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

Larry Beaty (labeaty@ieee.org) Twin Cities IEEE Phoenix Project January 2012

Project Description

Background: The U of MN Chronobiology Laboratory 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 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 methods 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, and cost effective enough to use at home.

Therefore, 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. The student design project will help to realize this exciting concept.

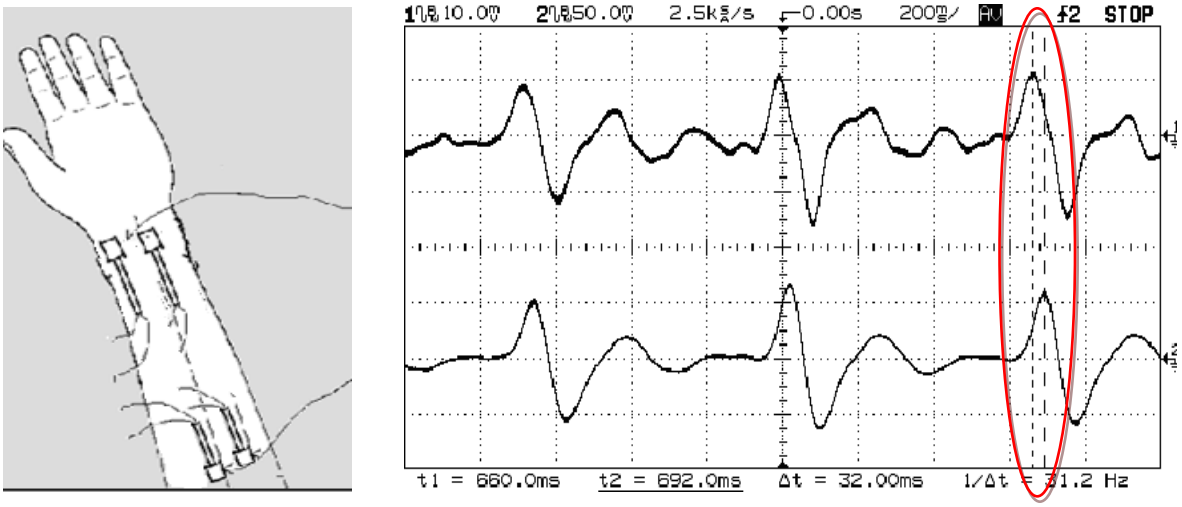

Fig 1. An example of pulse propagation delay between forearm and wrist

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). The student team will choose a piezoelectric sensor to purchase or construct by considering criteria such as ease of implementation and the ability to meet required accuracy and precision. A multi-channel amplifier circuit will be constructed, and experiments with an array of sensors at the wrist, forearm, and other localtions will be performed, with subsequent data analysis.

Project Goals:

1) Understand and describe the supplied pulse model, and derive expected transit times and accuracy.
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.
3) Design and build an expanded amplifier/sensor circuit for use with Infrared sensors. Measure problems in the current system we have, include improvements in your new design. Handle a larger number of sensors with less noise than our current system. Design a new cable and connector arrangement, with more physically-flexible cabling and a mechanism for getting cables through the enclosure to the board for testing.
4) Design, build, and test a sensor system to record pulse waveforms at two locations on the body (e.g. forearm and wrist), using at least four sensors.
    - 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.
5) Perform experiments with electrical and/or mechanical interfacing of an IR sensor to the skin to enable detection of the entire pulse wave by using different wavelengths and lenses.

Possible stretch goals:

1) Design the system to be battery operated and wearable.
2) Develop the algorithms and software to determine the pulse transit times.
3) Determine the pulse transit time calibration constants for specific test subjects.
4) 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).

Project Orientation: This is primarily a project of sensor and associated circuit requirements development, design, and construction, followed by data collection and analysis. There is also a small optional 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 and discussed. This includes freely discussing the project with prospective employers and inclusion 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 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.