Improving on an FPGA-Controlled AI Vision for a Prosthetic Hand
(Technical Topic)

Exploring How Verbiage Influences Prosthetic Use Decision
(STS Topic)

A Thesis Project 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 field programmable gate array (FPGA) is a logic device that users can program. It is a circuit that is reconfigurable after production, and is used in fields such as computer, automobile, communications. It can be combined with a variety of other logic units such as the central processing unit, graphics processing unit, and artificial intelligence accelerators (Huang, 2023, Pg 1-2). FPGAs can be useful in myoelectric prosthetics as a processor, which essentially carries out instructions provided by computer programs. Myoelectric prosthetics are devices that are electrically powered and driven by the electrical activity in the muscles of the remaining limb (Washington State).

Prosthetics are important to help amputees become independent in performing their daily activities and reintegrate in society. There must be means of enhancing performance, customization, power efficiency, and reliability of the prosthetic in order to create products that will greatly benefit the user (Losier, 2011). Without improvements in prosthetics, users may have difficulty achieving the full functional independence of an able-bodied individual. Moreover, the rejection rate of all prosthetics is a staggering 44% (Salminger et. al, 2020). It is evident that prosthetics are not being designed according to the users needs, and it is significant to create prosthetics that will be useful.

My technical project would focus on how to improve on an existing FPGA-controlled prosthetic hand. My STS topic would focus on how verbiage surrounding the discussion of amputees affects prosthetic usage.

Technical Topic: Improving on an FPGA-controlled AI vision for a Prosthetic Hand

By integrating FPGA's into prosthetics, users will have new features and advancements in their devices that will enhance the quality of life. There are existing prosthetics with FPGA, such as an FPGA-controlled AI vision for a prosthetic hand (Sola-Thomas et al, 2023). There are things to consider when designing a prosthetic for an individual, such as cost/affordability, degrees of freedom, controllability, and modular/flexible design (Losier, 2011). Moreover, when a prosthetic has a long response time, users feel a mental burden from using their prostheses (Losier, 2011). It is evident that many factors go into considering the design of a prosthetic, and it is significant to ensure that the prosthetic closely resembles the functionality of a real hand. The goal is to improve on an existing FPGA-controlled prosthetic hand to fit the desires of the user.

There are advancements that can be made to the existing FPGA-controlled AI Vision prosthetic hand. The existing prosthetic has a megapixel camera, FPGA as a processor, pressure sensors, and a distance sensor (Sola-Thomas et al, 2023). The camera is used to capture the color and depth to determine the best grasp for an object. The pressure sensor is used to relay pressure feedback, and the distance sensor provides accurate distance measurements of objects. Since FPGA's are flexible in the sense that the hardware can be configured according to the needs of the customer, it has the potential for energy-efficient processing for artificial intelligence and lower production costs. However, there are problems with this device. Data is collected from the cameras and processed with the FPGA, but there is nothing telling the device what to do. In order to improve this prosthetic, a device that utilizes data from other components to interact with the environment would be useful.

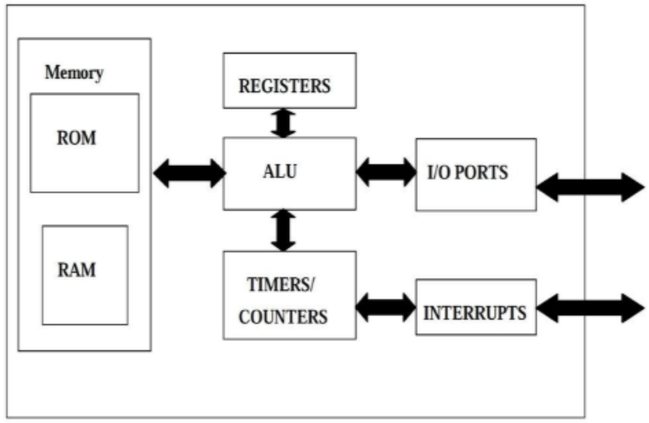

Figure 1. Schematic Block Diagram of Microcontroller (Parai et. al, 2013, p. 228)

A possible device that could process data for appropriate instructions for the prosthetic would be a microcontroller. A microcontroller would allow the existing AI Vision prosthetic hand to interact with its environment based on the data it consumes. An example of how a microcontroller is structured is provided in Figure 1. A microcontroller is a chip with memory that helps with monitoring and control in the system (Gridling & Weiss, 2007, p. 7). This means that the microcontroller could interpret the data processed by the FPGA, determine the appropriate instructions or actions for the prosthetic limb based on that data, and then send commands to the prosthetic limb's control system to execute those actions. It would act as a bridge between the vision processing system and the prosthetic limb by translating visual information into instructions for the limb to follow.

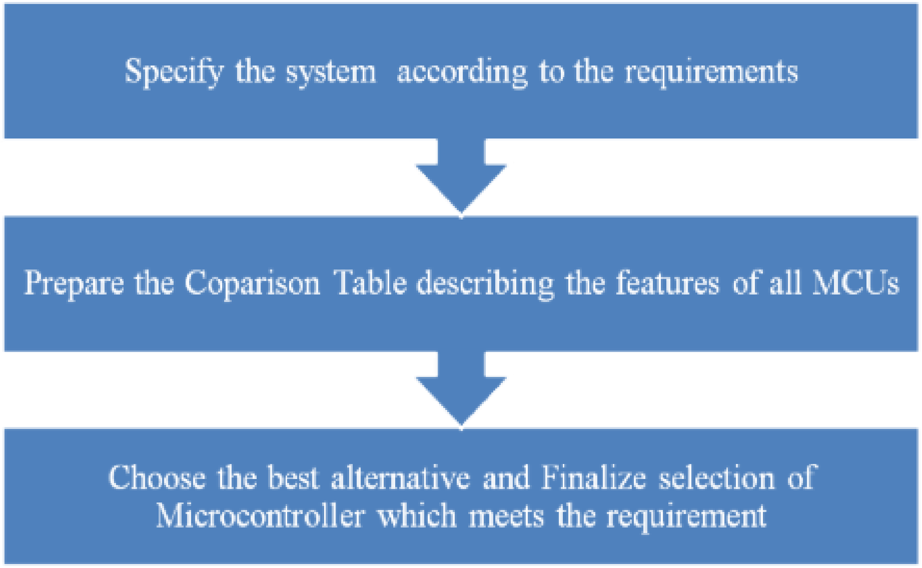

Figure 2. Selection Process Flow (Parai et. al, 2013, p. 230)

The appropriate microcontroller would have to be chosen based on the specifications of the prosthetic system. The flowchart of the selection process is seen in Figure 2. In my technical project, I would explore and compare the different microcontrollers that I could utilize. Some aspects to consider are cost, architecture compatibility, availability of software development tools (Parai et. al, 2013, p. 230).

STS Topic: Exploring How Verbiage Affects Prosthetic Use Decision

The acceptance and utilization of prosthetics among amputees are influenced by a multitude of factors, including cultural beliefs, societal perceptions, and the language used to describe prosthetics and individuals with limb loss. This section goes over the impact of diction and terminology on prosthetic acceptance through three instances. If engineers ignore why these prosthetics are being rejected, it defeats the purpose of creating these products since the intended audience is not using it.

A study in Haiti offered different prosthetics to amputees, with one prosthetic limb being named "Cyborg Beast" (Arabian et. al, 2016). It was found that a patient chose this prosthetic for use but later rejected it because of its size and non-anthropomorphic appearance. In Haiti, the belief system Vodou emphasizes the fact that a spiritual wholeness is tied to their physical wholeness, so amputees would value the aesthetics of the prosthetic heavily to resemble a natural human hand. Cyborgs are evident in science fiction movies and literature with superhuman characteristics. Having a prosthetic named after such an entity can evoke a sense of alienation. The term "beast" implies a wild, non-human entity, further distancing the prosthetic from the natural and human elements within the Vodou belief system. As a result, amputees may feel a disconnect between their own identity and the prosthetic, potentially leading to rejection or reluctance to embrace the technology.

Prosthetics are sometimes labeled as "terminal devices," a term with potentially negative associations (Salminger et. al, 2020). For instance, "terminal" is commonly linked with terminal illnesses, suggesting an incurable condition leading to death. If a patient unfamiliar with the term associates it with such diseases, it may deter them. Additionally, "terminal" implies limitations and finality, suggesting loss rather than empowerment. This perception can be daunting for amputees already facing physical and emotional challenges. The sense of permanence may discourage exploration of the prosthetic's potential and hinder acceptance.

Making definitive, generalizing claims in scholarly articles about amputees can reinforce negative stereotypes and assumptions. Vujaklija et al. (2016) mentions that the “absence of an upper limb leads to severe impairments in everyday life, which can further influence the social and mental state”. This statement is lacking nuance and is not backed by any factual means. While upper limb loss can present significant challenges, the degree of impairment and its impact on social and mental well-being can vary widely among individuals. Moreover, their quality of life can improve through coping mechanisms, religion, acceptance, and humor

(Pereira, 2018). Some people may adapt well to their limb loss and lead fulfilling lives with minimal impairment, while others may face more struggles. Framing upper limb absence as a source of severe impairment may inadvertently contribute to the stigmatization of disability. Individuals may internalize these negative perceptions and feel ashamed or embarrassed about their condition, leading them to avoid seeking prosthetic interventions out of fear of judgment or discrimination.

The language used to describe prosthetics and amputees plays a significant role in shaping perceptions, attitudes, and ultimately, acceptance. These examples underscore the importance of considering cultural beliefs, individual experiences, and societal norms when discussing prosthetic technology and limb loss. I will leverage these insights to understand the sociotechnical system that prosthetics reside in, specifically the cultural aspect. I have already accumulated some examples of how diction can affect prosthetic usage, and I plan on broadening my background on this topic through exploration in different realms such as psychology and semantics. By learning from those in different fields, I can better understand the cultural context.

Conclusion

The technical and STS topic provided a deeper understanding of how prosthetics can be better accepted and utilized. In the technical topic, I suggested improvements on a particular FPGA-controlled AI Vision hand by implementing a microcontroller that allows the hand to interact with the environment. In the STS topic, I intend to gain a better understanding in the ways in which professionals address prosthetics and speak of amputees that can perpetrate negative connotations with prosthetic usage. By improving on existing prosthetics to suit the needs of the user as well as being more aware of the amputee experience, engineers can create prosthetics that are more functional, useful, and accepted.

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