

## Omni-Directional Mobile Robot with Mecanum Wheel

Jefri Efendi Mohd Salih, Profesor Dr Sazali Yaacob, Prof. Madya Dr Mohd Rizon Mohd Juhari.

*School of Mechatronics Engineering  
Kolej Universiti Kejuruteraan Utara Malaysia  
01000 Kangar, Perlis, Malaysia  
E-mail: jefri\_salih@kukum.edu.my*

**Abstract-***In this paper, we review researches on omni-directional mobile robot design which Mecanum wheel as component in mobile robot propulsion. Omni-directional mobile robot has vast advantages over conventional design likes differential drive in term of mobility in congested environments. Omni-directional mobile robot could perform important tasks in environments congested with static and/or dynamic obstacle and narrow aisles, such as those commonly found in manufacturing floor, warehouses, offices and hospitals. A variety of designs of Mecanum wheel mobile robot have been developed in recent years in order to improve their omni-directional maneuver and practical applications.*

**Keywords:** Omni-directional mobile robot, Mecanum wheel,

### 1. INTRODUCTION

One of the common omni-directional wheel designs is Mecanum Wheel or Ilon wheel. Mecanum wheel was design and invented in Sweden in 1975 by Bengt Ilon, an engineer with Swedish company Mecanum AB[1,2-4]. Mecanum wheel is based on the principle of a central wheel with a number of roller placed at an angle around the periphery of the wheel . The angled peripheral roller translates a portion of the force in the rotational direction of the wheel to force normal to the wheel directional. Depending on each individual wheel direction and speed, the resulting combination of all these forces produces a total force vector in any desired direction thus allowing the platform to move freely in direction of resulting force vector, without changing the direction of the wheel. Figure 1 shows a traditional Mecanum wheel design by Ilon with the peripheral roller with 45° degree slope held in place from the outside.

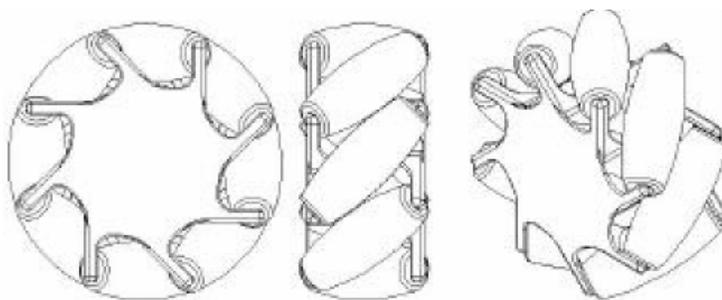


Figure 1: Mecanum wheel based on Ilon's concept. Source from [1].

This design only can operate in even work surface. When encountering an inclined or an uneven work surface, the rim of the wheel can make contact with the surface instead of the roller, thus preventing the wheel from operating correctly. To encounter this problem a simple alternative design, also proposed by Ilon, which consist two split roller mounted centrally on the periphery of the wheel as shown in figure 2:

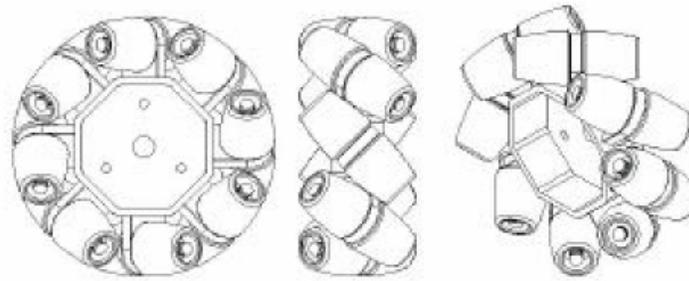


Figure 2: Mecanum wheel with centrally mounted rollers. Sourced from [1]

This design ensures that the rollers are always in contact with the work surface, thus allowing better performance on uneven surfaces. Using four of Mecanum wheels provides omni-directional movement for a vehicle without needing a conventional steering system. Slipping is a common problem in the Mecanum wheel as it has only one roller with a single point of ground contact at any one time. Due to the dynamics of the Mecanum wheel, it can create force vectors in both the x and y-direction while only being driven in the y-direction. Positioning four Mecanum wheels, one at each corner of the chassis (two mirrored pairs), allows net forces to be formed in the x, y and rotational direction. Refer to Figure 3. A difficulty with this strategy is that there are four variables to control three degrees-of-freedom. In this case the system is said to be over determined and it is possible to create conflicts in the actuation. As a result of the constraints associated with the Mecanum wheel some form of controller is required to produce satisfactory motion.

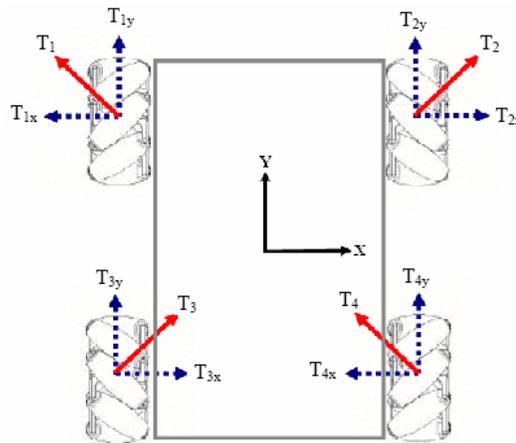


Figure 3: Force vectors created by Mecanum wheel.

## 2. BACKGROUND

Many researches in Mecanum wheel mobile robot for various purpose and applications has been develop in recent years. Researchers from Mechatronics and Robotics Research Group of Massey University have developed two improved Mecanum wheel design [1,2]. The first design is Mecanum wheel with lockable rollers illustrated in figure 4. This design is to overcome the loses of efficiency when the mobile robot driving in longitudinal (forward/backward) motion due to energy lost through the peripheral rollers which bleed off available as they rotate [1].

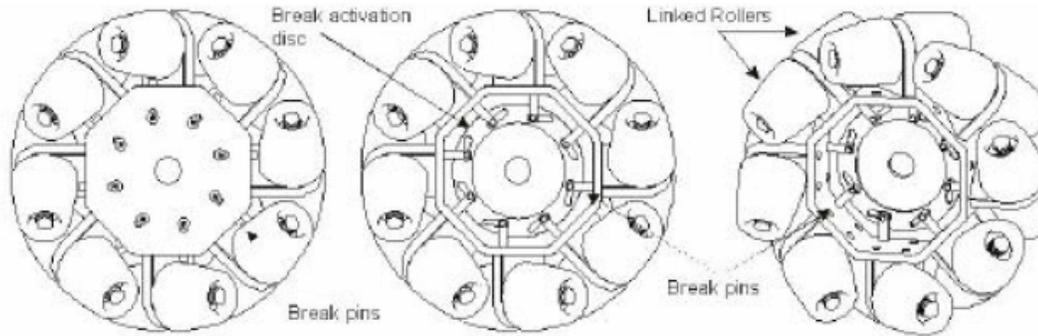


Figure 4: Mecanum wheel with lockable rollers. Sourced from [1].

The simple actuators used to rotate the brake activation disc to lock and unlock the roller when the mobile robot traveling. The peripheral rollers will be locked and act as heavy thread when mobile robot driving in longitudinal motion but unlocked when driving in sideways motion. This design is effective to reduce lost force in longitudinal motion but do not improve any loses in other direction.

The second design is mecanum wheel with rotatable roller illustrated in figure 5. This design more effective than Mecanum wheel with lockable rollers but mechanically more complex.

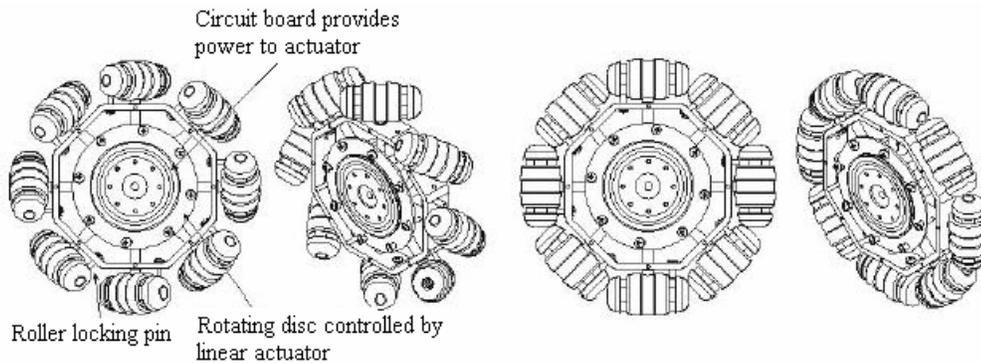


Figure 5: Mecanum wheel with rotatable rollers. Sourced from [1].

In this design, peripheral rollers are split and centrally mounted on an axle which can be pivoted through 135°. This allows the rollers to be adjusted in straight position for longitudinal motion to an angle of 45° or -45° in a normal position of mecanum wheel for driving sideways. The angle of the rollers on each wheel is controlled through all the rollers shafts being connected through a bevel gear system in such a way that rotary actuator on one of the shaft controls all the others simultaneously. A software algorithm to determine the ideal angle for each set of rollers is depending on desired direction of travel.

Some researchers, such as Braunl from University of South Australia have developed two different Mecanum wheel omni-directional mobile robots, Omni-1 and Omni-2 [7,8]. Figure 6 show the structure of Omni-1 and Omni-2.

The first design, Omni-1 used the Mecanum wheel design with rims that only leave a small gap/clearance for the roller. The motor and wheel assembly tightly attached to robot's chassis. The Omni-1 can drive very well on hard and flat surface but it loses the omni-directional capability on soft surface.

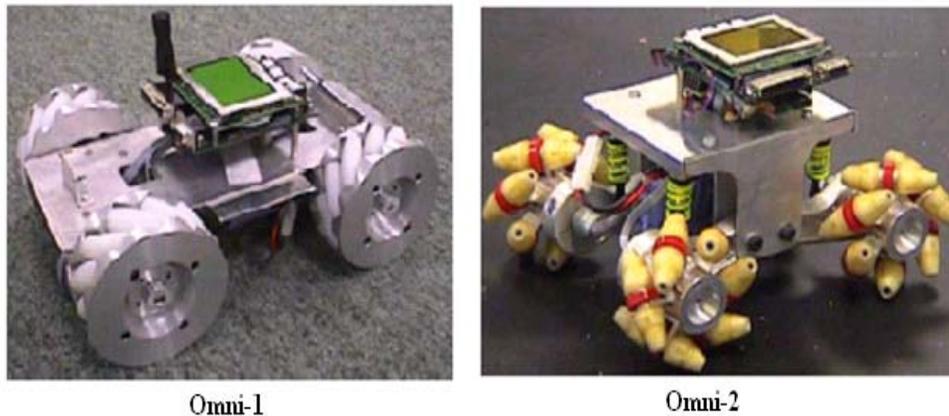


Figure 6: Mecanum Wheel Mobile robot Omni-1 and Omni-2 from University of Western Australia. Sourced from [8].

Omni-2 was developed using rimless and with centrally mounted roller. The motor and wheel assembly attach to cantilever wheel suspension with shock absorbers. The rimless Mecanum wheel and shock absorbers encounter the sinking-in on softer surface and uneven work surface as a result allows omni-directional driving for Omni-2.

The Mechatronics and Robotics Research Group (MR2G) at Massey University have developed all terrain Automatic Guided Vehicle (AGV) using a set of Mecanum wheels combined with a set of conventional wheels [1]. Any terrain change is automatically detected and a set of pneumatics actuators used to change from Mecanum wheels for indoor and high mobility requirement to conventional wheel for outdoor and rough terrain. This new driving mechanism of AGV has been implemented on Mapped Environment Guided Autonomous Navigator (MEGAN). Figure 7 shows the structure of MEGAN.

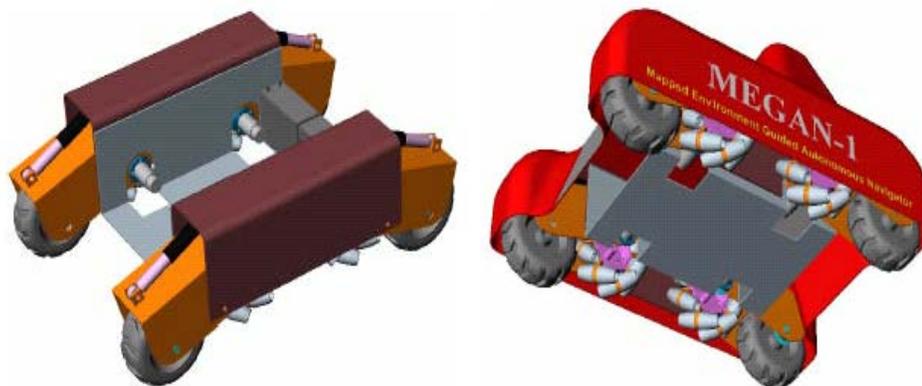


Figure 7: Mapped Environment Guided Autonomous Navigator (MEGAN). Sourced from [1].

Omnix Technology Systems, Inc had developed Mecanum wheel vehicle for U.S Navy for inspection of areas inaccessible to humans and vehicles capable of transporting very heavy loads in military environments [9]. These vehicles can be seen in figure 8 are especially adaptable for autonomous or teleported operations due to the unrestricted maneuverability and simplicity of control.

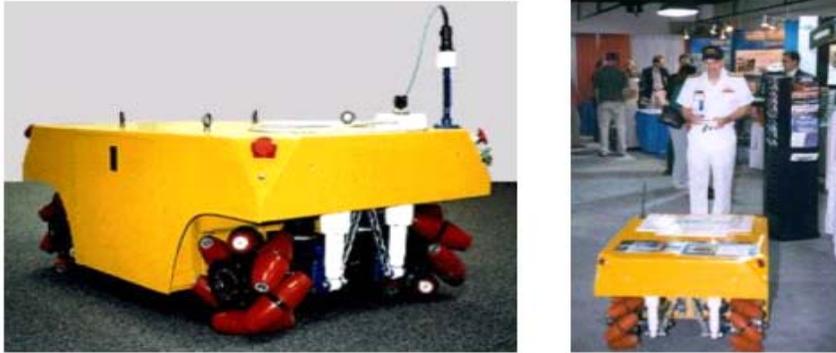


Figure 8: Mecanum Wheel Vehicle for U.S. Navy. Sourced from [9].

### **3. CONTROL TECHNOLOGY**

To control and optimized the omni-directional capabilities for Mecanum wheel mobile robot the following technologies are needed [5]:

- a) Motion control technologies that includes omni-directional control, collision avoidance system and shock avoidance for accident.
- b) Management technologies that includes environment recognition, motion learning and motion planning.
- c) Intelligent human interface technologies.

The motion control technologies must be established to integrate the electromechanical systems with multi-sensors system that can detect and analyt the surrounding environment base on develop control algorithm to achieve the application objective.

### **4. SYSTEM INTERGRATION**

Mecanum wheel mobile robot research addresses many problems in robotics such as 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 [10]. Moreover, building Mecanum wheel mobile robot provides a stringent test bed for new concepts and approaches in both mechanical design for Mecanum wheel and overall mobile robot chassis and also the design for electronic hardware and software. This design and development of an omni-directional platform, using mechatronics system and Mecanum wheel to implement intelligent behaviors and maneuvers, with the help of a microcontroller interfaced with sensors.

All Mecanum wheels are independently powered using four units of DC motor and four units of bi-directional motor driver interface with microcontroller system. The challenge to control the Mecanum wheel mobile robot compare to the conventional differential drive is all of the wheels must be independently streerable with appropriate speed and direction (forward or backward) in order to have the ability to move in desired direction on the surface and at least two wheels be independently powered.

### **CONCLUSION**

This paper presents an overview over the design of omni-directional mobile robot using Mecanum wheel. The strength of this wheel is the enhanced maneuverability of the mobile robot that needs extreme maneuverability in congested environment. The paper also presents some research that being carried out in Mecanum wheel mobile robot in order to improve the wheel design and practical application using Mecanum Wheel mobile robot.

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