Senior Design Proposal

Desktop Pinball Machine

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11 November 2021

1 Introduction

Our project is motivated by a desire to create something that can improve the recreational lives of our fellow students at Notre Dame. The University provides students with countless resources for academic and professional development, but when it comes to recreational activities, students struggle to find options that can fit into their busy schedules. Our proposed desktop pinball machine would offer a communal source of offline entertainment for students, that can be used for either short or long periods of time, and could easily be moved between dorm rooms. Developing this machine will test our skills in electrical engineering, particularly circuit board design, programming, use of communication protocols, debugging, and the acquiring of appropriate parts. In addition, it will also test our skills in design, as we will have to construct the machine itself, fitting our electronics into an eye-catching cabinet that is still easily moveable from one dorm room to another.

2 Problem Description

Students are overwhelmed by stress from daily academic and extracurricular commitments. Their demanding schedules leave only small gaps of time throughout the day in between classes and meetings that often go to waste, and are too short to participate in longer recreational activities. With online platforms crowding university spaces, students long for a source of “unplugged” entertainment that can be shared with friends. Students need an offline means of recreation that can be used for short breaks of time, played either alone or with

friends, and can easily be placed in a college dorm room. It also should be fun and eye-catching to a college-aged audience.

3 Proposed Solution

We propose a pinball machine that can fit on a standard dorm room desktop. It will be broken down into the following functional block elements: (1) a main chassis with the pinballs inside and a “goal” hole for the ball to fall into, where a sensor will detect a point has been scored; (2) a reloading mechanism which will send a ball from the bottom of the machine into the playing area; (3) a display which will keep track of the current score, and may play messages to the user; (4) peripheral LED’s and speakers which will contribute to the recreational atmosphere; and (5) a microcontroller which will supervise the electronic elements of the machine and keep track of anything that requires memory.

The main body of the machine will be in a roughly rectangular shape, subject to choices about the artistic aspect of the design. The course for the balls however, will be rectangular in nature. Features will be raised from the surface to serve as obstacles for the balls, and a hole at the top of the course will be the goal for the ball to reach. Flippers attached to levers for the user will allow them to hit the ball. The hole will have a sensor that will signal the microcontroller when a “goal” is hit. This microcontroller will then save the score to memory, and update the score on the display (either a 7-segment or LCD display) via the appropriate communication protocol for that device. A reloading mechanism, located under the course, can send a new ball into the course for play.

Throughout play, the LED’s and speakers will provide a festive atmosphere for the user. Both peripherals will be controlled via the microcontroller; the speakers will require the presence of a DAC on the board. Audio clips will be stored in the microcontroller’s memory, and can be played on the speakers via the DAC. The LED’s can be controlled by the output pins of the microcontroller, and the specific timing and colors governed by software.

4 Demonstrated Features

We will demonstrate a fully functional pinball machine that can fit on a space the size of a standard Notre Dame dorm room desktop, and can be carried from one room to another by a college student.

Power

It will be powered by any wall outlet, or potentially a USB connector as well. The cord will be long enough to accommodate various dorm-room set-ups.

Score-Keeping

The machine will be able to track each ball that makes it through the “goal”, hits various obstacles, and travels through designated tracks. The incremented score will be displayed. At that point, the player can release a new ball into the playing field by pressing a button.

Entertainment/Atmosphere

LED’s will light up throughout play, and will have a specific pattern when a goal is scored. Speakers will also do the same. Particularly, we would like to include pre-recorded sounds of our own, such as quotes from famous ND EE professors, as part of the speaker output.

5 Available Technologies

Both hardware and software components will be utilized to construct our pinball machine. In order to bring our idea to life, the following technologies will be used:

- Power system/regulator: <$2
- 3D printer (Notre Dame Innovation Hub): $1/hour
- Sensors

        - Limit switches: $0.58/each
    - LEDs: $11.95/each
    - Speakers (piezo?): $1.95-$4/each
    - Buttons: $2.50/each
    - Display
        - LCD 16x2: $10.95/each
        - 7 Segment Display: $4.95/each
    - Sound responses: produced by us, no cost
    - Board - with microcontroller and communication interfaces

6 Engineering Content

The pinball machine will involve a combination of electrical hardware, software, and physical design. The main components of the electrical hardware will involve the development of a central board anchored by a microcontroller, and connections from said board to sensors, a display, and actuators. This board will be developed using the EAGLE PCB software, and will then need to be assembled and soldered. The power regulator and any external processing components, such as a DAC, clocking circuitry, and communication circuitry will be placed on this board as well. The LED's can be connected directly to the external pins of the microcontroller, and controlled via PWM signals, as we will either choose LED's in the appropriate voltage range, or use switching circuitry between the microcontroller and LED's. Audio can be sampled and stored on the microcontroller by means of an ADC, and then a DAC will allow output to speaker circuitry from the microcontroller. A sensor circuit for the "goal" will be constructed using a limit switch, or a similar pressure plate switch, which will signal back to the microcontroller via an interrupt. Finally, a spring-loaded device will be placed for reloading the ball into the active area, likely through the use of a relay or similar electro-mechanical switch.

The most challenging portion of the electrical hardware will be either the “goal” sensor, or the reloading mechanism. For the former, this is due to the difficulty of finding a sensor that is responsive and neither misses a ball nor reacts to something that is not a score. For the latter, this is due to the fact that many electro-mechanical devices tend to have high currents, and it may not be possible to power them through the current output of a microcontroller.

The software portion of our project features two major aspects: code for operating the microcontroller and tracking scores and actuator output, and managing sound files for the speakers. The code will be in the C language, and will be developed in MPLAB and programmed onto the board with a Pickit programmer. The most challenging aspect of this portion will be the sound files to use with the speakers, as we do not have familiarity with these files on a microcontroller. We will have to get them loaded into the controller’s memory, as well as make them available to send to the DAC for conversion into a waveform playable by the speakers. A possible solution to this may be the use of piezo speakers, which can operate with the PWM signals producible by microcontrollers.

The physical design portion of the project will involve the construction of the pinball machine casing, course, and flippers. The sloped interior will include obstacles, the ball launcher track, and a trough to collect the balls. The outer components mounted onto the cabinet itself will consist of buttons to start the game, launch the ball, and activate the flippers. Design features, colors, artwork, and backdrops will enhance the playing field and provide an immersive experience for the player. In order to design the mechanical parts, a 3D modeling software, such as Solid Works, will be used. If it is not possible to construct the entire casing via 3D printing, we may design the casing using wood and craft the structure together instead.

The most challenging portion of this section will be the construction of smaller parts inside of the casing, such as the obstacle course or flipper controls. As we

do not have the same experience with physical design as we do with electrical engineering, physical construction may prove challenging for us, especially in cases where precision is needed.

7 Conclusions

A dorm room desktop pinball machine will enhance the student experience at Notre Dame by filling unused time with offline entertainment. Through the integration of hardware and software, the tactile gaming experience would promote student well-being and communal recreation. Our project will demonstrate electrical engineering concepts through the integration of electrical hardware, software, and physical design components. Intentional design decisions will have to be made to ensure that the pinball machine is aesthetically pleasing, easy to use, and fits comfortably on any dorm room desktop. This project will challenge our abilities to integrate these components properly, and to work with technologies and designs that we have not experienced before.