

ABSTRACT

The COVID-19 pandemic forced educational institutions everywhere to pivot to an online format for remote learning. During the rapid transition to online instruction, STEM courses with physical laboratories or hands-on exercises embedded in the instruction suffered the most. Limited access to labs prevented students from efficient use of physical devices to complete their work. Beyond the pandemic, general attitude changes have been observed where some students are still limited in their on-campus presence due to continuing off-campus commitments.

We describe the initial steps for hands-on engaged student learning (ESL) off-campus focused on creating learning environments and materials designed to support such remote ESL at two Hispanic Serving Institutions (HSI), namely, Texas A&M University-Corpus Christi (TAMUCC), and Texas A&M University-Kingsville (TAMUK). The approach utilizes Internet of Things (IoT) kits as remote learning tools that are lent to students to provide hands-on learning experiences at students' own chosen safe and convenient environment.

INTRODUCTION

The IoT involves infrastructure in which a wide variety of physical devices interact with one another and share information. When designing, working with or combining these devices, engineering and computer science students must consider many aspects of their disciplines, such as sensors, signals, device integration and interfaces, system functions, control, testing and measurement, cloud infrastructure services for the support and management of IoT devices, security and communication aspects of these systems, among other topics.

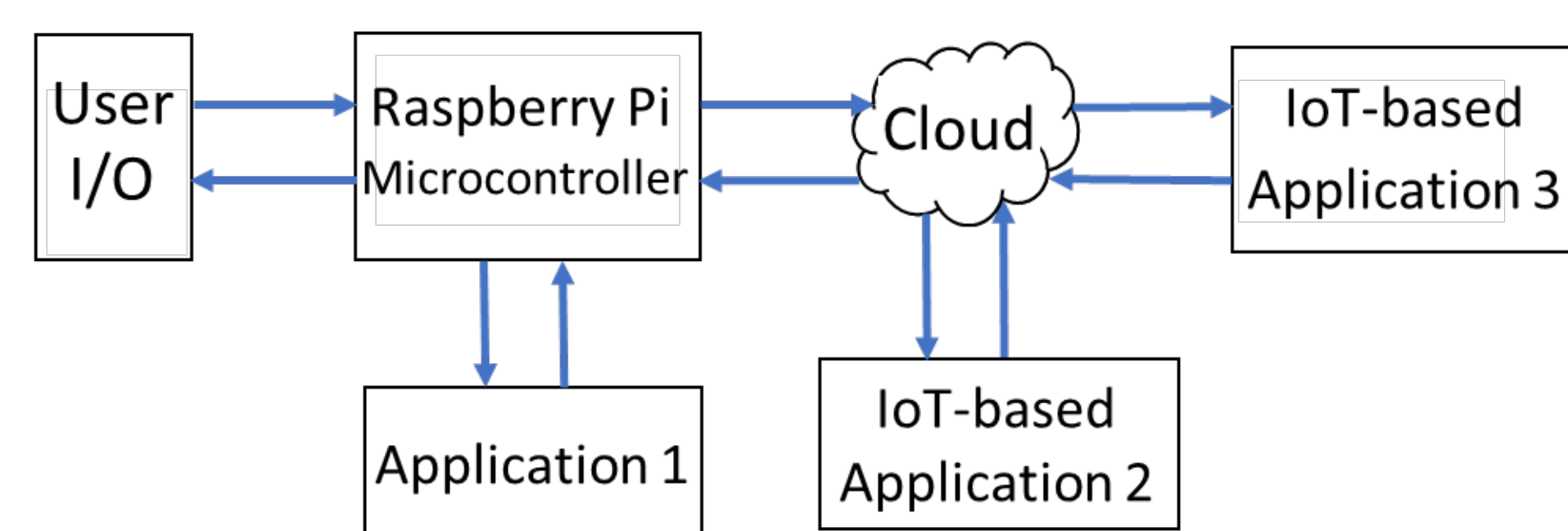
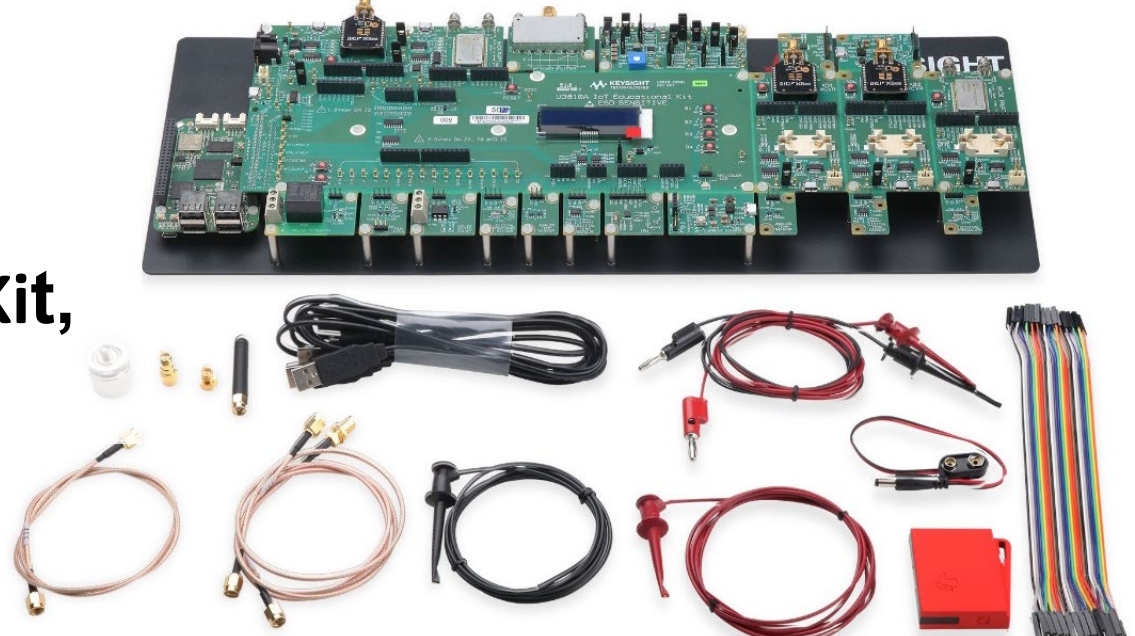


Figure 1. Representation of an IoT System, Modified from [1]

Figure 2. Keysight IoT Kit, U3817A [2]



RESEARCH QUESTIONS

1. How does the use of IoT help with hands-on active problem- and project-based learning (PBL) through the use of IoT kits?
2. How does the use of IoT (kit) help with off-campus engaged student learning as a hands-on project tool?

METHODS

TAMUCC:

Introduction of IoT kits to students in Capstone Projects and DIS courses

Project Management / Capstone Projects, Directed Independent Study (DIS) courses:

- Identify projects for student / team
- Lend IoT kits
- Collect Student Opinion Survey (before/after)
- Evaluate student coursework

TAMUK:

Developing IoT based exercises for use in senior design capstone courses in electrical engineering and computer science to introduce students to IoT

- Identify projects for student / team
- Lend Raspberry PI kits
- Collect Student Opinion Survey (after)
- Evaluate student coursework

IoT based exercises will be modified for use with either IoT kits or Raspberry PI kits and any needed sensors

STUDENT PROJECTS WITH IoT

Two example senior design capstone projects at TAMUK involve a smart irrigation system (IoT-based) and a robotic arm application (IoT-based cloud-based learning).

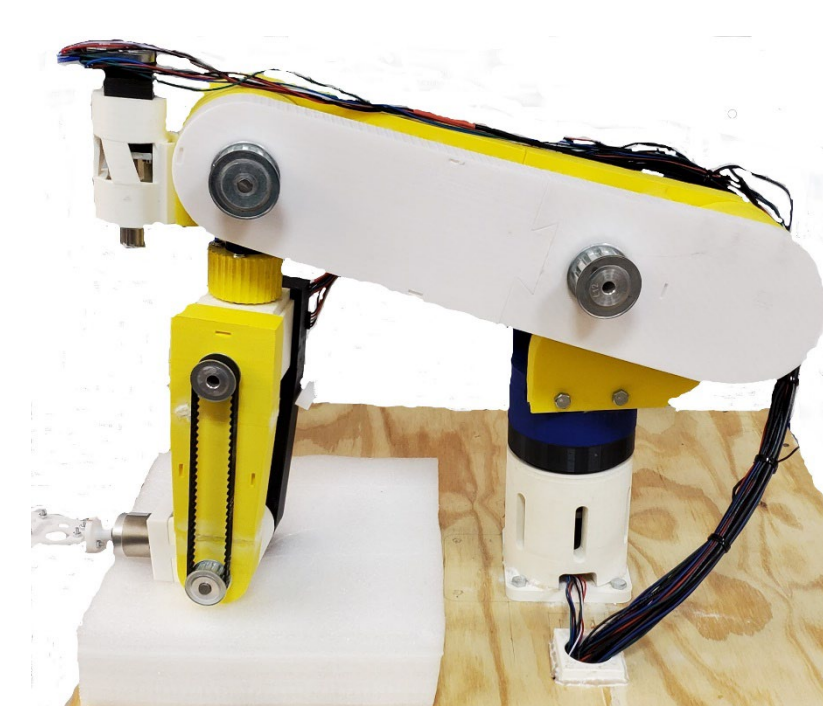


Figure 3. Machine Learning Manufacturing Arm (TAMUK) [3]

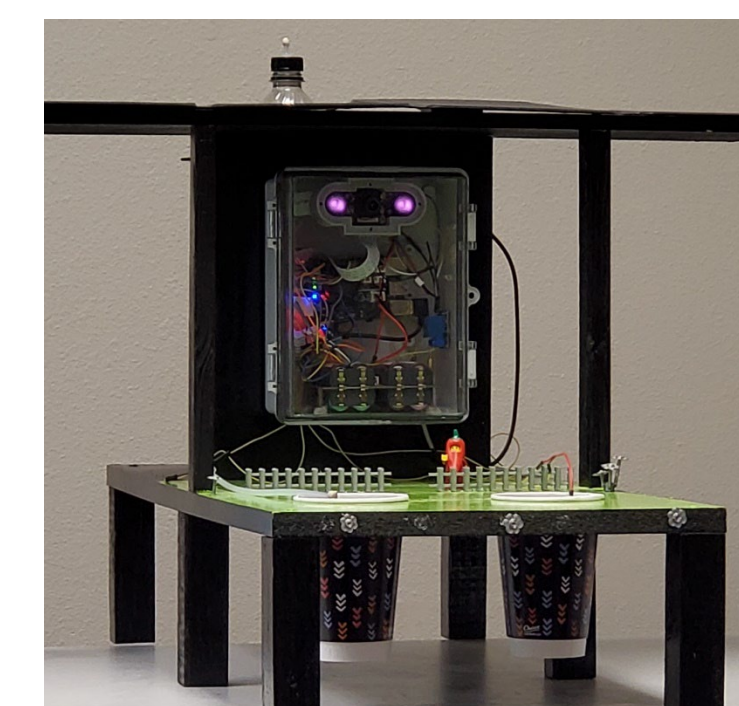


Figure 4. Smart Irrigation System (TAMUK) [4]

STUDENT PROJECTS WITH IoT

TAMUCC:

CAPSTONE PROJECTS

- Smart Knee: Knee Sleeve as an IoT-based Sensing and Vibration Device [5]
- Autonomous Debris Detection and Removal Autonomous Robot – Phase II (ADDRAR-II) [6]

DIS PROJECT

- Application of IoT-based sensing and signal processing for rehabilitation using a Knee Model [7]

TAMUK:

SENIOR DESIGN

- Machine Learning Manufacturing Arm Design (IoT-based, but not fully implemented in prototype) [3]
- Smart Irrigation System (IoT based) [4]

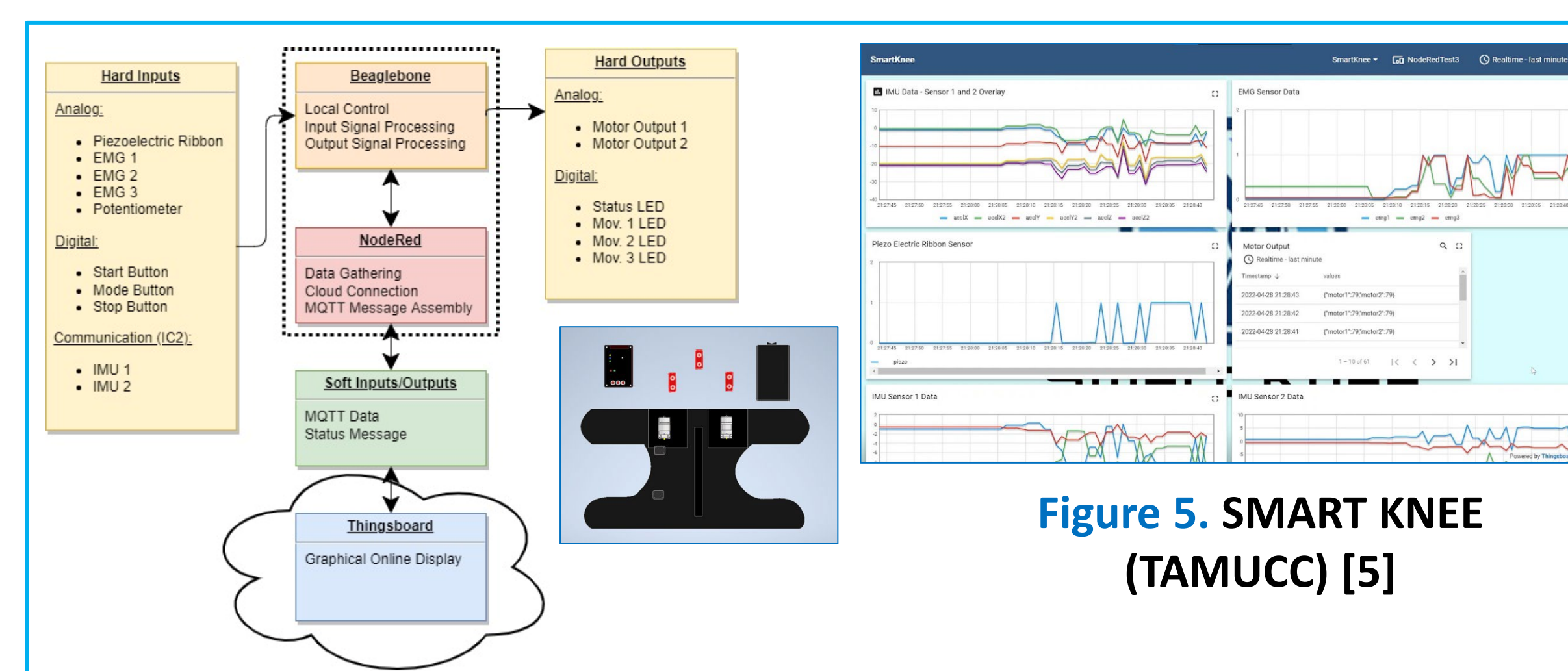


Figure 5. SMART KNEE (TAMUCC) [5]

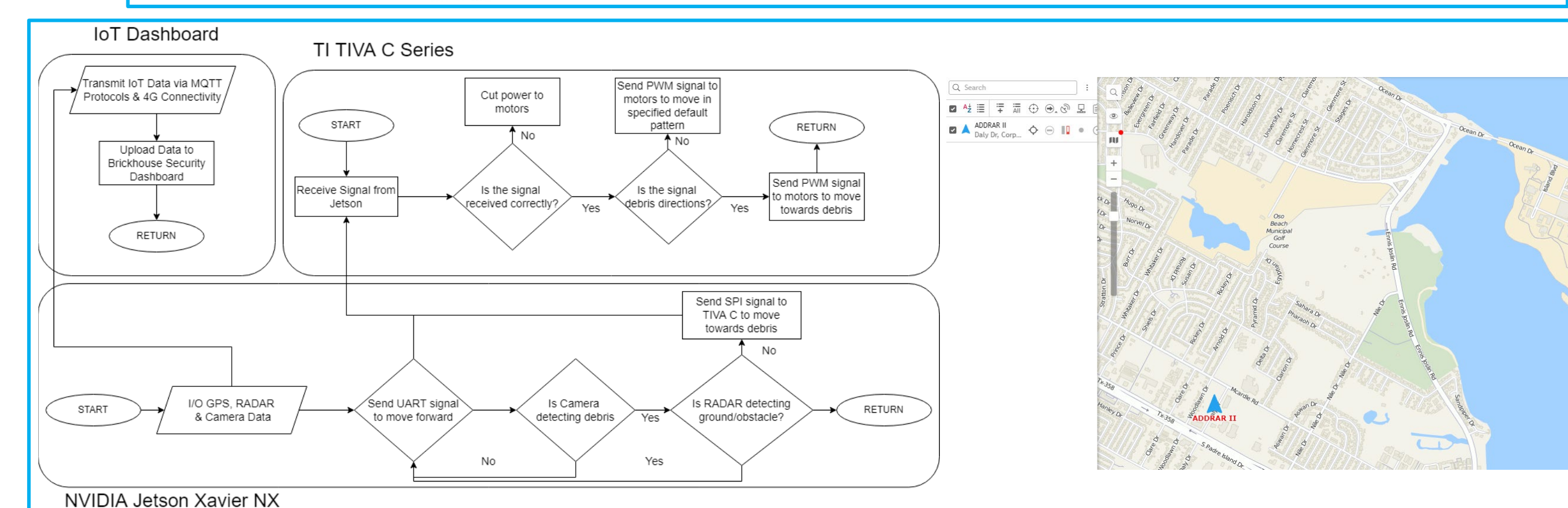


Figure 6. ADDRAR-II (TAMUCC) [6]

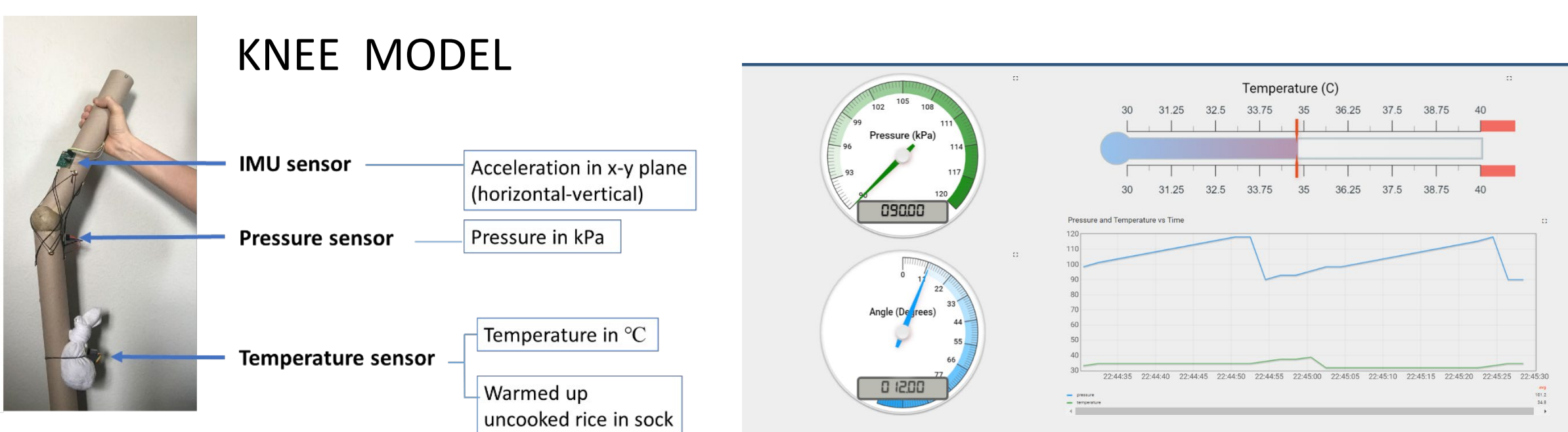


Figure 7. IoT-based Sensing and Signal Processing for Rehabilitation (TAMUCC) [7]

PRELIMINARY RESULTS

1. How does the use of IoT help with hands-on active problem- and project-based learning (PBL) through the use of IoT kits?

"... helped ... by having to figure out the process of IoT without prior knowledge. Having the project ... be remotely accessible is going to be a requirement soon as technology is advancing everyday therefore learning to access a project via the Internet will be a necessary skill."

"IoT kits are helpful in gaining hands on experience with the BeagleBone controller as well as the integrated sensors in the IoT kit. The flexibility of the sensors on the kit allows the student to interface with different board mounted sensors, over different means of connectivity ... in order to test an idea as well as sensor integration to the board. ..."

2. How does the use of IoT (kit) help with off-campus engaged student learning as a hands-on project tool?

"... helped by being able to learn problem solving skills since there was no prior knowledge of IoT before ..."

"Off campus use of the kits is necessary in my opinion due to the time investment it takes to learn and implement IoT in a project. Having the kits at home allows time for trial/error when testing different methods of connectivity protocols such as MQTT or HTTP to get to the cloud. ..."

FINDINGS

In its first year of its implementation, project's findings include:

- IoT serves as an effective tool for hands-on ESL in remote environments.
- Students participating in IoT-related projects engaged in hands-on learning off-campus with increased flexibility.
- Both Capstone Projects/Senior Design an DIS students were able to deliver the student learning outcomes of their projects through IoT, with one exception due to time constraints.
- There is a steep learning curve involved in learning complex IoT systems. For students who have not been exposed to IoT applications before, simpler hardware/software may be a better resource for introduction to IoT.
- Completion of IoT based assignments are expected to facilitate more groups utilizing IoT concepts in their design projects, furthering ESL through IoT.

Acknowledgment

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References

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