DragonMama: A Music Mix Player Controlled by Limbs

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Abstract

This paper presents our demo system DragonMama, a music mix player featuring limbs control. DragonMama is designed for DJs or music fans to control and mix their music with hands and feet instead of laborious keyboard manipulations. So the operators can focus on the essence of music without distraction.

DragonMama, as a typical HCI prototype, consists of a sensor-based gesture input module, a server for listening signals, and a web-based client with graphical and audio output. The input module is implemented with an Arduino module and peripheral pressure-based sensors, responsible for transferring fingers or feet gestures into digital signals. The server is implemented on a host with Noduino.js that receives sensor signals from the socket and triggers the related operations defined in the client. The client is a stack of webpages written in HTML5 with jQuery and jPlayer library that presents visual and audio feedback of music selection, sound setting, and mix indication.

The paper also presents the usability evaluation based on an empirical method, i.e. collecting data from questionnaires and assessing the usability by analysing the summative user data.

Unpublished manuscript
Do not share, do not cite

Author Keywords
Arduino, Sensor, Javascript, Usability

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

General Terms
Design; Development; Evaluation

Introduction
Normally, musicians work in a professional musical studio with sophisticated instruments. They mix music and auxiliary sounds on a complicated keyboard panel with multiple types of buttons. But this is so laborious job for DJs or musical fans who need only primary music mix functions. So is there a solution that facilitates the usability of such instruments?

Upon such a motivation, we designed a prototype system DragonMama, which enables the use of fingers and feet as instruments to play music mix. The purpose of our design is to replace those fixed sophisticated keyboard interactions with natural body-controlled interactions. The proposed scenario is as follows. A DJ in a party wears gloves and shoes equipped with DragonMama sensors. Then he steps into the dancing pool and moves his parts of body with the pace of music. He made the music mix by bending his fingers or stomping his feet. He can even have a drink or talk with partners when mixing his music.

Figure 1: Banana piano: an example of Arduino application.

Currently, we implemented such an amazing idea in a prototyping system based on a laptop and an Arduino board. We have four sensors in the demo system: 2 flex sensors bound to fingers, and two tapping sensor to simulate stepping gestures on feet. The Arduino board judges and captures such gestures from sensors, and send positive signals to the server on the laptop. The visual interface is designed as a HTML webpage where the user can get visual feedbacks (sensor indicator shaking) and audio output (music with mixed sound).

We also conducted the evaluation and usability testing on DragonMama demo system. The usability defined in such a context is evaluated with an empirical method, i.e. questionnaire survey. The questionnaire is specifically designed for this context with background information, questions with response options in a specific rating scale, and general subjective impressions.

The following sections focus on my contributions, i.e. Arduino gesture judging algorithm, client interface prototyping and implementation. Besides, Evaluation Section elaborates details on our usability testing methods, questionnaires and data analysis.

Related Work
Banana piano [1] (as shown in Figure 1) is a typical application based on Arduino, with its use case scenario being similar to ours. The idea is to use bananas as 'button's instead of a fixed keyboard of piano. A geek can develop such an Arduino application and play piano by tapping those banana 'buttons'. The theory under the hood is simple: every time the finger touches the banana, a circuit establishes with the body acting as a resistance. So the status of 'button's can be judged by the level of resistance in the circuit. There is no usability evaluation for Banana piano application, but it had enlightened us on the original idea of DragonMama.

Music Hero [3] (as shown in Figure 2) is an well-known Android music rhythm game. Players tap the touch screen with the rhythm of preloaded songs. The beats or rhythms are preset for each loaded songs, and scores are based on

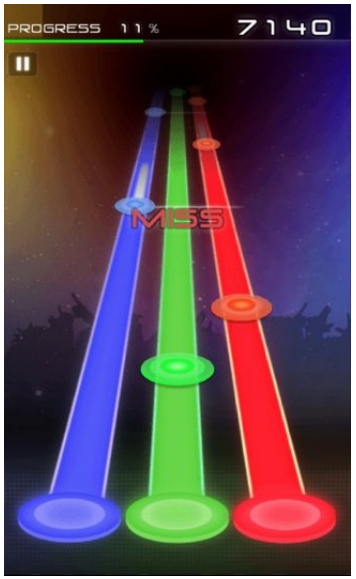


Figure 2: Music Hero: an Android music rhythm game.

how well the player's tapping follows the pace of beats. Currently over 10 million users tried this application on Android devices and the overall grade is 4.4 indicating the satisfaction of users, as another viewpoint of user experience. It had enlightened us on how to augment the attraction and the user experience for a long period.

Prototyping

Given the general use case scenario in Introduction, We mock-up the system visual interface (i.e. the front-end webpage) into three views: Selection View, Playing View, and Setting View. The three views share the same framework.

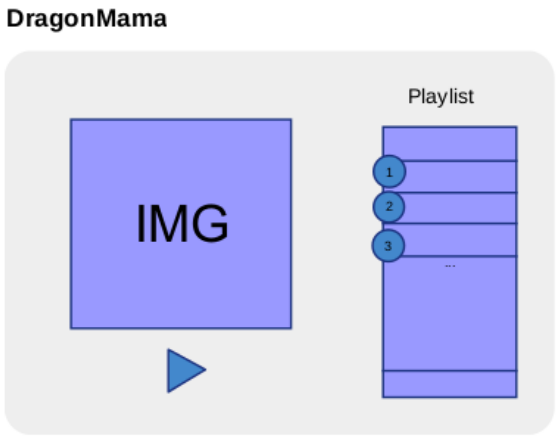


Figure 3: Selection View: selecting background music.

Selection View as shown in Figure 3 is used for selecting background songs. Playlist presents a list of available songs, and the 'IMG' rectangle represents the preview of related MV. The triangle button is used for confirmation after selecting a certain item from the playlist.

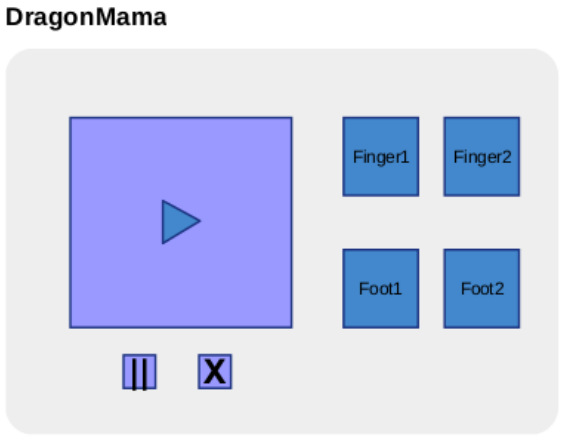
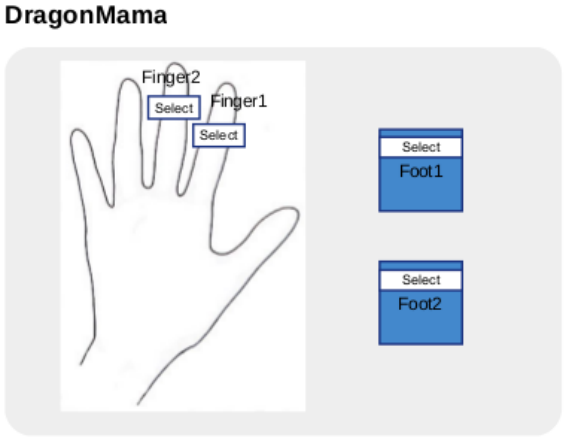


Figure 4: Playing View: play with indicators.

Playing View as shown in Figure 4 is the ongoing view when playing with DragonMama. The left-hand rectangle displays MV, while the right-hand rectangles representing corresponding sensors shakes and blinks as indicators.



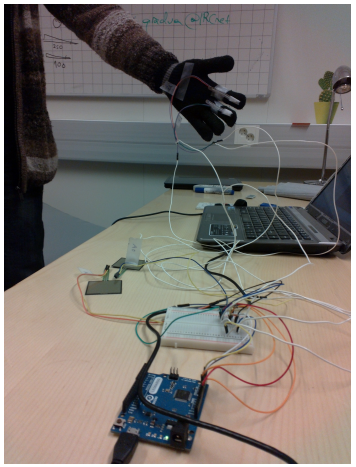


Figure 6: Setting up DragonMama demo system.

Figure 5: Setting View: set sounds for sensors.

Setting View as shown in Figure 5 is used for customizing single sounds for each sensor. The selection widgets represent the selected sounds mapped to sensors.

System Description

Here we present the usage of DragonMama demo system.

To setup the system, we need to connect all sensors to Arduino board with wires (as shown in Figure 6). A breadboard extension is used to support multiple pins for 4 sensors. Then Arduino board is connected with the host laptop with a mini-USB line. By pressing the starting button on Arduino board and starting the back-end server, DragonMama is prepared.

Before playing DragonMama, the user wears the glove. The first page of front-end is Selection View implemented as Figure 7. There is a full-featured MV player in the center with the playlist at the bottom. The playlist selection cursor and Start button are controlled by fingers. By bending the index finger, the cursor jumps to the next item in the playlist; by bending the middle finger, the cursor jumps to the previous item. The user confirms his/her choice by tapping the pad sensor 1 when the main player view as shown in Figure 8 shows up.

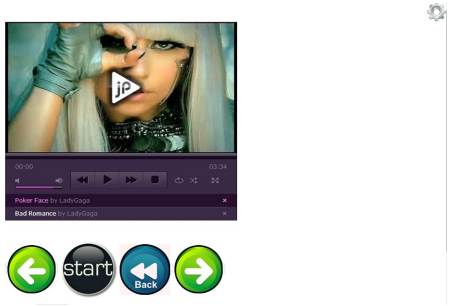


Figure 7: Selecting background music.

The background music starts playing automatically when entering the main page. Now the user composes his beats by bending fingers and tapping the pad sensors (like stepping feet). The beats in mix is freely composed since there is no explicit sequences of rhythms. Every time the user moves his limbs, the related sensors trigger the corresponding indicators to shake and blink as the visual feedbacks.

Figure 8: Player main view with ongoing visual & audio feedbacks.

On both pages, the user can customize the default sound mapped to each sensors by clicking the geared button

when the setting page (as shown in Figure 9) shows up.

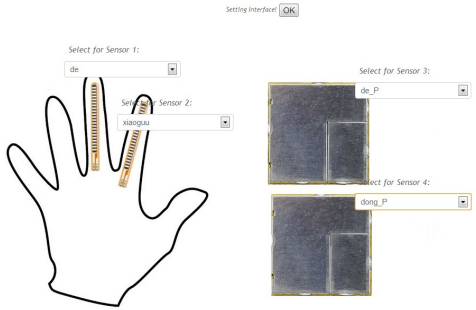


Figure 9: Customizing sounds mapped to sensors.

Use Case Scenario

A DJ in a party wears gloves and shoes equipped with DragonMama sensors. Then he steps into the dancing pool and moves his parts of body following the rhythm of background music. He made the music mix by bending his fingers and stomping his feet. He can even have a drink or talk with partners when mixing his music.

Development

We divided the implementation into 3 subtasks: the gesture capturing module with Arduino programming, the back-end server as a signal listener, and the HTML5 client presenting visual & audio feedbacks. I participated into 2 subtasks: Arduino gesture judging algorithm, and client interface implementation.

Arduino gesture judging algorithm is designed for giving ground truth for limb-motion including bending a finger and stepping a foot. We mapped the current flow values into a degree scale of 0 to 180. Now it's acceptable to set up a single threshold for the pad sensors, but setting up the thresholds for the flex sensors calls for more delicate tuning. As we had tested on flex sensors, a single threshold around 40 to 60 results in multiple entrance of the positive area. We tried setting up blocks to eliminate the false positive errors but in vain. Then we decided to implement double thresholds to minimize false positives as well as false negatives. When bending the finger over 60 degrees, the ground truth turns true; when relaxing the finger below 40 degrees, the ground truth turns false. Our choice of thresholds is proved to be precise in practical experiments.

And for the client interface implementation, one of my task is to find the proper 3rd party javascript library with open APIs of playlist. In this sense, the target library show be wrapped with low-level interfaces which can be used for playlist selection. Finally, I found jPlayer library as an extension of jQuery, providing properly wrapped video player object with open playlist interfaces. We used the next() and previous() functions to implement those triggered actions on bending fingers. The other task for me is to implement the setting page. It's easily done by mapping jQuery onClick callback functions with sensor signals.

Evaluation and Usability Testing

Usability [4] as illustrated in ISO9241-11 should be measured in a specific context, with the constraints like who is the testing user, what is the goal of application, and in what scenario is the application tested. Usability can be measured in 3 aspects: effectiveness (whether the user can achieve his goals), efficiency (how much resource is consumed in the process), and satisfaction (the user's estimation of experience).

We conducted the summative evaluation of usability

based on our demo application in order to assess the whether the users achieve the objectives, the level of performance, and how the users satisfy with our demo application. We use questionnaires, a typical and easiest empirical method, to collect user subjective comments. We asked the testing users to filled in the questionnaire after using our DragonMama demo application.

In this questionnaire, we designed questions for background informations (gender, age, eduation, occupation, etc.) in Part 1, usability evaluation questions in Part 2, and open questions on what the user like or dislike in Part 3. Part 2 is the main section of this questionnaire, and we adopted Likert scales [2] in the 10 questions each of which has 5 response options as ordinal values from 'Strongly Disagree' to 'Strongly Agree'. The Likert scales with little overlaps can constraint user's subjective feelings to degrees of characteristics. The sample questionnaire can be found in Appendix.

We collected questionnaires from 14 users: 71% of them are male, 86% of them are within the range of 18-35 years old, and 97% of the users have an higher education background. 93% of the users had the experience of playing instruments, and 93% of them have the experience of playing HCI games.

The first 5 questions are about effectiveness. 77-78% of the users agree or strongly agree on the positive estimation ('Agree' or 'Strongly Agree') of graphics, screen layout and playability. And none of the users strongly disagree with the positive evaluations. So our visual interface design and game idea are successful. 71% of the users agrees that 'the bending sensitivity is precise and appropriate' and no one disagrees. 93% of the users have positive evaluation of clicking sensitivity while 7% have the negative ideas. In this sense, both bending and clicking sensitivities are sufficient, but still there is room for clicking sensitivity.

The next 3 questions are about efficiency. 78% of the users believe that 'It is easy to play with a pre-chosen song' and 'It is easy to configure your own preferences', and 93% of them agree that 'It is easy to understand the feedback'. None of the testing users has negative opinions on these questions. So the cost of playing, configuring the game and understanding the feedbacks achieved the satisfactory level.

The last two questions are about satisfaction. 93% of the users would like to play it and expect new features, and 92% of them would recommend the game to others. None of the sample users holds a negative opinion of such satisfaction opinions.

So generally speaking, the usability of DragonMama demo application is satisfactory especially the efficiency and satisfaction, but there is still need for developing the effectiveness such as clicking sensitivity.

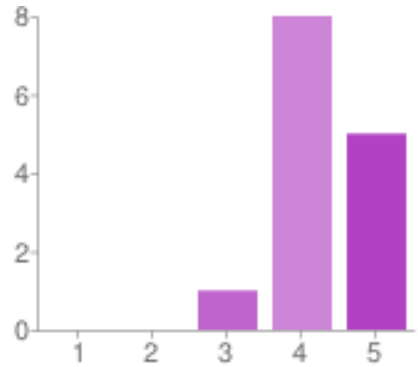


Figure 10: Overall impression distribution.

The distribution of overall impressions is shown in Figure 10. 36% of the users scores 5, 57% of them scores 4, while 7% of them scores 3. Besides, we received subjective comments from the two open question asking about likes/dislikes. Most of such comments and suggestions are quite useful in further development, such as 'it would be better if the system gives feedbacks of the performance' and 'The hardware setup looks interesting, next challenge is to add more fun'. The suggestions focus on two aspects: adding vibration feedbacks to gloves, and improve playability of the game.

Conclusion and Future Work

The goal of our project was achieved, i.e. we developed a demo system of music mix player controlled by limbs. We realized the sensor inputs and visual& audio feedbacks. It was awesome group work just like geeks. But it was still not a complete HCI system due to the limited time and resource. According to our plan and user feedbacks, there are 3 aspects to be developed in the further plan: replacing wired connection between limb sensors and Arduino board with Bluetooth modules, adding vibration actuators to gloves and shoes to give feedbacks, and improve the playability of game by learning from 'Music Hero' or similar games.

Acknowledgement

We thank all users that participated the demo session, gave comments and filled in the questionnaire. We also thank the staffs of HCI research group especially Eve Hoggan who supported us in giving instructions on evaluation and purchasing Arduino parts from Sparkfun, and Matti Nelimarkka who helped us with implementation.

This project DragonMama is completed with all 6 group members: Mian Du, Yonghao Li, Linhong Sun, Qijia Zeng, Junlong Xiang, Xiang Gao. And each of us have contributed to the success of development and evaluation.

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