Motion control of Robots by using Smartphones

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Abstract — This study presents the motion control of a robot by using a smartphone instead of the classical microcontrollers. The robot is guided by computer and electronic programming. The robot actions and movements can be carried out with higher efficiency and less time loss by using this new application.

Technical innovations are becoming an important part of our life. The modern phone is perhaps the most common innovation which all individuals on the planet can have access to. Cell phones, despite their little size, contain rapid processors, numerous sensors and numerous other parts that we don't utilize. In this study, a cell phone application is built up to control the robot movements through Bluetooth experience.

Keywords *- Smartphone, AT mega microcontroller, robot, Bluetooth*

I. Introduction

Nowadays the smartphones and tablets are becoming powerful and with new and useful characteristics, and they will be a perfect match with robots to develop control systems. The use of smartphones and tablets in development and research is not only found in control systems but in all areas, as they represent a significant business opportunity for manufacturers who consistently develop better hardware and operating systems.

In the development of remote-control systems, the telecommunications, electronics and control concepts, makes it possible to control any mechanism, system or interface from a computer, mobile device or tablet with a friendly remote interface. In most smartphone applications in use, the device only acts as a remote control by using their integrated touch screen displays.

II. System Design

The system consists of two parts, one is Robot, and the other is the Smartphone as shown in Figure 1.

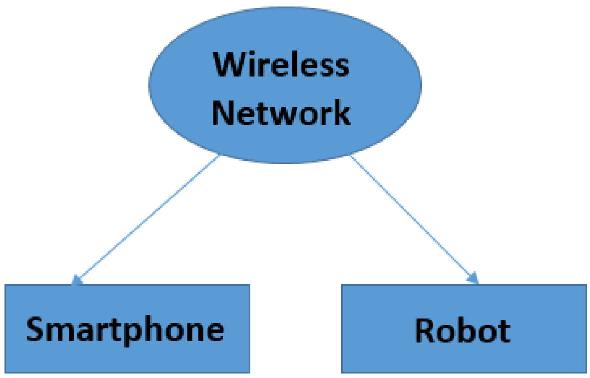

Figure 1: System block diagram

The robot has been programmed using IOS smartphones (iPhone) and an input/output interface board. The I/O panel acts as a connector between the smartphone and the connected devices as shown in Figure 2.

The application reads the information from smartphone sensors and processes the data and appropriate control commands for other parts that are generated. The control screen includes a small size combo buttons which represent the control commands.

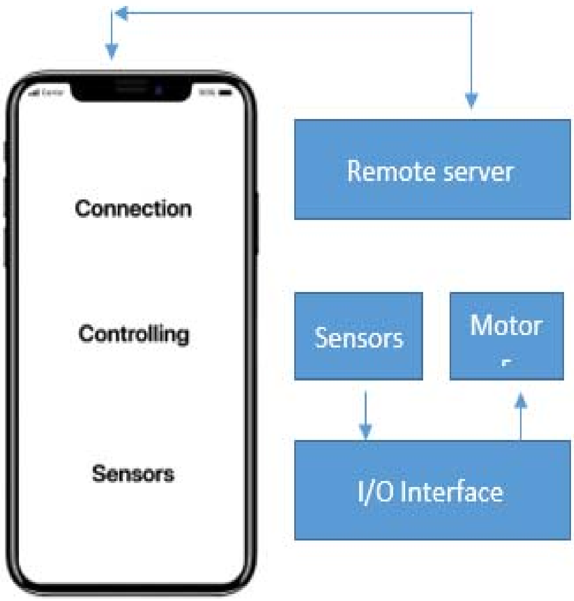

Figure 2. Smartphone and the I/O interface panel

The robot direction in the application of the IOS smartphone client is in positive X and Y axes as shown in Figure 3a. When given an input area, in order to draw a line strip, the initialization process occurs with variables current angle, target angle and step angle. The current angle is the angle that occurs when the initial position of the icon before the spin direction or on the straight track. The target angle is the angle changes that will occur, as the track conditions are made curved or angled. Step angle is the angle until the current pattern of accretion to be equal to the target angle.

Furthermore, the changes in the value of variables to find the direction of motion is determined on the application smartphone client. When the target angle is counterclockwise to the current angle then the target angle is negative. Otherwise, if the target angle is clockwise with the current angle then the target angle is positive. As shown in Figures 3b and Figure 3c, Once the resultant rotational directions are determined, related directional lines are drawn on the image area. When Target Angle is the same as the current angle and has a distance value that is less than the path length, the icon will continue to move a straight line like in Figure 3a. If the distance value has the same value as the path length, the icon will stop as in Figure 3d. Each of the logic movement data of the icon is sent via Bluetooth to shape the motional direction according to their respective angle commands.

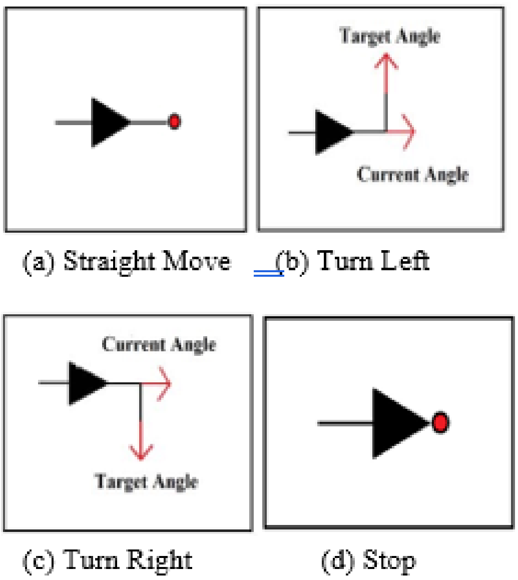

Figure 3: Robot direction of motion

III. Bluetooth Application Kit

The Bluetooth Application Tool Kit is a platform and consists of a circuit board, which can easily be connected to the host computer with a UART or USB connection. It ensures ease of use at full speed for Bluetooth data transfer. The Bluetooth tool kit has been developed to have short-range radio communication between the smartphone and the computer.

A Bluetooth device is connected to the serial port of the PC while the mobile robot is connected to another Bluetooth device through its RS232 port. Software with source code to communicate between PC and Bluetooth is provided together with the Bluetooth devices.

During the navigation of the mobile robot, all the sensor readings can be viewed from the server (PC). At the. same time, the PC can send direct commands to the mobile robot. Thus, an autonomous mobile robot is constructed.

IV. IOS Application

An application was developed with the software called IOS Studio. It can be installed on an iPhone smartphone or iPad to control the robot via Bluetooth. The application deploys buttons on the touch-sensitive screen menu for the movement of the Robot in different directions. These commands are as follows: Arm movement, left, right, forward and backward. See Figure 4.

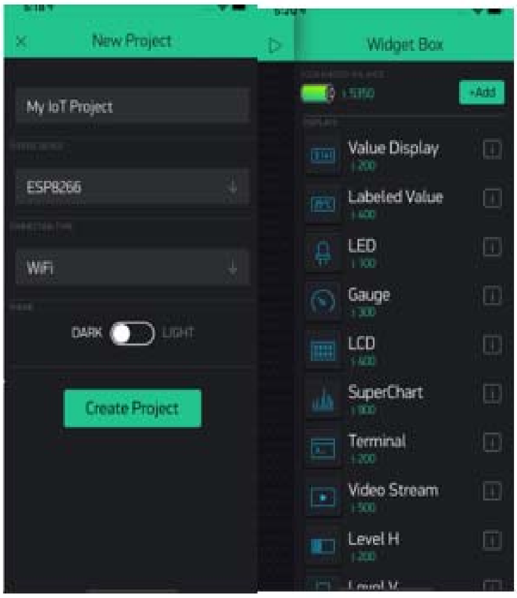

Figure 4: Application menu

Additionally, a sensor app shows the temperature and humidity value of the current atmosphere and these values are sent together with the motion data. The source code for the app is written in.Java. The application is described by the flowchart in Figure 5.

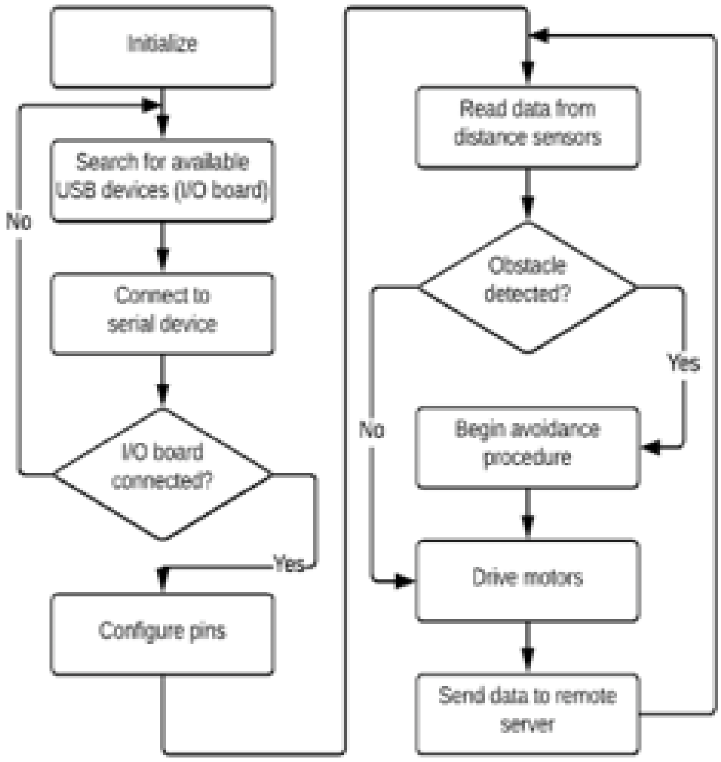

Figure 5: Control flowchart

The test robot is controlled by using the user-provided direction Figure6a. User-provided direction and the direction of the test robot are made to match each other through information provided by a compass sensor in a smartphone. With a smartphone in the user's hand, a change in the direction to the right or left can be made, as shown in Figure 6b and Figure 6c.

Figure 6a: Test robot

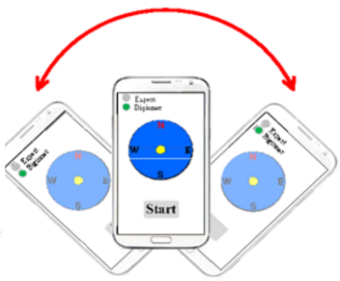

Figure 6b:Smartphone interface

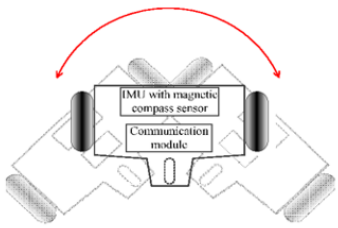

Figure 6c: Robot İnterface

V. DIRECTION CONTROL

In this paper, the implemented Robot arm is a differential drive Robot arm model. The differential drive robot model is described by three vectors. The three vectors are the current position (xc, yc) and orientation angle □c with respect to a reference frame. See Figure 7.

If the wheels of a robot are against the ground with no slippage, the equation for the position and orientation angle is given by:

$\sin(\theta_c)=y_c/v \quad v=y_c/\sin(\theta_c)$ (1)

$\cos(\theta_c)=x_c/v \quad v=x_c/\cos(\theta_c)$ (2)

$\Delta x_c \sin(\theta c) - \Delta y_c \cos(\theta_c) = 0$ (3)

where P is the center between both sides of a wheel and θ_c is the orientation angle of the robot. The robot is not able to move in the x or y direction immediately because of natural constraints and integration is impossible. The tangent velocity v and angular velocity **w** of the robot are given by:

$\Delta x_c \cos(\theta_c) - \Delta y_c \sin(\theta_c) = v , \Delta\theta_c = w$ (4)

These equations will be:

$$\begin{bmatrix} \Delta x_c \\ \Delta y_c \\ \Delta\theta_c \end{bmatrix} = \begin{bmatrix} \cos(\theta_c) & 0 \\ \sin(\theta_c) & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} V \\ w \end{bmatrix} \quad (5)$$

v and w are

$v = (v_r + v_i) / 2$, $w = (v_r - v_i) / 2dc$ (6)

Where v_i and v_r are the tangent velocities of the contact points between each side wheel and the ground, w_r and w_i are the angular velocities of each side wheel and $2d_c$ is the horizontal distance between the wheels on both sides.

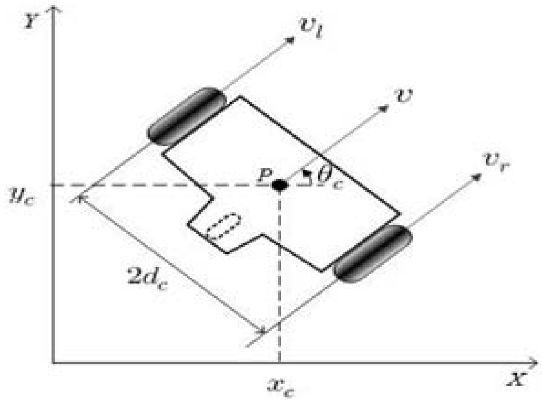

Figure 7: Differential drive robot model

To control the speed of a motor vi and vr we used pulse width modulation (PWM) of the left and right motors.

PWM speed control works by driving the motor with a series of “ON-OFF” pulses and varying the duty cycle, the fraction of time that the output voltage is “ON” compared to when it is “OFF”, of the pulses while keeping the frequency constant. Figure 8.

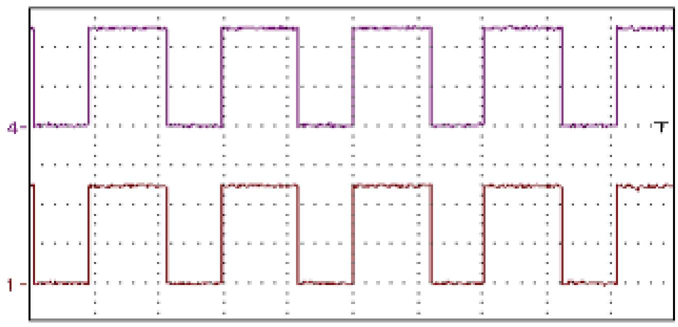

Figure 8: PWM signals for a duty cycle of 0.6 (TOP: front motors, BOTTOM: back motors)

The power applied to the motor can be controlled by varying the width of these applied pulses and thereby varying the average DC voltage applied to the terminals of the motor. By changing or modulating the timing of these pulses the speed of the motor can be controlled, i.e., the longer the pulse is “ON”, the faster the motor will rotate and likewise, the shorter the pulse is “ON” the slower the motor will rotate. Without using PWM the motor generates a lot of heat and wasted power in the resistance.

The interface I/O board is designed to be a general-purpose board, without the need of re-flashing the memory chip for every specific application. It uses a static buffer for serial data communication, which leads to significant overhead in the transmission process.

This can be reduced by optimizing the I/O board software to allocate the buffer dynamically only for the declared input pins. However, the extra computations required might actually increase the final response time

The remote WebRTC server is built using NodeJS and JavaScript. Using these technologies, it is possible to add real-time filters to the received video. Many types of filters can be applied in real-time, including object detection and classification. Currently, this is possible on the remote server, which is not useful in the control of the mobile robot. The goal is to enable object detection directly on the smartphone, without relying on data from a remote location.

VI. Results

To get a robot that can move closer to the desired distance, speed and distance measurements are taken so that the encoder sensor can be calibrated in accordance with the actual measurements. In the following Figures 9 and 10, the measurements of two motors with maximum speed and measurement distance of 1 meter are shown.

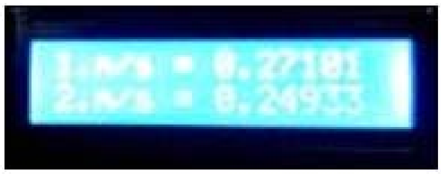

Figure 9. Measurement Maximum Speed

Figure 10. Measurement Distance of 1 meter

VII. Conclusions

In this paper, a test robot system is guided based on the compass sensor of a smartphone. A smartphone-controlled test robot system using a magnetic compass sensor allows the robot to move according to the heading direction of the smartphone, which is controlled by the user. The robot gathers data from external sensors and sends control actions to the device by means of a simple I/O board. The system is also capable of streaming live video, which makes it suitable for applications such as disaster relief, remote scouting, archeology, etc. In the current implementation, the robot uses only one ultrasonic distance sensor, which has a limited range and working angle. The performance can be greatly improved if different kinds of sensors are used, such as Lidar, but in the future, we aim to improve the obstacle detection and identification, by using the smartphone camera and detect objects in real-time. In this way, not only can the external sensors be eliminated, but it can also serve as an automatic mapping device of remote locations.

References

[1] Baki Koyuncu, Mehmet Güzel, Chessboard Application of 6 Axes Robot Arm by using Inverse Kinematics Equations, Journal of Computer Engineering, Vol. 1, No. 1, 2007.pp: 59 – 68

[2] J. C. Yepes, J. J. Yepes, J. R. Martinez, and V. Z. Perez, “Implementation of an Android-based teleoperation application for Controlling a KUKA-KR6 robot by using sensor fusion,” Health Care Exchanges (PAHCE), pp. 2013, pp 1-5.

[3] H. F. Chen, C. Y. Chiang, S. J. Yang, and C. C. Ho, “Android-based patrol robot featuring automatic license plate recognition,” Computing, Communications, and Applications Conf. (ComComAp), 2012,.pp. 117-122.

[4] A.Rusdinar, J. Kim, J. Lee, and S. Kim, "Implementation of a real-time positioning system using extended Kalman filter and artificial landmark on the ceiling," Journal of Mechanical Science and Technology, vol. 26, no. 3, pp. 949-958, 2012.

[5] S. W. Moon, Y. J. Kim, H. J. Myeong, and C. S. Kim, “Implementation of smartphone environment remote control and monitoring system for Android operating system-based robot platform,” 8th International Conf. on Ubiquitous Robots and Ambient Intelligence (URAI), pp. 211-214, 2011.

[6] Prof. Y. M. Naik, C. M. Deshpande, R. R. Shah and R. R. Kulkarni, "Android Controlled Spy-Robot," International Journal of Software and Web Sciences, vol. 4, no. 1, pp. 54-57, 2013.

[7] "Android-er," 6 August 2014. [Online]. blogspot.co.id/2014/08/bi-directional-communication- between.html. [Accessed 21 March 2016.

[8] Shadia Elgazzar, “Efficient Kinematic Transformations for the Puma 560 Robot”, IEEE Journal of Robotics and automation vol Ra- 1, No.3, September 1985

[9] B. S. Kwak, J. H. Lee, "Smartphone Application Interface for Intelligent Human-Robot Interactions," Korean Institute of Information Scientists and Engineers, vol. 37, pp. 399-403, 2010.