Self-Correcting Ping Pong Launching Robot (PPLR)

A Dive into Microcontrollers: A Dark Horse Technology

A Thesis Prospectus Submitted to the

Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree

Bachelor of Science, School of Engineering

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December 14, 2022

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Since the inception of the first computer, the Turing machine in 1936, there has been an unfathomable development in computers. Today, we live in a world where our phones have the comparable processing power to a stationary PC. Such growth can be attributed to a huge focus both in the semiconductor industry and improvements in software design. Now, digital computers and their counterparts have entirely replaced archaic analog and mechanical systems. When we think of computers, most people immediately think of their laptops or PCs, but a computer is any sized CPU with counterparts like memory and various IO (input/output) devices.

A microcontroller is a powerful but smaller version of a computer on a single integrated circuit chip. The development of the microcontroller and its uses has affected a lot of implementations of engineering systems. The microcontroller is present in almost everything humans own today. Whether it be key fobs, televisions, or even ATMs, the microcontroller is highly applicable in a consumer's daily life. Because of its importance, the social impact of its technology is necessary to explore.

In my STS project, I will investigate the history and timeline of microcontrollers and how their increased role in technology directly affects society. These questions are critical to understanding how a specific technology can gain traction in industry and also have a profound impact on society and human culture. My STS project is connected in tandem with my proposed technical project which is a self-targeting and self-correcting ping-pong launching robot. The microcontroller in the technical project acts as the central nervous system of the robot allowing it to deterministically change its behavior in real-time. A big reason for my focus on microcontrollers in my STS project is in part due to the significance of a microcontroller in my technical project. The structure of the rest of this prospectus will discuss in detail my technical

and STS projects and how they are connected as well as plans of action when researching and implementing both projects.

Technical Project

Ping Pong Launching Robot System

The Ping Pong Launching Robot (PPLR) is a user-controlled and self-correcting robot that explores a targeting system in the form of a recreational device. The goal is to create a robot capable of launching ping-pong balls into a grid of boxes with greater accuracy than a human player. The objective of this project is to holistically design a user-controlled targeting system with a deterministic feedback loop that allows the robot to make corrections and be as accurate as possible.

On user input, the robot will redirect and aim using a pan/tilt mount with servo motors. The mount will have a custom track on it for the ball to rest. After aiming at a cup, a solenoid push launcher will shoot a ball at the targeted location. Aiming and shooting will require vigorous testing as well as several changes to code parameters to ensure high accuracy. If a ball lands within a cup, image processing of the cups will communicate with the system that the robot has ‘scored.’ The figure on the next page is an overall system diagram that encompasses what the robot will look alike open completion of the prototype.

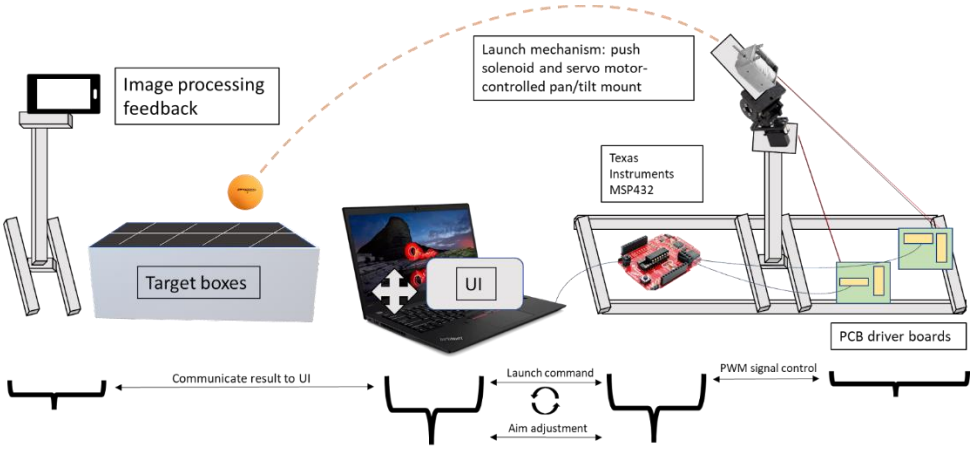

Figure 1. System Level Design

The MSP432 Microcontroller will dictate the movement of the pan/tilt mount by incrementally moving the servo motors. The plan is to have each grid have a preset servo condition based on probability and repeatable launches. When the user selects the grid, the information will be sent to the microcontroller and the servos will move accordingly in real time.

The launching mechanism will be centered around a pushing solenoid that will deliver a "kick" upon command. In deciding to use a solenoid as opposed to other choices such as a flywheel or compressed air, it was observed in an experiment with soccer ball kicking robots by that with limited space for the firing mechanism, an "electromagnetic launcher" was a good choice for this application (Gies, et al., 2020). This was the case for us given our launching design had to be housed on top of a pan/tilt mount. Another reason for using the solenoid was because of its reliability and consistency. Based on a another paper written, it detailed the use of a solenoid coil to launch a steel ball reliably (Yamada et al., 1997). The McMaster-Carr linear solenoid will act as the launching mechanism and can be connected to a 12V power supply and a circuit containing a resistor, transistor, and diode. The purpose of the diode is to keep the reverse current from going back into the microcontroller after the solenoid pushes initially and is

returning. The transistor will serve to switch to the external power supply and deliver the kick when commanded to from the microcontroller.

With both the push solenoid and the servo motors being run by the microcontrollers, there will be a requirement to house a custom PC header board onto the microcontroller. This will allow the servo and solenoid to be driven with the intended specifications and to add surge protection within the system. Alongside the requisite hardware design of the project, there are software requirements that come with it.

The software portion of the project has two distinct components - communicating using the UART transmission protocol. The embedded programming on the MSP432 controls the I/O devices (motors, servos, and is connected to the UI) – effectively controlling all the mechanical components of the robot. The microcontroller is responsible for receiving instructions from the computer, sending commands to I/O devices, and transmitting received data back to the computer for user feedback and analysis. The software on the computer will serve as the front-end interface for a user to control the robot and receive feedback on whether the robot has properly launched the ball in the desired grid.

Given a successfully built prototype of the technical project, it will specifically highlight how powerful a microcontroller can be, and how malleable it is. Alongside these objectives, a successful project will also indicate a real-time deterministic response with our robot proving the complexity of the microcontroller as well.

STS Project

How and why does the development of the microcontroller affect society? How does its continual advancement continue to change its legacy?

My research question discusses the development of the microcontroller and how its timeline has impacted society. To support the claim of social impact, I will examine the inception of the microcontroller and how its technology improved over time. Revealing its development is critical in showing the audience its importance. The overarching research question is how and why the development of the microcontroller affects society and how its continual advancement continues to change its legacy. These small computers are embedded in almost any digital system that humans can think of. Not only are they powerful but they are adaptable to any situation. Part of formulating this kind of research question is also to bring light to a technology that is not well-known by the average consumer. This way, my findings can educate individuals while simultaneously revealing their impact and importance.

When discussing relevant social groups concerning my project, there are two identifiable groups. The first group is the engineer. The microcontroller was developed as the brainchild of impactful engineers. Part of my STS project must appeal to an engineer and specifically discuss the technology and use of a microcontroller. To understand the social impact of a certain technology you must first explain how and why it is impactful in its own industry. In this case, the engineer fits this demographic perfectly. The second identifiable group is the consumer. In parallel to the engineer, the microcontroller has an impact on the daily lives of individuals. My STS project must specifically discuss how the microcontroller technology affects the consumers' daily lives and also how it affects the entirety of society. These two social groups work in tandem and must both be appealed to when answering my research question. Ideally, these two

social groups are the only necessary social groups for discussion. Identifying these groups is critical in developing a sound argument to answer my research question. By defining these groups, it is understood which voices need to be addressed and how to leverage one group over another. Overall, I will use both the engineer and the consumer to develop a clear argument.

To bolster the argument and to properly answer my research question, I will implore various STS methods and frameworks. These methods and frameworks will be used as a benchmark in creating a strong argument. Specifically, the first pair of methods will be history and philosophy. These specific methods are used together so that you can better understand the STS implications by procuring, reading, and synthesizing previous literature. Part of my research question is to investigate the timeline of microcontrollers, which requires obtaining older literature like scientific journals and research papers and extrapolating information from them. Along with this, using public policy we can also explore the different views humans have on microcontrollers. Public policy as a framework is to show the regulation and guidelines a technology has in society. Part of my research question is revealing social impact and also showing to the reader the inherent purpose of the technology. Using public policy directly answers that portion of my research question. Another potential framework is ethnography. Talking and interviewing certain people help reveal certain viewpoints that can support my argument. I plan to interview various faculty in the ECE department like Professor Mircea Stan or Todd Delong who have industry experience doing Embedded Systems and FPGA Design. These interviews can be critical in developing my argument.

To attack my STS project in a structured way, research acquisition is necessary. There will be research done in two avenues: one being the history and development of microcontrollers, and the other being social impact. Social impact may require research that is

more outside the box but still effective in answering my research question. Once research acquisition is done, the requisite timeline will follow an outline phase and then an implementation phase. This structure for the STS project will help create a regimented schedule and ultimately a complete project.

Key Texts

Since research is critical for the STS project there must be primary documents that help provide evidence for claims made in my argument. As so, the following four sources are provided that can and will be used in my paper to bolster my claims.

The first piece of literature will be a journal entry from the IEEE Micro. The piece is titled “History of Microcontrollers: First 50 Years”. As direct as a title can be, this particular journal entry discusses the impact of microcontrollers through its history between company allocations and changes in integrated circuit design. Directly, this passage is a key text in exploring the timeline and history of microcontrollers which will be prevalent in my STS project (Raghunathan, 2021).

The second piece of literature is a Conference Paper called “Introduction to Microcontrollers”. This particular piece will be referenced when explaining the ins and outs of microcontrollers and how they are designed. In order to captivate the audience and make it clear I must introduce such devices in order to reveal their impact and also their importance. This text will be key in providing introductory information but also informing the reader in a direct and formal way (Bannatyne & Viot, 1997).

The third piece of text is another conference paper titled “The design and implementation of a vending machine based on a state machine, FPGA, and microcontroller”. One of the biggest

parts of my research question is that microcontrollers can be embedded into systems that we use/see in our everyday lives. Part of this text is to show how there are actual experiments and designs that are using microcontrollers for daily use. In this case, the paper discusses how we can use a microcontroller to build a vending machine. Something as palpable as a vending machine will attract the audience and once again support my claims (Guo & Liu, 2021).

The last key text that will be used is a World Congress Paper that talks about the benchmarks to find the most optimal microcontroller architecture. The paper is an in-depth discussion of how to use varying microcontroller architectures in different scenarios. Part of choosing this piece of literature was that it can be used to show the malleability and scalability of a microcontroller. Using this evidence, I can discuss how scalability in industry is important and thus conclude the importance of microcontrollers (Kramer et al., 2009).

Overall, these key texts, along with a selection of other pieces, will work in tandem to help support the claim and also develop the topic and capture the audience within the STS project.

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