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A NOVEL HYBRID LOCOMOTION MECHANISM FOR SMALL MOBILE ROBOT

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Abstract. *Robots are the inventions of the modern world that has reduced manual efforts to a greater extent. Humans usually utilize robots to do works that are dangerous, dirty, and difficult. Mobile robots are operated using remote controlled mechanism. They are agile and can move from one place to another using remote mechanism. This paper includes the information on a novel hybrid locomotion mechanism for small mobile robots. By hybrid locomotion mechanism, we mean that the wheel and track type motion are merged to increase the agility of the mobile robots. This not only makes the robot flexible, but also adds up a hybrid and interchangeable movement. The robot can move in any direction. The robot transforms from track mechanism to wheel mechanism by using a switchover module. A switchover module is a track sensor unit and is usually operated by the old school wheel and track mechanism. The wheel exerts force on the track, making the switchover module move in upward and downward direction supporting the movement of the wheel in rotatory motion. It is assumed and believed that the hybrid locomotion mechanism is able to perform in rough grounds as well.*
Keywords: Mobile robots, Locomotion, Wheel, Track, Hybrid, Locomotion

1. **Introduction.** Robots were made for the betterment of mankind. The invention of first commercial robot was done in 1961 by Ford Automobile Industry. The range of applications these robots could cover, gave rise to the research and development to create faster, smarter, and better robots. The only limitation with the industrial robots was that they were fixed and could perform tasks that require no movement. The tasks included welding, drilling, counter boring, painting. The applications improved to packing of product and robots started to contribute in the assembly line, too. Then came the era of sensors and advanced tools, using which scientists started making robots that were not limited by motion. Sensors and advanced tools can give an advantage to fixed robots. The locomotion added more value to their tasks as they could move from one place to another [2].

Joystick controlled wheelchair is also a locomotion mechanism where through wheels the wheelchair reaches the patient. The patient can control the mechanism using a remote control. Due to big size, the wheels are big and hence the wheelchair can surpass small obstacles easily [7].

After making the robots mobile, the challenge was to increase their speed and allow them to operate in difficult terrains. A better locomotion system could provide the robots high flexibility and speed. It would ultimately kill their difficulty to work in complex environments.

The mobility of a robot can be classified in three major types:

i. Wheeled robots

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ii. Tracked robots
iii. Legged robots

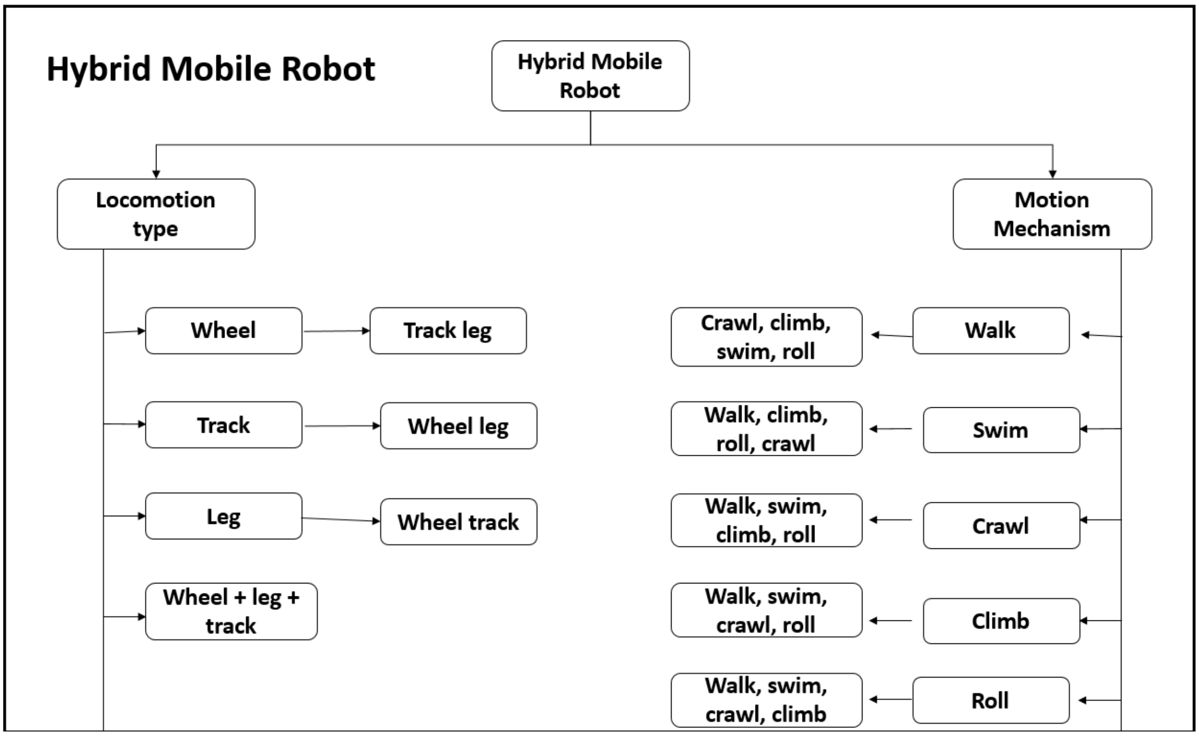

Figure 1. Hybrid mobile robot

A novel hybrid locomotion system in mobile robots could help them work in natural terrains. The robots could then also coordinate with their human partners and help them organize things in their workspace.

Now, coming back to the point, all that have been said above can only be improved by a few implementations. An effective and efficient motion mechanism would truly help the robots work in multiple environments. These locomotion mechanisms have their own fair share of advantages and limitations with respect to their design, working conditions, and works that they perform.

This research paper explains how a novel hybrid locomotion mechanism can induce agility in small mobile robots. The improvement presented in this paper could be a ground-breaking innovation which can enable working of mobile robots in wheeled mechanism, tracked mechanism, and combination of both. The issues said above can be resolved by means of introducing a hybrid locomotion mechanism to robots that might no longer simplest permit them to tackle tough terrains but additionally provide an easy shift in motion. It would make the robots extra efficient and extra bendy. The work has been carried out before and is defined below. We provide the info of the prevailing hybrid kind movement robotic. The details are nice and replicate the difficult paintings and cognizance of the researchers in the direction of creating a super layout for hybrid locomotion mechanism. The operating of the required design relies upon the motion of two locomotive mechanism. One mechanism is wheel and the other is music. These are changeable locomotive device. The robot as in line with layout ought to flow on both wheel, or song, or the mixture of each. These forms of more than one movement mechanism allow robots to journey in hard and special environments. They can interchange their mechanisms as according to the surroundings. The layout and management of the tune wheel mechanism are pretty easy and compatible whilst as compared to other locomotive mechanisms. It is easy to observe, the mechanism, but there are a few obstacles in this mechanism. One of the biggest limitations is that their mechanism may be flawed in relation to more willing surfaces.

They are unable to benefit swiftness and acceleration in inclined surfaces. At easy surfaces, they pick up excellent pace in seconds. The front wheel majorly drives the mechanism and the track enables to synchronize the front wheel motion with the opposite wheels.

A switchover module may be used to exchange the wheel track mechanism to solely tack and entirely wheel locomotion.

2. **Literature Survey.** There have certain improvements in the field of mobile robots. Robots are contributing too many military, healthcare, surveillance, and industries. To achieve any objective in any of the field, a robot must have a good locomotive system that can guide its movement correctly. The control and the path planning come next. Usually, the robots come with a single type of locomotion mechanism, which is not suitable for the robot to work in all types of terrains. There are certain terrains that have deep trenches and the working environment is usually very complicated. On the other hand, the wheeled mechanism is a great innovation but suitable only for plain surfaces where the movement is smooth and not obstructed. There is one more mechanism called legged mechanism, which has higher adaptability in terms of tackling complex terrains and moving nicely. However, they have one limitation of designing and controlling flawlessly. After all, a human takes months to learn walking, let alone be a legged robot with no brain.

The problems stated above can be resolved by introducing a hybrid locomotion mechanism to robots that would not only enable them to tackle difficult terrains but also offer a smooth shift in movement. It would make the robots more efficient and more flexible. The work has been performed before and is explained below. We provide the details of the existing hybrid type movement robot. The details are fine and reflect the hard work and focus of the researchers towards creating a perfect design for hybrid locomotion mechanism.

1) Adachi and Koyachi tried creating a hybrid mechanism by merging wheel and leg. The robot had 4 legs and 4 wheels on the tip of each leg. The robots utilized both the boons to move on rough as well as smooth terrains. This offered the robots high flexibility and greater movement ratio [1].
2) Michaud et al. [6] went a step ahead and used track, leg, and wheel for creating a hybrid mechanism for the robot. Here, the track flippers also used to comprehend as leg. The mobility services were astoundingly improved by using this mechanism.
3) Dubowsky et al. created a robot that would swim like a fish and crawl like a snake [5]. It has the applications on surface as well as underwater. The crawling abilities improved its applications in rough terrains. Ultimately, the researchers claim that the robot can swim faster than a fish and crawl faster than a snake [4].
4) Dubowsky et al. worked on a hybrid robot that could hop and roll. These micro bots are spherical in shape and had its applications in deep and narrow surfaces. The scholars used the micro fuel cells at an elevated energy density that could merge with inexpensive DEAs [5].
5) Shi et al. [3] created a hybrid locomotion for robot with the help of wheel and legged mechanism. It was in the shape of a rat and had 18 degrees of freedom. This brought the movement of the robot close to a real rat. The robot has two legs and two wheels that help it to accelerate rapidly, whereas the legs are helpful for slow movement.

3. **The Proposed New System.** In this paper, we are proposing a new kind of hybrid locomotion mechanism which is superior to only wheel and only leg mechanism.

When neither wheel mechanism nor leg mechanism work effectively for complex terrains, track-drive locomotion tackles the environment and helps robot move smoothly.

The track-drive mechanism is usually used in heavy military tanks and bunkers. There are certain construction vehicles as well such as cranes, where this system is used.

A track-drive is a hybrid locomotion mechanism that has several wheels attached to the machine and all the wheels are attached to one single belt acting like a conveyor belt. It helps the robot with movement in dirt, sand, gravels, and rough surfaces.

4. **Parts of Track-Drive Locomotion Mobile Robot.** There are certain parts applied in the design of track-drive locomotion which align together to work and achieve smooth motion in rough terrains full of small rocks, sandy surfaces, and smooth surfaces.

i. Wheels: The design needs to have 3 wheels on either side to support the robot in movement.
ii. Conveyor belt: The wheels on either side should be wrapped by a conveyor belt that would keep the wheel rotation in sync. The advantage of using a belt is that it can move in rocky and sandy surfaces.

In other mechanisms, there are computers, transmitters, receiver, mobile robot, microcontroller, and circuits.

The computer sends signal to microcontroller. On the other hand, the mobile robot commands the wheel and track mechanism. The receiver which is connected to the transmitter receives the signal and transfers it to microcontroller. The microcontroller sends the power to three wheels on either side and track mechanism as well.

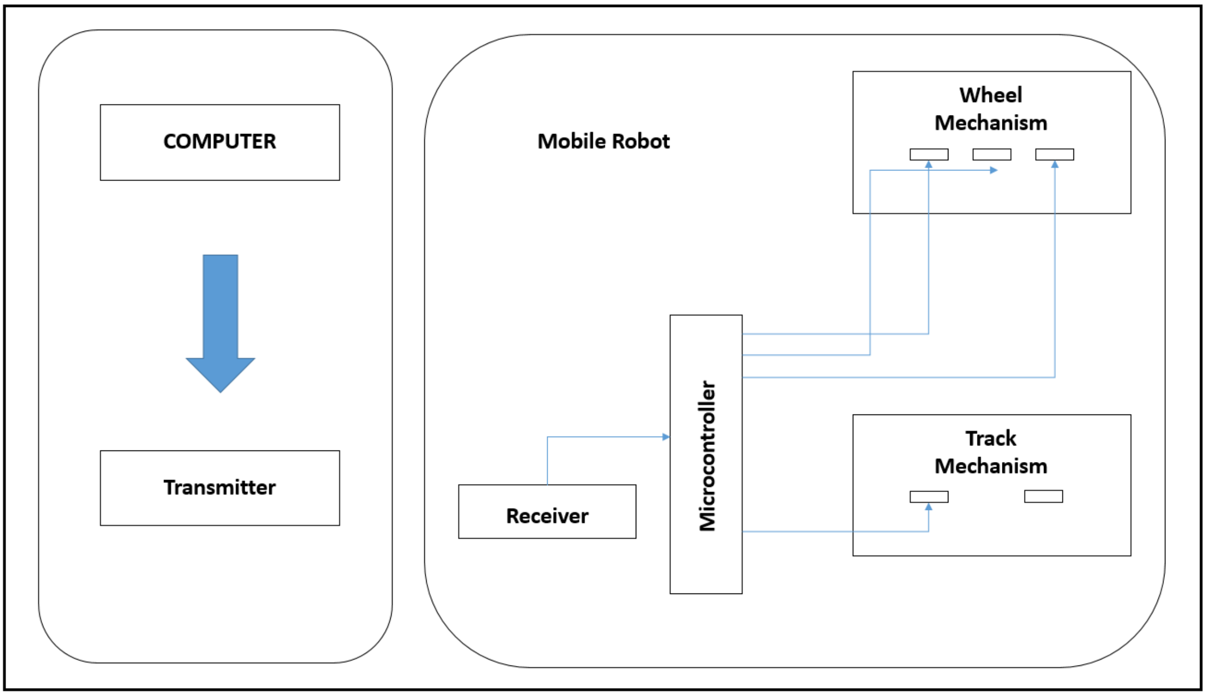

Figure 2. Transmitter & receiver

5. **Simulation.** When a mobile robot is required for uneven terrains, track-drive locomotion mechanism small robot seems to be a perfect fit.

One of the advantages is that the wheels can be individually suspended to maintain the traction against obstacles like rocks and stones. It reduced the chances of small obstacles like stones shaking the balance of the robot and make it fall.

In track-drive mechanism the steering seems to be a little more difficult than the same compared with wheel drive mechanism. We noticed that while the robot took a left turn, the right hand track was comparatively quicker than the other track. The steering radius can be adjusted according to the difference in speed between both the tracks.

Track-drive locomotion also enables the robot to climb on the stairs. The only limitation is the size of track-drive. If the size is bigger than the space between the stairs, it can climb easily. If the space between the stairs is larger than the track-drive mechanism, then the robot might fumble and will not be able to climb.

It was also noticed that the complete track-drive mechanism is able to incline at an angle of maximum 45 degrees, keeping the robot straight. If the robot does not stay upright during the track-drive locomotion inclination, it might fall and could not climb the stairs. A tri-star wheel locomotion could be a better option as well when it comes to making robots climb the stairs.

6. **Limitations.**

i. There were moments where the track started working its way off. The job of the track is to align all the wheels and aggravate motion. This can be reduced by adjusting wheel and track design.

ii. The second problem was similar to the first one, but from the perspective of wheel. There were times when the wheel started slipping inside the track, giving no chance to the track to make it move. The track was just not following along. Such situations occurred usually when the robot started moving up on the stairs. Perhaps it can be avoided by using wheels that have protruded teeth. The teeth would fit perfectly in the track.

This was also concluded that smooth surfaces do not go well with smooth surfaces. The track locomotion is certainly needed only in inclined and rough terrains.

7. **Discussion.** The working of the specified design depends upon the movement of two locomotive mechanism. One mechanism is wheel and the other is track. These are changeable locomotive system. The robot as per design could move on either wheel, or track, or the combination of both. These types of multiple movement mechanism allow robots to travel in difficult and different environments. They can interchange their mechanisms as per the environment. The design and control of the track wheel mechanism is quite simple and compatible when compared to other locomotive mechanisms. It is easy to follow, the mechanism, but there are a few limitations in this mechanism. One of the biggest limitations is that their mechanism can be flawed when it comes to more inclined surfaces.

They are unable to gain swiftness and acceleration in inclined surfaces. At smooth surfaces, they pick up good speed in seconds. The front wheel majorly drives the mechanism and the track helps to synchronize the front wheel movement with the other wheels.

A switchover module can be used to change the wheel track mechanism to solely tack and solely wheel locomotion.

8. **Conclusion.** The above stated study conveys that the wheel track locomotive mechanism works well for smooth, grainy and sandy surface. The wheel and track work in synchrony and perform the novel movement of the small robots.

The robot has good dynamic structure, although it bears a little difficult to climb inclined surfaces due to design limitations. The limitation of the mechanism not interacting with each other due to friction can be resolved by using wheel with pointed teeth. The teeth would create a grip with the track to ensure a smooth movement of the small robot.

This hybrid locomotion result falls majorly in the highly effective maneuverable motion category of mechanisms. Their transformation from one mechanism to other, such as, from wheel to track and from track to track-wheel is smooth. This novel hybrid locomotive mechanism for small robots is effective in different environments and terrains. In this paper, we are proposing a brand new sort of hybrid locomotion mechanism that is superior to simplest wheel and most effective leg mechanism.

When neither wheel mechanism nor leg mechanism paintings correctly for complex terrains, tune-power locomotion tackles the surroundings and enables robot circulate s-moothly.

The song-pressure mechanism is commonly used in heavy military tanks and bunkers. There are positive creation motors as nicely together with cranes, in which this system is used.

A music-power is a hybrid locomotion mechanism that has numerous wheels attached to the system and all the wheels are connected to one unmarried belt performing like a conveyor belt. It helps the robotic with motion in dirt, sand, gravels, and rough surfaces.

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