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

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Project Description

Background: The U of MN Chronobiology Center determined that when blood pressure is monitored by an ambulatory (wearable) blood pressure monitor every half hour, day and night, for a week, six "Vascular Variability Disorders" (VVDs) 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 still 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 devices are awkward, intrusive, and not conducive to being worn 24 hours a day for a week. The Phoenix Project mission is to design and construct a monitor system that would be comfortable enough to wear for 24 hours a day, cost effective enough to use at home, and robust enough to deploy on a very large scale.

A 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 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.

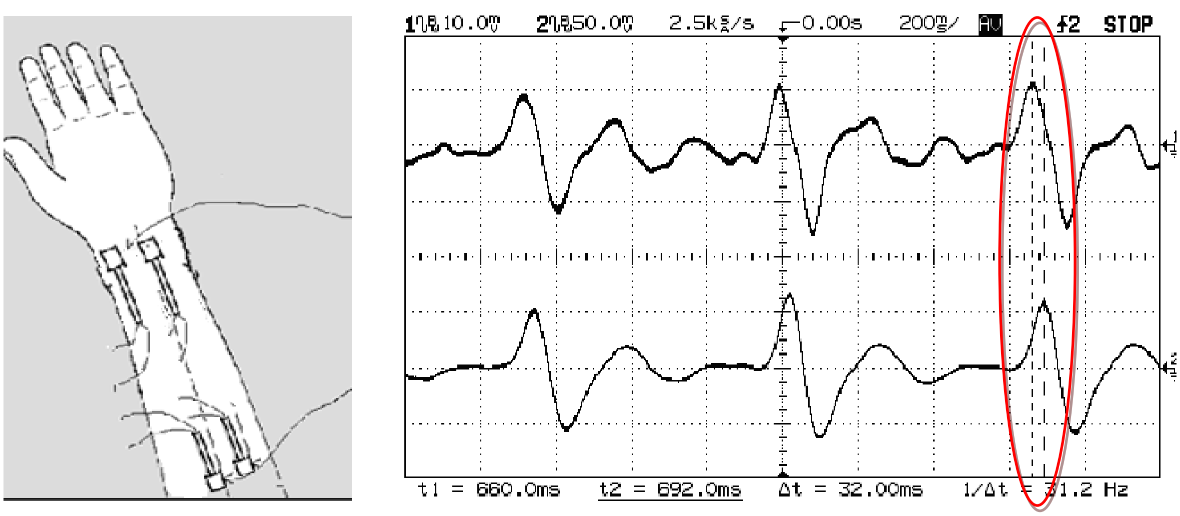

Fig 1. An example of pulse propagation delay between forearm and wrist

Scope: The scope of the student project is to improve the signals used in a feasibility/concept system for a blood pressure (BP) monitor based on the pulse transit time (a.k.a. pulse wave velocity) concept. The student team will choose an infrared sensor, considering implementation, physical mounting, power, and accuracy/precision requirements. A multi-channel filter/amplifier circuit will be constructed, and experiments with an array of sensors at the wrist, forearm, and other locations will be performed, with subsequent data analysis.

Student Project Goals:

1) Label the connections and parts on last semester's board. Capture data from 2 channels (two locations on the body, e.g., forearm and wrist) with a DAQ from last semester's board early in the project. Develop Labview program to capture data. Develop a primary and secondary peak & trough detection algorithm (e.g., in Matlab).
2) Develop accuracy and precision requirements for recording the shape of individual pulses at two locations on the body to determine adequate blood pressure readings early in the project. Express these requirements verbally in a formal requirements statement.
3) Starting from last semester's design, simulate the analog filter with Spice and adjust the design to eliminate DC drift. Use a new bandpass filter with a steep rolloff (active multi-pole, brick-wall filter) if the existing design can't be adjusted sufficiently. Redesign to lower the voltage to a 3-volt range or 1.5 volt range without saturating the amplifier.
4) Design and build a new 4-channel filter/amplifier circuit, with stronger, flexible, shielded cables and connectors (instead of loose wire and terminal blocks). Build into a shielded box or package.
5) Capture data from 2 channels (two locations on the body, e.g., forearm and wrist) with a DAQ from the new circuit board, Labview program, and your peak/trough algorithm. Derive numeric accuracy and precision requirements experimentally using data taken from the new circuit board.

Possible stretch goals:

1) Design the system to be wearable.
2) Determine the pulse transit time calibration constants for specific test subjects.
3) Test the system's accuracy against the cuff pressures at various blood pressures by inducing changes in a subject's blood pressure with exercise.
4) Perform experiments using an array of sensors to eliminate sensitivity to the exact positioning of the sensors that we have observed in our previous work.

Known User Specifications: Blood pressure is to be correlated to cuff pressure within +/- 3mmHg. The system design should have a path to achieve ease of use, wearability, and low cost (less than $100).

Project Orientation: This is primarily a project of sensor and associated analog circuit requirements development, design, and construction, followed by data collection and analysis. There is also a small software component that can be done in parallel to support the electronics work.

No Proprietary Information: The Phoenix Project is completely open source; all information can be freely distributed, discussed with prospective employers, and included on résumés.

Available Resources: 1) Funds for the materials and supplies needed to build and test the system. 2) Lab equipment in the IEEE student room in Keller Hall (EE/CSci building). 3) Participants of the Phoenix Project are available for consultation. 4) Reference documents for the pulse waveforms. 5) List of tasks that can be supplied to help get a project plan started.