A gaming social platform for In-home senior rehabilitative care

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Abstract

To assist older adults with disabilities in recovering physical, psychological, and social skills in order to maintain a more independent life, the project designs a socializing rehab game that takes into account both affordability and gaming experience. The platform allows multiple seniors to play MahJong, a tiled-based game originated from Qing Dynasty, with wearable devices serving a particular rehabilitating purpose: hand joint exercise. The game consists of two players where they could play tiles with controllers while exercising at the same time.

Keywords

wearable technology, elderly rehabilitation, gaming

1 Introduction

Forty percent of all people with disabilities are over age 65 and 85 years and older comprise the highest percentage of persons with disabilities. Geriatric rehabilitation aims to assist older adults with disabilities in recovering physical, psychological, and social skills to maintain a more independent life. Currently, there are rehabilitation centers, home, and office settings, remote caring policies, and long-term nursing homes, each practicing different geriatric caring strategies. However, most of the rehabilitating exercises are not entertaining or engaging but repetitive. Moreover, the older participants in rehabilitation sessions are often reluctant to use high-tech rehabilitation aids such as an exoskeleton, stating that they are terrified by the “technology” and low tech aids such as playdough, claiming that the procedures are “not interesting”. The problem with elderly care is not just technology advancement and physiology; it should also be addressed from an anthropological perspective. The issue for frail elderly is their isolation, loneliness, and desire for excitement. Technological advancement is not enough to solve the problem; designers should also adopt an anthropological perspective.

To address the problem, many worked on game development for rehab exercises. Nevertheless, many of them used devices such as VR headsets, Kinect, and other advanced technology that are not accessible for everyday senior citizens. Moreover, the elderly population could not bear the dizziness brought by VR headsets since eye diseases are one of the most popular disabilities among people and such products are often expensive and not portable.

Our project provides the elderly population with a wearable device that could be connected to the web game we developed. The wearable is composed of gloves with bend sensors attached to it and is used as a controller to the interactive MahJong games we design for rehabilitating purposes. For this iteration, users could practice hand joint rehabilitative exercises with our product engagingly and intuitively.

2 Related Work

The paper by S. Gabrielli on In-Home Rehabilitation[1] is closely related to the project because it explores the patient-centered design of game environments to raise patients' motivation and compliance with motor-cognitive rehabilitation programs. The paper introduces different gaming platforms and interactive tools such as Kinect, LeapMotion, etc. Another paper called "The Present and Future of Robotic Technology in Rehabilitation"[2] gives a thorough introduction of how and what has been done in the past regarding technological advancement in rehab. It shows the big picture of current rehabilitating technology and how expensive rehab devices are. One article from Harvard Magazine[3] evaluates elder care in China. The article is indeed inspiring to this project not only because it addresses different technologies in elderly aids and rehab devices, but it also states the influences of culture on rehab and stresses the importance of the human aspect of eldercare. From the article, we can see the importance of social engagement for the elderly population.

There are some articles about projects addressing the issue with gaming platforms, such as Morganti's project "Preliminary data of a game-based protocol for acute treatment of cervical spinal cord injury rehabilitation with Kinect." The article introduces how cervical spinal cord injury rehab practice could be achieved by games using Kinect. The gaming platform is interesting and engaging but Kinect itself is expensive and not popular among the elderly. The book "*Clinical Rehabilitation Experience Utilizing Serious Games: Rehabilitation Technology and a Technical Concept for Health Data Collection*." introduces[7] wearable device computing and its application in serious games for rehab exercise. It also provides a critical analysis of user needs and points toward specific clinical possibilities.

To create a better gaming experience, it is crucial to consider user engagement in game. The project needs to optimize patients' engagement level in the game. The paper "Does Body Movement Engage You More in Digital Game Play? and Why?"[4] shows that user movement in-game improves the engagement level. Addressing more movement, even the minor once, could make the process more enjoyable for the users. This statement indicates that we need to find a natural way to integrate body movement with the gaming interface. Another paper, "Does Winning or Losing Change Players' Engagement in Competitive Games? Experiments in Virtual Reality," shows that having multiple players/having a feeling of winning or losing could increase engagement in a game. The paper offers the advantages of having a multiplayer game.

3 Methodology

3.1 Research

Since the project targets a specific demographic, it is crucial to address questions in the research phase prior to the prototype and production stages.

The general questions to examine are:

1. *Which form of controller do I want to use that is user-friendly and good for rehabilitating the elderly?*
2. *Which online game should I make for the audience?*
3. *(Continued on question 2) What is the ideal interaction for this game?*
4. *Which platform is most suitable for game playing?*

I sent out questionnaires to 30 residents and did one-on-one interviews with 5 residents at the rehab center in Shanghai called "RenShouTang Senior Center". Specific questions asked in the surveys are 1) List out 5 games in the order of familiarity, likeness, and frequency. 2) Which of the following are you most familiar with: television, web, and mobile games. 3) Which hand joint exercise you do here at the senior center do you like the most?

The top-rated games are chess and card games. Among all the games, Mahjong, a tiled-based board game that was developed during the Qing Dynasty in China, was the most participated game among the elderly respondents. From the questionnaire, the elderly respondents are most comfortable with television, but mobile phones and computers are also high. Some respondents also stated that they use rubber bands for hand stretching exercises.

During interviews, I sent out playdoughs to five participants and asked them to make different shapes using the playdough. After five minutes, I asked the participants if they enjoyed the process. The participants with joint pain pointed out that playdough is hard to control the softness to maintain the practice purposes. I also gave them gloves and asked them to wear them. They were all comfortable with the medium and stated that they could see it as a controller for games.

Based on the survey results and interview process, I decided to design an online version of a two-player Mahjong game where the elderly could take actions in-game and perform hand joint exercises with a single pair of gloves.

3.2 Prototype - Preface

Before the actual implementation, I created prototypes in Figma to mock the User Interface of the Mahjong web game. You can see from Figure 1 that for both players, 13 tiles are drawn randomly at first.

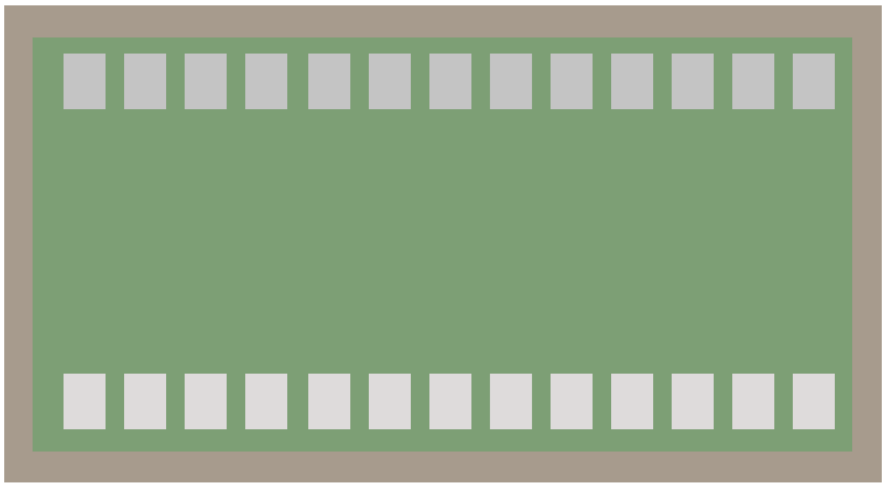

Figure 1

There are tiles in total in MahJong games(as shown in figure 2). I did research on how to make the Mahjong patterns and decided to create the patterns using String.fromcodetopoint() function in javascript. I also make the tiles with WebGL. The visual outcome is as shown in figure 3.

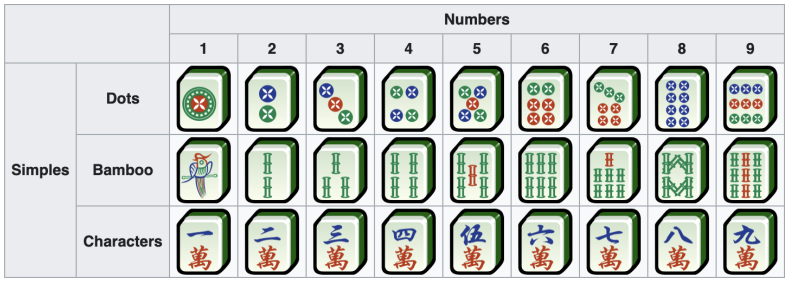

Figure 2 (source from Wikipedia)

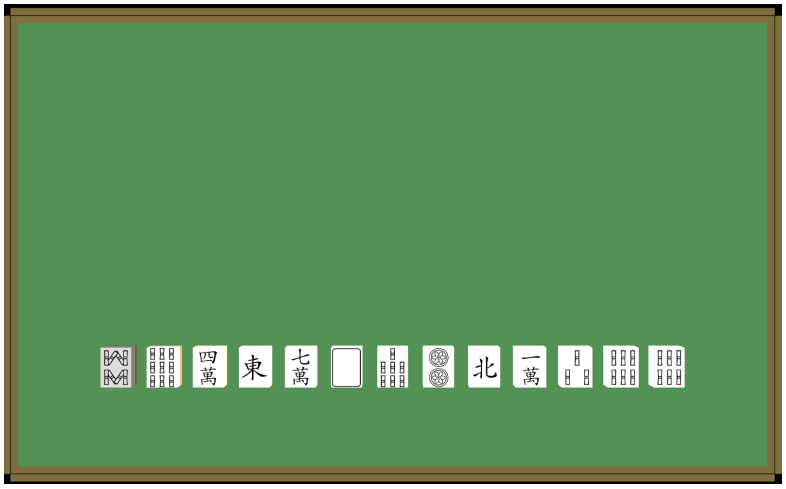

Figure 3

Now that the basic layout is created, I moved on to the possible player actions in MahJong Game: 1) Draw a new Tile 2) Select Tile 3) Play Tile. It is crucial to find an intuitive way to interface the wearable controllers to the actions.

For the wearable part, I tested with sensors before sewing them to the actual wearable gloves. The few things that need to be tested are the range of analog input of the bend sensor, the ideal placement of the sensor on the user's hand, and the communication between the analog input and the game.

After the circuit was successfully connected, the bend sensor range is between 10 - 55. For the ideal placement of the sensor, I tested two different strategies: sensors on the top of fingers and sensors at the bottom of fingers as shown below.

Figure 4

Figure 5

When I place the sensor at the top of my finger, the sensor is not as sensitive as when I place them at the bottom of my finger. To optimize the user experience as well as the responsiveness of the web game, I decided to put the sensors at the bottom of the user's fingers.

After successfully testing the analog input of sensors, I started to think about the posture indication of actions: To draw a new tile, the user needs to make a fist. By default, the cursor will be set at the first tile and the user could select the "next tile" by bending his middle finger. Similarly, he/she can choose the previous one by bending his index finger. To send the selected tile, the user needs to bend the ring finger and little finger together.

Lastly, I prepared and tested the communication between the analog input and the website. I am creating the web with node.js as a backend server and the game with p5.js. I managed to communicate between the sensor and client-side of the web with serial communication.

```
myPort.pipe(parser); // pipe the serial stream to the parser

myPort.on('open', showPortOpen);
parser.on('data', readSerialData);
myPort.on('close', showPortClose);
myPort.on('error', showError);
// WebSocket Portion
// WebSockets work with the HTTP server
function showPortOpen() {
  console.log('port open. Data rate: ' + myPort.baudRate);
}

function readSerialData(data) {
  console.log(data);
  datafromarduino = data;
}      You, 8 hours ago • updated server

function showPortClose() {
  console.log('port closed.');
}

function showError(error) {
  console.log('Serial port error: ' + error);
}

app.get("/getuser", (req, res) => {
return res.send(datafromarduino);

})
```

Figure 6

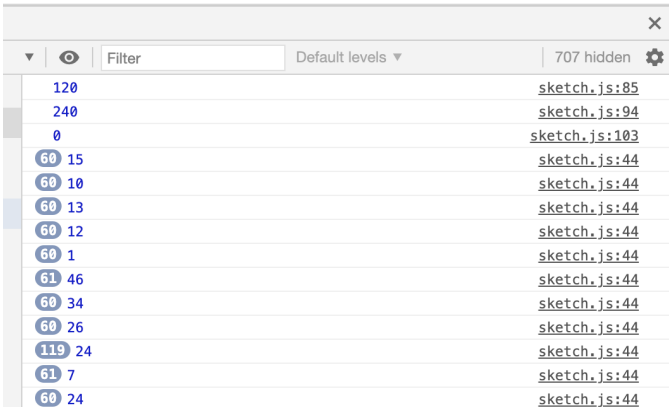

Figure 7

3.3 Final Prototype

The final prototype can be divided into two parts: the physical wearable device and the online web game.

I used one glove and sewed four bend sensors to four fingers for the wearable controller part. To protect the sensors and to make it easier for the users to bend the sensors, I put protectors on the fingertips(shown in figure 8.2).

Figure 8.1

Figure 8.2

There are three major components for the web game: the game itself and the connection to rehab exercise. Each time a user is logged in, the user is marked as a new client and will get 13 randomly generated tiles only visible for him/herself. When user one plays a tile, user two would see it displayed on the screen in real-time.
All the visual elements and interactions are made with p5.js and the web is running on the server written in node.js.

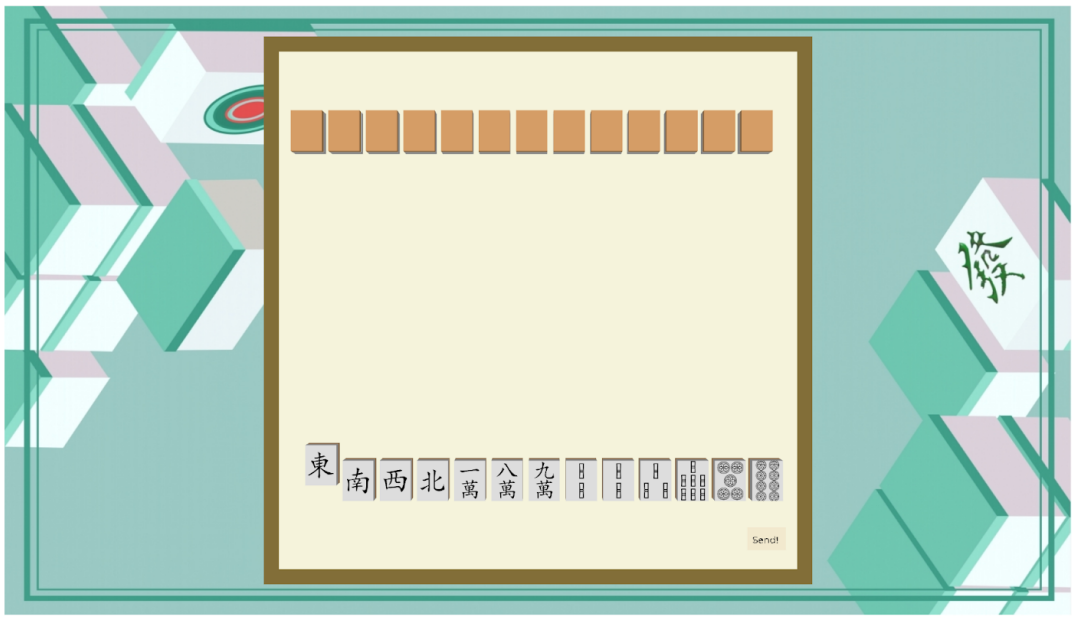

Figure 9- Final UI

```
> node server.js "/dev/cu.usbmodem141401"

Example app listening at http://localhost:3000
port open. Data rate: 9600
We have a new client: 4NwbetUKLRDvkcYSAAAA
```

Figure 10 - Connection

When connecting the controller to the gaming interface, the program read the data 1000 times per second to recognize the intended gesture. When the data for the index finger hits a certain threshold, the selection changes. Similar for the middle finger. The program does condition checks and gives out corresponding responses to the users to provide an interactive and engaging experience.

Possible actions are: Draw new tile: User fold four fingers to draw a new tile;

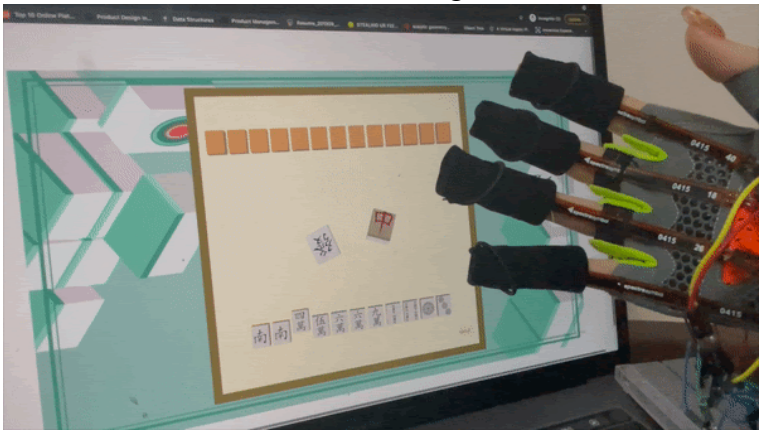

Figure 11 - Draw new Tile

Select tiles: User fold index finger to select the next tile and fold the middle finger to select the previous one.

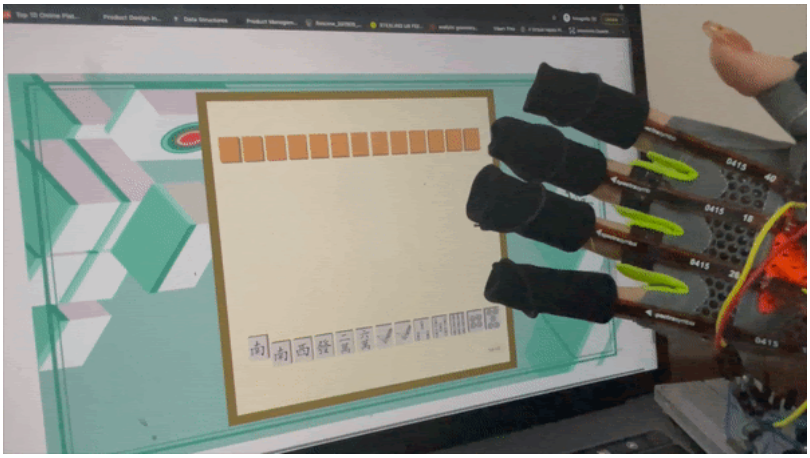

Figure 12 - Select Tile

Send selected tile: User fold ring finger and little finger together to send the current selected tile.

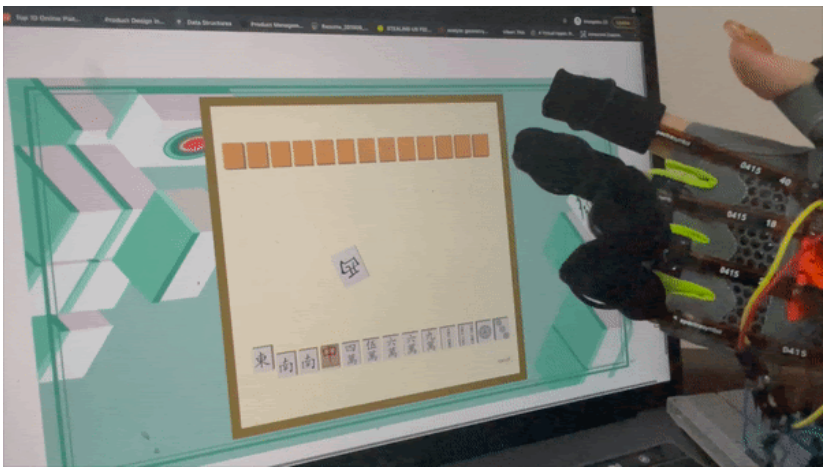

Figure 12 - Send Tile

4 Evaluation

To evaluate the prototype, I took it to the same local rehab center where I did my user research and asked them to use my platform. The elderly group who tried my game liked it and played for around 10 minutes with no break. The exercise matches their daily hand exercise, and they think the interaction is new to them, but the game is engaging since they are already familiar with the game rules. However, some participants are stating that the exercise is not intense enough for them.

To further analyze the rehab value of the wearable device, I took the wearable controller to Shanghai Spine and Joint Medical Center for their professional advice. They suggested adding a solid board to the wearable device to use a rubber band as a stretch resistance to obtain a different intensity level for rehabilitating exercises. They showed me an existing tool that they use, and I recreated the wearable device based on that.
I added a stick to each of the fingers; then wrapped a rubber band around both the finger and the stick to add pressure. The new device can be a starting point for the next iteration of the wearable device.

Figure 13

Figure 14

5 Conclusion

Overall the production fulfills its original intended purpose: to provide an engaging gaming platform that allows multiple participants to play MahJong, a tiled-based game, with wearable devices serving hand joint rehabilitation purposes. The project is done in an attempt to assist the elder community with disabilities in recovering both physically and psychologically. The design of the game takes into account both affordability and user experience by conducting user research and one-on-one interviews before the actual prototype.

However, there are still some drawbacks in the methodology section. As suggested by the nurses, the project needs to take into account the variability among the elderly rehabilitation needs: that is, to consider the capability range. In the future, the project should implement a user “difficulty level” setting associated with each patient so that the rehabilitation progress would be more effective and could be tracked by the nurses. It would also be helpful to have a tutorial prior to the actual game to learn different gestures beforehand.

In the future, I wish to make more interactive games targeting different body part rehabilitating exercises and make multiple wearable devices together into a toolbox. Such a platform could help the elder community to perform effective home rehab exercises in an engaging and fun way.

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