Non-Invasive Bladder Volume Awareness for SCI Patients

Many patients suffer from the consequences of spinal cord injury (SCI) and congenital spinal anomalies. Although many of these individuals have obvious limitations in mobility, unbeknownst to the general public is that nearly all of them lack control of their bladder. These patients have to catheterize periodically, e.g., every 3 to 4 hours, throughout the day to empty their bladders. This high frequency of emptying adds "insult to injury". A commonly reported problem is making the difficult trip to the bathroom in a wheelchair or requesting help from a caregiver, to only find a small amount of urine in the bladder. Or worse, not getting to the bathroom in time and leaking urine because the bladder was too full. To address this problem, we have built a non-invasive, flexible, patch-like device that would be discreetly worn by SCI patients under their clothing to receive (or to send to their caregivers) timely alerts for starting to look for a bathroom to perform self- or assisted-catheterization. The device utilizes an array of light-emitting diodes (LEDs) and photodetectors to infer bladder size. The underlying physical principle exploited by our device is measurement of back scattered light at wavelengths for which water has high absorption coefficient.

To complement our existing hardware prototype, we would like to invite a team of students with interest in software/embedded systems to join us to build software to address the following tasks. The tasks are presented in the descending order of the priority (highest priority task first, etc.).

a) Desktop and embedded software for sensor configuration; data acquisition, analysis and visualization (during development and maintenance). The analysis would ideally include sifting through noisy data to identify anomalies and patterns of interest in the data. Note that the data has both temporal (time series) and spatial (64 channels) aspects. There is no constraint on the choice of technology/software programming language.
b) Mobile/smartwatch software that would be used by SCI patients (during production/use by patients). The applications would interface with the sensor (already built by our team) via Bluetooth to read data, infer bladder volume, and alert the patient when appropriate. In addition, the application would provide a means for patient to provide feedback on the accuracy of the device. Either Android or iOS application is acceptable.
c) Given the variation in patient's body shape, size, and other circumstances, the data analytics algorithms on the watch/phone will need to be personalized and/or incrementally improved to better serve the individual who is using the device. This can be accomplished partly via personalized ML models during deployment, and partly via incremental improvements to the prediction as user feedback trickles in.

The quality of developed software and good practice of software engineering principles (readability, extensibility, documentation, etc.) is of essence in this project. The team is expected to develop the software as an open source project under BSD license.