A Gesture Controlled LED Matrix with Pedagogical Applications in Electrical and Computer Engineering

A Buddhist Approach to Engineering

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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

Our project consists of a large matrix of Light Emitting Devices (LEDs) and time of flight sensors, all linked using two separate microcontrollers (MCUs). The time of flight sensors will be used to determine the position of the user's hand in front of the LED matrix in three dimensional space. The real time data collected by the time of flight sensors will be transmitted, processed, and analyzed by the MCUs, allowing the user to draw and manipulate the LED display, as if drawing on a canvas, using natural gestures. This project could have significant applications in the realms of education and art accessibility (Kader et al., 2014). The pedagogical applications of this project will be emphasized through a pamphlet describing the various electronic components of the system in layman's terms, such that they could be understood by younger schoolchildren.

In the field of engineering, the frameworks and systems used to understand the ethical side of engineering, and engineering processes themselves, are largely sourced from the global north; specifically, the West. Oftentimes, this takes a very reactionary form, where engineers are taught what not to do based on what mistakes have already been done (Harris Jr. et al., 1996). Additionally, engineers are often constrained to very rigid modes of analysis when it comes to researching and determining the potential negative effects of their engineering design, such as by looking only at how technology affects society (Pool, 1997). I will look at utilizing Buddhist practices, philosophies, and theories, to better understand engineering and engineering ethics in attempts to devise a more interconnected, interdisciplinary, and greater understanding of this discipline.

Throughout the design process of my group's technical capstone project, we will be, and have been, utilizing a variety of practices taught to us throughout our undergraduate engineering education in order to construct our project, as well as to analyze its potential effects on society. These practices are very Western in their origin, and may lack in the breadth needed to fully understand our project and it's direction. While there are a few texts that look into utilizing Buddhism within the field of engineering, this idea is largely otherwise unresearched. Furthermore, beyond the scope of our technical project, analyzing engineering and its facets is an important way to continuously ensure engineers are contributing to society in a positive manner — at least, in a way that ensures net positivity.

Utilizing an LED Matrix in Pedagogical Applications

Through a simple google search, it's clear that there is no shortage of hobbyists inventing their very own LED matrices for personal use, LED Matrix Wave Moves With Hand - Hackster.io (n.d.) shows a great example of an application of this technology. This could be attributed to the fact that there are a wide variety of easy-to-use Microcontrollers (MCUs), such as the Raspberry Pi Pico and Arduino, as well as LED lights becoming cheaper to manufacture. Most of these hobbyist's displays utilize store-bought LED displays or strips due to the fact that they are easier to control than a custom matrix. However, there are even more hardcore hobbyists, such as Babu (2019) and Bouazza, et al. (2016) that have built their own displays using a combination of individual LEDs, drivers, MCUs, and Printed Circuit Boards (PCBs). The aforementioned displays are an interesting art piece and proof-of-concept, but ultimately have no other real-world applications. Our group believes that there are several

applications for these devices that are being missed out on; namely, educational purposes.

Kader, et al. (2014) shows an example of the use of these matrices for pedagogical purposes as a fun way to engage with children, and get them excited about learning; specifically, in remote areas with minimal technology. Rather than watching their teachers draw on blackboards, students can now engage with a brightly colored display, making learning in the classroom more fun. One of the main drawbacks of current LED matrix designs is that while they may be appealing to look at, there isn't much interaction from the students.

Additionally, using hand tracking to draw on a computer is not a new concept. Telsang, et al. (2022) show a barebone "Virtual Drawing Board" that uses a laptop camera to sense the user's hand movements, which is then processed in a Python program. The program then draws the corresponding sketch on the drawing board. This project was not used to drive any through-hole LEDs, nor did it use hall effect sensors to track the user's hand movement, but it did demonstrate the concept of using real-time motion-detection to generate a drawing.

Our project will allow students to use their hands to draw on the matrix, creating a fun way for them to learn about electronics, while also giving the teacher a way to display messages on it, combining concepts from Kader, et al. (2014) and Telsang, et al. (2022). Additionally, we plan to design a pamphlet to accompany this system in the classroom that will utilize the various components in our design to explain basic Electrical and Computer Engineering concepts. For example, the pamphlet will go over how an LED works, how the MCU is controlling it, and how the MCU knows which LEDs

to light up. This will give the teacher a better sense of how to approach a lesson utilizing this technology; and, as Kader, et al. (2014) showed, will help get young students excited about the vast field of Electrical and Computer Engineering.

A Buddhist Approach to Engineering

What can be learned from Buddhist practices and principles within the field of engineering and engineering ethics? Engineering is a vastly pervasive field of study which affects the entire population of the earth. It is important to analyze fields with such a large scale effect from a variety of perspectives, especially perspectives that are known to be designed for the sole purpose of bringing good to all forms of life (Loy, 2003). Furthermore, since the vast majority of engineering design approaches were formed in the Western world, it is crucial to offer up a more global, Eastern perspective.

Buddhism at its core is driven by a pure desire to promote universal well-being. This desire is cultivated through a variety of practices and adherence to principles such as following the eightfold path, abstaining from the five precepts, and acknowledging the four noble truths. Without iterating each of these and the variety of their interpretations, the general message is to recognize the impermanence of one's own life experiences, and to abstain from harming all life forms — sentient, or non-sentient. Generally, Buddhism is advertised as something that one must “come and see”. In other words, a lot of the ideas must be discovered on one's own account, and understood for what they are, otherwise you are just blindly following a dogma (Rahula, 1974).

Seeing as engineering is a field that has caused a great deal of harm to a variety of life on earth, it is crucial to look at approaches to this study that could impede, and ideally, cease, the harm done by engineers (Schultz-Bergin, 2021). As Buddhism does

such a good job at cultivating goodness, and exists more as a framework through which to approach a variety of problems rather than an actual religion, it has great potential for successful application in the realm of engineering (Santiago, 2013). Furthermore, the various offshoots of Buddhism, such as Zen Buddhism, could have great applicability in this discussion (Pirsig, 2006).

To question the fundamental nature of the engineering design process, as well as the ethical approaches to engineering, as they exist today, and then to propose an alternative approach to such a pervasive field, is a hefty task that will undoubtedly require some tact. To analyze this question, a variety of answers, or approaches, should be formulated, and then investigated through comparison to existing engineering frameworks, application to real world scenarios, and the ethical dimensions of the designs said framework could produce. Throughout this process, it will also be crucial to look at existing frameworks originating from across the globe in order to determine what Buddhism can bring to the table.

In order to perform this analysis, a vast amount of sources pertaining to existing engineering frameworks will need to be collected. This will involve a hefty amount of research and discovering and exploring a variety of readings. Aside from the existing frameworks, these readings will include case studies on engineering failures, and successes, to attempt to determine the common causes of both, and see how that correlates to Buddhism. In addition to reading, there may be a use for interviews of parties who have great knowledge of Buddhism, or have experience of applying Buddhist principles in engineering or engineering-adjacent fields.

Conclusion

Engineering, as it stands, does not always provide benefit to society; and, more importantly, all life on earth. In fact, in a lot of cases, it has proven to be quite detrimental for life. If we know engineering can be done for good, then why must we do it for bad? It is crucial to look at the current, popular engineering design processes and ethical frameworks and understand how so many detrimental engineering designs are making it to market. Our earth is nearing the end of a decades long, slow, suffocation, all because humans decided to take more than they give. Will this obsession with our own selves cause the end of our humanity as it has already led to the extinction of other life we share this earth with? As engineers, maybe it is time we take a step back from our engineering designs, and utilize the Buddha's teachings on mindfulness to see ourselves as we are, and see that we are, in fact, without self. If we can remove our egos from engineering, remove selfishness from arguably the discipline that designs the world, maybe we can save life from ourselves.

References

Babu, B. N., Kumar, G. S., Jawahar, I., & Mohan, T. K. (2019). *Wireless Based LED Dot Matrix Message Display*. *6*(1).

Harris Jr., C. E., Davis, M., Pritchard, M. S., & Rabins, M. J. (1996). Engineering Ethics: What? Why? How? And When? *Journal of Engineering Education*, *85*(2), 93–96. https://doi.org/10.1002/j.2168-9830.1996.tb00216.x

Kader, M. A., Rahman, Md. M., Haider, S. M. I. B., & Islam, M. (2014). LED matrix based digital learning display for children with wireless control. *2014 17th International Conference on Computer and Information Technology (ICCIT)*, 397–400. https://doi.org/10.1109/ICCITechn.2014.7073134

LED Matrix Wave Moves With Hand—Hackster.io. (n.d.). Retrieved November 3, 2023, from https://www.hackster.io/Mostafa_Abcreno/led-matrix-wave-moves-with-hand-183166

Loy, D. (2003). *The Great Awakening: A Buddhist Social Theory*. Wisdom Publications.

Pirsig, R. (2006). *Zen and the Art of Motorcycle Maintenance*. Mass Market Paperback.

Pool, R. (1997). *Beyond Engineering: How Society Shapes Technology*. Oxford University Press, USA.

Rahula, W. (1974). *What the Buddha Taught*. Grove Press.

Santiago, M. M. (2013). What Can Buddhism Offer to a Socially Just Engineering Education? In J. Lucena (Ed.), *Engineering Education for Social Justice: Critical Explorations and Opportunities* (pp. 85–109). Springer Netherlands. https://doi.org/10.1007/978-94-007-6350-0_5

Schultz-Bergin, M. (2021). *Engineering & the Environment*. https://pressbooks.ulib.csuohio.edu/principles-of-engineering-ethics/chapter/engineering-

the-environment/

Telsang, Prof. S., Dongre, R., Rajeshirke, S., Rajput, K., Rajpurohit, R., Rakhewar, M., & Rajguru, T. (2022). Virtual Drawing Board (Drawing and Writing Using Hand Gestures). *International Journal for Research in Applied Science and Engineering Technology*, *10*(12), 359–361. https://doi.org/10.22214/ijraset.2022.47873