Figure 1: Final prototype of MoodBall by Team POP 5

Emotion Detection through Physical Interactions in Modulating Music as A Way of Improving Emotion Communication across Distance

DECO7385 Physical Computing & Interaction Design Studio
Critical Reflection

Team POP5
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Abstract

This reflection report will explore an emotion detection ball with lights, music, and visual feedback through various physical interactions, involving touch, press, rotate, roll and squeeze to enhance mood communication remotely. It analyses the background research with respect to the relationship between modulating music and emotion sharing. The domain and theme will be investigated in the process of the MoodBall project and the problem spaces will be addressed based on the literature review. Finally, reflection on the success and failure of the whole design process will be presented in the perspective of techniques, development, teamwork, functionality, usability, etc...In addition, suggestions, expectations and future directions of the project MoodBall will be further discussed according to the user testing and public responses in the final exhibition.

Contents

1. Introduction

Looking back to history, the solution to music communication has been transferred from physically -- the CD player and Walkman, to virtually -- apps and websites on smart devices. With the third wave of HCI, hi-tech and smart devices are widely applied from work to non-work space, crossover from public to personal, and focus on mundane events on mobile and ubiquitous[1]. Based on AI, deep learning and machine learning, voice and speech recognition speakers have brought screen-free, hardware surfaces or gestural controlled physical interactions[1], which help users create emotional connections remotely through identifying and sharing emotions from various music. Recently, the number of people with negative mental status has dramatically increased due to the pandemic situation, particularly between long distance relationships. Up to 50% of college campus relationships regarded as long distance relationships[2] meet challenges in emotional communication. In the stressful modern society, people require to receive comfort or understanding from close others when they feel lonely or depressed. Those who are ashamed to share feelings through language or words tend to turn to music communication to get mental support and to feel understood[3]. Therefore, emotion detection inserting into modulating music may improve music sharing in a more immersive and intelligent approach, which allow users to connect feelings through.

MoodBall is our team project constructed through DECO 7385. Regarded as a Ubiquitous Computing device, it connects emotion detection with various music, lights and visualization modulating sensors, providing a new platform for music playing and emotion transfer across distance. Various physical interactions such as touch, squeeze, rotate, press, or shake could receive different music and visual feedback. Emotion detection systems receive a user's interaction inputs and analyse their emotions in three parameters including pressure level (pressure sensor), rotation rate (accelerometer gyroscope) and galvanic skin response (GSR sensor). Mood based music could be played through the speaker on MoodBall with charming lights and visualizations (played from projector). When users shift their interaction, for instance, rotate the ball in a high level, the music tempo and pitch, lights, and visualizations could be changed accordingly. In addition, the remote ball can receive the data and simultaneously play songs, with lights colour and visual feedback. Our objective is to build an immersive and playful music modulating device for families, friends, and others with close relationships to receive emotional comfort through music playing and sharing activities in daily life.

This report will summarize my individual contribution to our project, rather than discussing details on the design and development process. It is presented in three parts, including:

1. the literature review related to music and emotion theory, human based music modulating interactions and emotion detection solutions for investigating our domain problem, and how these contributions reflect to the project;

2. the analysis from idea generation, prototype construction and user evaluation during the design process to the final results and outcomes, and how these data affected our iterative prototype;
3. the summary of the success criteria of the design process to explore the outcomes and future direction of our project, and as a UX designer, how to contribute my skills to address the research questions and to reach the team objectives.

2. Background investigation

2.1 The development of HCI in modulating music

Modulating music is the shift of one key to another, which provides great joy and surprise for listeners, and as an amazing tool for musicians, the most popular and smoothest way in digital music modulation is to use a pivot chord[4]. With the development of hi-tech and digital technologies, the expression of emotion in modulating music has been greatly improved. While smart devices become popular in all perspectives of music modulating, music playing and music sharing, which stimulate researchers to focus on exploring music interaction[5]. Starting from the CD players in 1980s, music recorder and player shifted form of interaction with the computer[5]. Then, smart devices with social apps and music website such as Facebook, iTunes, YouTube and Spotify changed people's way of playing and sharing music from physically to virtually[5].

According to the study, combined with the first wave cognitive science and human factors and the second wave on groups working with a bounce of applications, the third wave of HCI (human computer interaction) challenges bring technologies from working to non-working places, crossover from public outdoors to private spaces, and focus on ephemeral, ubiquitous and mundane activities[1]. Having explored several examples of the third wave of HCI in recent decades, the physical computing interaction in the near future seems to concentrate on users participation and experience sharing[1]. Study shows that novel technologies with respect to screen-free and real-time control, vocal and gestural control of modulating music on personal computer has become a major trend recently, while more HCI research including bodystroming should be conducted to further evaluate user experience in new areas[7].

2.2 Music enhance the communication of emotion

Music, as another form of language, brought a wealth of possibilities to communicate feelings in a subtle way. When a major life event occurs, people proposed to require mood-congruent, comforting music, and emotional support from an empathy friends[3]. Therefore, the affect-congruent music plays a role in a social representative for an empathic one in a close relationship.

Under the high working and living pressure, individuals assume to receive more empathy or comfort in loneliness or depressions. Over 50% of campus partners in college in long distance relationships[2] have issues on emotion connection. According to the research, music, as a best way to express feeling, improving introverts share feelings music instead of words or texts to receive mental comfort[3],

while consoling music provides a positive feeling that can help those in negative mental status reduce loneliness and increase the sensor of empathy[5].

According to the musical psychology study, music emotions can be separated as four major sections including energetic, happy, calm and anxious/sad, and four minor sections including exuberance, frantic, contentment and depression, which is illustrated in the mood classification coordinate diagram below[8].

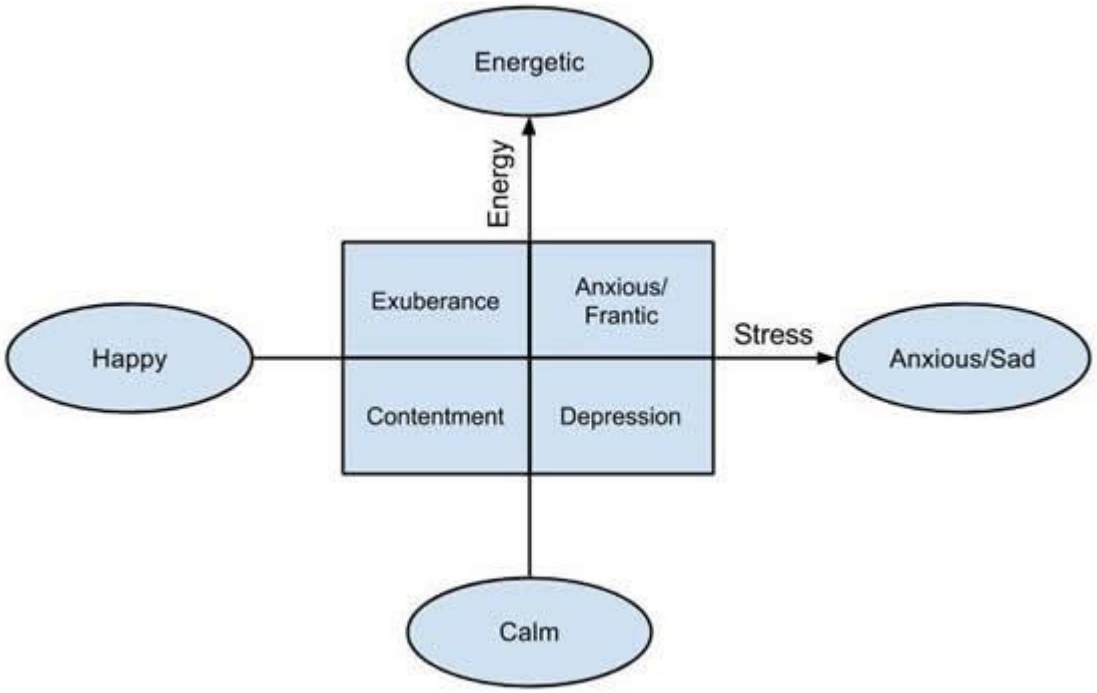

Figure 2: Music mood classification, source from [8]

Different category of emotions traces various types of music. According to the musical emotion theory, the characteristic of music including intensity, timbre, pitch, and rhythm represent listener's current feelings, including happy, exuberant, energetic, frantic, anxious/sad, depression, calm, and contentment[8]. The table below presented the relationship between mood and music.

Mood	Intensity	Timbre	Pitch	Rhythm
Happy	Medium	Medium	Very High	Very High
Exuberant	High	Medium	High	High
Energetic	Very High	Medium	Medium	High
Frantic	High	Very High	Low	Very High

Anxious/Sad	Medium	Very Low	Very Low	Low
Depression	Low	Low	Low	Low
Calm	Very Low	Very Low	Medium	Very Low
Contentment	Low	Low	High	Low

Figure 3: Audio Feature Extraction, source from [8]

Basic Emotion theory has greatly affected the music psychology, where most scholars have supposed that music expressivity is constrained to basic emotions, and these represent acoustic code sharing to communicate emotions in music and speech melodies[9]. In addition, music visualization could communicate music information through the visual approach of graphic images and videos, which assists to improve the accuracy and effectiveness of music information communication by using K-means clustering method in software development[6].

3. Reflection of the project

3.1 Role and contribution

During the design and construction of the prototype, I played a role in UX designer and multimedia support including video shooting and editing, front-end development, documentation, remote cooperation, etc. Unfortunately, as an external student, I haven't participated in the final exhibition on campus. However, I focused on contributing conceptual design in our team project based on research and exploration.

During the design process

The first contribution in the design process was documentation and reflection. In the beginning, we set our domain in a broad area as it supposed to be a modulating music installation. In the stage of idea generation, I searched sample materials products, videos and websites and conducted brainstorming and online survey to further investigate how people share emotions through music and their attitudes towards music sharing.

In the stage of background exploration, I conducted semi-structured interview to provide fundamental research support for our domain and problem space. According to the results, we narrowed down our domain space from public outdoors to personal space and confirmed our potential users as families, friends, and people in close relationships.

In the prototyping stage, I was responsible for preparing and conducting bodystroming to evaluate physical interaction for iterative design. The results from this activity help us understand user experience and interaction flows. I contributed to the preparation of the evaluation protocol, data collection, documentation, and other multimedia support.

Explore the relationship between emotion and music

Literature review provided a valuable research support in our project. Based on emotion theory[8], the major classification of music mood includes including energetic, happy, calm and anxious. Considering interaction flow and mode of expression of music mood, music visualization[9], we set the emotion detection system to collect user’s interaction data with three parameters including heart rate, touch pressure and rotation rate, which aimed to detection four basic emotions - calm, happy, angry, and energetic, which played a vital role in the form and function building of our project.

Reflect to the background research, theme, and domain

Several research methods including interview and bodystorming were applied followed by “novel technologies with respect to screen-free and real-time control, vocal and gestural control of modulating music”[7]. Based on the example study in the paper of *the third wave of HCI*[1], emotion detection speakers proposed a novel approach of music sharing and emotion connection. Novel technologies in terms of remote and voice controlled smart devices providing a playful and immersive music modulating experience[7].

Guided by the theory of "music communicates basic emotions as well as constructivist account"[9], we focused on investigating the expression of core emotions through music by detecting people’s mental status.

According to the music mood theory and the relationship between music expression and emotion[10], we promoted the interaction mode from music to vocal and visual aspects. Music emotion detection solutions promoted by Lie Lu[11] help us improve the techniques for constructing the emotion detection function in our project and using K-means clustering method to ensure accuracy of music mood detection in the project[6].

3.2 Outcomes and future direction

The final exhibit completed in entirety, with all the sensors in a good performance. As an external student, I have attended the whole courses remotely through Zoom. In the early exhibit, our lights and visual interactions couldn’t be presented charmingly because of the brightness, but extraordinary visualizations were displayed from the projector lately.

According to the public responses, most participants were absorbed in the immersive interaction. When interacting with MoodBall, they seemed to promptly know their current emotions and expected to see what types of music, lights, and visual feedback they could receive. MoodBall was quickly integrate into all aged groups, especially young generations. While challenges were children and teenagers may confuse to trigger the happy and energetic mode, and they were not able to get the correct feedback on the calm mode, due to their less pressure on press sensors. These valuable feedbacks may help to go through further investigations on user experience in various generations.

Remote functions of the MoodBall including emotion comfort and remote-control system haven’t been fully constructed due to the time limitations. The real-time music, lights and visual feedback on the remote ball was built and displayed on the final exhibit, but it was not as attractive as the MoodBall. In the future, we should pay more attention on user experience and strive to develop more functions with respect

to the remote comfort and emotional connection. Hope MoodBall may come into people’s daily life and provide mental support through music sharing in the near future.

3.3 Personal reflection

During the project design and development, I have explored the theme of future mundane and deeply understood the problem space on emotion connection across distance. In the beginning of this semester, we considered our domain and problem space as an installation art for music modulation. In this direction, I conducted quantitative and qualitative research and began to understand the conflicts on our concept to the potential users. We decided to improve emotion connection between families, friends and those in close relationships based on the results from previous research. As a UX designer, I should take responsibility of the user evaluation for providing research-based directions to the iterative design. Literature review for background exploration as I have already presented in this report helps team to solve domain problems and reach our project objectives.

Remote study was a tough to me, particularly in group discussion and prototype construction. The first I learned from this course is how to follow my own schedule and complete tasks in a more effective and efficient way without disturbing by the households. Then, after performing several documentation tasks, I found it required more patience and played a vital role in pitch and presentation. Last and the most important, cooperation made more perfect than individual works. As personal skills and knowledge is limited, one cannot perform best but the team can. To fully contribute my part and provide multimedia support, I tried and learned many new tools and technologies that I have never used before. These helped me become a good cooperator in the team project.

4. Conclusion

Objectives		Success criteria	Measures
Physical construction: develop the complete function and display full functions on the final Exhibit	All sensors work smoothly	The accuracy of the sensors more than 90%	Prepare same type of sensors or different sensors with same applications to ensure every function works, check Arduino and electricity circuit connection, program and coding debug before Exhibit, perform effective hardware testing with users
	Emotion detection works well	80% of users can input mood successfully with different interactions The matching accuracy of music and user mood reaches 90%	Conduct user evaluation and record the process of emotion detection activity Explore users the feeling when they listen to the music after interacting with the device through bodystorming and think aloud Compare the data received from the GSR sensor with the users response to see if they have a gap and change the algorithm of emotion learning functions
	Remote interaction works well (music and emotion sharing with light & music feedback)	85% of users can successfully complete remote interactions within 30 seconds 50% of users are attracted by remote interaction and willing to share music/emotion	Record the number of users who use the remote interaction function and the time they complete the whole process Conduct bodystorming to explore user's behaviour and attitude towards remote interaction (how to join others music sharing activity and how to comfort others) Summarize and analyze data collecting from the users for further research and iterations
Research and Evaluation: Find potential users and willing participants in a proper way Collect data and users feedback for iteration through effective and efficient evaluations Provide academic support for final product		Go through every physical evaluation activity smoothly no longer than 2 hours Collect useful data that can be used in our project, Effective data and data usage rate must be higher than 80% Data documentation should be completed promptly within one day after receiving data	Start early research, investigate the target audience through interview or survey and keep in touch with them Plan a strategy for users authority, every evaluation activity should be voluntary with users consent Propose guidelines and regulations related to privacy and security If users worry about security and privacy, provide a way for them to make choice use this function or not Use Miro to record data as team journal after conduct evaluation activities
Project management: Finish final prototype on time or correspondence with the timeline Well cooperate with other (internal and external) team members		Each member should engage in team project minimum 20 hours weekly Follow the task plan, 100% complete each task on time, 100% submit assessment document before due date	Start early and organize the progress two days behind timetable Weekly progress report to the team member and tutors and get feedback Review the work achievements for the previous week Plan a task list for the work need to be completed in the coming week by using Gantt Chart project management (see Appendix 5: Gantt Chart)

Figure 4: Success criteria by team POP5

In the prototype demonstration, the form of success criteria was presented as above. I considered we have reached most success criteria, that we have made all sensors worked smoothly with the accuracy rate of emotion detection system over 90% in the

final exhibit. Remote interactions worked well but less than 50% of the participants were interested in them. We have conducted several evaluation activities and collected effective results and over 90% of these data were used in the prototyping. Each member followed the task plan, carried out and completed tasks on time. No delay or failure submit after due date.

To sum up, through the research process of the whole project, including modulating music, music visualization, music mood theory, emotion detection techniques, and human-based interaction on emotion detection and music sharing, my individual contributions to the MoodBall project provided a basic research support for team to address the theme and domain space, as well as to successfully reach our team goals in the final exhibition. This valuable experience helped to become a qualified UX design with comprehensive research strategies in the future career.

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