UTILIZATION OF ROBOTICS AS CONTEMPORARY TECHNOLOGY AND AN EFFECTIVE TOOL IN TEACHING COMPUTER PROGRAMMING

Aaron R. Rababaah*[1], Ahmad A. Rabaa'i[2]
[1]arababaah@auk.edu.kw
[2]arabaai@auk.edu.kw

Abstract

Traditional computer programming is typically taught in class room using hypothetical examples that does not go beyond the keyboard and the monitor of the machine. While this approach may be useful to some extent, it certainly does not provide the students a real world experience with real systems that demand serious responsibility, hardware intimacy, coding with physical consequences and high-impact feedback. In this paper, we are presenting the efforts of the Computer Science and Information Systems (CSIS) department at the American University of Kuwait (AUK) to adopt this philosophy in establishing a new robotics course that involves real world robotic and physical computing programming. The structure of the course, the design of the lab experiments and the hardware and software are discussed. Strategies and objectives throughout the course development process are clearly defined to maximize the effectiveness of the new learning experience and environment. This work is hoped to be a reliable example for other CSIS departments to follow and implement.

1. Introduction and Related Word

Robotics is recognized as one of the most important technologies that will shape the future of human civilization [1]. Robotics came a long way from merely mechanized machines to autonomous mars rovers and humanoids. The evolution of the robotics technology has a strong analogy to its predecessor, the PC technology. On Scientific America [2], Bill Gates said "A Robot in Every Home" which used to be "A PC in Every Home", where he predicts that the next hot field will be robotics. We believe that robotics is a very exciting and interesting field due to the fact that we are fascinated with the idea of making the robots as smart as a humans (arguably, possibly smarter). Given the rapid rate at which the robotics technology is progressing, we as educational institutes have a real responsibility toward spreading the awareness of this technology and promoting it through our educational systems so our students are well informed with robotics and hopefully enrolled in robotics classes. One of the side effects that robotics can have on computer science education is using robotics to recruit students to not only studying robotics, but also computer science. The nature of robotics learning environment is hands-on and highly interactive. This style of learning has been proven to have higher impact on students interest and information gain as referenced in the study of [3]. In this paper, we intend to propose our methodology to utilize robots to enhance the learning experience of computer programming using robotic technology.

The concept of using robotics in education has been proposed by different studies including: the work of [5] demonstrated the utilization of Khepera and Somo robots in teaching assembly language. The researchers reported very positive outcome of this study on their students as well as the feasibility of the adopting such a technology in class rooms given the available inexpensive software and hardware robotics platforms. In [6], the author sheds light on several benefits of using robots in classrooms. These benefits include: launching pads for student's passion, robotic projects provides rich teamwork and leadership experiences, communicate across different technology platforms, etc.

2. Hardware and Software Platforms

Our class is planned to utilize the Arduino micro controller as our hardware platform. Arduino is an open-source prototyping platform based on easy-to-use hardware and software [7]. As it can be seen in Figure 1, the microprocessor main components are as follows:

Figure 1: Arduino Micro Controller

CPU: the central processing unit is the heart of Arduino. Just like a regular computer, Arduino has a CPU that takes care of all computational operations. Of course the performance is far incomparable with a modern CPU! the ATmega CPU on Arduino's board runs at 20MHz [8] compared to Core I7 processor which runs at 4GHz.

USB port: to facilitate the communication between Arduino and a computer, a USB port is provided. The USB is needed to load a program to the Arduino memory and to send/receive messages through serial communication.

I/O Pins: Arduino interacts (senses and affects) with the physical world through a set of input/output pins. Arduino has 17 overall all pins; 11 of these are digital whereas the other 6 are analog. The difference between analog and digital is the range of values can be represented. For digital I/O, it is a binary state with 0v representing logical 0/false and 5v representing 1/true state. For the analog I/O, it is capable of representing 256 levels on the input side and 1024 on the output side.

The aforementioned components are really what a user of the Arduino needs to know in order to go about using the board. Of course, we still need the software platform that can communicate with and produces programs that runs on Arduino board.

Software Platform: The Arduino creators developed an IDE that is based on C++ to create a programming development environment. This IDE allows programmers to write a C++ program according to Arduino language restrictions and load the program to the board and the Arduino would run it immediately. Arduino achieves physical computing by interfacing between the programmer's programs and the physical world through sensors and actuators.

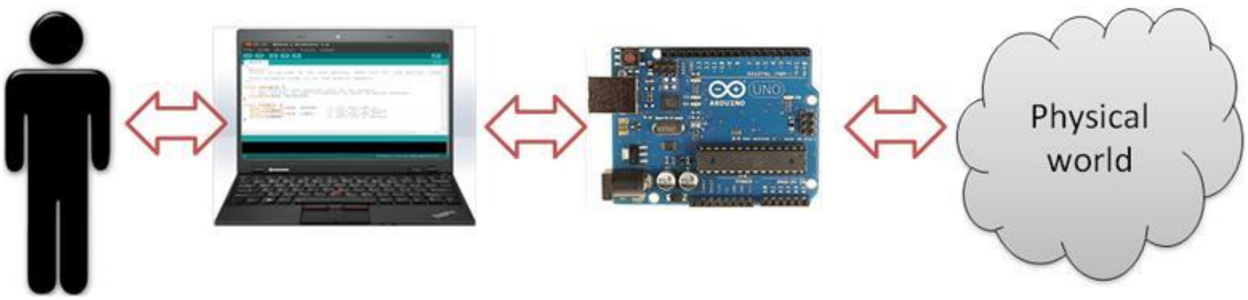


Figure 2: Concept of Physical Computing

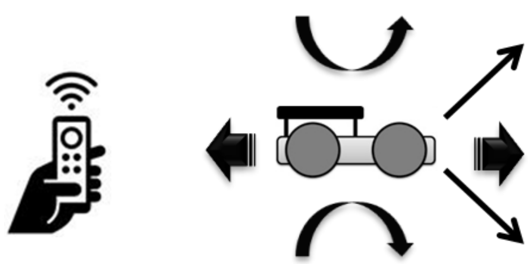
3. Hands-on Labs

The class consists of two major components: theoretical background of robotics and hands on labs. The theory will be covered using a well-known text of [9]. As for the hands-on labs, they consist of experiments that start basic, intermediate to advance levels. 10 labs will be given including these topics:

- Working with LEDs, resistors and push buttons
- Potentiometers to control I/O levels
- Serial read/write
- Sensors: photo cell, temperature and ultrasound.
- Remote control
- RFID
- Motors: DC & Servo
- LED Matrix
- Basic robot commands
- Advanced robot operations

Among the important labs are the robotic ones. We will be doing a series of labs that demonstrates how we can make the robot perform a range of tasks from basic to advanced ones including these:

- Using a remote control to control robot mobility as shown in Figure 3.



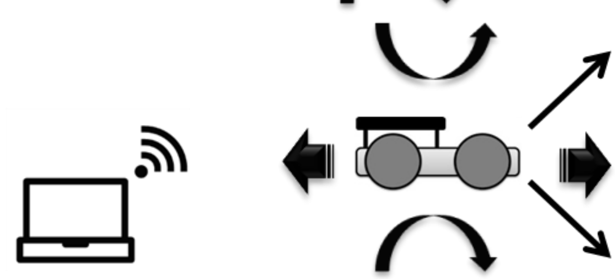


Figure 3: Remote Control for robot control

Figure 4: Bluetooth wireless for robot control

- Using Bluetooth to remotely control robot operations as in Figure 4.
- Wall-follow algorithm as in Figure 5 and Find exit and leave algorithm in Figure 6.

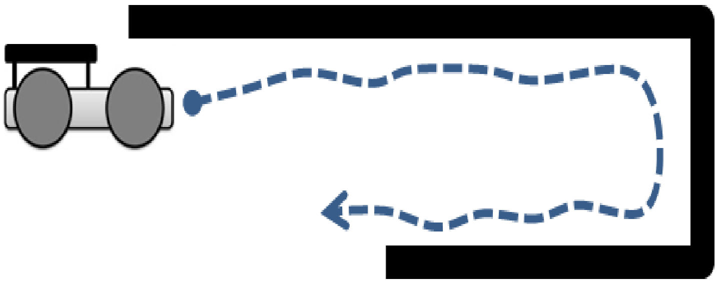


Figure 5: Wall-follow Algorithm

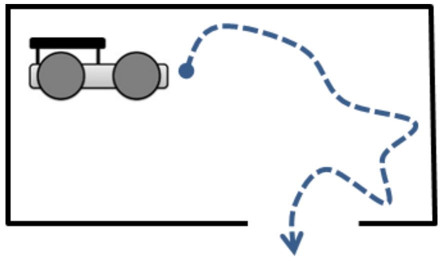


Figure 6: Finding exit and leave

- Another lab will demonstrate how the robot is able to approach a target object at specific coordinates using ultrasonic sensors for obstacle avoidance. This experiment is depicted in Figure 7.

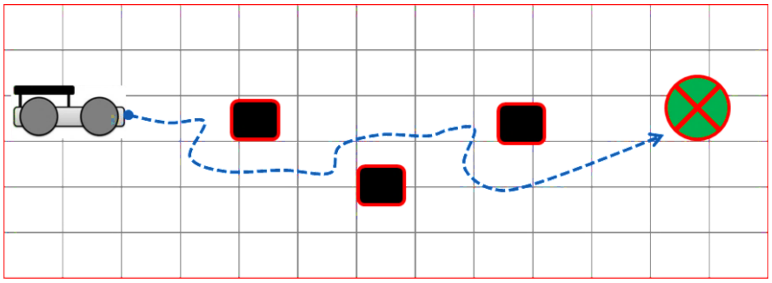


Figure 7: Find Object using dead-reckoning

- Tele operating the robot using Bluetooth wireless communication is shown in Figure 8.

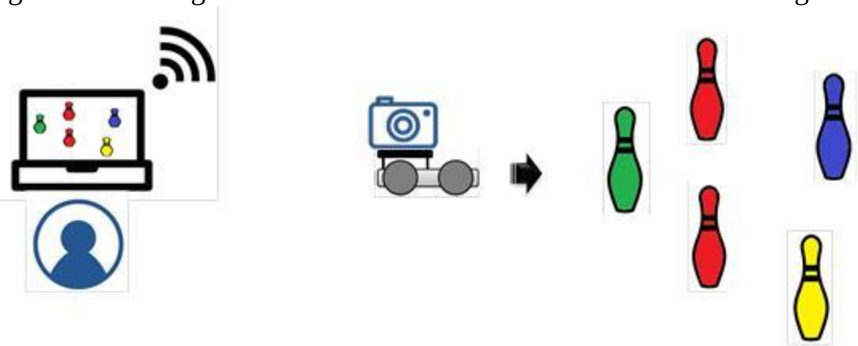


Figure 8: Teleop Mobile Robot using Bluetooth wireless communication

- Another lab will utilize the RFID technology to tag certain target objects and task the robot to find them among other objects in the environment, as illustrated in Figure 9.

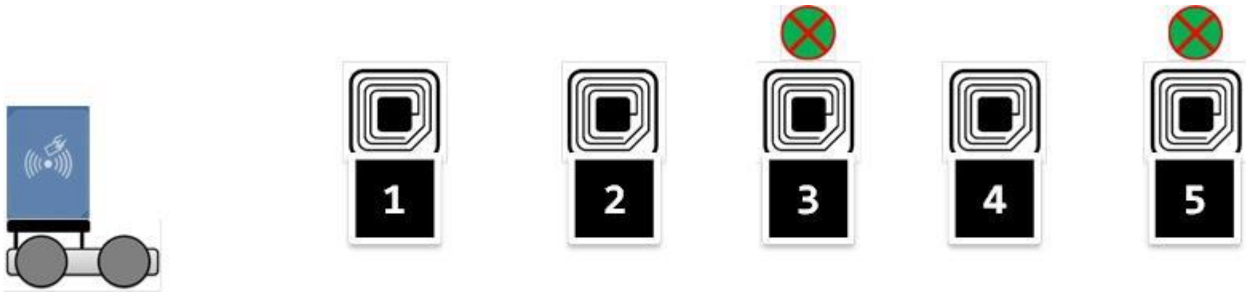


Figure 9: The robot is tasked to find RFID tagged objects

- One lab also should train the students how to assemble the robot from scratch. 10 kits have been acquired that contains all required hardware for the sensors and robot components shown in Figure 10.

Figure 10: Robotics kit and the Assembled robot

4. Conclusions and Future Work

We have presented a development of robotics lab based on the Arduino hardware and software platforms. This attempt at the department of Computer Science and Information Systems at the American University of Kuwait is hoped to be fruitful and a has a positive impact on student learning outcome through the expected benefits that the use of robotics in the classroom proven to deliver. We aim to survey the students after offering this class and collect their feedback on the differences between this class and a traditional programming class and study their responses analyze results to see if this attempt has valid and significant impact on the learning environment. After offering this class, we intend to reevaluate the used labs and tools and enhance them to improve upon any findings that we may encounter throughout our experience in a semester.

References

[1] David Hall and Sonya McMullen, "Mathematical Techniques in Multi-Sensor Data Fusion", 2004, Artech House, Inc. 685 Canton Street, Norwood, MA 02062.

[2] http://www.scientificamerican.com/article.cfm?id=a-robot-in-every-home

[3] Jennifer S. Kay, "Robots as Recruitment Tools in Computer Science: The New Frontier or Simply Bait and Switch?", Association for the Advancement of Artificial Intelligence (www.aaai.org), 2010.

[4] http://www.jumpthecurve.net
[5] James Wolfer & Aaron Rababaah, An Integrated Khepera And Sumo-Bot Development Environment For Assembly Language Programming, International Conference of Engineering and Computer Education, ICECE, 2005.
[6] http://www.gettingsmart.com/2016/11/unexpected-benefits-robotics-in-the-classroom/
[7] http://www.arduino.org/
[8] http://www.atmel.com/images/Atmel-8271-8-bit-AVR-Microcontroller-ATmega48A-48PA-88A-88PA-168A-168PA-328-328P_datasheet_Complete.pdf
[9] The Robotics Primer, Maja J. Mataric, MIT Press, 2007.