

Romulus: Automatic-Aiming Robotic Airsoft System

The Intersection of Automation and Competition

A Thesis Prospectus

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By

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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

Airsoft has been and continues to be a favorite past-time of many all around the world. A brief history of airsoft is recounted by Abbey Supply, an airsoft manufacturer. Developed in the 1970s in Japan in response to strict firearm regulations, airsoft guns are non-lethal guns that shoot small plastic pellets (Abbey Supply, 2023a). They are modeled to be as close to real guns as possible. As the world adopted airsoft guns, the primary focus shifted from military simulation to recreational sport. The recreational sport of airsoft is not centralized, leading to many different types of game modes from capture the flag to 1-on-1 duels (Duthie, 2023). These games have a common denominator of pitting two groups against each other with a clashing objective, forcing conflict.

Airsoft is a growing industry worldwide with a market size of 1.9 billion USD in 2022 and has a predicted annual growth of 7.8% until 2030 (Grand View Research, 2023). While there is no published data for the number of people that play airsoft, an estimate of 4 to 6 million active airsoft players can be calculated using the above market size and an estimated price to play of \$300 to \$500 (Abbey Supply, 2023b).

With the projected growth of airsoft, there is a chance to introduce it to more demographics. One of the primary groups that should be targeted is veterans as airsoft has been shown to help with PTSD (WFMY, 2016). However, 5.3 million veterans (30% of the veteran population) have a disability (Bureau of Labor Statistics, 2024). Beyond veterans, there are 1 billion people in the world who experience some form of disability (McClain-Nhlapo, 2023). Given that aiming an airsoft gun requires both fine-motor control and keen eyesight, this could create a barrier to entry for people with disabilities to engage with airsoft.

There is no product with aim assistance that is currently on the market. However, the airsoft community is full of hobbyists who try to innovate. For example, Excessive Overkill published a YouTube video showing a prototype of an aim-assisted airsoft gun (Excessive Overkill, 2024). It used an infrared camera to target highly reflective surfaces and used two industrial servos to adjust the barrel of the custom gun. This solution functioned well but has a limited targeting system, is not compatible with other airsoft guns, and has expensive parts that would create a financial barrier to entry.

My capstone group has created an automatic-aiming robotic airsoft system called Romulus. This system will allow people with disabilities, and without disabilities, to always hit their targets. Automation within competition will be explored through the lens of airsoft and other competitions and, using Star's framework of infrastructure, will show that Romulus breaks the foundation of meaningful competition and should not be adopted outside of accessibility (Star, 1999).

Technical Breakdown

A system named Romulus has been designed for the automatic aiming of any airsoft gun with military-standard picatinny rails (U.S. Army ARDEC Standardization Office, 1995). This system, pictured in Figure 1, consists of three main sections: the frame, the robot arm, and the imaging system.



Figure 1. Rendered Romulus automatic aiming system.

Every component that is white in Figure 1 is a part of the frame. It connects the airsoft gun to the robot arm and provides a place for the user to hold the whole system comfortably. This frame is modeled after the P90 firearm which is said to have an ergonomic grip (Matthews, 2024). The system uses a secondary trigger as part of the handle, making sure the user isn't holding the airsoft gun as it's pivoted. This is an important safety consideration as the user fighting the airsoft gun when it's moving poses a potential threat to their safety.

Linear actuators are rods that extend or retract depending on the voltage input. Three linear actuators are attached to base and aiming platforms to create a 3-RPS parallel manipulator (Nayak et al., 2018). These actuators are the grey square rods that attach to the rear of the airsoft gun seen in Figure 1. The 3-RPS parallel manipulator is a well-documented and studied robotic

configuration that controls the angle of the aiming platform which is how Romulus physically aims the airsoft gun.

The imaging system uses a light-weight computer connected to a camera positioned above the attached airsoft gun. This computer is battery powered, allowing the system to be handheld and mobile. This computer takes video input and runs an image recognition model to find targets. Archery targets were chosen for safety and the ability to give an accuracy metric during testing. When a target is recognized, the computer controls the robot to properly aim the gun at the target.

When the system is fully realized, it will allow anyone to aim an airsoft gun with high accuracy. This lowers the barrier to entry in airsoft by making aiming near-trivial. With Romulus, more people will be able to engage and enjoy airsoft, improving accessibility to people with physical disabilities.

Societal Discussion

There are two primary social dimensions to address with this project. First, as airsoft guns are modeled after real guns, this system has the potential to cause harm if equipped with a real firearm using the picatinny rail system. This system may incite panic if it fell into the wrong hands. However, the design of this system was chosen to not support real guns. This primarily has to do with recoil a real gun has, with an example of a peak force of 1.6 – 2.2 kN as measured in sport shotguns (Hall, 2008). The 3-RPS robotic system would break due to the recoil, providing a built-in safeguard to limit the harm the system can create after one shot is fired.

The second social dimension is how Romulus has the potential to disrupt the status quo of airsoft. While it is not explicitly outlawed in the rulebook, Romulus would likely not be

allowed when an equipment check is performed by an airsoft referee (Airsoft Revolution 15, n.d.). If this system is allowed in competition and sees widespread adoption, it would change the core of airsoft competitions by making aiming trivial. To understand these effects, it is first important to establish what makes competition enjoyable.

According to Franken and Brown, who conducted a factor analysis on 27 different studies, competition has 3 motivators: it satiates the need to win, it provides an opportunity to improve, and it encourages a high-level of effort to reach high-level performance (Franken & Brown, 1995). Shields and Bredemeier, who are experts within sports psychology, claim that competition needs to be implemented in a way that fosters the well-being of athletes, positive outcomes, and a challenging stimulus to overcome (Shields & Bredemeier, 2009). If these are not met, then it fosters aggressive behavior and becomes detrimental to society.

With the motivators and precursors necessary for good competition established, Star's framework of infrastructure will be used to analyze rules and automation as the infrastructure for competition (Star, 1999). Star defines infrastructure as something that is always relational such as doors being a part of a building. Star then claims that infrastructure is built and holds inherent social value, citing the example of, "For the person in a wheelchair, the stairs and doorjamb in front of a building are not seamless subtenders of use, but barriers" (Star, 1999, p. 380). Star then defines characteristics of infrastructure, including links with conventions of practice, built on an installed base, and fixed in modular increments. Links with convention relates the adoption of new infrastructure to previously established norms, the example given being the QWERTY keyboard. Built on an installed base is defined as infrastructure does not change independently of its previous creation, it inherits and wrestles with the previous installed base. Fixed in modular increments is defined as infrastructure does not change in one fell swoop, it changes in small

increments over time. This framework of how society affects the adoption of changes to infrastructure will be used to analyze how automation would affect the infrastructure of competitions.

In 2023, Kevin Kouchoukos interviewed a baseball player and fan to discuss the addition of a pitch clock (Kouchoukos, 2024). Both interviewees supported the change and said that it was implemented due to how long baseball games were taking. In 1973, baseball also saw the addition of the designated hitter, allowing the pitcher to play without needing to hit (Referee, 2021). Both examples show how the rules changed in modular increments over time, embodying infrastructure. A literature review of rule modification in sports shows that accepted rule changes respect the basic rules of the game and consult players which was done with both above baseball rule changes (Arias et al., 2011).

On the contrary, Romulus would not be adopted into airsoft because implementing it would break the modular incremental change of infrastructure, changing the system drastically. Romulus would get rid of a lot of the challenge within airsoft by lowering the skill ceiling through automation, breaking the challenging stimulus required for healthy competition established earlier. Romulus also breaks the model of infrastructure by violating the current conventions of practice. Airsoft guns are designed to replicate real combat which does not include the Romulus system. This means there is a disconnect between Romulus' design and the conventions of practice, leading to a likely rejection from the airsoft community.

Even though Romulus would likely not be adopted, there are other applications of automation that have been adopted within sports. According to Dr. Brittany Jacobs at American Public University, automation through case studies in smart technology like biometric monitors has allowed athletes to push their potential even farther (Jacobs, 2024). Automation in this sense

fits into infrastructure as it is built upon the installed base of training programs. By improving practice, automation has allowed for athletes to reach higher performance without changing the sport itself, maintaining healthy competition.

Research Question

How should automation interact and embed itself within competition? Answering this question will give an understanding of how automation may affect different aspects of competition. With these predictions, rules can be made to pre-emptively keep competition healthy and engaging. This topic will be analyzed through understanding the sports' psychology of why people compete and through Star's framework of infrastructure (Star, 1999).

Interviews with professionals or semi-professionals within airsoft, baseball, Valorant, and Super Smash Bros. will be conducted. Valorant and Super Smash Bros. are video games that have a global competitive community. Multiple different competitions need to be investigated to help generalize the findings to competition as a whole.

For airsoft, an interviewee will be found by visiting an airsoft field and consulting with the workers. The interview will be conducted at the field or virtually after the game. Baseball season starts in April so the interview will be conducted by reaching out to the Salem Red Sox for a contact. For Super Smash Bros., there are open in-person competitions around the country that will have professionals at them. For Valorant, there is a UVA student that is playing on a professional team that will be interviewed.

The core questions of the interviews are outlined below.

1. What motivates you to compete?
2. How has technology and automation changed competition?

3. Where do you draw the line at technology and automation changing the rules of your game?

Using these questions as a base, follow-up questions will be asked to further understand these competitors' mindsets. This also allows the questions to tailor themselves to the specific competition. Examples of automation within each competition include aim-assist for airsoft and Valorant, pitching machines for baseball, and custom controllers for Super Smash Bros. This data will be interpreted and analyzed where automation intersects with infrastructure. Secondary sources such as public interviews and literature will be used to bolster this data.

Conclusion

The Romulus automatic-aiming airsoft system was developed to increase the accessibility of airsoft for people with disabilities. This system trivializes aiming, allowing anyone to compete in airsoft. Romulus is easily modified to suit the needs of each individual while also not being extremely cost-prohibitive. While not the intended use case, this system completely trivializes the skill of aiming, potentially ruining the enjoyment of airsoft competitions.

This highlights how we need to be careful of how we allow technology and automation to interact with competition as it is not inherently beneficial. The research paper will focus on interviewing how competitors feel about automation within their competition of choice. The expected result is that there will be a clear line drawn where automation for training skills will be supported while automation of core competition mechanics will be opposed.

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