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Final Project Report: Project Firestone

**Abstract**

The goal of this paper is to outline the planning, development, and implementation of the Project Firestone artificial rock wall solution. The Project Firestone solution uses light up, touch sensitive rock climbing holds controlled through a mobile application to provide a more dynamic and interactive artificial rock wall experience. This results in the ability to expand artificial rock walls from poor imitations of traditional rock climbing to unique experiences in their own right.

**Executive Summary**

The Project Firestone project was conceptualized about a year ago while several of my rock-climbing friends and I lamented the unnecessary troubles and wasted potential of artificial rock walls. We found the system of placing tape to designate a route unnecessary burdensome, unintuitive, and difficult to use. We also realized that allowing the holds to react to a user’s touch would allow for new and compelling ways of interacting with the artificial rock wall.

After its ideation, the concept remained a pipe dream until the opportunity presented itself to develop the project through a senior design project and be partially funded by a company named Plexus. After deciding upon this project, we initially researched the technology and parts necessary to accomplish our original goal as well as what other patents and competition existed. After developing our initial design, we ordered the necessary parts and began construction.

We ran into a few initial design problems, but have since fixed them. We are now at the stage where we can interact with a hold wirelessly, change its color at will, notice when the hold is grabbed, and set-up walls, routes, and interesting games with the application. We still need to improve the reliability of our radio transmission and fully integrate and react to touches. Beyond these steps, we can focus on abstracting our set-up process for the user, minimizing our design’s space and power requirements, and market research, and actually starting a business.

**The Plan**

Our ideal goal for our project was to have rock climbing holds that could be controlled wirelessly via a mobile application, would light up an RGB LED according to an input color, and which could sense touches and have a relative idea on the stress being placed on a given hold. However, we realized the loftiness of these goals and our lack of knowledge surrounding wireless technology. Therefore, we set realistic goals for ourselves. We wanted to be prepared to communicate over UART with holds and get LEDs to respond to our commands through the mobile application.

Due to our layout of our microcontroller being the mirror of the actual pin layout we had to re-mill our circuit boards. Finding out that this was the problem and getting new circuit boards set us back a few weeks. We attempted to parallelize and work on code while waiting for our second round of circuit boards, however, we ended up prototyping software with a tool that was incompatible with our boards due to hardware differences. This meant that several weeks of our already limited schedule was wasted.

After we got our new boards, we had some initial problems getting our boards set up, but otherwise things went relatively smoothly. However, at this point we did not have enough time to make our wireless communication reliable, improve the accuracy of the algorithmic filter of our piezoelectric sensor, and get precise timing on the wall. This means that we fell short of our lofty goal, however, we realized the difficulty of our project and expected such difficulties. Therefore, I can positively say that we are all proud of the efforts we have made and would not have sacrificed our wide scope for the sake of feasibility. We pushed ourselves to accomplish something extraordinary and succeeded in accomplishing something merely remarkable.

Beyond our hiccups within the project, our timelines and cost analyses were relatively correct. Our initial analyses had our wireless communication function fairly early in the project, but our corrections for this lofty ideal early in the project and our corrections after our initial bugs set the wireless communication completion around the time that we completed it. We realized that we had a tight schedule and many of our features were set to be completed around the time the project was due. This ended up being accurate.

Our cost analysis might have been a bit inaccurate as to what expenses the money would go towards, but we budgeted some wiggle room and our total expenses for our first batch of production were roughly correct. However, we needed to create to different designs by the end of our project, so our final budget was roughly 1.85 times our original budget which is consistent with the idea that we had two different builds of our project (the initial parts for the first board were for the most part unused as we ended up going with larger and more easily placed components for the beta build).

**The Result**

We created a solution that allowed us, despite some packet loss, to control the holds with a mobile application, to control the holds individually, to create and display routes, and to play games based upon the touch sensing features of the holds. The packet loss decreased the reliability and, in a significant sense, the functionality of our design. We feel that with a minimal amount of additional time we could polish our project into something that exceeded our initial expectations, but, unfortunately, we were limited by our inexperience and bugs in our design prevented us from reaching the projects full potential.

**Appendix: What We Learned**

Through this project, we learned about several distinct aspects of the design process. Through coming up with the design, we learned about drawing initial concepts and creating an outline of a project plan. Through initial research, we learned about the current state of artificial rock walls and existing technologies such as sensors, LEDs, and microcontrollers. Through initial prototyping, we learned about common problems prototyping, the overall prototyping process, the molding process, and circuit design and layout. Through my initial business plan research, we learned about patents, how to research patents, patent law, the core tenants of planning and starting a business, and about several resources available to me. Through recording my progress, we learned to be estimate the time taken for activities, the likelihood of encountering issues, how to accurately represent the state of a design, and the importance of documenting a project. We also added to my knowledge of specific technologies such as radios and microcontrollers as well as learning new programming concepts and algorithms.

During the course of this project, we have researched technology, designed a circuit, assembled the circuit, molded holds, developed a computer vision algorithm, developed a fully-functional artificial climbing wall management application, achieved wireless transmission, developed a multi-layer networking protocol that sends information from an application to a server, to a transmitter, and to a hold.