University and Small Business Collaboration for Undergraduate Research Projects in Healthcare Robotics

Lee Gatton[#] and Saeed Khan[*]
[#]Gatton Research and Development
[*]Engineering Technology Department, K-State Salina

Abstract

This paper will discuss the on-going research collaboration between a university's engineering technology department and an engineering research firm. The purpose and the reasons for this joint research project will be detailed from both the university's viewpoint and the small business viewpoint.

This research project involves applying Social Assistive Robotic technology to reducing in-home healthcare costs which continue to rise. The project focuses on interfacing commercially available physiological sensors, such as for blood pressure or heart rate, with a mobile robotic platform that is equipped with a conversational interface. This conversational interface will engage the user to remind them of measurement times, reschedule times as required, and provide feedback and encouragement all done in a conversational manner. This is done to keep the user involved and participating in their healthcare and their well-being. This is necessary because a program of continually monitoring one's own healthcare parameters can become very tedious and the temptation to forgo the monitoring process begins to grow as time progresses.

Collaboration on this type of research project between industry and a university provides undergraduate students with the opportunity to participate in real-world research that can have wide ranging impact on healthcare. This type of hands-on development and testing experience can build a foundation for a student's career.

This paper will examine the details of the research project, the advantages of such a partnership and the benefits to the researchers and students of this type of affiliation.

Introduction

This paper will discuss the on-going research collaboration between a university's engineering technology department and an engineering research firm. The project that will be discussed is that of developing a Healthcare Companion Robot to assist in providing in-home healthcare.

Collaboration on this type of research project between industry and a university provides undergraduate students with the opportunity to participate in real-world research that can have a wide ranging impact on healthcare. As a small business owner and a prospective employer I would place a high value on this type of experience. A student's participation in this type of hands-on development and testing experience implies that the student has been exposed to report writing, project management techniques, and hardware/software troubleshooting. All of these aspects indicate that such a student could rapidly become a productive employee without the

need for additional training. In fact a student could use this type of development experience in robotic healthcare as a foundation for their career. The Robotics Virtual Organization (Robotics VO) which is sponsored by the National Science Foundation, states in its 2013 edition of *A Roadmap for U.S. Robotics From Internet to Robotics*[1] that areas that present the key technological and research challenges in robotics are; physical human-robot interaction and interfaces; social human-robot interaction and interfaces; robot-mediated health communication; automated understanding of human state and behavior during robot interaction

This research project involves applying Social Assistive Robotic (SAR) technology to reducing in-home healthcare costs which the Centers for Medicare & Medicaid Services (cms.gov) are predicting to reach $154 billion by the year 2019, which will be more than double the amount spent in 2008. In this particular project the focus will be on interfacing commercially available physiological sensors, such as for blood pressure or heart rate, etc., with a mobile robotic platform that is equipped with a conversational interface. This interface will engage the user through conversation to remind them of measurement times, reschedule times as required, and provide feedback and encouragement all done in a conversational manner. This is more than simple speech recognition and response. It is a set of software routines that based on the user input and response will guide the user in a conversational fashion though the process of continuing to monitor physiological parameters on a regular basis in their home. This is done to keep the user involved and participating in their healthcare and their well-being. This is necessary because a program of continually monitoring one's own healthcare parameters can become very tedious and the temptation to forgo the monitoring process begins to grow as time progresses.

Research with Socially Assistive Robots has been conducted for the last few years. Research has been done in a number of areas including; assisting stroke victims with physical rehabilitation, assisting people with weight loss management and assisting the elderly with their meals. This assistance is in the form of social interaction, which is through verbal encouragements, feedback and reminders.

Dr. Mataric´, director of the Center for Robotics and Embedded Systems at the University of Southern California is prominent in the field of Socially Assistive Robotics. She has done research into using Socially Assistive Robots to help stroke victims with their physical rehabilitation. These robots have movable limbs and can duplicate the arm exercises used in the physical rehabilitation. The robots have embedded sensors that allow them to monitor the success of the patients in doing the exercises with the robots. Her research has shown that patients become more engaged in their in own healthcare when working with a socially assistive robot [2].

Dr. Cory Kidd did his doctoral thesis research [3] on applying Socially Assistive Robotics to weight loss. His research showed that participants in a weight-loss program responded very favorably to using a Socially Assistive Robot as an assistant in recording daily exercise and diet. This research is the basis for the Autom™ a personal weight loss coach that is schedule to be marketed later this year.

McColl and Nejat[4] describe in their paper, on using a Socially Assistive Robot to assist the patients at a long-term care facility during mealtime, of observing "positive attitudes towards Brian 2.1(the SAR) and found interaction with the robot to be enjoyable. The majority of participants especially liked the robot's human-like voice and the companionship the robot provided by just being there, and all the participants found its encouraging behaviors helpful."

This initial research conducted in different healthcare scenarios shows that a positive impact on healthcare was noted by employing Socially Assistive Robots.

Project Description

The goal of this project is development of a mobile, robotic healthcare companion.
The purpose of this robotic healthcare companion is to assist a user in taking, recording and transmitting physiological parameters such as; blood pressure, heart rate, blood oxygen levels, blood glucose levels, weight, and physical activity. This addresses the situation where an out-patient is required to monitor their blood pressure, blood oxygen level, etc., and have this data transmitted to a healthcare professional. This is accomplished by the robot engaging the user in a conversation to remind and encourage the user to take the required measurements at predetermined times. This is done by implementing a conversational interface that is under development at Gatton Research and Development.

In-order to accomplish this task the robot must be mobile, be capable of interfacing with wireless physiological sensors, and be capable of engaging the user conversationally. The iRobot iCreate was chosen as the mobile platform based on its low cost, ease of programming and it payload capability. There are multiple wireless sensors that are on the market and reasonable priced. Of these a kit consisting of a blood pressure monitor, activity monitor, and weight scale was selected from Lifesource. Also an oximeter was selected from Contec. To this setup was added a HP Mini-Dell netbook computer to provide a platform for running the robotics software (Microsoft Robotic Development Suite), the monitoring software, conversational software and the interfacing software. The MS Kinect motion sensor will also be added to this mobile platform to provide more accurate location and mapping as well as human detection.
A pictorial diagram of this setup is show in Figure 1.

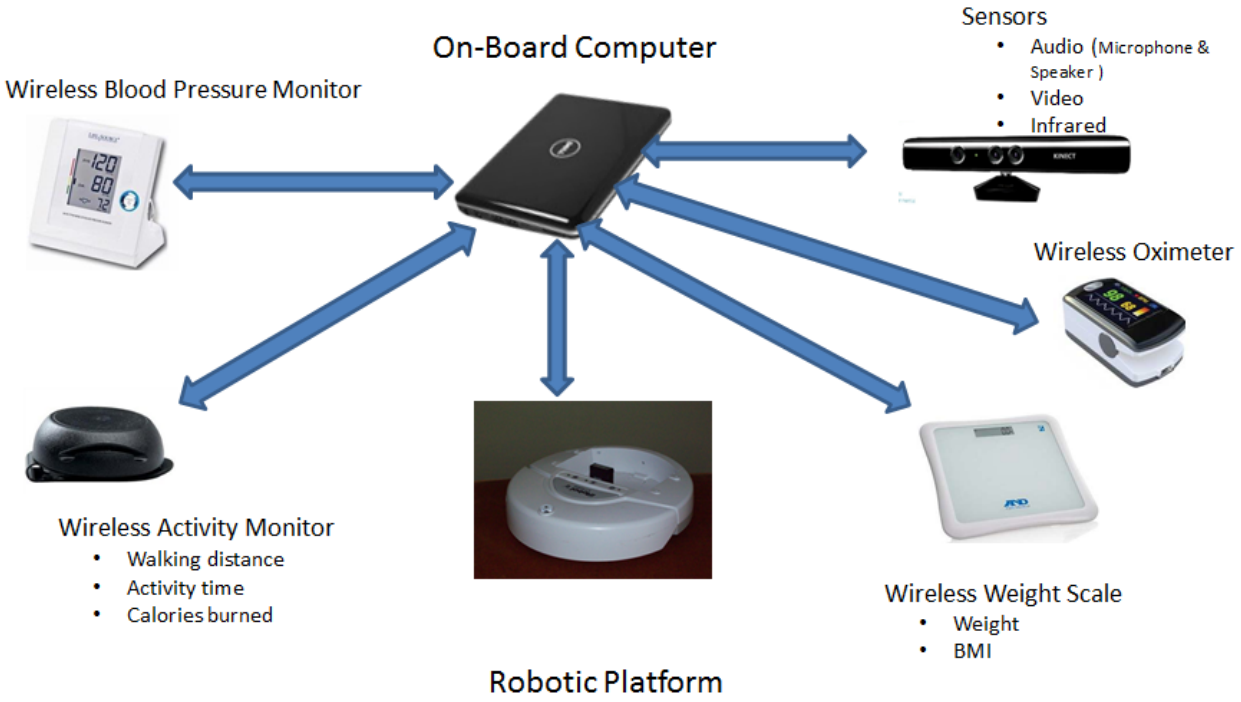

Figure 1 Robotic platform and various sensors

The conversational software used in this project is more than just a speech recognition and voice response unit. This conversational interface allows the user and the SAR to communicate in a conversational manner. That is, the conversational interface allows the SAR to engage the user in a two-way dialogue within the bounds of the user's healthcare measurements. Encouragement, review of data, reminders, rescheduling, and cautions of out of range readings can all be communicated to the user in a familiar manner.

A sample conversation is shown in Figure 2.

Sample # 1
SAR: **It is time for your Blood Pressure measurement**
User: Yes
SAR**: Ok, lets get started**

Sample #2
SAR: **It is time for your Blood Pressure measurement**
User: Later
SAR**: Ok, when would be a good time to take the measurement**
User: Not now
SAR**: How about in 30 minutes?**
User: Yeah that's fine
SAR**: I will remind you in 30 minutes**

Figure 2 A Sample Conversations

One of the key features on this interface is the ability to recognize synonyms of three main responses. That is, yes, no, and a deferred request.

The "no" and "deferred request" and their synonyms are used to trigger encouragement and reminders. The responses can range from "I will remind you in 30 minutes" to "oh, come on, you might as well do it now because you'll just get annoyed again when I come back in ten minutes to harass you." Any number of responses can be programed and triggered in a number of ways such as; random manner, time based, users based, or users choice of words.

Benefits

In this type of research collaboration between a university technology department and a small business concern produces benefits for all involved in the project.

Students involved in the research will gain practical research experience that can have wide ranging impact on healthcare. This type of experiences can lay the foundation for a specialized career in some combination of research, robotics, and/or healthcare which according to the 2013 Edition of A Roadmap for U.S. Robotics From Internet to Robotics is "also a promising domain for technologies for care taking for the elderly, toward promoting ageing in place (i.e., at home), motivating cognitive and physical exercise toward delaying the onset of dementia, and providing companionship to mitigate isolation and depression." [1] The experience gained in this type of project include[1-3] software development for real-world applications, practical troubleshooting experience, project management, time management, and report writing. All of which, from a prospective employer's viewpoint, is highly desired in any technical field. This type of background on a student's resume will make them standout in the job application process.

Small business research companies can benefit in a number of ways from this type of collaboration with a university's technology department. This association provides a small business access to the engineering technology resources without incurring the cost of salaries, benefits and other human resource expenses. These resources include high quality research experience, wide range of expertise, and in some cases specialized equipment. Also a university can provide access to non-technical resources as in our case the Center for Aging in the Ecology Department which has experience and contacts in conducting pre-clinical trials. There is also access to grant writing experience both at the researcher and the administration levels at the university. All of these are very valuable resources to a small business concern with a limited budget.

The benefits to the university collaborators in such an endeavor come primarily from working on applied research projects that create opportunities for faculty. Collaborating faculty in turn find ways to get undergraduates involved in high technology applied research projects that are of real world value. Students will also be able to appreciate and participate in the entrepreneur's approach and the value that innovation has in our society. This project in particular has a noticeable humanistic component in that it seeks to improve the quality of life for elders and therefore provides young people the opportunity and satisfaction of helping others; it is difficult to come up with a scenario that have better motivational drivers.

Summary

As we have seen collaboration on research projects between a universities' engineering technology department and an engineering research firm has the effect of producing valuable benefits to all parties involved in the collaboration. The students, university researchers, and the small business researchers all stand to gain from the relationship.

In the project outlined in this paper we will continue work to complete a working prototype and then pursue funding, through public funds through the Small Business Innovative Research (SBIR) grants or through private sources involved in the promotion or development of healthcare robots.

There are many possible projects that could be developed in the future through a similar collaboration. Among these are; personal assistant / companion for the elderly or homebound, physically assistive companion, educational companion, visual monitoring of children or patients, are just a few of the projects that could be developed around the conversational interface.

Bibliography

[1] Robotics Virtual Organization , "A Roadmap for U.S. 2013 Ed.," Robotics (VO), 2013.

[2] T. Kanade, "Using Socially Assistive Human-Robot Interaction to Motivate Physical Exercise for Older Adults," *Proceedings of the IEEE, Special Issue on Quality of Life Technology,* pp. 2512-2526, 2012.

[3] Cory, D. C., "Designing Long Term Human-Robot Interaction and Application to Weight Loss," Massachusetts Institute of Technology, 2003.

[4] D. McColl and G. Nejat, "Meal-Time with a Socially Assistive Robot and Older Adults at a Long-term Care Facility," *Journal of Human-Robot Interaction, Vol. 2, No. 1,* pp. 152-171, 2013.

Bibliographical Information

Lee Gatton is the president and senior research engineer at Gatton Research and Development. He received his Associate of Engineering Technology from Kansas State University, Salina Kansas, in 1971, B.S. in Electrical Engineering from Southern Methodist University, Dallas Texas, in 1975, and a Master of Management in Information Systems from Friends University, Wichita, Kansas in 2001. Gatton, who has 40 years of computer engineering experience, started Gatton Research and Development in 2008 to pursue his interest in developing Socially Assistive Robots.

Saeed Khan is an Associate Professor with the Electronic and Computer Engineering Technology program at Kansas State University at Salina. Dr. Khan received his Ph.D. and M.S. degrees in Electrical Engineering from the University of Connecticut, in 1989 and 1994 respectively and his B.S. in Electrical Engineering from Bangladesh University of Engineering and Technology, Dhaka, Bangladesh in 1984. Khan, who joined KSU in 1998, teaches courses in telecommunications and digital systems. His research interests and areas of expertise include antennas and propagation, novel materials for microwave application, and electromagnetic scattering.