Arduinos, Mobile Robots, and Smartphones for a Computer Engineering Summer Camp

Girma Tewolde and Jaerock Kwon
Electrical and Computer Engineering Department
Kettering University
Flint, MI 48504
Email: {gtewolde, jkwon}@kettering.edu

ABSTRACT

The open-source software and hardware community in the cyber world is growing at a fast pace. In the recent years hardware kits based on Arduino have become very popular because of their affordability and simplicity to quickly learn the technology and apply them to all kinds of projects. This paper presents a pre-college program developed at Kettering University using the low-cost Arduino microcontrollers, various types of sensors and actuators, mobile robot platforms, and Android Smartphones/tablets. The goal of the program is to expose high school students to the field of Computer Engineering by introducing them to basic concepts and practical hands on experience in electronics, digital logic, programming, interfacing, sensors, actuators, and wireless communication. Through this program students learn how technological advancements in embedded systems is a critical component of the smart devices everyone interacts with on a daily basis, ranging from consumer electronic products used in households, personal communications, fitness and health monitoring, factory automations, automobile safety and autonomous driving technologies. The curriculum also motivates the students to develop their creativity, problem solving, communication, and team skills.

INTRODUCTION

In the recent years the government and the educational community has been placing growing emphasis in STEM ((Science, technology, engineering, and mathematics) education at K-12 and higher education [1]. According to a report published by the US Bureau of Labor Statistics (US-BLS), the future of the economy where the jobs of tomorrow will be is in STEM [2]. In this report employment in occupations related to STEM is expected to grow to more than 9 million between 2012 and 2022, which is an increase of about 1 million jobs over 2012 employment levels. And the charts in Figure 1 show the projected levels of new and total STEM jobs through 2022 [3, 4]. From these charts it is obvious that the statistical projections show that the STEM jobs with the most growth will be in computing.

Even though there is expected to be fastest job growth in the STEM fields, studies show that the student population is not well prepared to fill those in-demand jobs. Only 16 percent of US high school seniors are proficient in mathematics and interested in STEM career [1]. The US is falling

behind in international rankings among industrialized nations in proficiencies in STEM related subjects [1]. Thus, to stay competitive in technological advancement and maintain global leadership the US government is creating strategies with high priorities in STEM education.

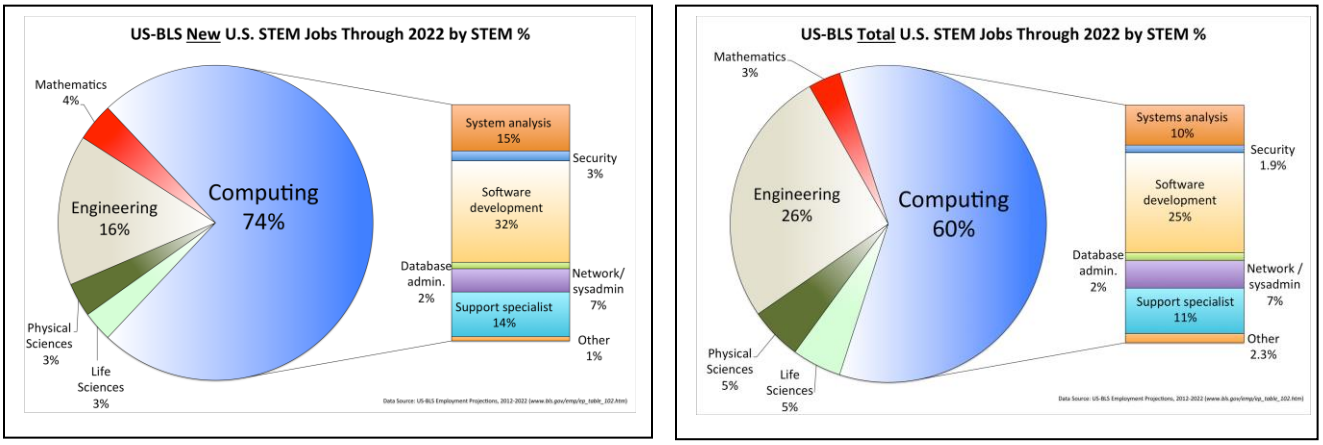


Figure 1: US-BLS New and Total projected STEM Jobs Through 2022 [3, 4]

Kettering University is a small private institute with primary focus in STEM fields, well known for training experts in the specific technical fields and leaders in global corporations as well as government and non-government organizations [5]. The university places great emphasis in classroom instructions tightly coupled with hands-on practical experience in laboratories, workshops, applied research, and real-world professional co-op experience in companies. This approach of combining the theoretical lessons with practical applications is found to be critical element in producing graduates who master the fundamental principles, advanced topics and the actual real-world application of the knowledge gained in the classroom.

COMPUTER ENGINEERING SUMMER CAMP AT KETTERING UNIVERSITY

The Electrical and Computer Engineering (ECE) Department at Kettering University has been putting a great deal of effort in motivating and attracting high school students to the ECE fields of study. Most of such activities are traditionally conducted in informal ways through on-campus visits by prospective students to the department and its laboratory facilities. During the organized visits, faculty and staff conduct presentations and demonstrations about the ECE program and its wide ranges of applications to prospective students. The department also participates in off-campus programs co-sponsored with outside community and educational organizations. The main goal of such programs is to increase awareness of the participants' about the field of ECE, and more importantly about what Kettering University has to offer, especially with its excellent laboratory and highly successful co-op program as one of the top experiential learning experiences. This has been one of the main recruitment activities for the department.

In addition to the above informal activities, the authors long recognized the need for more formal educational training programs targeted to high school students with the main goal of enhancing their level of basic understanding about the general field of ECE, with a specific focus in the Computer Engineering program. With this in mind the Computer Engineering Summer Day Camp was launched in the Summer of 2010, as a pilot program with only seven participants in the first year. This first offering was conducted as a half-day program for one-week. It used Lego mobile robots, sensors, and programming, as the main teaching tools for demonstrating to the students the practical applications of their STEM education.

The program recruitment personnel reach out to local school districts by contacting the high school counselors, mailing out promotional materials, distributing flyers during university open-houses, and posting program information on the university website. Since the region Kettering is located in is surrounded by traditionally underserved community, the summer program makes special effort to attract students from the local community by offering need based scholarships for families who cannot afford the program fees.

After receiving encouraging feedbacks from its initial offering, the following year the summer camp grew into a full-day, one-week long program with new material introduced in Android Apps development. To further enhance the hands on activities and increase excitement, the students get to learn how to develop their own App that allows them to wirelessly control their robot from an Android Smart device over Bluetooth interface. In the last day of the camp students are challenged to apply the knowledge they learned in the program and their own creativity to develop their solution and demonstrate their best performance at an organized competition. The summer camp soon turned out to be successful as it continues to attract talented students and gains recognition in the university as well as the surrounding community. Due to its success, the Computer Engineering Summer Camp program has managed to receive funding from community foundations and corporations. The program details and its curriculum are presented in depth in a previous paper of the same authors [6].

As a follow up to the first introductory level summer camp program, in the last two years (since Summer 2013) we created a second program based on the Arduino microcontroller, which is becoming increasingly popular, low-cost, open-source hardware and software platform. This second summer camp is geared towards intermediate and advanced level students, who may have some previous basic programming or robotics experience.

ARDUINO BASED SUMMER CAMP PROGRAM CURRICULUM

The main curriculum components of the Arduino based summer camp program are:

a. Microcontrollers – Understand how consumer electronics, automobiles, robots, etc. are made “smart” by using microcontrollers (“tiny” computers) embedded in these products.

b. Mobile Robotics – Use Arduino Microcontroller and robotic kits to build mobile robots and write programs to control them. Learn different sensor technologies that could help make the robots smart.
c. Smart Phone Programming – Basic introduction to App Development so that the participants will be able to use Smartphone or tablet to remotely control robot via Bluetooth.

The actual daily plan for the list of topics covered in this summer camp is as follows:

Day 1:

- General introduction: ECE, robotics, career opportunities
- Presentation by Kettering Admissions
- Introduction to electricity & electronics
- Electrical components – power supply, resistors, lights, switches, measurements of voltage, current, power
- Introduction to microcontrollers & the Arduino

Day2:

- Circuits, schematics, prototyping – breadboard, building simple LED circuit with switch control
- Inputs & outputs
- Arduino programming
- Hello World – with switches, lights, and LCDs

Day 3:

- Testing the robot motors using the motor controller
- Driving around – controlling speed and direction
- Arduino programming – time delays, loops, conditional statements
- Driving in square and circular paths
- Robot sensors
- Sense-plan-act paradigm
- Light sensor and applications – example: robot that seeks light or avoids light
- Line following robot using light sensor

Day 4:

- Ultrasonic sensor and applications
- Obstacle detection using Ultrasonic sensors
- Ultrasonic programming challenge
- Introduction to Smartphone Apps
- Making your first Android App

Day 5:

- Bluetooth communication
- Arduino program for Bluetooth interface
- Android App for wirelessly controlling the robot over Bluetooth
- Major design challenge (using Bluetooth and Android app)
    - Example: Obstacle course programming challenge with the ultrasonic and light sensors for providing added safety to avoid crashes

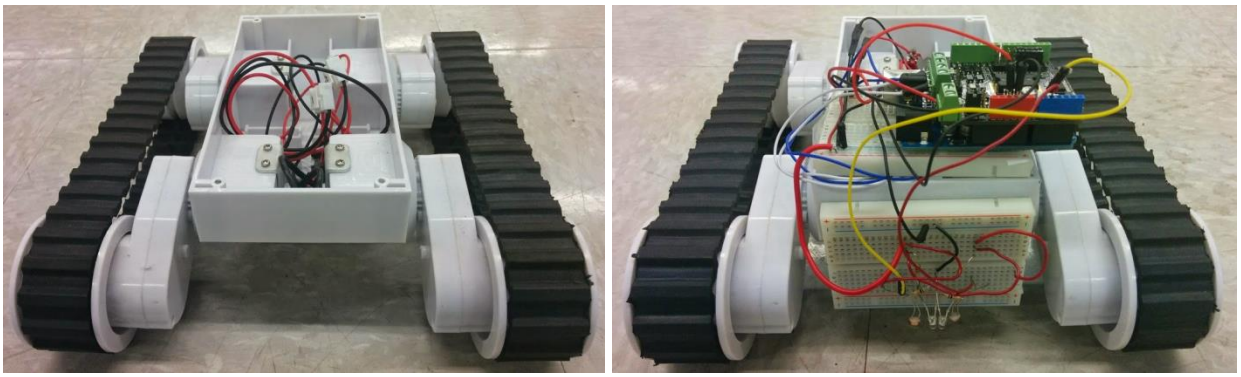


Figure 2: (Left) Mobile Robot Chassis [8]. (Right) Assembled with Circuit Boards

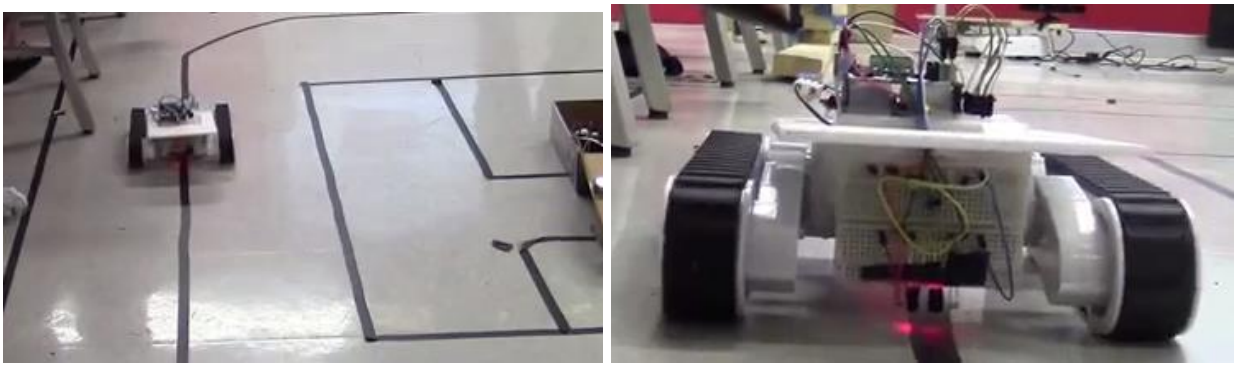
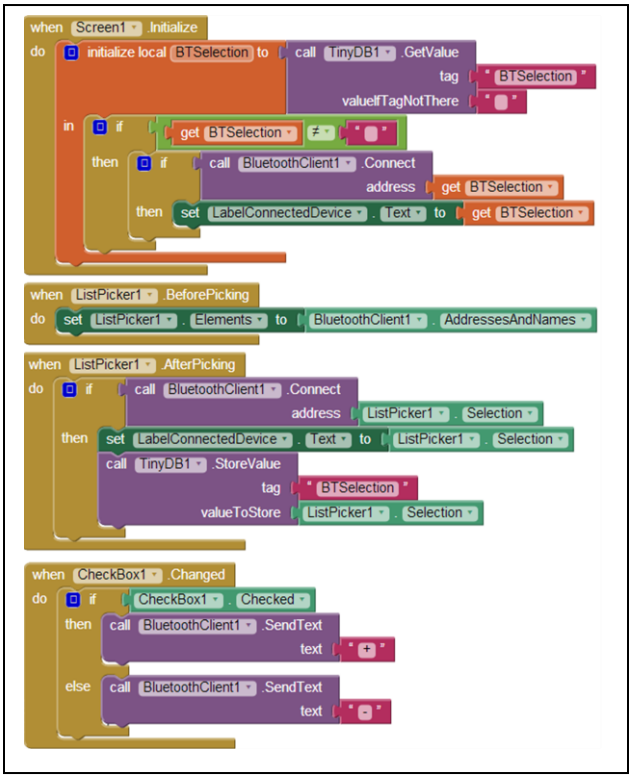


Figure 3: Line Tracing with Two LEDs and Light Sensors



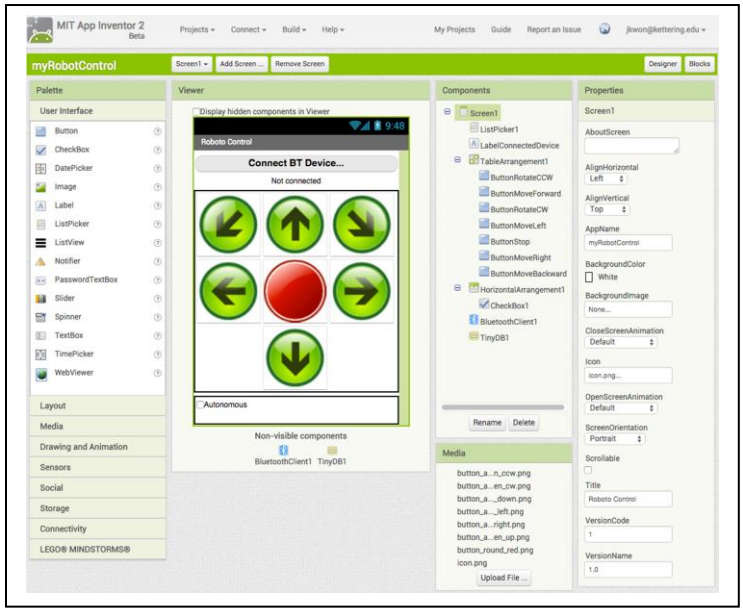


Figure 4: Sample App Inventor Block diagram and user interface for implementing remote control using Bluetooth connection

PROGRAM EVALUATION

The computer engineering summer camp presented in this paper is still a work in progress. Arduinos, mobile robots, and Android Smartphones make exciting tools for introducing students core concepts of computer engineering. The program is open to high-school students who have some basic programming or robotics experience. The first offering of the program as a pilot was run in the Summer of 2013, with only 9 students. The following year some revisions were applied to the program based on feedback received from the first offering. We had a total of 12 participants (9 males and 3 females) in the 2014 summer program. Below is a summary of the survey results from the these participants:

a) Whether the program met the participant's initial experctation:

   9 students (75%) reported that the camp satisfied their initial expectations (with scores of 4 or 5 out of 5). 1 student (8.3%) was neutral. And 2 students (16.7%) indicated that they had no initial expectations.

b) Leve of appropriatness of the course material to the participant's grade level or background:

   8 students (66.7%) reported that it was at the appropriate level (with scores of 4 or 5 out of 5). 2 students (16.7%) indicated it was too easy given their previous programming experience. 2 students (16.7%) found it to be a little bit hard because of lack of programming background.

c) How much the participant had fun while learning the material:

   9 students (75%) reported that they had fun while learning and participating in the activities (with scores of 4 or 5 out of 5). 3 student (25%) were neutral (with score of 3 out of 5)

d) Whether the particpant would be interested to pursue Computer Engineering, Electrical Engineering, Computer Science or related fields in their college study:

   7 students (58.3%) reported that they are interested to pursue one of those listed fields. The rest are either uncertain or may not be interested in these fields.

e) Whether the participant recommends this program to others?

   9 students (75%) reported that they recommend the program to others (with scores of 4 or 5 out of 5). 3 students (25%) were neutral (with score of 3 out of 5).

From a previous year data we received from the Admissions Office of Kettering University 3 former participants of the first Computer Engineering summer camp have matriculated to Kettering University. One of the students is majoring in Computer Engineering, another one in Electrical Engineering, and the third one in Computer Science. We count this as a success since one of the main goals of our summer camp programs is to expose the participants to what Kettering and ECE have to offer and be able to attract them to our programs. Even though we don't have data at this point, from the survey conducted many of the participants of the new Arduino based program also indicated their desire to enroll at Kettering University for their College education.

DISCUSSION AND CONCLUSION

This paper presented the effective use of the low-cost and open-source Arduino microcontroller, mobile robots, and Smartphones for attracting and inspiring students to STEM education. Even though it may take a few more years to see the actual long-term impact of the program, the initial survey results demonstrate that there is promising future for the success of this program. The practical hand-on nature of the program keeps the activities exciting and the students constantly engaged. It offers opportunity for the participants to exercise their power of creativity in dealing with challenging problems, by collaborating in a team setting.

In conclusion, we believe that we are going in the right direction to achieve the main goals we set out at the start of these Computer Engineering Summer Camp programs. These are work in progress as we constantly adapt the programs to respond to the specific needs of the participants.

ACKNOWLEDGEMENT

We would like to acknowledge the generous support of the Donald Lee Smith Fund of the Community Foundation of Greater Flint, the GM Foundation, and the Best Buy's Children's Foundation, which made financial contributions for the development and delivery of the Computer Engineering summer camps.

References:

1. http://www.ed.gov/stem
2. STEM 101: Intro to tomorrow's jobs. http://www.stemedcoalition.org/wp-content/uploads/2010/05/BLS-STEM-Jobs-report-spring-2014.pdf
3. The Market for Computing Careers. http://cs.calvin.edu/documents/computing_careers
4. US Bureau of Labor Statistics (US-BLS), Employment Projects. http://www.bls.gov/emp/tables.htm
5. Kettering University. http://www.kettering.edu/
6. Tewolde, G.; Kwon, Jaerock, "Robots and Smartphones for attracting students to engineering education," *American Society for Engineering Education (ASEE Zone 1), 2014 Zone 1 Conference of the* , pp.1,6, 3-5 April 2014
7. Arduino Uno. http://arduino.cc/en/Main/arduinoBoardUno
8. Rover 5 Robot Platform. https://www.sparkfun.com/products/10336
9. MIT App Inventor. http://appinventor.mit.edu/explore/