Design and analysis of a wheeled type robot prototype for uneven terrain

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ABSTRACT: This research discussed the design and construction of a mobile robot prototype for uneven terrain with a wheel type mechanism to ensure the stability of the mobile robot prototype for a full ground contact. The design of the prototype is different from the usual design, inspired by the rover which consists of a supporting system and shock absorber to enhance the stability when moving through an uneven terrain. In order to improve the function of the mobile robot, an obstacle avoiding function were added to prevent the robot prototype from collision. In this research, the mobile robot stability test was evaluated with two different PWM values, i.e.: PWM200 and PWM255. It was depicted that the change of the tilted angle is still under control, which is below 90^{o}. In this case, it is impossible for the mobile robot prototype to tilt due to high thrust during motion as the angle changes is within a safe range.

Keywords: M*obile robot; Uneven terrain; Freedom of suspension*

1. INTRODUCTION

The purpose of this research is to develop an uneven terrain robot prototype which mainly can be used on several types of terrain. Mobile robot for uneven terrain is defined as a vehicle which is able to go through rough path without having any difficulties. All-terrain vehicle has advanced mobility systems for enabling traversal over uneven terrain. These robots are progressively used in various applications such as environmental explorations, mine detection, agriculture, operations at hazardous sites, search and rescue operation and firefighting [1]. Nowadays, a great number of natural disaster make the mobile robots more necessary. High demands for the use of mobile robots to help with the problems quickly and the capability due to terrain adaptability of the vehicle [2]. There are a lot of robot designs that can undergo uneven terrain function based on the change in accordance due to customer demand. There are three major classifications of locomotion systems in the field of rescue: surveillance robots; wheeled and tracked; and legged systems. Tracked systems are largely used because of their capability to move on uneven terrains and avoid obstacles. Wheeled robots can climb up obstacles but depending on the diameter of the wheels while a smaller tracked robot has the same capability. For the Legged robots, the number of actuators and sensors is fairly high which makes it more expensive and their analysis more intricate [3].

2. METHODOLOGY

In this research, the aim is to improve the movement of the mobile robot for uneven terrain function. In order to achieve the flexibility of the motion, some mechanism is attached. The mechanism added are: (a) suspension system, (b) supporting bar and (c) universal joint.

2.1 Mechanism

The suspension system is to maintain the shock movement while it is in motion. It allows a relative motion upon body and wheel. The suspension system mechanism is shown in Figure 1. The supporting bar is connected to assist the wheel attached to the suspension, so it avoids being miss - alignment during motion. The connection of the supporting bar from the mobile robot body, and the connection at the front and rear holder are shown in Figure 2. Furthermore, the attachment of the supporting bar is to evade a critical bend generated from the suspension as it is the only mechanism that will support the mobile robot body. Otherwise, the system will not be stable. The last mechanism is the universal joint which is connected on the rear wheel shaft of the mobile robot in between the rod and the wheel as shown in Figure 3. The two rigid rods connect with this axle to create a smooth angular change at the rear wheel during turning motion.

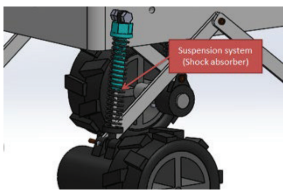

Figure 1 Suspension system

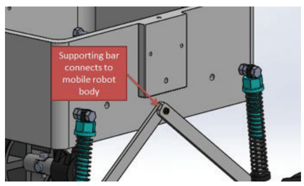

Figure 2 Supporting bar

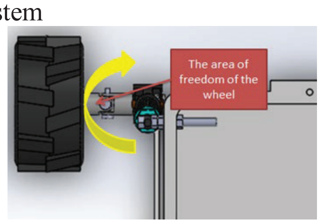

Figure 3 The use of universal joint.

2.2 Wheeled type robot prototype

The overall design of the robot prototype is shown in Figure 4 which consists of suspension system, supporting bar and universal joint in order to be driven on an uneven terrain and IR sensors which are connected to each sides of the mobile robot for obstacle avoidance. Figure 5 shows the fabricated prototype. The obstacle avoiding function will help to avoid the mobile robot from collision. The flowchart of the obstacle avoiding function is shown in Figure 6.

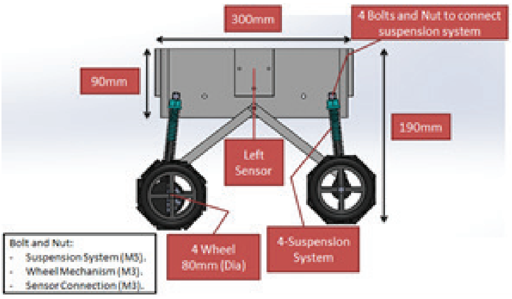

Figure 4 Design of the prototype using SolidWork.

Figure 5 Fabricated prototype

3. RESULTS AND DISCUSSION

3.1 Mobile robot stability test

In this research, the stability test is evaluated to ensure the stability of the mobile robot prototype for full ground contact. The data collected is the changes of angle of the mobile robot when it is in motion vs. the distance where the angle is captured. The mobile robot speed was set to two different PWM value: i.e.: PWM200 and PWM255. The reason of the experiment of collecting the changes of angle of the mobile robot due to the thrust is because to identify the correct angle of the mobile robot before it reaches the maximum angle of 90º where it might cause the mobile robot to tilt upside down. Based on the results in Figure 7 and 8, the change of the angle is still under control, which is below 90º. In this case, it is impossible for the mobile robot prototype to tilt due to high thrust during motion as the angle changes is within a safe range.

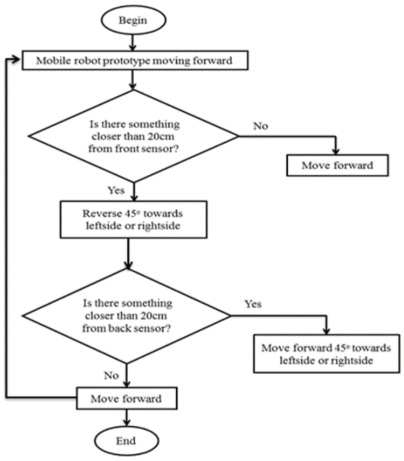

Figure 6 Flowchart of obstacle avoiding function.

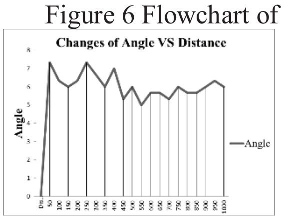

Figure 7 200PWM.

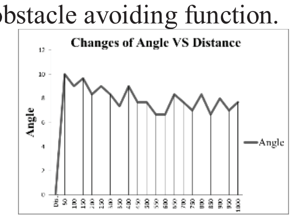

Figure 8 255PWM.

4. CONCLUSION

In conclusion, a wheeled typed robot prototype was successfully design, fabricated and tested for motion on uneven terrain. The results suggested that the robot has a satisfactorily stable motion, which is below 90º tilt for both both PWM200 and PWM255, respectively.

ACKNOWLEDGEMENT

The authors wish to express their gratitude to Universiti Teknikal Malaysia Melaka (UTeM) for supporting the research and publication. This research is supported by Ministry of Education Malaysia (MOE) under the Fundamental Research Grant Scheme (FRGS) grant no. FRGS/2018/FKE-CERIA/F00353.

REFERENCES

[1] A. Tharakeshwar and A. Ghosal, "A three-wheeled mobile robot for traversing uneven terrain without slip: Simulation and experiments", in *Mechanics Based Design of Structures and Machines*, vol. 41, no. 1, pp. 60-78, 2013.

[2] W. Jia, H. Pu, X. Luo, X. Chen, D. Huang and O. Bai, "Reliable control of a quadruped walking robot in uneven terrain environment based on noninvasive brain-computer interface", in *Proceedings of IEEE International Conference on Mechatronics and Automation*, August 5 - 8, Chengdu, China, 2012, pp.1608-1614.

[3] S. H. Turlapati, A. Srivastava, K. M. Krishna, S. V. Shah, "Detachable modular robot capable of cooperative climbing and multi agent exploration" *in IEEE International Conference on Robotics and Automation (ICRA),* Singapore, May 29 - June 3, 2017, pp. 255-260.