**Wearable Ambulatory Blood Pressure(BP) Measurement Device**

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A wrist worn BP measurement device that can be designed for home use(self-monitoring) or clinical use. Most BP measurement devices required an arm or wrist cuff to measure the BP non-invasively. The current way of BP measurement is to use an inflatable cuff placed on the upper arm over the brachial artery. **The research idea is to see if there is any way to develop a method/device to measure BP non-invasively without the need for a pressure cuff, to allow user friendly ambulatory BP measurement in a home environment**.

Some website, papers and documents reviewed.

Journal paper [1] is a good reference for finding out more about blood pressure measurement. Website [2] has a list of BP measurement devices that have been reviewed and found accurate. Website [2] discourages the use of the following type of BP measurement devices:-

* Finger devices – position of limbs and peripheral vasoconstriction affects accuracy.
* Wrist devices -
* Community BP measurement devices

The website recommends the use of Finapres Medical Systems | Portapres [3] in certain situations for continuous ambulatory BP monitoring. Accuracy is subject to various inaccuracies. The first version of the Portapres was developed in 90s. It works by measuring the BP at the finger using 2 finger cuffs in alternating pattern. Paper [4] has details on the device which uses Finger Arterial Pressure Recording or Vascular Unloading Technique[5]

The only paper that has something close to a wrist worn BP measurement device is [6]

Also found a survey paper [7] on signals and systems in ambulatory blood pressure monitoring using pulse transit time which is very useful and relevant.

There is a research group in Monash University Melbourne led by Dr. Mehmet Yuce that specializes in blood pressure measurement via PPT.

On the 7th of March 2018, IEEE Spectrum [8] published an article on Smartphone based blood pressure monitoring via the oscillometric finger pressing method. Dr. Ramakrishna Mukkamala from Michigan State University published a paper [9] detailed the technique. The device produces a blood pressure reading as accurate as finger cuff methods. There is a IEEE standard for Wearable Cuffless Blood Pressure Measuring Devices.

On 7th of Feb 2018, Cardiogram co-founder Johnson Hsieh reported [10]on their software called DeepHeart – a semi-supervised machine learning model to detect diabetes with 85% accuracy. The paper [11] mentioned that the approach was unique.

Omron showed its HeartGuide watch at the 2018 CES. It uses a oscillometric method to measure BP.[12] Samsung has the Simband wearable system for research.

Fitbit devices are made for activity and exercise tracking. It has a webpage to explain it’s heart rate monitoring functions.[13]

Apple has pages that explain how their heart rate app works [14]and also what affects the heart rate sensor accuracy.[15]

References:

[1] T. Pickering, “Principles and techniques of blood pressure measurement.,” *Cardiol. Clin.*, vol. 28, no. 4, pp. 571–586, 2010.

[2] Dabl Educational Trust, “Blood Pressure Monitors - Validation, Papers and Reviews.” [Online]. Available: http://www.dableducational.org/index.html.

[3] FinaPres Medical System, “PortaPres.” [Online]. Available: http://www.finapres.com/Products/Portapres.

[4] B. P. M. Imholz *et al.*, “Feasibility of ambulatory, continuous 24-hour finger arterial pressure recording,” *Hypertension*, vol. 21, no. 1, pp. 65–73, 1993.

[5] Wikipedia, “Vasuclar Unloading Technique.” [Online]. Available: https://en.wikipedia.org/wiki/Continuous\_noninvasive\_arterial\_pressure#Vascular\_unloading\_technique.

[6] V. N. et. Al, “Smart Watches for Physiological Monitoring: A Case Study on Blood Pressure Measurement.”

[7] D. Buxi, J. M. Redouté, and M. R. Yuce, “A survey on signals and systems in ambulatory blood pressure monitoring using pulse transit time,” *Physiol. Meas.*, vol. 36, no. 3, pp. R1–R26, 2015.

[8] E. Waltz, “New Smartphone Sensor Checks Your Blood Pressure,” *IEEE Spectrum*. [Online]. Available: https://spectrum.ieee.org/the-human-os/biomedical/devices/measure-your-blood-pressure-using-just-your-phone.

[9] J.-O. H. and R. M. Anand Chandrasekhar1, Chang-Sei Kim2, 3, Mohammed Naji1, Keerthana Natarajan1, “Smartphone-based blood pressure monitoring via the oscillometric finger-pressing method.”

[10] B. Ballinger and L. Schwartz, “Ordinary wearables can flag signs of diabetes, according to new Cardiogram study,” *Upbeat*. [Online]. Available: https://app.upbeatpr.com/stories/cardiogram/cardiogram-android-4-2/?ref=sc3FAQ.

[11] B. Ballinger *et al.*, “DeepHeart: Semi-Supervised Sequence Learning for Cardiovascular Risk Prediction,” 2018.

[12] L. Lugmayr, “Cuffless Wearable Blood Pressure Monitor In The Works.” [Online]. Available: https://www.i4u.com/2018/01/126797/cuffless-wearable-blood-pressure-monitors-works.

[13] Fitbit, “What should I know about my heart rate data?” [Online]. Available: http://help.fitbit.com/articles/en\_US/Help\_article/1565?c=Topics%3AAccuracy&l=en\_US&fs=Search&pn=1.

[14] A. Inc., “Your heart rate. What it means, and where on Apple Watch you’ll find it.” [Online]. Available: https://support.apple.com/en-my/HT204666.

[15] A. Inc., “Get the most accurate measurements using your Apple Watch.” [Online]. Available: https://support.apple.com/en-my/HT207941#heartrate.

Other reference material

1. <https://en.wikipedia.org/wiki/Blood_pressure_measurement>
2. <https://en.wikipedia.org/wiki/Ambulatory_blood_pressure>
3. <https://en.wikipedia.org/wiki/History_of_continuous_noninvasive_arterial_pressure>