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EXPERIMENTAL INVESTIGATION AND PATH DEVIATION ANALYSIS OF SQUARE STRUCTURED OMNI DIRECTIONAL MOBILE ROBOT

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ABSTRACT

This paper describes a four wheeled, Square Structured Omni Directional Mobile Robot (SSODMR).The design, different motion analysis and prototype of SSODMR is fabricated. In this research, the Omni Directional wheel consists of eight rollers in a single row, which has been arranged over the circumference of the wheel. This SSODMR can move in all eight directions without steering its wheel. In addition, it can also make clockwise and anti-clockwise rotations. It consists of four Omni Directional Wheels, fixed with 12 V, 30 rpm D.C motors. A Square structured chassis holds the motors and they are manually controlled by DPDT switches. The motion analysis has been practically done on a cement floor. The deviation from the desired path has been measured and hence the mobility of SSODMR has been practically analysed.

Keywords: Omni directional wheel, mobile robot, path deviation analysis, square structure, experimental investigation.

INTRODUCTION

The design, kinematic model, real-time speed control and dynamic analysis have been examined for Four wheel Omni-directional mobile Robot and variable wheel arrangement mechanism (VWAM) has been analysed [1, 2]. The square and triangular structured robot combinations design has been attempted and the movements have been analysed [3]. The Omni-Directional robot position and orientation have been captured by an overhead camera and its position accuracy has been examined [4, 8]. An Omni-directional mobile robot with steerable wheels has been proposed. Design, motion, steering have been experimentally analysed [5]. An Omni-directional mobile robot with Meccanum wheel's Forward, backward, right side, left side, clockwise and counter clockwise movement had been analysed [6]. Mechatronics design and mobility analysis for a wheeled mobile robot with three-wheeled Omni Directional mobile robot had been examined and rectilinear translation and rotation of the wheeled mobile robot had been traced by using a pen [9]. Mathematical model, dynamic motion control has been derived and also the straight line, the circular and elliptical trajectory has been plotted [10]. The movement of the normal wheeled mobile robot and Omni Directional wheeled mobile robot have been compared. In turning how the wheels and robot have to move and to reach a particular position, how these robots have to be moved have been discussed [11]. Designs, Experimental results of sine curve movement and right angle movement have been plotted for Omni Directional vehicles with two wheels caster type odometer [12]. The "Y" structured Omni Directional mobile robot design and motion analysis had been done and deflections from the desired path have been examined [13].The torque, motor control and wheel control and the effect of slippage have been discussed. Graphs had been plotted in X axis and Y axis movements. Planned path motion in Cartesian coordinates has been examined, X displacement and Y displacement for open loop and closed loop path following performance have been analysed [7, 14]. The number of wheels will give a major impact in the design. The two wheel drive is having simple control. But the manoeuvrability will be less. The three wheels drive has simple control and steering but limited traction. The four wheels drive has more complex mechanics and control, but higher traction [15, 16]. In this research a Four wheeled, Square Structured Omni Directional Mobile Robot (SSODMR) is designed, a prototype is fabricated and different motion analysis have been analysed.

Omni directional wheel

Figure-1. Single row roller- Omni directional wheel.

Figure-1 shows a Single Row Omni-Directional Wheel. In this research four, single row Omni-Directional Wheel has been used. The four wheels are arranged in the square structure. Eight rollers have been placed over the circumference of the wheel such that the wheel axis and the roller axis are perpendicular to each other. The wheel's outer diameter is 100mm and the roller length is 25mm. The width of the wheel is 25mm and the wheel weighing 90 grams has the load carrying capacity of 5 kg.

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Square structured omni directional mobile robot (SSODMR)

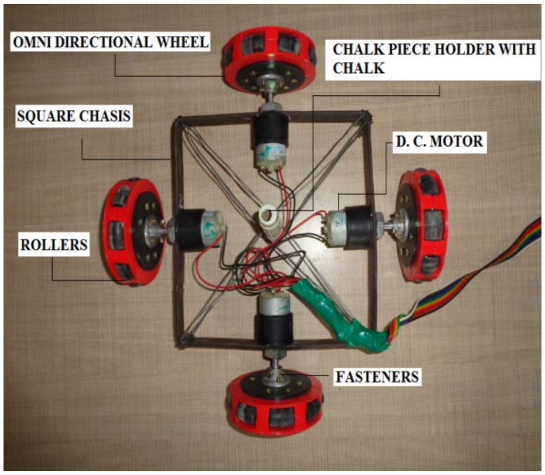

Figure-2. Four wheeled, square structured omni directional mobile robot (SSODMR)-prototype.

Figure-2 shows the Square Structured Omni Directional Mobile Robot (SSODMR). In this SSODMR, four Single row Omni-Directional Wheels have been placed in a square in a square structured chassis. The length of the chassis is 250mm whereas the diagonal length is about 354mm. A 12V, 30rpm DC motor has been fixed on all sides of the square structured chassis. This 12V battery is giving power supply to all the DC motors. The wheels are fixed to the motor's shaft. By using four DPDT (Double Pole Double Throw) switches, all the four motors have been controlled. A chalk holder with chalk has been placed in the middle of the square structured chassis as shown.

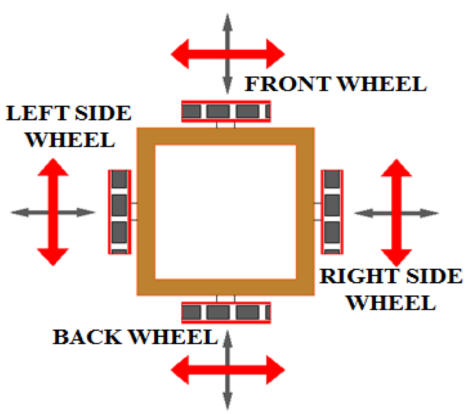

Figure-3. SSODMR Wheel and Rollers rotation-Line diagram.

In the front motion of the SSODMR, right and left wheels rotate and the front and back wheel's rollers involve in the rotation. For backward motion, all those wheels and rollers have to create rotation but in opposite direction with respect to the front motion as shown in Figure-3.

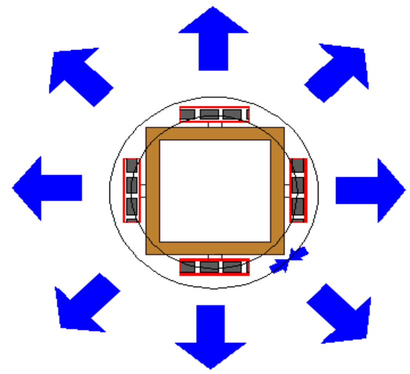

Figure-4. SSODMR's eight different motions, clockwise and counter clockwise rotations.

To create the right side motion, front and back wheels of SSODMR should rotate whereas the right and left side wheel's rollers should make the rotation. The SSODMR can create Front-Right, Front-Left, Back-Right, Back-Left directions as shown in Figure-4. To create these motions all the four wheels and rollers of the Front, Back, Right and Left have to rotate.

EXPERIMENTAL SETUP

The SSODMR has moved up to 3m on a concrete cement floor. The robot has to move in the ideal path, without deviations. An ideal path for this robot has been marked by a white chalk as shown in Figure-5. In the chalk holder, six different colour chalks have been used for six different trials, which trace the actual path of the robot over the cement floor as shown in Figure-6. This traces the deviations from the ideal path (ie) it traces the actual path. The starting point has been marked as "0" and for each 20cm, the robot starts to deviate from that of the ideal path and this has been traced by the help of the chalk fitted with that of the chalk holder, placed over the square chassis diagonally.

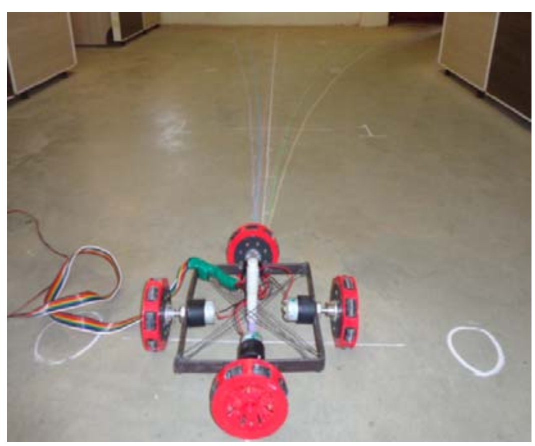

Figure-5. Experimental set up for front motion of SSODMR.

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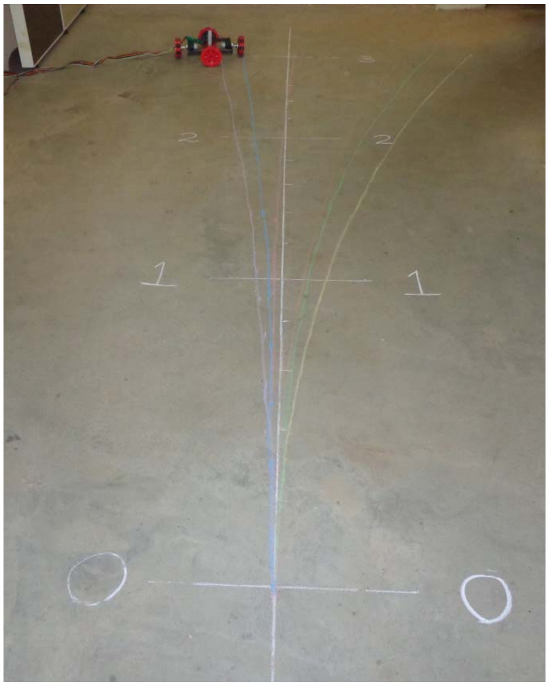

Figure-6. Experimental front motionof SSODMR in Trail 6.

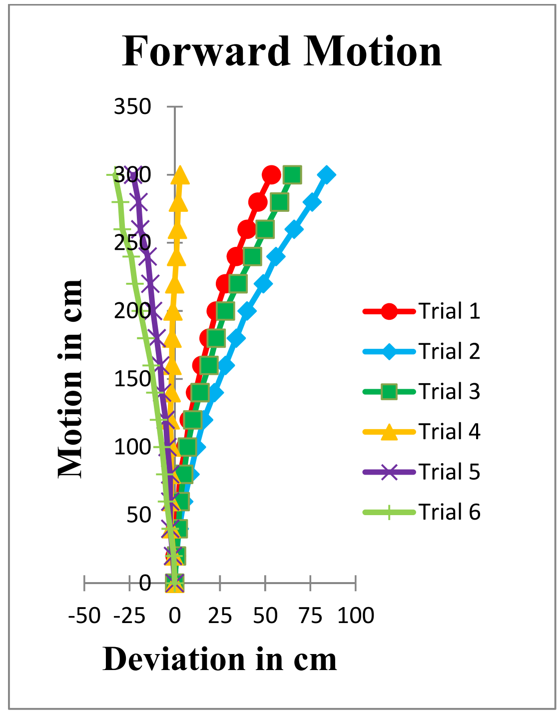

Figure-7. Forward Motion vs Deviation in cm.

RESULTS AND DISCUSSIONS

SSODMR's path deviation analysis for front, back, right and left motions

The Square Structured Omni-Directional Mobile Robot (SSODMR) can move in all eight directions (i.e) front, back, right, left, front-right, front-left, back-right and back-left, in addition to it, it can make clockwise and anti-clockwise rotation. In the front motion, the robot is deviating from ideal path more than 25 cm in most of the cases. It is because of the front and back wheels create unwanted rotations. In front motion, right and left side wheels rotates whereas front and back wheels should not involve in the rotation, but the wheel's rollers rotate. Right and Left side wheel's motors should create equal rotations. In SSODMR, the motors could not be synchronised because SSODMR moves in all eight directions so the motors have to rotate accordingly to different directions. In the front motion, the left side DC motor rotates faster than right side motor. This SSODMR is made to move over the concrete cement surface. The deviations may occur due to uneven cement surfaces. In the backward motion, the deviations are more than 25 cm. In all the six trials SSODMR is deviating up to 30 cm within a travel of 3 m. the backward motion also involves the same wheel and roller motions as that of the front motion but in opposite directions as shown in Figure-3.

Figure-6 shows that the experimental analysis of SSODMR and Figure-7 shows the exact deviations made by the SSODMR from the desired ideal path. The readings are measured for every 20 cm and it is plotted in the graph as shown in Figure-7. Like this, for Backward motion is plotted in Figure-8. Right side motion is plotted in Figure-9 and Left side motion is plotted in Figure-10.

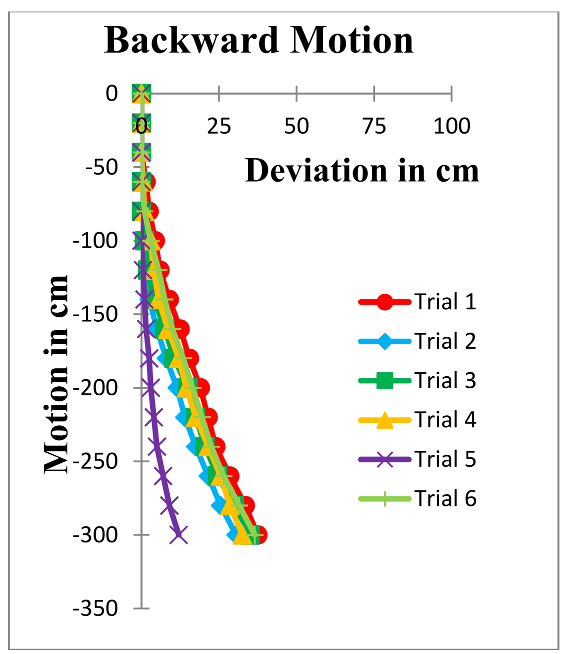

Figure-8. Backward Motion vs Deviation in cm.

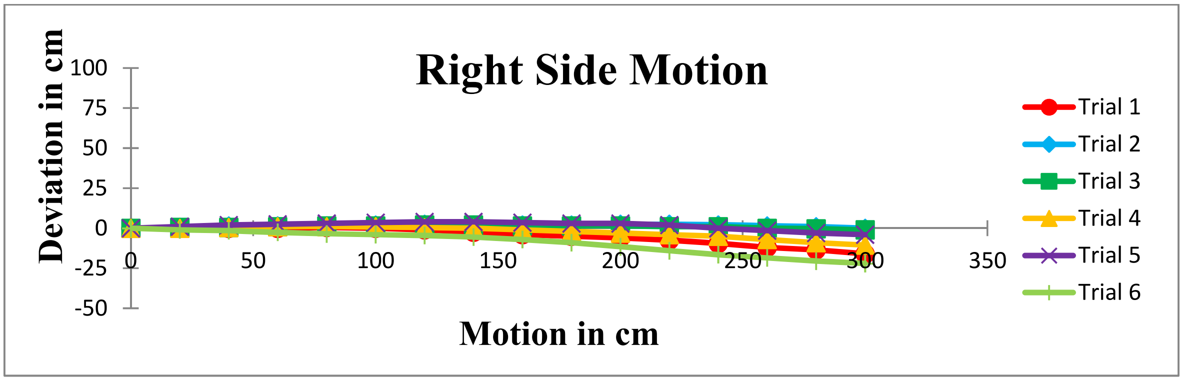

Figure-9. Right side Motion vs Deviation in cm.

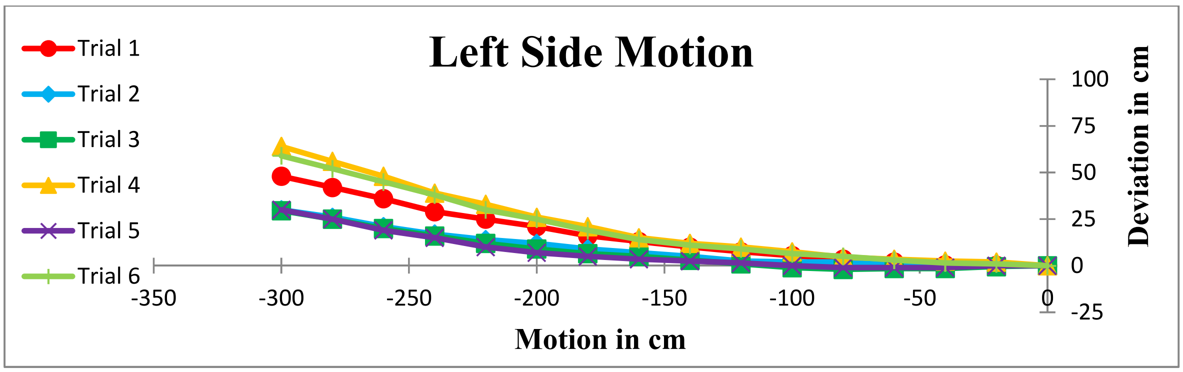

Figure-10. Right side Motion vs Deviation in cm.

SSODMR's Path Deviation Analysis for Front-Left, Front- Right, Back-Left and Back- Right cross motions

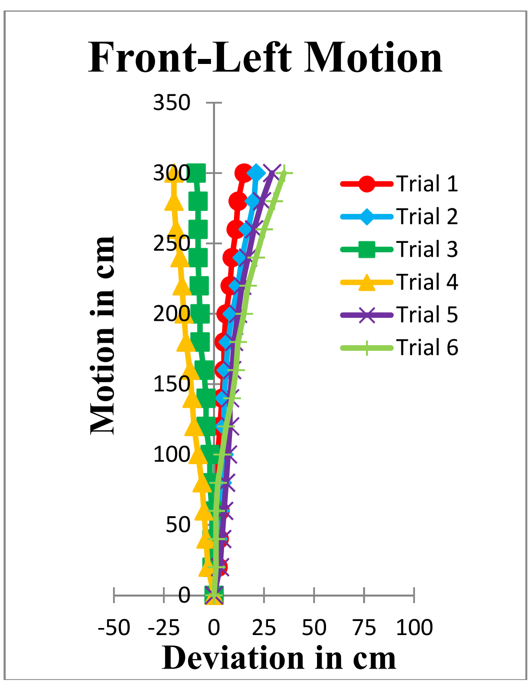

Figure-11. Front-Left Motionvs Deviation in cm.

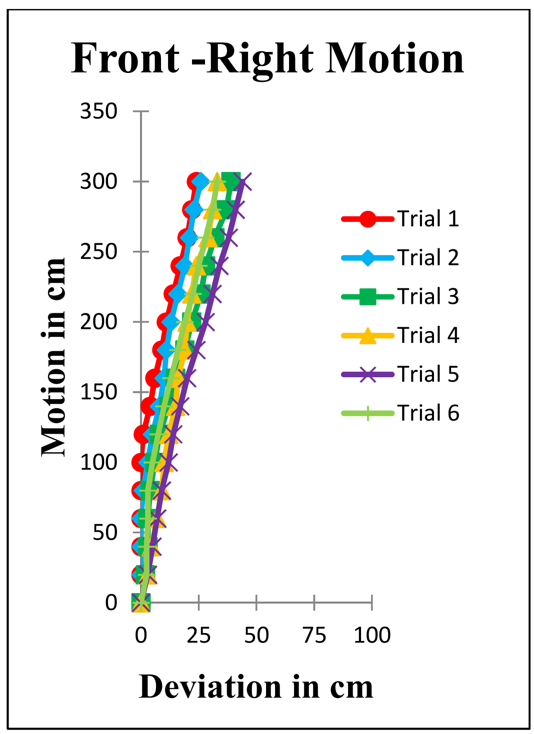

Figure-12. Front-Right Motionvs Deviation in cm.

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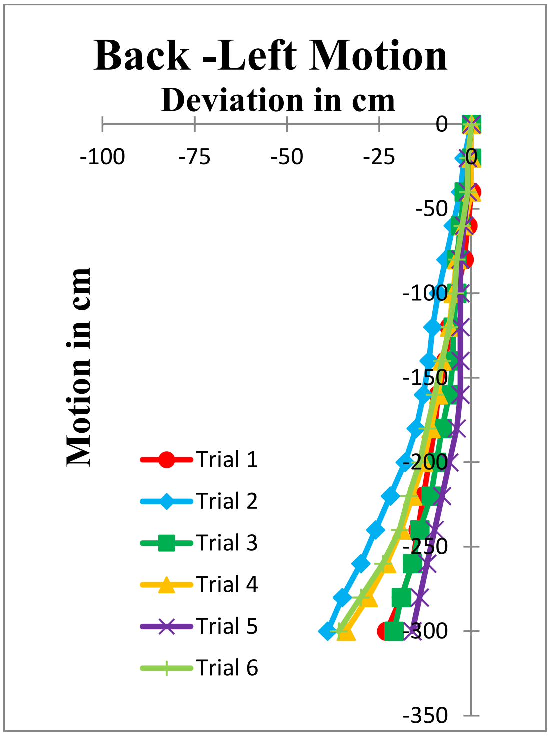

Figure-13. Back-Left Motion vs Deviation in cm.

The SSODMR can create exact cross motions like Front Right, Front Left, Back Right and Back Left directions.

In Front Right motion, the SSODMR's front, back, right, left wheels and rollers have to rotate. The wheels and rollers rotations have been shown in Figure-3 and Figure-4. As per the Front Right motion graph, shown in Figure-12, the SSODMR is deviating towards the right side from the ideal path, for more than 25 cm. All the four Omni-Directional wheels have to create exact resultant force, but due to the motor speed variation, contact between the rollers and cement surface are being the reasons for the deviations.

In Front Left motion, shown in Figure-11, all the four Omni-Directional wheels have to create the resultant force. In this motion25 cm in the positive and negative directions. This is due to; in the initial stage itself, the SSODMR may have created some deflection. The surface contact between the rollers and the cement surface may be the reasons for deviations,

In Back Left motion also, as shown in Figure-13, all the wheels and rollers have to create the resultant force. In this motion, SSODMR's deviation is 10cms from the ideal path up to 1m and 20cms up to 2m, and more than 25cms when it reaches 3m.

In Back Right motion, as shown in figure 14, in Trial 2 and Trail 3 have no deviations; the SSODMR tries to follow the ideal path. In some trials, it tries to deviate up to 20cms.

In Front, Back, Right, Left motions two wheels are creating the motion and two wheels are in ideal position. One wheel is placed in front and other wheel is placed in the backside. These Front and Back wheels rotations are the major reasons for deviations.

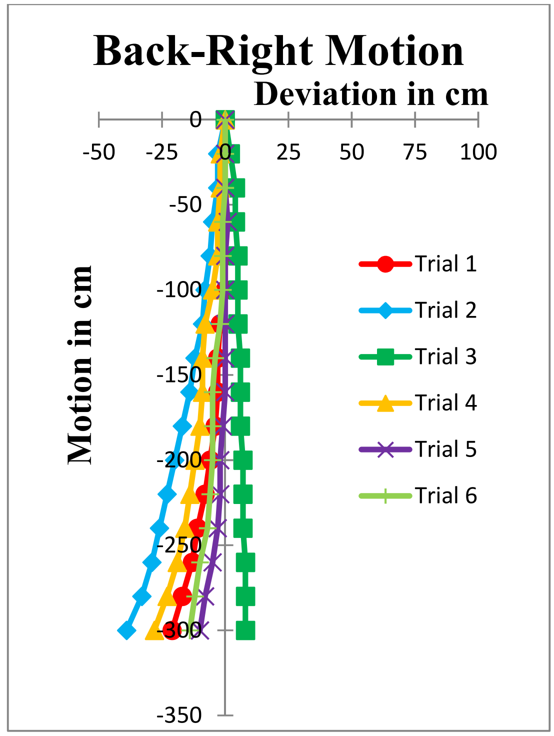

Figure-14. Back-Right Motion vs Deviation in cm.

In Front Right, Front Left, Back Right and Back Left motions, the deviations are somewhat low, because, in these wheels, four wheels have to be actively involved in rotation. And in Front side and Back side, there are no wheels to create the deviation. The four wheels are activated, and so the manoeuvrability is high. From experimental results, the graphs show that linear motions such Front, Back, Right and Left are creating more deviation and cross motions like Front Right, Front Left, Back Right and Back Left are creating less deviation.

Here in this, Experimental Investigation and Path Deviation Analysis of Square Structured Omni Directional Mobile Robot (SSODMR), single row Omni-Directional wheel with only eight rollers on its circumference of the wheel equally spaced, have been used. This also has to be taken into account on the analysis of deviation due to roller contact. Also the shape of the rollers has to be considered.

Here the rollers are not in perfect cylindrical shape but with a slightly concaved outer surface profile. Hence, while during the linear motions of the SSODMR two wheels and two wheel's rollers has to rotate. Due to the curved shape profile of the roller the contact point on the surface of the roller may not be at the exact contact point of roller and may be sometimes at the edge of the roller causing non-uniformity in the rotation of the rollers and thus causing deviation in the motion.

Since there is no synchronization between the motors, the irrelevant rotation of the wheels with one

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another may lead to a position where the rollers edges alone are in contact to the surface leading to increased friction drag of the wheels to the surface leading to torsion effect on the wheels causing deviation from the ideal path. Thus from the experimental results; surface, motor and roller contact play a predominant role.

CONCLUSION

The Square structured Omni Directional Mobile Robot (SSODMR) can move in all eight directions and can make clockwise and anti-clockwise rotations. But in front, back, right and left side motions the SSODMR deviates from the desired path. Because in these motions any one wheel is arranged in front, back side of the robot motion. These front and back wheels should be in ideal condition and its rollers only has to rotate, but the wheels are slightly rotating. In a long run, more than 1m, the deviation is very high. In these motions any two wheels and any two wheel's rollers has to rotate. The motor speed also causes the deviation. The experimental results and the graphs illustrates that, when the SSODMR is moving in a long distance, the single row roller Omni Directional wheels create more deviations.

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