Robot Foosball

For the Mazilu Engineering Research Fellowship, I am proposing the creation of a robotic foosball table. Foosball is a tabletop game that involves two to four players attempting to hit a ball into each their opponent’s goal. Each team has 4 sets of players, goalies, defenders, midfielders, and strikers, that are connected by a rod, and can be moved side to side or rotated. Because of the relative simplicity of the players’ motion, this is a task that can be easily performed by a robot using linear and rotational actuators. The movement of the players, however, is only one small part of the game. Additionally, the ball’s position can be tracked using a camera that watches the field and locates the ball on the table. The complexity of foosball arises mostly from the fact that the ball moves quickly and unpredictably. Not only can the ball cross the full length of the table in under a second, but due to all the players on the field, and the ball’s interactions with the walls, it is very hard to know where the ball is going to be. In addition, there is lots of strategy involved in the game. From faking your opponent out, passing between your own team, and complex shots like angle shots and bank shots, there are nearly infinite amounts of complexity that arise from this theoretically simple game.

This project is worth pursuing because it is an ideal platform to apply techniques developed in a wide variety of research fields. For example, to track the ball’s movement accurately and have enough time to move players into position, the system needs to be able to quickly convert the data it receives from the camera into a position while dealing with obstructions caused by the players and people leaning over the table. This has led to efforts such as those by Gregory Cohen and colleagues, who mimicked techniques used by the human brain to detect changes in the state of the table to significantly reduce the amount of information being fed to the system, thus allowing for much faster processing of the ball’s position (). Outside of computer vision and image processing, there is significant potential for the application of machine learning (ML) to the system. From the dynamics of the ball on the table and trajectory prediction to the development of artificial intelligence for movement and strategy, there is much potential for application of existing ML techniques in a new environment. Additionally, this platform will aid in the development of new approaches in ML, as there are novel challenges that foosball presents through combining interaction with the physical environment and strategy. Finally, since this is a physical system with high demands for speed and precision, there will be significant emphasis on controls, applying techniques from multiple different domains including non-linear controls and state estimation, optimal control, and adaptive control.

This project is not without precedent, with teams from Brigham Young University and the École Polytechnique Fédérale de Lausanne creating their own robotic foosball tables. There were differences, however, in the design and construction of their systems that allowed them to focus on different aspects of the game. For example, the team from BYU placed the camera above the table, which introduces obstructions and other factors that meant that they had to place greater emphasis on computer vision and state estimation (). The EPFL team, on the other hand, focused on the design of their actuators so that the system could move quicker and be more precise (). From these two examples, one can see that this project offers many different avenues for exploration.

Outside of its potential as a tool for research, it also can be used to support multiple different Thayer classes. For example, ENGS 147 Mechatronics is an ideal candidate for the use of this project. The class is focused on the fusion of electronics with mechanical systems in applications such as robotics. Professor Ray, the teacher of that class, proposed that this system would be an excellent option to explore the software side of robotics and mechatronics, and could be offered up as an option to students to explore during the class. Additionally, ENGS 108 Applied Machine Learning would be a great opportunity to allow students to apply the techniques they develop in class to a physical system and could act as a competition for students in the class to develop predictive models, and artificial intelligence to control the system. Finally, because this project is built to be played with, it has the potential to inspire future engineers. By interacting with the project, children, undergraduates, and adults will see the potential that engineering has to solve complicated problems and be applied to many different domains.

My work on the project will initially involve the creation of the physical hardware. I will design the mechanisms for actuation, as well as supports for the camera, and any other changes to the table that are needed. Then, I will shift my focus to the electronics, integrating the vision, and actuation systems together so that they can be controlled in one place. Finally, I will spend the rest of my time working on the software. This will involve designing controllers for the motors, image processing, trajectory prediction, and strategy development. My advisor, Professor Ray, will assist me by providing her years of expertise in the design and implementation of robotic systems. I will inevitably run into issues or have questions that she will be able to answer. Additionally, she will share potential research areas to investigate further as she knows the space much better than I.

Finally, I would like to thank Saguaro Technology and Jamie Mazilu Brown for establishing this research fellowship. This fellowship presents the opportunity to dive deep into an engineering research project. The skills I develop during this project, from research and investigation of literature to hardware and software design, will aid me as I pursue graduate school and a career in engineering research.