Proposed Senior Design Project: Blood Pressure Monitor Utilizing a Pulse Transit Time Technique

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Project Description

Background: The Chronobiology Laboratory at the U of MN has known for years that when blood pressure is monitored by an ambulatory (wearable) device every half hour, day and night, for a week, five "Vascular Variability Disorders" can be detected. One of these disorders is a more precise definition of hypertension (high blood pressure) than is currently being used in mainstream healthcare; the others are either unknown or unused in mainstream healthcare. All of the VVDs, however, represent tangible risks of stroke and/or other health concerns. The Phoenix Project goal is the design of a blood pressure monitor that would enable bringing the use of VVD detection into everyday use in mainstream healthcare. This student design project will allow you to be a part of this groundbreaking endeavor.

Current methods for continuously monitoring blood pressure require the use of inflatable cuffs, pumps, and electronics similar to the automatic systems used in clinics and pharmacies. These methods are awkward, intrusive, and not conducive for wearing 24 hours a day for a week. The idea is to design and construct a monitor system that would be comfortable enough to wear for 24 hours a day, and cost effective enough to use at home.

Therefore, a new concept to monitor blood pressure has been proposed as described in the "Chen patent" (US Patent No. 6599251) to derive blood pressure from the timing of specific parts of the pulse waveforms. By recording a non-calibrated blood pressure pulse at two different distances from the heart, blood pressure can be determined by relating transit time between the two pulses using the equation: P=a+b*ln(T). Where “P” is the pressure, “T” is transit time, and “a” and “b” are constants and are determined by correlating the cuff blood pressure to the transit time. The student design project will help to realize this exciting new concept.

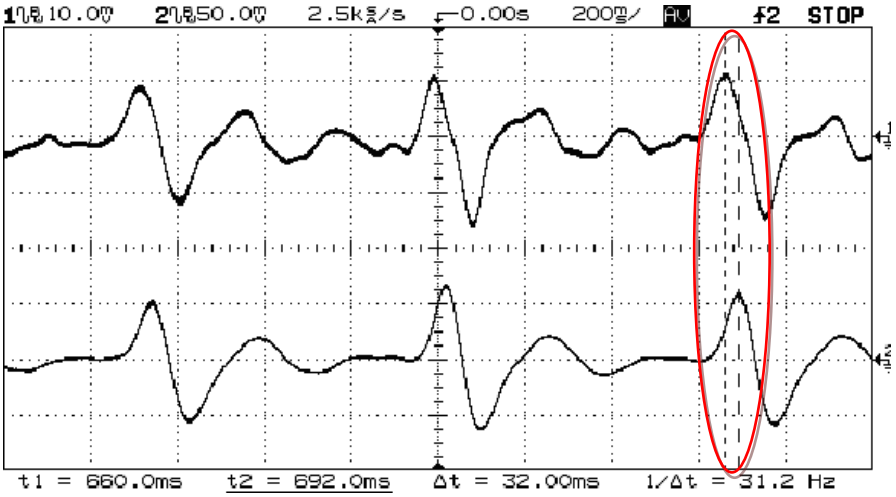

Fig 1. An example of pulse propagation delay between forearm and wrist

Scope: The scope of the project is to develop a feasibility concept system for a blood pressure monitor that monitors blood pressure (BP), based on the pulse transit time (a.k.a. pulse wave velocity) concept. There are several sensor technologies to choose from to achieve a successful system (e.g. piezoelectric films, IR optoelectronic sensors, acoustic sensors, etc.). The student team will choose a sensor to use by considering criteria such as ease of implementation and the ability to meet required accuracy and precision. Either analysis or experimentation could be used to choose the best path.

Project Goals:

1) Understand and describe the supplied pulse model, and derive expected transit times and accuracy.
2) Develop requirements and an error budget for a sensor system to record the shape of individual pulses at two locations on the body to determine adequate blood pressure readings.
3) Design, build, and test a sensor system to record pulse waveforms at two locations on the body (e.g. forearm and wrist).
4) Publish a final report that will be posted on the Phoenix Project website.

Possible stretch goals:

5) Design the system to be battery operated and wearable.
6) Develop the algorithms and software to determine the pulse transit times.
7) Determine the calibration constants for test subjects.
8) Test the system's accuracy against the cuff pressures at various blood pressures by inducing changes in a subject's blood pressure with exercise.

Known User Specifications: Blood pressure to be correlated to cuff pressure within +/- 3mmHg. Also, the system should have a path to achieve ease of use, wearability, and low cost (less than $100 CGS – Cost of Goods Sold).

Interdisciplinary Opportunities: Since the project requires the mechanical model for the expected transit times and error budget requirements as well as the need to develop a method for attaching the sensors, a mechanical engineer and/or biomedical engineer might be required. Also, since part of the project would include data acquisition, a computer science engineer might be needed to design and write programs to interface with the system. Due to the physiology involved, a medical student might be helpful in determining characteristics of the circulatory system. Finally, a nursing student might be useful in setting up calibration tests.

Proprietary Information: The Phoenix Project is completely open source; all information can be freely distributed and discussed. This includes freely discussing the project with prospective employers and inclusion on your résumé.

Available Resources: 1) There are funds available for the materials and supplies needed to build and test the system. 2) There is equipment available in the IEEE student room in Keller Hall (EE/CSci building). 3) The participants of the Phoenix Project will be available for consultation during the project. 4) There are many reference documents that can be made available for the various methods to capture the pulse waveforms. 5) There is a list of possible tasks that can be supplied to help get a project plan started.