Building A Fully Autonomous Robotic Foosball Table

The Role of Superhuman AIs in Society

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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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Overall Introduction

Board games such as chess, go, and poker have existed for centuries. They remain popular today among humans as recreational activities as well as viewing entertainment. Humans play these games just for fun, to reach personal goals, or for chess's many benefits such as improving cognitive, strategic, visualization, and decision making skills (Levinson, 2011, p. 178). Separately, the rise of artificial intelligence (AI) and machine learning has found its way into almost every other industry. They have allowed computers to assist humans in powerful ways, such as in object detection, natural language processing, and forecasting. Board games are not immune to the widespread impact of these algorithms. Development on AI algorithms to play these board games have been underway since the mid 1900s, when Alan Turing and Claude Shannon made some of the earliest attempts to create fully autonomous algorithms to play chess (Edwards, 2013).

Recent developments have complicated the role of AI in the ecosystems of these board games. The main development is that AI has surpassed the ability of humans, reaching the so-called superhuman level. According to philosopher Nick Bostrom, superintelligence is "an intellect that is much smarter than the best human brains in practically every field, including scientific creativity, general wisdom and social skills" (Bostrom, 1998). In the context of chess, a superhuman AI is an AI that can outperform all humans in chess. In 1997, a computer called Deep Blue made by IBM became the first computer to defeat the world chess champion, Gary Kasparov at the time ("Deep Blue," n.d.). In 2015, a computer called AlphaGo made by Deepmind became the first computer to defeat a professional go player, 3-time European champion Fan Hui. These algorithms have since improved and have become much stronger than humans ("AlphaGo," n.d.).

Superhuman AIs have had many positive influences for the games that they play. For example, in chess, players can play against AIs to improve their play or when they can't play against a human (Levinson, 2011, p. 181). However, these algorithms have largely only been applied to board games and not physical games such as foosball or ping pong. Players of these physical games are not able to experience these benefits of superhuman AIs. The sudden rise of superhuman AIs also introduces social issues within those games as well. It can be quite shocking that computers can become stronger than humans in games that require creativity and intuition. For example, in chess, despite not being undefeatable (every few years, stronger computers are created), these computers have been treated as the "perfect" or "correct" move, which has removed a lot of the human elements of these board games (Strogatz, 2018). Former chess world champion José Raúl Capablanca viewed chess as a "battle of ideas" (Wilkenfeld, 2019, p. 44). However, players are becoming increasingly dependent on memorizing the moves of these superhuman AIs (Wilkenfeld, 2019, p. 43), which devalues human ideas and creativity. So how can we maintain these human elements such as human ideas and creativity while still enjoying the benefits of superhuman AIs?

To fix the absence of superhuman AIs in physical games, my technical project will research combining these algorithms with robotics to create a fully autonomous robotic foosball table. To improve this situation regarding the compatibility of humans and computers within these games, I propose finding ways to still allow for human creativity alongside these technologies. Solving this is crucial for ensuring the smooth integration of AI into physical games, without the problems that it has brought to board games.

Technical Topic

The specific technologies used to create superhuman AIs for board games such as chess, go and poker include deep learning and reinforcement learning. In recent years, a lot of research has been able to successfully create programs that significantly outperform humans (Silver et al., 2018). However, these programs have only been developed for games that can be easily interfaced with a computer. The turn-based nature and well-defined set of actions makes chess a particularly good candidate for developing AI algorithms for (Shannon, 1950). For physical games such as foosball and ping pong, in addition to developing the algorithms, actually performing the moves is very complicated because sophisticated robotics is required. As a result, players of these physical games cannot experience the benefits of playing with superhuman AIs. For instance, they cannot use superhuman AIs to improve their play in the same way that chess players can (Levinson, 2011, p. 181). Without AIs finding novel ways of gaining subtle advantages, it is impossible to know if foosball can be played at even higher levels. Players also have no way of playing individually, unlike board games. Players of board games can play against AIs set to varying difficulties or even play styles to practice (Levinson, 2011, p. 181). Foosball players do not have this luxury. It can be hard to find another person to play against, the skill and even harder to find an opponent of the right skill level.

To resolve this, my technical portion will research developing a fully autonomous robotic foosball table. It will consist of robotics to move and spin the levers to kick the ball, as well as a camera mounted overhead to run computer vision algorithms to locate the position and movement of the ball. Then, it will apply the algorithms used on board games to perform superhuman level strategies. There have been previous attempts, but most only use basic strategies and none have reached the level of a professional foosball player. Some of the challenges that these previous attempts have faced is that training is much slower because you

are constrained by the physical requirements, unlike simulated board games (2018). The goal of the project is to develop a robotic foosball table that can defeat any human opponent.

STS Topic

The rise of superhuman AIs has led to a complex relationship between the human players and the computers. In general, while AI can be used to supplement human creativity by automating laborious tasks and freeing up humans for more creative tasks, it can also inhibit creativity. As the uses of AI expand, humans find themselves spending more time with AI. This ironically turns into less time for creativity (Bieser, 2023).

This effect is already very profound in board games, particularly chess. Superhuman AIs have fundamentally changed how higher level recreational players and professionals play. Humans use the programs to improve their play by analyzing what they could have done during a game or memorizing what the computer does in commonly occurring situations. For example, players prepare for games by memorizing what superhuman AIs do in the "opening," which is the beginning stage of the game (Wilkenfeld, 2019, p. 40). Players are literally memorizing moves, rather than using their own judgment or intuition for a large portion of the game. When watching professional games, viewers compare the moves made to the moves made by the computer. Many of these moves are virtually impossible for humans to find, so players are being compared to an almost unattainable standard (Campitelli, 2013). Players used to be characterized as "attacking", "positional", "tactical", etc., but with superhuman AIs, it is now "wrong" to play one way or another, in that some moves are objectively suboptimal compared to others. This has led to a pursuit of playing the perfect move and less creativity, individually, and personal styles. Human insight is thus devalued compared to what the computer spits out (Strogatz, 2018).

These factors have led to decreased enjoyment by players. It can be boring when all of the perfect moves are given. Professional players preparing for matches using engines results in more draws, which are less entertaining to watch (Wilkenfeld, 2019, p. 40-41). This has led to some of the best chess players in the world (most of which started playing before superhuman AIs) say that they would not have started playing chess if they knew that superhuman AIs would eventually become so powerful (Roeder, 2023).

The main question I hope to address is how human values such as creativity are impacted by superhuman AIs. Specifically, I will analyze the game of chess. According to Bruno Latour, "certain values … can be achieved through the construction and employment of technologies" (Latour, 1992, p. 151). Shannon (1950, p. 4) acknowledges that it is impossible (due to computing constraints) to design a computer to always play the "perfect" move (the move that guarantees an eventual win, or maximizes the probability of an eventual win), but tries to play as close to the "perfect" move as possible. This suggests that the values of the computer developers are perfection, which they try to achieve through constructing nonhuman superhuman AIs. However, these nonhuman values of perfection sometimes conflict with human values. Former chess world champion José Raúl Capablanca believed chess should turn from a "struggle of technique into a battle of ideas" (Wilkenfeld, 2019, p. 44), suggesting he values insightful and unique ideas rather than perfect moves. Much like how music experts can detect and appreciate fine intricacies of a performance that others cannot, chess experts can recognize the nuances of high level chess ideas. The current highest-rated chess player Magnus Carlson once stated in an interview: "I appreciate creating something unique… also just an idea, something I haven't seen before" (McGourty, 2015). We can see that Carlson values creative ideas and uniqueness over the purely most optimal move. There is a distinct conflict between nonhuman values of

perfection and human values of creativity, ideas, and uniqueness. Technology shapes human behavior. The values delegated to technology can change existing human values (Latour, 1992, p. 151). Thus, the rise of technology could lead to diminished human values such as creativity. It is important to recognize this inherent difference in values in order to understand how the differences in values will impact the human experience of playing games such as chess.

There are potential solutions that allow for the aforementioned creativity, individuality, and intuition using techniques such as lower time controls and variants. Lower time controls means that players have less time to think about the perfect move, allowing intuition and personal styles to shine through (Wilkenfeld, 2019, p. 44). Another solution, proposed by former chess world champion Bobby Fischer, is a variant of chess called Chess960 where the starting position is scrambled randomly (Wilkenfeld, 2019, p. 44). Fischer's approach confronts the contrasting values between nonhuman technology and humans by removing the effectiveness of the nonhuman technology since players can no longer use superhuman AIs to memorize moves. By changing the rules of the game to being different from normal chess, the uses of superhuman AIs can be diminished, reducing their impact on the game. However, if you change too many rules, the game stops resembling chess, which chess players may not like. This presents a tradeoff that can be further explored by analyzing the willingness of players to adopt variants of chess.

Without fully addressing the sociotechnical impact of these technologies, the sudden introduction of a superhuman computer would be devastating to the communities of physical games such as foosball.

Overall Conclusion

My anticipated deliverable for the technical portion is an investigation towards the specific methods that can be used to create a fully autonomous robotic foosball table, capable of defeating human players. I will research state-of-the-art technologies that can be applied to this task. For the STS research, my anticipated deliverable is a better understanding of how to coexist with superhuman algorithms, while maintaining individuality and enjoyment for humans. While most of the direct research is for board games, the research can be easily transferred to other games, such as foosball. Thus, when the technology exists in physical games such as foosball, we can have a better understanding of the best way to interact with the technology while maintaining human values within the game.

If a fully autonomous robotic foosball table were to be created, players of foosball would be able to leverage the benefits of superhuman AIs in foosball, such as aiding their improvement and playing without another person. The technology could then be applied to other physical games such as ping pong. With a better understanding of how superhuman AIs influence human values such as creativity, humans would be able to benefit from superhuman AIs while enjoying games that involve individual styles and creativity, rather than just the "perfect" actions.

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