Undergraduate Thesis Prospectus

Enhanced Awareness for the Visually Impaired: "Visually Assistive Hat"

(technical research project in Computer Engineering)

One Emergency from Disaster: The
Impact of High Healthcare Bills

(sociotechnical research project)

by

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General Research Problem

How can the inclusivity of medical care be improved?

In the U.S., despite medical advancements, several factors cause unequal quality and access to medical care. "Black persons had an overall mortality rate that was 1.6 times higher than white persons in 1995... for multiple causes of death (heart disease, cancer, diabetes, and cirrhosis of the liver) the racial discrepancy was larger in 1995 than in 1950" (Williams, 2000). African Americans are more likely to be financially unstable; research exploring correlations between disease, gender and socioeconomic status found "25 of the 29 diseases analysed showed a significant inverse [socioeconomic position (SEP)] gradient: the lower the SEP, the higher the frequency" (Carrileo et al., 2021). With the rising rate of uninsured Americans, and with 73.7 percent of uninsured adults claiming cost as their reason to not be insured (Orgera et al., 2020), it is important to consider the limitations in quality and access to medical care.

Enhanced Awareness for the Visually Impaired: "Visually Assistive Hat"

How can the visually impaired safely navigate their surroundings?

This capstone project is with the Computer Engineering Department, advised by Professor Powell and Professor Delong. This is a team project with Mary DeSimone, Hafsah Shamsie, and Ricky Morales.

Visual impairment is a widespread issue. In 2015, over one million Americans were blind and over three million Americans were visually impaired (CDCP, 2020). Visual impairment is a major disability that hinders one's ambulation (NASEM et al., 2016); this creates a lack of independence that complicates chronic illnesses and negatively impacts mental or physical health

(NASEM et al., 2016). This project combats these issues through building a device that mitigates the dangers of ambulation for the visually impaired.

Methods for creating the prototype entail using sensors embedded into a hat to obtain information regarding the distance between the user and obstacles to their front, sides or back, and changes in incline. The MSP430FR2433 launchpad will process information from the sensors and trigger appropriate auditory warnings from speakers or tactile vibrations from DC motors. The alert frequency increases as the object approaches. Software will be written using Code Composer Studio to handle communications with the MSP430FR2433 launchpad. The ultrasonic sensors communicate using UART, the LiDAR sensors communicate using I^2C, and the speakers and vibration motors communicate using pulse-width modulation. A task scheduler will manage the execution order of events. Other key components include a battery, waterproof casings, the hat, a PCB, and wiring components.

Constraints include IPC standards for electrical safety of PCBs (All About Circuits), IEC standards for the use of lasers (Rockwell Laser Industries), NEMA standards for the use of hardware components outdoors (Engineering Toolbox), and the Barr Group safe coding standards (Barr, 2018). The size of the hat and amount of weight it supports are physical constraints. Other anticipated obstacles include finding optimal placement of the sensors, ensuring durability and accuracy of the device after rough use or exposure to water, and balancing physical constraints with a battery capable of generating enough power for several hours of continuous use.

Socioeconomic considerations include a potentially high purchase price and required access to electricity for charging. Certain hair types may cause difficulty wearing a hat and feeling the sensor vibrations. Safety considerations include unexpected device failures during a

journey and how the user might be warned of the failure. There are ethical concerns surrounding who would be at fault should someone get into an accident while using the device. Environmental concerns influence the design of the hat (Boyden et al., 2016), with a goal of easy deconstruction of the device for proper disposal of the sensors and battery.

The design of sensor-based object detection systems for the visually impaired is not completely novel. The Smart Cane uses ultrasonic sensors to detect obstacles and relays notifications using either auditory speakers, or tactile vibrations through special gloves, where each finger represents a different warning (Wahab et al., 2011). However, this product generates audio from a speaker mounted on the cane, which can be difficult to hear. Associating vibrations on different fingers with different meanings is overly complex, especially when considering the typical demographic for visual impairment products. The Path Force Feedback Belt uses video cameras placed around one's waist to build 3D images of the user's surroundings (Elmannai et al., 2017). This belt attempts to give the user an idea of their surroundings from all sides, but the use of video cameras results in the detection range for this system being too small to be effective (Elmannai et al., 2017). A commercially available product is the iGlasses Ultrasonic Mobility Aid, which detects obstacles using ultrasonic sensors and warns users through gentle vibrations increasing in frequency as the object gets nearer (iGlasses). But ultrasonic sensors are limited in range, and the device can only detect obstacles to the front of the user.

The final deliverable is a hat with five sensors, speakers, motors, a power supply, and the PCB mounted on it. The hat will provide feedback upon startup to confirm the device has been calibrated successfully; object detection will be periodically performed through the sensors. Auditory and tactile feedback will be provided upon object detection, increasing in frequency as the object grows nearer to the user. The user will be able to adjust speaker volume and which of

the feedback methods are active at any one time. The hat will be powered independently through a battery; all components will fall within reasonable size and weight constraints for usability. This deliverable provides a comprehensive awareness of surroundings to enhance the safety of the visually impaired.

One Emergency from Disaster: The Impact of High Healthcare Bills

In the U.S., how do low-income people with medical bills, the advocacies that represent them, and the institutions that seek to collect on the bills compete to advance their respective interests?

With inflation and the stagnant minimum wage, building up savings is increasingly difficult. Among U.S. adults, 35 percent could not easily afford an unexpected expense of $400; 12 percent could not afford any such expense (BGFR, 2021). With healthcare costs trending higher and a tendency towards pushing off non-emergent care to handle more immediately consequential emergencies (Kalousova and Burgard, 2013), how have interest groups managed the financial risk?

Researchers have investigated the impact of mounting medical bills. Kalousova and Burgard (2013) found that individuals with negatively connoted debt were more likely to neglect preventative or non-emergent care necessary to reduce the possibility of medical emergencies. Weiner et al. (2006) found even free healthcare options for the uninsured were often difficult to access, citing long multi-day wait times as a deterrent beyond financial security. Long et al. (2020) found that, specifically for hand surgery, even those who actively pursued treatment within their insurance network could receive surprise charges falling outside their coverage, leading to distrust of medical professionals. These interactions discourage the financially disadvantaged from attaining help, allowing preventable diseases to deteriorate into more

significant problems. O'Toole et al. (2004) found that aggressive collections practice towards those unable to pay was unethical, unjustified, and caused greater reluctance to pursue necessary healthcare. The burden of finding financial aid or contesting unreasonable bills falls on the consumer, causing undue stress that further alienates patients. Tice et al. (2011) found restrictions placed by insurance companies forced doctors to spend additional time negotiating which medications they could affordably prescribe; doctors were also less likely to take on new patients under plans with uncooperative insurance companies, thus further restricting patient access to care. Overall, research indicates that high levels of competition between the interests of participants sustain a convoluted process to manage medical debt.

Participants include unorganized individuals with shared values being billed for these medical services, both those who work to mitigate costs of recurring medical bills from chronic illnesses (Ungar, 2020), and those surprised with emergency hospitalizations (Aleccia, 2019). These patients are hospitalized and feel temporary relief from their illnesses, claiming, "'I didn't have the fear I'm gonna drop dead every minute,' he says. 'I felt a lot better.' Then the bill came" (Ungar, 2020). These participants have a shared value of billing transparency and affordability in healthcare, with increased "'fairness and equality in the system… This should be ingrained into the system so that when you have a problem and you're due relief, you get it'" (Aleccia, 2019).

Participants also include advocacy groups striving to reduce healthcare costs, such as the NAACP (NAACP, 2021). Their website states their values to "collaborate with communities through coordinated action to improve the social determinants of health — racism, poverty, exclusion, inferior schools, unsafe housing, poor nutrition, and toxic environments" (NAACP, 2021). The organization's overall focus centers around their perspective that equality through

overall advancement of African American welfare is necessary. Access to healthcare is a

significant subset, and many social factors they target will support equitable access to healthcare.

      The final participants are health insurance companies and trade associations. Health

insurance companies, such as Anthem, strive to maximize money paid into policies while

minimizing payouts on claims (ABCBS, 2018); the trade associations, such as AHIP, represent

the insurance companies' interests. Their stated perspective is that "health insurance providers

are an advocate for Americans, fighting for lower prices and more choices for them" (Swann,

2021). These claims may be a misleading form of astroturfing; unwaveringly protecting

consumers conflicts with the business interests to retain as much money as possible. This is

supported by a policy where only certain hospitals and medical professionals will be paid for by

insurance. A press release explaining this policy states "Your health plan's network of healthcare

professionals and facilities makes it convenient for you to find affordable, high-quality care

quickly" (ABCBS, 2021). This could also be an instance of astroturfing, with research

concluding these restrictive methods introduced high complications into the process (Tice et al.,

2011).

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