GESTURE-CONTROLLED LED MATRIX FOR PEDAGOGY

THE IMPACT OF FACIAL RECOGNITION TECHNOLOGY ON LAW ENFORCEMENT

A Thesis Prospectus
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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

In recent years, the Department of Electrical Engineering (EE) at the University of Virginia, has experienced a reduced quantity of graduating electrical engineers, keeping with the national trend of decreasing EE graduates. Following statistics published by the Office of Undergraduate Programs for the University of Virginia, the quantity of undergraduate degrees awarded in electrical engineering from 2018 to 2022 has fallen by nearly 9% (*Enrollment statistics*, 2022). To address the diminishing interest in the electrical engineering major, my team has selected a technical project with the intention of promoting electrical engineering in secondary education institutions. For the technical project, my team is designing, building, and marketing a gesture-controlled LED matrix to educate adolescent students about fundamental topics of electrical engineering. The STS project covered in this prospectus, separate from the technical project, seeks to explore the impact of facial recognition technology on law enforcement. The use of facial recognition technology by law enforcement has become a polarizing issue, often yielding incorrect results. In 2018, an African-American man was arrested in Detroit for larceny on the basis of a facial recognition match from security camera footage which was later confirmed to be false (). This example represents only a small part of the greater problem facing the country with furthering development of the technology.

Technical Project

For the technical project, my group is designing a gesture-controlled LED matrix to be used for pedagogical purposes. The project consists of a large matrix of approximately 500 Light Emitting Diodes (LEDs), and 4 Time of Flight sensors (ToF), all linked using two microcontrollers. LEDs are a light source that operate by emitting photons with the excitation

provided by an applied electrical current. ToF sensors are sensors that send out beams of infrared light and measure the time it takes for that beam to return. Using the time of travel and the known speed of the light, the distance can then be calculated by the sensor. Following that calculation, the real time data collected by the sensors will be transmitted, processed, and analyzed by the microcontrollers, to send the correct signal to each LED. This will allow the user to draw and manipulate the LED display using natural gestures. To mitigate power consumption, the project will implement scanning, which involves the quick power-cycling of each successive row in the matrix. With this methodology, one row is turned on and off in under one millisecond before the next row is turned on and off. At these speeds, the human eye perceives the LEDs to be constantly on despite the rapid blinking. Using hand tracking to interact with a computer is a well documented and researched concept, with one example being a “Virtual Drawing Board” that uses a laptop camera to sense the user’s hand movements, which is then processed in a Python program (Kader, et. al). The program then draws the corresponding sketch on the drawing board. This project was not used to drive any LEDs, nor did it use time of flight sensors to track the user’s hand movement, but it did demonstrate the concept of using real-time motion-detection to generate a drawing. Integrating this concept with the LED matrix adds a degree of novelty to the project to help attract potential users.

Rather than watching their teachers draw on chalkboards or lecture on difficult topics, students can now engage with a brightly colored display, creating a simple, tangible example of electrical engineering for students. Our project differs from the typical LED matrix in two ways, through gesture sensing and the user manual focused on breaking down the design into understandable concepts. In the current public education system, there is a consistent lack of

engaging resources for students interested in electrical engineering. The emphasis on simplicity will be used to garner interest in electrical engineering in secondary schools.

STS Project

As technology has developed, engineers and scientists have endeavored to apply new advancements to increase efficiency or quality of life. One of these developments that has grown substantially in recent years is facial recognition technology (FRT). As the name suggests, FRT is a simple software tool used to compare faces, typically through the mapping of facial features to certain data points. Companies such as Cognitec, Sensory, and iProov have built their brand around selling and marketing FRT to the public and private sector. As a budding development, FRT has been utilized in a variety of applications, ranging from scientific research to implementations as a tool for criminal justice. At the moment, there is a large debate of the legitimacy of FRT due to noted biases, to the degree that several states, including Virginia, have banned its use for law enforcement purposes. This use in law enforcement will be the focus of my research in the future, with the goal of identifying biases and seeking to explain them in context with its implementation by the government.

Research

For my research, I will be focusing on the impact of the technology on law enforcement, mainly in minority communities where the issues are most relevant. I want to research the extent of the FRT biases as well as the impact these biases have on law enforcement. To fully analyze the impacts of FRT within law enforcement, the Social Construction of Technology (SCOT) framework will be utilized, which states that the development and use of technology is shaped by

human behavior rather than base technological reasons. When observing facial recognition technology through the lens of SCOT, the current implementation of facial recognition technology clearly functions under the marked influence of privileged groups. FRT is often hailed as ‘racist’ and ‘misogynist’, labels stemming from the proven inaccuracy of the technology when applied to analyze non-white, non-male people. In order to better understand these claims, the underlying causes rooted in the reactions of society must be analyzed and determined. It is believed that the problems in the technology originate from biases in development, mainly the individuals responsible for development and training of the models. Typically, the models are developed by mostly wealthy white individuals which often leads to a racial bias in the models as a result of the narrow perspectives applied when designing. Furthermore, the bias is enhanced through biased training, where models are trained on facial data lacking an even spread of race and gender. This technological behavior exhibited by the FRT fits well within the scope of SCOT given the basis on human behavior. The technology is created by white individuals and used to identify faces in minority communities. In the United States, FRT as the basis of arrests is most prevalent in African-American communities, which is where I will focus my analysis. With this in mind, the relevant social groups for my analysis are the individuals creating FRT and the African-American communities affected by the technology.

Methodologies

To analyze this data, I will be using several different methods. I plan on using history and case studies on facial recognition technology to demonstrate the biases in the technology. History is an important aspect of my research process which will allow me to establish a relationship between FRT and law enforcement. This method will provide context for the overall situation

and investigate the effects on minority groups. Case studies will also be critical for my methodology, allowing me to present clear examples of the biases stated in my research and strengthen my overall argument. There are many instances of FRT yielding false positives and false negatives, recorded both through scientific experimentation and through false arrests. Philosophy will also be an important aspect of my methodology through the use of STS texts to explain the effects and behavior FRT using SCOT.

Timeline

For my thesis in the spring, I want to begin my research by establishing clearly the biases of facial recognition technology through case studies, then further those examples with scientific research that verifies the validity of those case studies. Following the completion of that research, I would like to incorporate several texts to analyze FRT through the chosen STS framework. Once that has been finished, I will compile the research into my thesis to be submitted by the final deadline for graduation.

Conclusion

If facial recognition is to grow in usage and development, those responsible for its advancement must address these politics created by the technology. Racial and gender bias in any organization, even more so in law enforcement, is not a permissible flaw. As I research this topic in the coming semester, I hope to highlight all of these shortcomings in my thesis through thorough research, hopefully shedding more light on the causes of these issues and even potential solutions for long term development.

Key Texts

Do Artifacts Have Politics

In this article, Winner discusses the ways in which technologies can have politics, both inherently and through their use. Winner discusses the way that technologies can structure their environment to increase functionality, an important point to make for my thesis. I will use this reading to discuss the political biases created by FRT. For the technology to function well and provide meaningful results, a massive quantity of data is required to train the programs successfully. The data requirements of these systems lend themselves to the creation of a constant surveillance state to both integrate the technology into daily life as well as to generate the data necessary for improvement. In this system, facial recognition promotes a cyclical development of infrastructure; the development of facial recognition fosters surveillance which in turn leads to increased development of facial recognition. Being used by law enforcement most commonly in minority communities, this mass surveillance fostering cycle is a clear issue with the technology.

Race After Technology

In this book, Ruha discusses the relationship between race and technology, an important concept for my thesis. The author even writes a chapter on facial recognition technology and its racial bias, an example of what she calls “The New Jim Code”. The author provides multiple explanations for the racial bias present in new technologies, mainly resulting from the human bias of technological innovators. This follows my STS topic closely with implementations of facial recognition often trained with clearly biased data that creates an abysmal final product. Certain facial recognition technologies have been documented to discriminate against minority

groups, whether that be through erroneously identified voters on election day or biased criminal matches built upon a stereotyped profile of a criminal. This source allows me to further the main point of my thesis.

The Computer Got It Wrong

In this article, the author discusses the issues with computer systems and how those small inaccuracies can propagate into biases. The text discusses instances of mistakes made by computers in a vast array of fields, illustrating the fallibility of computer systems that I will have outlined through my research on FRT.

The Social Construction of Technology

This book discusses the way that technology is shaped by the society around it. A key element of technological constructionism is the idea that technology is shaped by social factors. This framework provides a clear method of analyzing FRT by highlighting both the stakeholders and the affected groups and their perspective on the technology.

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