Shoes Identifying Foot Problems

The Relationship Between African Americans and Cancer

A Thesis Prospectus

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By

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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

There are cancer disparities among the African American community in the United States. According to "*Why Are Cancer Deaths Higher Among African Americans, and What Can be Done About It?*", the death rate among cancer for African-American men "was 24 percent higher than for white men." and breast cancer for African-American women "were 42 percent higher than for white women" (Lillie D. Shockney, 2019). This disparity stems from the economic imbalance that African Americans experience in America. The two main issues that relate to cancer mortality are "Unemployment and public expenditure on health care" (Emmons, K. M., & Colditz, 2016). A low socioeconomic status directly relates to African Americans as the ethnicity has the second highest unemployment rate in America as of 2020 (Statista, 2018), which also leads to the ability to afford health care.

How are African Americans having a higher death rate than other racial groups? According to the American Cancer Society, their research proves that African Americans are "more likely than whites to be diagnosed with cancer at a regional or distant stage" (*Cancer Facts & Figures for African Americans 2019-2021*, 2021), where the cancer has already been developed in one's body. Theoretically, if African Americans were able to identify earlier when they were diagnosed with cancer, then their survival rate for the disease would increase as more time would be allocated to better prepare and treat the cancer. This leads to the first proposed project in this portfolio that addresses the following research question: What diagnostic measures can be taken to reduce cancer disparities for African Americans? This STS paper attends to the health imbalance among different races along with how so many African Americans are contracting cancer.

In relation to diagnostic measures for the proposed research project, the research team is designing a smart shoe sole that will be able to measure pressure at different points in your foot and display it in real time. The sole will be used to identify foot deformities, provide a diagnosis for gait disorders, and will provide strategies for preventing foot ulcers in diabetics (Hessert, M et al., 2005). The technology will also be utilized by athletes; for example, golf players use the technology to assess the stability and form of their swing (H. Odabas et al., 2019). The research team is attempting to create a low-cost and accessible device to provide accurate FPD measurements for all potential use cases. The goal is to have a finished product by mid-December, along with a final report detailing the functionality of the shoe-sole sensor.

Technical Topic

The shoe-sole sensor is a shoe in-sole with pressure sensors placed throughout various areas of it that will collect data. These sensors will be connected to a microcontroller, which will store the data that is collected while the sensors are active. The microcontroller can then be used to wirelessly transmit data to a computer. Afterwards, a specialized software application will be used to display the data. This application will present heatmaps, store data from previous sessions, and show which specific part is experiencing the most pressure. The goal of this project will be to enable this insole-sensor to be used as a diagnostic tool to help reduce and prevent joint pain in the future.

Additionally, it should be useful for elderly people who have mobility issues. It has been estimated that our sole will work accurately on people up to 280 lbs. To get to this estimate, a study was found where the pressure in various regions of the foot was measured during physical activity. This study exhibited that at maximum, the heel exerted a pressure of approximately 65

PSI. With a maximum weight of 100 pounds on the sensor, spanning an area of 0.5 in^2, a force of 200 PSI can be applied to it. Based on this information and assumption that the people used in the study weighed an average of 180 pounds, a theoretical maximum weight of 553 pounds could be supported. This number was then halved to account for inaccuracies in data generalization from the study and to also give us a more comfortable working range. Only the heel was taking into consideration when determining a maximum operable weight because the heel experiences the most pressure when standing or doing physical activity and that the maximum PSI for the other sensors were 500 due to their small area, making the heel sensor the bottleneck for the weight limit. The project consists of three main parts: the sole, the processing unit (PCB), and the data visualization.

When determining the number of sensors to use, common pressure distribution in a foot was researched. The heel carries around 60% of the load on a common foot, the "midfoot" (or bridge between top and heel of foot) carries around 8%, and the front of the foot carries around 28% of the load ("Ultimaker 3D Printers & Filament,"). With that information and taking inspiration from the design in (Cavanagh, P. et al., 2016), it was decided by the team to use a range of 6-10 sensors for the whole foot. 1 sensor for the heel (which will be able to take more load), two for the midfoot / arch, and at least three for the top of the foot. The number of sensors is being left as a range for now to allow for flexibility when placing them on the sole.

The sole will contain the sensors and padding for comfortable wear by the user. A sole will be created for the average foot, so hopefully people with shoe sizes that do not differ too much will still be able to use it. The sensors on the sole will connect to the microcontroller (TI MSP430FR5969) which will be housed on a PCB separate from the sole. There will be a 3D

printed casing to ensure that the circuitry on this chip is not exposed to water or dirt. From the sole, the data read by each sensor is passed into the microcontroller (L. Shu et al., 2017).

The team anticipates there may be some signal processing necessary to input the data directly from the sensors, so a block has been placed on the below diagram to indicate that. The sole does this by sampling multiple pressure sensors at once. These signals are processed before being passed into a microcontroller. A microcontroller will communicate with a computer, which will be able to display the data in real time (or at least close to that).On the microcontroller there will be software to capture the data and interpret it. Next, the data will be transmitted via Bluetooth to an external computer. This will be done with the help of a Bluetooth module (CC2650MODA from Texas Instruments) which will be connected to an interface to the microcontroller. After this step, the data will be visualized, with a map of the shoe sensor being displayed to a screen and various pressures resulting in different colors for each sensor. This should look like a live heat map that glows brightest at the points where pressure is highest.

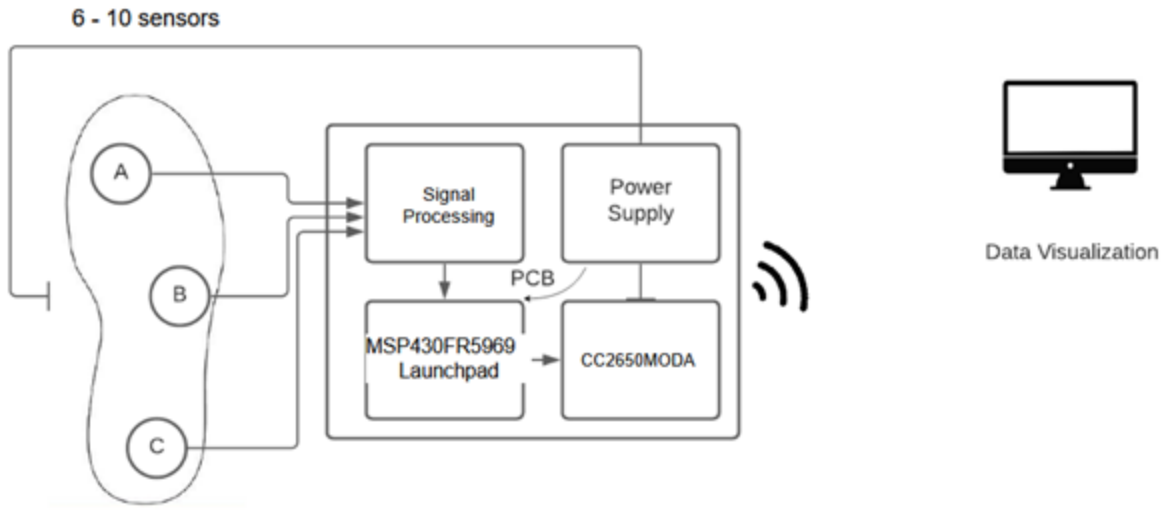

Figure 1: Block diagram of shoe sole project process. Created by Ahmad Tamanna, Xinyuan Zhu, Eric Csehoski, Kieran Humphreys, and Merron Tecleab

There are a lot of problems that is anticipated with this project. The first challenge is calibrating the sensors properly and making sure that the pressure readings are accurate between them. There will be problems with sampling this data as well, as finding the proper sampling frequencies and make sure there is no aliasing. It is also anticipated that there will be problems with transmitting the data via Bluetooth within our embedded software. Lastly, there could be some discrepancy with trying to display data in real time, so the team is hopeful there will not be a delay between the gathering of data and the visualization. To calibrate our device a user should turn on the sensors so they can see the heat map with no pressure being applied. Then, they can step into the sole and see the pressure distribution in real time.

Our expected outcome is to create a finished sole with multiple sensors that can display data in real time. It should be able to sample the sensors frequently and show a heat map on a display to illustrate where pressure is being distributed in the foot in real time. Some resources that will be needed outside of the required ECE lab equipment are a 3D printer (probably from the mechanical engineering department, a PCB manufacturer, and WWW electronics to solder the PCB. Some of our required software will be Multisim, Ultiboard, Code Composer Studio (for embedded C code), Visual Studio Code (for data visualization), Autodesk Inventor, and Ultimaker (for 3D printing).

Cancer Background

Cancer is a disease that causes cells to rapidly grow at an abnormal speed. Human cells "normally grow and multiply (through a process called cell division) to form new cells as the body needs them. When cells grow old or become damaged, they die, and new cells take their

place" (National Cancer Institute, 2021) The cause of getting cancer is unknown however, there are risk factors that increase the likelihood of getting cancer such as "lifestyle factors (smoking, poor diet), family history, inheritance, genetics, exposures to certain viruses, environmental exposure" (Stanford health care). However, cancer occurs when the cell division process is interrupted, meaning new cells are growing at an abnormal rate or old cells are not dying when they need to. The four most common cancers that kill Americans are lung, colon and rectal pancreatic, and breast cancer (National Cancer Institute, 2015). Cancer is broken up into four stages: Stage zero is where the cancer starts to appear yet has not spread to any other part of your body. Stage one is where the cancer is starting to spread, however it has not grown deeply into nearby tissues of where it is located. Stage two and three is where it has grown deeper into the tissue. Stage four is the final stage where the cancer has diffused to other organs and parts of one's body.

African American History Background After Integration

For most of American history, African Americans have been mistreated by society with the roots of slavery and segregation still rooted in present America. Even after the civil rights movement, discrimination still occurred for African Americans, and it was still a challenge to fit in society. It was clear that "racial tensions were high in 1970, as blacks became frustrated with economic conditions that did not improve despite advancements in civil rights" (*Racial Tension in the 1970s*). The intentional marginalization that persisted even after slavery and segregation made it difficult for African Americans to progress in society. In 2016, "the median net worth of non-Hispanic White households was $143,600. The median net worth of Black households was

$12,920." (Amadeo, 2016). The social issues that the average African Americans face today have affected their economic status to be low-income, unable to live comfortably in America.

STS framework

The STS framework that will be in use is the SCOT (Social Construction Of Technology), which is the idea that technology does not dictate the actions of humans, but the actions of humans shapes technology. SCOT theory proves that the result of technology can be dependent on how society is constructed in a social manner. The social groups that have a stake in a conflict must be resolved between one another to find the most optimal solution. One main issue with having many diverse perspectives coming together to find a solution is that the solution may either be very difficult to come up with or a solution will not be found. The SCOT framework will be used to understand the relationship between the American healthcare system and African Americans. According to Cancer Health Disparities, a low socioeconomic status "has been associated with poor access to high-quality care, lower screening rates, delays in treatment after diagnosis and lower treatment adherence" (Zavala, V et al., 2020). The need for more medical assistance poses a challenge to African Americans due to the lack of access to medical technology, given their economic status and inability to afford a proper healthcare system.

Methodology

Research question: What diagnostic measures can be taken to reduce cancer disparities for African Americans?

The first research method that will be used to analyze this research question is two case studies. The first case study is from the "Centers for Disease Control and Prevention". The study

is about a cancer intervention by community health advisors to encourage African Americans to take cancer screening seriously. The study is a "pre-posttest pilot study" that was held for a group of 800 members, aged 50 -75, of "African-Americans churches in South Los Angeles" who did not follow the "national cancer screening guidelines for breast, cervical, or colorectal cancer." (Centers for Disease Control and Prevention, 2019)

The second case study is from the National Center for Biotechnology Information, which is comparing the relationship between the economic well-being of a person and the possibility of one surviving cancer. This study includes all the countries from the GLOBOCAN 2012 database, along with the 27 different types of cancers recorded. Data from the World Bank Group compared other countries GNI (gross national income), GDP (gross domestic product), and HE (total health expenditure).

The second research method will be conducting interviews with UVA medical workers and AAS (African American and American studies) professors. The plan to obtain credibility from both the medical and social perspective of my research question. With the medical side, the goal is to interview one or two doctors about their experience and knowledge on handling patients with cancer and what they observed from people who survive/die from cancer. The social perspective will require me to interview one or two AAS professors from the University of Virginia to understand more about their experience and knowledge about their views on how they believe African Americans get treated during doctor visits. These two perspectives will further understand and bring me closer to a constructive answer to my research question.

Conclusion

The proposed technical project is a shoe sole-sensor that will have pressure sensors embedded onto the sole of the shoe. This shoe will be essential as a diagnostic tool for gait disorders and identifying foot deformities. The plan to finish this project will be in mid-December and a technical report will be produced with it. The research project will be answered through interviewing credible people and reviewing case studies related to the topic of my research. The plan to finish this project will be around March-April and an STS research paper will be produced with it. Overall, this thesis will promote the utilization of more diagnostic tools for others.

References

Research Report

American Cancer Society. (n.d.). *Cancer Facts & Figures for African Americans 2019-2021*. Retrieved October 23, 2021, from https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/cancer-facts-and-figures-for-african-americans/cancer-facts-and-figures-for-african-americans-2019-2021.pdf.

Centers for Disease Control and Prevention. (2019, September 19). *Promoting cancer screening in partnership with Health Ministries in 9 African American churches in South Los Angeles: An implementation pilot study*. Centers for Disease Control and Prevention. Retrieved October 23, 2021, from https://www.cdc.gov/pcd/issues/2019/19_0135.htm.

Choi, H. C. W., Lam, K.-O., Pang, H. H. M., Tsang, S. K. C., Ngan, R. K. C., & Lee, A. W. M. (2019, August 7). *Global Comparison of Cancer Outcomes: Standardization and Correlation with Healthcare Expenditures*. BMC public health. Retrieved October 24, 2021, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6686500/.

Emmons, K. M., & Colditz, G. A. (2016, May 25). *The Role of Universal Health Coverage in Reducing Cancer Deaths and Disparities Karen M Emmons*. Lancet. Retrieved October 24, 2021, from https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(16)30376-2/fulltext.

https://www.facebook.com/thebalancecom. (2018). *How to Close the Racial Wealth Gap in the United States*. The Balance. https://www.thebalance.com/racial-wealth-gap-in-united-states-4169678

National Cancer Institute. (2021, May 5). *What Is Cancer?* National Cancer Institute; Cancer.gov. https://www.cancer.gov/about-cancer/understanding/what-is-cancer

National Cancer Institute. (2015). *Common Cancer Types*. National Cancer Institute; Cancer.gov. https://www.cancer.gov/types/common-cancers

Racial Tension in the 1970s. (n.d.). WHHA (En-US). Retrieved November 1, 2021, from https://www.whitehousehistory.org/racial-tension-in-the-1970s#:~:text=Racial%20tensions%20were%20high%20in%201970%2C%20as%20blacks

Stanford Health Care. (2014). *Stanford Health Care*. Stanfordhealthcare.org. https://stanfordhealthcare.org/medical-conditions/cancer/cancer/cancer-causes.html

Why Are Cancer Deaths Higher Among African Americans, and What Can be Done About It? Work Stride. (2019, October 29). Retrieved October 24, 2021, from https://www.workstride.org/minorities-and-cancer/.

U.S. unemployment rate in 2018, by ethnicity | Statista. (2018). Statista; Statista. https://www.statista.com/statistics/237917/us-unemployment-rate-by-race-and-ethnicity/

Wolff, M., Bates, T., Beck, B., & Young, S. (n.d.). *Cancer Prevention in Underserved African American Communities: Barriers and effective strategies M*. Retrieved October 23, 2021, from https://www.researchgate.net/publication/9004984_Cancer_prevention_in_underserved_African_American_Communities_Barriers_and_effective_strategies_-_A_review_of_the_literature.

Zavala, V. A., Bracci, P. M., Carethers, J. M., Carvajal-Carmona, L., Coggins, N. B., Cruz-Correa, M. R., Davis, M., de Smith, A. J., Dutil, J., Figueiredo, J. C., Fox, R., Graves, K. D., Gomez, S. L., Llera, A., Neuhausen, S. L., Newman, L., Nguyen, T., Palmer, J. R., Palmer, N. R., … Fejerman, L. (2020, September 9). *Cancer Health Disparities in Racial/Ethnic Minorities in the United States*. Nature News. Retrieved October 25, 2021, from https://www.nature.com/articles/s41416-020-01038-6.

Technical Report

Cavanagh, P., Rodgers, M. and liboshi, A., 2021. *Pressure Distribution under Symptom- Free Feet during Barefoot Standing*.

Hessert, M., Vyas, M., Leach, J., Hu, K., Lipsitz, L. and Novak, V., 2005. Foot pressure distribution during walking in young and old adults. [online] BMC. Available at: <https://doi.org/10.1186/1471-2318-5-8> [Accessed 10 September 2021].

H. Odabas, C. Bulgan, B. Bingul and K. Sarpyener, The evaluation of foot pressure and postural structure of national golfers, AOTT, vol. 53, no. 2, pp. 150-153, 2019. Available: https://doi.org/10.1016/j.aott.2019.02.005. [Accessed 10 September 2021].

L. Shu, T. Hua, Y. Wang, Q. Li, D. D. Feng and X. Tao, "In-Shoe Plantar Pressure Measurement and Analysis System Based on Fabric Pressure Sensing Array," in *IEEE Transactions on Information Technology in Biomedicine*, vol. 14, no. 3, pp. 767-775, May 2010, doi: 10.1109/TITB.2009.2038904.

Orendurff, M., Rohr, E. and Segal, A., 2007. Regional Foot Pressure during Running, Cutting, Jumping, and Landing - Michael S. Orendurff, Eric S. Rohr, Ava D. Segal, Jonathan W. Medley, John R. Green, Nancy J. Kadel, 2008. [online] SAGE Journals. Available at: <https://journals.sagepub.com/doi/10.1177/0363546507309315?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%20%200pubmed> [Accessed 20 September 2021].

"Ultimaker 3D Printers & Filament," *Dynamism*. [Online]. Available: https://www.dynamism.com/ultimaker.html?position=&keyword=Ultimaker&device=c&network=s&matchtype=e&campaignid=388324046&adgroupid=1238050321885212&msclkid=2d3f96b0dc1f119a8460f7f778daa5bf&utm_source=bing&utm_medium=cpc&utm_campaign=_Brand_Ultimaker Exact&utm_term=Ultimaker&utm_content=Brand_Ultimaker. [Accessed: 19-Sep-2021].