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Development of Affordable and Powerful Swarm Mobile Robot Based on Smartphone Android and IOIO board

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Abstract

Nowadays, an approach for coordinating large numbers of autonomous robots, which is called as swarm robots, has becoming an important issue in robotics research. In swarm robot systems, each robot must cooperate with other robots in order to perform a given task. The main obstacle in swarm robot research is the cost of making robots. Building one robot with limited capabilities commonly has to spend substantial amount of money and certainly making robots for intelligent systems research need much more investment. In this paper, we would like to present the development of affordable mobile robot, but also having powerful capabilities and intelligence. The mobile robot is specifically designed and made to be used as a stand-alone or in swarm robot systems. It is essential that the mobile robot has learning ability to adapt the dynamic environments. Furthermore, for swarm robot systems, each mobile robot must be able to communicate with other robots in order to coordinate each other. In our research, we used differential drive model for mobile robot locomotion and then apply the model through Android smartphone based controller. The mobile robot was constructed by using two actuators on the right and left side, and one castor wheel which has no steering system and can move freely. The differences velocity between left and right actuators determines the direction and final position of the mobile robot. The angular velocity of two main actuators is set by Pulse Width Modulation (PWM) parameter in IOIO board microcontroller. In our experiment, we showed that the capability of our robot in performing several movement tasks. We are sure that Android based robotic platforms are ideal candidates for affordable robotics for swarm robot system research.

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Keywords: mobile robot, differential drive, Android, IOIO board, pulse width modulation, swarm robot system

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1. Introduction

Swarm robot system research is continuously expanding as important issue in robotics field. Nevertheless, swarm robotic system still remains out of reach for many students and researchers because of their typically high cost [1]. On the other hand, there is opportunity from affordable Android smartphone which has the high computing power and sensing capabilities as powerful robotic platform. In this paper, we provide a detailed description of Android robotic platform based on IOIO [2] microcontroller board. We also present experiments where this Android robotic platform has been used for research purposes, especially in swarm robot system. In literature, there is Android robot unfortunately based on the expensive LEGO Mindstorms NXT platform [3]. On the other side, there is very affordable robot [4] for STEM education, but this robot is not powerful for intelligent robot research. There is also quite affordable and powerful robot called as Pheeno [5] based on Raspberry Pi platform. Nevetheless, the robot still needs to be equipped with various sensors so that the price can increase considerably.

The development of smartphones has changed human civilization by facilitating interaction between man and machine. An increasingly affordable Android smartphone which can be purchased by almost everyone as a tool to communicate. This smartphone is not only as a communication tool, but also can support our activities effectively in everyday life. The modern smartphone has high computing power, which comes from its microprocessor, comparing to current robot microcontroller such as Arduino or STM32. Beside that it is equipped with various sensors [6] such as proximity sensor, accelerometer sensor, ambient-light sensor, and so on. Smartphones are also equipped with Bluetooth, Wi-Fi and even with various sophisticated operating systems like Android, IOS, and others. Furthermore, we employed Bluetooth and Wi-Fi as communication channels in controlling mobile robotics. In the research, we used smartphone based on Android operating system. Why are we using Android? Because Android is very popular operating system platform currently. It is not only popular, but the price of an Android phone can be very affordable. In addition, Android is using open source Java programming language, consequently its applications can be easily developed and modified as we want.

Robot is reprogrammable manipulator device, which designed to perform a command given by human to facilitate human work. Robot arms, which are bolted to a specific position, can move with great speed and accuracy to perform repetitive tasks in industrial production line. Yet, these robot arms have great disadvantage: lack of mobility. In contrast, a mobile robot would be able to travel throughout its environment [7] and has more flexibly in applying its abilities. In this research, we developed a mobile robot based on Android smartphone platform. Android mobile robot is very affordable, meaning we can build it under two million rupiah. Not only that, Android mobile robot can access all smartphone sensor output such as accelerometer and compass and also use powerful smartphone's microprocessor. Furthermore, it will be controlled by another Android smartphone, thus the user can see its environment by just using smartphone camera. Therefore, we can conclude that Android mobile robot is quite powerful for our research.

The fundamental challenge of mobile robot is its locomotion, which is how a mobile robot should move. The locomotion of our mobile robot is based on differential drive model that will be explained in next section. The Android mobile robot is designed to control its motions through smartphone camera. The user Android smartphone can access this camera and control the mobile robot though Wi-Fi networks. Furthermore, the smartphone in mobile robot connect to IOIO board microcontroller through Bluetooth communication, so that this smartphone can control the actuators. In conclusion, the mobile robot design requires two Android smartphones that serve as user controller, and the other as a camera sensor, which is integrated in the mobile robot.

The remainder of this paper is composed as follows: first we discuss kinematics of mobile robot in section 2, and then is followed by its implementation in our mobile robot based on IOIO microcontroller board in section 3. In section 4, we report the experiment result of the capability of our Android robot in maneuvering and coordinating. Finally, we summarize our work with future research suggestions in section 5.

2. Kinematics of Mobile Robot

In the study of robot kinematics, we discuss about the relationship between position, velocity, and acceleration which work on the robot system. While the robot dynamics study the causes of movement including, force, and torque