Control of Omni-Directional Robot Using Accelerometer Sensor on Android Smartphone

Faikul Umam
Mechatronics Program, Faculty of Engineering
Trunojoyo Madura University

Abstract

Sensors and network connection devices are generally embedded in the smart-phones to support its performance. An accelerometer sensor is one of the many sensors embedded in Android based mobile phones. Every swinging movement or rotation will be read by the accelerometer sensor, then, is used to change the orientation of the phone display. On the other hand, Wi-Fi is a wireless device that serves as a means of exchanging data between one phone and another phone or between the phone and another device, one of which is a robot. This study discusses the control of robot direction motion using the accelerometer sensor on Android Smart-phones with a Wi-Fi as the liaison. The control of the robot movement is done by sending the accelerometer sensor value changes to the robot via a wireless network.

1. Introduction

Currently, no single human being on earth is not familiar with android. For the layman, Android is interpreted as a smart-phone that can be used to play games and operate social media applications. Factually, Android is an operating system that is embedded in a mobile phone to be used to assist human activities. Thousands and even millions of mobile devices have already used this operating system.

Android is an operating system made by Google that is open-source. With such feature, Android grows rapidly since people can develop their own applications without the burden of certain regulations. Many application developers have contributed to create applications that run on this operating system. There is one who focuses on creating the application of game, one who focuses on creating the application of social media, and one who focuses on creating the application of administration system.

Not to be outdone from other developers, there is a group of people who focuses on developing android applications related to the field of robotics science. For instance, there is one who sets the robot movement with touch mode on the Android [1] and there is one who develops android application to control robot via USB cable [2]. Moreover, android is also used as a balance control in inverted pendulum [3], and more attractively, there is one who uses android to control vision and voice-based robot [4].

Usually a smart-phone is equipped with several sensors, such as accelerometer sensor. The accelerometer sensor is a sensor that can measure the acceleration due to gravity and vibration [5]. In android, this sensor is used to adjust the landscape or vertical position changes on the smart-phone screen and set the hand movements as a tool for gaming consoles.
On the other hand robot technology is developing rapidly, not only in software but also the hardware. Currently, it has already been developed a robot that can move flexibly, known as Omni-directional robot. The robot can move left and right and can be rotated on the axis point [6].

Based on the exposure and some research which have been done previously, this research developed a system to control the Omni-directional robot motion, in accordance with the tilt of accelerometer sensor for android smart-phone. In other words, the smart-phones will be used as a remote control for Omni-directional robot movement.

2. Methode

The concept of system

The control of robot movement which is developed in this study is the control of motion direction of the robot. They are forward, backward, right and left motion. As in Figure 1, when any change occurs, the axis in the accelerometer will be sent to robotino via Wi-Fi, then, the robotino will move according to the changes of the value, and the axis is accepted.

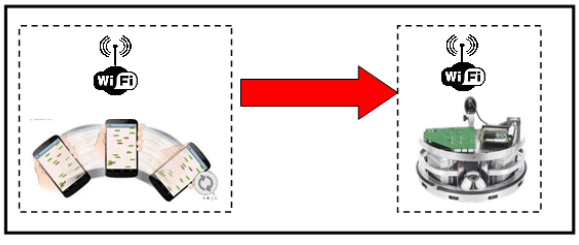

Figure 1. Concept of System

To be able to send information of the axis changes, there must first be established the connection between the smart-phones and the robotino via Wi-Fi. As in Figure 2, an application running on a network, when it will send the data to a device or another process using the TCP protocol, must use a socket, so that the transmitted data can be received by the TCP. Then, next is the task of TCP controlled by the operating system to be able to deliver the data being sent to the TCP on the other device or process. Each process which is associated with TCP will have the IP address and port

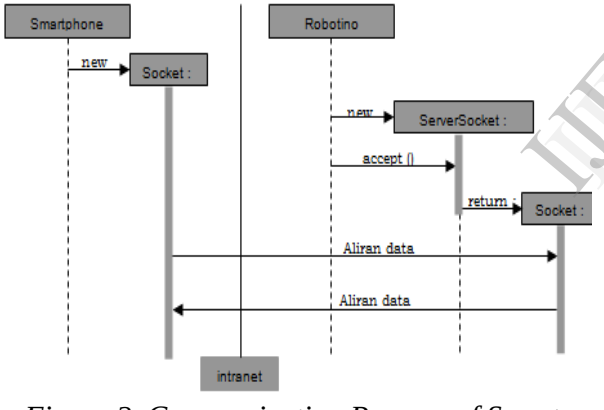

Figure 2. Communication Process of Smart-Phones with Robot

As in Figure 3, in detail, the system is divided into two parts; the smart-phone acts as a transmitter and Omni-directional robot as a receiver. The smart-phone as the transmitter, will process the axis change to be the value of natural numbers, both positive and negative. After the process of the axis changes to be natural numbers is done, then, the value is sent to the Omni-directional robot through a socket using a wireless network. At the time Omni-directional robot receives the data, the robot will cultivate the positive or negative natural numbers into speed for each Omni-directional robot motor.

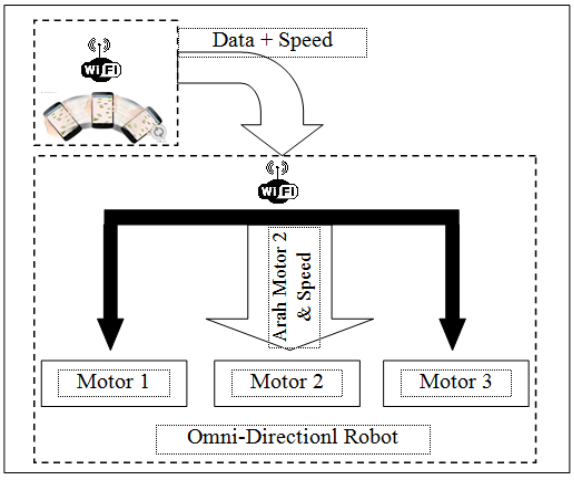

Figure 3. Process of Data Movement

Movement Direction Change Control

When the smart-phones and robotino have already connected, then, these two devices are able to transmit data. The data sent is the data of the axis changes on the smart-phone which is detected by the accelerometer sensor.

As in Figure 4, the x-axis is the horizontal position of the smart-phone, the y-axis is the vertical position of the smart-phone, and the z-axis is the axis that leads out of the smart-phone screen. In this system, behind the scene ordinate has negative value of z.

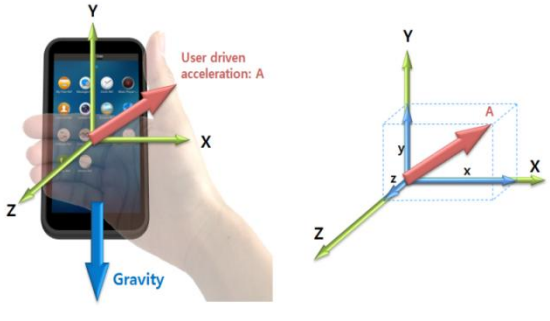

Figure 4. Coordinate System of Smart-phone

Acceleration occurs because of the increased velocity at a certain time. On the other hand, direction or orientation also affects acceleration, because the changing of motion direction of the an object will also cause acceleration. Therefore, to obtain distance data from the accelerometer sensor, the process of double integral to the sensor output is needed.

$$\vec{s} = \int (\int (a)\, dt)\, dt \qquad (1)$$

dt is the time of data picking that must be made as small as possible and constant. Integral is the area under a signal within a certain time period as what is shown in Figure 5.

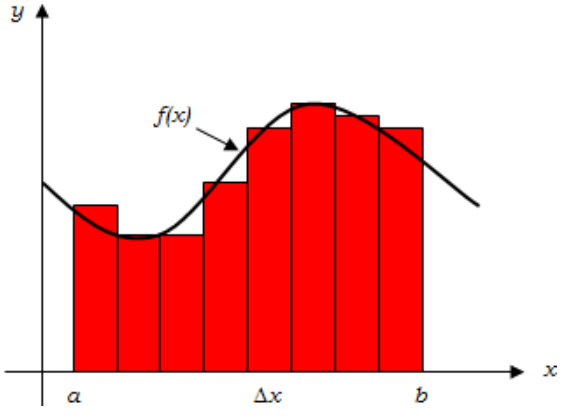

Figure 5. Simple Integral

$$\vec{s} = \int(\int(a)dt)\,dt \quad (2)$$

$$\int_b^a f(x)dx = \lim_{n\to\infty} \sum_n^{i=1} f(x_1)\Delta x \quad (3)$$

$$\Delta x = \frac{b-a}{n} \quad (4)$$

Actually, acceleration which is obtained from accelerometer measurements is not a pure object acceleration data, due to the noise is still there.

$$U = a + r + d \quad (5)$$

a is the acceleration of the real object, r is random noise, and d is the drift noise.

Having obtained the value of the accelerometer sensor, to determine the direction of the robot movement, a rule based on the value axis changes on the smart-phone should be made. As in Figure 3, the axis change taken as a reference is only x and y. In Table 1.

Table 1. Rule of Robot Motion Direction Change

Accelerometer Value	Motion Direction
X is Negative	Forward
X is Positive	Backward
Y is Negative	Right
Y is Positive	Left

Omni-Directional Mobile Robot Movement Control

Robot using Omni-directional wheels is capable to be translated (x, y), that can shift to the left and right freely. Besides, the robot also has the ability of rotating with fixed position.

Omni-directional robot has 3 degrees of freedom (3 DOF) and each degree of freedom is controlled independently. As in Figure 6, the Omni-directional mobile robot moves without changing toward orientation, while conventional robot moves by the way of turning little by little

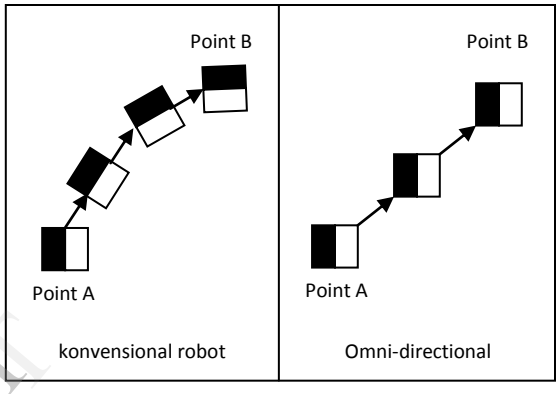

Figure 5. The difference of Wheel Conventional and Omni-directional Wheel

Wheel shaft speed and angle position are important variables that should be known, determining the movement of the robot. To determine the movement of an Omni-directional robot in programming is using equation 3 as follows:

$$\dot{\phi 1} = (-\sin(\theta) + \cos(\theta)\dot{x}_L + cos^2(\theta)\dot{y}_L + R\dot{\theta}\,)/r \quad (6)$$

$$\dot{\phi 2} = (-\sin(\theta + \alpha 2)\cos(\theta)\dot{x}_L + cos^2(\theta + \alpha 2)\dot{y}_L + R\dot{\theta}\,)/r \quad (7)$$

$$\dot{\phi 3} = (-\sin(\theta + \alpha 3)\cos(\theta)\dot{x}_L + cos^2(\theta + \alpha 3)\dot{y}_L + R\dot{\theta}\,)/r \quad (8)$$

3. Result And Discussion

Based on several experiments have been done, the first time Omni-directional robot receives the value of axis changes on the smart-phone sent by the accelerometer sensor, the response time required to do a movement is good enough, on average, every time it receives a value change, it takes only about 0.16 seconds to make a move. Difference in response time occurs when the Omni-directional robot moves forward, backward, right and left. However, the difference in the response time is not too significant; it is ranged only between 0.1-0.5 sec. The distance of communication, using Wi-Fi, between a smart-phone and Omni-directional robot is

only a maximum of 5 meters in a closed room, a distance of 5 meters is a safe distance to communicate well. Factually, more than 5 meters is also no problem, just that the response time required by the omni-directional robot to move becomes longer; the farther the distance of smartphone and omni-directional robot, the longer the response time to make a move.

In open space, the distance of communication between a smartphone and an omni-directional robot is approximately 15 meters. This happens due to interference from other devices which is relatively low.

4. Conclusion

The conclusion for the results of the use of Wi-Fi and accelerometer sensor on the android-based phone to control the mobile robot motion is as follows:

1. The accelerometer sensor on android smart-phone can be used as an omni-directional motion control of robots. Overall, the control process goes well.
2. The distance of the communication between the smart-phone and the omni-directional robot using Wi-Fi is only about 5 meters in a closed room and 15 meters in open space. The farther the distance between the smart-phone and the omni-directional robot, the slower the response time of omni-directional robot in motion.

REFERENCES

[1] Song, M., Kim, B., Ryu, Y., Kim, Y., and Kim, S., "Control Robot System Using Android Smartphone", The 7th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI), Busan-Korea, 2010

[2] Krofitsch C., Grabler R., "Android-Based Low-Cost Robot Controller", Practical Robotics Institute Austria (PRIA)

[3] Namratha S.N, Anjanaparua, Kumuda. S, Self Balancing Robot Using Android Phone, BMS college of Engineering, IT Department, Bangalore

[4] Pradeep N., Sharief M., Siddappa M., Building Vision And Voice Based Robots Using Android, 1st Annual International Interdisciplinary Conference, 2013

[5] M. Klingmann, "Accelerometer-Based Gesture Recognition with the iPhone", Goldsmiths University, MSc in Cognitive Computing, London,September 2009

[6] T.A. Baede., *Motion Control of an Omnidirectional Mobile Robot*, National University of Singapore, Faculty of Engineering, Departement of Mechanical Engineering, 2006