El Astrocade

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The following work was done during the class "project based research". To pass the class the authors created a motion controlled game that makes people do excercise while playing and is therefore targeting the problem of obesity.

1 Background

Childhood obesity is a worldwide public health issue (Ogden et al., 2014). It is reported that obese children are more likely to become obese adults and overweight young adults are more likely to stay obese during their life. Obese people also have a high chance of developing noncommunicable diseases like diabetes and cardiovascular diseases at a very young age. Overweight and obesity, as well as their related diseases, are largely preventable. Diet and physical activity behaviors, the cornerstones of obesity prevention, track into adulthood. Establishing a healthy diet and practicing sports during childhood is an important aspect of obesity prevention.
There were some approaches with electric games to counter this problem. Thompson, 2014 proposed a serious game which teaches how important diet and physical activity behaviors are. It is know that 97% of of 12-17 year olds play video games (Lenhart et al., 2008). Games could be a nice opportunity to teach this kind of knowledge. But in this case, there are some children who do not prefer to get physically active and this method can not motivate them to move as it teaches only theoretical knowledge.
In this work the authors would like to propose a novel game which encourages children to move and takes them through how physical activity is pleasing. This game is a shooting game in which the user controls a spaceship and shoots opponents. In our approach, we developed a whole body controller system, where users need to move their body to control a space ship. As shown in Figure 2, this game needs two participant to move one spaceship. One player is in charge of the movement in X direction and another player is responsible for movement in Y direction. Space ships can shoot when one of the players is jumping. The player can also defend the ship with a shield when they crouch down. To win a game, players need to destroy the opponents ship by moving along the side of the play area and jumping or crouching while cooperating with their team member.

2 Methodology

2.1 Tracking

To get motion data from the players a tracking system with 20 infrared cameras is used. The height and the position of the players is used to control the game. The height value is classified into jump motion, crouch motion and regular standing to trigger shooting and defense. The position of both players of a team is mapped to an x-y coordinate system to position a dot in space which is followed by the space ship.

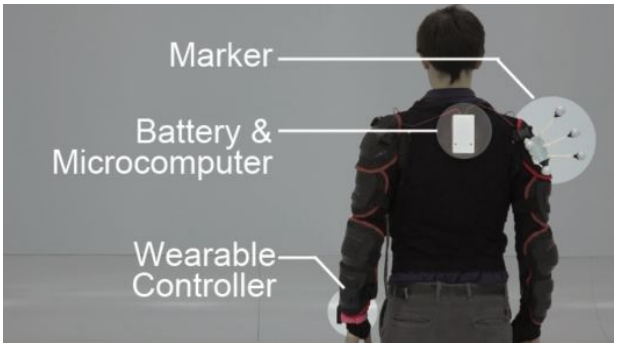

Figure 1: *Game suit with all wearable components. A reflective antenna on the shoulder is used to determine the position of the player. The microcontroller and the battery on the back transmit signals from the touch and the heart rate sensor and shows information on the display mounted at the wrist of the players.*

To get the motion of players, every player is wearing a rigid marker with an unique marker pattern. A sample of such a marker can be seen in Figure 1. To create the markers a 3D-printed base platform with 7 positions to connect antennas was created. Each marker pattern constisted of 4 antennas. On top of each antenna was a styrofoam ball covered with reflective tape. The IR cameras were recording the reflections from the balls and the positions in space were extracted with the motion software Motive. The extracted player positions were broadcasted into the large space network.

2.2 Projection

This is a tribute game to outer space which was the topic of the first arcade video game as well as the first commercially available video game. This type of game has a long history and it is easy to understand how to play. These are the reason why we introduce this kind of game in our project. In this game the space ship follows the motion of the players. The player who is moving in X direction can move the ship in x direction and another player can move it in Y direction. Because it is difficult to manipulate a space ship in 2D with two players directly, we introduce the dot following method, where the space ship follows a dot that is controlled by the players. We adopted this control method from the online game at *slither.io*. With this method there is a short delay between the motion of the space ship and the players motion. The delay can be controlled by changing the speed with which the space ship follows the dot.

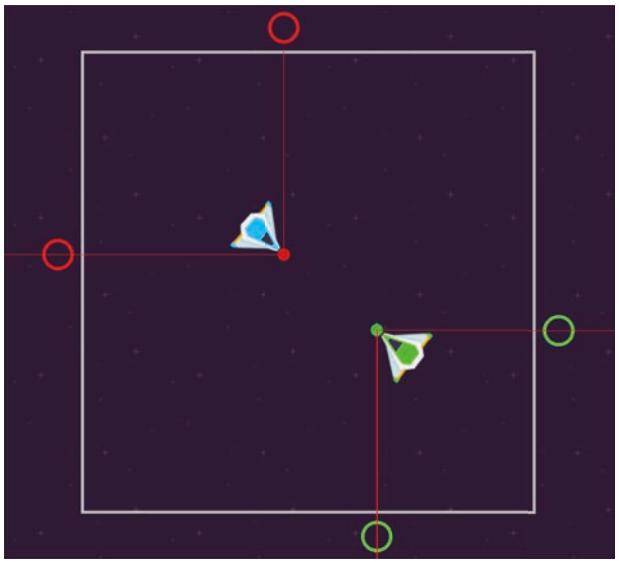

Figure 2: *Schematic overview of the projected game components. The space ships follow the colored dots that are controlled by the position of the players. The players position is marked with a circle around his position. A white line on the ground shows until where the space ships can go.*

2.3 Wearable Device

All players play the game with a suit and a wearable controller. The suit has markers on the shoulder which are used to detected the players position. The markers are placed on the shoulder to be easily detected by the infrared cameras. Between the shoulder blades there is also a box on the suit which carries the battery for the wearable controller and a microcomputer that does the bluetooth communication. As an extension to the controller on the back, players also wear a wearable controller on the wrist. Figure 3 shows the wearable controller. The controller has a display, a heart rate sensor and a gyroscope. The players can see their life points and heart rate on the display. Optional functionality that is not yet fully implemented is to use the heart rate and motion of the hands as input to trigger e.g. a special attack in the game. The evolution of the wrist controller is shown in Figure 5.

Figure 3: *The wearable wrist device is a 3D printed case fitted into a polar A300 fitness tracker wristband. Inside the case are a heart rate sensor, a IMU sensor and a display.*

2.4 Communication

The wearable devices were client nodes in a bluetooth network and communicated with a master node through the bluetooth low energy protocol. The master node was an Adafruit Bluefruit connected via USB to a Macbook Pro and communicated through serial protocol. The Macbook Pro ran a small openframeworks program that forwarded the received messages between the bluetooth master node and the large space master computer and showed the message content in a graphical user interface. A slightly modified copy of the openframeworks program also ran on the large space master computer to forward messages between the Macbook Pro and the large space cluster that is responsible for rendering the projections. The master computer also ran a commandline program to receive and forward a stream of UDP messages from the motion tracking software to the large space cluster. A schematic of the communication is shown in Figure 4.

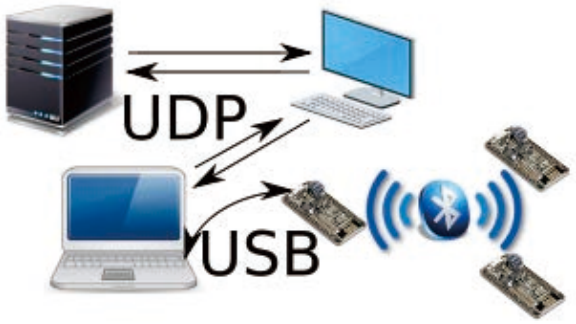

Figure 4: *Wearable devices communicate via bluetooth with the master node that is connected by USB to a laptop. The master computer forwards network packages between the laptop and the projection cluster.*

3 Final Presentation

During the final presentation the project "El Astrocade" got rated for different aspects of the project from the faculty staff on a scale from 1 to 5. Where 5 points are the highest rating and 1 point is lowest rating. Table 1 shows the ratings averaged per category over 3 ratings.

Category	Average Rating
Originality	4.67
Interdisciplinarity	3.67
Team Cooperation	4.33
Presentation	4.33
Overall Evaluation	4.33
∅	4.27

Table 1: *Ratings the project "El Astrocade" got from the faculty staff during the final presentation. Averaged over 3 ratings per category.*

The faculty also had some comments and ideas how to improve the work which are listed in the following without a particular order.

1. It was a good design as an application to move the body.
2. Some improvements are needed but this game is so interesting.
3. It is regrettable that the (wearable) device and the calibration (of the sensors) were not working.
4. It would have been better if the presentation cleared who was in charge.
5. It may be interesting to include feedbacks.
6. If I could summarize quantitatively how much exercise I do it would be research.
7. It might be interesting to include more interactions between players.
8. I would like to see if BGM (background music) and SE (sound effects) were good.

3.1 Observations

The authors also made some observations during the public presentation of the system. Participants quickly understood how to control the space ships. Once they understood the controls, each round was very competitive which automatically increased the doing sports aspect of the system. The authors could observe that players were quiet happy as they were laughing out loud and smiling while running and jumping to either side of the play area. However, players asked how they could control in which direction the space ship will turn. The turning is automatically in the direction the player moves and in which less distance needs to be travelled. This might sometimes not coincide with what the players wanted the space ship to do and therefore might need a little explanation or short demonstration at the beginning.

3.2 Problems

Before the initial public presentation of the system the authors faced a few problems that prevented them from finalizing all the system features originally intended. One problem was that all the lithium batteries discharged to a point where they were useless. Due to that problem 9V blocks had to be used and the case used to hold the microcontroller and the battery had to be remodeled. The change of battery also lead to a problem with the capacitive touch sensors which are highly dependent on the connected power source. The sensor readings changed dramatically and previously identified touch thresholds didn't work any longer. In an attempt to fix the problem time became too short to work on the code implementation of the heart rate sensor and the integration of feedback messages to the display of the wearable device. Luckily enough a minimum valuable system could be created anyway.

4 Future Work

As suggested by the faculty staff and originally planned but due to time restrictions and other problems not yet done, improvements to the game experience are already planned. As a first step because it is rather easy to do, background music and sound effects will be added. Also the basic functionality of the wearable device will be fixed so that the touch sensors work reliable and the display shows heart readings and the space ship health. After the heartrate sensor is included, measurements of the players excercise can be recorded and proper research can be done. The plan is to measure the game intensity and the amount of movement each player to verify that this game can be used instead of excercise. It is also of interest how long players need to play to achieve a certain fitness goal. The IMU sensor inside of the wrist type wearble device will be included in a later version of the game. To provide additional

feedback the suits will be equipped with LEDs and two small vibration motors for feedback after the space ship is hit by the opponent. Further the authors might think about how to increase interaction between team players by adding shared control tasks where both players are needed to trigger a certain action, e.g. a special attack. To make the difficulty of the game variable it is planned to include obstacles like asteroids the players have to avoid. These would damage the ship on contact and can either be avoided or destroyed. This would increase the amount of movement needed to survive the game. If a game becomes to difficult players get frustrated. To avoid this we can add items or power-ups that help the team and reduce the difficulty of the game.

5 Conclusion

In this work a new game for virtual reality projection systems based on motion tracking with wearable extensions and biosignals was proposed. The main goal of the game is to motivate players to get active, move their whole body while playing and practice to collaborate with their team member. At the public presentation, the proposed game received high evaluations in five categories and an overall average score of 4.27 out of 5 points. During the first test of the game all players were observed and showed active participation and joy while playing the game. Further improvements, as requested by the faculty staff, are already planned by the authors. Additional sound effects, new game objects and more social interactions are incentives for players to increase their physical activity and motivate them to move. To verify the effect of increased activity, the game intensity and the amount of each players movement will be measured and condensed into research. A short teaser about the game can be found online at https://youtu.be/RdcgmeO6gCI.

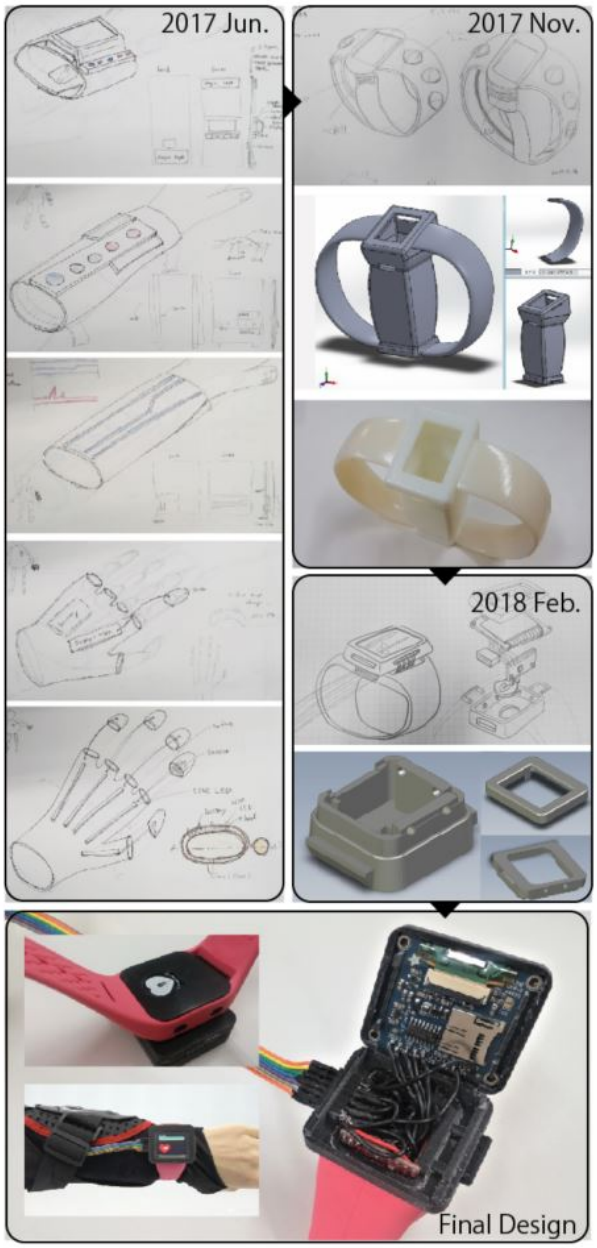

Figure 5: *Evolution of the wearable controller. Concept drawings, prototypes and final design.*

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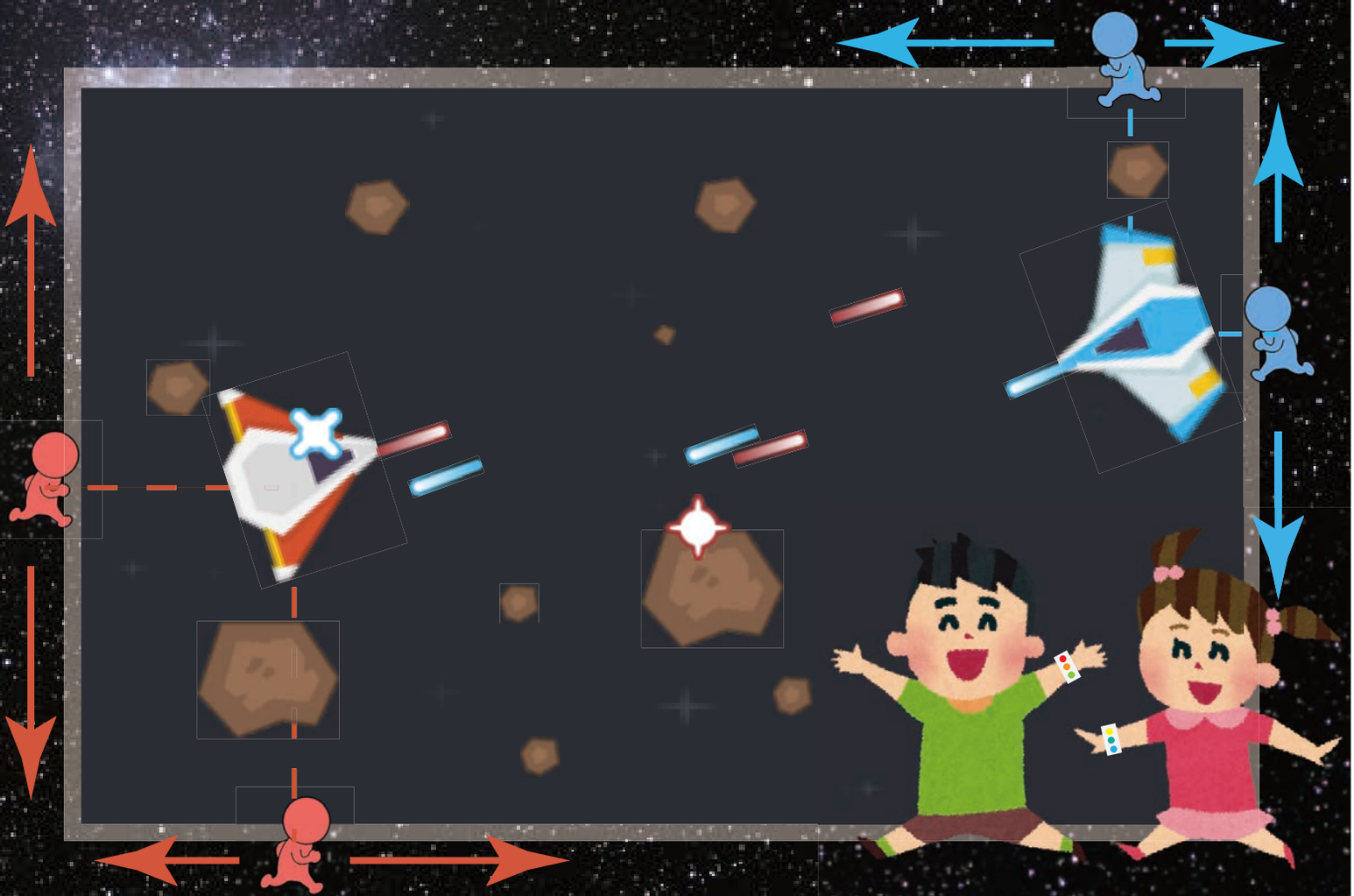
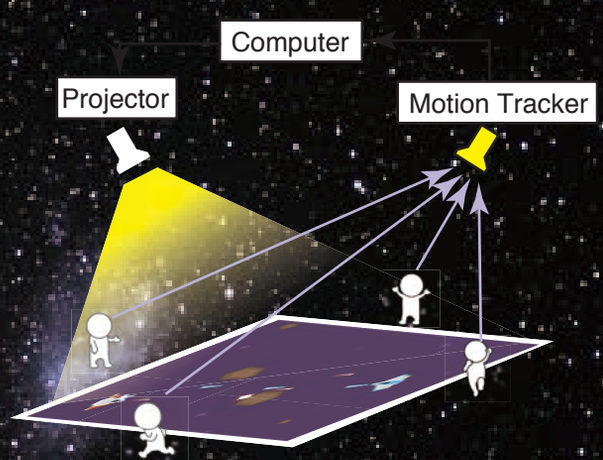
EL-ASTROCADE



ABSTRACT

This concept makes you move.
Do you like the phisical education class?
In these days, the obesty of children is a big problem because of high calorie food and TV games.
So we will try to solve these problem with the new game system which makes you move.
You can enjoy the shooting game with your body movement. Also you need to cooperate with a your partner.

CONFIGURATION



This system captures the movement of the participants. Going along with it, the agent will move shoot and do the killer technique.
Also the participants need to wear a device which can detect your heart rate and some other biosignals. The wearable device will indicate the health point of your rocket and give tactile feedback when your rocket gets damaged.

CONTROLLER