Smartphone-Based Blood Pressure Monitoring
Vishaal Dhamotharan\textsuperscript{1}, Mark Freithaler\textsuperscript{1}, Cederick Landry\textsuperscript{1}, Anand Chandrasekhar\textsuperscript{2}, Sanjeev G. Shroff\textsuperscript{1}, Ramakrishna Mukkamala\textsuperscript{1}
\textsuperscript{1}University of Pittsburgh, Pittsburgh, PA, USA
\textsuperscript{2}Massachusetts Institute of Technology, Cambridge MA, USA

Motivation: Hypertension management requires regular, out-of-clinic blood pressure (BP) monitoring in every adult. Conventional devices are cuff-based and not readily accessible. Smartphones are widely used nowadays, and our goal is to convert these everyday devices into absolute BP sensors.

Research: We extended the oscillometric principle, commonly used in automated cuff devices, to develop cuffless BP monitoring tools using smartphones. The main idea is for the user to serve as the actuator to vary the transmural pressure of the artery (instead of cuff inflation), while photoplethysmography (PPG) and other sensors are used to measure the variable blood volume oscillations and transmural pressure changes. The blood volume oscillation versus pressure function (“oscillogram”) is then analyzed to compute BP. We first developed an oscillometric finger pressing device, where the user presses steadily on a custom PPG-force sensor module to vary the external pressure of the underlying artery. We also developed an oscillometric hand raising application (android), where the user raises their hand to vary the internal pressure of the artery, measured via the built-in accelerometer while maintaining finger pressure on the smartphone camera (PPG). This application only estimates pulse pressure since standard smartphones do not include force sensing to measure contact pressure. We then developed algorithms based on a reduced mathematical model of oscillometry to estimate BP (systolic/ diastolic/ pulse) from these methods. We tested the devices in healthy volunteers under IRB approval and compared them to reference brachial cuff BP measurements.

Results and Conclusion: Volunteers were able to perform the finger pressing technique easily. Hand raising was relatively harder to perform but was learned upon practice. The smartphone-based methods yielded BP estimation precision errors in the range of 8-10 mmHg against cuff BP. Further research on smartphone-based BP monitoring via the oscillometric principle could help improve hypertension awareness and control rates around the world.