REMOTE CONTROLLED 4WD OMNI DIRECTIONAL ROBOT USING MECANUM WHEELS

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ABSTRACT

This paper presents a novel design of an omni directional robot made from using four mecanum wheels. An omni directional robot is a robot that is capable of moving in any direction and is able to instantaneously change its direction at any given time. This can be advantages over a conventional mobile robot as it can avoid obstacles more easily and move through more complex paths that a conventional robot could not. This omni directional robot is designed to have both autonomous capabilities as well as the ability to receive instructions from a remote control. An introduction to the workings of a mecanum wheel, the motion analysis and the kinematic modeling of a 4WD omni directional robot using mecanum wheels are presented.

Keywords*: Omni directional robot, Mecanum wheel, Remote control, Autonomous*

1. INTRODUCTION

A robot is defined as a machine that is capable of carrying out a complex series of actions automatically. However most of the conventional wheeled robots out in the world is only capable of moving in a forwards, backwards and in a rotational motion. However an omni directional robot is not your everyday conventional wheeled robot.

An omni directional robot is a robot which can move instantaneously in any direction from any configuration. It is capable of translating in both directions and rotating about its center of gravity. Most conventional vehicles however do not have the capability to control every degree of freedom independently and are not capable of moving in a direction parallel to their axis, whereas an omni directional vehicle can.

Omni directional robots are especially helpful in crowded environments as it has the ability to easily maneuver its way past both stationary and moving obstacles as well as move through a narrow, complex aisles that a conventional robot of the same size would normally get stuck in.

An omni directional robot are most commonly made out of two different types of wheels which are the omni wheel*[1]*and the mecanum wheel. However omni directional robots can be made in other ways as well. For example, normal wheels can be used if the motors driving them are connected to a servo motor. Also there are spherical robots that have the capability to move in any required direction using weights and moments*[2]*.

(a) (b)

Figure 1: (a) omni wheel (b) mecanum wheel

For our project, we decided to use the mecanum wheel instead of the omni wheel as the mecanum wheel possessed some advantages that the omni wheel did not. In this paper, we present a design for an omni directional robot that uses four mecanum wheels.

The design of a mecanum wheel includes rollers that are at a 45° angle to the x and y axis *(as shown in figure 2)* which translates a portion of the force in the rotational direction of the wheel to the direction normal to the wheel's direction. Since the rollers are in a 45° to the x axis and the y axis, the translated portion of the force to the direction normal to the wheel's direction will be equal to the force in the rotational axis of the wheel *(as shown in figure 3).*

The following sections will include background theory on mecanum wheel and the kinematics and motion analysis. Then the design and implementation is presented followed by results, discussions and future work.

2. BACKGROUND

The main advantages of choosing the mecanum wheel were that the mecanum wheel has a greater number of degrees of freedom than an omni wheel does. Also the mecanum wheel is easier to work with when programming as the movement of the robot in any direction can be controlled by changing the direction of rotations of the mecanum wheels.

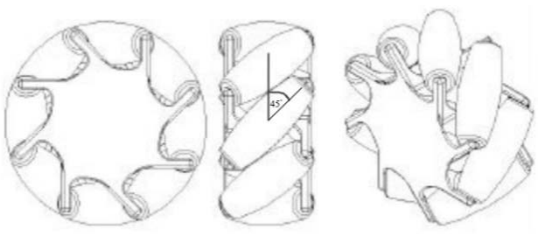

Figure 2: Drawing of the mecanum wheel

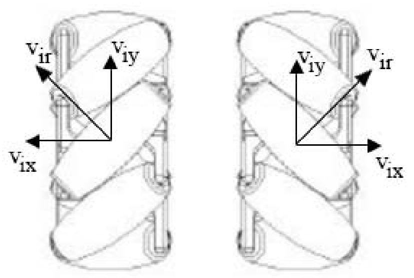

Figure 3: The velocity components of the mecanum wheel *(i = 1,2,3,4 depending on the wheel)*

When making an omni directional robot out of four mecanum wheels, it is essential to make sure that the center of gravity of the robot coincides with the center of rotation of the robot. The reason for this is since a mecanum wheeled omni directional robot can move in any direction; accelerating and decelerating in any combination of x and y components as well as a rotational component about the z axis, the instructions to the robot have to be incredibly precise. Because of this, there cannot be any unexpected and unwanted moment that arises when the center of gravity does not coincide with the center of rotation.

As mentioned before, an omni directional robot can move in any direction required and it is because of the unique design including the rollers that allow it to do so. When using four mecanum wheels to make an omni directional robot, the four different wheels have to be controlled in a specific way so that the robot can move in the required direction. For these different controls, refer figure 5.

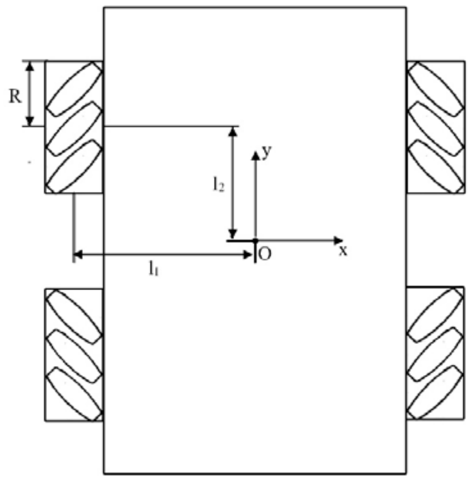

Figure 4: Basic schematic of the robot chassis
Note: In this schematic, the center of rotation is equal to the geometric center

R → Radius of wheel
l_1 → Distance between the center of the wheel and the center of the robot (y-axis)
l_2 → Distance between the center of the wheel and the center of the robot (x-axis)

The angular speeds (ω_1, ω_2, ω_3, ω_4) for wheels 1-4 respectively can be found by equation (1) below;*[3]*

$$\begin{bmatrix}\omega_1\\ \omega_2\\ \omega_3\\ \omega_4\end{bmatrix} = \frac{1}{R}\begin{bmatrix}-1 & 1 & -(l_1+l_2)\\ 1 & 1 & l_1+l_2\\ 1 & 1 & -(l_1+l_2)\\ -1 & 1 & l_1+l_2\end{bmatrix}\begin{bmatrix}v_x\\ v_y\\ \omega_z\end{bmatrix} \rightarrow (1)$$

If we want to move the omni directional robot in a straight line in a given angle at a given speed, we can use the speed and angle to find v_x and v_y and since the robot is moving in a straight line, ω_z will be equal to 0. Using this information, we can find the angular speeds required for each wheel to move the robot in any given angle.

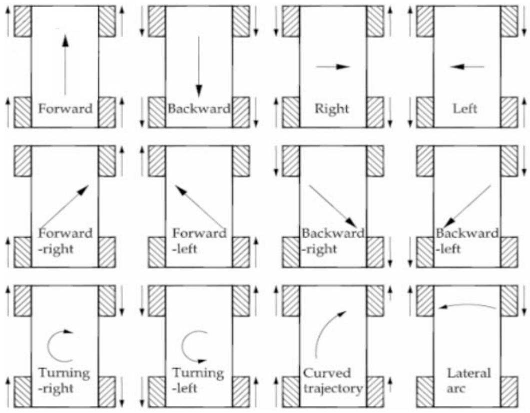

Figure 5: Diagram depicting the different motor controls to achieve different directions*[4]*

3. DESIGN AND IMPLEMENTATION

The scope of this project is to design a robot with autonomous capabilities where it gets an input from a number of ultrasonic sensors and figures out the best path to reach a required destination, and also have the capability to receive instructions from a remote control. This robot should be able to move in any flat surface in an indoor environment. However the scope of this project does not include the robot moving up and down any slopes.

This can be made by using for mecanum wheels in the configuration shown in figure 4.

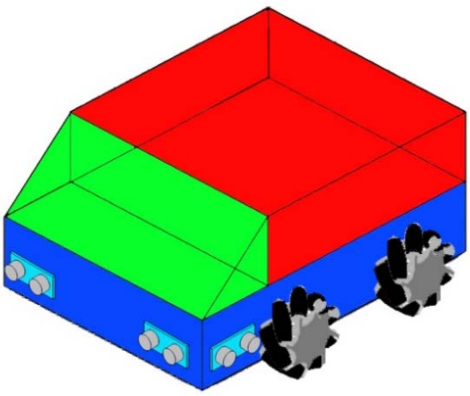

Figure 6: An isometric sketch of the chassis that will be used

Figure 6 shows the basic design of the chassis of the robot. As the figure shows, the chassis will be comprised of 3 main sections; the blue, the green and the red sections. This design was chosen because with this design, the center of gravity will coincide with the geometric center of the robot.

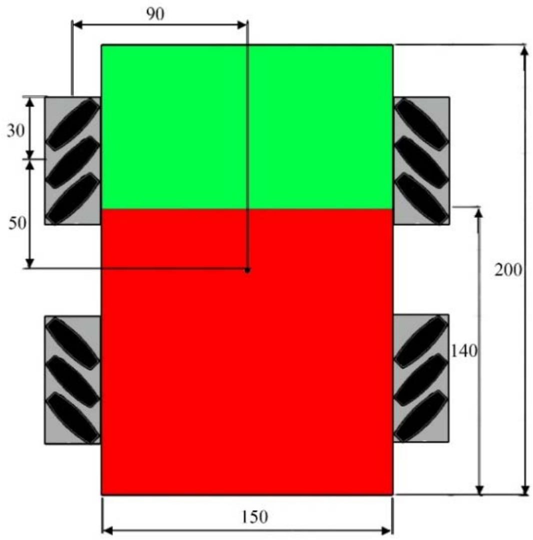

Figure 7: Top view of the chassis *(Note that the sketch is not to scale)*

The blue section will house the 4 motors as well as the motor driver circuits. The motors will be equidistant from the center of the robot as shown in figure 4. The motor drivers will also be placed in such a manner. There will also be 4 ultrasonic sensors fixed onto this section of the chassis as shown in the figure.

The green section will hold the battery. Since the battery is relatively heavy compared with all the other components, the part of the chassis that houses it will be relatively smaller and thus lighter.

Finally in the red section, the main PIC circuit and the wireless transceiver module can be found.

The robot is controlled by a single microcontroller (PIC18F45K22) and the mecanum wheels are driven by a motor driver (L293D). One motor driver is capable of driving only 2 motors, so therefore 2 motor drivers will have to be used.

As mentioned before, this robot will have two main modes; an autonomous mode and a remote controlled mode. So for each mode, there are different components to help control the robot. For the remote controlled mode, there will be a NRF24L01+ wireless module that connects to a remote control so that it can receive commands from the user. For the autonomous mode, there will be a number of sonar sensors so that when the robot is moving to its designated position, it can detect obstacles in its way and properly maneuver to avoid them. There will also be a button connected to the microcontroller that will enable the switching between the two modes.

Figure 8shows all the components and modules of the main robot and how they are all interconnected with each other. Figure 9 shows how all the components and modules are connected together in the remote control.The microcontroller in the remote will be another 40-pin microcontroller as the I/O ports will be needed for all the various different control commands.

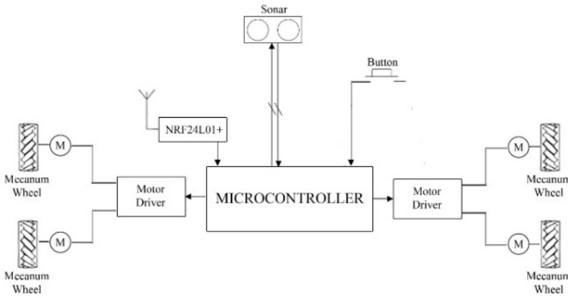

Figure8: Block diagram of the robot

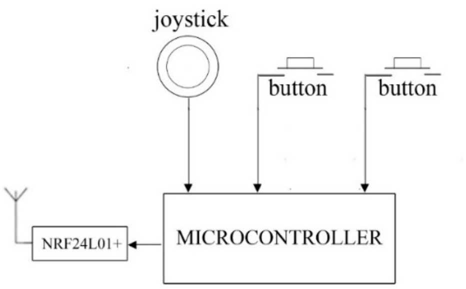

Figure 9: Block diagram of the remote control

Motor	Voltage (V)	No Load Current (mA)	Max. Speed (rpm)	Power (mW)
1	12	0.05	160	0.60
2	12	0.06	160	0.72
3	12	0.06	160	0.72
4	12	0.05	160	0.60

Table 1: Ratings of the four motors used

From table 1, it can be seen that if there is a small difference in the four motors. Therefore, when programming, we will need to add extra lines of code for the robot to self-correct itself.

Total Weight	824.6g
Dimension of Chassis	20cm x 15cm x 11.5cm
Wheel Diameter	6cm
Number of Rollers	8

Table 2: Details of Robot

Currently, the robot has been hard coded to move in all angles. By doing this, the robot can be tested to see if there is any error in the movement and if it does indeed move in a straight line and reach its required destination without detouring off its path.

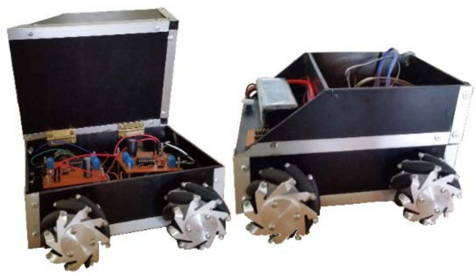

Figure 10: Picture of the robot

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