Wearable Medical Device for Bladder Monitoring

Irfan Wisanggeni, Skyler Justis
Industry Sponsors: Nasser Saber, Fuxing Yang, Joon Hwan Choi
Faculty Advisor: Dr. James Peckol

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Introduction

Urinary incontinence affects up to 3-17% of women and 3-11% of men at some point in their life [1]. This inability to control the bladder increases with age and can make everyday life troublesome for a lot of people. This project seeks to address that by providing continuous monitoring of the user's bladder with notifications alerting the user to use the restroom.

Requirements

- Qualitative readings for bladder volume
- Communicate with mobile app to display warnings
- 8-12 hour battery life

Components of Design

Initially, the hardware for the project was to be the Valencell Development Platform. Due to issues with restrictions made by the manufacturer, we switched to the Arduino Nano halfway through the project. We used the Arduino as the main processing component of the project in conjunction with Near-Infrared (NIR) Light Emitting Diodes (LEDs) as well as NIR sensors.

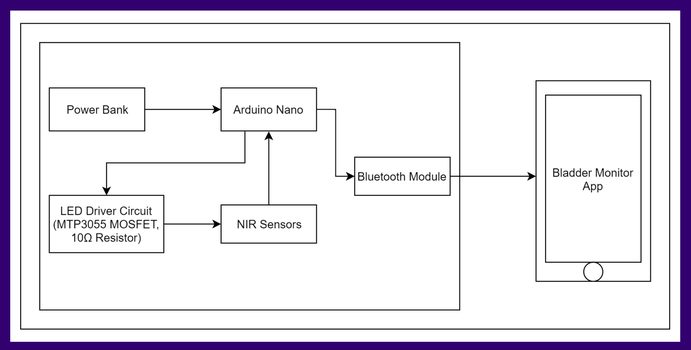

Figure 1: Block Diagram of Bladder Monitoring System

Theory

Rather than measuring the exact volume of the bladder, we measure the expansion of the bladder, As the bladder fills with urine, it increases in size. By using multiple sensors at varying heights, we can track this change in size.

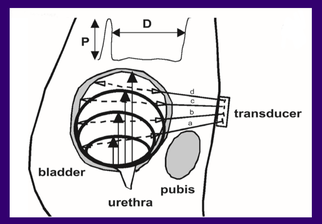

Figure 2: Diagram of Staggered Sensors [2]

Software

The software in the app can be categorized into 2 elements: Signal processing and the mobile app. The signal processing was written in Arduino code and ran directly on the Arduino Nano. It was responsible for intaking the data from the ADC on the Arduino and computing the corresponding bladder volume. The mobile app was developed for Android using Android Studio. It produces push notifications corresponding to: empty bladder, semi-filled bladder, and a completely filled bladder.

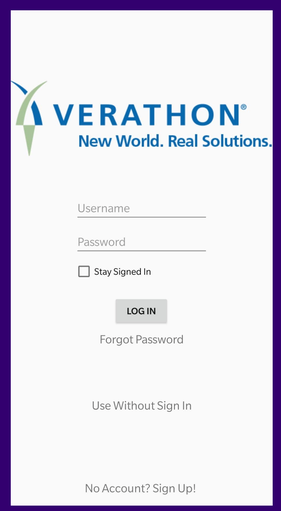

Figure 3: App Login Screen

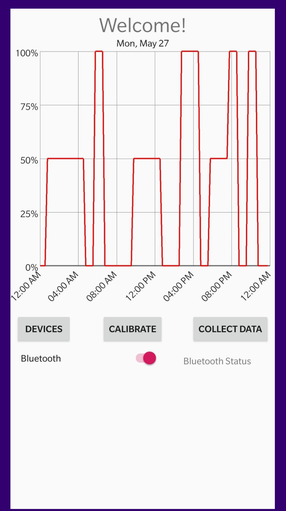

Figure 4: App Data Logging

Testing & Results

In order to accurately simulate the human bladder, we used the following:

- Biomimic optical phantom to replicate the optical properties of human skin/flesh
- Water to simulate urine. Since urine is 95% water, the optical properties are very similar
- Acrylic box as a receptacle for water used to mimic the human bladder

Near-infrared light was selected due to water's peak absorption being with 975 nm light. For this project, we used 940 nm LEDs.

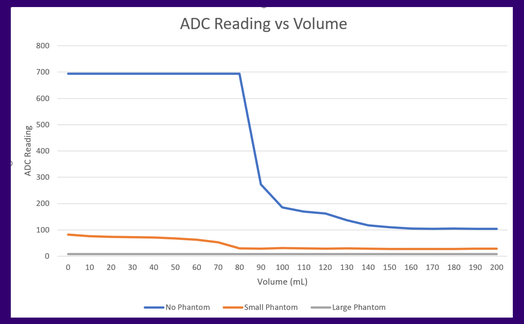

Figure 5: Sensor Output vs. Liquid Volume

Conclusion & Future Work

Our prototype is successful in determining a qualitative assessment of the volume of liquid in the simulated bladder. The mobile application also successfully alerts the user of when they need to use the restroom. By using infrared, our prototype is also safe for repeated human use.

In future adoptions of this project, it would be helpful to explore more ways of increasing the precision of the readings. While our project provides a qualitative output, it may be helpful to provide specific readings in mL.

References:

[1] V. Nitti, "The Prevalence of Urinary Incontinence", *PubMed Central (PMC), 2019. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1476070/. [Accessed: 18- Mar- 2019].*

[2] H. Kodama, H. Yoshimura, and Y. Nagata, "An ultrasonic urine sensor," *Gerontechnology,* vol. 8, no. 1, 2009.