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Wireless Mobile Robotic Arm

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Abstract

In recent year, with the increase usage of wireless application, the demand for a system that could easily connect devices for transfer of data over a long distance - without cables, grew stronger. This paper presents the development of a wireless mobile robot arm. A mobile robot that functional to do pick and place operation and be controlled by using wireless PS2 controller. It can move forward, reverse, turn right and left for a specific distance according to the controller specification. The development of this robot is based on Arduino Mega platform that will be interfaced with the wireless controller to the mobile robotic arm. Analysis such as speed, distance, load that can be lifted of the robot has been done in order to know its performance. Finally, this prototype of the robot is expected to overcome the problem such as placing or picking object that far away from the user, pick and place hazardous object in the fastest and easiest way.

Keywords: Robotic arm, mobile robot, wireless PS2 controller, Arduino Mega 2560.

1. Introduction

Nowadays, robots are increasingly being integrated into working tasks to replace humans especially to perform the repetitive task. In general, robotics can be divided into two areas, industrial and service robotics. International Federation of Robotics (IFR) defines a service robot as a robot which operates semi- or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations. These mobile robots are currently used in many fields of applications including office, military tasks, hospital operations, dangerous environment and agriculture [1].

Besides, it might be difficulties to the worker whose must pick and place something that can affect itself. For example, things like chemistry that cannot be picked by human and for the military such as defuse bomb that needed robot to pick and place the bomb to somewhere and for user that needed robot to do pick and place item while sitting and much more. Therefore a locomotion robot can be replaced human to do work.

The robot is wireless controlled to ensure it can journey a long way from the user. For example, previous project robot *Autonomous Robot Navigation using radio frequency* that similar to this project [2]. The robot was prepared mechanically to be suitable for this RF to work.

Other than wireless controlled, Bluetooth is also a platform to control robot without using the cable [3]. The movements of the robot are controlled remotely using Bluetooth connectivity. For this project, robot will be controlled in the all directions (forward, reverse, right and left). The actuator (arm robot) is controlled by generating pulse width modulation, PWM from the pin at Arduino Mega board.

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2. Robotic arm definition

A robotic arm is a robot manipulator, usually programmable, with similar functions to a human arm. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement [4].

The links of the manipulator can be considered to form a kinematic chain [5]. The business end of the kinematic chain of the manipulator is called the end effectors and it is analogous to the human hand. The end effectors can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application.

The robot arms can be autonomous or controlled manually and can be used to perform a variety of tasks with great accuracy. The robotic arm can be fixed or mobile (i.e. wheeled) and can be designed for industrial or home applications. The wireless mobile robots also have been developing in previous years [6].

3. Methodology

3.1. Project overview

In this project, the hardware and software function are combined to make the system reliable. The Arduino Mega will be the interfacing for the robot and controller PS2 wireless will control the movement of the robot. The project overview is shown in Fig 1.

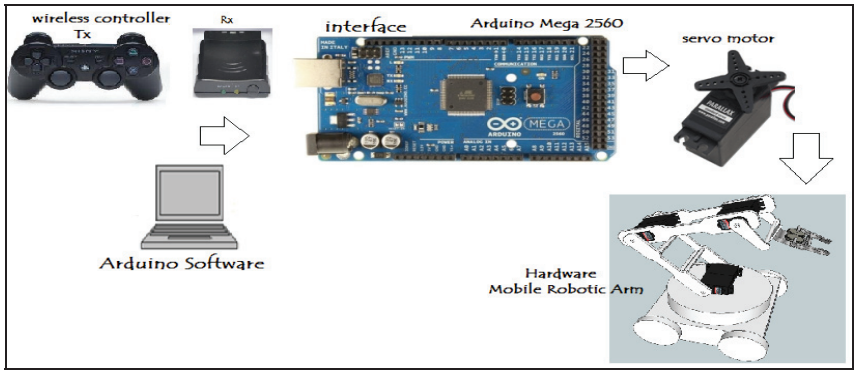


Fig. 1: Project overview of controlling robot arm.

3.2. System architecture

Table 1 shows the project specification for this wireless mobile robotic arm. The main purpose of producing this specification is to clarify some important aspects of the project and to make sure that the project is feasible as well as appropriate to use in the market.

Table 1: Specification of Wireless Mobile Robotic Arm.

Module	Specification
Interface	Arduino Mega
Controller	Sony PS2 wireless
Programming language	Arduino language
Actuator	Servo motor

3.3. Mechanical design

Fig 2 illustrate the designing of the robot with (a) main structure arm robot (b) arm robot design and (c) mobile for carrying arm robot. Robot arm wills have 5 outputs which consist of the base, shoulder, elbow, wrist and gripper.

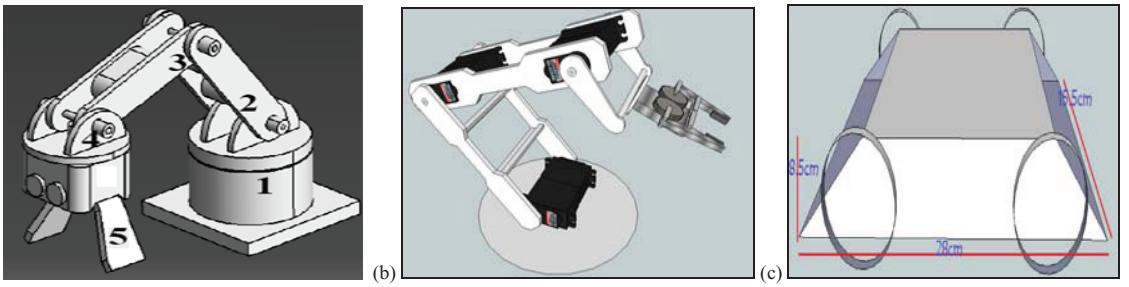


Fig. 2: Robot design (a) main structure arm robot (b) robot arm design and (c) mobile for carrying arm robot.

For arm robot, servo holder such as bracket and U joint is use to place the motor and it is made from aluminums because it is lightweight. The robot gripper is also made of aluminum because of the same reason as the main robot arm structure.

The mobile robot, it has dimension (28 x 15.5 x 8.5) cm which is the length, width, and height respectively, as shown in Fig 2 (c). Acrylic is used as the main material for mobile robotic arm because it is easy to be formed, cheap, strong and can bear the motor weight and movement. There are 4 servo motor and servo wheel attached to this mobile.

3.4. Electrical design

Fig 3 (a) shows the electrical designing using Proteus simulation for motor driver mobile robot and (b) by using PCB wizard software, each electrical component has been arraged specifically to create space for Arduino Mega.

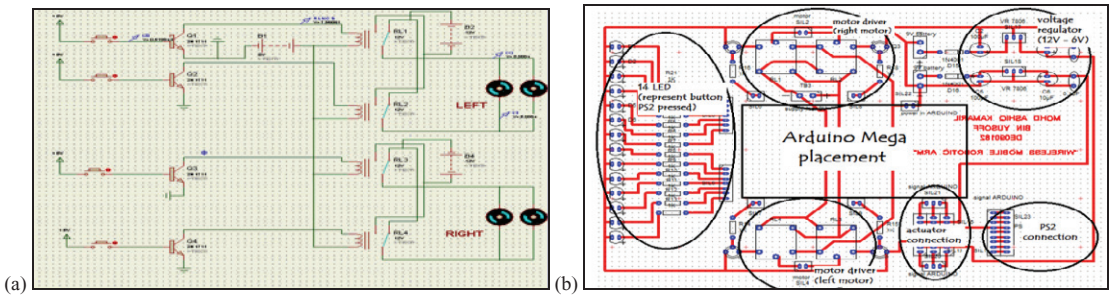


Fig. 3: Electrical design for (a) motor driver and (b) complete circuit for mobile robot arm.

3.5. Software development

Software is a set of programs, procedures, algorithms and its documentation concerned with the operation of a data processing system. In this case, software is needed in order to complete task for the project.

- **Arduino IDE:** Arduino hardware is programmed using a Wiring-based language (syntax and libraries), similar to C++ with some slight simplifications and modifications, and a Processing-based integrated development environment. Arduino is programmed using Arduino IDE that has been develop using Java and based on Processing, avr-gcc, and other open source software.
- **Proteus 7 Professional:** This software been used in order to design the motor driver circuit for mobile robot arm only. It is because, to make the mobile goes forward, reverse, turn right and turn left it must needed an electronic component such as relay and transistor to function it.
- **Google Sketch Up:** To design the whole project that divided into two designing part. First is for the arm robot and other part is for the mobile robot.
- **PCB Wizard:** Software that will be used to create and design the arrangement of an electronic device into board. This project used single layer board due to less component used.

3.6. Arduino Mega 2560

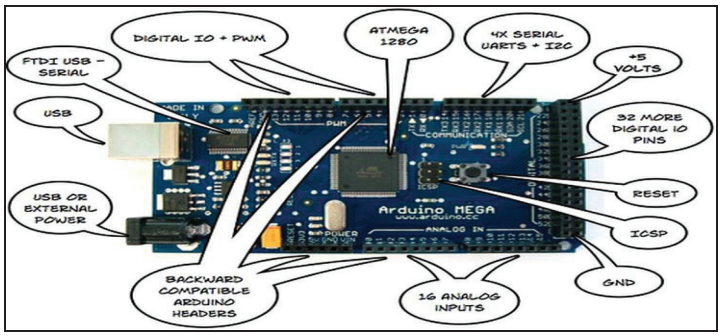


Fig. 4: Arduino Mega 2560.

The Arduino Mega 2560 as in Fig 4 is a microcontroller board based on the ATmega2560. It has 54 digital input and output pins of which 14 can be used as PWM outputs, 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an alternating current (AC) to direct current (DC) adapter or battery to get started.

3.7. Sony Play Station 2 (PS2) wireless controller

Fig. 5: Sony PS2 wireless controller.

For this project, PS2 wireless controllers as in Fig 5 are used to control the movement of servo including the gripper and mobile robot arm. In addition, wireless controller has an advantage compared to cable because it can communicate with the robot wirelessly. The controller used 2.4GHZ frequency and has a vibration feedback capability. It has transmitter (Tx) and receiver (Rx) to operate separately. The controller used 2x'AAA' battery size.

4. Result and discussion

4.1. Complete designing robot

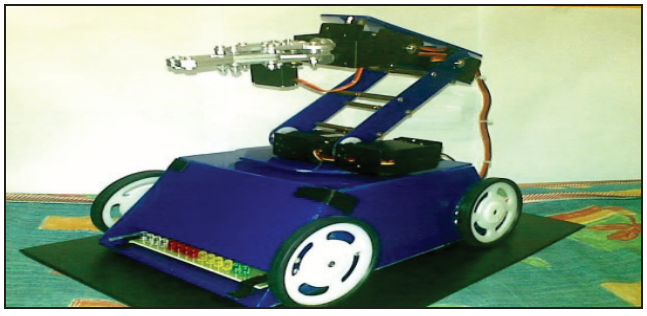


Fig. 6: Completed wireless mobile robotic arm.

Fig 6 shows a completed mechanical structure of wireless mobile robotic arm. The dimension of the robot when not working is (29 X 19 X 25.5) cm and the weight of the robot is 1.55kg.

4.2. Mobile robotic arm analysis

Fig 7 shows the wheel movement of the mobile robot. The robot can move forward, reverse, turn right and left. Light Emitting Diode (LED) will light up when button of controller is pressed.

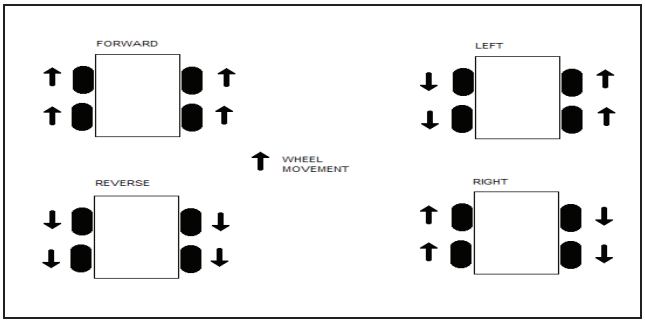


Fig. 7: Wheel movement of mobile robot.

The incoming power supply is important for mobile robot because it will control the speed of servo motor. Therefore, Table 2 shows the analysis for velocity of the robot in difference supply for 1metre distance.

Table 2: Time taken for difference power supply.

No	Power Supply (V)	Time taken (s)	Velocity (m/s)
1	9	4.83	0.20
2	8	5.83	0.17
3	7	23.8	0.04
4	6	Not finished	-

It show that, if power supply for mobile robot is decrease, it takes more time to reach 1metre distance. But when 6V power supply is used, there are no movement for mobile robot. So, it can be conclude that power supply for mobile robot (360^0 servo motor) is proportional to the speed of the robot.

4.3. Operational of robot arm

The workplace for arm robot is illustrated in Fig 8. The arm robot workplace is in revolute manipulator. It consist of axis that represent the degree of freedom (DOF). For this project, the mobile robot has 4-DOF.

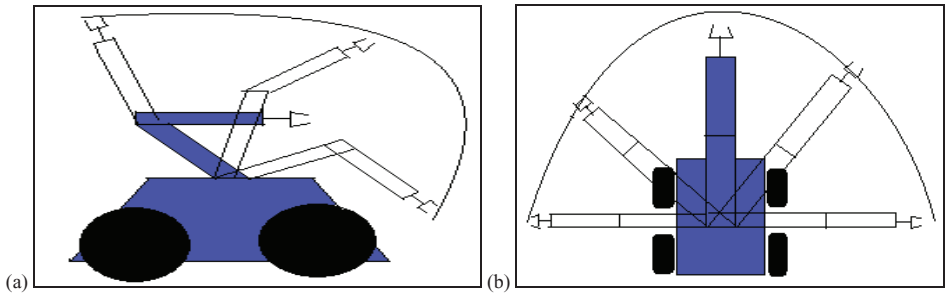


Fig. 8: Robot arm workplace (a) side view (b) plane view.

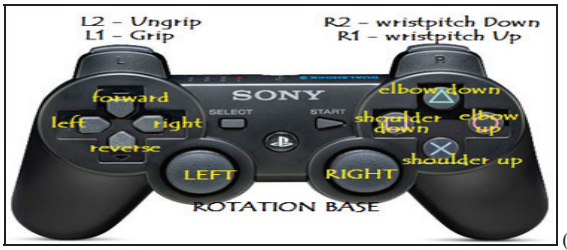
For the load that the robot arm can pick depends on the strength of servo motor. If the load exceeds the strength of the servo, it will cause the servo not working and can caused more usage of current in the servo motor. Table 3 shows the different load that can be lifted by the robot arm. Because this is a prototype project, the load that can be lifted by the robot arm is quite small.

Table 3: The different load that can be lifted by the robot arm.

No	Load (g)	Function
1	50	Yes
2	100	Yes
3	150	Yes
4	200	No

4.4. Wireless PS2 controller application

Wireless mobile robotic arm should be able to move and can be controlled by using PS2 wireless controller. In this case, the prototype of robot should move simultaneously when controller button is pressed. There are 14 LED represent each button in controller and will lights up when controller button is pressed. Fig 9 (a) shows the navigation of controller based on programming code and (b) shows the LED represent on each button in the controller.

(a) 

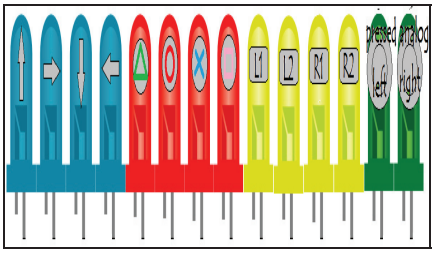
(b) 

Fig. 9: (a) Navigation and (b) LED represent on each button of the controller.

The controller is using 2.4GHz wireless frequency and operating range (maximum) for wireless control is 8 meter, 45-degree angle. If the power of battery for the controller decrease, signal strength become weak. Therefore, there will be lost of connection between the transmitter (Tx) and the receiver (Rx). Table 4 shows the effective distance for this mobile robot.

Table 4: The effective distance for wireless controller.

Distance(m)	Obstacle	Rx Detect
8	No	Yes
	Yes	No
7	No	Yes
	Yes	No
6	No	Yes
	Yes	No
5	No	Yes
	Yes	Yes

4.5. Servo motor analysis

A servo motor has three wire output. Two of them are for power and ground and another one is lead feeds a position control signal to the motor. The positional of the servo will be controlled by using PS2 wireless controller. Initial position for robot is 90 degree of each servo. Fig 10 shows the different positions angle when different pulse width is injected into the servo motor signal wire.

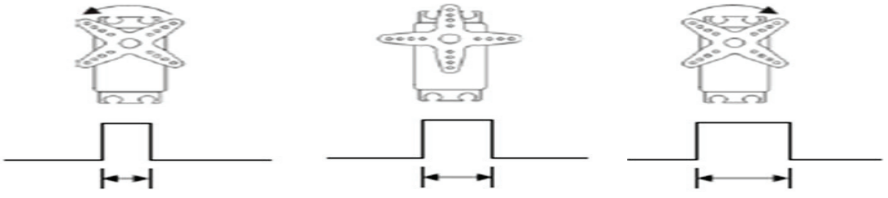


Fig. 10: (a) short pulse width (180 degree), (b) neutral position (90 degree) and (c) wider pulse width (0 degree).

4.6. Circuit analysis

There will be 3 power supplies in the overall circuit for this project as shown in Table 5.

Table 5: Specification for power supply in the circuit.

Power Supply	Battery	Circuit	Operation
1	9V (battery)	Supply for Arduino Mega	Arduino Mega On, receiver (Rx) operates and LED will lights up when controller (Tx) button is pressed.
2	9V (battery)	Motor driver	When controller button is pressed, Rx receive signal from Tx and send data to Arduino (interface). Then, data will be an output from Arduino and become input (5V) for motor driver to move the mobile robot as desired.
3	12V/1.2 Ah (Sealed Lead Acid battery)	Servo motor (actuator)	Robot arm will be in standby mode (90 degree). When controller (Tx) send signal (controller button is pressed) to Rx, the signal will be sent to actuator (servo motor) and drive the arm robot as desired.

For the power supply 3, LM7806 will be used to regulate 12V to 6V because it was the maximum voltage for the servos. By using this sealed lead acid battery rechargeable with such a high current (1.2Ah) compared to lithium battery, servo motor (actuator) can move and lift the load.

5. Conclusion

Overall, the objectives of this project have been achieved which are developing the hardware and software for wireless mobile robotic arm, implementing the pick and place system operation and also testing the robot that meets the criteria of purpose project. From the analysis that has been made, it is clearly shows that its movement is precise, accurate, and easy to control and user friendly.

The mobile robot has been developed successfully as the movement of the robot including mobile and arm robot can be controlled wirelessly. This robot is expected to overcome the problem such as placing or picking object that away from the user, pick and place hazardous object in the fastest and easiest way.

6. Recommendation

Generally the robot program runs smoothly as planned. For the future recommendation, this robot can be equipped with a camera to view and display at the monitor screen. Besides that, the prototype robot's materials can also be upgraded so it can lift heaver load and do multifunction operation.

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