AC 2010-2259: RFID BASED ASSISTIVE DEVICES: AN INTERDISCIPLINARY PLATFORM FOR SENIOR DESIGN PROJECTS IN ENGINEERING DISCIPLINES

Kumar Yelamarthi, Central Michigan University

Kumar Yelamarthi received his Ph.D. and M.S degree from Wright State University in 2008 and 2004, and B.E. from University of Madras, India in 2000. His current research interests are in the areas of RFID, VLSI Circuits, Field Programmable Gate Arrays, Computer Aided Design tool development, digital design automation, autonomous adaptive systems, applied electronics, and engineering education. He has served as a technical reviewer for several IEEE/ASME/ASEE international conferences and journals, and has written over 45 publications in both technical and educational fields. He is an elected member of Tau Beta Pi and Omicron Delta Kappa honor societies.

P. Ruby Mawasha, Wright State University

P. Ruby Mawasha is the Assistant Dean in the College of Engineering and Computer Science at Wright State University. He received a B.E. degree in mechanical engineering from the City College of New York in 1990 and an M.S. and Ph.D., from the University of Akron in 1993 and 1998, respectively. His areas of specialization include engineering education and thermo-fluids. He has co-authored over 15 journal articles and over 50 conference proceedings. He is a registered professional engineer in the state of Ohio; and a member of the American Society of Mechanical Engineers and American Society for Engineering Education.

RFID based Assistive Devices: An Interdisciplinary Platform for Senior Design Projects in Engineering Disciplines

Abstract

Interdisciplinary projects involving electrical engineering (EE), mechanical engineering (ME), and computer science (CS) students are both exciting and difficult to conceptualize. Answering this challenge, this paper presents an interdisciplinary project platform focused on Radio Frequency Identification based Assistive Devices. The combination of software, hardware, and mechanical design makes this platform an excellent choice for undergraduate student projects in both design and research aspects. Senior CS students have required programming experience to develop software programs, EE seniors have sufficient knowledge to understand the basics of radio frequency, signal processing, and circuit design, and while ME seniors have sufficient knowledge to understand the basics of structural dynamics and thermodynamic analysis. This integration of complex programming, electrical hardware, and mechanical system design provides an excellent educational experience for undergraduate students.

Also, this interdisciplinary platform is systematic and integrated that involves investigating a complex process or system with multiple design and research elements, such as wireless communication, control system design, statistical analysis, structural dynamics, and design for manufacturability. Through working on projects based on this platform, students will be able to study a complex engineering and technology system that: (1) exposes them to applied and cutting-edge technologies; (2) encourages them to participate in an integrated, interdisciplinary curriculum; and (3) involves them in methods of applied technology and skills necessary to transition from academic to professional environments.

1. Introduction

The rapid advancement in technology has laid a path for the design and manufacture of many interdisciplinary integrated technologies. These advancements have provided new avenues for the engineering educators to better prepare tomorrows global citizens through innovative methods capable of responding to the challenges of tomorrow[1]. On the other hand, the number of individuals/prospective students pursuing Science, Technology, Engineering, and Mathematics (STEM) professions in United States (US) is far less when compared to developing nations. For the US to continue being the global leader in engineering and technology, engineering educators needs to be proactive in preparing tomorrow's global citizen through interdisciplinary integrated approaches.

One significant methodology that can be used to prepare tomorrows global citizens is actively engaging them in interdisciplinary projects that models professional collaboration, and highlights the significance of engineering and technology in socio-cultural aspects. Radio-Frequency Identification based Assistive Devices (RFID-AD) is one such focus area that can be used for interdisciplinary research in STEM disciplines. Rooted with the key disciplines of electrical engineering, mechanical engineering, computer science, and industrial technology, the RFID-AD projects teach students how to work together on projects of national importance, and highlights the significance of engineering and technology in socio-cultural aspects.

In December 2008, the US Census Bureau reported 54.4 million (19% of the population) Americans with disabilities[2]. In January 2009, the employment-population ratio for people with disability is 20%, compared with 65% for people with no disability[3,4]. There are many other alarming data points about this segment of population. For example:

- Three times as many (26% vs. 9%) live in poverty
- Half (50.3%) have family annual incomes of less than $20,000
- People with disabilities are twice as likely to drop out of high school (21% vs. 10%)
- They are twice as likely to have inadequate transportation (31% vs. 13%)
- More than twice as many go without needed health care (18% vs. 7%)
- Two out of three of those capable of working are currently unemployed
- The number of people pursuing higher education is very low

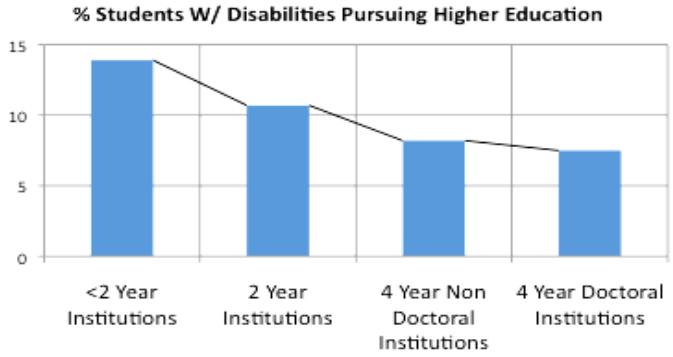

Figure 1: Percentage of Students with Disabilities Pursuing Higher Education

Given the persistence of the above gaps, it is not surprising that life satisfaction for people with disabilities is also significantly lower. As the average life span is predicted to increase with the population by 2020[1], it is clear that the number of people with disabilities is going to increase proportionately. With the unemployment rate increasing and life satisfaction decreasing for this segment of population, there is an immediate requirement for the design of new assistive devices. Based on the Disability Act of 1998, assistive technology is defined as "any item, piece or equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities."

Research demonstrated that more people with disabilities could be assisted to become a part of regular learning environment through assistive technologies[5]. This calls for an immediate requirement in the design of assistive technologies such as an automated wheel chair, smart cane for the blind, data processing software for the blind etc. The design and manufacture of these assistive devices does not depend on just one engineering discipline, but through collaboration of several. The STEM education community must take advantage of serving the disabled through an integrated curriculum that allows the engineering and technology students to participate in new assistive technology design projects. Involvement in student-focused integrated curriculum will help students re-conceptualize their view of engineering in a context that addresses societal needs that are driven and influenced by the global market place for engineering services of the future[1].

2. Significance of Interdisciplinary Teams

The conventional senior design projects in the engineering curriculum have substantial drawbacks such as limiting the bounds to just one discipline and focus on improvement rather than innovation. A student-focused curriculum should be designed to address some of these drawbacks. Undergraduate education is a stimulation and nurture process where students are open and eager to learn new things. It is up to faculty mentors to provide opportunities to actively involve and guide the students. Engineering education, on one hand requires the adaptive grasping of basic theories, and on the other hand, emphasizes hands-on experiences, innovative ideas and creativity that meet societal needs. Therefore, there is a genuine necessity to bridge the gap between theory and practice. A practical approach is to improve student participation in innovative design methods and education.

Two critical success factors for an engineer in the flat world are their ability to adapt to changes, and be able to work at the interface of different disciplines[6]. In this "flat-world"[7], engineers and scientists need to constantly absorb and teach others new ways of doing old or new things, and mostly learn how to work well with others. By working with others, students: (a) obtain opportunities to experience a different domain; (b) combine knowledge and skills from different disciplines; (c) work as a team member; and (d) solve real-time research problems. Also, interdisciplinary collaboration provides students with significant personal development opportunities[8].

ABET describes that engineering programs focus on theory, and engineering graduates spend their time planning, while technology programs focus on application and technology graduates spend their time making plans work[9]. An interdisciplinary collaboration of engineering and technology students on research and design projects answers some of the challenges in this "flat-world". Based on this background and the significance of interdisciplinary projects, the RFID-AD platform is designed to update the engineering and technology programs. Additionally, this platform is in accordance with the National Academy of Engineers recommendation that, "Engineering schools should introduce the interdisciplinary learning in the undergraduate environment, rather than having it as an exclusive feature of the graduate program"[1].

3. RFID Based Assistive Devices in Senior Design

Sternberg in their work has stated that the pedagogical purpose of capstone design is to allow the student an opportunity to experience how the content in the undergraduate curriculum fits together to provide a coherent vision of the knowledge necessary to complete a significant engineering project[10]. The capstone design project provides an opportunity for the student to implement their skills combining what they have learned from a spectrum of their core classes.

Students upon completion of the capstone design project and graduation enter the professional workforce where they work in multidisciplinary teams. This requires a good understanding of other disciplines so as to communicate the technical details of their respective discipline to others in a different discipline. As this is a skill that nourishes over practice, engineering students need to be trained in this skill prior to graduation. On the other hand, the rapid advancement in technology is mandating engineering educators to introduce new concepts

in the engineering curriculum and prepare students prior to graduation. As it is not feasible to increase the number of courses required for graduation, new methods of educating students about cutting edge technology in the existing curriculum is necessary more than ever before.

RFID technology has emerged as one of the most advanced and promising types of real-world awareness technology[11]. Topics in RFID add an exciting dimension to the student's educational experience, and they fit easily into an established engineering curriculum. Based on the concepts students learned from core engineering classes, they could design a product utilizing this new technology. However for the students to learn and implement new concepts, constant motivation is required. Demonstrating the applicability of their work to enhance the societal needs of the community, such as helping the disabled people provides substantial motivation for the students. Utilizing the new RFID technology and source of motivation from assistive devices, an interdisciplinary RFID-AD capstone design project is an ideal platform to answer the rising challenges of preparing the future engineers.

One of the primary advantages of RFID-AD projects is that instead of each student team requiring initiation of a project from ground zero, they can work on the project based on a platform that has been set in stone previously. This provides ample time for the students to deal with integrated and complex projects, and have a deeper understanding of new concepts. Overall, the RFID-AD projects cover several focus areas in the engineering and technology disciplines as depicted in Figure 1.

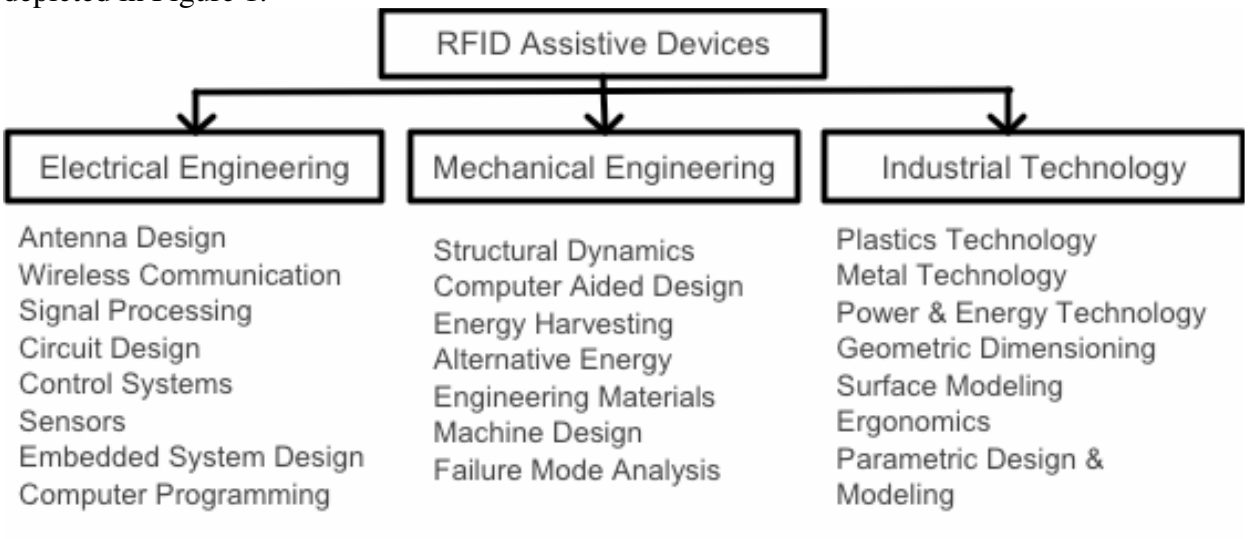

Figure 1: Technical Focus Areas Covered in the RFID-AD Projects

4. Sample RFID Based Assistive Device Projects

4.1 RFID Based Smart-Cane for Location Identification and Navigation to Assist People with Alzheimer's

For people with vision disabilities, it has always been difficult to accomplish many day-to-day activities. Identifying different buildings and finding the best route to reach a location is a difficult task for a person with limited or no sight capabilities. Technological advancement such as RFID is the answer for this and many other challenges for people with vision

impairments. This project is primarily focused on the design of a Smart Cane for the blind. Utilizing RFID tags for location identification, and radio signals for obstacle detection, the smart cane system helps the blind to safely navigate in predefined locations.

4.2 RFID Based Robotic Arm to Identify & Retrieve Books from the Library Shelf

For people using wheelchairs, it has always been difficult to retrieve books from the appropriate bookshelf in the library. Answering this challenge of dependency on others increases self-efficacy of the person with respective disability. The design team will formulate a plan to navigate the wheelchair in the library by avoiding obstacles and reaching the appropriate locations in the library. Upon reaching the appropriate location, the robotic arm will protrude, identify and retrieve the book based on RFID tags.

4.3 RFID/GPS Based Navigation Assist Scooter for People with Physical Disability

One of the common problems faced by people with disabilities is conveyance. Answering this challenge provides ways for people to commute without depending on others. The student team formulates a plan to design and navigate a scooter indoors and outdoors using RFID and GPS based technologies respectively. With the multidisciplinary nature of the projects involving statics, electronic circuit design, embedded system design, and design manufacture, it is ideal for this interdisciplinary curriculum.

5. RFID-AD Projects and ABET Criterion

One method to evaluate the RFID-AD projects is so review how they meet ABET Criterion 3 requirements[9] addressing the skills, knowledge, and behaviors students should have at the time of graduation.

5.1 Demonstrate the ability to apply knowledge of mathematics, science, and engineering

With the RFID-AD projects requiring collaboration of students from multiple disciplines, it is a good platform to nurture knowledge in mathematics, science, and engineering during design and implementation. Specifically in EE, students can nourish their skills in signal processing and communication such as interference and shielding, antenna- gain, length, angle, multiplexing, placement, polarization, propagation pattern, resonance, and tuning, crosstalk, multipath fading, Faraday's Law, Gauss's Law, signal modulation, circuit design, and programming of an embedded system. In ME, RFID-AD project nurture student skills in force calculation, friction, concurrent forces, moments of inertia, kinematics, work and energy calculations, stress and strain theories, loading and deformation, power transmissions, and kinetics etc.,

Although the listed topics are logical and straightforward in each discipline, the RFID-AD requires the application of topics from multiple disciplines together towards completion. This allows students from other discipline to gain an understanding of how to work together in interdisciplinary teams. This would help them realize the significance of applying engineering knowledge to make a fully functional design and suggest recommendations for further improvement.

5.2 Demonstrate an ability to design and conduct experiments, as well as to analyze and interpret data

The RFID-AD projects require extensive design and experimental analysis. For instance the deployment, placement, and orientation of RFID tags vary the reading range significantly. Incorrect implementation might reduce the system reliability to failure. Accordingly, students need careful experimentation through implementation and analyzing data. On the ME side of the RFID-AD projects, with majority comprising of moving elements, students need to perform detailed stress, strain, loading, torque, and power transmission calculations.

With these projects requiring extensive experimentation and data analysis, students can be taught how to design efficient experiments and analyze data through statistical analysis such as ANOVA, Taguchi, and Scheffes methods. Reinforcing this statistical analysis further helps them understand the utility of experimental design within an engineering context.

5.3 Demonstrate an ability to function on multidisciplinary teams

In this "flat-world"[7], engineers need to constantly absorb and teach others new ways of doing old or new things, and mostly learn how to work well with others. All the RFID-AD projects require collaboration of students from multiple disciplines. Through these projects and by working with others, students obtain opportunities to experience a different domain; combine knowledge and skills from different disciplines; work as a team member; and solve real-time research problems. Also, this interdisciplinary collaboration provides students with significant personal development opportunities[8].

5.4 Demonstrate an ability to identify, formulate, and solve engineering problems

Each student team working on RFID-AD platform was assigned a design project to undertake an engineering problem. The whole process exemplified the students' ability to identify, formulate, and solve engineering problems. This requires students to plan the design process comprising of project definition and planning, specification definition, concept development, detail design, testing and refinement, and production.

5.5 Demonstrate an understanding of professional and ethical responsibility

The RFID-AD design platform is a natural place to introduce ethical as well as global engineering issues. By working on these projects, students obtain first hand feedback from the end user. This helps students obtain a clear picture of the health and wealth of public, and to disclose promptly the factors that might endanger the end user. By working with end user, but not the corporate industries, students have the ability to approach system design based on usability rather than monetary profits, realizing the ethical responsibility of engineers.

Overall, the RFID-AD helps students use their knowledge and skills for the enhancement of human welfare, and motivates them to strive for increasing the competence and prestige of engineering profession.

5.6 Demonstrate knowledge of contemporary issues

Knowledge of contemporary issues such as economical, environmental, social, and ethical factors are crucial in the design process of any engineering system. Engineering students prior to graduation must be able to identify these factors and make appropriate judgments in any project they undertake. The RFID-AD platform in capstone senior design is ideal to educate the students in this process. For instance, consider a project designed to assist a blind person. Two primary challenges faced by a blind person are mobility and orientation. The inability and fear of conquering such overwhelming challenges often prevent them from leading productive and socially active lives. Students can relate how technological advancement such as RFID and GPS can be used for navigational cues, and ultrasonic sensors for obstacle avoidance, thus answering the challenges of mobility and orientation.

On the other hand, some blind people use guide dogs for mobility and orientation. Over time, these guide dogs become their best friends, and an essential part of their daily life. The RFID based assistive devices reduce the dependency on guide dog, affecting the overall relationship between the user and the dog. On the positive side, these devices reduce the users dependency on family and friends, and help them become more active in the community. As it can be seen here, the RFID-AD projects have both positive and negative impacts on the end user. It is up to the design engineer to qualitatively assess both the pros and cons in contemporary issues and make a judgment as to the directions to pursue in this project.

Overall, the RFID-AD serves as an excellent platform for students to enhance their knowledge and understanding of contemporary issues in the engineering design process.

6. Conclusion

This paper described an RFID based Assistive Device platform for capstone senior design projects. With majority of the concepts required for this projects already taught in existing core engineering classes, this platform can fit into any engineering curriculum to educate students in the cutting edge technology, while at the same time show how they could make an impact on the society.

Upon initial implementation at the host institution, students have reported a high degree of satisfaction and were able to publish their work in technical conference. There were a number of other gains from this platform including the establishment of a working relationship with the disability services on campus, obtaining significant equipment donations from the university, industry partners, obtaining internship positions for students in the local industry. With the RFID technology progressing from an emerging technology to essential commodity, the RFID-AD platform can be adapted for success in any institution offering engineering and technology degree programs.

References:

1. The Engineer of 2020: Visions of Engineering in the New Century, National Academy of Engineering, 2004.
2. Americans with Disabilities: 2005, US Census Bureau, Dec 2008.
3. CPS Disability Data, Labor Force Statistics from the Current Population Survey, Bureau of Labor Statistics, Feb 2009.
4. Occupational Outlook Handbook, Bureau of Labor Statistics, 2008-09 Edition, 2009.
5. T. Cavanaugh, "The Need for Assistive Technology in Educational Technology," Educational Technology Review, Vol. 10, No. 1, 2002
6. D. Schaefer, J. H. Panchal, S-K. Choi, F. Mistree, "Strategic Design of Engineering Education for the Flat World," International Journal of Engineering Education, vol. 24, no. 2, pp. 247-282, Mar 2008.
7. T. L. Friedman, "The World is Flat: A Brief History of the Twenty-First Century," Farrar, Straus and Giroux, New York, 2005.
8. G. W. Skates, "Interdisciplinary project working in engineering education," European Journal of Engineering Education. Vol. 28, no.2, 187-201, 2003.
9. Accreditation Board for Engineering and Technology, Internet: www.abet.org, Jan 2010.
10. S. P. K. Sternberg, A. Johnson, D. Moen, J. Hoover, "Delivery and Assessment of Senior Capstone Design via Distance Education," Journal of Engineering Education, vol. xx, no. xx, pp. 115-118, Apr 2000.
11. Car Anti Theft Prevention Pagewise, Inc., 2002 [Online]. Available: http://la.essortment.com/antitheftcarp_rhme.htm