# Designing An Omni Wheel Robot

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## ABSTRACT

In the millennium age the development of technology is very rapid, especially in the field of robotics from my own thesis, I talk about how do I build this OMNI wheel robot, start from robot base framework mechanical designing then electrical circuit designing and finally program it through Arduino Mega as a microchip of Soccer Robot. Additionally, to accomplish both thesis and the project OMNI wheel robot it self I consider some several Artificial Intelligent (AI) that has been developed around the world then implemented to my Robot. Besides, basically, this thesis is a combination of computer science which is my major, an Artificial Intelligent and also electrical engineering then finally produce this OMNI wheel robot that features three Omni wheels and controlled by wireless PlayStation joystick as an output. Also in this thesis, both mechanical and electrical components description that used in this OMNI wheel robot are given one by one.

After robot base framework mechanical has designed and built, then next is design and build an electrical circuit of each component. The whole Omni wheel robot electrical circuit of all the electrical components was designed on Proteus one of electrical circuit simulation software, software that allows a designer to simulate and test the design before implementation and manufacture it as a real life robot.

Additionally in order to simulate how does this robot will be placed on I designed and built the arena of this robot consider the kind of robot is an Omni Wheel robot, therefore, I decide to make an official Omni field and definitely has been scaling down and conditioned based on the Omni robot size itself and this Omni field design is printed out on some kind of flat surface, therefore, could be arena that Omni Robot will be placed and played on. I used CorelDraw X8 to design the robot Omni field, a vector graphics editor developed and marketed by Corel Corporation this design software gives us an exact parameter dimensions values when our design will be printed on and also as based on vector graphics software our design would not be scratched or blurred out while it comes to be printed out.

**Keywords: Omni Wheel Robot, Arduino Mega, Mechanical, Electrical Circuit**

# 1.Introduction

In the millennium age the development of technology is very rapid, especially in the field of robotics from my own thesis, I talk about how do I build this OMNI wheel robot, start from robot base framework mechanical designing then electrical circuit designing and finally program it through Arduino Mega as a microchip of Soccer Robot. Additionally, to accomplish both thesis and the project OMNI wheel robot it self I consider some several Artificial Intelligent (AI) that has been developed around the world then implemented to my Robot. Besides, basically, this thesis is a combination of computer science which is my major, an Artificial Intelligent and also electrical engineering then finally produce this OMNI wheel robot that features three Omni wheels and controlled by wireless PlayStation joystick as an output. Also in this thesis, both mechanical and electrical components description that used in this OMNI wheel robot are given one by one.

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Additionally in order to simulate how does this robot will be placed on I designed and built the arena of this robot consider the kind of robot is an Omni Wheel robot, therefore, I decide to make an official Omni field and definitely has been scaling down and conditioned based on the Omni robot size itself and this Omni field design is printed out on some kind of flat surface, therefore.

## 1.1 Omni Wheel Robot

Omni-directional robots are unique as they can roll freely in two directions. It can roll like a normal wheel or roll laterally using the wheels along its circumference. Omni-directional wheels allow a robot to convert from a non-holonomic robot to a holonomic robot. A non-holonomic robot is that which uses normal wheels and has only two out of three controllable degrees of freedom, which move forward/backward and rotates. The robot cannot move side ways` which make it slower and less efficient in reaching its given goal. The holonomic omni-directional wheels can overcome this problem, as it is highly maneuverable. Conventional wheel mobile robots (WMRs) are restricted in their motion because they cannot move sideways without a preliminary maneuvering [3] arious mechanisms were developed to improve the manoeuvrability of WMR.A design which uses three centered wheels with independent steering and driving capability [1], is capable of continuously varying its orientation through 360°,as such the design may be termed omni-directional [2] . It was not known widely that the very first omni-directional wheel was patent in 1919 by Grabowiecki [3]. The assembly consists of main wheels and transversal rollers, such as those used by most Robo Cup teams [3] . Inventors were considering the design of vehicles to be capable of moving forward and sideways without steering the wheels. Robots constructed with these wheels normally possess three driven omni-directional wheels arranged in a Δ or Y manner [5]. Langlois [6] shows that modularity makes it easy for users to change the platform or add components to it. There are many

robotic platforms that are developed to simplify the design of software and hardware. These platforms fall short of meeting the objectives of our design. These design objectives were: modularity, ease of use and construction, low cost, and an emphasis on straight forward control, in a mobile robot performing search algorithms; it must be intelligent enough to navigate the environment, avoid obstacles and finally locate the search target with the help of adequate sensors. Usually works regarding robot autonomy were studied and the usefulness of some ideas could apply and combined in an effective way to achieve.

# CHAPTER 2 KINEMATIC ANALYSIS

## 2.1 Wheel Driver System

The wheel system designed on this robot uses a 6V DC motor with an omni wheel measuring 42 mm in diameter.

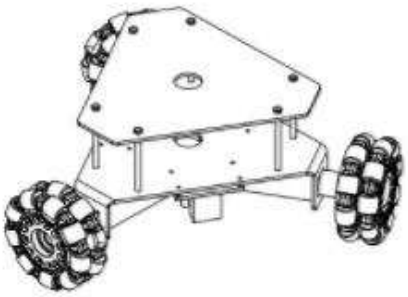

Figure 2.1 Wheel Driver System

## 2.2. Omni Wheel Robot Algorithm

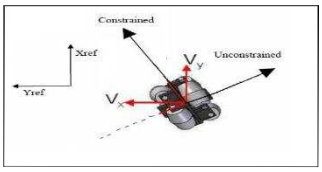


Figure 2.3 Kinematics Representation of the Three Omni-Directional Drive System

Using Figure 2.3 the kinematics equations of the drive system can be derived. Equations hat are used in the robot control system are

$$V_x = V_3 - V_1 \cos(\delta) - V_2 \cos(\delta) \quad (1)$$

$$V_y = V_1 \sin(\delta) - V_2 \sin(\delta) \quad (2)$$

$$V_\phi = V_1 / L + V_2 / L + V_3 / L \quad (3)$$

$$V_{i\,(1,2,3)} = w \cdot r \quad (4)$$

Where;

r : Omni wheel radius (cm).

w : Angular velocity of the wheel (rad/sec).

$$\begin{bmatrix} V_x \\ V_y \\ V_\phi \end{bmatrix} = \begin{bmatrix} \frac{-1}{2} & \frac{-1}{2} & 1 \\ \frac{\sqrt{3}}{2} & \frac{-\sqrt{3}}{2} & 0 \\ \frac{1}{L} & \frac{1}{L} & \frac{1}{L} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} \quad (5)$$

So the velocity for each of the three wheels will be equal to the servomotor speed multiplied by wheels radius in the theoretical analysis. As the wheels are arranged in symmetrical manner (120°) apart, then δ = (60°). So Equations (1) to (3) can be rewritten in a matrix form;

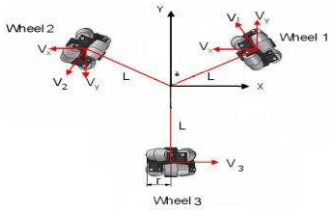


Figure 2.3 Kinematics Representation of the Three Omni-Directional Drive System

To find the robot velocity and orientation at any point the following equations will be used

$$\boldsymbol{V = \sqrt{Vx^2 + Vy^2}} \quad (6)$$

$$\psi = tan - 1\frac{Vy}{Vx} \quad (7)$$

Two search algorithms (the wall-following search and the "most-open-area" search) were tested and their accuracy were compared in experimental work using a room like prototype.

# CHAPTER 3 KINEMATIC ANALYSIS

Robots are essentially motion devices. So, kinematics is a fundamental part of the multidisciplinary research area of robotics. The kinematic model of a manipulator describes the relationship between joint displacements and end effector motion. It is composed of position and velocity formulations. The position kinematic model relates joint positions and end effector posture.

After the design process is completed, this chapter will be disclosed and described on the preparation of the components and equipment used, as well as the practical steps, then preparing the test result data. Implementation of data collection using a series and done repeatedly to produce data that really appropriate. Before doing the data collection, first learn the components then determine the measurement point.


Figure 3.1 Omni Wheel Robot

## 3.1. Control of Omni-Directional Mobile Robot Motion

Tsshis Thesis presents the motion programming and control of Omni directional mobile robot through the process of building and programming a small robotic platform with secondary design criteria of modularity and simplified control. This is accomplished by combining the positive aspects of several different robotics platform ideas. The platform is shaped like an equilateral triangle with a servo motor, sensors, and Omni-wheel, controlled by a Wireless PlayStation stick.

In this work the kinematics, inverse kinematics and dynamic module for the platform are derived. Two search algorithms (the wall-following search and the "most-open-area" search) is designed, tested, and analyzed experimentally.

Keywords: Omni-directional mobile robot.

## 3.2. List of Materials that Used in Omni Wheel Robot

| No. | Components | Amounts |
|---|---|---|
| 1. | Arduino Mega 2560 | 1 |
| 2. | 12V/24V,150W, DC Motor | 3 |
| 3. | OMNI Wheels | 3 |
| 4. | Battery 7.4 V / 2600 mAh | 1 |
| 5. | 2L29BN Motor Dricer Board Stepper Robot Smart Car DC 12000 | 3 |
| 6. | Top Body | 2 |

Table 2.1 List of Materials that Used in Omni Wheel Robot

## 3.3. Schematic Diagram

To realize the robot to be tested, then the whole system of Arduino-based robot simulation circuit controlled by play station stick using communication via Bluetooth is like picture 3.1.

The schematic diagram for the Omni wheel is as follow:

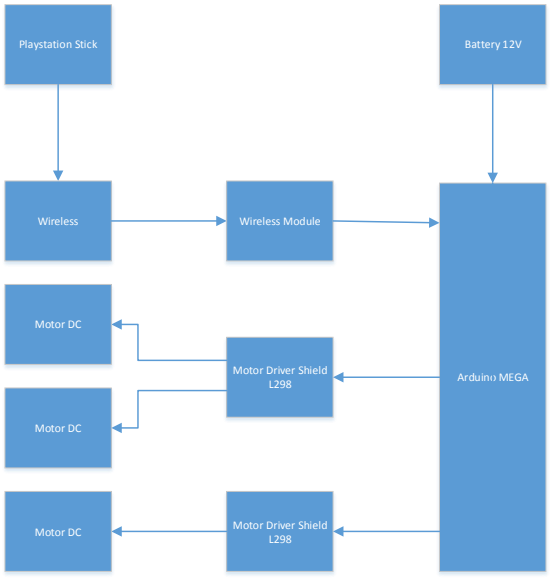


Figure 3.2 Omni Wheel components diagram

The function each part of the diagram is as follow:

- Battery

  Battery 7.4V/2600 mAh is used as power supply for Arduino.
- Arduino Mega 2560

  Arduino Mega 2560 is used as control system for the Hexapod robot
- Servo Motors

  Servo motors are used as joint to connect between links in the wheels.

## 3.4. Mechanic Design

Mechanical design of a robot created in such a way that supports the ability of the robot to move in the field arena. The material components of robot used the aluminum, both Robot base and upper body construction using the aluminum material. The use of aluminum selected because these materials are relatively easy to set up and light weight it's given and advantages while the robot chase and dribble a ball in its behavior.

## 3.5.Omni Wheel Robot Electric Design

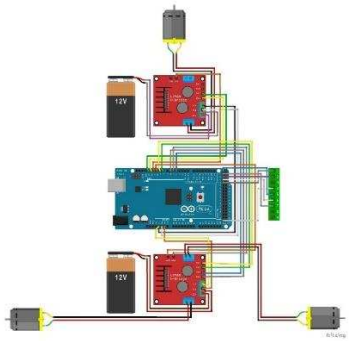

Figure 3.4.Omni Wheel Robot Electric Design

## 3.6. Structure of Omni Wheel Robot

A picture is The frame top vie
B picture is The frame the middle view
D picture is the motor of The frame

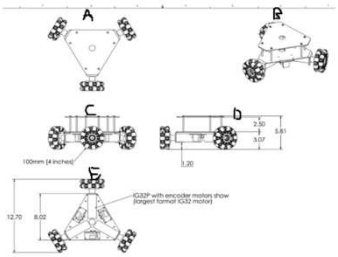

Figure 2.5 Structure Omni Wheel Robots

## 3.7. Forward Kinematic Analysis

The forward or direct kinematics analysis is the process of calculating the end-effector posture from the joint positions given. It is used in design and simulation of robotic kinematic chains [11].

## 3.8. Inverse Kinematic Analysis

Inverse kinematics analysis is the process of obtaining the joint positions necessary to establish a desired end-effector posture. Both analyses are important in motion study. It is essential for motion planning resolution algorithms. One problem of the inverse kinematics is the possibility of multiple solutions, or even infinite solutions if the kinematic chain is redundant. [11]

## 3.9. Soccer Robot Arduino Simulation

Before we execute it would be nice we simulate the design we created because when there is an error it we can anticipate and overcome from the simulation and we can save from lost connection or other human error there is lot of simulation method I decide to use proteus software to simulate our design through is picture that can simulate thin electrical circuit by default the proteus Library does not include some particular part or component, seen the design use arduino device we need to add arduino library folder manually

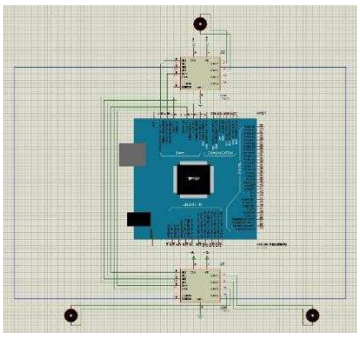

Figure 3.2 Omni Wheel Robot Arduino Simulation

## 3.6 Programing Design

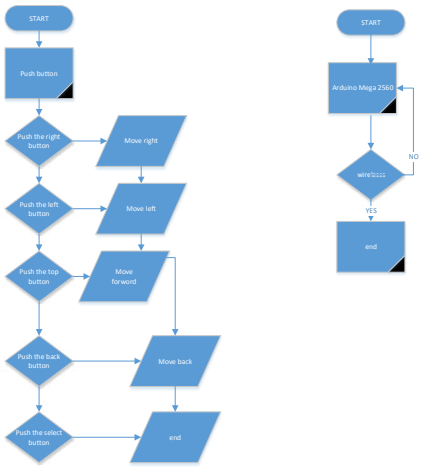


Figure 3.4 Omni Wheel Arduino Simulation Flowchart

In this Project I use manual wireless controller, there so we only need to push navigation push button on Playsation 2 wireless controller.

| No | Stick Button | OMNI Wheel 1 | OMNI Wheel2 | OMNI Wheel 3 | Robot Movement |
|---|---|---|---|---|---|
| 1 | Up button | _ | CW | CCW | Moving Forward |
| 2 | Down button | CCW | | CW | Moving Backward |
| 3 | Right button | CW | CCW | _ | Turning Left |
| 4 | Left button | CCW | _ | CW | Turning Left |
| 5 | Select | _ | _ | _ | _ |

4.1 Omni wheel Robot Movement Testing

# CHAPTER 4
# IMPLIMINTATAION AND TESTING

## 4.1. Omni wheel Robot Movement Testing

The purpose of testing the system as a whole is to know how the robot moves and communicates in accordance with the control performed by the user. Testing is done by trying the existing buttons on the control application that has been installed on Android. Each test is done step by step forward, backward, right, left, and stop.

**4.7. Omni Wheel Robot Unit Function Testing**

from did lot of testing and analyst on the omni wheel robot than got complete result like the table given billow .

| No | Unit | Function | Description | Testing Result |
|---|---|---|---|---|
| 1. | Voltage | Gives the power by voltage to drive the motor. | When the button on the robot voltage on turn it will automatically give power | The voltage on this omni wheel robot is 3.5v , 7v and 12v |
| 2. | Motor | Motor can be interpreted as a driver. Because of its main function as a converter source of electrical energy, a driving force | When given the voltage of the battery then the motor will move to some direction that is specified in the program | Motor running on fast |
| 3. | Wireless Communication | Is a wireless network that uses air as its transmission medium to deliver electromagnetic waves | When the network is given the program, then the network will send orders to Arduino and directed to the motor drive | The Wireless Communication Work as well until 15M |
| 4. | Omni Wheel | Omni wheel Is kind of wheel they are able to move in many directions and it has small discs around the wheel will roll with full force. | When the motor is given the power and the program runs then the wheel will move according to the in the construction | The Omni Wheel work as well on $60^0$ - $80^0$ |

Table 4.3 Omni Wheel Robot Unit Function Testing

# REFERENCES


[1] Y. Low, J. Angeles, and K. Low, "A comparative Mobility Study of Three Wheeled Mobile Robots", Proc. The Sixth International Conference on Control, Automation, Robotics and Vision, Singapore, 2000

[2] M. West, and H. Asada," Design of Ball Wheel Vehicles with Full Mobility, Invariant Kinematics and Dynamics and Anti-slip Control", Prco. The 1994 ASME Design Technical Conference 23rd Biennial Mechanisms Conference, pp.377- 384, 1994.

[3] J. Grabowiecki,n, "Vehicle Wheel", US Patent 1,303,535, June 3, 1991

[4] S. Saha, J. Angeles, and J. Darcovich, "The Design of Kinematically Isotropic Rolling Robots with Omni-directional Wheels", Mechanism and Machine Theory, Vol. 8, pp.1127-1137,1995