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Review on Hyper Maneuverable Multi-Functional Robot

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Abstract - *There is a need for a compact yet hyper maneuverable robot capable of carrying out multiple functions in this modern day world. Industrial robots have endless applications, with the increasing constraint in space it is favorable to make use of a jointed arm configuration on top of the mecanum wheeled robot to attain its multifunctional applications. With the current technology, most of the robots are controlled using a remote control, but this is not always efficient and sometimes it's better to imitate the arm using our own hands, which lead us to develop an idea to control the robot arm using our arm movement. In order to control the arm in real time, an accelerometer, gyroscope and hall-effect sensor are placed precisely on a human arm and the data from these sensors will act as the input to control the robot. In this paper we will be doing a detailed analysis on mecanum wheels, controlling based on mecanum wheels, robot arm and controlling robot arm using human arm gestures.*

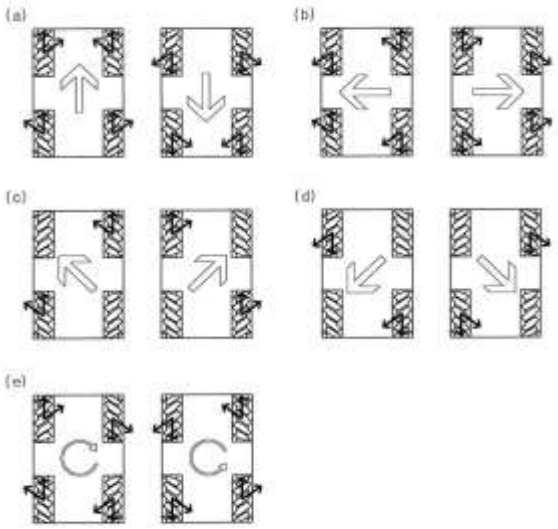
Key Words: **Mecanum Wheels, Omni-Directional, Hyper Manoeuvrable, Robot arm**

1. INTRODUCTION

Robots have long laboured alongside humans, mostly harmoniously. One such is the load carrying robot. For far too long, these robots have used the standard 4-wheel config of which two are fixed and two can be rotated which gave them the manoeuvrability they require in assisting humans. But as the need for efficiency has increased significantly over years and space constraints started to become a factor in robot design. Thus, the industry started moving toward omni directional robots. There are quite a large number of designs and ideas to meet the requirement. After researching a lot, we came to a conclusion that mecanum wheels are perfect for designing a hyper maneuverable robot. A robot can be made multifunctional by using an arm over the body to do multiple activities.

1.1 Robot Base using mecanum wheels

Mecanum wheels are designed in such a way that it can move in any direct, hence coming under the omni-directional category. It was invented by a Swedish engineer, Bengt Erland Ilon. They are conventional wheels whose rollers are attached to the circumference of respective wheels. Roller can be moved in either direction, in such a way the force between mecanum wheels and the base of the wheel is at 90 degrees to one another, this leads to the stability of the autonomous vehicle which helps the same to move in any direction.



Let us briefly understand the working of the robot using mecanum wheels. Figure (a) shows how the robot moves forward or backward, and all the 4 wheels are active. (b) Shows how to move the robot horizontally left or right, again all 4 wheels are active. (c) And (d) shows how to move the robot diagonally which only require 2 wheels active at a time. (e) Shows how to rotate robot about its axis clockwise or anticlockwise.

Using clever control logic, we can move the robot in any direction we want.

1.2 Robot arm

Considering all the advantages and disadvantages of all the different types of arm configuration, we have come to a conclusion that jointed arm performs the best for multi functionality.

We can define a robot as "An Industrial Robot is a reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or special devices through variable programmed motions for the performance of a variety of tasks."

Jointed arm is the most popular arm configuration because of its manueveribility as it has the ability to reach most

parts of the work environment. The arm in these configuration robots resembles human arm. It gets three rotary joints and three wrist axes, which form into 6 DoFs. Subsequently, it is capable of controlling the arm at any adjustments in the work space. These types of robots are used for performing several operations like spray painting and more.

The end effector can be replaced with any tool required by the application. Temperature and pressure probes can be attached and the arm can be used in servicing industries.

2. LITERATURE REVIEW

1. Self-Tuning Fuzzy PID control of a Four-Mecanum Wheel Omni-directional Mobile Platform by Ehsan Malayjerdi. (2018)

This paper majorly focuses on the auto-tuning control of a mecanum wheeled omnidirectional robot using fuzzy PID control. Although the mecanum wheels possess the omnidirectional capability, the major disadvantage is its vibration due to its unique structure, thereby reducing the accuracy in positioning. So in order to overcome these issues the kinematic mathematical models are formulated, to obtain proper robot control. Other than this, slip is also a major drawback in mecanum wheels. In order to overcome this drawback, four encoders used which help to increment the voltage needed to drive the mechanum wheels At the end, the Fuzzy PID controllers are explained in detail, which are used to achieve proper mapping and control the motion of the mecanum wheeled robot.

2. Influence of Mecanum Wheels construction on accuracy of the omnidirectional property by B.I. Adamov. (2018)

The most important objective of study in this paper is an omnidirectional mobile robot KUKA youbot which constitutes four mecanum wheels. A detailed study of the number of roller wheels and geometry of the system is done. Characteristics of the kinematic model is also studied. A step by step study for odometric navigation is done. In this study, the magnitudes of navigational errors are high and they increase in a linear manner.

So in order to increase the accuracy of odometric navigation, an improvised algorithm is proposed. Here, in this algorithm the accuracy of the odometric navigational error is reduced by certain magnitude and thereby increases the performance of the system.

3. Overview on Latest Gesture controlled systems for robotic arm by Akash Ugale and D M Chandwadkar. (2016)

The main purpose of this paper is to propagate the arm of the robot by making use of the gestures made by humans. In order to do so this paper focuses on the leap motion technology, which uses leap motion controller and its implementation in modern robotic arm. There is no need of any external device to make the robot arm work. Human intervention is required just to make a gesture and ensure that the robot arm is working. This type of robot arm is of a great use during natural calamities. Also the Gesture controlled systems are studied in detail. These controllers provide the latest gestures and position tracking system with high precision and its operations are based on the concept of IR optics making use of cameras.

4. Adaptive Control for Omni- directional Wheeled Robot by Kota Kawamura. (2016)

In this paper the modeling of an Omni-directional robot consisting of changes in load, shifts in centre of gravity and force due to friction is studied. Also a detailed study of adaptive controller is done. The stability of the system is tested and its performance was found to be better than that of Proportional Integral controller. The control method adapted in this paper can follow a target speed by estimation of parameter. Rest of the paper includes the specifications of the omni wheel which is used for experiments and frictional properties of the omni-wheel. The omni-directional robot used in this study is the MDT-RO-02. Each wheel has a rotary encoder, with the help of which their velocities can be measured and hence the velocity of the robot can be calculated. Coming to properties of friction of the mobile wheel, only the friction of the rotational direction is considered.

5. The Sources of Positional Errors of Omni-directional Robot with Mecanum Wheels by Kyung- Lyong Han, Hyosin Kim and Jin S Lee. (2010)

In this paper the position errors in the kinematic equation for the omni-directional mechanum wheeled robot. The main cause of position errors is the slip on the mecanum wheels. So as to avoid the position errors, a simple and efficient method which constitutes of adjustment of certain parameters on the kinematic equation is employed. Also in order to obtain accurate results recent technology can be used in robots in place of vision sensor. As a result the difference between the estimated robot position and the actual position of the robot is minimized to a greater extent. This is observed when the both conventional and adjusted kinematic equations are applied to POSTECH Omni-directional robot and the results obtained are compared.

6. Development of Autonomous Mobile Robot Platform with Mecanum Wheels by Kanin Piemngam and Itthisek Nilkhamhang. (2019)

In this paper the development of Autonomous Mobile Robot platform and its contribution in autonomous navigation is discussed. Also its architecture, design of system and instruments and sensors required for construction is studied in detail. This type of mobile robot finds many applications in the industries because of its capability to find the shortest and best path to reach the area of target by making use of map which is pre-loaded with the location of the destination. It uses the visual data

and LIDAR to create an autonomous computer map for path planning. The mechanical design of this type of robot constitutes four mecanum wheels which includes fourteen rollers which rotate at an angle of 45 degrees. An aluminum block is used in construction of the robot frame to provide the necessary durability. The system design includes a robot schematic mainly consisting of low-level microcontroller for the movement of robot and high level components for sensor data processing. The instruments and sensors used includes LIDAR, depth camera and inertial measurement unit (IMU).

7. An Omnidirectional Mobile Operating Robot Based on Mecanum Wheel by Yiqun Liu. (2017)

This paper consists the study of an omnidirectional mobile operating robot based on mecanum wheels. Omnidirectional robot has 3 DoFs in the plane and can move freely at the same time in three directions. The directions of its movement are left, right, forward, and backward and it can rotate. In this paper a manipulator with six degrees of freedom is designed and its kinematic model is established. Also the simulation of the omnidirectional robot is done and the performance of the robot is verified. The kinematic model states that the edge of the mecanum wheel is different from the regular wheel in the fact that it consists of a set of rollers inclined at an angle of 45 degrees to the wheel axis.

Mecanum wheels produce rotational and axial movement. The mecanum wheel is selected based on manipulator's weight and that of the omnidirectional car. Servo motor is used as a driver to enhance the current and voltage capacity due to its speed adjusting and accurate positioning properties.

8. Development of Mobile Robot Drive System using Mecanum Wheels by Taha Bin Mohamed, Norsehah Abd Karim and Dr Norzlin Ibrahim. (2016)

Here, we can learn how a mechanum wheeled robot is controlled, which thereby is used to drive the Omni-directional mobile robot. The use of mecanum wheels is due to its excellent mobility.

Also the control of mecanum wheel is explained using Arduino Mega as a controller. The sensors used for avoiding the obstacles is also discussed in this paper. The movement of the robot is forward, reverse, left and right or rotate with control command. Here, the control is established using a playstation 2 controller. The major application of this robot is that it can be used as a platform carrier which has the ability to move in any direction in order to help humans carry things. The study of this robot is further classified by studying the hardware and software components separately in detail. The hardware components consist of distance sensors, photoelectric sensors and encoders which act as inputs to the robots. This robot receives the command from the Arduino Mega controller. The software development completely depends on the path of the robot which is planned, and the controller being used. Arduino IDE is the software used for development.

9. Review on development of industrial robotic arm by Rahul Gautam (2017)

The purpose of this prototype is to develop a robot arm which can mimic the actions of the human arm up to a certain extent. Here, the sensors used are accelerometers for acquiring visual and spatial data and also the movements of the arm. It is observed that the robotic arm has higher flexibility and can be mobile or fixed. Applications of this implementation is quite low.

10. LWH-Arm: A Prototype of 8-DoF Lightweight Humanoid Robot Arm by Hua Yang. (2019)

The main objective of this paper being the high degree of freedoms of the arm. In this arm model, other than the 7-DoF arm, a 1-DoF end effector is affixed to fill in as hand, that is, LWH-Arm comprises of 8-DoF and is endeavored to be intended to copy the movement degree and example of a genuine human arm. The expense of the model is low and is light weight. We likewise saw that the exactness and solidness is low.

11. Mimicking Robotic Arm by Gargi Saha. (2018)

In this paper, they explained how the change in current due to the flex. Sensors makes a voltage drop over the foil which has been instituted as the sensor yield. The voltage is taken as a controlling component for altering the turn of the distinctive servo engines for exact development of the automated arm. The accelerometer-spinner gathering gives the speed of the hand development. The model does mimic the arm to certain efficiency. But, after 10-15 minutes of usage, the flex sensors show deviation in movement. Disadvantage being requirement of continuous power supply and weight of the entire system is very high.

12. Design and Development of a Competitive Low-Cost Robot Arm with Four Degrees of Freedom by Ashraf Elfasakhany. (2011)

Here, they clarify how the connections of a controller are associated by joints permitting rotational movement and the connections of the controller is considered to shape a kinematic chain. The work end of the kinematic chain of the controller is known as the end effector or end-of-arm-tooling and it is closely resembling the human hand. The servo engines are picked, since they incorporate encoders. The control for the introduced robot arm comprises of three levels: a microcontroller, a driver, and a PC based user interface. It is favorable that it permits adaptability in programming and controlling of arm. Scope of servo engines was seen as under 180 degree. It isn't perfect for loads more than 50gms.

13. Adaptive Grasp Control through Multi-Modal Interactions for Assistive Prosthetic Devices by Michelle Esponda and Thomas M Howard. (2018)

In this paper, they present novel system architecture for multi-modal control and adaptation of a prosthetic hand. EMG, visual and audial data is interpreted, classified, and utilized by a grasping controller. The conduct of the controller is represented by an artificial neural system that predicts ideal handle shapes to be tons of flexion or expansion of the lower arm muscles read by the EMG sensor. The data for arm movement is acquired through multi-modal interface. Here, they don't explain the feedback network from fingertips and classification of performance for general objects is absent.

14. Heavy-Duty Omni-Directional Mecanum-Wheeled Robot for Autonomous Navigation. (2015)

It consists of superior control system and intelligent autonomous control. This paper presents AuckBot, an uncompromising omni-directional Mecanum robot stage created at the University of Auckland, including its equipment review, the control framework engineering and the reenactment structure. Specifically the control framework, synergistically consolidating the Beckhoff framework as the Controller-PC to serve low-level movement execution and ROS as the Navigation-PC to achieve significant level keen route assignments, is created. Backdrop of the system is that requires lots of power to operate and is bulky.

15. Mechanical and Electrical design about a Mecanum wheeled omni-directional mobile robot. (2013)

In this paper, there is a real time electrical embedded processor that allows the robot to move in all directions, thereby making it omni-directional. There are distance sensors that actually calculate the distance of the robot from the obstacle which prevents collisions. The control system used here is quite advanced. But, the disadvantages of this robot are, it is bulky, it has no real world application and there is the slip factor which is of major concern. The robot used here has the ability to sensing the changes in the environment and adapting to them in real time thereby causing no lag.

16. Navigation system for Omni-directional autonomous guided vehicle with mecanum wheels. (2012 ICRA Paper)

Usually, slip is caused by the rollers which are attached to the wheels circumference. Here, the autonomous guided vehicle is localized with the help of the mecanum wheel. The localization is done with the help of an encoder, a gyroscope and an accelerometer. This type of robot provides stable performance and can be reliable. But, one major concern is the cost of individual parts. This robot has few applications and can be used in industries where heavy machineries are used.

CONCLUSION

After reviewing a handful of papers, we have come to a conclusion that mecanum wheels offer specific advantages over the conventional wheels in terms of maneuverability, mobility in congested environments. One major disadvantage is the slip factor of the mecanum wheels, which can be overcome using feedback from the robot with the help of PID controllers and fuzzy logic. Jointed arm being the most multifunctional configuration, controlling the arm using human hand movement will help us learn more about the dynamics and constraints of robots and technology and help bridge the gap between humans and robots. Hyper maneuverable multifunctional robots are the need of the hour and using mecanum wheels and jointed arm robot together as one could help us achieve the same.

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