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Work in Progress: Assessment of a Freshman Engineering Project on Contrasting Automatic Blood Pressure Measurement Approaches

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Work in Progress: Assessment of a Freshman Engineering Project on Contrasting Automatic Blood Pressure Measurement Approaches

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Abstract

This paper introduces a new multidisciplinary design and development project, entitled Automatic Blood Pressure Measurement (ABPM), which freshman engineering students can take to fulfill part of their first year curriculum requirements. The paper first describes ABPM and then presents an overview of a preliminary assessement.

Introduction

The College of Engineering Core Course Sequence: A new freshman engineering core course sequence was developed and initiated in The College of Engineering at Villanova University in the Fall of 2009. This six-credit two-semester sequence is divided into four half-semester blocks: the first half-semester block is the *Core Course [1]*, consisting of lectures and micro (one-class) projects; the middle two half-semester blocks are *seven-week long multidisciplinary mini-projects*; and the last half-semester block consists of *program-specific mini-courses*. In a given academic year, six different mini-projects are offered in each of the two mini-project half-semester slots. A student experiences two of these projects of his/her choice. The ABPM Project, which was introduced in Fall 2011, is currently one of these mini-projects.

ABPM Mini-Project Overview: The ABPM Project introduces students to stages of the design and development process of an ABPM device through a sequence of interleaved lectures and labs. The lectures are multidisciplinary, addressing technical areas pertinent to the project – namely fluid dynamics, cardiovascular physiology, health care, sensors and analog electronics, digital signal processing, and digital electronics. Lectures are given within a "just-in-time" schedule. In four labs students investigate various aspects of ABPM device design.

A primary strategy used to guide students to a better understanding of the engineering design process in general, and engineering trade-offs in particular, is to have them consider different design options. Students learn and conduct experiments on different approaches to blood pressure measurement, and they consider several types of digital processors for implementation. The most innovative aspects of this project are: its intercollegiate nature, with professors from the College of Engineering, College of Liberal Arts & Sciences, and the Nursing College lending their expertise; and the extent to which different designs are contrasted.

Three non-invasive blood pressure measurement approaches were selected for consideration: 1) automatic stethoscope (a.k.a. the sphygmomanometry); 2) oscillometric; and 3) finger-pulse. In the culminating Lab 4, each student team builds an ABPM device based on one of these approaches and one of several types of digital processor (currently a Digital Signal Processing (DSP) chip or an Advanced RISC Machine (ARM) processor). Each team has a different approach/digital-processor combination. During a discussion in the final class, the teams share their experience and contrast the different approaches and processors.

Automatic Blood Pressure Measurement Project Description

The ABPM Project schedule consists of fourteen 75 minute classes (two per week for seven weeks) along with once-a-week open lab sessions. As mentioned earlier, these classes are an interleaved sequence of lectures and labs. Table 1 is a list of the class activities.

Class #	Type	Topic
1	Lecture 1	Introduction: motivation, blood pressure measurement approaches, Profs. Buckley & Khuon (ECE)
2	Lecture 2	Fluid dynamics & blood pressure, Prof. Bill Kelly (ChemE)
3	Lecture 3	Cardiovascular physiology, Prof. Phil Stephens (Bio)
4	Lecture 4/ Lab 1	Health Care & blood pressure; manual blood pressure measurement, Prof. Teri Capriotti (Nur)
5,6	Lab 2	Blood pressure signal evaluation & signal processing in Matlab (provided signals)
7	Lecture 5	Sensors & Analog interface electronics Prof. Lunal Khuon (ECE)
8,9	Lab 3	Sensors & Analog electronics: build filter to derive oscillometric signal from cuff pressure signal
10	Lecture 6	Digital processors & development systems Prof. Kevin Buckley (ECE)
11	Lab 4a	Acquiring blood pressure signals onto desktop, evaluate and process in Matlab (as in Lab 2)
12-13	Labs 4b-d	Acquiring blood pressure signals into digital processor, building an ABPM device
14	Discussion, Assessment	open discussion contrasting different approaches, assessment

Table 1: ABPM Project schedule of lecture & lab activities.

The six lectures overview interdisciplinary topics for which expertise is required. The four labs, which provide students experience in development of a device, cover: 1) manual blood pressure measurement, 2) digital signal processing, 3) sensors & analog electronics, and 4) building a digital ABPM device. Figure 1 provides illustrations of activities covered in these labs.

Overview of a Preliminary Assessment

Four project objectives are introduced and assessed. Assessments are based on: 1) entrance & exit surveys conducted specifically for this project; 2) evaluation of quizzes, lab reports, poster presentations, final design reports, and "engineering scenario videos"; and 3) results from a Villanova University Class and Teacher Survey (CATS) issued for each Villanova course.

Project Objective 1: Exemplify to Students the Engineering Design/Development Process. With a seven week freshman project there is a limit to how much of the design process students can experience. It is not expected that freshman will actually design an ABPM device. Instead,

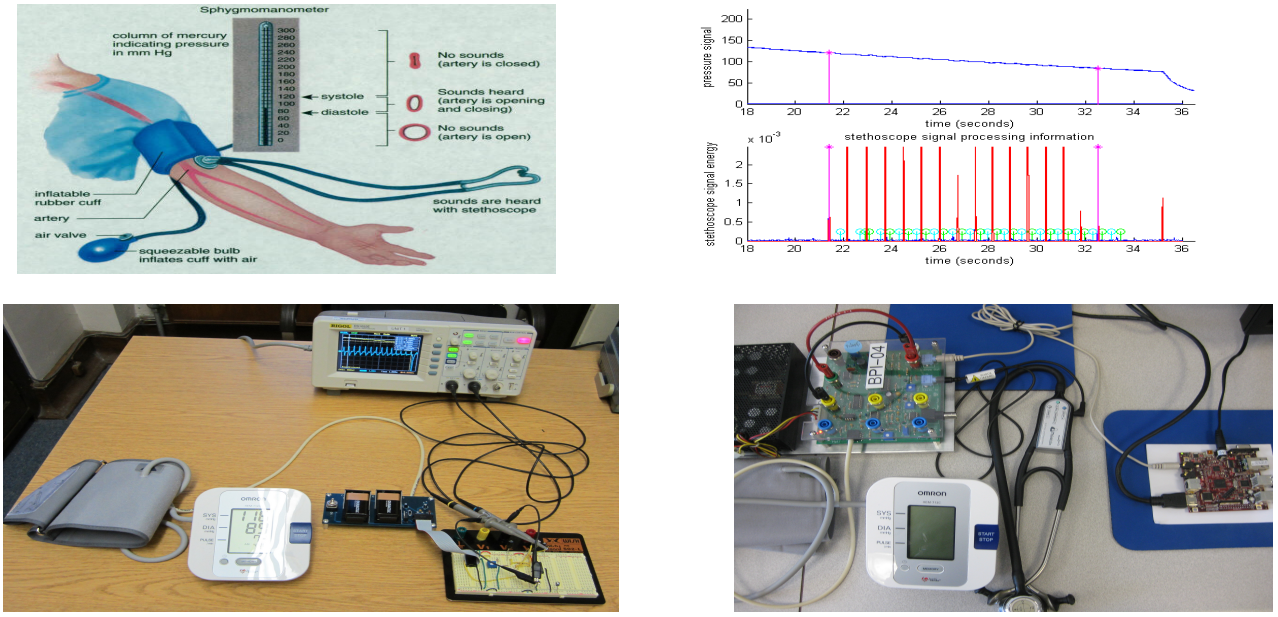

Figure 1: **Lab 1**: manual blood pressure measurement; **Lab 2** digital signal processing of ABPM signals using Matlab; **Lab 3**: investigating sensors and building/testing analog interfacing hardware; and **Lab 4** digital processors and building an ABPM device.

students are basically given designs, and they have to perform a sequence of procedures to understand, implement and test them. In the first class the engineering design and development process is overviewed and it is emphasized that the project is structured to parallel (not implement) this process. Throughout, students are required to study and tweak given designs – they can not simply "go through the motions" with the procedures.

> *Outcome:* Students can successfully associate different topics introduced with different steps in the engineering design/development process.

Assessment: In a quiz taken at the end of the project in Spring 2012, students were asked to match engineering design process phases to lab objectives. Students answered this question with 76.5% accuracy, indicating that they understood how the project labs paralleled the engineering design/development process. In Fall 2012 the same question was asked in both pre- and post-project surveys with, respectively, 61% and 75% accuracy.

Project Objective 2: Expose Students to Multidisciplinary Aspects of Engineering. Students are introduced to several areas of expertise.

> *Outcome:* Students can successfully answer questions concerning the reliance of different disciplines to accomplish an ABPM device design/development.

Assessment: In pre- and post-project surveys, students are asked to comment on relationships between the areas of expertise and the project design activities. In assessing their responses, a numerical rubric was defined with 1 indicating "limited" and 3 indicating "mastered". For Fall 2012, the pre-project survey mean and standard deviation were 1.5 and 0.31. For the

post-project survey they were 2.25 and 0.55 respectively. No student mastered the pre-project survey. In the post-project survey, a third of the class scored 3. In both the Fall 2012 surveys, a significant number of answers were vague. Results indicate some effectiveness, but also suggest a need to improve the survey questions. Until this is done, results can not be used to motivate project changes.

Project Objective 3: Motivate Students to Continue Pursuit of an Engineering Profession

Relating engineering to every-day experience is a priority throughout the project. Additionally an "engineering scenario" video project requirement encourages students to consider engineering in every-day life. These videos portray hidden engineering stories in TV, movies or advertisement. The videos are evaluated using the criteria that they: should be fun; relate to automatic blood pressure measurement; and illustrate the engineering design/development process.

Outcome: Students found the project intellectually stimulating.

Assessment: In Fall 2011 CATS results, response to the statement "I found the course intellectually stimulating" was very positive. 61% of the students strongly agreed with this statement, and 32% agreed. Results for Spring 2012 closely matched these.

Project Objective 4: Student Teams Successfully Build an ABPM Device while Experiencing Most Aspects of the Engineering Design/Development Process

In Lab 4, design teams complete the project design/development steps covered in this project. Each team acquires blood pressure signals using the sensors, analog electronics, and digital processor for its assigned measurement approach and digital processor. Signals are processed in real-time to generate systolic & diastolic blood pressure measurements.

Outcome: Teams successfully implement real-time automatic blood pressure measurement for their measurement approach and digital processor combination.

Assessment: Lab 4 culminates with each team demonstrating a functioning blood pressure measurement device to an instructor. Although an accurate ABPM reading is not required, to be judged successful a team is required to be able to show good signal acquisition technique, good acquired signals, an understanding of the underlying digital signal processing, and a reasonable result. Of the 37 design teams to date, all but one was successful.

Summary

The ABPM Project is a freshman mini-project which is succeeding in realizing the objectives identified in this paper. Preliminary outcome assessment indicates that objectives are being achieved, and suggests areas for improvement in both the assessment process and the project itself.

References

[1] Caverly, R., Fulmar, H., Santhanam, S., Singh, P., O'Brien, J, Jones, G., Char, E., Mercede, F., Weinstein, R., and Yost, J., *Project-Based Freshman Engineering Experience: The Core Course,* ASEE Annual Meeting, 2010.

[2] L. Khuon, T. Camise, C. Bannan and K. Buckley, "Contrasting Blood Pressure Measurement Approaches in a Freshman Engineering Design Project," Spring 2012 Mid-Atlantic ASEE Conference, Newark, Delaware, April, 2012.