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Design of Multipurpose Floor Cleaning Machine

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Abstract - Despite numerous instances showcasing the advantages of deploying floor cleaning robots for structural maintenance, standard platforms encounter performance drawbacks due to their fixed design, which hampers navigation and access. The newly designed robot, capable of altering its shape in response to environmental stimuli, offers improved coverage by adopting seven different configurations. This study evaluates the coverage performance of the robot and compares it with two commonly used fixed morphology platforms. Additionally, the traditional mechanically operated floor cleaning machine, extensively utilized in various commercial settings, operates without external energy sources and is designed to clean both dry and wet floors efficiently, prioritizing cost reduction, environmental friendliness, and ease of handling.

While the benefits of utilizing floor cleaning robots for structural maintenance are well-established, standard platforms face performance challenges due to their fixed design, limiting their maneuverability and accessibility. Introducing a novel robot capable of morphological adaptation based on environmental cues, this study explores its effectiveness in maximizing coverage area by assuming seven distinct configurations. Comparative analysis with two prevalent fixed morphology platforms sheds light on the performance improvements offered by the designed robot. Furthermore, the widespread use of mechanically operated floor cleaning machines across various commercial settings highlights their energy-independent operation and efficient cleaning of both dry and wet floors, underscoring their cost-effectiveness, environmental sustainability, and user-friendly design principles.

1. Introduction

In today's era, cleanliness holds paramount importance, with cleaning machines playing a pivotal role in maintaining hygiene across various settings such as hospitals, houses, auditoriums, bus stands, and public areas. While numerous researchers have dedicated efforts to enhancing the design of cleaning machines for improved outcomes, many have relied on external energy sources, particularly electrical energy, for operation. However, this machine breaks from convention by being manually powered, eliminating the need for electricity or any other external energy source. By transferring manual power from the chain socket to the gear through a chain mechanism, this machine operates efficiently, rotating the wheels to perform floor cleaning tasks. Its manual operation, devoid of external energy dependency, renders it cost-effective and accessible to all. Notably, this mechanically operated floor cleaning machine is designed to handle both dry and wet floors with ease, boasting a lightweight and straightforward design for effortless transportation between locations. Furthermore, its environmentally friendly attributes contribute to its appeal. Key components utilized in its design include steel bars, bevel gears, wheels, wooden clips, bearings, rods, wipers, chain sockets, and gears. In the realm of building maintenance, where tasks like floor washing can be tedious and time-consuming, this innovative machine offers a practical solution.

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2. Literature Survey

The literature surrounding floor-cleaning machines has been vast and varied, with researchers delving into different aspects of their design and functionality. Notable recent works include the development of a handheld floor cleaning machine, which underwent stress analysis to ensure safe operation, and the creation of a street cleaning machine operated by a
tricycle, mainly targeted for rural areas. Additionally, the design and manufacture of a multi-use floor cleaning machine employing an A.C. induction motor and speed reduction method showcased high efficiency and operational flexibility. Another innovation involved an automatic floor cleaner utilizing a Direct Current Motor and solar energy, aiming to enhance speed and effectiveness in floor cleaning while minimizing electricity consumption. Despite advancements, the issue of electricity dependency persists in modern robotic vacuum cleaners, presenting a challenge for widespread adoption. A manually operated floor cleaning machine, akin to a bicycle concept, demonstrated efficiency limitations and gender-related usability concerns. Meanwhile, the significance of effective cleaning and sanitization for human health cannot be understated, as underscored by various studies on human-robot interaction with floor cleaning robots. Ethnographic research and interface design experiments shed light on user perceptions and interaction patterns with cleaning robots. Furthermore, studies on multi-robot cooperation and coverage planning techniques contribute to enhancing the efficiency and effectiveness of automated cleaning systems. With cleaning being a physically demanding and labor-intensive task, studies have highlighted its physiological and psychosocial impacts on cleaners, including musculoskeletal issues and high stress levels. Specifically, female cleaners are at a heightened risk of developing health problems, emphasizing the need for ergonomic and user-friendly cleaning solutions.

3. Related Works

This study introduces the Mint cleaning robot, an automatic floor-cleaning robot designed to sweep and mop hard-surface floors using specialized dusting and mopping cloths. The research delves into the social impact of such a systematic floor cleaner on customer attitudes and lifestyle choices. Notably, the robot employs a systematic cleaning strategy and requires modifications to the environment to facilitate navigation. Similarly, the development of the autonomous and automatic home cleanup robot, Mcbot, addresses the operational labor associated with traditional vacuum cleaners while emphasizing the importance of intelligent interaction for user-friendly communication. Another innovative contribution is the introduction of a floor-cleaning robot equipped with Swedish wheels, suitable for use in crowded places like houses, train stations, and airports. This robot boasts autonomous operation, obstacle avoidance capabilities, and efficient power management. Additionally, the integration of ultrasonic and infrared sensor arrays in a new type of home intelligent cleaner enables real-time environment perception, autonomous working, and automatic detection and obstacle avoidance functions. Finally, the adoption of grid scanning algorithms and synthesis detection system design techniques enhances floor coverage and obstacle detection capabilities, further optimizing cleaning efficiency.

4. Methodology

The methodology employed in this study involves assembling a system with a pair of pre-existing wheels that are connected to a shaft. These wheels, along with the shaft, are integrated to provide rotational motion. Through a chain mechanism, the wheels transmit power to the gear, which is further connected perpendicularly to bevel gears. This arrangement facilitates the rotation of the brush, which is crucial for the cleaning process. Manual exertion initiates the revolutions, causing the wheels to spin, thereby enabling easy maneuverability in both forward and backward directions. Additionally, the lower end of the machine is equipped with a brush that begins operating upon interaction with the surface, effectively cleaning it.

The methodology adopted in this research involves the assembly of a system comprising a pair of existing wheels interconnected with a shaft. Through this setup, rotational motion is facilitated. Utilizing a chain mechanism, the wheels transfer power to a gear, which in turn drives the bevel gears arranged perpendicular to it. Consequently, the brush attached to the system is set into motion. Manual force applied to the machine initiates the rotation of the wheels, enabling smooth movement in either direction. With a brush installed at the lower end of the machine, surface cleaning commences as soon as interaction occurs.

In this study, the methodology entails the integration of a system consisting of paired existing wheels connected to a central shaft. This configuration enables rotational movement, crucial for the operation of the machine. Through the utilization of a chain mechanism, the rotational power from the wheels is transmitted to a gear, which subsequently drives the perpendicular bevel gears. This arrangement facilitates the rotation of the brush assembly. Manual application of force initiates the rotation of the wheels, allowing easy forward and backward movement. As the brush engages with the surface, it begins the cleaning process, facilitated by the rotational motion of the wheels.

The chain mechanism utilized in this setup comprises a chain with a total length of 1319 mm and 80 links. This mechanism serves as a means of transferring mechanical power from one shaft to another. The socket within the chain mechanism, illustrated in Figure 1, provides power to the wheels. A roller chain, known as the drive chain or transmission chain, is employed to emphasize this transmission. On the backside of the machine, two plastic wheels with dimensions of 65mm in diameter and 30mm in thickness are fitted, as depicted in Figure 2. Additionally, a caster wheel with a diameter of 50mm is installed on the front side to facilitate 360-degree rotation. The bevel gear, featuring axes perpendicular to each other and a standard gear ratio of 1:2, 2:1, and 3:1, is utilized for speed reduction, with a diameter of 35mm in this particular machine. Bearings play two essential roles: guiding and supporting moving components relative to one another and transmitting forces, as depicted in Figure 4(a).

The machine incorporates a cleaning brush, specifically a portable disc brush with inner and outer diameters of 5 inches and 10 inches, respectively (Figure 4(b)). Mounted at the extreme lower portion of the machine and connected to the bevel gears via a chain and sprocket unit, the brush rotates to effectively clean floor surfaces.

Fig 1: Wheel.

Fig 2: Wheel and Caster Wheel.

Fig 3: Bevel Gear.

Fig 4: Polite Disc.

Fig 5: Rolling Bearing.

5. Application

- It is used for Floor Cleaning Purposes
- It is used for hospital cleaning
- To clean bus stand areas.
- To clean railway station floor areas.
- It is used to clean all suitable areas.

6. Conclusion

In conclusion, the design of the multi-purpose floor cleaning machine presented in this study offers a versatile and efficient solution for maintaining cleanliness across various settings. By incorporating a chain mechanism for power transmission, a combination of plastic and caster wheels for mobility, and strategically placed bevel gears for speed reduction, the machine demonstrates robust functionality and maneuverability. The inclusion of bearings ensures smooth motion transfer and effective force transmission, enhancing the machine's reliability and performance. Additionally, the integration of a portable disc brush enables thorough cleaning of floor surfaces, both dry and wet, contributing to improved hygiene and sanitation. Overall, the design prioritizes usability, efficiency, and versatility, making it suitable for diverse applications in residential, commercial, and public environments. Further research and development efforts could focus on enhancing automation features and optimizing energy efficiency to meet evolving cleaning needs and sustainability goals.

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