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Designing Of Wheelchair Based On Rover Robot

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Abstract— *Driving a manual wheelchair is a difficult task and people with disabilities face many problems in moving and steering using it. In addition to that, the electric wheelchair is expensive for people in developing countries. The purpose of this project is to design a low-cost wheelchair by considering the developing countries' environment and roads where it is nearly impossible for the disabled to move freely without the need for help. The constructed wheelchair has six wheels based on the rover robot rocker-bogie mechanism which makes it more flexible in moving on the terrain. PVC tube has been chosen as a wheelchair material due to it is good sustainable stress, low cost, and availability. Arduino UNO module is used to control the wheel's direction by push buttons. The proposed wheelchair deletes the problem of the normal wheelchair in addition to its ability to adjust the size to fit a growing person especially kids.*

Keywords— wheelchair; rover robot; disability; rocker bogie; mechanical design.

1. INTRODUCTION

Person's environment has a great influence on the experience and extent of disability. According to the World Health Organization's Disability Report, most wheelchairs in developing countries have been rejected because it is not suitable for the environment, and the person with a disability needs assistant to be with them all the time [1]. The purpose of this project is to present the preliminary design of a wheelchair based on the rover robot platform principle in order to enhance disabled people's mobility and accessibility. The concept of movement relay on rover robots used for space exploration. These types of rovers have flexible wheels mechanism, rocker-bogie navigation system is one of the designs that has been used on NASA's Mars rover Sojourner it consists of two arms with a wheel mounted to each. Both arms are connected through a movable joint. This enables us to have a suspension-based mechanism that distributes the vehicle load as evenly as possible even on bumps and irregular surfaces [2][3].

Fig. 1. *NASA Sojourner rover*

The main aim is to provide access to affordable wheelchairs for all community classification with the ability of easy maintenance, flexible movement and size adjusting.

This paper is organized as follows: Section 2 takes an overview of related work. Section 3 presents the system design and the implementation of the hardware while section 4 the results are presented and discussed, and finally, our conclusions and further work are presented in section 5.

2. RELATED WORK

In order to understand the recent state of art, different designs of a wheelchair are reviewed below. A reconfigurable prototype of a wheelchair presented in [4], the design made to fit an average weight of 35 kilograms, but it can also resize to fit an older adult. In addition to flexibility in sizing, the proposed wheelchair has a feature of sit-to-stand and stand-to-sit which gave the child more confidence in moving around. In [5] the author proposed a model that aims to develop a wheelchair with a human-machine interface

(HMI). The idea is to enable the user to save his/her own settings, it can be used with different types of disabilities. The interface of the model contains; joystick for controlling moves, hand movement tracker, and eye tracker and suggests adding an obstacle detection system and brain signal interface in the future. K. Hameed et. al provides an in-depth analysis of the work of stochastic dynamic programming for smart wheelchair using Euler-Lagrange equations for controlling the motion dynamics [6]. In [7] a model of autonomous vehicle RANGO rover has been presented, the main feature is that it has a stereo vision system which enables it to avoid obstacles in the unknown environment. R. Siegwart et. al present an innovative design of a wheeled rover that enables it to climb stairs and moving in rough terrain smoothly using six wheels [8]. Overall, these studies provide up to date insights into smart wheelchair features and the rover's design. In this paper, we introduce a design of wheelchair for disabled people considering the African environment and roads where it is nearly impossible for the disabled to move freely without the need for help.

3. DESIGN AND IMPLEMENTATION

3.1 System Overview

The proposed wheelchair is designed to help disabled people to have more flexibility in stirring by making a design like rover robot's moving system. The system is divided into two parts; Mechanical and Electronic. The mechanical part contains the frame chassis, wheels and sitting chair. On the other hand, the Electronic part contains the hardware and software needed to control the wheelchair.

3.2 Mechanical Design

3.2.1 Frame

The frame is the structural outline that supports most of wheelchair's components. The design the fame platform is similar to rover robot rocker bogie, with small change in the center connection of the mechanism, as it shown in Fig. 2, the connection moved to the front to adjust the design to be suitable.

Fig. 3 shows the frame design in SOLIDWORKS software [10]. The design has four main parts;

a) Oblong Part which is shape the chair and holding the battery, sitting chair and other parts.

b) Rocker Buggy platform which is contain and holding the wheels.

c) Gear motors with suspension system; it designed by same mechanism of NASA's Rover robot.

d) The leg part; which is used to hold the wheels together with Gear motors.

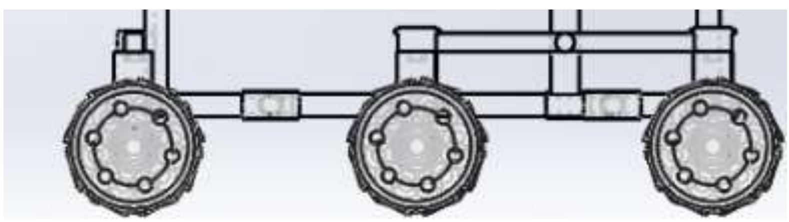

Fig. 2. *Frame connection*

Fig. 3. *Frame design*

The wheelchair dimensions were chosen based on the required space for normal children with comfortable and ergonomic considerations. Fig. 4 presents an overview of the wheelchair's frame dimensions.

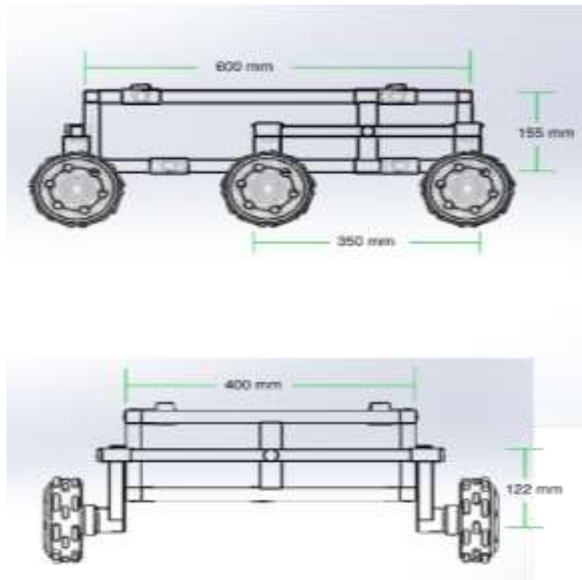

Fig. 4. *Frame dimensions*

3.2.2 MATERIAL

PVC pipe have been selected for frame material with an outer of 25mm and 4mm thickness. The property of this material is given in Table I.

Table 1: Properties of the PVC 25mm

Property	Value
Compressive strength	1250N
Impact resistance	2J – 5C
Tempreature use	-5°C - 60°C
External influnces	IP 54

3.3 ELECTRONIC DESIGN

The aim of the electronic circuit is to control the movement of the wheelchair, the hardware interface includes Arduino UNO [11], DC gear motor, relays and push-buttons. In order to verify performance and operation before implementation, the simulation was done using PROTEUS software [12]. As shown in Fig. 5 the circuit consists of 8 relays, 4 for the forward wheels and 4 for the backward wheels. To change the wheel direction forward or backward, two relays are used for each wheel's motor. When the user pushes the right button, the wheels on the left side turn on and the wheels on the right side turn off. On the other hand, when the user pushes the left button, the wheels on the right side turn on and the wheels on the left side turn off.

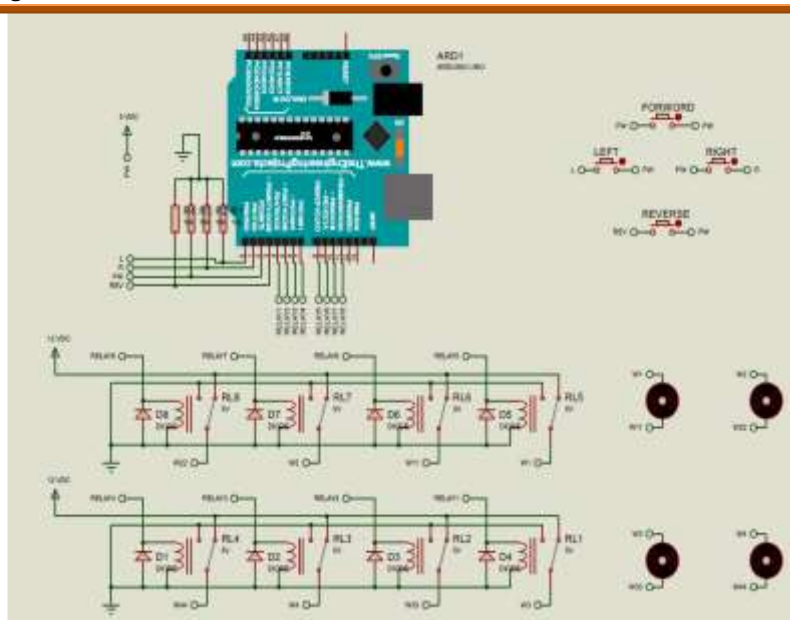

Fig. 5. *Electronic circuit*

4. RESULTS

4.1 Analysis

To evaluate and validate the finalized prototype, some analysis has been done on the frame using SOLIDWORKS software. A load of 100 N was applied to the center of gravity. The stress analysis was done by using the maximum principal stress theory [9]. The loading and boundary conditions applied during the analysis is as shown in Table 2. Fig. 6 and Fig. 7 shows the results of the analysis when applying force. The complete structure of the frame appears in Fig. 8. and the final prototype shown in Fig. 9.

Table 2: Analysis parameter

Parameter	Condition
Type of element	PVC rigid
Boundary conditions	Frame legs - fixed
Loading condition	100N on model

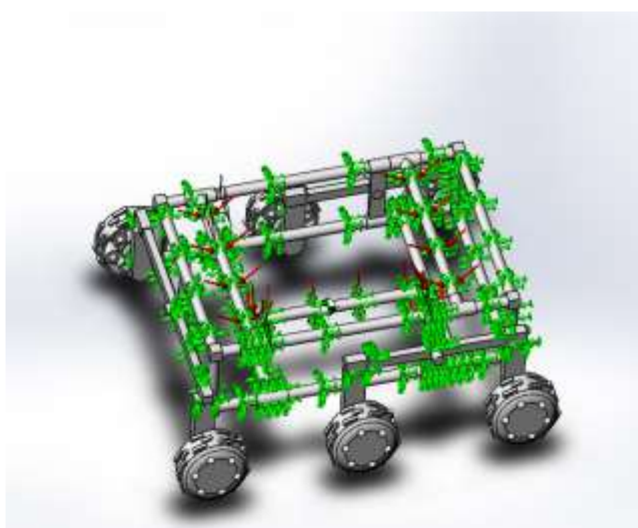

Fig. 6. *Force applaying position on the frame*

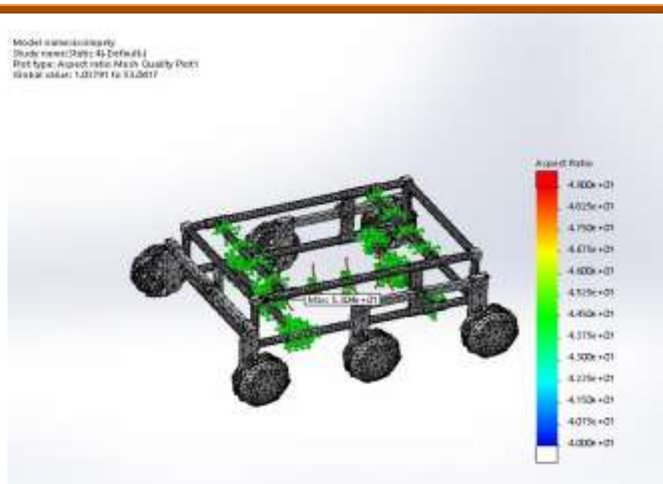

Fig. 7. *Force analysis with meshing on the frame*

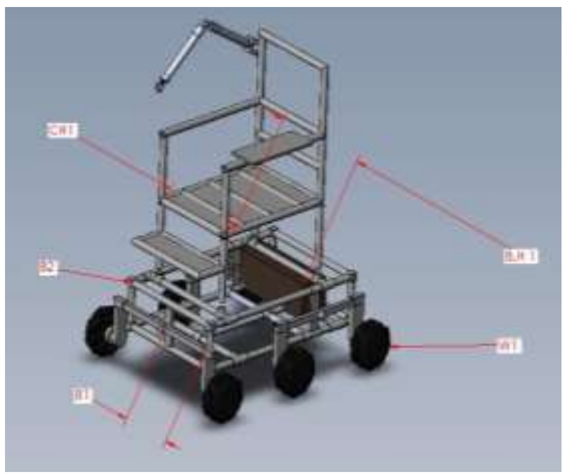

Fig. 8. *Complete structure of the frame*

Fig. 9. *Prototype*

4.2 COMPARISION

Table 3 shows a comparison between the proposed wheelchair, normal wheelchair and electric wheelchair. It is apears that the proposed wheelchair has features over the others specially in cost, mobility and size adjusting feature.

Table 3: Comparison between the proposed wheelchair and other wheelchairs

	Proposed wheelchair	**Normal wheelchair**	**Electric wheelchair**
Cost	$400 - $600	Up to $2000	Up to $15000
Material	PVC Tube – Polymer	Metal steel Carbon aluminum	Metal, steel carbon Fiber aluminum Titanium
Control	Arduino	Non	Control system
Mobility	High	low	High
Weight capacity	Up to 25kg	Up to 136kg	Up to 226kg
Adjust size	Yes	No	No

5. CONCLUSION AND FUTURE WORK

The main goal of this paper was to design a low-cost wheelchair that can move flexible in a harsh and terrain environment. This was done by using six wheels depending on the rocker-bogie mechanism. The prototype made of PVC tubes material which makes it low cost compared with other wheelchairs that used metallic materials, in addition to that the PVC gives the wheelchair a feature of adjusting it to fit the size of a growing person. The current prototype has only designed for children with weight less than 25kg. Further work can take into account the following aspects: increase the weight and size availability, electronic circuit improvement to enable more controlling tools, obstacle detection, and stair climbing mechanism.

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