Design and Use of a Modular Gesture-Controlled LED Matrix

Analysis of Apple's History in the Right to Repair Movement

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

A notable issue facing the industry of Electrical and Computer Engineering is the difficulty in preparing young students for the workforce (Valiente et al., 2019). The innovation in the field of electronics inherently causes problems in keeping curriculum current. Part of this problem can be attributed to a rise in proprietary technology and restrictive practices by major electronics companies. Principally in this case, the Apple corporation is one of the most well-known companies on the planet and has until recently been vehemently against the concept of the Right to Repair (Klosowski, 2023). The Right to Repair is the idea that a consumer should have the ability to fix, modify, or change their devices as they see fit (Klosowski, 2021). Many companies are implicitly against this right because they have an economic incentive to prevent devices from being repaired by a user. These challenges to independent repair can cause issues in the advancement of industry through the education of young engineers. Many young people already do not have confidence in their ability to fill the gaps in the tech workforce (Hughes, 2021).

This evolution of the landscape of technological literacy follows the main concept set forth by technological momentum; that technology once shaped by society gains momentum and shapes society later in its life. Through designing a modular gesture-controlled LED matrix that can be reconfigured for many potential uses, I will demonstrate a new method of enhancing current engineering pedagogy. To examine the shortcomings of the currently accepted teaching methods, the sociocultural impact of rapid and profit-driven electronics innovation must be addressed alongside the technical complexity preventing a proper understanding of current electronic devices. To do this, I will apply the framework of technological momentum to examine the need for such a tool and what specific objectives it should achieve in an educational

space. These projects should detail how the current methods of electronics education and the modern understandings of electronics are becoming increasingly shaped by specific technological design, as in the case of Apple and its proprietary repair methods for Mac computers.

Technical Project Proposal

This technical project consists of a matrix of Light Emitting Diodes (LEDs) and time of flight sensors, linked using two microcontrollers. Most hobbyist LED displays utilize store-bought parts or light strips since they are easier to control than a custom matrix. However, there are hobbyists that have built their own displays using a combination of individual LEDs, drivers, MCUs, and Printed Circuit Boards (PCBs) (Babu et al., 2019) (Bouazza et al., 2016). The displays are interesting art pieces and proofs-of-concept but have few specific real-world applications. My technical project group believes that these displays can be used as educational aids for teaching electronics concepts.

To develop the design, we will be following manufacturer datasheets to learn about and adapt components for use, as well as using skills learned from previous courses in our department. We will also be learning about the technical concepts of time-of-flight sensors and LED matrices using online references to design a guide for the students we aim to inform. In our demonstration of the device, we will take feedback from different audiences to learn what could be done differently or improved for real-world use.

An example of the use of these matrices for pedagogical purposes is shown in (Kader et al., 2014) as a fun way to engage with children and get them excited about learning. Rather than watching teachers draw on blackboards, students can interact with a vivid display, making learning more engaging. Additionally, using hand tracking to draw on a computer is not a new

concept. In (Telsang et al., 2022), a barebone “Virtual Drawing Board” is shown that uses a laptop camera to sense users’ hand movements, which are then processed in a Python program to draw on a “board”.

This device will be designed to work with precision and minimal latency. There will also be gesture-based control for interacting with the device naturally to change functions or modes. Below (Figure 1) is a block diagram showcasing the overall system design.

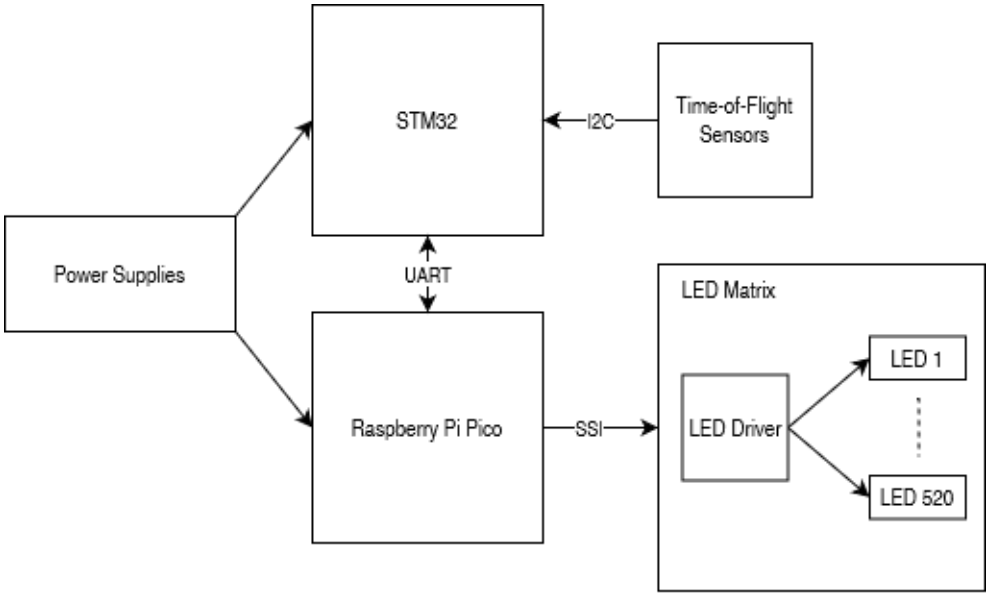

Figure 1. Simplified Block Diagram of the Device

As shown in Figure 1, interaction with the device is driven by time-of-flight sensors positioned throughout the LED matrix, which detect the position of the user’s hand and their gestures and communicate that data to an STM32 microcontroller. This microcontroller then calculates the position in the matrix and the configuration of LEDs to manipulate and sends this data to a Raspberry Pi Pico microcontroller, which manages the LED matrix using drivers to interact with many LEDs at once. The separation of the two microcontroller functions will increase the modularity of the system, which is key for inspiring students to adapt the design for their own hobbies and learning.

As an important deliverable for this project, a guide will be designed to walk users through the design of the device and how to apply the concepts in it elsewhere. In essence, this technical project serves as another proof-of-concept, but importantly also teaches users about its design and functionality in depth. The device takes advantage of a wide range of electronics concepts, including optics, embedded systems and communication, power system design, and logic design. This produces an all-inclusive case study for students interested in learning the fundamentals of electronics engineering without many layers of abstraction. All the components of the device are ordered directly from online stores accessible anywhere, and any custom designs will be made available as part of the technical guide. This guarantees that any student with sufficient knowledge from the guide will be able to reproduce similar projects using the skills they have learned.

STS Project Proposal

The Right to Repair movement is focused on protecting the ability of the consumer to repair their own devices or take them to be repaired by a provider of their choice. This means preventing manufacturers from limiting repairs performed outside of their certified establishments. The right for consumers in America to deconstruct and repair their purchased items without consequence is already protected by law, allowing consumers to keep things like warranties even if they take apart devices or remove “Warranty Void” stickers in the process of fixing them. However, the information and parts required to perform these repairs are not always available, and this issue has given rise to the movement to secure access to these resources under law (Klosowski, 2021).

One of the most well-known examples of a company working against consumers wanting to repair their own devices comes from Apple and their Mac computers, which are hard to find

repair materials for, since they are restricted only to certified technicians (Purdy, 2023). It may seem now like Apple computers were always meant to be a kind of “magic box”. Originally Apple was founded on the idea that their technology should be friendly and familiar to users and easy to access when compared to the huge mainframes present at the time. The original Apple I was based on a $20 microcontroller that Steve Wozniak bought from a store (Brashares, 2001, pp. 15–19). This is far from the Apple of today, which uses custom chips and proprietary technology. Thinking of Apple’s current Mac computers as a black box ignores their beginnings as a more accessible and simpler computer that inspired many young engineers. Despite its initial design as an accessible tool for people to learn more about and use computers to their advantage, today Mac computers have become so attuned to the concept of “just working” that they are almost impossible to fix for new users, affecting technological literacy.

A key takeaway when examining the right to repair and Apple’s Mac computers is thusly: The Electronic Frontier Foundation (EFF) views the right to repair as a step toward allowing “security researchers, consumer protection groups, and other device owners to be able to understand, control, and improve upon the technology they rely upon every day” (Klosowski, 2023). This is important in understanding how the lack of consumer rights regarding devices has led to a reduction in understanding and innovation in electronics. According to a study by CWJobs, 56% of young people view a career in technology as “too complicated”, and over half of businesses in the survey didn’t even have resources to train young people in the field. On top of this, a third of industry leaders “claimed they wouldn't know how to train them up even if the resources were available” (Hughes, 2021). This shows a growing lack of understanding due to complexity, and it shows that companies which were once shaping the technology they produced are inadvertently being shaped by an inability to keep up with increasingly complex products.

Technological Momentum is a framework designed to analyze how technology's impact, shapers, and power changes over the course of its lifespan and development. It posits that initially technology is shaped by the society that creates it but gains momentum and resistance to change through an increase in complexity, scale, or skills required to maintain it, among other things (Smith & Marx, 1994, pp. 101–113). This framework is apt for the long-term changes in Apple computers and can be used to examine the impacts that their evolution has had on society.

In my analysis of Apple and its Mac computers, I will show that a growing lack of confidence and increased complexity in tech training has been spurred by restrictions placed on users of products containing proprietary technology. Using technological momentum and the case of Apple's changing designs and policies, I will examine to what extent the electronics industry evolved from a culture where engineers and users alike shaped the advancements of technology to one where the industry has been shaped by a disproportionate growth in complexity relative to the education of students. For this analysis, I will examine the economic and social impacts of Apple's computer designs over time in regard to consumer reactions and economic changes using studies and statistical data and try to discover links to technological literacy using statistical evidence about workers and performance in the electronics industry.

Conclusion

The deliverable for the technical project in this paper will be a gesture-controlled LED matrix accompanied by an in-depth guide for adaptating and understanding its functions. The STS research paper will expose the need for such projects in the current pedagogy of the electronics industry. This will be achieved through an analysis of Apple's Mac computers using the framework of Technological Momentum to show how current consumer electronics practices

are negatively shaping the future of the field. The technical project in tandem with the STS paper will provide an explanation for the growing lack of confidence in understanding electronics.

Word Count: 1757

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