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Kinematic Analysis of Omnidirectional Mecanum Wheeled Robot

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ABSTRACT

This study used the V-rep simulation environment to develop an omnidirectional, four-wheeled Robot model and perform kinematic analysis using Omnirob. Given their extensive use, it is essential to understand how Mecanum wheels' speeds convert into robot velocities before moving on to a dynamic model that governs how wheel torques translate into robot accelerations. This paper investigates the rate at which the wheels must be driven given the desired chassis velocity, also studied the limit on the chassis velocity, given a limit on the individual wheel operating speed.

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LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
AMR	Autonomous mobile robots
AGV	Automated Guided Vehicle
VPC	Visual predictive control
WMRs	Wheeled mobile robots
DOF	Degree of Freedom
PID	Proportional Integral Derivative

1. INTRODUCTION

To date, many methods have been proposed in the framework of autonomous robot navigation to construct maps. Each has advantages and drawbacks, from precise geometric maps based on raw data or lines to purely topological maps using symbolic descriptions. From reading, cognitive scientists and roboticists have different opinions on mapping issues. Autonomous mobile robots (AMR) are currently introduced in many intralogistics operations, like manufacturing, warehousing, cross-docks, terminals, and hospitals. Their advanced hardware and control software allow autonomous operations in dynamic environments. Compared to an automated guided vehicle (AGV) system in which a central unit takes control of scheduling, routing, and dispatching decisions for all AGVs, AMRs can communicate and negotiate independently with other resources like machines and systems and thus decentralize the decision-making process. Decentralized decision-making allows the system to react dynamically to changes in the system state and environment. These developments have influenced the traditional methods and decision-making processes for planning and control. To control the inputs, usually for small displacements of the camera between the initial and desired poses, which limits the impact of the prediction errors and the need for a large prediction horizon, (Durand-Petiteville & Cadenat 2020) investigated the design of visual predictive control (VPC) for a differential drive of mobile robot navigation in a cluttered environment. Wheeled mobile robots (WMRs) are frequently uncrewed vehicles with varying degrees of autonomy and teleoperation. They may be assigned to carry out laborious or hazardous jobs, improving worker health and safety or freeing up personnel for more imaginative work. Wheeled mobile robots have developed into critical tools in our daily lives. They have a wide range of purposes, including assisting the disabled in hospitals and museums, moving cargo in warehouses, controlling army explosives, and guarding vital locations (El-Shenawy et al., 2007). Choosing the most appropriate kinematic structure for a robot for a particular application is one of the essential issues. This issue is related to the choice of the right wheels, how they are arranged together, the utilized number of drives, etc. Mechanical properties and complexity, which are directly related to cost, are typically traded off when choosing the best solution. The kinematic model is a mathematical description of the Robot: its functional dimensions and degree of freedom (DOF). It describes the Robot's workspace, its positional capabilities, and constraints. It is used in the WMRs (Wheeled Mobile Robot) to obtain stable motion control laws for trajectory following or goal-reaching.

The Mecanum wheel has passive rollers positioned around its circumference at a 45-degree angle to the wheel plane, allowing in-place rotation with no ground resistance and little driving torque. The URANUS omnidirectional robot, an intelligent wheelchair, a forklift, and other mobile robots that use Mecanum wheels typically have four wheels to allow for agile movement in any direction without changing orientation. In crowded areas, this omnidirectional capability offers additional flexibility. Although a typical Mecanum wheel has the advantage of being omnidirectional, this negative side effect of projecting a portion of the motor force into a force perpendicular or at an angle to that produced by the motor reduces the motor's effective driving force through the rollers. As a result, moving the platform in a straight line, particularly when moving diagonally, may not be efficient. A planar mobile robot with four Mecanum wheels has one redundant degree of freedom since it only has three degrees of freedom (DOF): two translational motions along the X and Y axes and one rotation about the Z axis (Han et al., 2009).

A mobile robot's kinematic model controls how wheel speeds translate into robot velocities, and its dynamic model controls how wheel torques map into robot accelerations. We overlook dynamics in this paper and concentrate on kinematics. We further assume that the robots move without slipping on horizontal, hard surfaces (i.e., tanks and skid-steered vehicles are excluded). Therefore, this paper presents the kinematic analysis and modeling of an Omnidirectional mobile Mecanum wheeled Robot with four-wheel and answers a kinematic question i.e.

- Given the desired chassis velocity, the wheels must be driven at what speed?
- What is the limit on the chassis velocity, given a limit on the individual wheel driving speed?

2. RESEARCH METHOD

Wheeled mobile Robots are the most frequently utilized Robot among the numerous highly developed, mature robots. The body, the wheels, and the wheel-supporting and wheel-drive mechanisms make up most of the standard WMRs chassis. The chassis can be separated into two-wheel, three-wheel, and four-wheel configurations depending on the number of wheels. Commonly, these structures are employed. However, one of the most famous structures is the four-wheel chassis. The chassis with such a structural design is used as the mobile platform of mobile robots in the medical field, agriculture, and other areas.

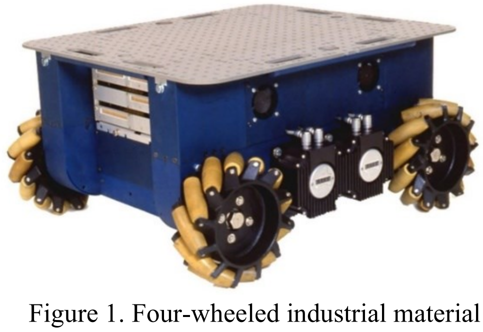


Figure 1. Four-wheeled industrial material moving robot

Figure 2. Four-wheeled space robot

2.1. The Platform Configuration

A Mecanum-wheeled robot is a well-known and typical omnidirectional mobile Robot that can travel in all directions on the work plane, augmented with rollers on its outer circumference. These rollers enable sliding sideways as the wheel drives forward or backward without slipping. Instead, they spin freely about axes tangential to the wheel's outer rim and in its plane.

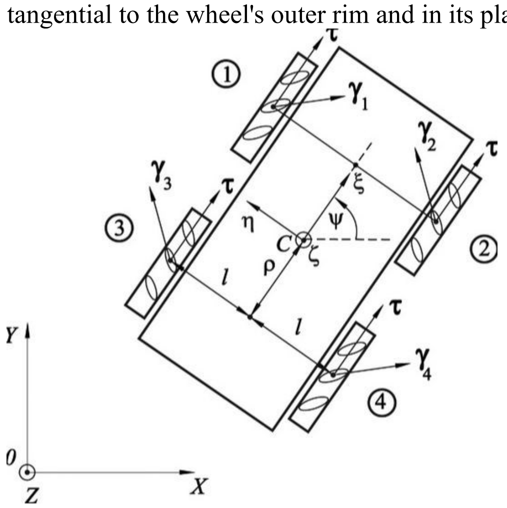


Figure 3. Mecanum four-wheel platform configuration

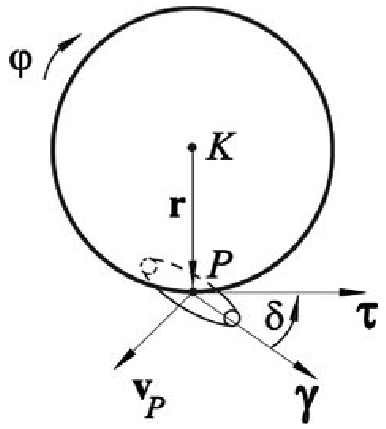


Figure 4. Mecanum wheel model

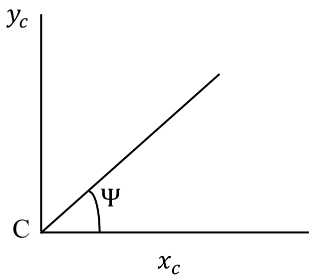


Figure 5. Coordinate of the wheel centre

As shown in figure 3, the mobile robot moves so that all the wheels have permanent contact with the plane. The body of the robot has a mass m_o, its center of mass lies on the longitudinal axis of the symmetry of the body. The distance from the center of mass C of the robot to each of its wheel axles is ρ, and the distance between the center of the wheel is 2l. The coordinate of the center of mass in a fixed coordinate system XOY is x_c and y_c, the angle formed by the longitudinal symmetry of the body with axis OX is Ψ, and each wheel has a mass m_1 as shown if figure 5. The angles of rotation of the wheels relative to the axes that are perpendicular to the planes of the respective wheels and pass through their centers are φ_i , and the torques applied to the wheel are M_i(i=1,…4) (Zeidis & Zimmermann, 2019).

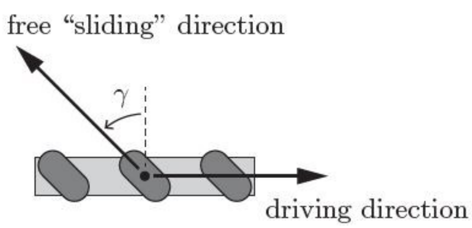


Figure 6. Driving direction and the direction in which the rollers allow the wheel to slide freely.

One of the Mecanum wheels was also shown in the aforementioned figure in both the direction in which the wheel slides naturally due to the rollers and how the wheel rolls steadily when powered by the wheel motor.

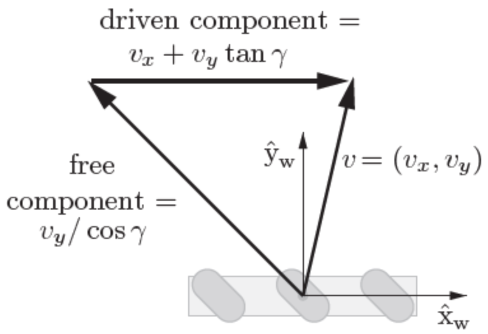


Figure 7. Driving Direction of the wheel.

Figure 6 shows the driving direction and the direction in which the rollers allow the wheel to slide freely, of which $\gamma = \pm 45^0$.
The wheel frame $\hat{x}_w - \hat{y}_w$ given at the driving and free sliding speeds for wheel velocity $v = v_x - v_y$.
From figure 7, the velocity of the robot can be expressed as;

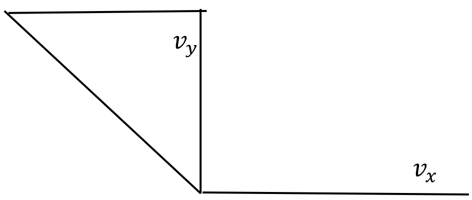
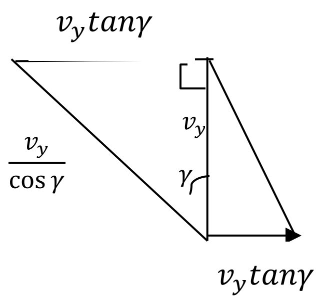


Figure 8. Velocity of robot

By decomposing v_y, figure 8 becomes;



The wheeled robot chassis is assumed to be the rigid body with a configuration $C_{sb} \in SE(2)$ which represent chassis fixed frame {b} relative to a fixed space frame {s} in the horizontal plane as shown in figure 9. C_{sb} is represented by three coordinates $r = (\emptyset, x, y)$, and the velocity of the chassis as the time derivative of the coordinate, $\dot{r} = (\dot{\emptyset}, \dot{x}, \dot{y})$. The planar twist of the mobile robot is given as; $V_b = (w_{bz}, v_{bx}, v_{by})$ which is expressed in frame b, as;

$$V_b = \begin{bmatrix} w_{bz} \\ v_{bx} \\ v_{by} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & cos\,\emptyset & \sin\emptyset \\ 0 & -\sin\emptyset & \cos\emptyset \end{bmatrix} \begin{bmatrix} \dot{\emptyset} \\ \dot{x} \\ \dot{y} \end{bmatrix} \quad (1)$$

$$\dot{r} = \begin{bmatrix} \dot{\emptyset} \\ \dot{x} \\ \dot{y} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\emptyset & -\sin\emptyset \\ 0 & \sin\emptyset & \cos\emptyset \end{bmatrix} \begin{bmatrix} w_{bz} \\ v_{bx} \\ v_{by} \end{bmatrix} \quad (2)$$

Omnidirectional mobile robots have no equal-speed limitations $\dot{r} = (\dot{\emptyset}, \dot{x}, \dot{y})$ on the chassis. From figure 7;

$$\emptyset = angle\ at\ which\ the\ rigid\ body\ at\ frame\ \{b\}\ can\ move\ wrt\ space\ frame\{s\}$$

$$(\dot{x_\iota}, \dot{y_\iota}) = velocity\ of\ robot\ at\ frame\ \{s\}$$

$$\beta_i = direction\ of\ motion\ for\ each\ wheel$$

$$\gamma = angle\ at\ which\ free\ sliding\ occur, which\ is\ 45^0$$

$$v = v_x, v_y = velocity\ of\ robot\ written\ in\ frame\ W$$

$$v_{drive} = driving\ speed$$

$$v_{slide} = sliding\ speed$$

$$v_{drive} = v_x + v_y \tan\gamma \quad (3)$$

$$v_{slide} = \frac{v_y}{\cos\gamma} \quad (4)$$

Assuming:

R=radius of the wheel

U=angular speed of the wheel

$$U = \frac{v_{drive}}{R} \quad (5)$$

From equ.3, equ.5 becomes;

$$U = \frac{1}{R}\left[v_x + v_y \tan\gamma\right] \quad (6)$$

Equ.6 can be transformed too;

$$U = \begin{bmatrix} \frac{1}{R} & \frac{(\tan\gamma)}{R} \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \quad (7)$$

To obtain the full transformation from chassis velocity, $\dot{r} = (\dot{\emptyset}, \dot{x}, \dot{y})$ to the driving angular speed U_i as shown in figure 9 i.e., the chassis frame {b} at $(\emptyset, x, y)\ in\ \{s\}$, and wheel i in (x_i, y_i) with driving direction β_i which is expressed in frame {b}. The direction in which wheel i slides is expressed as γ_i.

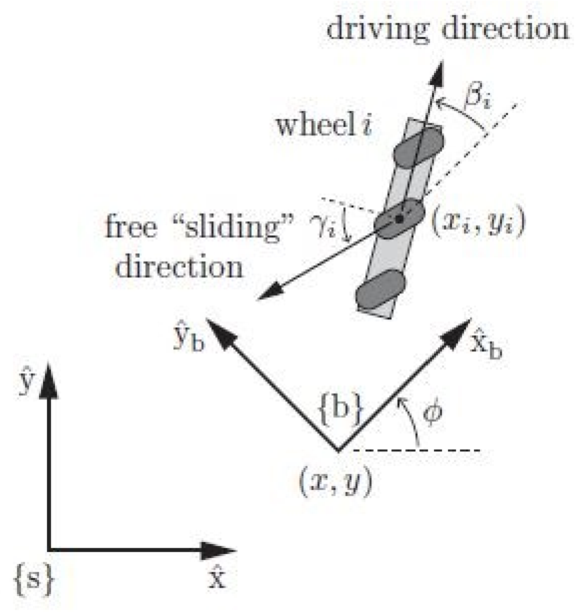


Figure 9. The fixed space {s} and chassis frame {b}

The chassis frame {b} is at $r = (\emptyset, x, y)$, in the fixed frame {s}. The center of the wheel and its driving direction are described as (β_i, x_i, y_i) as expressed in frame {b}. Hence, the angular speed U_i is related to $\dot{r}$ (Pose velocity $\begin{bmatrix}\dot{\emptyset}\\ \dot{x}\\ \dot{y}\end{bmatrix}$ $in\ frame\ \{s\}$) by;

$$U_i = h_i(\emptyset)\dot{r} \tag{8}$$

Transforming from frame {s} to the new frame {b} at z-axis, we have;

$$U_i = \begin{bmatrix}1 & 0 & 0\\ 0 & \cos\emptyset & \sin\emptyset\\ 0 & -\sin\emptyset & \cos\emptyset\end{bmatrix}\begin{bmatrix}\dot{\emptyset}\\ \dot{x}\\ \dot{y}\end{bmatrix} \tag{9}$$

Transforming from old frame {b} to the wheel frame, since the two frames are not at the same center, frame {s} is translated by $\begin{bmatrix}-y_i & 1 & 0\\ x_i & 0 & 1\end{bmatrix}$, followed by rotating it;

$$U_i = \begin{bmatrix}\cos\beta_i & \sin\beta_i\\ -\sin\beta_i & \cos\beta_i\end{bmatrix}\begin{bmatrix}-y_i & 1 & 0\\ x_i & 0 & 1\end{bmatrix}\begin{bmatrix}1 & 0 & 0\\ 0 & \cos\emptyset & \sin\emptyset\\ 0 & -\sin\emptyset & \cos\emptyset\end{bmatrix}\begin{bmatrix}\dot{\emptyset}\\ \dot{x}\\ \dot{y}\end{bmatrix} \tag{10}$$

Rotation of the wheel velocity U is then given as;

$$h(\emptyset) = \frac{1}{r_i}\frac{\tan\gamma}{r_i}\begin{bmatrix}\cos\beta_i & \sin\beta_i\\ -\sin\beta_i & \cos\beta_i\end{bmatrix}\begin{bmatrix}-y_i & 1 & 0\\ x_i & 0 & 1\end{bmatrix}\begin{bmatrix}1 & 0 & 0\\ 0 & \cos\emptyset & \sin\emptyset\\ 0 & -\sin\emptyset & \cos\emptyset\end{bmatrix}\begin{bmatrix}\dot{\emptyset}\\ \dot{x}\\ \dot{y}\end{bmatrix} \tag{11}$$

By evaluating equation (11),

$$h(\emptyset) = \frac{1}{r_i\cos\gamma_i}\begin{bmatrix}x_i\sin(\beta_i+\gamma_i) - y_i\cos(\beta_i+\gamma_i)\\ \cos(\beta_i+\gamma_i+\emptyset)\\ \sin(\beta_i+\gamma_i+\emptyset)\end{bmatrix}^T \tag{12}$$

Since the research focus is on the omnidirectional robot for four Mecanum wheels, i.e. $m \geq 3$, the matrix $H(\emptyset) \in R^{3\times m}$, mapping the chassis velocity $\dot{r} \in R^m$ to the vector of the wheel driving speed $U \in R^m$ is developed by;

$$U = h(\emptyset)\dot{r} = \begin{bmatrix}h_1(\emptyset)\\ \cdot\\ \cdot\\ h_m(\emptyset)\end{bmatrix}\begin{bmatrix}\dot{\emptyset}\\ \dot{x}\\ \dot{y}\end{bmatrix} \tag{13}$$

The velocity $\dot{r}$ in the space {s} is known, and the goal is to obtain speed U a which each wheel should be rotated to achieve a certain speed. This makes equ.13 Inverse Velocity equation.

As the relationship between the driving speed U, and body twist V_b is not dependent on chassis orientation $\emptyset$. Hence it is describing the wheel speed in the body frame {b} can be expressed as;

$$U = H(0)V_b = \begin{bmatrix}h_1(0)\\ \cdot\\ \cdot\\ h_m(0)\end{bmatrix}\begin{bmatrix}w_{bz}\\ v_{bx}\\ v_{by}\end{bmatrix} \tag{14}$$

Hence, equ.13 is considered a constant matrix.

2.2. Kinematic Model of Mecanum wheeled Robot.

An omnidirectional wheel robot has three degrees of freedom (DOF), one is in the direction of the wheel orientation, the second DOF is provided by the motion of the roller mounted on the periphery of the main wheel, while the third one is the rotational slip around the point-of-contact. To make the modeling tractable, the following assumptions would be harnessed(Muir & Neuman, 1987);

- all steering axes are perpendicular to the surface to apply rigid body mechanics.
- the wheel mobile robot does not contain any flexible part.
- there is zero or one steering link per wheel.
- The WMR move on a planar surface.
- The translational friction at the point of contact between the wheel and the surface is large enough so that no translational slip may occur.
- The rotational friction at the point of contact between the wheel and the surface is small enough so that no rotational slip may occur.
- Since the speed of the wheel cannot be choosen arbitrarily, the speed of the wheel is chosen as $U = 50/s$ so as to obtain the motion of the robot.

Since equ.11 represent the relation for one of the wheels, combining this equation for four Mecanum wheel robot, m=4; inverting the inverse velocity equation forward velocity equation.

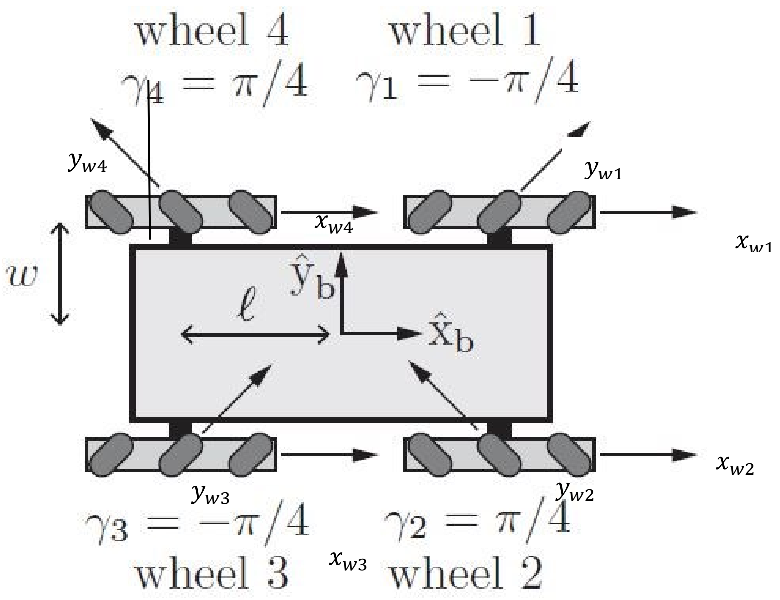


Figure 10. Kinematic Model for four Mecanum wheels mobile Robot

To achieve the unique value for U, the Matrix H (0) has to be full rank which means $(\beta_i, \gamma_i, x_i, y_i)$ must be chosen.

Table 1. Parameters of Mecanum Robot wheels

i	wheel	x_i	y_i	β_i	γ_i	l
0	1	l	ω	0	$\frac{-\pi}{4}$	l
1	2	l	$-\omega$	0	$\frac{\pi}{4}$	l
2	3	$-l$	$-\omega$	0	$\frac{-\pi}{4}$	l

3	4	$-l$	ω	0	$\frac{\pi}{4}$	l

Since there is no angle between x_b in the b frame and the x_i for all the four wheels in the wheel frame as shown in figure 9, $\beta = 0$. Regarding the wheel velocity in equ.11, the velocity of each wheel can be analyzed as followed;

Inserting the parameters of the first wheel as shown in table 1;

$$U_1 = \frac{1}{r_i \cos\frac{-\pi}{4}} \begin{bmatrix} l\sin\left(\frac{-\pi}{4}\right) - \omega\cos\left(\frac{-\pi}{4}\right) \\ \cos\left(\frac{-\pi}{4}\right) \\ \sin\left(\frac{-\pi}{4}\right) \end{bmatrix}^T \tag{15}$$

$$U_1 = \frac{1}{r_i} \begin{bmatrix} l\tan\left(\frac{-\pi}{4}\right) - \omega \\ 1 \\ \tan\frac{-\pi}{4} \end{bmatrix}^T \tag{16}$$

$$U_1 = \frac{1}{r_i} \begin{bmatrix} -l - \omega \\ 1 \\ -1 \end{bmatrix}^T \tag{17}$$

By applying the Transpose in equ.17;

$$U_1 = \frac{1}{r_i} [-l - w \quad 1 \quad -1] \tag{18}$$

Inserting the parameters for the second wheel as shown in table 1;

$$U_2 = \frac{1}{r_i \cos\frac{\pi}{4}} \begin{bmatrix} l\sin\left(\frac{\pi}{4}\right) - (-\omega)\cos\left(\frac{\pi}{4}\right) \\ \cos\left(\frac{\pi}{4}\right) \\ \sin\left(\frac{\pi}{4}\right) \end{bmatrix}^T \tag{19}$$

$$U_2 = \frac{1}{r_i} \begin{bmatrix} l\tan\left(\frac{\pi}{4}\right) + \omega \\ 1 \\ \tan\frac{\pi}{4} \end{bmatrix}^T \tag{20}$$

$$U_2 = \frac{1}{r_i} \begin{bmatrix} l + \omega \\ 1 \\ 1 \end{bmatrix}^T \tag{21}$$

By applying the Transpose in equ.21;

$$U_2 = \frac{1}{r_i} [l + w \quad 1 \quad 1] \tag{22}$$

By following a similar process in obtaining the third- and fourth-wheel velocity, the velocity of each wheel becomes.

$$U_1 = \frac{1}{r} [-l - w \quad 1 \quad -1] \tag{23}$$

$$U_2 = \frac{1}{r} [l + w \quad 1 \quad 1] \tag{24}$$

$$U_3 = \frac{1}{r} [l + w \quad 1 \quad -1] \tag{25}$$

$$U_4 = \frac{1}{r}[-l-w \quad 1 \quad 1] \tag{26}$$

By concatenating Equ.23,24, 25, and 26, the differential drive velocity of the omnidirectional Mecanum wheel becomes;

$$U = \begin{bmatrix} U_1 \\ U_2 \\ U_3 \\ U_4 \end{bmatrix} = H(0)V_b = \frac{1}{r}\begin{bmatrix} -l-w & 1 & -1 \\ l+w & 1 & 1 \\ l+w & 1 & -1 \\ -l-w & 1 & 1 \end{bmatrix}\begin{bmatrix} w_{bz} \\ v_{bx} \\ v_{by} \end{bmatrix} \tag{27}$$

If the values of U are chosen arbitrarily, there will be sliding in the direction of motion which is an error. This simulation is carried out in V-rep, a robot simulator used in the industry, education, and research. The speed of the wheel is chosen to be $q = 10m/s$ to obtain the velocity for the forward-backward motion, left-right motion, and rotational motion.

3. RESULTS AND DISCUSSIONS

From equation 10, each expression represents the kinematics transformation of the wheel, that is;

The first transformation, $\begin{bmatrix} \dot{\emptyset} \\ \dot{x} \\ \dot{y} \end{bmatrix}$ express the chassis velocity $\dot{r}\ as$ planar twist V_b.

$\begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\emptyset & \sin\emptyset \\ 0 & -\sin\emptyset & \cos\emptyset \end{bmatrix}$ express the linear velocity of the wheel at frame {b}

$\begin{bmatrix} -y_i & 1 & 0 \\ x_i & 0 & 1 \end{bmatrix}$ produces the linear velocity at the wheel frame $\hat{x}_w - \hat{y}_w$

The driving angular velocity is given by the transformation, $\frac{1}{r_i}\frac{\tan\gamma}{r_i}\begin{bmatrix} \cos\beta_i & \sin\beta_i \\ -\sin\beta_i & \cos\beta_i \end{bmatrix}$

From equations (12) and (13), the position of the wheel (β_i, x_i, y_i) in frame {b} and their free sliding angle γ must be chosen such that H (0) is ranked 3. This is because, if a mobile robot of the Mecanum wheel is constructed whose driving direction and sliding direction are all aligned, the rank H(0) would be 2, and this implies that there would be no way to generate a translational motion in the sliding direction.
From the Mecanum robot Model as shown in equ.27, for the robot to move in the direction $+X_b$ as shown in figure 9, all wheels must drive forward at the same speed; to move in the direction $+Y_b$, wheels 1 and 3 must drive backward and wheels 2 and 4 drive forward at the same speed. And to rotate in the counter-clockwise direction, wheels 1 and 4 drive backward, and wheels 2 and 3 drive forward at the same speed.
The constraints between the U_i for w_{bz}, v_{bx}, v_{by} in equ.27 shows that;

The wheels $U_1 = U_2 = U_3 = U_4$ to achieve a perfect speed in the forward direction in v_{bx} i.e., $\begin{bmatrix} 0 \\ V \\ 0 \end{bmatrix}$. Also, to obtain an ideal sideway speed in v_{by} which is $\begin{bmatrix} 0 \\ 0 \\ V \end{bmatrix}$ in equ.26, Wheel $U_1 = U_3, U_2 = U_4, U_1 = -U_2$. To achieve a rotation only, $\begin{bmatrix} W \\ 0 \\ 0 \end{bmatrix}$, wheel $U_1 = U_4$, $U_2 = U_3$, $U_1 = -U_2$.

Using the V-rep simulator to visualize the kinematics of the Mecanum wheel robot, Omnirob was used with the speed set at 3 rad/s. The ideal motion was obtained after the weight of each column was considered instead of chosen $U_1, U_2, U_3\ and\ U_4$ arbitrarily.

Simulation result of Omnirob Robot

Figure 11. View of Omnidirectional Youbot

With induction motor on the wheels of Omnirob Robot, the simulation was carried with the following fixed dynamic properties as follows;

Wheels	Length(m)	Diameter(m)	Max. Torque (Nm)	Max. Acceleration (deg/s^2)
Rear left wheel	0.3	0.04	100	360
Rear Right Wheel	0.3	0.04	5	360
Forward Left	0.3	0.04	5	
Forward Right	0.3	0.04	5	360

Table 2: Dynamic Properties of Omnirob wheels Motor.

While the chassis velocity(U) was set at 100m/s in order to achieve the required motion, the slipping and rolling velocity of the wheels was obtained for the four wheels, as described below;

Wheels	Rolling Velocity(m/s)	Slipping Velocity(m/s)
Rear left wheel	17	20
Rear Right Wheel	22	25
Forward Left	41	44
Forward Right	46	49

Table 3: Velocity-based result of Omnirob robot.

It is shown from the result obtained that the wheel velocity is dependent on the on on the motor properties rather than the chassis velocity. Hence, given the limit of individual wheel driving speed, the chassis velocity remains unchanged.

4. CONCLUSION

This paper introduced a mobile platform with four omnidirectional Mecanum wheels. Kinematic equations of motion were carefully derived from arriving at the conclusions, which was verified in a V-rep simulation environment. The results showed that the weight of the chassis must be taken into account to determine both the linear and rotational speed and that the chassis speed cannot be selected randomly. Additionally, the motor speed is not affected by chassis velocity, they are rather altered by its dynamic properties. This demonstrates that the Robot can move in any direction between 0° and 360° by employing Mecanum wheels on the platform.

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REFERENCES

[1] Deepak BBVL, Parhi Dayal R, & Jha Alok Kumar. (2011). Kinematic Model of Wheeled Mobile Robots. Int. J. on Recent Trends in Engineering & Technology, 05(04), 5–10.
[2] Durand-Petiteville, A., & Cadenat, V. (2020). Mobile Robot Navigation in a Cluttered Environment via Visual Predictive Control. September. https://doi.org/10.48011/asba.v2i1.1451
[3] El-Shenawy, A., Wagner, A., & Badreddin, E. (2007). Kinematics and dynamics analysis for a holonomic wheeled mobile robot. ICINCO 2007 - 4th International Conference on Informatics in Control, Automation and Robotics, Proceedings, 2 RA(January), 485–491. https://doi.org/10.5220/0001650404850491
[4] Gao, X., Li, J., Fan, L., Zhou, Q., Yin, K., Wang, J., Song, C., Huang, L., & Wang, Z. (2018). Review of wheeled mobile robots' navigation problems and application prospects in agriculture. IEEE Access, 6(September), 49248–49268. https://doi.org/10.1109/ACCESS.2018.2868848
[5] Han, K. L., Choi, O. K., Kim, J., Kim, H., & Lee, J. S. (2009). Design and control of mobile robot with mecanum wheel. ICCAS-SICE 2009 - ICROS-SICE International Joint Conference 2009, Proceedings, September, 2932–2937.
[6] Muir, P. F., & Neuman, C. P. (1987). Kinematic modeling of wheeled mobile robots. Journal of Robotic Systems, 4(2), 281–340. https://doi.org/10.1002/rob.4620040209
[7] Zeidis, I., & Zimmermann, K. (2019). Dynamics of a four-wheeled mobile robot with Mecanum wheels. In ZAMM Zeitschrift fur Angewandte Mathematik und Mechanik (Vol. 99, Issue 12). https://doi.org/10.1002/zamm.201900173