Design and Fabrication of A 360-Degree Rotating Electric Vehicle for Enhanced Maneuverability in Confined Spaces

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Abstract–This paper presents the design and development of a compact 360-degree rotating electric vehicle aimed at addressing mobility challenges in constrained urban and industrial environments. Traditional vehicles suffer from limitations in maneuverability, especially in tight spaces such as parking lots and narrow alleys. To overcome these challenges, the proposed system integrates a hybrid drive mechanism utilizing gear motors for linear motion and turbulent motors for rotational capability. The vehicle employs an innovative control system using toggle switches, facilitating omnidirectional movement without a turning radius. Detailed mechanical design, torque calculations, and fabrication processes are discussed. Experimental results confirm the prototype's effectiveness in executing precise forward, reverse, and lateral maneuvers, demonstrating its potential for applications in robotics, logistics, and automated parking systems.

Key Words: Omnidirectional vehicle, 360-degree rotation, zero turning radius, electric mobility, turbulent motor, urban transportation, maneuverability.

1.INTRODUCTION

Urbanization and industrial automation have rapidly increased the demand for intelligent mobility solutions capable of navigating constrained environments. Traditional wheeled vehicles, designed with fixed steering mechanisms, often encounter difficulties when maneuvering in compact areas, such as narrow roads, parking facilities, or crowded industrial spaces. These limitations highlight the need for enhanced vehicular maneuverability and space efficiency.

The concept of a 360-degree rotating vehicle offers a promising alternative to conventional mobility systems. By enabling omnidirectional movement—including forward, backward, lateral, and diagonal directions, along with on-the-spot rotation—these vehicles eliminate the necessity for a conventional turning radius. This capability is especially advantageous in indoor logistics, robotic applications, and autonomous navigation systems.

This paper presents the design, fabrication, and performance analysis of a low-cost, battery-powered 360-degree rotating vehicle prototype. The design incorporates two gear motors for translational movement and four turbulent (stepper) motors for directional rotation. The system is controlled through a manually operated switch panel, ensuring intuitive operation. The objective is to demonstrate a practical and scalable solution to modern-day mobility constraints with minimal energy consumption and environmental impact.

2. LITERATURE SURVEY

Several research efforts have focused on the development of zero-turn or omnidirectional vehicles to solve the mobility issues faced by conventional transport systems.

Dr. P. Mohammad Ali et. al. (2019) proposed a vehicle using individual stepper motors to rotate each wheel independently, allowing full directional control via RF remote. However, limitations in load-bearing capacity and control synchronization were observed.

Aher Vaibhav Balasaheb et. al. (2023) emphasized reducing the turning radius using a four-wheel drive mechanism, with a focus on automated control rather than traditional gear-driven systems. The study demonstrated notable improvements in parking efficiency and road safety, but lacked detailed fabrication methods for low-cost implementation.

Adedeji A. Kasali et. al. (2023) introduced a design known as AKEA, which used a combination of lifting plates, chain drives, and quad-steering systems to enable 360-degree mobility. Although effective in maneuverability, the design was mechanically complex and difficult to replicate without access to advanced fabrication tools.

Sarvind Kumar et. al. (2020) also explored a similar vehicle employing both stepper and DC motors for directional and linear movement respectively. However, latency issues with stepper motor response during dynamic directional changes remained unresolved, especially during continuous forward or reverse motion.

Sk. Naseer et. al. (2019) introduced a 360-degree car rotation concept aimed at simplifying parking in tight urban areas. The system incorporated spur and worm gears, coupled with motorized mechanisms, to lift and rotate the vehicle, effectively reducing the spatial requirement for maneuvering.

Yogendra Kumar et. al. (2022) explored the concept of a zero-turn vehicle by replacing traditional gear-based systems with an automated four-wheel drive layout. His design involved mechanical linkages that allowed front and rear wheels to rotate in opposite directions, enabling the vehicle to pivot about its own axis. This significantly minimized the turning radius and enhanced movement in narrow streets and confined zones.

Jaishnu Moudgil et. al. (2015) proposed a vehicle with a zero-degree turning radius, capable of rotating around its center of gravity. Designed to address parking challenges, this model allowed rotation within a space no larger than the vehicle itself. The concept showed promise for applications in industrial and institutional environments such as factories, hospitals, and railway stations.

Sudip Kachhia et. al. (2016) advanced a similar omnidirectional design, emphasizing comfort, cost-efficiency, and environmental sustainability. His battery-operated prototype provided multi-directional mobility, facilitating smooth navigation in compact spaces. The work also underscored the importance of steering response and road feel for user experience.

K. Lohith et. al. (2013) introduced a four-wheel steering mechanism where the rear wheels rotated in coordination with the front wheels, improving efficiency and control. A DC motor allowed wheel rotation up to 90 degrees, optimizing the vehicle's ability to maneuver in limited space.

Er. Amitesh Kumar et. al. (2014) focused on enhancing steering functionality through a zero-turn four-wheel steering system. His model enabled precise directional control and improved vehicle stability, especially during straight-line motion and sharp turns.

Our project builds upon these foundational studies by combining both gear motors and turbulent motors in a simplified mechanical layout. Unlike previous models that required dual-mode systems or external controllers, our design offers seamless directional transitions using a toggle-based manual interface. Additionally, it improves on earlier shortcomings by optimizing motor torque and structural stability through appropriate material selection and load distribution.

3. DESIGN AND METHODOLOGY

3.1 System Architecture

The proposed 360-degree rotating electric vehicle is designed to achieve omnidirectional mobility using a combination of gear and turbulent motors. The vehicle's movement is divided into two subsystems:

- **Linear Propulsion:** Driven by two 250W, 24V gear motors responsible for forward and reverse motion.
- **Rotational Steering:** Enabled by four turbulent motors (138W, 220V AC) mounted vertically to control wheel orientation.

This hybrid configuration allows the vehicle to move in any direction with zero turning radius, making it highly adaptable to narrow and congested environments.

3.2 Design Considerations

- **Load Capacity:** The total load (vehicle + user) was estimated at approximately 100 kg. The frame was designed using mild steel (MS) bars with 2x1 inch and 1x1 inch cross-sections, selected for their availability, cost-effectiveness, and structural strength.
- **Torque Calculation for Gear Motors:**

  Assumptions (same unless specified):

  Total load (vehicle + payload): 100 kg

  Number of motors: 2

  Wheel radius (r): 0.05 m (5 cm / ~2-inch radius wheel)

  Rolling resistance coefficient (μ): 0.02

  Gravity (g): 9.81 m/s²

  Even weight distribution between the 2 wheels

  Flat surface movement (no slope)

  Step-by-Step Calculation:

1. Total rolling resistance Force:

   $F_{total} = \mu \cdot m \cdot g = 0.02*100*9.81 = 19.62$ N

2. Force per Motor (2 motors):

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F per motor = F total2 = 19.622 = 9.81 N

3. Torque per motor:

T = F × r = 9.81 × 0.05 = 0.4905 Nm

4. With Safety Factor:

Including a safety factor of 2 (recommended for startup load, friction, slight incline,

etc.):

T required = 0.4905 × 2 = 0.981 Nm

- **Turbulent Motor Selection:** Based on required wheel angle adjustments, the system uses turbulent motors with 5.38 Nm torque and 28 RPM, enabling accurate and controlled angular movement.

3.3 Fabrication Process

- Frame Construction

The vehicle chassis was fabricated using MS rectangular and square pipes. MIG welding was employed to ensure structural integrity. The frame was dimensioned to support two front and two rear rotating wheels with central load distribution.

- Wheel and Motor Assembly

Each wheel is mounted to a shaft connected to a turbulent motor secured with a custom-fabricated C-clamp. The gear motors are fixed directly to the rear section of the frame using steel brackets and connected to the wheels via a sprocket-chain drive system.

- Control System

A manual toggle switch panel was used to control the directional states of the motors:

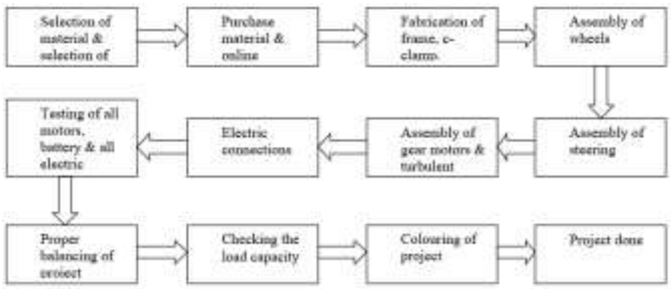
- Two switches control forward and reverse movement.
- Four switches independently manage the rotation of each turbulent motor for steering.

The entire system is powered by a 12V, 32Ah lead-acid battery, supplying energy to the DC gear motors, while the AC turbulent motors operate through an external 220V AC power supply during testing.

3.4 Component Summary

Component	Specification	Quantit
Gear Motor	250W, 24V, 2830 RPM	2
Turbulent Motor	138W, 220V, 28 RPM	4
Battery	12V, 32Ah (Lead Acid)	1
Bearings	6202 (2 units), 6208 (4 units	6
Toggle Switch	6-Leg Toggle	6
Sprockets & Chai	13 Teeth, 12.7mm pitch	2 sets
Wheels	Tubeless, 40mm diameter	4

3.5 Block Diagram Overview



4. RESULTS AND PERFORMANCE ANALYSIS

4.1 Experimental Setup

The fabricated prototype was tested under controlled conditions to evaluate its mechanical stability, directional flexibility, and load-bearing capacity. The testing area simulated real-world use-cases such as narrow corridors, parking spaces, and inclined surfaces.

The following test parameters were evaluated:

- Load response with varying user weights
- Time required to cover a 5-meter distance
- Ability to change direction without rotation of the vehicle body
- Smoothness of directional transition (forward to lateral, etc.)

4.2 Test Conditions

Parameter	Value
Test Surface	Smooth indoor floor
Distance Travelled	5 meters
Battery State	Fully charged (12V, 32Ah
Supply Voltage (AC	220V for turbulent motors
Payload Range	45–55 kg (based on users)

4.3 Observations

User	Weight (kg	Time to Travel 5m (s	Avg. Speed (m/s
ABC	45	20	0.25
XYZ	48	18	0.28
PQR	55	12	0.42

Note: Performance improved slightly with increased load due to better traction between the wheels and the surface.

4.4 Functional Capabilities

- **360-Degree Rotation**: The vehicle successfully rotated in place without displacement, proving zero-radius turning.
- **Lateral Motion**: Turbulent motors reoriented wheels to allow sideward movement.
- **Forward/Reverse**: Smooth acceleration and deceleration using toggle-controlled gear motors.
- **Real-time Directional Change**: The system handled direction changes effectively without mechanical lag or need for manual realignment.

4.5 Performance Analysis

The prototype met the core functional objectives, including:

- Seamless multi-directional movement
- Stable motion under moderate payloads
- Efficient power consumption for short-range operations

However, the system's rotational speed and dynamic responsiveness were limited by:

- Use of turbulent motors instead of programmable stepper motors
- Manual switching system lacking automation
- Absence of onboard sensors for feedback and control

These findings highlight opportunities for future enhancement through automation and smart control integration.

5. CONCLUSION

The design and fabrication of a 360-degree rotating electric vehicle presented in this paper demonstrate a practical and effective solution for maneuverability challenges in compact and constrained spaces. By integrating a hybrid mechanism of gear motors for linear movement and turbulent motors for directional rotation, the vehicle achieved omnidirectional motion with zero turning radius.

The successful implementation of this system validates its potential application in environments such as parking structures, automated warehouses, and robotics. The vehicle showed stable performance under variable payloads and offered responsive directional control via a simplified toggle switch interface.

Although the current model is manually operated and limited by fixed-speed motors, it lays a strong foundation for future developments involving automation, sensor integration, and intelligent navigation.

6. FUTURE SCOPE

The scope of omnidirectional electric vehicles extends far beyond the presented prototype. Several future enhancements can be implemented to improve performance, usability, and applicability:

Autonomous Control: Integration of microcontrollers or PLCs with feedback sensors (e.g., encoders, gyroscopes, and ultrasonic sensors) can enable automatic navigation and obstacle avoidance.

Wireless Operation: Replacing manual toggle switches with wireless remote or smartphone-based controls via Bluetooth or Wi-Fi would enhance usability and range.

Swarm Coordination: In industrial settings, multiple units can be coordinated using swarm intelligence for collaborative tasks like material handling or automated logistics.

Solar Charging & Regenerative Braking: Adding energy recovery and solar-based charging would improve the sustainability and off-grid operability of the system.

Application-Specific Design: Tailoring the platform for hospital trolleys, airport luggage carriers, or factory robots could significantly expand its real-world utility.

These advancements could transform the prototype into a commercially viable and scalable mobility solution for smart cities and Industry 4.0 ecosystems.

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