122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Making Value for Society
Paper ID #13838

Find That Plane!: Evaluation of a High School Summer Science and Engineering Camp Introducing Robotics to Simulate the Search for Malaysian Airlines Flight 370 (Works in Progress)

Dr. Ricky T Castles, East Carolina University

Dr. Ricky Castles is an assistant professor in the Department of Engineering at East Carolina University. He is primarily affiliated with the ECU Electrical Engineering concentration. His research work focuses on the use of wireless sensor networks, microcontrollers, and physiological data collection for a variety of applications. His primary interest is in the area of adaptive tutorial systems, but he has ongoing projects in the area of hospital patient health monitoring. He is actively engaged in K-12 outreach through several venues including Summer Ventures, high school STEM day, the NC Science Olympiad, a Math Science Partnership grant, volunteer work with a local literacy camp, Boy Scouts Robotics Merit Badge counseling, and teaching the science portion of VBS and children's Sunday School at his local church.

Dr. Zhen Zhu, East Carolina University

Zhen Zhu is an assistant professor at East Carolina University. From 2010 to 2013 he was a senior research engineer and a principal investigator with the Navigation Systems Division and the Advanced Concepts and Technologies Division in Northrop Grumman Electronic Systems. From 2006 to 2010 he was a Senior Research Engineer with the Ohio University Avionics Engineering Center and an adjunct assistant professor with the School of Electrical Engineering and Computer Science. He has developed various systems and algorithms for automatic navigation and guidance of manned and unmanned aircraft. His research interests include sensor integration, vision-aided navigation, aircraft navigation, software radio and GPS receiver design.

Find That Plane!: Evaluation of a High School Summer Science and Engineering Camp Introducing Robotics to Simulate the Search for Malaysian Airlines Flight 370 (Works in Progress)

Each summer East Carolina University (ECU) is one of several university host sites throughout North Carolina for a four-week summer science and engineering enrichment camp for high school juniors and seniors. During the first two weeks of the camp experience students engage in interactive classes and short research projects in two or three STEM fields. Upon completion of the first two weeks of the program students then choose to conduct an in-depth research project in one of the disciplines they have been studying during the final two weeks of the program.

The engineering portion of this camp was team taught by a pair of electrical engineering faculty members assisted by undergraduate research assistants. This initiative utilized the Parallax Boe-Bot to introduce students to several STEM concepts such as computer programming, circuit development and analysis, sensor-driven control logic, data collection and storage, and pattern recognition within the context of the search for the missing Malaysian Airlines plane. Students learned how to program a robot to navigate a course, how to use sensors to avoid other robots also searching for the plane, how to create and store in memory a simulated map of the ocean floor using depth sensors, and how to detect objects of interest that may be the missing plane. The overall search and discovery methodology was introduced through various short tasks and concluded with students using mobile robots to examine a simulated ocean floor to identify anomalies indicative of areas of interest that may be the missing plane.

During the final two weeks of the program, seven students conducted in-depth engineering research projects including development of an EEG-based brain-machine interface to control mobile robots, simulation of a prosthetic hand, automated routing of materials for supply chain management, and development of a quad-rotor helicopter.

Details of the course modules are presented including logistical considerations, shortcomings, lessons learned, and suggestions for assessment of future course delivery. The details of each research project are also discussed showcasing broader implications for the research.

Introduction

Summer Ventures is an enrichment program for rising high school juniors and seniors. There are four host sites throughout North Carolina including Appalachian State University, North Carolina Central University, the University of North Carolina at Charlotte, and ECU. In this program, students have the opportunity to learn about diverse topics in fields of science, technology, engineering, and mathematics (STEM). They spend a total of four weeks on campus at their selected host site. In general, students are selected to attend Summer Ventures at host sites inside their home state, but outside of their home area so they get the experience of being away from home at camp. During the four weeks of camp, the students live in dormitories on campus, eat in campus dining halls, have access to campus recreation facilities, and take classes and conduct research projects. The program is provided to students at no cost to them, so students can participate regardless of socioeconomic standing. Students are selected based upon their state residency status, academic record, and references from teachers and counselors.

During the first two weeks of the Summer Ventures program the students rotate through three courses introducing key concepts in STEM disciplines. At ECU the course options included engineering, big data/statistics, physics, DNA fingerprinting, archaeology, and medical sciences. The archaeology and medical sciences programs required more time per day than the others due to travel and the nature of the courses, so students who took those programs may have only been able to select one or no other courses. At the end of the first two weeks, the students select one of the areas they have been learning about to conduct a two-week research project and spend the entirety of their day developing and conducting a research project in that research area. A total of 56 high school juniors and seniors attended Summer Ventures at ECU in Summer 2014.

Engineering Summer Ventures Program Goals

There were several goals of the engineering portion of Summer Ventures. First, the camp was intended to introduce students to topics they may not be otherwise exposed to in a traditional high school classroom and to allow for free exploration of advanced topics. Second, the camp provided opportunities to expose high school students to an engineering program at a large state university, in order to allow students to learn about the opportunities available to them in a university setting to pursue studies in engineering should they be interested in learning more about the discipline. Third, the program was designed to give students opportunities to collaborate with a diverse group of highly-motivated students from around the state in order to learn from each other and to build upon each other's talents in order to complete a research project. Fourth, the program was designed to introduce students to research methods, both from the standpoint of learning about the research interests of engineering faculty members and from the standpoint of a researcher conducting studies. The students had to learn how to formulate hypotheses, conduct experiments, collect and analyze data, learn from trial and error, perform engineering design iteration, learn how to work under deadlines, and learn how to document their research in a report and oral presentation.

Structure of Engineering Summer Ventures Program

The engineering portion of the Summer Ventures program at ECU was co-taught by both authors. The lead author has done extensive work in mechatronics education in both the K-12 and university setting. The second author has significant industry experience designing unmanned vehicles. Both faculty members brought their expertise to the camp and designed developmentally-appropriate activities to introduce high school students to the engineering discipline. Additionally, support was provided by three undergraduate engineering students who helped to prepare hands-on kits prior to the start of camp and assist students in the lab throughout the camp experience. Undergraduate student assistants were selected based upon their academic record and availability and consideration was also given to diversity in order to portray engineering as a welcoming field to all students regardless of race or gender. The undergraduate mentors included an African American male, a Caucasian male, and a Caucasian female.

Various studies worldwide have shown that robotics is one the engineering topics that can effectively motivate high school students in STEM learning[1,2,3,4]. Thus, robotics was selected as the main theme of the program. During the weeks that the instructors were developing the course, a hot topic in the international news was the loss of Malaysian Airlines Flight 370. In order to make the Summer Ventures experience relevant to the students and engaging, the instructional portion of the course was structured around the idea of finding a missing airplane. The students learned to program a robot to navigate a course which simulated how a search and rescue robot may travel to look for a missing airplane. The students also were introduced to basic programming and robotics hardware including sensors and motors. A total of 27 students participated in the engineering sessions during the first two weeks. During the last two weeks of the program, 7 students elected to do research in the engineering field. These students worked on a total of four projects including building and researching the flight of a quad rotor helicopter, developing a prosthetic hand using 3D printing and color sensing technology, simulating supply chain routing using smart cards, and the development of a brainwave driven mobile robot.

Introduction to Engineering Sessions (first two weeks)

During the first two weeks, Summer Ventures students attended an engineering session once per day for 2 hours, they met a total of 10 times. The 27 engineering students were divided into morning and afternoon sessions with 13 students attending in the morning and 14 attending in the afternoon. These small class sizes allowed for more faculty-student interaction and individualized support as the students built circuits and tested computer programs. Each day the tasks assigned became increasingly more difficult and built upon the knowledge the students gained in the previous day at camp. The students were given an overview on how to program, how to use sensors, how to navigate a course using a robot, how to get a robot to avoid obstacles, etc. Each day the students were given a brief lecture showing how engineers use the technologies they were working with and were introduced to the state of the art including video clips from work being done by researchers at various universities and tours of laboratories at ECU. They then had to put this knowledge together to build a robot that could navigate a lined circular path while determining how far it had traveled along that line, avoid running into other robots on the line, and determine what the depth was of some artificial terrain designed to simulate the ocean floor. The students worked in pairs and in some cases groups of three to accomplish the daily tasks.

Challenge and Course Layout

The context for the two-week course was learning to program a mobile robot that would simulate the search and discovery mission underway to find missing Malaysian Airlines flight 470. Students began by learning how to get their robots to navigate around a circular track formed by yellow masking tape on a gray foam mat as shown in Figure 1. Along the yellow circle was checkered black and white masking tape, which served as an encoder to allow the students to detect how far their robots traveled. The students also learned how to avoid colliding with other robots on the track using sensors and learned how to detect depths using sensors. In the center of the course was cardboard bent at different angles to simulate the contours of the ocean floor. The entire course was simulating the ocean turned on its side with the ocean floor in the middle of the course and the robots traveling around it. At the end of the two week period it was expected that the students could get a robot to navigate the circular track, keep track of how far their robot had traveled using the encoder tape, use sensors to avoid colliding with other robots, collect information about the depth of "the ocean" at various points around the circular track, and then use the stored information about ocean depth to detect a toy plane (Figure 2) hidden at random along the sea floor.

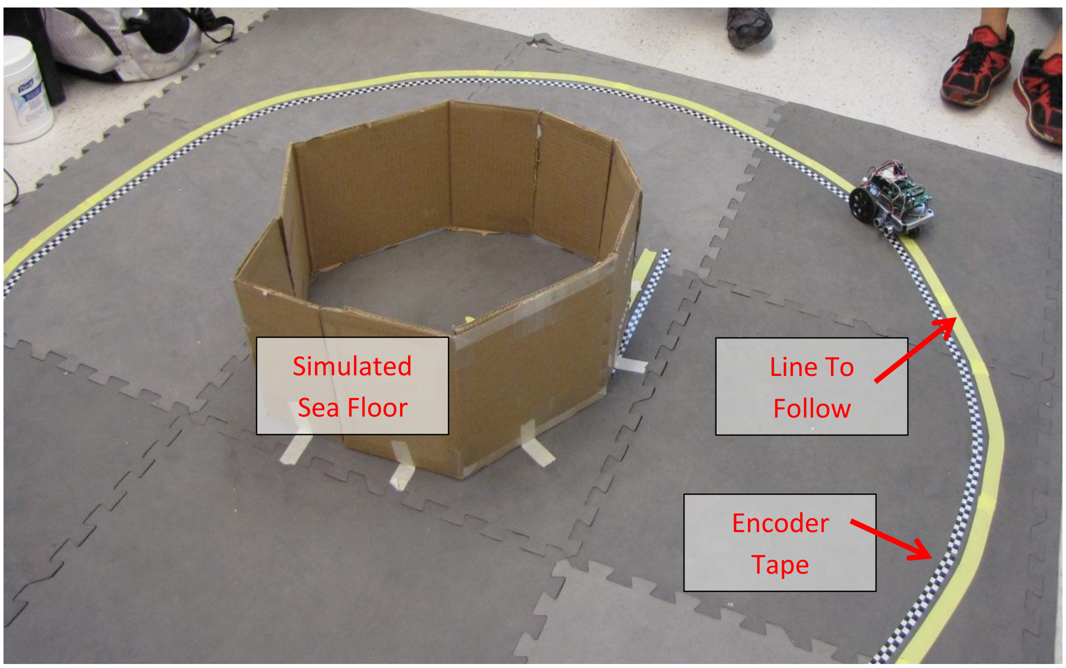

Figure 1 The Challenge Course

Figure 2 The "missing airplane"

Hardware Used

The Boe-Bot, a robotic kit manufactured by Parallax[5], was used in the introduction session for the plane searching task and later was used in several individual research projects during the last two weeks of the camp experience. The Boe-Bot platform is a rolling cart controlled by a BASIC Stamp 2 microcontroller, which is embedded in a Board of Education, as can be seen in Figure 3. The Board of Education is compatible with several types of external data interfaces (such as serial, USB and WiFi), servo motors and a large variety of analog and digital sensors. In this program, the students had opportunities to use continuous servo motors to drive the robot around the track, SONARs (PING))) sensors[6]) to detect depth and distance to nearest obstacles, and QTI line following sensors[7] for tracking the lines. Additionally, during the research portion of the course, students also investigated using color sensors to detect specific colored cards, smart card readers to route pathways through a simulated supply chain, and WiFi interfaces to stream data and commands. In most cases, students were able to successfully assemble the circuitry, develop the code, interface with sensors and motors, process and store the data by simply following manuals and studying example code and circuits, but one-on-one interaction was a key part of the learning experience as students relied on working directly with faculty members and undergraduate student assistants as they wired their circuits and developed their code.

Introduction to programming

Although several of the students had some prior exposure to high-level programming languages such as JAVA and MATLAB, few had ever used microcontrollers or BASIC.

"Robotics with the Boe-Bot-student guide[8]" was used as a textbook in the introduction session, for BASIC programming and learning to use the integrated development environment (IDE). The book included several robotic tasks as examples, such as maneuvering the Boe-Bot, basic navigation and obstacle sensing, which were later used as reference designs in the plane searching project. By following these examples, the students were not only able to independently develop BASIC programs, debug and test the hardware-software system, but also to become familiar with algorithms and techniques useful to various robotic tasks.

Basic Robot Movement

As shown in Figure 3, a Boe-Bot is equipped with two drive wheels, each with a continuous servo motor and a front caster for balance. The speed and direction of motion are directly driven by the servo motors, which are controlled via continuous pulse width modulated signals generated by the microcontroller. The frequency and duty cycle of the pulse signal determines the direction of motor rotation, forward, idling or backward.

Students were introduced to the basic terms of signal timing (frequency, cycle, pulse width, duty cycle), digital logic (low and high, logic conditions) and control flow (conditional statements and loops) from completing this task. They learned to use a few different data types in the program, and some basic debugging skills. Since the motors used were not identically tuned, they could not be controlled with the exact pulse frequencies specified in the textbook examples. The students were encouraged to jointly calibrate the motors and software settings, which helped them to understand the interaction between hardware and software in a robotic system and the importance of system calibration and tuning. Finally, the students were able to define subroutine programs to control the Boe-Bot, such as turning to a desired direction, moving a set distance, sharp turns and spins.

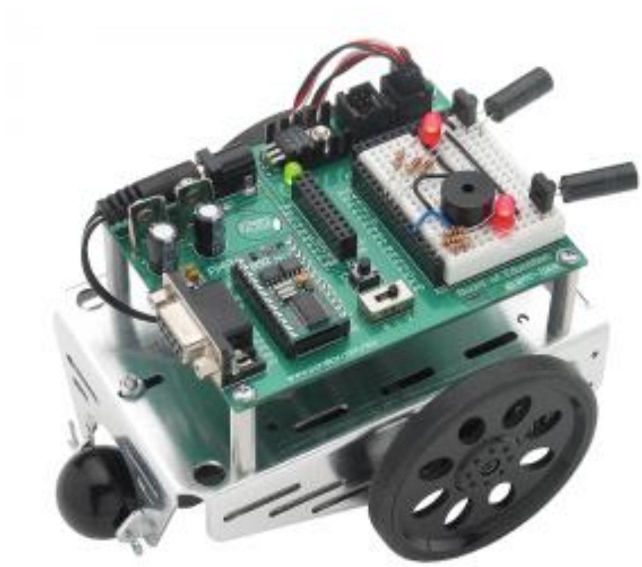

Figure 3 A Boe-Bot Kit with BASIC STAMP 2 Board of Education and Sensors[9]

Line-following Task

Once the students became more familiar with the basic operation of the servo motors and could appropriately control the robot by having it drive in the forward and reverse direction and make turns, they were tasked with getting their robots to follow the circular lined course. The course was designed to be approximately 5 feet in diameter and was laid out on interlocking gray mats. The students used 3 QTI sensors for this task. The sensors were placed underneath the robot using small standoffs attached via metal brackets to the Boe-Bot frame. The sensors were lined up side-by-side and spaced such that the middle sensor could be above the line while the outside two sensors were just barely off the line. Any divergence from the line could be detected by the QTI sensors and corrective action could be taken by the motors, for example if the sensors detected that the center sensor was no longer over the tape, but the left sensor was, this would mean that the robot was too far to the right and should steer back toward the left.

Use of Ultrasonic Sensors

Mapping and target detection rely on the observation of a desired object and the estimation of its 3D location or the distance between the object and the sensor. In an underwater environment, SONAR sensors installed on submarines have been used to measure the distance to the ocean floor. With known locations of the submarine and the sensor, one can use the distance estimation to scan and map the ocean floor. If *a priori* maps of the ocean floor are also available, the SONAR scans can then be used to search for any foreign objects, which in this case may be the fuselage of the missing plane.

Ultrasonic SONAR sensors can also be used on the ground, although the range is often limited. In the lab environment, the Parallax Ping))) SONAR has a range of 0.02 to 3m, with a beam width of approximately 20 degrees[6]. It is estimated that the range accuracy is approximately 0.1 m (1 σ). In this project, the simulated ocean floor was placed in the center of the circular track, and a Boe-Bot would use a side-looking SONAR to scan it. The radius of the Boe-Bot track was thus made shorter than 3 m, and the simulated plane was 0.2 m off from the floor for easy detection. In the unmanned vehicle industry, other sensors such as vision cameras and laser scanners have also been used in place of the SONAR. The students were introduced to the concept of multi-sensor unmanned systems via a lecture from an expert on unmanned systems. Although they only learned to use the Parallax Ping))) sensor in the training session, a group of students dedicated their research project to Unmanned Aerial Vehicle (UAV) geolocation by using cameras.

An underwater unmanned vehicle will need to be equipped with a sense-and-avoid system in order to avoid collisions with the terrain and other vehicles. This system is typically based on SONAR sensors as well. A similar problem exists in the simulated environment, as multiple Boe-Bots would be attempting to search the ocean floor simultaneously on the same track, and they would not travel at the same speed or even at the same direction. The Boe-Bots were equipped with a secondary, forward-looking SONAR to detect the proximity of other Boe-Bots. The students designed and developed the software for proximity detection and collision avoidance reaction of the Boe-Bots. Through experimenting with the SONAR sensors, students were exposed to the concepts of range measurement, resolution and noise. They learned to improve the SONAR signals via mechanical adjustments, such as increasing the reflection area, and also some fundamental gating and filtering methods in software.

General Navigation Strategies

Most students were already familiar with the concept of navigation using GPS, and a few students were even able to describe a simplified mathematical model for GPS positioning. Although GPS-based navigation would be convenient, it is not available underwater for the actual plane search task, nor was it in the simulated environment indoors. The students were introduced to alternative strategies of navigation, guidance and control in a GPS-denied case. One of the most commonly used strategies is dead-reckoning, in which a vehicle measures its own motion. By accumulating the motion estimates over time, the vehicle can deduce its current location from a starting point. Whereas an underwater vehicle may use a high-quality inertial navigation system for dead-reckoning, such a sensor is certainly not affordable in this project. Instead, dead-reckoning was simulated with the Boe-Bot QTI sensor while a tape served as a feedback loop for an encoder system. Figure 4 depicts the Boe-Bot with all sensors attached.

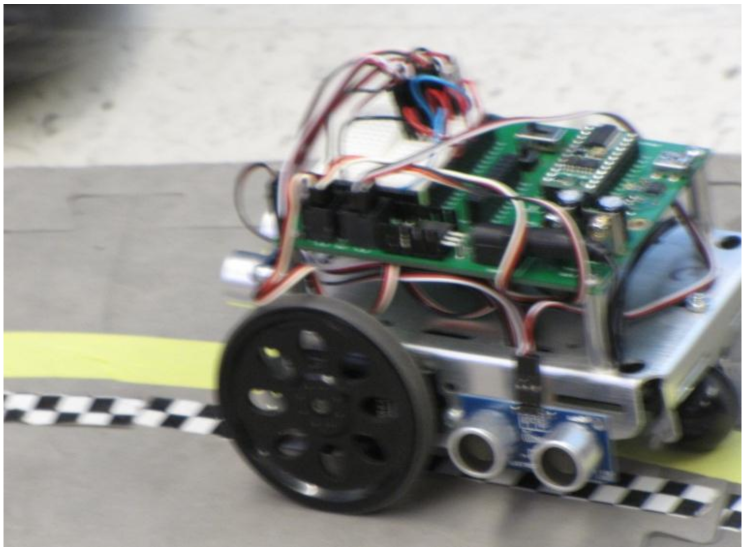

Figure 4 A Boe-Bot with all sensors mounted to navigate the course and detect the ocean floor

Travelling a Set Distance, Storing Map Information, and Detecting the Lost Plane

In order to accurately determine a map of the "ocean floor," the students needed to program their robots to reliably move a set distance and collect data from specific points around the circle. If the robots were simply programmed to move a certain number of program cycles or for a set period of time using dead reckoning, then the robots could get off course and the repeatability of their pathway would not be possible. In order to ensure reliable and consistent traversal of the course such that each depth measurement was taken from the same point, a checkered grid tape was placed around the track in a circle concentric to the one the robots were programmed to follow. The students measured the length of each square on the checkered grid and used a fourth QTI sensor to detect each time their robot passed from a black to white square and vice versa, indicating that the robot had traveled one square length. The students were then free to decide how far apart they wished to sample the depth of the ocean in order to get a comprehensive map of the ocean floor. Students were also free to choose a starting point anywhere along the circle to define their own origin.

Upon getting their robots to travel a fixed distance and getting a side-mounted ultrasonic sensor to collect ocean depth information at set intervals, the students needed to store this information as the general map of what the ocean floor looked like in the absence of a plane. The students were then instructed on how to use arrays to store information in memory and how to store their map into the Basic Stamp's EEPROM to serve as a reference. Once each group had a map of the ocean floor stored in memory, the course instructors placed a toy plane randomly next to the ocean floor. The students were then instructed to develop a program that would travel around the entire track comparing the measured depth to the depth stored in the stored ocean floor map depth at each point. When differences were detected between the stored ocean floor information and the current reading at any given point along the circle, the students could identify that area as the potential location of the wreckage. When the robots identified possible wreckage locations they were to notify observers that a candidate location for wreckage was found. The students were free to decide how to perform this notification, but could do so by blinking a light or making their robot do a specific movement. Each group took on their own approach to notification.

In Figure 5, a student can be see using polar coordinates to plot the data collected from the ultrasonic sensors to map out the ocean floor. Using various software packages, such as Excel and Matlab, allowed students to examine the data collected by their robots to determine if the mapping was being done correctly and the sensors were appropriately detecting the simulated terrain. In a few portions of the map in Figure 5 it can be seen that the sensor overshot the terrain and in these cases the sensor missed the ocean floor and detected obstacles on the other side of the circle instead. This allowed the students to refine their design and rethink the placement of the sensors. In Figure 6 student mapping data is depicted. In this data the spikes indicate places where the plane may be located as indicated by significant differences between the map data and the currently sensed data.

As can be seen in Figure 7, the students took turns testing their robots on the track. While some students ran their robots on the course, other students reprogrammed their robots. In Figure 8, two Boe-Bots are depicted in search of the missing plane. All groups were able to get their Boe-Bots to navigate the track and to avoid colliding with other robots. Some groups were successful in finding the missing plane, while others were unable to achieve the goal of finding the missing airplane. Since this camp was designed to be an enrichment experience, more emphasis was placed on the learning process and understanding how technology is used than on the success of finding the missing airplane.

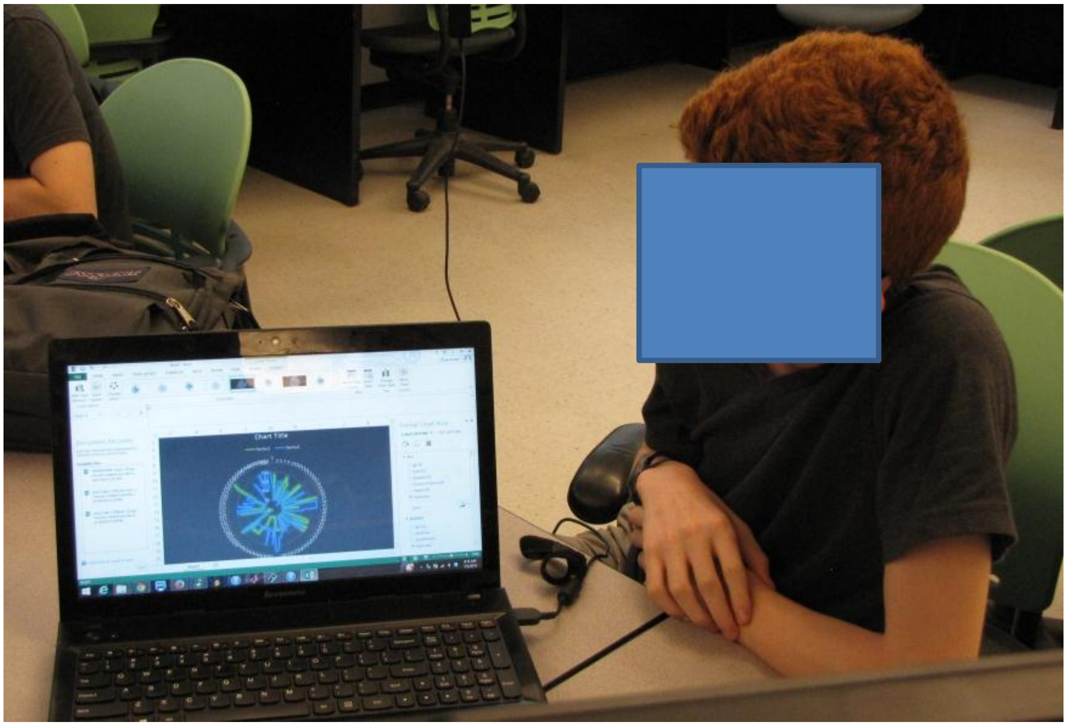

Figure 5 A Summer Ventures student uses polar coordinates to plot the ocean floor

Figure 6 Data collected by Summer Ventures students' robots. The spikes indicate possible areas where the missing plane may be located

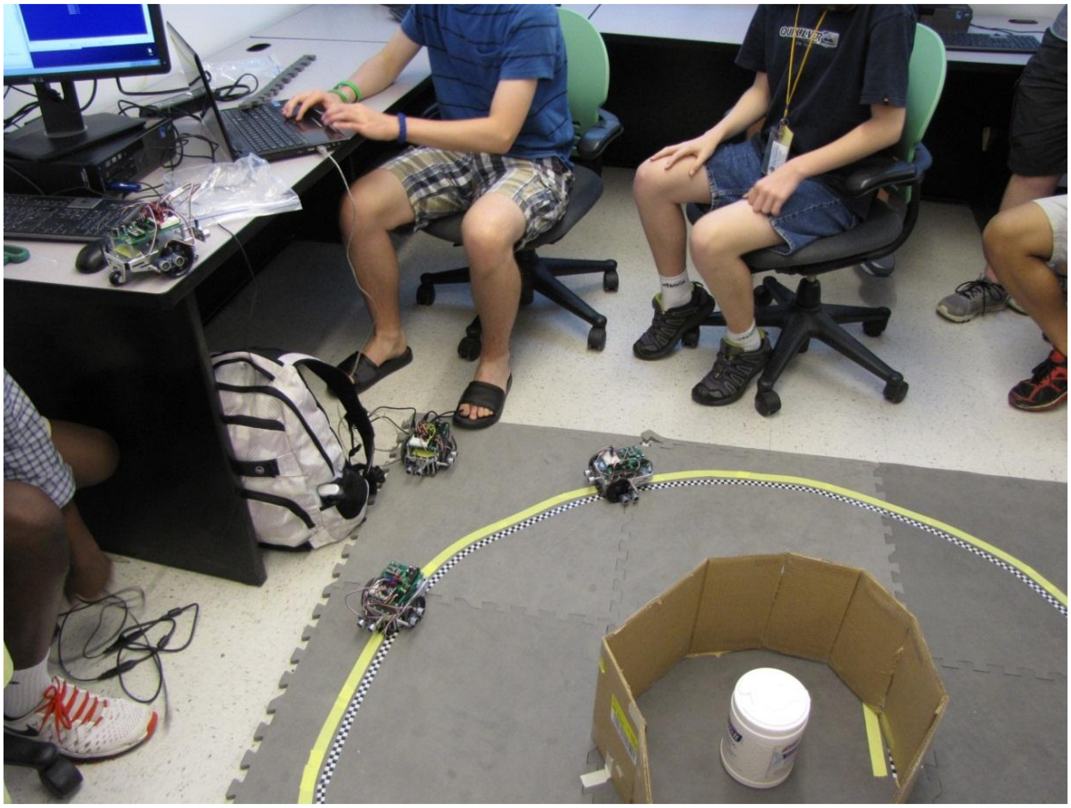

Figure 7 Students test their robots on the track while other groups reprogram their robot

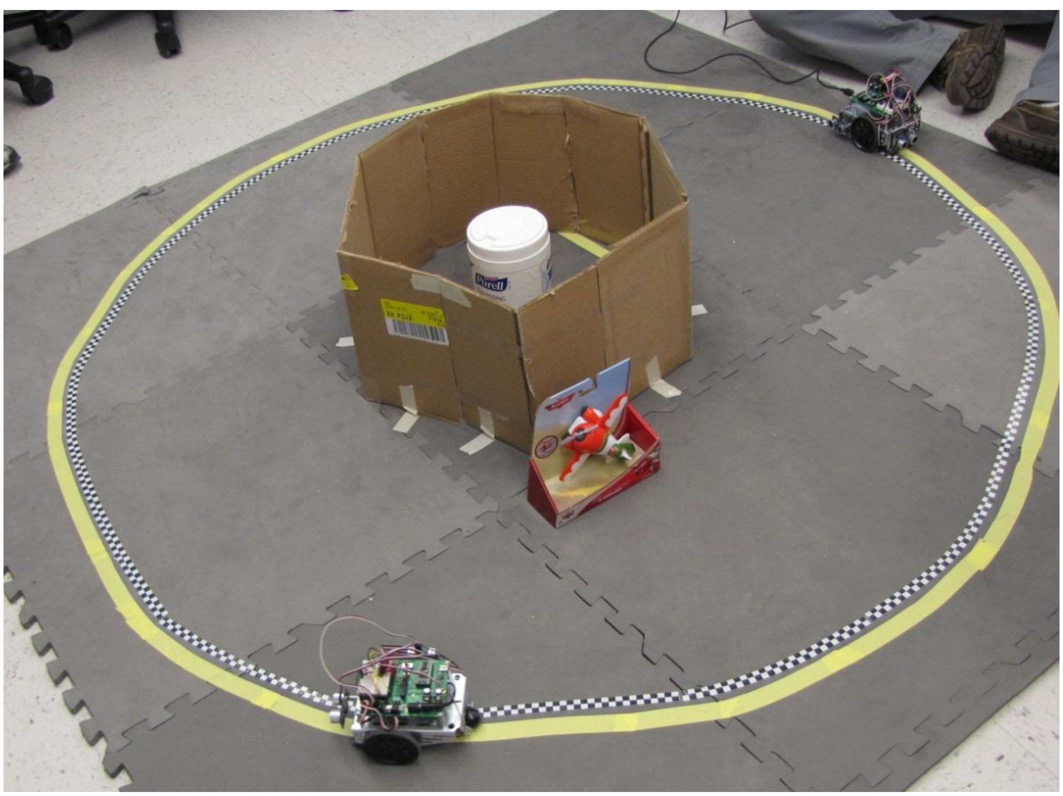

Figure 8 Two Boe-Bots in search of the missing plane

Research Projects

Upon completion of the first two weeks of the Summer Ventures camp, students submitted their choice of program in which to conduct research. Out of the 27 students who studied engineering during the first two weeks, 7 students decided to continue their pursuits in an engineering research project. This group of researchers was quite diverse including 3 females and 4 males. The engineering researchers included two African Americans, two Asian Americans, and three Caucasians.

Quad Copter Project

A group of two students decided to investigate cutting-edge technologies involved with small UAVs. They had two specific goals, 1) assembly of a small UAV using a 3D-printed frame and 2) tracking of UAV motion using a camera. They ordered low-cost components including a micro-controller, engines, propellers and batteries, and then explored several open-source designs of the UAV frame. The particular design selected in their project was 3D-printed by a rapid prototyping machine. Within days, the whole UAV was assembled and tested in an indoor flight using a remote control. Through the initial flight test they quickly came to understand the pros and cons of the 3D printed frame. Although flexible and convenient, the material used in the rapid prototype machine limited the strength of the frame. They modified the design by using soft landing pads instead of rigid landing gear, as shown in Figure 9, which lead to successful flights and safe landings.

Figure 9 Small UAV Using 3D Printed Frame and Soft Landing Pad

Inspired by the plane search project, they were further motivated to design a vision-based UAV tracking system. They designed a ground station that could track the image of the UAV, which consists of a webcam and a PC installed with MATLAB®. Since most parts of the UAV were blue, a simple blob tracking algorithm was used to detect and trace the UAV. For safety reasons, the software was tested and successfully demonstrated using a toy micro-UAV in the lab, instead of the one shown in Figure 9. As they studied the principles of navigation and target geolocation, they understood that the 3D location of the UAV could be computed using triangulation. They expressed interest in designing a 3D tracking systems with multiple cameras using stereo vision in the future.

Prosthetic Hand Project

A group of two students were interested in designing realistic prosthetic hands using low-cost components. They were able to construct a robotic hand-eye system in this project, which is a prosthetic hand with a human-machine interface. The hand was driven using a Board of Education, the same microcontroller-driven logic board using in the Boe-Bot platform, with low-cost servo motors, and a color sensor functioned as the "eye". The parallax color sensor[10] could identify the color of the object placed underneath it within a few cm. Once the microcontroller received the color reading, the hand would show a gesture in return. As a demonstration of their capabilities, the students programming in hand gestures for making the hand signs used in the classic game rock, paper, scissors. For green, blue and red colors, the hand gestured "rock", "paper", and "scissors," respectively.

The students were able to program subroutines for color detection. They understood the nature of RGB colors and how they would be represented in the BASIC stamp 2. They developed simple color detection algorithms, which were based on the threshold values calculated through repeated trials. The hand, thumb and fingers were designed in Solidworks® and 3D printed using a rapid prototyping machine, as shown in Figure 10. The fingers and thumb were controlled with individual servo motors, which had motion pre-programmed as subroutines for rock-paper-scissors.

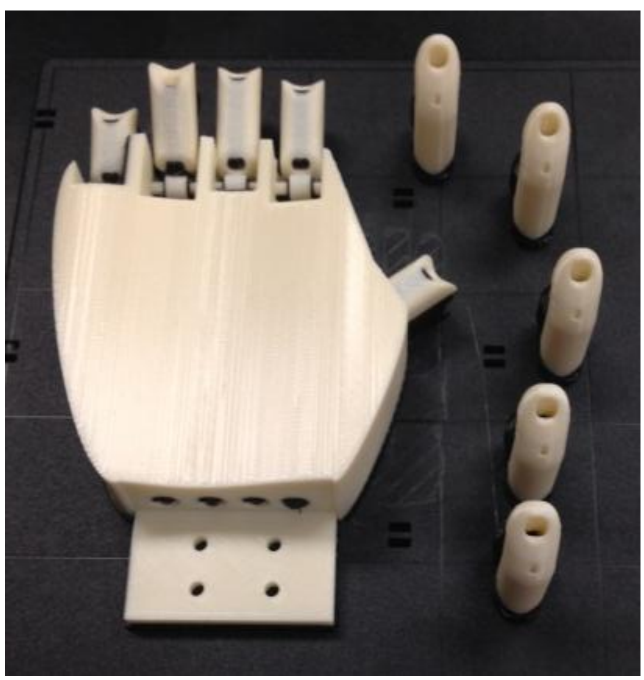

Figure 10 3D Printed Palm, Fingers, and Thumb (photo courtesy of students)

The lab demonstration was successful. The hand-eye system correctly recognized different colors printed on paper, and provided correct feedback consistently. The students also learned about the limitations of the 3D printed components, especially the weight-bearing joints, as they had to repair a joint on the thumb that was damaged by the weight.

Supply-chain Management Project

One student was particularly interested in learning more about the use of Radio Frequency Identification (RFID) technology. While there was not enough time to procure RFID tags for her research, the university did have some smart cards available to mimic the behavior of RFID-based systems. This student then developed a project driven by the Parallax Board of Education to read in information from one of four smart cards and to route a marble to the appropriate bin. She was also interested in 3D printing technology and designed a hopper to hold marbles for her project using SolidWorks® and printed her hopper using a 3D printer. As can be seen in Figure 11, when a smartcard was inserted into the smartcard reader, servo motors attached to each ramp were actuated to turn the ramps to the appropriate angles to route the marble into bins 1, 2, 3, or 4. The hopper then released the marble and it traveled down the ramps into the appropriate bin. The student also added a whisker sensor and a digital counter in order to count the number of marbles placed into bin 1 (the leftmost bin). The student extensively studied the datasheet for the smartcard to learn how this sensor worked, performed trial and error testing of different angles for the ramps to ensure that the marble would gently land in the bins without bouncing out, and learned about the electronics of a touch sensor and a interfacing 7-segment counter display to detect when a marble traveled into bin 1 and to appropriately display a count on the display.

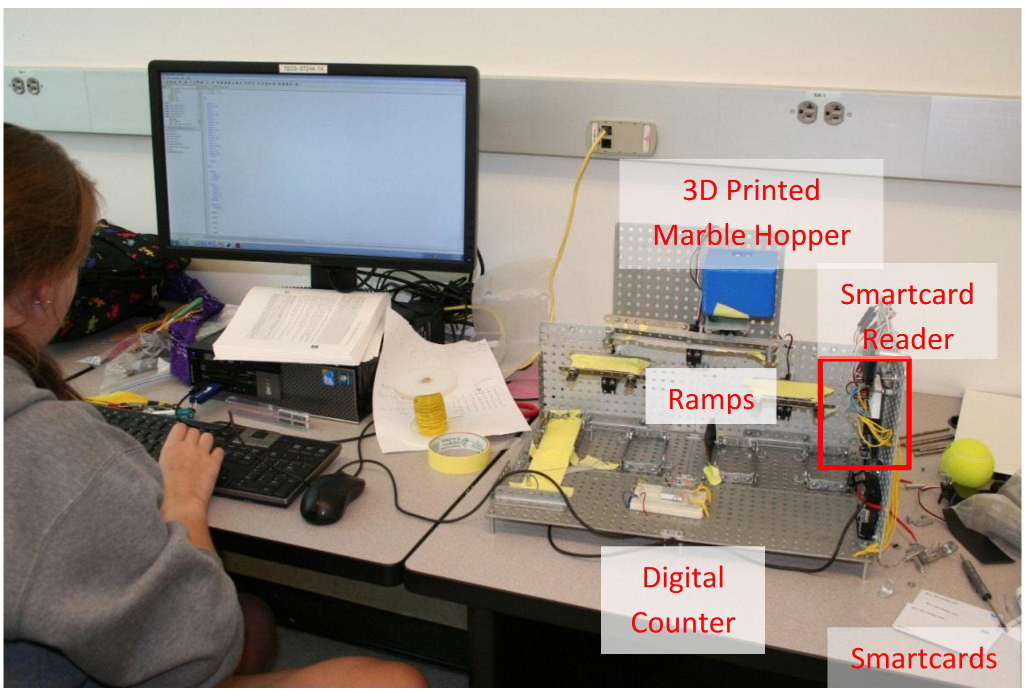

Figure 11 A Summer Ventures engineering researcher works on her project on supply chain management

Brainwave-based control of Boe-Bot

The fourth research team was comprised of two students who were interested in brain-machine interfaces. Their project involved collecting brainwave data using the Emotiv[11] system, a Bluetooth-based wireless electroencephalogram (EEG). The Emotiv is a 14-channel EEG system capable of monitoring brain waves topically. The students collected one of the two student's brainwaves on each channel as he was imagining the robot moving forward, moving in reverse, and remaining still. The students then analyzed the signals on each EEG channel to determine which ones showed variation under the different thought patterns. Students were introduced to the frequency domain and the use of Fast Fourier Transforms (FFTs). The students then isolated these channels and developed some statistical models based upon what they learned in the big data/statistics class during the first two weeks of camp and developed predictive algorithms to determine what the user was thinking in terms of robot motion. From these predictions the students then generated a text file that would serve as a script for the robot to determine how long it should take on each motion (move forward, move backward, and remain at rest). They worked with undergraduate assistants to translate the script into signals that could be sent wirelessly to a Boe-Bot using XBee WiFi chips[12]. This team of researchers is depicted in Figure 12 with one student wearing the Emotiv EEG headset and collecting data. Despite only working on this project for two weeks, the students were able to correctly determine the desired motion the student was thinking of 71% of the time after the algorithm was trained.

Figure 12 Students collecting EEG data to train their Boe-Bot

Design Documentation

At the end of the camp experience, all research students completed a final research paper. Writing the research papers allowed students to survey the literature to gain greater understanding of their research topic and to understand the advances in these areas and the drawbacks. The paper assignment also introduced students to the techniques scholars used to formally document their work. In addition to the research paper, all students made an oral presentation of their work on the last day of the camp and the public was invited to see their project work. Parents and other faculty members were very impressed by the quality of work the students were able to produce in such a short period of time.

Outcome Assessment and Recommendations

This was the first time that either author taught this course. As the main goal of this year was to develop and mature the curriculum, a formal outcome assessment procedure was not yet implemented. In order to quantitatively evaluate the outcome of this program in the following years, a combination of objective and subjective assessment tools is proposed.

Students will be surveyed on their opinions and knowledge of robotics, engineering and STEM, both pre-camp and post-camp. A comparison of pre-camp vs. post-camp survey results will be used to gather data on the change of student perception as well as their learning outcomes. In addition, systematic interviews and classroom observations can be planned throughout the program. Results from such interviews and observations can help determine the overall effectiveness of using robotics in engineering education[4].

Finally, longitudinal tracking of student progress in the upcoming few years should be evaluated, which would provide data to directly assess the long-term outcome of the program. For example, three of the juniors who participated in the research projects have applied for top pre-college research programs. Although their status was not actively tracked, they requested reference letters from both faculty members. Ultimately, what is of interest is whether the students gain an appreciation and greater understanding of the STEM disciplines and how that manifests itself by participating students electing to pursue a career in STEM fields. This can be tracked by the percentage of students enrolled in STEM majors in college[1].

Recommendations for Improvement and Student Feedback

When the pre-camp surveys are implemented, it will also allow the university to better prepare to accommodate research projects more tailored to the interests of students. Without knowing the research interests of students and how many students may decide to pursue research projects in engineering while at camp, the lab supervisors and instructors had to guess at how much equipment would be needed and order supplies in anticipation of student project needs. More tailored information prior to camp would allow camp instructors to better prepare and to ensure that all supplies were readily available without having to wait on shipments. Despite many students participating in engineering activities during the first two weeks of the camp, only 7 students conducted engineering research. One student commented during the first two weeks of camp that she thought engineering was her favorite camp activity, but she decided to pursue research in another area because she felt she could be more successful there. It seems that although these students are all high-achieving and highly-motivated, that many of them are risk-averse and despite not receiving any sort of a grade for the camp or being judged on the success of their projects, students often gravitated toward areas and projects they perceived to be more attainable instead of areas that would provide them with a more rigorous challenge.

Students commented on how they enjoyed working with the undergraduate assistants. The authors believe that having mentors only a few years older than the students helped the students to see a pathway forward into an engineering career that is attainable.

Since the Summer Ventures camp experience, three of the engineering research students have requested letters of recommendation for college scholarships from the Summer Ventures engineering instructors and have cited their work at Summer Ventures as one of their proudest accomplishments.

Conclusions

The Summer Ventures experience allowed 56 students to be exposed to STEM disciplines in an intensive 4-week camp program. The projects created by the students were of high quality and the students rose to the challenge of learning to program mobile robots, building circuits, and learning how to scientifically collect, analyze, and present data.

References

[1] Fox, H.W. and Overton, M.R., "Using Robotics to Enhance Outreach Programs for High School Students," American Society for Engineering Education Illinois-Indiana and North Central Joint Section Conference, March/April 2006.
[2] Kauffmann, P., Hall, C., Batts, D., Bosse, M., & Moses, L., "Factors influencing high-school students' career considerations in stem fields," Proc. American Society for Engineering Education Annual Conf. & Exp., Austin, Tx, Jun 2009.
[3] Ruiz-del-Solar, J. " Robotics-centered outreach activities: An integrated approach," IEEE Transactions on Education, 53(1), 38-44, 2010
[4] Ayar, M.C., Yalvac, B., Ugurdag, F., and Sahin, A. "A Robotics Summer Camp for High School Students: Pipelines Activities Promoting Careers in Engineering Fields," Proc. American Society for Engineering Education Annual Conf. & Exp., Atlanta, GA, Jun 2013.
[5] Parallax, Inc. Boe-Bot Robot, Online:http://www.parallax.com/product/boe-bot-robot
[6] Parallax, Inc. Ping))) Ultrasonic Distance Sensor, Online:
http://www.parallax.com/sites/default/files/downloads/28015-PING-Sensor-Product-Guide-v2.0.pdf
[7] Parallax, Inc. QTI Sensor, Online: http://learn.parallax.com/KickStart/555-27401
[8] Parallax, Inc. Robotics With the Boe-Bot Student Guide, Version 3.0, Online:
http://www.parallax.com/sites/default/files/downloads/28125-Robotics-With-The-Boe-Bot-v3.0.pdf

[9] Parallax, Inc. Boe-Bot Kit-USB, Online: http://www.parallax.com/product/28132
[10] Parallax, Inc. Color Sensor Module, Online: http://www.parallax.com/sites/default/files/downloads/28302-TCS3200-doc.pdf
[11] Emotiv EPOC Online: http://emotiv.com/epoc.php
[12] Digi XBee WiFi Online: http://www.digi.com/products/wireless-wired-embedded-solutions/zigbee-rf-modules/point-multipoint-rfmodules/xbee-wi-fi