responses and external behaviors when performing, with contextual data. For example, when performing an agitated piece, anxious facial expressions as well as tensed body movements may appear automatically. In the contrast, performer's body will swing along with the rhythm of the piece unconsciously. In addition, the bio-sensors are used as collecting the real-time information of performers while they perform on stage.

4.2.2 Processing

According to collected information from input, interactive re-analysis and computing mechanism is applied, and then response the results back to the responsive skin. This research focuses on the visualization of performer's emotion and behavior. On the other words, the system transforms the internal emotion of performer to external environment.

4.2.3 Output

The results before computing are showing in responsive skin. Responsive skin not only frames the space, but joins the factors of crossing time and songs, and then makes a perception of space, visual space, auditory space, perceptual space.

4.3 Technologies

The current AIDA is built on Arduino and bio-sensors as the input/process parts. The dynamic transformation of responsive skin is done by a set of servo motors and metal structures. For testing the overall outcome, this research designs a simple machinery structure to simulate the presentation in the real concert hall.

5. IMPLEMTATION

An experimental implementation is conducted for testifying the system concept. According to the interactive behavior analysis, heart beats and skin temperature of performers are chosen as the input. The corresponded changes of responsive skin are following the case studies.

5.1 The design of the responsive skin

The responsive skin is surrounding the performer and the major display components are facing the audiences (as shown in figure 5). The bio-sensors are carried by the performer and using wireless to transmit the information to the responsive skin.

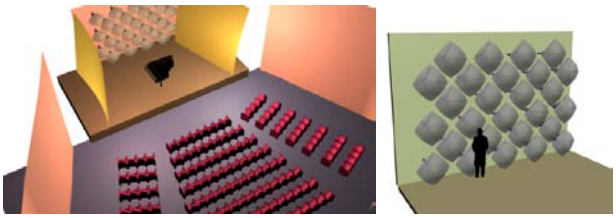

Figure 5. Angle of depression of the concert hall.

The responsive skin is surrounding the performer and the major responses of the skin are located in the middle of stage and facing the audience as shown in figure 5.

5.2 The Mapping Mechanism

5.2.1 The heartbeats

The mapping mechanism between heartbeats is shown in figure 6. The highest will release the umbrella. When the heartbeats change to lower, the surface starts to shrink gradually.

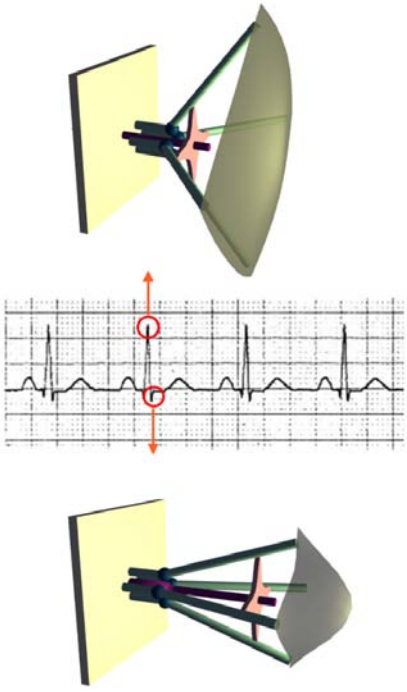

Figure 6. The structures of heartbeat a wave crest and trough

5.2.2 The body temperatures

Body temperatures of performers are captured and mapped to the responsive skin shown in figure 7.

Figure 7. Audience view and the left (right) is high (low) body temperature of performer.

5.3 The reflection of the responsive skin in colors and form

With the aid of sensing technology, emotions of different forms are captured and transformed into the responsive skin in the form of light, fabric, and mechanical conversions. The mapping is shown in figure 7. The implementation is conducted as an experimental concert.

6. DISCUSSION AND CONCLUSION

With the support of AIDA system, abstract and intangible emotional expressions of performers are transformed into tangible and concrete visual elements, which clearly facilitating the audiences' threshold for music appreciation.

The comparison between the traditional concert hall and the one with AIDA system is created (table 1).

Table 1. Comparison between traditional music hall and AIDA

	Traditional Music Hall	AIDA Music Hall
Performer	Besides music, performers only from the physical movements and expressions to convey musical emotion.	Through the original musical elements, physical movement, and with the environment of the assistance, to enhance performance a sense of accomplishment; to share the music, atmosphere with the audience.
Audience	Besides music, the audiences only feel the music emotion by body movements from the performers.	Existing music feast, together with the performers' body movements and facial expressions, and integrating of environmental change; audience enjoy more visual stimulation.
The Milestone of Performing Arts Development	Classical music is only with a formal dress and dressing up in general, it is difficult with other modern emerging field of performing arts combined.	In addition to the field of music, it merges the building, stage effects and so on arts, and integrates a variety of performing arts at the same time.

AIDA provides a way to connect the emotional expression between performer and audiences, and the affect is clearly and direct. However, due to the representation of mapping and responsive skin, the usability and affection of AIDA remains a further study.

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