Final Project Proposal: Self-Reporting Dice

Katherine Cummings
Rochester Institute of Technology
Rochester, NY 14623, USA
rmc9454@rit.edu

Amanda Yung
Rochester Institute of Technology
Rochester, NY 14623, USA
aky2875@rit.edu

Abstract
We propose to create a self-reporting die that can be used to play tabletop games over the internet. This paper outlines the problem to be solved by our project and the steps we will take to implement our solution. Additionally, current research in the field that supports our proposed solution is outlined within.

Author Keywords
Dice; Tabletop Gaming; Orientation Sensors.

ACM Classification Keywords
H.5.m [HCI]: Miscellaneous

Problem
Recently there has been a rise in popularity of tabletop gaming, ranging from board games to role-playing games. Typically, tabletop games must be played in a shared space, but this has not prevented players from attempting to play remotely with their friends. We would like to make tabletop gaming a more engaging and efficient experience when one or more of the game's players are playing together via an internet connection. In particular, we would like to improve the experience of dice rolling in tabletop role-playing games. Currently, this is most often solved with a webcam and random number generator. However, for the player who must rely on these methods to be a part of the game, their

game experience is diluted: they miss out on the interactions that come with sitting in the same room with friends and playing together.

Players in this situation often try to improve their game experiences by rolling their own physical dice, but this only further complicates the situation. The die roller must self-report their roll results to their fellow players as opposed to having the random number generator post it for all to see. This adds one additional step to the process of play, which seems small, but given the number of rolls that can take place during one session of play, the time lost will add up swiftly. The self-report is also vulnerable to fabrication; in a critical moment, a player whose dice rolls cannot be seen may lie about their results, changing the outcome to suit their needs. Without the automated self-report to keep all players honest, there might be a degree of cheating that arises from some players.

Literature Review

Virtual & Augmented Gaming

Several consumer software products attempt to address the problem of playing tabletop role-playing games remotely [1]. However, these only offer a digital environment to play in. Tabletop games are enjoyed in part due to their physical nature: the tactile feedback given in these games, such as a player moving game pieces or rolling dice, can enhance the game experience [2, 6].

Previous research has been conducted to determine ideal ways to augment physical games with digital environments. For example, Hinske et al.'s work involving the tabletop miniatures game Warhammer 40K used digital information collected from natural play to automate some of the more mundane game mechanics, such as determining line of sight for a unit [2]. They also developed augmented dice with RFID tags to automatically determine the roll result, but RFID dice have their limitations: one of the drawbacks is the necessity to use an external sensor, which limits the space a player can roll the dice [3].

Magerkurth et al. have also investigated how to augment the act of rolling dice with the Smart Dice Cup [6]. The Smart Dice Cup mimics the act of shaking dice in a cup and revealing the outcome, such as for the game Yahtzee. An accelerometer detects the shaking motion, which activates the random number generator. Additionally, LEDs on the Smart Dice Cup light up to indicate the roll result. However, the physicality of the dice is lost, as they have become digitized and replaced with a single cup.

Orientation Sensing

Orientation sensing technology can allow for a handheld object to report its positioning to a user. While limited research has been conducted about orientation sensing for dice in particular, a great deal of research has been done in regards to orientation sensing technology and its application for smartphone use. Most prominently in this area, smartphone orientation sensors are being explored as potential control mechanisms for the phone, allowing the user to perform tasks by shifting the position and angle of their phone. Specifically, its application as a form of authentication has been a popular subject with several proposed methods having been put forward [4, 5]. These studies have claimed a high degree of precision from the orientation sensor's readings: the sensors could detect unique subtleties in a user's hand and wrist motion, such that they were able to tell two users apart who performed the same gestures.

Concepts for tracking orientation sensor positioning via the internet have also been proposed. Uhchikoshi et al. have created a method of tracking a smartphone's location from

Figure 1: A standard D20.

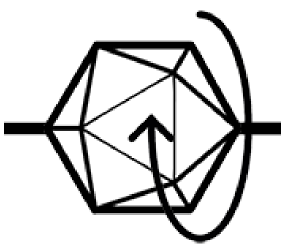

Figure 2: First axis of rotation.

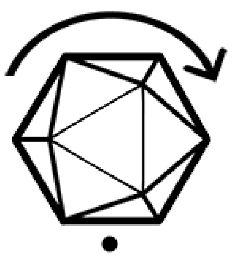

Figure 3: Second axis of rotation. Cross-section of axis is illustrated with dot.

data provided by a smartphone's orientation sensor and camera and transmitted via Wi-Fi, allowing users to reclaim a misplaced phone. Difficulties exist when executing this method in real-time however, due to the pronounced processing cost [7].

Proposal

We propose an internet-connected twenty-sided die, or D20 (see Figure 1), that will send its roll outcome via Wi-Fi. This information will be sent to a paired D20 that will be rolled to match the other D20's outcome. The D20 was chosen due to its iconic status in role-playing games like Dungeons & Dragons: typically D20 rolls determine the outcome for major events in the game. For clarity, we will refer to the first D20 as the *player D20*, and the other as the *DM D20*, as a reference to the overseeing dungeon master (DM) who needs to be aware of player actions.

The player D20 will contain an absolute orientation sensor, a Photon, and a battery. The orientation sensor will integrate data from an accelerometer, magnetometer, and gyroscope to determine the orientation of the die. The Photon will process the orientation sensor data to indicate what side the D20 landed on, and it will also send this data using the Particle Cloud. The battery will power the Photon in order for the player D20 to be wireless.

A node.js server will be used as an intermediary between the player D20 and the DM D20. When the server receives the final die roll result from the player D20, this information will be then sent to the DM D20 via serial port.

The DM D20 will consist of a 3D-printed D20 moved around by two stepper motors. The stepper motors will serve as external forces to automatically re-position the D20 so that the rolled side is facing upwards, in order to indicate what the player D20 landed on. One stepper motor will rotate the D20 around an axis through two opposing points of the die (see Figure 2). The D20 will appear like it is suspended in air, as we intend to use a clear material, such as acrylic, for the motor axle. The D20, stepper motor, and axle supporting the D20 will then be attached to a platform. The platform will have a stepper motor built into it that will be capable of rotating the entire platform. This gives the D20 a new axis of rotation (see Figure 3). With these two rotation axes, it will be possible to spin any side of the D20 to face upwards.

To indicate activity on the player D20 side, the DM D20 will randomly spin around and then eventually land on the player D20's outcome. This action will help the user of the DM D20 know when to pay attention to display. Furthermore, it helps to mimic the typical characteristic of randomness inherent in all standard dice. The stepper motors will be controlled by a motor shield attached to an Arduino. The motors will be powered by a wall power adapter, due to the amount of power the two motors will require to run.

Implementation

We intend to take the following steps in order to successfully implement our project. The steps for the player D20 and the DM D20 will be completed in parallel:

Player D20

1. Wire orientation sensor and battery to Photon.
2. Test and calibrate the orientation sensor.
3. Solder internal components for smallest form factor.
4. Design a D20 case that houses internal components.
5. Prototype D20 cases to check for proper size and durability.

6. 3D print the final D20 case and integrate internal components.
7. Collect data to determine what orientation information corresponds to which side of the D20.
8. Test sending this data to the node.js server.

DM D20

1. Wire stepper motors to Arduino.
2. Test the stepper motors.
3. Test commands sent to Arduino via serial port for controlling the stepper motor positions.
4. Build and test first axis of rotation rig that is directly connected to D20.
5. Build and test second axis of rotation platform that supports the first axis rig.
6. Test sending actual data from player D20 to DM D20 and displaying the correct output.

REFERENCES

1. Charlie Hall. 2015. There's more than one way to play D&D with your friends online. (2015). http://www.polygon.com/2015/4/23/8482451/cheap-free-dungeons-and-dragons-online-tabletop-pen-and-paper.
2. Steve Hinske and Marc Langheinrich. 2009. W41K: Digitally Augmenting Traditional Game Environments. In *Proceedings of the 3rd International Conference on Tangible and Embedded Interaction (TEI '09)*. ACM, New York, NY, USA, 99–106. DOI: http://dx.doi.org/10.1145/1517664.1517691
3. Steve Hinske, Marc Langheinrich, and Yves Alter. 2008. Building RFID-Based Augmented Dice with Perfect Recognition Rates. In *Proceedings of the 2Nd International Conference on Fun and Games*. Springer-Verlag, Berlin, Heidelberg, 59–64. DOI: http://dx.doi.org/10.1007/978-3-540-88322-7_6
4. Ankita Jain and Vivek Kanhangad. 2015. Exploring orientation and accelerometer sensor data for personal authentication in smartphones using touchscreen gestures. *Pattern Recognition Letters* (2015), –. DOI: http://dx.doi.org/10.1016/j.patrec.2015.07.004
5. Chien-Cheng Lin, Deron Liang, Chin-Chun Chang, and Ching-Han Yang. 2012. A New Non-Intrusive Authentication Method Based on the Orientation Sensor for Smartphone Users. In *Software Security and Reliability (SERE), 2012 IEEE Sixth International Conference on*. 245–252. DOI: http://dx.doi.org/10.1109/SERE.2012.37
6. Carsten Magerkurth, Timo Engelke, and Carsten Röcker. 2006. The Smart Dice Cup: A Radio Controlled Sentient Interaction Device. In *Proceedings of the 5th International Conference on Entertainment Computing (ICEC'06)*. Springer-Verlag, Berlin, Heidelberg, 211–216. DOI: http://dx.doi.org/10.1007/11872320_25
7. Daisei Uhchikoshi, Takeshi Iwamoto, and Michito Matsumoto. 2014. Location Method for Smartphone Using Camera and Orientation Sensor. In *Proceedings of the 2014 International Workshop on Web Intelligence and Smart Sensing (IWWISS '14)*. ACM, New York, NY, USA, Article 21, 2 pages. DOI: http://dx.doi.org/10.1145/2637064.2637108