Thesis Portfolio

2020 Vision: Wearable Haptic Ultrasonic Object Detector

(Technical Report)

The Role of Human-Centered Design in Humanitarian Engineering

(STS Research Paper)

An Undergraduate Thesis

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Table of Contents

Sociotechnical Synthesis

Since technological advancements increasingly define societal interactions and shape individual lifestyles, engineers must incorporate user-centered design into their project design cycles. After all, designs that fail to meet the needs and desires of their end users are at best unimpactful and at worst harmful. This portfolio documents the methodology and results of two independent research projects that unite under the common theme of user-centered design thinking. More specifically, the technical research topic joins the techniques of ultrasonic object tracking with haptic feedback through vibration motors, and the science, technology, and society (STS) research topic addresses the role of human-centered design (HCD) in humanitarian engineering. Both projects place a heavy emphasis on designing for the needs of the end users. For the technical research topic, the final product is a wearable device called 2020 Vision that detects object collisions, which seeks to serve the visually impaired. Throughout the process of the project design, the 2020 Vision team considered how to build and refine the device to fully meet the needs of the intended users. Although this product is not included with the portfolio, it includes thorough documentation of the ideation and development of 2020 Vision. For the STS research topic, the enclosed final deliverable is a paper that discusses the answer to its related research question: To what extent does HCD increase the effectiveness and impact of humanitarian engineering? Overall, the STS paper investigates the usefulness of design thinking, specifically HCD, in user-centered projects, of which 2020 Vision is an example.

2020 Vision is a device that increases situational awareness in users' blind spots, and involves the design, development, and production of a wearable device that communicates with users using haptic feedback concerning incoming objects. The MSP430 microcontroller performs the necessary calculations and powers the embedded system, which entails detecting incoming

collisions and notifying users as appropriate. Users may wear this device throughout the day so that it informs them of such dangers in their environment. What sets this project apart from current projects is the use of haptic feedback that responds not to human touch, but rather to object detection. More specifically, if an object is coming towards a user, the wearable device uses haptics to communicate the upcoming collision, more specifically through a vibration motor. The device relies on the MB1010 ultrasonic sensor, which detects approaching objects within 0 to 6.45 meters away, with an approximate 45-degree cone around the sensor. Sufficiently fast objects within a minimum distance threshold of 30 centimeters trigger the haptic feedback system, and users consequently feel a vibration depending on where they mount the motor(s). In short, the portion of this project that creates new knowledge is the development of an algorithm for object detection on an MSP430, specifically to interface with an ultrasonic sensor and wearable vibration motor.

As for the STS project, in a world where many humanitarian engineering efforts fail to create sustainable impact in their recipient communities, engineering design must implement an approach to project development that cultivates long-lasting and truly beneficial technological systems. One such method of design thinking, known as HCD, promises to deliver solutions that are both useful and meaningful to end users. As such, focusing on the issue of poverty, the research question is as follows: To what extent does HCD increase the effectiveness and impact of humanitarian engineering? Overall, this exploration demonstrates that the three E's of an effective and impactful humanitarian engineering project are empathy, education, and empowerment. Through the STS framework of technological momentum, empathy informs the beginning phases of a project with respect to the social construction of technology (SCOT) theory, education increases community engagement with the project, and empowerment defines

the lasting impact of the project through technological determinism. Analysis of various scholarly perspectives on the effectiveness of current humanitarian aid, as well as on HCD itself, bolster the proposition that these three E's are quintessential to sustainable humanitarian engineering projects. Evidence from interviews and IDEO.org case studies agree with these results. For decades, critics of humanitarian work have lamented the lack of pedagogical value and overly simplified intervention approaches that often characterize aid projects, and this paper proposes that HCD is an inseparable part of the solution that they have been looking for.

Case studies within academic papers harbor their unique value in providing key evidence through documentation of real-world events. Overall, this portfolio is such a paper, where 2020 Vision functions as a case study of the more theoretical exploration of user-centered design thinking in the STS research. Even though the STS portion focuses the answer to the research question on projects that aim to alleviate poverty, the 2020 Vision team designed the device in response to problems in the health sciences field, which is just yet another context for the analysis of HCD. As scholars know, divorcing theoretical premise from the experimental evidence delivers a great blow to the overall analysis of the subject at hand. For these two research topics, the dual focus on humanitarian engineering and biomedical applications provides two complementary perspectives on the same common theme. With the theoretical premise of the STS research and the tangible evidence of constructed hardware, the portfolio overwhelmingly affirms the effectiveness of user-centered design thinking and encourages its extensive use in engineering projects, for the sake of engineers as well as their local and global communities.