SlapBot: The Automated Slapjack Robot

About-Face: The Two Sides of Facial Recognition

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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

Have you ever run into someone you recognize, but forgotten their name? Embarrassing, right? But what if that person was refused access to a service, or was framed for a crime they did not commit? Or worse: what if one misidentified person gets in trouble, but another gets off scot-free?

This is a representation of the current state of facial recognition technology; the way it is being made, used, and trained is inherently inequitable. Multiple studies have been published on its biased results, especially on the basis of race and gender (Buolamwini, 2017). It is important to study because, while this technology is still fairly new, it could soon become ubiquitous in the realm of security, from personal use, such as unlocking your cell phone (Apple Support, 2024), to broadband societal use, such as identifying criminals in public (Nabil et. al, 2022). Additionally, it serves as an example of SCOT (the Social Construction of Technology), the idea that technology is constantly evolving with input from society "in a 'multidirectional' model" (Pinch and Bjiker, 2012, p. 22). This will be the focus of my STS paper; I will analyze many secondary sources to explain how facial recognition technology works and how its development is directly linked with societal factors, including privacy, safety, and equality.

For my technical research paper, I will be reviewing and discussing my team's Capstone project. We are creating a Slapjack-playing robot, using image recognition technology to differentiate between cards. It is similar to facial-recognition algorithms, only we are using it to recognize card faces rather than human faces. In the same way that facial recognition algorithms can fail, the SlapBot's algorithm will fail if it misidentifies, or fails to identify, a Jack card. In this paper, I will describe the development of our project, how the technology we used works,

and the future applications of our work. I will discuss how our team engaged with societal factors while making our project, and I will review secondary sources similar to our work, to help better illustrate its scope in the technological world.

SlapBot: The Automated Slapjack Robot

Slapjack is a simple game. With two or more players, you take turns placing cards face up onto a pile. Once someone places a Jack card, the first person to slap the card takes the whole deck. Using a Raspberry Pi V3 camera, we are running an image recognition algorithm to teach our robot to differentiate between the cards. Once a Jack card is detected by the camera, an electrical signal is sent to a servo motor which controls a robotic hand, causing it to "slap" down onto the cards.

Playing cards are a common subject for image recognition, due to their distinct patterns. A team led by Xuewen Hu (2021) made a poker card recognition algorithm similar to the one our team is using, and presented their results at an IEEE Conference. Their technique was to simplify the image with grayscaling and contouring, then converting that image into data based on the patterns preloaded into the algorithm. Their results found that their algorithm worked quickly, but its success was dependent on the environment in which the photo was taken, such as against a high contrast background. We experienced a similar outcome with the algorithm we used for SlapBot, causing us to redesign the physical interface to incorporate a dark surface for the cards to be seen on. This is an important note, because it demonstrates how technology needs to be accommodated sometimes to work correctly.

When designing the robot arm's behavior, our team had to deliberate societal influence in the form of human-robot interaction; if our robot reacted too fast or too slow, it would never be

fair to the human player. For guidance in regulating an automated game, we looked to the work of a previous Capstone group. Patrick Zheng and his team (Spring 2024) created a machine to play foosball for their project, using one of the same tools as our team: an OpenCV camera. They used the camera to track the foosball's movements, then send signals to various servo motors to control the handles of the foosball table. Their results proved that the machine was capable of defeating a beginner-level foosball player. Zheng's team's work can be considered a positive example of automation working correctly and reliably. This is our goal for our project, as well as a standard that all automated technology should be held to.

For this paper, I will focus on the topic of automation and how it can be helpful for society in the form of accessibility. Our goal in making this project is to solve the problem of accessibility in Slapjack; people with physical impairments, such as hand injuries, are able to use our product to play the game. As a primary resource, I plan to conduct surveys on people interacting with our Capstone project to measure their experiences with the timing and reliability. As secondary sources, I plan to use prior studies and technical papers published by engineers doing similar projects.

About-Face: The Two Sides of Facial Recognition

Facial recognition works by using a camera to scan or take a picture of someone's face, then comparing that data to a photo saved in its database. Its primary purpose is for identity verification, especially in the federal government (Wright, 2022, p. 6). Despite its widespread use, it has been undergoing scrutiny from researchers, most namely because it misidentifies persons of interest in public settings.

Cameras have long been a staple for surveillance and safety, but facial recognition takes it to a new level. In an article for the *IEEE Technology and Science Magazine*, professor Kevin Bowyer writes about how people reacted to the facial recognition used at Super Bowl XXXV in 2000: “some observers may argue that…face recognition technology should result in a change to the Supreme Court's traditional interpretation of the right to privacy.” (2004, p. 15) Bowyer opened questions regarding the protection of privacy with this technology, including whether people should be notified if they are in a surveillance zone, or if their face has been added to a watchlist. Furthermore, he notes that the efficacy of the technology is correlated with its privacy concerns: “If the technology does not work, it can’t be a real threat to privacy.” (Bowyer, 2004, p. 16) Facial recognition in public places has a history of lacking reliability. In her 2011 book *When Biometrics Fail,* professor Shoshana Magnet discusses some examples of facial recognition failure. In 2004, a city-based surveillance program in Ybor City, Florida had to be canceled for its poor results, while in 2006, a study of a program at the Logan National Airport had a failure rate of 1 misidentification out of 100 people, for an airport that handles 27 million passengers a year (Magnet, 2011).

In addition to privacy concerns, studies have been performed on the racial biases in facial recognition technology. Doctorate researcher Cavazos and coauthors (2020) tested the accuracy of four different facial recognition algorithms and their success rates on East Asian and European faces; they found that the latter had higher rates of false acceptance. In another example, graduate researcher Joy Buolamwini (2017) conducted a study comparing the identification efficiency of three top recognition algorithms against Nordic faces and African faces. She found that the African women were misidentified 32x more than the Nordic men (Buolamwini, 2017, p. 3). The datasets of the algorithms she studied were “overwhelmingly lighter-skinned:

79.6%-82.6%" (Buolamwini, 2017, p. 3). In her report, she also explores the implications of the data collected by the technology, and how it can proliferate existing societal biases: "Race or ethnic classification can be used by advertisers to exclude showing housing listings to a protected class like African-Americans. Individuals classified as female based on their facial appearance may be subjected to higher prices as has been reported in instances where vendors use gender information to set prices" (Buolamwini, 2017, p. 24).

Researchers are finding ways to solve these problems with AI. Professor Rita Cucchiara and coauthors (2024) published an article exploring AI-powered privacy protection in *Computer,* a respected technological magazine. They argue that AI could be used in place of people to monitor cameras for public safety purposes, granting people privacy in the form of data protection, or have AI look specifically for dangerous actions, rather than people's faces. As a solution to the bias problem, Nicolò Di Domenico and coauthors created an AI algorithm to generate hyper-realistic faces with a variety of features, such as gender and ethnicity (2024). Their AI faces aligned with the ISO/ICAO standards, meaning they followed the legal layouts for identification photos. After training their dataset on a ICAO verification system, the algorithm produced 25% more European faces and 25% less East Asian and South Asian faces (Domenico, 2024), illuminating the bias present in the existing system.

While facial recognition technology is a step forward in terms of technological convenience, its actual implementation is rife with bias (Buolamwini, 2017), as well as ethical issues of privacy (Bowyer, 2004). These are problems because they demonstrate the inequity of convenience; the technology often benefits certain demographics more than others, creating inaccessibility. To analyze this problem, I will research reputable sources, like technical reports and journal articles, about the various aspects of the technology, including the bias and privacy

concerns. I plan to focus on investigating how this technology has changed with these concerns presented by society and offer possible solutions to these problems, as well as speculate how it will continue to grow within the scope of SCOT.

Conclusion

Overall, these two papers will be an exploration in how image recognition technologies are developing alongside society, as an example of both SCOT and how technology can affect accessibility. For the technical report, this will be accomplished by creating a working prototype of an automated game-playing robot, and studying how it interacts with people and potentially evolves as a result. The STS paper will be an analysis and critique of the current state of facial recognition-based technologies, and how their shortcomings are rooted in societal constructs. The major discussion points include the inconsistencies of the technology's output, as well as its inherent biases. Ethical problems of privacy arise as well, as data collection is essential for facial recognition. Both papers will investigate possible solutions that align with SCOT and societal development, including the use of artificial intelligence, an emergent new technology.

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