DuelReality

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Abstract—DuelReality is a mixed reality gaming system aiming to change traditional user experience by combining virtual reality and physical reality. Implementing the Yu-Gi-Oh! Trading Card Game - gaming model, a two-player game is setup with each player wearing the wristband device as the physical support for the gaming system. Each wristband device contains 5 RFID readers for reading IDs of cards equipped with RFID tags, and a Bluetooth module to communicate with a user's smartphone, all being handled by an internal processor. A phone app serves as the midway connection between the wristband device and a web server that hosts the game model and performs the required calculations.

I. INTRODUCTION

As technology became an essential part of our world, the preponderance of social interactions in our lives has diminished. The large number of people interacting on social networks without ever meeting once provides overwhelming evidence to the above statement. As Mark Fischetti from Scientific American puts it, technology "makes us less attentive to the people closest to us and even makes it hard for us to simply be with ourselves" [1]. Thus, people prefer to interact virtually while failing to develop or strengthen relationships with people that are physically present. With that goes the fact that they embrace the opportunity given by the virtual world to display an ideal image of themselves to others. In the online gaming world in particular, users play everyday against hundreds of opponents, whom they view as digital profiles whose only attributes are points or scores.

The negative impacts of technology on social interactions is a fairly new problem that arose with the introduction of mobile devices like tablets and smartphones in the last decade. It is a problem that has often been overlooked because the benefits of new technologies largely compensate for their disadvantages. Thus, little effort has been made to address this problem.

Our gaming system makes use of modern technologies to allow users to play against each other while being physically present and develop meaningful relationships. In our system, we implement the Yu-Gi-Oh Trading Card Game (TCG)[2] as it is one of the most popular and successful card games in history with the Guinness World Record of "Best-selling trading card game company" [3]. Currently players only have two options of playing a traditional Yugioh TCG. They have the option of playing solely online against opponents, and the solution of playing face to face with a physical card set. Our model combines the two existing models to create a hybrid (physical/virtual) gaming system which catches the interest of many users and draws them out of their virtual world.

To build our system, we used RFID readers that read card IDs from RFID tags placed on the cards. The readers communicate with an ATMega 2560 processor[8] which sends the data to the user's smartphone through a Bluetooth module. The bulk of our system is located inside the wristband casing shown in Figure 1. The readers are placed under the card slots; the processor and the Bluetooth module under the capsule (top node); a 5000 mAh battery is attached to the bottom of the wristband, overall giving our module a total weight of 0.6 kg.

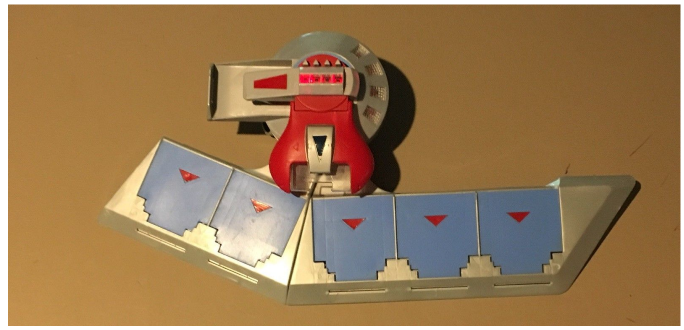

Figure 1. Wristband Casing that holds most of the components

Under the capsule in the top node, there is a strap that allows a user to attach the device to his forearm and wear it. Table 1 summarizes the system specifications.

Rich Gaming Experience	Minimum of 20 cards required in each player's deck, game between 2 players
Lightweight Product	The total weight of each wristband device is less than 1kg, which is light enough to wear during game play
Wide User Base and Affordability	Device meets child safety standard and the cost for each device is less than $100
Sufficient battery life	Battery life greater than 4 hours

Table 1. List of requirements and Specifications

II. DESIGN

A. Overview

In an attempt to reconcile technology and interpersonal interactions, we built DuelReality. This gaming system immerses users in the virtual world while facilitating physical interactions. The virtual aspect consists in the graphical representation of the game through our spectator screen available online; and the augmented reality experience we provide to the user through a Hololens. The fact that users use

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physical cards to play instead of purely virtual cards represents the physical aspect of the game.

We use RFID technology[4] to read the attributes of the cards. Each card is equipped with an RFID tag [5] storing an ID. The data collected when a user taps a card on an RFID reader is sent to our ATMega 2560 processor, which then sends the data to a smartphone app through a Bluetooth module. The smartphone app ultimately sends the data to a server where most of the game calculations take place.

We chose RFID technology because it works well for implementing the physical aspect of the game. The RFID readers that we use are Mifare RC522 readers [6] with a read range between 0 and 50 mm. Our HC-06 [7] bluetooth module allows us to meet our power requirements with an operating current of 150 mA.

Initially we considered using a GSM module on the wristband to upload our data to the server, but a GSM module would require users to buy a network plan from an cell phone carrier. For that reason we decided instead to create a smartphone app that is able to communicate with our system through Bluetooth; and to the server through the user's mobile Internet connection. This way, users can enjoy DuelReality everywhere their smartphones' could have an internet connection or data plan.

To verify power consumption requirements, we tested our system at the worst possible working conditions, which is when all the components are drawing peak current from our power source at the same time. The total current draw at the worst condition is about 440 mA. Since our battery has the capacity of supplying 5000 mAh, our device has the capability to work for more than 11 hours at worst condition, satisfying our system specification.

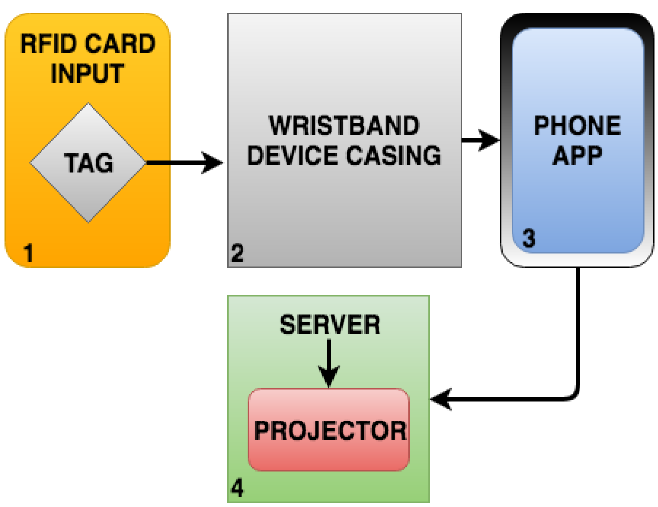

Figure 2. Block diagram

In our block diagram (see Figure 2), the first subsystem is an input card with an RFID tag attached to it. The RFID tags are relatively cheap and effective, 50 tags cost $20 dollars approximately [11].Using these tags allows us to reduce the cost of our device as well as provide accurate card reading.

The second subsystem is the wristband casing itself which includes our PCB that contains the ATMega2560 processor[8], five RFID readers, one LCD screen, a voltage regulator, that provides a stable DC voltage output independent of the load current, temperature and AC line voltage variations, the power supply, a step up boost converter, and a Bluetooth module, all of which are installed on the wearable wristband device. These components allow us to meet our requirements which are: power consumption, weight specifications, and child safety requirements. The Bluetooth module, the LCD screen, the 5 RFID readers and the processor draw a total of 440 mA which is well within our expected range at worst case scenario. The weight of the components is in total 0.15 kg; when we add that to the weight of the wristband itself which is 0.45 kg, we find the total weight of our device to be 0.6 kg. The battery that we are using meets the child safety standards of the Consumer Product Safety Commission.

The third subsystem represents the smartphone app that is the link between our device and the server. It allows our system to support a 2-player mode since each player is be able to install the app on their phone to play.

The fourth subsystem is our server where the game algorithm runs. Implementing our game algorithm on a server allows us to significantly reduce the processing power and memory required for our processor, which in turn keeps the price of our system low. Designing our system this way, we are able to keep our device inexpensive, light; support 2-player mode; meet Child Safety Standards; and enable users to play for more than 11 hours.

A. Block 1: RFID Card Input

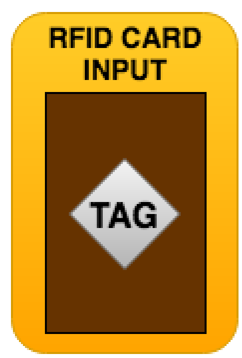

Figure 3. Card with RFID Tag used to transmit Card ID

Figure 3 represents an input card with an RFID tag attached to it. The cards come from Yu-Gi-Oh trading card game. We choose tags that contain a unique 48-bit ID so all cards can be uniquely identified and we can have billions(2^48) of unique IDs. Each card is registered at an online server by its ID. The server data under this ID contains the card's attributes, ie. attack points and defence points, the card's appearance and it's animation. RFID readers read the tags and send the data to our processor. To test this system, we repeatedly tapped a card on the RFID reader and recorded the number of times the reader read it correctly and noted whether or not the card was touching the reader or if it was in the 50mm range. Using the results of this experiment, we are able to tell how close a card should be for a reader to read it.

B. Block 2: Wristband Device System Components

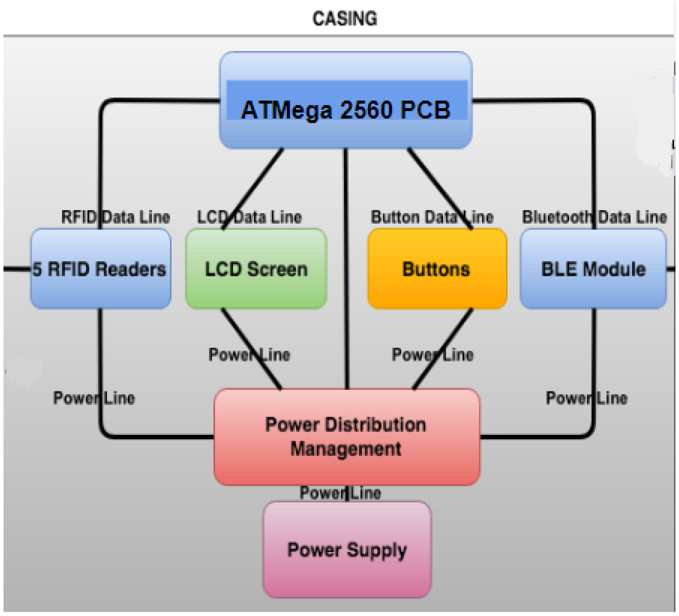

Figure 4. Wristband device casing encompassing PCB, RFID readers, screen, buttons, Bluetooth module, power distribution circuit, and battery.

Figure 4 represents the casing that contains five RFID readers, the PCB that contains the ATmega 2560[8], the LCD screen[9], the power distribution management unit, the power supply, and the Bluetooth module. This block is the bulk of our physical system. Our design needs to have the RFID readers placed approximately 10cm away from each other to prevent interference when a card is placed on a specific reader. The operating frequency of our RFID readers is 13.56MHz with a reading range less than 40mm [6]. Our PCB that contains the ATMega 2560 chip is shown in Figure 6. This PCB functions as the microcontroller of the wristband device. When a user places a card on the wristband device, the PCB works as follows: first, it receives the card IDs sent by the readers, then it transmits this information to the bluetooth module through the processor. The bluetooth module then ultimately pushes the card IDs to the phone app.

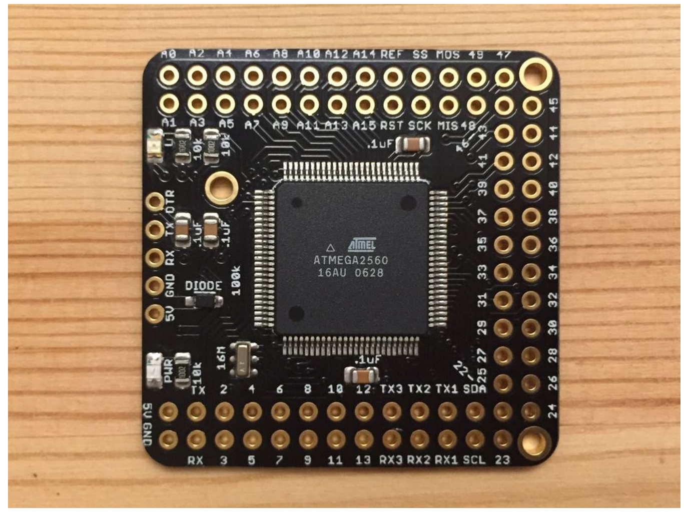

Figure 5. Printed Circuit containing ATmega 2560 chip

The PCB also updates the LCD screen when a reader sends a card ID and when it receives updates from the phone app. The design of this PCB requires a small board size and a low component count which reduces weight and cost. The final size of the PCB is 38mm*38mm. It has bypass capacitors from Vcc to ground to reduce noise, two LED indicators for power and transmission, and a Pull-up resistor between reset and Vcc/AVcc. We programmed this board in C using AVR Studio and uploading the code by a TTL serial cable.

Our power supply is a 5000 mAh rechargeable battery [13] which outputs 3.7V. Our boost converter brings the voltage to 5V. With an AMS1117 voltage regulator, we supply power to our components: 3.3V to each reader, 5V to the processor, the LCD screen and the Bluetooth module. The readers send card data to the processor which outputs it on the LCD screen and sends it to the Bluetooth module. To build this subsystem, we had to learn how to interface the readers and the LCD screen to the processor. To test this subsystem, we tapped a card on one of the readers and observe if the card attributes are displayed on the LCD screen and if they are successfully transmitted to our smartphone app through the Bluetooth module. On our smartphone we expect to see the ID corresponding to the card that was played.

C. Block 3: Smartphone App

Figure 6. Phone App for data transmission between wristband device and server.

Figure 6 represents our Smartphone app. Our app reads the card IDs from the Bluetooth module and sends this data to the server. To develop the app, we used Android Studio[10] as the development environment. The programming language was Java. Learning about an object oriented language in CompSci 121 and Data Structures was very helpful in designing the app since our courses were taught in Java. To test the app, we used an Android phone in developer mode. We ran it on the phone to see if it connects to and communicates with Bluetooth devices. We considered the experiment successful when we were able to send and receive data to/from Bluetooth devices and to/from our server.

D. Block 4: Server, spectator screen, and Projector(Hololens)

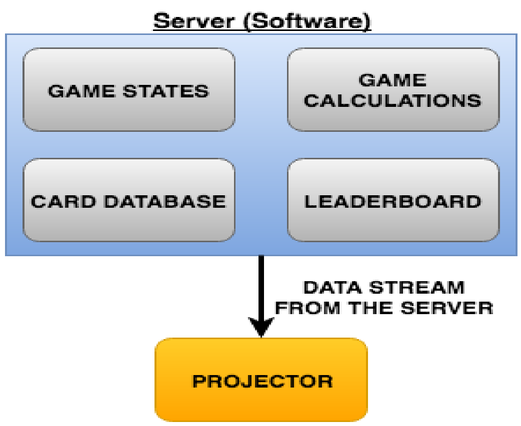

Figure 7. Server subsystem where all calculations, databases, and game states reside. Projector receives the current game state from server and project game against a surface.

Figure 7 represents the server portion of our system where most of the game play actually occurs. Running on a Google platform, our server is responsible for the game calculations, card database storage, current ongoing game states and sessions, as well as side features such as an online spectator screen (Figure 8) that people can access from across the world. Essentially when a player initiates a "duel" with another, the two gaming systems connect to each other and create a session on an online hosted server. There, our system constantly waits to receive messages from both systems regarding new actions taking place such as attacks and new card placements. Once the messages are received by the server, after any necessary game calculation or state has taken place, the server pushes the updated states to each player's devices, alerting the opponent of the last action of the other user. From the beginning, the server is responsible for game initialization, calculation, and end.

Figure 8. Spectator screen

The bottom portion of our block titled "projector" is our HoloLens (Figure 9) that provides an augmented reality to the user. The HoloLens receives messages from the server and displays the game state: monsters, life points, attacks, etc., to the user.

Figure 9. Hololens view

III. PROJECT MANAGEMENT

By keeping adequate communication, meeting once a week, and constantly staying in touch through group chat we were able to meet all the deliverables that we set. By the end, we had built 2 functional systems where each system was able to read card IDs and send them to the server through our mobile app. The server uses this data to perform game calculations; update the spectator screen; send updates to each system for display on the LCD screen, and to the HoloLens which creates the augmented reality. Power is adequately provided to each system by using a 5000mAh battery, a boost converter, and a voltage regulator. Jerry and Hadi worked together tackling the software side of our system while Xiaobin took care of the hardware portion.

5 Readers	$8
Microprocessor	$20
Bluetooth Module	$6
LCD Screen	$6
Wristband Casing	$20
PCB Power Supply & Accessories	$22
Total	$82

Table 2. Estimated Budget (Per Device)

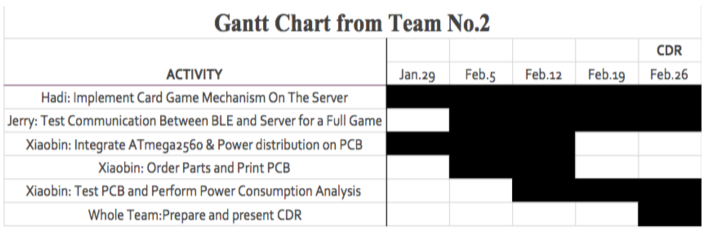

Figure 10. Gantt chart timetable up to CDR

IV. CONCLUSION

For MDR, we had the communication between the processor and the readers; and between the processor and the LCD screen established. We also had a smartphone app that was able to send and receive data to/from the processor. Our server was setup and we were able to provide steady power to the processor, the readers, the LCD screen, and the Bluetooth module.

After MDR, we enabled the app to send and receive data to/from the server, and allow users to login. After CDR, we completed our PCB design and were able to use it to connect the different parts of our system. We encountered difficulties establishing the communication between the app and our PCB, but nevertheless persevered.

For FPR, we were able to complete the project. That is, start and finish a full game between 2 systems. Our Gantt chart in Figure 10 summarized our progress.

We achieved these goals by fostering discipline and following a thoughtfully built schedule. We also followed the pieces of advice from our faculty advisor, Professor Jackson, and from our evaluators.

ACKNOWLEDGEMENT

Team DuelReality would like to thank Professor Robert Jackson for his continued support and advice regarding our project. We would also like to thank our evaluators, Professor Qiangfei Xia, Professor Christopher Hollot, and Professor Aura Ganz for their constructive feedback. Finally, we would like to thank Jeremy Paradie and Shira Epstein for their continued assistance and support

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