LOW-COST ROBOTICS

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Received: January 12, 2023
Revised: January 18, 2023
Accepted: January 20, 2023

ABSTRACT

Nowadays, robotics is increasingly popular in industry, education, and robot competitions. In education, robotics combines study, design, construction, operation, and use of robots. Robotics is deemed to promote students' interest. However, not all students have the access to robotics, especially in Thailand. This review article presents the information and implementation of low-cost robotics in an Arduino robotics control. The reviewing shows that low-cost robotics are beneficial for the students to exercise students' skills particularly on low-cost robotics applications and robotic education can be explored.

Keywords: Robotics; Low-cost robotics; Arduino robotics control

I. INTRODUCTION

Robotics is an interdisciplinary learning of engineering and computer science. Robotics involves study, design, construction, operation, and use of robots. The objective of robotics is to design machines that can help and assist humans. Robotics combines fields of electrical engineering, computer engineering, mechanical engineering, software engineering, etc. The use of robotics can engage students in playful collaborative problem serving activities. Robotics can serve as cognitive learning tool in the teaching and learning process. However, technology robotics always comes with a high cost. One of concerns is that school and students will struggle with the financial budget of robotics. This is a need to create awareness on the important knowledge and it can be done in the low-cost robotics.

Elfasakhany et al. (2011, pp. 47-55) designed and developed a competitive low-cost robot arm with four degrees of freedom. The low-cost robot worked as designed and moved with four degrees of arm freedom as the prospective goal. Junior et al. (2013, pp. 1-7) constructed a low-cost and simple Arduino-based educational robotics kit. They succeeded in the development of educational robotics by using Arduino and applied the robotics in the educational kit. Plaza et al. (2016, pp. 1-4) designed and constructed a collaborative robotic educational tool based on programmable logic and Arduino. In addition, Eguchi (2016, pp. 692-699) used the RoboCupJunior for promoting STEM education, 21st century skills, and technological advancement through robotics competition. Plaza et al. (2017, pp. 132-136) presented home-made robotic education, a new way to explore. Darrah et al. (2018, pp. 107-110) designed and developed a low-cost open-source robotics education platform which was useful for teachers and students in school on the minimum components in a low-cost

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robotics. Plaza et al. (2018, pp. 1-8) used Arduino as an educational tool to introduce robotics. Chicas et al. (2019, pp. 379-383) developed STEM competences by building low-cost technology robots. Ong and Ling (2020, pp. 467-473) constructed low-cost educational robotics car to promote STEM learning and 21st century skills. Rajapakshe and Hettiarachchi (2022, pp. 71-76) designed, constructed, and developed a research oriented low-cost robotics platform with a novel dynamic global path planning approach. As a reviewing, there is a collaborative robotic educational tool based on programmable logic and Arduino (Plaza et al., 2016, pp. 1-4) and Junior et al. (2013. pp. 1-7) constructed a low-cost and simple Arduino-based educational robotics. The reviewing shows a new way to explore the robotics on home-made robotic education (Plaza et al., 2016, pp. 1-4) In addition, it is very important to use Arduino as an educational tool to construct robotics as a low-cost robot (Plaza et al., 2018, pp. 1-8). Moreover, Rajapakshe and Hettiarachchi (2022, pp. 71-76) presented the construction low-cost robotics and designed the methodology to estimate the manufacturing overhead in building the robots.

This review article presents the implementation of low-cost robotics in an Arduino robotics control. The reviewing showed that low-cost robotics were created particularly on low-cost robotics applications. The information is to identify the minimum components to build low-cost robotics that can be explored.

II. LOW-COST ROBOTICS

Low-cost robotics is a minimum component to build a robot that can meet the needs of work, study, and competition. As we know that technology robotics always comes along with a high cost. One of concerns is that school and students will struggle with the financial budget of robotics. This is a need to create awareness on the important knowledge and it can be done in the low-cost robotics. In Table 1, the minimum components to build low-cost robotics are presented as the requirements and the result as a cost in Bahts. The components for low-cost robotics are single-board computer/central processing unit (CPU), graphic processing unit (GPU), actuators, cameras, additional sensors, wireless devices, and power supply. In the table, there are different robotics models that need the minimum components or required components in different objectives and goals.

According to the Table 1, there are six models of robotics, TurtleBot 3 (Burger), ROSbot 2.0, Jet Racer, JetBot AI Kit, DuckieBot (DB19), and AlphaBot2 +Intel ealSense +AnkerPowerCore II. There are ROSbot 2.0 and AlphaBot2 +Intel ealSense +AnkerPowerCore II that are full components to build the robotics. However, ROSbot 2.0 cannot be a low-cost robotics because of high cost. So, AlphaBot2 +Intel ealSense +AnkerPowerCore II can be easily called as a low-cost robotics. For the models that used the minimum components to build robotics, there are Jet Racer, JetBot AI Kit, and DuckieBot (DB19). They are low-cost robotics but JetBot AI Kit and DuckieBot (DB19) are low-cost robotics with lowest cost. For TurtleBot3 (Burger), it can be a low-cost robotics but it is only one model that does not have a camera. So, in this case, TurtleBot 3 (Burger) is not low-cost robotics when compares to Jet Racer, JetBot AI Kit, and DuckieBot (DB19). Moreover, concerning only on the minimum components and cost of building the robotics, there are two out of six robotics models that are low-cost robotics. JetBot AI Kit and DuckieBot (DB19) are low-cost robotics on the minimum components with lowest cost.

TABLE 1: The minimum components to build low-cost robotics.

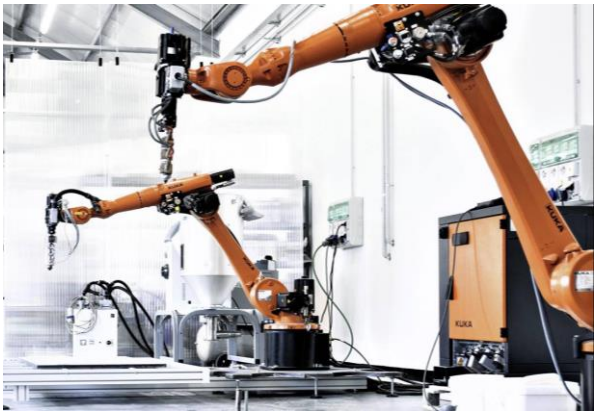
	TurtleBot3 (Burger)	**ROSbot 2.0**	**Jet Racer**	**JetBot AI Kit**	**DuckieBot (DB19)**	**AlphaBot2 +Intel ealSense +AnkerPowe rCore II**
Single-Board Computer /CPU	Raspberry Pi 3	Asus Tinker Board with Rockchip RK3288	Nvidia Jetson Nano	Nvidia Jetson Nano	Raspberry Pi 3 Model 3	Raspberry Pi 4 Model B
GPU	Broadcom VideoCore IV	ARM Mali-T764 MP2	128-core Maxwell GPU	128-core Maxwell GPU	Broadcom VideoCore IV	Broadcom VideoCore IV
Actuators	DYNAMIXEL XL430	Xinhe Motor XH-25D	37-520 DCgearmotor Reduction rate 1:10 Idlespeed 740RPM.MG996R 9kg/cm torque	TT motor Reduction rate 1:48 Idle speed 240RPM	Two DC motors with (Hall effect sensor based) wheel ncoders	N20 micro gear motor reduction rate 1:30, 6V/600RPM
Camera	N/A	Orbbec Astra RGBD camera	Sony IMX219, 8MP, 160 FOV wide angle camera	IMX219 8MP, 160 FOV Wide angle camera	FBA RPi Camera (F)	Intel RealSense D435
Additional Sensors	360 LIDAR (HLS-LFCD2)	RPLIDAR A2 laser canner, MPU 9250, VL53L0X, 4 x quadrature encoders	N/A	N/A	N/A	Reflective infrared photoelectric sensor (ST188) Reflective infrared photoelectric sensor (ITR20001/T)
Wireless	2.4GHz 802.11n wireless	802.11 b/g/n with upgradable IPEX antenna	2.4GHz / 5GHz dual-band WiFi, Bluetooth 4.2	2.4GHz/5GHz dual-band WiFi, Bluetooth.2	Edimax AC1200 EW-7822ULC 5 GHz wireless adapter	2.4 GHz / 5.0 GHz IEEE 802.11ac wireless,Blue tooth 5.0,BLE
Power Supply	Li-Po Battery 1.1V 1800mAh	Li-on batteries: 3 x 3500 mAh	12.6V, 18650 battery × 3	12.6V, 18650 battery × 3	RAVPower Portable Charger 10400mAh	Anker PowerCoreII 10000 mAh
Cost (Bahts)	**21,863.7**	**68,449**	**14,147.1**	**10,789**	**10,789**	**13, 254**

III. LOW-COST ROBOTICS METHOD

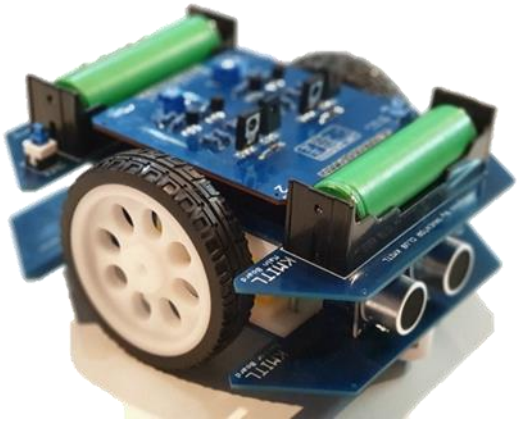
Rajapakshe and Hettiarachchi (2022, pp. 71-76) presented the idea of construction low-cost robotics and designed the method to estimate the manufacturing overhead in building the robots for three steps as follows

1. Robotic Platforms: RP
2. Robot Operating System: ROS
3. Manufacturing Overhead: MO

Firstly, RP is the platform that needs to be defined. There are many platforms in the robotics markets, however, there are three platforms in general, industry, education, and robotics racing. as shown in Figure 1. Secondly, ROS needs to be designed and recommended by using Arduino as a robot operating system. Finally, MO is the last important one with the estimated cost for manufacturing and additional matters. After three big steps, low-cost robotics method is required to follow the minimum components including single-board computer/central processing unit (CPU), graphic processing unit (GPU), actuators, cameras, additional sensors, wireless devices, and power supply.



(a)



(b)

(c)

Figure 1: Robotics platforms in (a) industry, (b) education, and (c) robotics competition.

IV. ARDUINO LOW-COST ROBOTICS

Junior et al. (2013, pp. 1-7) constructed a low-cost and simple Arduino-based educational robotics kit. They succeeded in the development of educational robotics by using Arduino and applied the robotics in the educational kit as shown in Figure 2. In addition, Plaza et al. (2016, pp. 1-4; 2017, pp. 132-136; 2018, pp. 1-8) designed and constructed a collaborative robotic educational tool based on programmable logic and Arduino.

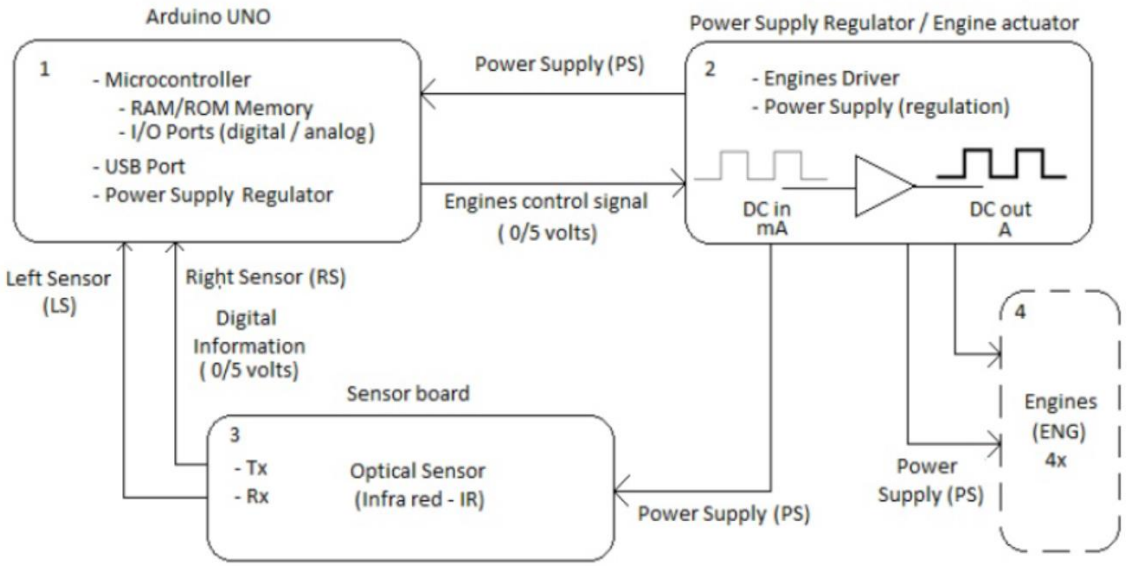
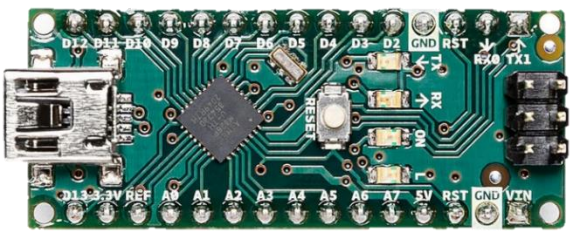


Figure 2: Simple Arduino low-cost robotics components.
Source: Junior et al. (2013, pp. 1-7)

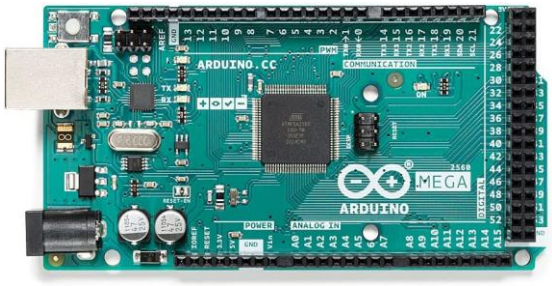
There are three components that are considered in Arduino low-cost robotics, Arduino board, regulator and actuators, and sensor board. Arduino board as recommended by Arduino UNO board as an open-source microcontroller board including with microcontroller, USB ports, and power supply regulator. For regulators and actuators, there are engine drivers and power supply for all components as regulation. Sensor board consists of designed sensor such as optical sensor, camera (if needs), and as required.

The advantage of Arduino is low-cost and open-source microcontroller with well documented learning. Arduino can work with different operating systems such as Windows, Macintosh OSX, and Linux. There are favorite models on Arduino are Arduino Uno Rev3, - Arduino nano, Arduino MEGA, NodeMCU (ESP8266), and Node32Lite as shown in Figure 3.

(a) Arduino Uno Rev3



(b) Arduino Nano



(c) Arduino MEGA

(d) NodeMCU (ESP8266)

(e) Node32Lite

Figure 3: Favorite models on Arduino for low-cost robotics.

V. CONCLUSION

This review article presents the information on robotics and implementation of low-cost robotics in an Arduino robotics control. The review article is to identify the minimum components to build low-cost robotics that can be explored. The reviewing showed that low-cost robotics were created particularly on low-cost robotics applications which were beneficial for the students to exercise students' skills particularly on low-cost robotics applications and robotic education can be explored.

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