Wearable Medical Device for Bladder Volume Monitoring

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Introduction

In the United States, 25 million patients suffer from urinary incontinence issues [1]. To combat urinary incontinence, our team has developed a discreet wearable medical device for bladder volume monitoring. Unlike most bladder scanners, our device does not require ultrasound gel, can automatically take bladder volume measurements at given time intervals, and is easy for patient use.

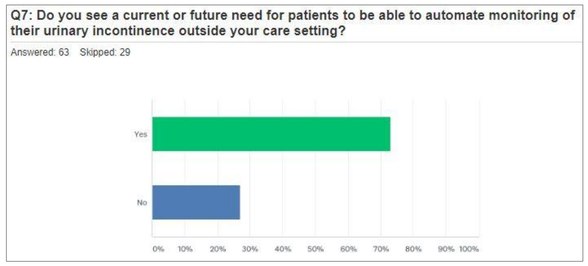

Figure 1: Results from survey given to various medical professionals

After conducting a survey with 98 different medical professionals, we learned:

- 74% of the participants see a need for bladder monitoring outside of the care setting
- 68% would like automated scheduled monitoring of their patients
- 61% would like to have results automatically sent to them

Based on these responses, we believe our Wearable Medical Device for Bladder Volume Monitoring will meet the needs of patients suffering from urinary incontinence.

Urine Detection Method

Based on the article “Noninvasive Optical Monitoring of Bladder Filling to Capacity Using a Wireless Near Infrared Spectroscopy Device” published by IEEE [2], we chose to use near infrared (NIR) sensors and emitters to detect urine in the bladder.

Figure 2: NIR sensor

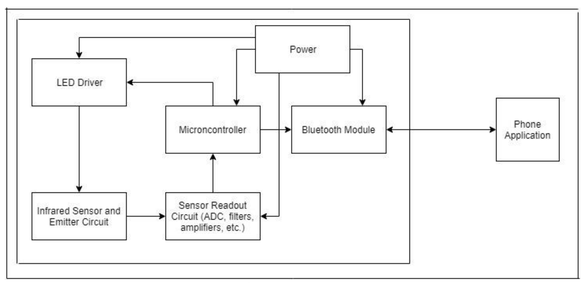

FIgure 3: Block Diagram for Wearable Bladder Monitor Prototype

Water experiences peak absorption with 975 nm light, and this wavelength can easily penetrate through human tissue. Since urine is typically 95% water, we can expect urine in the bladder to absorb 975 nm light. Our prototype works by shining 975 nm light at the bladder and measuring how much light is returned to our sensor. If a large amount of absorption occurs, we can determine that the bladder is full and needs to be voided. NIR is safe tool commonly used for medical devices, and NIR sensors and LEDs are an inexpensive solution to bladder volume monitoring.

Results

Our test set up consists of NIR sensors, NIR LEDs, and hardware for the Bladder Volume Monitoring Prototype. Since pork and human tissue have similar optical characteristics, we used pork meat as a barrier between our sensors and the bladder. Once the sensors and LEDs were attached to the pork, we would drain or fill a cup or balloon with water and observe the voltage output of the sensors. Our goal was to determine if our sensors and LEDs could detect water. Figure 5 below shows an early version of our test setup.

By measuring the light absorption through pork and water, we were able to observe a 10% to 30% voltage drop from our sensors when comparing our empty water container to our full water container, shown in Figure 4 below. This allowed us to reliably measure water through tissue with our Bladder Volume Monitoring Prototype.

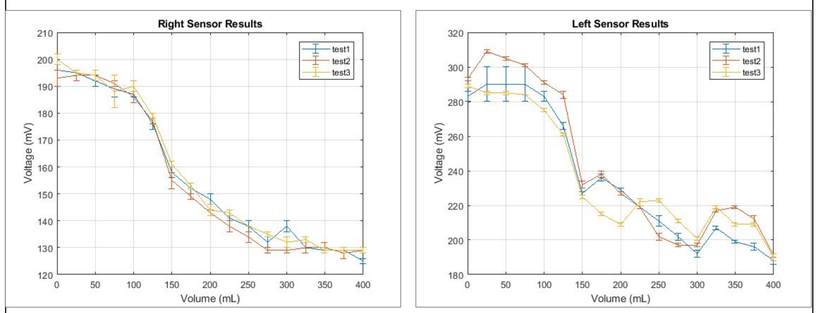

Figure 4: Voltage output of NIR sensor (mV) versus water volume (mL)

Figure 5: Early test set up with pork, water, and NIR sensors and LEDs

Mobile Application

Our user-friendly Android mobile application was developed to help users keep track of bladder volume status continually. Features of the app include:

- Communicating with the device via Bluetooth making it more convenient to use.
- Allowing users to determine the time interval between bladder measurements for the device.
- Showing bladder volume status with a color bar (green means “empty”, yellow means “half full”, and red means “full”).
- Storing bladder volume status during the previous 12 hours and drawing them as a graph.
- Automatically notifying users with a message as bladder volume is detected as “full”.

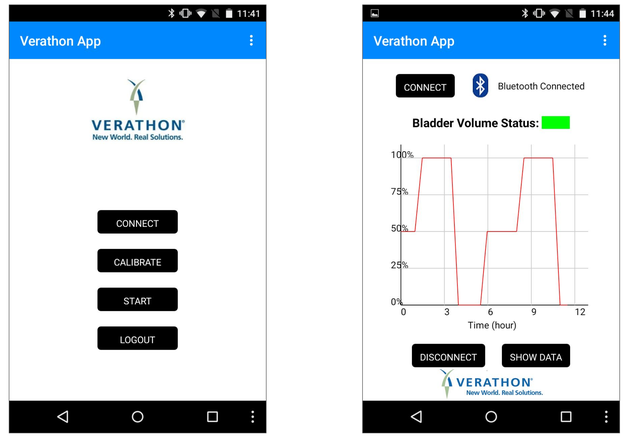

Figure 6: Mobile app graphic user interface

Conclusion

Our prototype successfully detects water through a human like tissue and sends the results to an Android phone application. This phone application will alert a user of the need to void the bladder when the volume reaches near full capacity. Caretakers can also receive this notification remotely via our phone app. Our prototype is safe and easy to use. We believe these features will benefit patients who struggle with urinary incontinence as well as the medical professionals who care for these individuals.

References:

[1] "How To Create A Fundraiser On Facebook", LEARN ABOUT #INCONTINENCE AND #BLADDERLEAKAGE CAUSES AND TREATMENTS | NATIONAL ASSOCIATION FOR CONTINENCE, 2018. [Online]. Available: https://www.nafc.org/nafc-facebook-fundraiser/?rq=facts%20and%20statistics. [Accessed: 26- Feb- 2018].

[2] Molavi, B., Shadgan, B., Macnab, A. and Dumont, G. (2014). Noninvasive Optical Monitoring of Bladder Filling to Capacity Using a Wireless Near Infrared Spectroscopy Device - IEEE Journals & Magazine. [online] Ieeexplore.ieee.org. Available at: http://ieeexplore.ieee.org/document/6581922/ [Accessed 27 May 2018].