Board 372: Remote Engaged Student Learning through Hands-on Internet of Things

Dr. Lifford McLauchlan, Texas A&M University, Kingsville

Dr. Lifford McLauchlan is an Associate Professor and Interim Chair in the Electrical Engineering and Computer Science Department at Texas A&M University - Kingsville, and has also worked for Raytheon, Microvision, AT&T Bell Labs, and as an ONR Distinguished Summer Faculty at SPAWAR San Diego, CA. He has over 55 publications covering areas such as adaptive and intelligent controls, robotics, an ocean wave energy converter, green technology, education, wireless sensor networks and image processing. He is a co-inventor on 3 US patents related to control systems. Dr. McLauchlan is a member of ASEE and was the 2012-2014 Chair of the Ocean and Marine Engineering Division. He is also a member of IEEE (senior member), SPIE, Eta Kappa Nu, ACES and Tau Beta Pi, and has served on the IEEE Corpus Christi Section Board in various capacities such as Chair, Vice Chair, Secretary and Membership Development Officer. Dr. McLauchlan has received the Dean's Distinguished Service Award twice and the Dean's Outstanding Teaching Award once for the College of Engineering at Texas A&M University-Kingsville.

Dr. David Hicks

David Hicks is an Associate Professor in the Electrical Engineering and Computer Science Department at Texas A&M University-Kingsville. Before joining TAMU-K he served as Associate Professor and Department Head at Aalborg University in Esbjerg, Denmark. He has also held positions in research labs in the U.S. as well as Europe, and spent time as a researcher in the software industry.

Dr. Mehrube Mehrubeoglu, Texas A&M University, Corpus Christi

Dr. Mehrubeoglu received her B.S. degree in Electrical Engineering from The University of Texas at Austin. She earned an M.S. degree in Bioengineering and Ph.D. degree in Electrical Engineering from Texas A&M University. She is currently an associate professor in the School of Engineering and Computing Sciences at Texas A&M University-Corpus Christi. She is interested in multidisciplinary research in imaging applications using a variety of imaging modalities, including thermal imaging, hyperspectral imaging, and other digital imaging that engage targeted sensors, spatial and spectral data processing, pattern recognition and classification. She has a special interest in energy generation and real-world applications, as well as pedagogical methods in teaching and learning.

Remote Engaged Student Learning through Hands-on Internet of Things

Abstract

Remote learning environments have become integral to higher educational institutions even when most courses, particularly in STEM, have returned to face-to-face or hybrid instruction. Although the impetus for this project was the COVID-19 pandemic which forced institutions of higher education everywhere to move to an online remote teaching and learning format, and as such negatively affected STEM fields which require hands-on labs and access to instrumentation, remote learning still remains part of most courses today.

We describe continuing efforts to create learning environments and materials to support remote hands-on engaged student learning off-campus at two Hispanic Serving Institutions (HSIs) to enable and enhance student learning beyond the institutional walls. The approach utilizes Internet of Things (IoT) kits as remote learning tools that are provided to students to allow hands-on learning experiences at students' own chosen environment and time. Problem- and Project-based Learning approaches are utilized to achieve student learning outcomes and equip the students with the problem-solving skills necessary to succeed in STEM fields. Team-based projects engage students from multiple disciplines and demographics to collaborate on projects, make individual contributions, and integrate their work with that of their team members. General feedback from students has been positive. Assessment of student performance also demonstrates the effectiveness of IoT-based learning in engineering and computer science disciplines.

Introduction

Internet of Things (IoT) based projects and assignments facilitate students being able to learn remotely. Applications and lab projects can be controlled using IoT capabilities. As processors have improved more affordable microprocessor or computer alternatives such as Arduino, Raspberry Pi and other similar platforms have become more commonly utilized in educational settings. In this project, IoT concepts, educational materials and methods are introduced to students through various avenues such as Independent Study courses, Capstone Senior Design courses and Sensors courses.

Background

Figure 1 shows a simple representation of an IoT system that utilizes a Raspberry Pi. The Raspberry Pi could be replaced by an Arduino, Field Programmable Gate Array (FPGA), or a Programmable Logic Controller (PLC). In this research, Independent Study courses, Capstone Senior Design courses and Sensors courses are all utilized to demonstrate or to encourage students to utilize IoT-based designs to solve a problem or project that has been identified as one that could incorporate IoT capabilities to enhance the solution to the problem or the developed prototype or project.

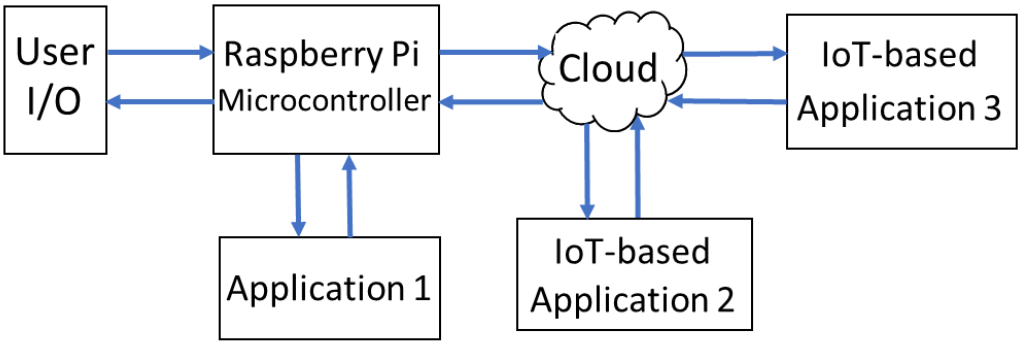
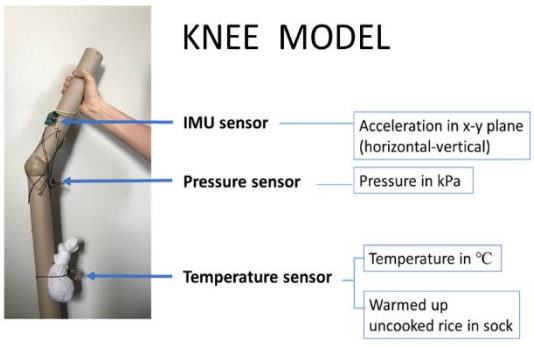


Figure 1. Representation of an IoT System [1]

Example IoT Student Projects

Senior Capstone Design IoT related projects in Electrical Engineering and Computer Science were developed at Texas A&M University-Kingsville (TAMUK) and Texas A&M University-Corpus Christi (TAMUCC). Examples of TAMUK student capstone design projects include a robotic arm that used machine learning and a smart irrigation system as seen in Figures 2 a) and 2 b). Other example student IoT related projects from TAMUCC include a knee sleeve and a debris removal robotic vehicle as seen in Figures 2 c) and 2 d).

Figure 2 a) Machine Learning Robotic Arm [2] 2 b) Smart Irrigation System [3]



2 c) Knee Sleeve [4]-[5] 2 d) Debris Removal Robotic Vehicle [6]

Other recent projects at Texas A&M University-Kingsville include a PLC based IoT related project to record pressure sensor readings and develop a website to post the data for analysis.

IoT Assignments

Lab assignments to introduce students to IoT concepts and how to implement some selected IoT capabilities have been developed at Texas A&M University-Kingsville. These assignments utilize the Raspberry Pi platform as the basis for the assignments. These assignments will be further modified to be utilized on other platforms or more capable platforms. "The five assignments include the following topics:

1. Introduction and Running a Simple Program on a Raspberry Pi,
2. Connecting to the Internet with a Raspberry Pi,
3. Getting sensor data readings using a Raspberry Pi,
4. Sending data to the cloud and plotting the data, and
5. Remotely driving a motor, LED or other device over the internet using a Raspberry Pi." [7]

The assignments will step the students through from basic concepts about the Pi board through controlling a motor over the internet. For more information on these assignments please see [7].

Assessment

A survey was administered to determine what IoT related concepts and knowledge has been gained or strengthened by students who participated in the IoT related activities and projects. Preliminary results demonstrate that students felt that the IoT kits helped them learn new skills. Eight of the IoT related questions on the survey are included below [8]:

1. IoT kits are helping me learn new tools and technologies in my field.
2. Learning with IoT kits is interesting.
3. Learning with IoT kits is engaging.
4. I am gaining hands-on skills with IoT kits.
5. I like what we do with IoT kits.
6. I like the IoT-based projects.
7. I can do collaborative work with IoT kits.
8. I find IoT kits and associated assignments to be relevant to my major/field of study.

Most of the students in the Electrical Engineering (EE) Senior Capstone Design course at Texas A&M University-Kingsville (TAMUK) in Spring 2022 who filled in the survey (7 students) responded to the above eight survey questions Very True (average of 51.8%) or Mostly True (average of 10.7 %) as seen in Table 1.

Table 1. - Survey Results for TAMUK EE Students - Spring 2022

Question (see above)	Very True	Mostly True	Somewhat True	Not True	N/A or Unsure
1	57.1 %		28.6 %		14.3 %
2	57.1 %		28.6 %		14.3 %
3	57.1 %	14.3 %	14.3 %		14.3 %
4	42.9 %		28.6 %		28.6 %
5	42.9 %	14.3 %	14.3 %	14.3 %	14,3 %
6	57.1 %	14.3 %	14.3 %		14.3 %
7	42.9 %	28.6 %		14.3 %	14.3 %
8	57.1 %	14.3 %	14.3 %		14.3 %

The survey actually includes many more questions. A more detailed analysis will be performed and more students will be asked to complete the survey this Spring semester 2023.

Conclusions

With the prevalence of IoT in applications and devices, learning IoT skills has become more important. This project has developed new educational materials that will facilitate student learning of IoT concepts and encourage students to utilize their new skills to enhance and improve their Senior Capstone Design projects. Most of the surveyed Electrical Engineering students at Texas A&M University-Kingsville responded favorably to the eight noted IoT related questions on the survey. The average number of students responding Very True or Mostly True on these eight questions was 62.5 %.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 2044255.

References

[1] M. Mehrubeoglu, L. McLauchlan, D. Hicks, and B. Zimmer, “Internet of Things for Remote Hands-on Engaged Student Learning” poster presentation - 2022 IUSE Summit in Washington, D.C.
[2] B. Platt, V. Urioste, J. Villarreal, A. Villasenor, F. Cuellar, M. Galvan, G. Ramon, J. Ramon and A. Villarreal, “Machine Learning Manufacturing Arm,” – Senior Design Project, Texas A&M University-Kingsville, Spring 2022.
[3] A. Cantu, A. Gonzale and B. Kark, “Smart Irrigation System” – Senior Design Project, Texas A&M University-Kingsville, Spring 2022.
[4] A. Mooney, A. Chicas, M. Keene, *et al.*, “Smart Knee Sleeve”– Capstone Project Final Report, Texas A&M University-Corpus Christi, Spring 2022.

[5] A. Moore, M. Mehrubeoglu, A. Mooney, and L. McLauchlan, "Application of IoT-based sensing and signal processing for rehabilitation," *SPIE Defense and Commercial Sensing*, Orlando, FL, 3-7 April 2022.
[6] M. Zuniga, D. Hinojosa, *et al.*, "ADDRAR-II" – Capstone Project Final Report, Texas A&M University-Corpus Christi, Spring 2022.
[7] L. McLauchlan, D. Hicks, M. Mehrubeoglu and H. Bhimavarapu, "Enabling Remote Student Learning of Technologies," submitted to *2023 ASEE Annual Conference and Exposition*, (accepted).
[8] M. Mehrubeoglu, L. McLauchlan, D. Hicks, and B. Zimmer, "Engaged Student Learning Off Campus: Hands-On Distance Learning through IoT" survey - developed in 2020.