Virtual Collaboration in Mechatronic Projects: Design, Development, and Continuous Improvement

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Virtual Collaboration of Mechatronic Projects: The Development, Implementation and Continuous Improvement

Abstract

This paper describes the process and the continuous improvement of an online collaboration project within the scope of teaching microcontroller projects through distance learning. This virtual collaboration project was first established for the NSF funded grant TUES Type 2: "Dissemination of Microprocessor Courses through Classroom and Interactive Cyber-Enabled Technologies", and later improved the communication mechanism through the second NSF funded grant I-Corp L: "Transform the Innovated Design and Development of an Embedded Design Training System and Associated Support Curricula into a Commercial Available Product". Faculty in two and four-year institutions often find themselves working in isolated subject domains with little opportunity to collaborate with other faculty with the similar expertise at his/her institution simply because they are the only faculty available in that subject area. The need for collaboration among faculty members from different institutions was addressed and supported by the NSF funded grant projects. However, the challenge in creating the environment for faculty members from different institutions and diverse geographic regions became vital. The virtual collaboration platform was designed to enable faculty members from different institutions to communicate through the Internet and share project ideas regardless of their geographic location.

Introduction

The advancement of technology has profound impacts to our daily activities and experiences. Most people would agree that technological change has had a significant influence on the way we teach and learn in past couple decades. Distance Education, Distance Learning or Hybrid Learning has become a more demanding practice in academia as indicated in research. Accordingly, 29.7% of all graduate and undergraduate students have taken at least one distance education course. [1] It not only provides learning opportunities for learners from distant regions, but educators also see the potential to increase communication among a group of scholars without physically travelling a great distance and creates a borderless virtual collaboration. [2] and [3] Many people are still skeptical of the effectiveness of distance learning; however, several research projects have indicated that distance learning can be as effective as traditional face-to-face education. [4] and [5] An NSF funded grant TUES Type 2: "Dissemination of Microprocessor Courses through Classroom and Interactive Cyber-Enabled Technologies" provided the foundation and launch of this virtual collaborative project. The initial research team of this project developed a common microcontroller platform hardware (Rev1 Trainer Board) and a set of instructional materials and labs in a modular format. The researchers conducted three consecutive summer workshops through distance learning and delivered the course information to 60 faculty members (2- and 4-year institutions) in the United States. The distance learning workshops were primarily implemented using a synchronous video conferencing strategy. Project team members also used other media to allow attendees to download files related to the workshops for pre-workshop preparation. As the workshops were conducted throughout the years, the research team found it challenging to provide all attendees with a secured account to access instructional materials. This led to the development of the virtual collaboration web portal.

Virtual Collaboration – Phase one

Effective distance learning methodologies consist of balanced utilization between synchronous and asynchronous delivery tools. Research shows that there are benefits in using video conferencing systems to deliver content through a distance. [6] However, it was also reported to be beneficial by incorporating various asynchronous tools such as discussion forums and bulletin boards. [7] The microcontroller workshops conducted in this project used synchronous video conferencing to train faculty members during the 3-day summer workshop on how to design microcontroller systems and conduct lab exercises. To ensure that faculty members were prepared prior to the workshops, a set of instructional materials were made available for them to download and install on their personal computer stations. A web portal was created and hosted at Old Dominion University (ODU) with information for the workshop attendees. The information was open to public access. This information included workshop events, schedules, labs modules, pre-workshop file downloads, and project team member information.

The purpose of the workshops was to train faculty members and provide them with updated knowledge about microcontroller applications. Subsequently, the faculty members could then incorporate the information they learned into their classroom experiences that included microcontroller teaching materials, lab modules using C, Basic and Arduino programming languages, testing questions and answers, and lab solutions. [8] and [9] The web portal is open to public access; however, this limited the capability of the project team to provide access to secured documents and distribute files to a diverse group of faculty members across the United States. Unfortunately, the Office of Information Technology could not accommodate 60 external users outside of the university domain and provide them with user accounts. After thoughtful consideration of scalability and reliability of the project, the team decided to transfer the web portal to a commercial quality hosting service. The content was revised and restructured for posting on the subscription-based host server. A domain name was selected and purchased. The official project domain was established at www.ucdistancetraining.org. With the transition to the new hosting company, the Learning Management System (LMS) was incorporated into the web portal as a means to distribute updated instructional material to the faculty members. This achieved the goal of distributing instructional materials and lab modules, at the same time; it also prevented students and other unauthorized persons from gaining access to tests and lab answer keys.

Virtual Collaboration – Phase Two

The web portal, www.ucdistancetraining.org, was established as a central hub to serve as the asynchronous distance learning location, where microcontroller projects that were created by various users were shared. The web site was structured as an e-Learning portal that provided general information to all users as well as secured (pass word protected) access to a wide range of instructional material and learning resources for faculty and teachers. [7]

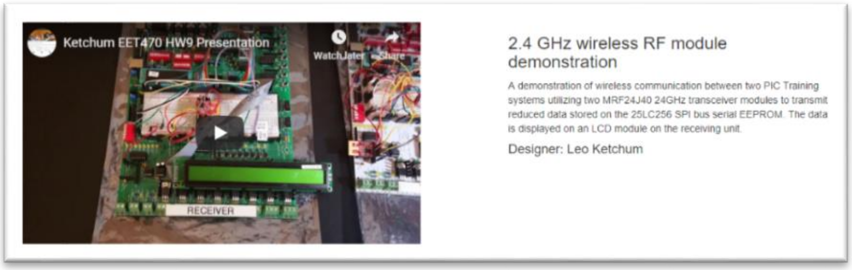

Figure 1 Embedded YouTube Video, Project Title, Description and

To broaden the information disseminated to the group, instructional videos were created and rendered, media-based information were embedded to the web portal. Instructors who used the common hardware platform to create classroom projects shared their accomplishments through the web portal. Project videos were published to a YouTube channel and embedded in the web portal as shown in Figure 1, which also included the project title, description, and project designer. The overall hierarchy of the web portal content is shown in Figure 2, which includes hardware and software product information, project videos, previous workshop information, community partners, course curriculum, FAQ, contact information, and a resource download page.

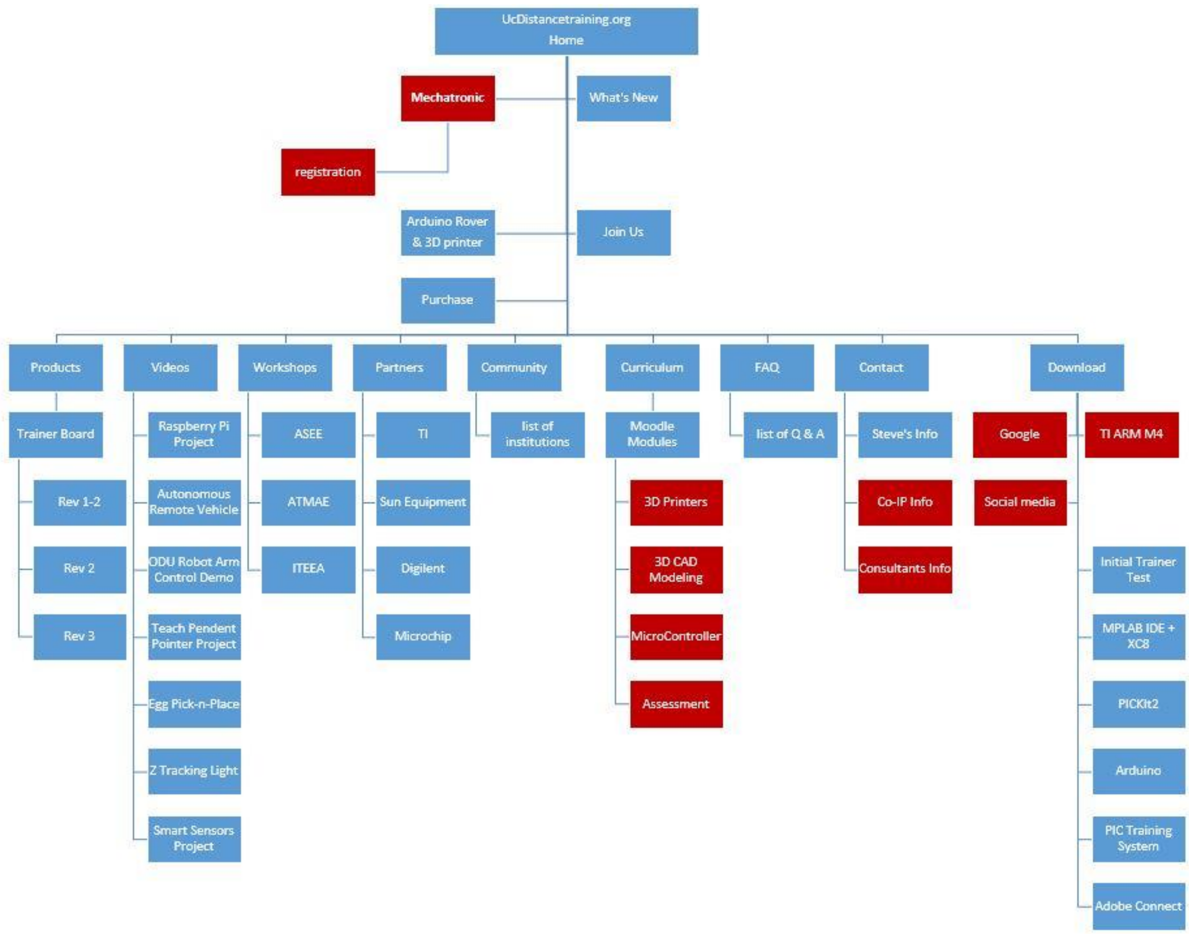

Figure 2. Hierarchy of the Web Portal

After the completion of the NSF grant TUES Type 2: “Dissemination of Microprocessor Courses through Classroom and Interactive Cyber-Enabled Technologies”, the researchers had the opportunity to investigate the possibility to commercialize the microcontroller trainer board that was developed through the NSF funded grant I-Corp L: “Transform the Innovated Design and Development of an Embedded Design Training System and Associated Support Curricula into a Commercial Available Product.”

In the process of implementing the I-Corp for Learning grant, the research team interviewed 97 prospective trainer board users, 63 of them are academic faculty members that teach microcontroller or related courses. The overall demographics of interviewees range from 9 different positions (Figure 3), 29 different states (Figure 4), all regions in the United States (Figure 5), and whether they are from two or four-year institutions or high schools (Figure 6). The researchers found a key factor in the data collected that indicated a user’s desire to collaborate regardless of their geographic locations. Among the 63 faculty interviewed, 53 of them indicated a strong desire to collaborate with other faculty members. They are interested in knowing what other projects were created and what can be shared to improve their teaching and professional development. The virtual collaboration platform www.ucdistancetraining.org was designed to allow faculty members from different institutions to communicate through the Internet and share their project ideas regardless of the geographic location of the institution.

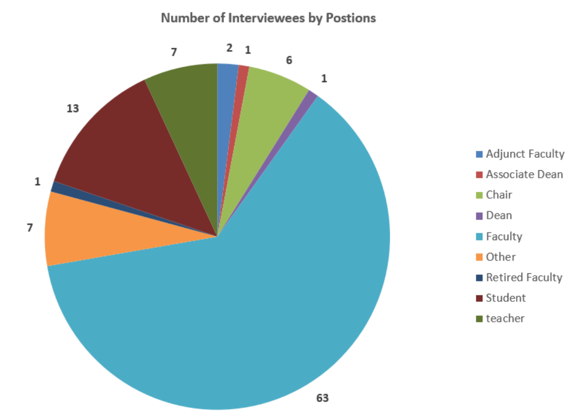

Figure 2 Number of Interviewees by Position

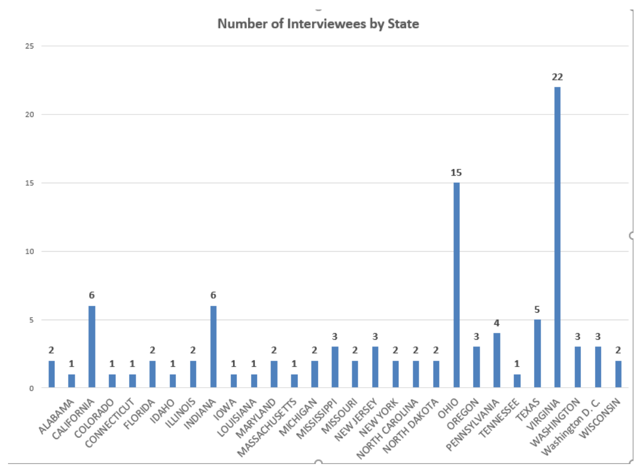

Figure 4 Number of Interviewees by State

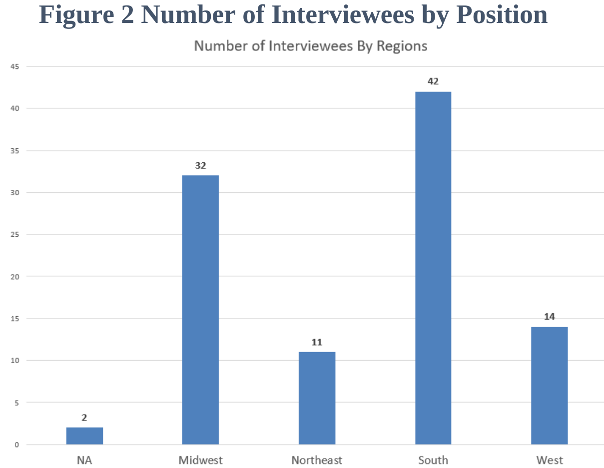

Figure 3 Number of Interviewees by Regions

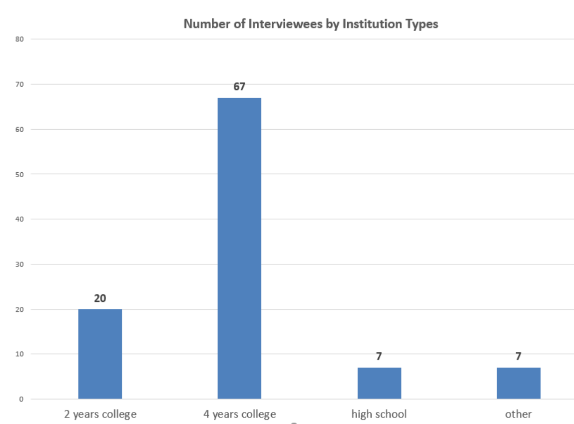

Figure 5 Number of Interviewees by Institution Types

Virtual Collaboration – Phase Three

As Technology advances, the team continues seeking the improvement to revise both hardware platform and software of the project. Virtual Collaboration continues even though the NSF funding had ended. After the completion of the NSF grants, the faculty members revised the trainer board to increase its capability and uses not only Microchip PIC, Arduino ATMEL but also TI ARM M4 series. The *uC Training System* (Rev 3) trainer board was designed, produced, and tested based on the demand from the academic community that acknowledged that microcontroller course curricula need an advanced microcontroller platform to meet industry technical training demands. This was a direct reflection of the NSF I-Corp L project results.

Lab Modules Design and Implementation Project Collaboration: With the new *uC Training System* Rev 3 Trainer Board specifications (Figure 7), The initial lab modules were created by Old Dominion University (ODU), Norfolk, Virginia and Farmingdale State College (FSC), Farmingdale, New York faculty as a team, and using the web portal managed by Ohio Northern University (ONU) faculty to facilitate the collaborations among the institutions. Later, Prairie View A&M University (PVAMU), Prairie View, Texas faculty were invited to join in the collaboration with their 2018 courses. The importance of the common platform was one of the key factors which allows faculty members collaborate on the projects and to revise and update course curricula for continuous improvement. Figure 7 shows the common platform for the *uC Training System* Rev 3 and TI Tiva LaunchPad that was used in the lecture and lab classes at ODU, FSC, and PVAMU. With the efforts from the faculty's collaboration, newly created lab modules as listed below are stored at the LMS where members can access the materials with proper authentication. Project dissemination at the web portal, the virtual hub at www.ucdistancetraining.org, achieved the effective and realistic virtual collaboration. Furthermore, faculty members from all participating institutions used the same lab modules in their classes and conducted assessments for further improvement.

1. Introduction to TI Tiva Launchpad w uC Trainer
2. TI Tiva C Series LaunchPad ARM M4 Hardware and Software Setup
3. Flashing LED Control with Tiva *uC Trainer*
4. GPIO and LED Control
5. Interrupts and the Timer
6. Stepper Control with Tiva uC Trainer
7. Parallel Communication with a LCD Module
8. 4*4 Keypad Scanning, Debouncing, and Decoding
9. ADC12
10. Generate SOS type coding via Tiva *uC Trainer*
11. Hibernation Mode
12. Floating Point
13. Low Power Modes
14. USB
15. PWM

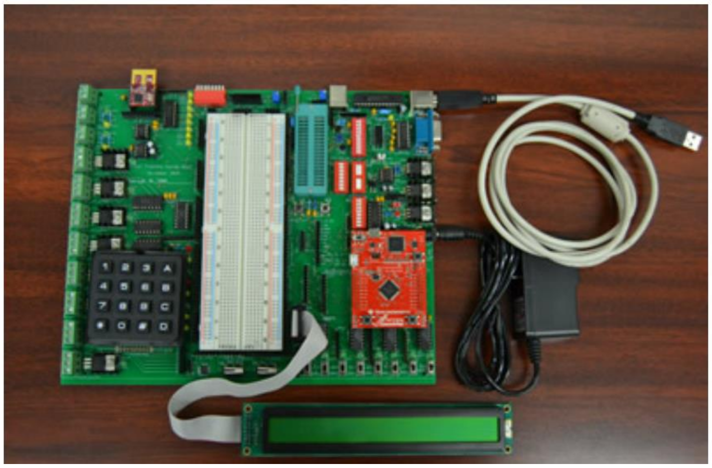

Figure 6 The REV 3 Training System

UNITE Army Educational Outreach: Introduction to Mechatronic Project Collaboration.

Another recent collaboration project between the team and Jackson State University faculty (JSU) was the development of the 3D Rover Robot. Robotics technology has become more advanced in the modern world. The robotic design technology is getting more sophisticated. The collaboration on this project was to design a rover robot with 3D printing know-how and incorporate an integrated drive system and microcontroller technology. The introduction of the Arduino UNO®, Integrated Development Environment (IDE) software and 3D printing experience facilitates STEM technology-based critical thinking and problem-solving skills for technology and engineering students. This mechatronic project encompasses many STEM-related experiences. These experiences included 3D printing concepts, basic programming skills and the integration of Bluetooth smartphone control technologies, electronic controls, programming microcontrollers, mechanical design of the vehicle, remote control operations, and the assembly of the 3D Rover Robot.

Figure 8. 3D Rover

The new 3D Rover design incorporates a smart sensor - an ultrasonic range finder, to provide a degree of autonomy. To incorporate the new smart sensor into an existing project was a challenge The research team went back to the "drawing board" to design a simple mount to attach an ultrasonic sensor to a model R/C servo. The ultrasonic sensor was carefully measured using a digital caliper and machinist's scale to produce dimensions for sketching designs. Several of the criteria for the mount were to require a good fit for the sensor, easily attached to servo, minimum ABS material and printing time as shown in Figure 8. All of the structural parts for the revised 3D Rover were printed using XYZPrinting's Da Vinci 1.0 3D printer and ABS material. Shown here is a "revised" 3D Rover with a cutout to mount a standard model servo to the rover platform. An HC-SR05 ultrasonic sensor was installed in the 3D-printed mount and attached to the servo. The servo is attached to the rover base using machine screws and 3D printed spacers. All the software and step-by-step instructions can be found at www.ucdistancetraining.org.

The redesigned 3D Rover platform featured a cutout for a standard model R/C servo and changing the drive motor mounting arrangement. Alternatively, a smaller 9g micro servo can be used in place of a standard servo. Additionally, there were changes in the electronic controls used with the revised 3D Rover to simplify its design and fabrication. The revised 3D Rover components incorporated the original drive motor and wheel assemblies and Arduino UNO board. However, the motor controller and battery system were changed. An Arduino L298P motor shield was selected to eliminate the separate 9-volt battery supply for the Arduino UNO and provide a means to control the drive motors. The motor shield is a miniature add-on board that plugs into the Arduino UNO. Additionally, the motor shield simplifies the wiring and input/output connections to control the motor direction and speed. Two 18650 3.7-volt lithium polymer (LiPo) batteries, battery holder, and off-on slide switch provide the necessary power for the rover.

Instructions for the complete mechatronic project was disseminated through the project web portal. A sample page display as shown in Figure 9. It includes all documentations with enough detail for users to recreate the project on their own. The step-by-step instructions for the 3D Rover Robot design project include 3D sketching and printing, electronic controls, and computer programming, to print and assemble a Robot Rover that can be operated autonomously and by remote control operation. This project is intended to promote STEM and STEM-related teaching and learning. It is significant to note that the web portal serves as a hub for these virtual collaborations.

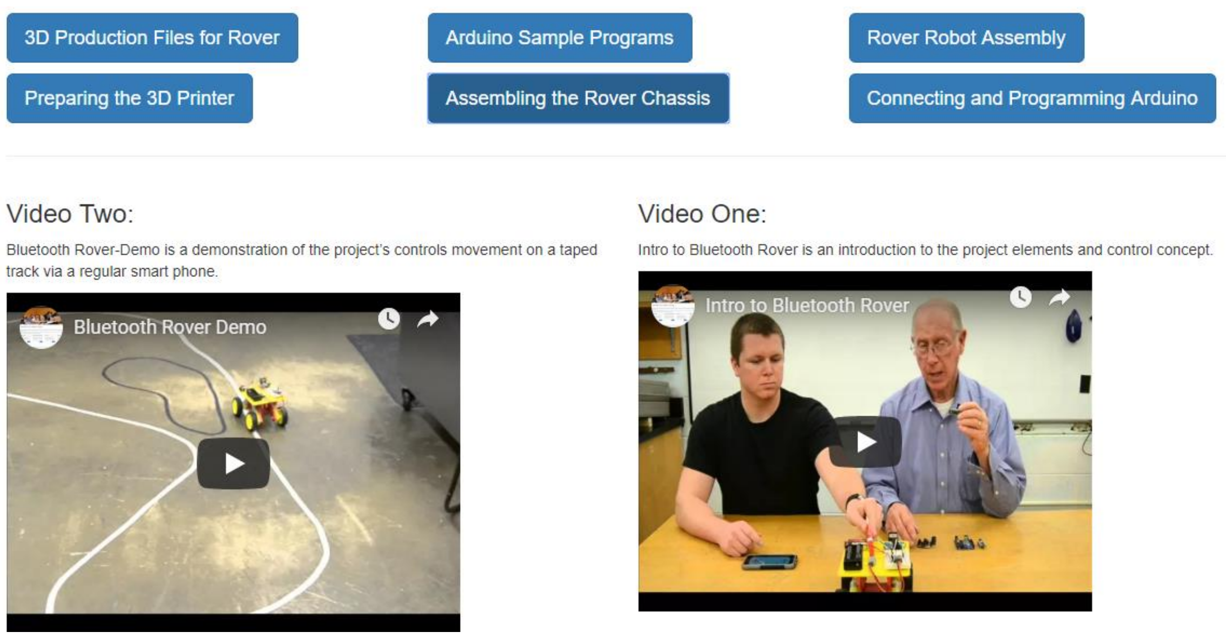

Figure 7 - 3D Robot Rover Resource Page at www.ucdistancetraining.org

This development material was used in the UNITE summer workshops that were hosted at JSU. These workshops were sponsored by US Army and Verizon. Their purposes are to generate awareness of STEM studies and career path to local middle school students.

Conclusion

The central hub www.ucdistancetraining.org for virtual collaboration was created as the result of the two NSF funded projects. It provides instructional material to general users and secured documentations for faculty educators for their professional development and collaboration. The success and value of the current web portal is the result of the tireless effort in collaboration among the faculty members that are continuously working toward the improvement of microcontroller teaching strategies and pedagogy. At the post grant period, project ideas and collaboration remain. The UNITE summer workshop hosted at JSU in 2017 was a perfect example for the collaborations among faculty at different institutions, where the web portal served the central information exchange and distribution. The research team members invite all who are interested in collaboration to continue working with them. The data shared at the web portal are open to all users; however, the LMS is dedicated to faculty members only. Collaboration cannot be done by one individual; it is a collective effort among the group. We advocate the resource sharing among faculty members and wish to mentor new professionals with our existing project results and expertise. The virtual collaboration hub keeps serving faculty members for their professional development endeavor.

The project researchers and team look forward as virtual collaboration projects continue to evolve. The project team continues to expand the concept and currently is working toward including an online resource center for students where faculty members can direct their students to this resource center for updated microcontroller information and mechatronic project ideas. It is the hope of the authors that this web portal development can serve the needs of faculty in different categories and expand to the applied engineering research.

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