**DESIGN AND PERFORMANCE ANALYSIS ON MOVEMENT OF SQUARE, TRIANGULAR AND OCTAGONAL STRUCTURED OMNIDIRECTIONAL MOBILE ROBOT**


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**Abstract:**

This paper addresses the issue of development of a three wheel, four wheels and eight wheel Omni directional mobile robot. The Omni directional wheel is used in this research consists of 8 rollers made from synthetic rubber coated polypropylene rollers. All Omni wheel are independently powered using 3, 4 and 8 units of precision gear DC motors and the wheel/ motors assemblies where mounted directly to the robot chassis made using an aluminum frame. Basic mobility algorithm was developed to test the basic mobility capability and test the qualitative view of the systems and mobility performance. An experiment was setup to analysis the motion characteristics of the mobile robot motion in y-axis, x-axis and rotary motion. Data from the experiment will be used for mathematically model for mobile robot platform and speed controller modeling and design. The combination of mechanical design on the wheel and chassis, motion control allow the exploration of large number of control algorithm and software to be implemented to the robot for practical applications.

**Keywords:** Omni Directional Mobile Robot, square & triangular structured robot, octagonal structured robot, motion control.

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**Introduction:**

In industries the applications of mobile robots are continuously gaining in importance. They are already widely used for surveillance, inspection and transportation tasks. A further emerging market is that of mobile entertainment robots. One of the main requirements of an autonomous mobile robot is its ability to move through the operational space, avoiding obstacles and finding its way to the next location, in order to perform its task. In order to know where to go, the robot must have accurate knowledge of its current location. In means, it should use a great variety of sensors, wheels and algorithm. In order to move in tight areas and to avoid obstacles mobile robot should have good mobility and maneuverability. These are capabilities mainly depends on the wheels design. Research is continuously going on this field, to improve the autonomous navigation capability of mobile robotic systems.

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**Kinematic Model:**

Figure shows a top view of an Square structured Omni Directional Mobile Robot (SSODMR). The coordinate $X_0, O_1, Y_1$ is attached to the robot body and $XOY$ denotes the world coordinate. The radius of the wheel and the radius of the robot body denoted by $r$ and $b$ respectively. The angle between the axles of the wheels are denoted by $\alpha_i$ (i = 1,2,3,4) respectively. The angular velocity of each wheel is denoted by $\omega_i$ (i = 1,2,3,4) and the direction of the linear velocity of the of the wheel is indicated by $v_i$ (i = 1,2,3,4) with respect to coordinate $X_0, O_1, Y_1$. The angle between the coordinates $X_0, O_1, Y_1$ and $XOY$ is denoted by $\theta$. The linear and angular velocities of the robot are denoted by $v=[v_x, v_y]^T$ and $\omega$ respectively.

The overall dimensions of the physical robot are: 283mm ( Diameter formed from the square) X 110 mm (Height). The CAD drawing can be found I Figure 2.
Each wheel can move the robot forward, but since they are located on the periphery of the robot, they can also rotate the robot’s frame. In order to derive the relationship between the motors’ torques and the movement of the robot, we need to analyze the geometry of the problem. Let us use a robot with \( n \geq 3 \) wheels, as shown in the diagram (Fig. 2). All the angles of the motor axis are measured relative to the \( x \) direction in the coordinate system of the robot. Call the angles of the motor axis for the \( n \) wheels \( \theta_1, \theta_2, \ldots, \theta_n \). The driving direction of the \( i \)-th wheel is therefore \( \theta_i + \pi/2 \). When the \( n \) motors are activated, we obtain \( n \) traction forces \( F_1, F_2, \ldots, F_n \) from the motors, which add up to a translational force and a rotational torque. Each traction force \( F_i \) is the torque of the motor multiplied by the radius of the wheel. The sum of the forces depends on the exact wheel arrangement.

Omni-directional wheels are unique as they are able to roll freely in two directions. It can either 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 that uses normal wheels has only 2 out of 3 controllable degrees-of-freedom which are, moving forward/backwards and rotation. Not being able to move sideways makes a robot slower and less efficient in reaching its given goal. The holonomic Omni-directional wheels are able to overcome this problem, as it is a highly maneuverable. Unlike normal non-holonomic robot, the holonomic Omni-directional robot can move in an arbitrary direction continuously without changing the direction of the wheels. It can move back and forth, slides sideways, and rotates at the same position. This ability allows the robot being built to be able to search the ball and maneuver to it faster and more efficiently than the opponents.

Omni-wheels are usually mounted on an equilateral triangular base with each wheel taking a side. Using vector summation and by individual control of the speed of each motor, the robot is able to turn in any direction quicker than robots on normal wheels. The diagram depicts the different ways the robot can move using Omni-directional wheels. However, this equilateral triangular base design was not suitable for the soccer-bot as it was inadequate for maintaining stability in a fast paced environment and it lacked the capability to mount all the different actuators, effectors and sensors needed on the player in order for it to function properly.

**Materials And Methods:**

As this was a complete Mechatronic project incorporating mechanical, electronic and software development, the different areas were developed synergistically thus allowing interactions between the disciplines to be viewed and managed. It also meant that all three core disciplines needed to be developed to a certain stage before any one area could be further worked on. Although it was physically possible to use other means to develop the core areas independently, a synergistic approach tends to be more efficient. Even though this parallel design approach was used, the areas of development shall be discussed in sections assuming that other sections have already been completed to a certain level and are referenced where necessary.

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**Specifications:**

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<th>S.No</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Effective Diameter:</td>
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<tr>
<td>2</td>
<td>Wheel Width:</td>
<td>25mm without hub</td>
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<tr>
<td>3</td>
<td>Shaft Hole Diameter:</td>
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<tr>
<td>4</td>
<td>Number of Rollers:</td>
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<tr>
<td>5</td>
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<tr>
<td>6</td>
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**Developments and Implementation:** The development for this project can be divided into the major process, the mechanical design for Meccanum wheel and mobile robot chassis, electronics design for 4 channel motor driver and interfacing with BasicStamp microcontroller board and software development for motion control.

**Electronic Design:**

Four channel bi-directional motor driver been design to drive all four Omni directional wheels. The specifications developed for the necessary driver.
Microcontroller: In order to give the existing robot any intelligent functionality some form of on-board processor was essential. Microcontrollers are ideally suited for such an application as they are compact, have many built-in hardware features such as timers and UARTS, have a significant number of digital I/O lines and have low power requirements. The essential microcontroller specification for this project was its ability to generate four independent PWM signals. Other general requirements were; high speed operation to ensure environmental data could be processed at real-time. BASIC Stamp micro-controllers have been chosen this project for well-known for their ease of use, comfortable programming language and easy debugging using a PC.

Experiment setup:
With the use of the prototype motor driver board and test software to programming the microcontroller output as list in Table 1, the basic mobility control was gained via programming the basic motion software to the microcontroller. This setup allowed the following motions as well as the increase and decrease of speed.

- Forward – Right side wheel and Left side wheel rotate forward, front and back rollers rotate forward
- Backward – Right side wheel and Left side wheel rotate backward, front and back rollers rotate backward,
- Right slide – Front and Back wheel rotate Clockwise, RSW and LSW rollers rotate.
- Left slide – Front and Back wheel rotate Counter-Clockwise, RSW and LSW rollers rotate.
- Clockwise - All wheels will rotate in same speed in Clockwise
- Counter-Clockwise – All wheels will rotate in same speed in Counter-Clockwise

The following list in Table 1, show the basic motion of omni directional wheel mobile robot with their corresponding wheel direction. By varying the individual motor/wheel speed we can achieve driving direction along any vector in X-Y axis. The actuation required for these movements can be seen in Figures.
Triangular structured Omni Directional Mobile Robot Movement:

- Forward – Right side wheel and Left side wheel rotate forward, back rollers rotate forward, Right side wheel and Left side wheel rollers will rotate according to the direction.
- Backward – Right side wheel and Left side wheel rotate backward, back rollers rotate backward, Right side wheel and Left side wheel rollers will rotate according to the direction.
- Right slide – Back wheel rotate Clockwise, RSW and LSW rotate, Right side wheel and Left side wheel rollers will rotate according to the direction.
- Left slide – Back wheel rotate counter-Clockwise, RSW and LSW rotate. Right side wheel and Left side wheel rollers will rotate according to the direction.
- Clockwise – All wheels will rotate in same speed in Clockwise
- Counter-Clockwise – All wheels will rotate in same speed in Counter-Clockwise
Future work:

Octagonal Structured Omni Directional Mobile Robot Movement:

In square structured Omni directional wheel is having advantages and disadvantages. In this square structured robot the control and movement is very easy, but accuracy may miss. The number of usage of motors should be minimum 4. In Triangular structured robot control will be little bit difficult, very fast in movement and accuracy will be high. Usage of motor is 3. In this research the combination of square and triangular structured has been proposed. The shape is octagonal structure. The movement will be easy as well as the accuracy of the robot.

CONCLUSION:
This paper presents an overview over the primary design stage of Omni-directional mobile robot using 3,4,8 wheels. In the usage of 3 wheels the accuracy is good but the control of the motor and wheel movement is very tough. In the square structured 4 wheel, the accuracy of movement is not good, but the control of the wheel is very easy. The combination of square and triangular structured robot has been tried in the Octagonal shaped 8 wheel Omni directional robot. In this accuracy, control of the motor and wheel movement will be good, compared with both square and triangular structure. This research has to address lots of issues like sensor integration, real-world modeling, actuator and sensor control, path planning and navigation, task-level planning and execution and the control of the robotic system as a whole. This research provides new concepts and approaches in both mechanical design for different Omni directional structured wheel and overall mobile robot chassis and also the design for electronic hardware and software. By using Octagonal structured Omni directional robot the movement, control and accuracy will be good and load carrying capacity can be increased.

REFERENCES: