**Robotic Foosball Opponent**
(Technical Paper)

**The Technological Momentum of Robots**
(STS Paper)

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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

For better or worse, robots are changing the world. Since the first appearance of the word "robot" in *Rossum's Universal Robots* (originally Rossumovi Univerzální Roboti) by Karel Čapek (Flatow, 2011), robotic technology has pervaded many facets of life, from industrial labor to performing household chores. As we imagine the future and the shape of society in it, robots are often an integral part of it, as in *The Jetsons* (Hanna et. al, 1962), where Rosie the robot maid essentially runs the house, cooking, cleaning, and watching over the children. As robots have become more and more advanced, there have been growing concerns about robots replacing humans in their jobs, leaving many without livelihoods. This concern primarily focuses on robots in industrial and company settings, but there has also recently been a rise in robots targeted at consumers. Many of the uses of these robots, current and envisioned, have changed, or will change, the way society operates and the daily rhythms of life, but do the time and money put into the development match the gravity of the issues that they address? The proposed research paper will analyze this question and more specifically, how have developments in robotic technology historically impacted the socioeconomically marginalized and how might they solve true societal issues rather than those of comfort and convenience?

The proposed technical project will address a portion of this question through the development of a robotic system to play against a human on a miniature foosball table. Though arguably not a major societal issue, this project offers the team an insight into the production of robotic systems. This project must be done on a constrained budget in a short timeframe, and thus provides an example of how robotic technology could be made more accessible with lower cost development.

**Technical Topic**

One of the largest barriers impeding the accessibility of robotic technology is the high cost that both its development and production carry due to the components that comprise the systems and the expertise required to develop the product. This capstone project aims to address that gap by creating a robotic entertainment device that can be made available to a much broader socioeconomic demographic. The proposed project is to construct a low-cost, low-footprint robotic foosball table which will control two player rods against which a human player can compete. This idea is not an entirely novel concept, and there have been other similar systems developed in the past. Representative examples include robots from École Polytechnique Fédérale de Lausanne (EPFL) (École Polytechnique Fédérale de Lausanne, 2013), in Switzerland, Brigham Young University (BYU) (Hollingshead, 2016), Indiana University (Bambach & Lee, n.d.), and Western Sydney University (*Why We Built a Neuromorphic Robot to Play Foosball*, 2022). The primary differences between this project's proposed system and the aforementioned projects are that this incarnation is significantly constrained in size, time, and budget and that this project is much less focused on developing optimal autonomous algorithms to play foosball, though that will be explored to some extent, and much more interested in developing the product from scratch with cheaper parts. In this way, the process of creating the proposed foosball table will serve as a simulated case study of developing accessible robotic solutions.

*Figure 1: Base Foosball Table (*Amazon.Com : WIN.MAX Mini Foosball Table, *n.d.)*

The approach to achieve a system capable of this level of play is separated into three main steps: detecting the ball's position and velocity, determining where players should be to block or hit the ball, and moving the players accordingly. The system will be built on top of a commercial miniature foosball table that the team will purchase as shown in Figure 1. The ball will be detected with a camera connected to a small computer known as a Raspberry Pi (Raspberry Pi, n.d.) which will then process the images to determine the ball's exact location, speed, and direction on the foosball table. It will then send commands detailing the position the foosball player rods need to be in to block or take a shot to an MSP432 microcontroller (Texas Instruments, n.d.). This microcontroller will then control the motor assembly that moves the player rods back and forth linearly and rotationally through driver circuitry. A full diagram of the system is seen in Figure 2.

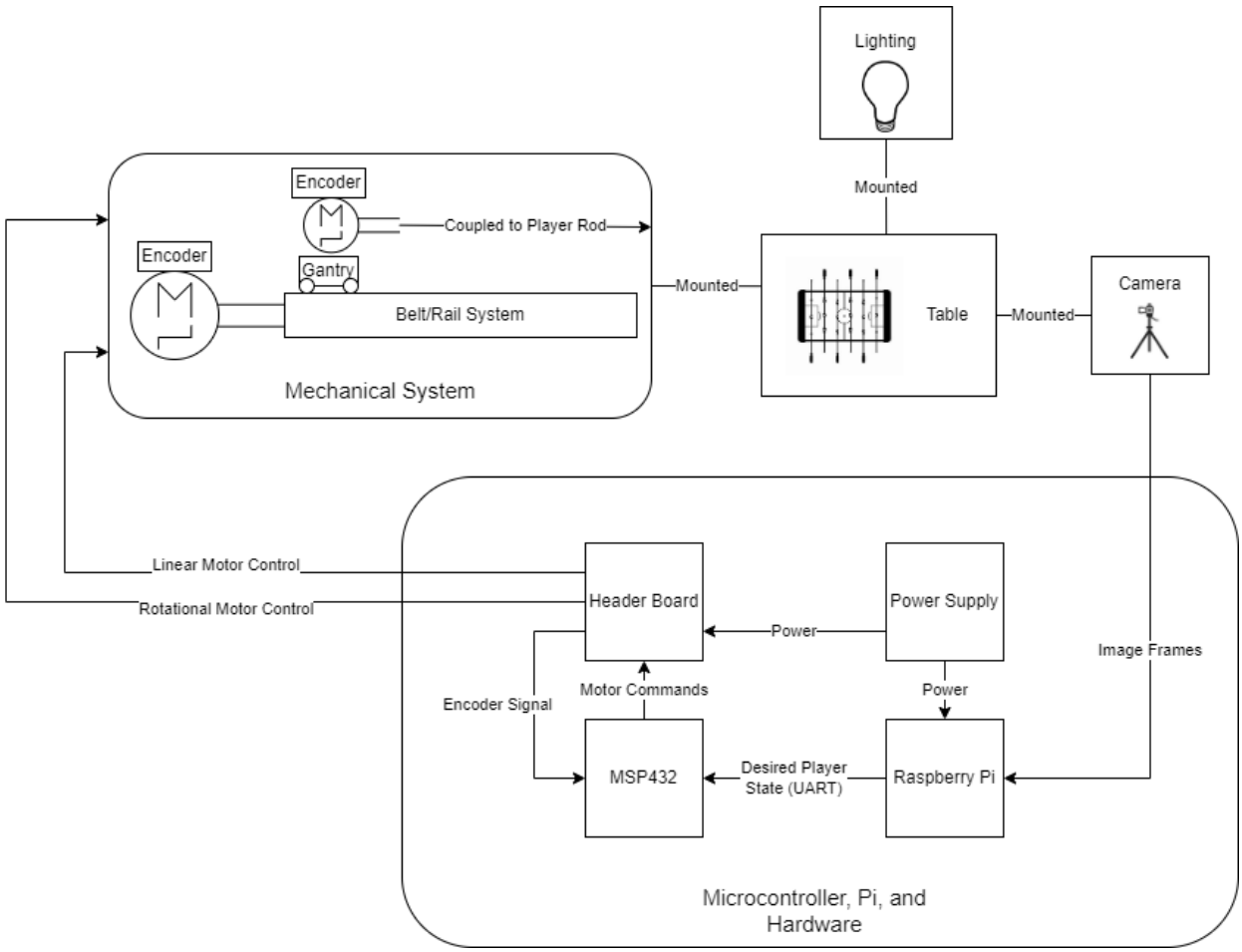


*Figure 2: Proposed Robotic Foosball Table System Diagram (Burke et al., 2022)*

In its end state, the robot will be able to perform as well if not better than the average human player, blocking shots made by its human opponent and taking shots on its opponent's goal. This metric was quantified by analyzing a game of foosball played on a miniature foosball table and categorizing 100 different shots made by the users to determine the speed and accuracy that the average human could achieve and react. Once the physical device is completed, a report will be created documenting the process and measuring its final performance.

**STS Topic**

Robot vacuums, colloquially known as Roombas, have found their way into 40 million homes worldwide as of 2021, only counting those sold by the original company, iRobot (iRobot,

n.d.). Some of these devices sell for up to $1000 (iRobot, n.d.), begging the question, who can actually access the technological solution they provide? The high cost associated with creating these technologies means that the primary developers are the wealthy, and the subsequent high price when the technologies reach the market means that the wealthy are also the primary consumers. Furthermore, do technological advancements such as this meet needs that have a significant impact on the average person, or does it just make life a little bit easier for the upper class? These examples mainly focus on the field of consumer robotics. There are many more areas that robots operate in that this paper will analyze. Through the many facets of life that robotic technology has begun to impact, this paper will answer the question: how have developments in robotic technology historically impacted the socioeconomically marginalized and how might they solve true societal issues rather than those of comfort and convenience?

To answer this question, this paper will follow the framework of technological momentum posed by technology historian Thomas P. Hughes. This theory posits that the influence that technology has on society is time dependent: early in the life of a new technology, it is much more susceptible to the influences of society and culture, but as it matures and becomes more established, the technology becomes increasingly independent and has its own influence on society. Technological momentum is intricately linked with those of the social construction of technology (SCOT) and technological determinism. SCOT claims that technology is a product of the society it is created in and given its shape by the social constructs in place (Klein & Kleinman, 2002). In contrast, technological determinism argues that technology and its changes are some of if not the greatest influences on societies (Smith, 1994). In Hughes' words, "The social constructivists have a key to understanding the behavior of young systems; technical determinists come into their own with the mature ones. Technological

momentum, however, provides a more flexible mode of interpretation and one that is in accord with the history of large systems" (1994, p. 112). Critics of the framework claim that it should not be considered its own framework as it amalgamates SCOT and technological determinism, or that it is simply a reframing of technological determinism (Colarossi, n.d.). While it certainly incorporates the main aspects of both, the main helpful contribution is the linkage of the frameworks with a time dependent relationship and demonstrating how the deterministic nature of a technology can develop through its lifetime. Robots are a relatively new technology in the grand scheme of the world, but the social constructs surrounding their creation and development have greatly influenced their development. This paper hopes to trace the trajectory of the momentum the technology has gained to see the current ways that it shapes society and how that momentum may need to be redirected to serve different needs than they were originally constructed to meet.

**Methodologies**

*Research Question: How have developments in robotic technology historically impacted the socioeconomically marginalized and how might they solve true societal issues rather than those of comfort and convenience?*

To answer this question, this paper will utilize Literature Review and Discourse Analysis methodologies to explore the chronological development of robotic technology up to the present and its imagined future. First, this paper will explore the inception of robots and their introduction into society, especially how the needs of the society in which they were born shaped their development. Literature review involves gathering secondary sources related to a topic, summarizing them, and synthesizing them (Labaree, n.d.). Utilizing this methodology, this paper will analyze the early examples of robots in society and the problems that they were constructed

to solve. Subsequently, this paper will trace the development of robotics, the influences on it, and the impacts it had on the surrounding society of the time up to the present. Finally, utilizing discourse analysis, this paper will provide a glimpse at the imagined future of robotics based on the current public sentiment towards robots and their uses, drawing from sources similar to those in the literature review, but also some more non-traditional sources that will be able to more broadly represent the general population. This will support the answer to the research question by creating a timeline for the development of the technological momentum accrued by robotic technology, how it was influenced by the society of its time, and how it influenced or changed the society around it.

**Conclusion**

Robots have the potential to be an invaluable asset to society. This paper will explore the social constructs that have influenced their development, the ways that they have impacted society positively and negatively since their introduction, and the potential futures that the technologies could bring about. Furthermore, this paper will offer commentary on the current uses of robots and propose alternatives. This analysis will be performed through the framework of technological momentum utilizing literature review and discourse analysis to synthesize sources. As a technical deliverable, the team will create a robotic foosball table opponent that can match, if not far surpass the abilities of the average human. This will provide insight into how robots can be used to improve life through entertainment and be made more accessible through low-cost development.

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