Design Modification and Manufacturing of Rover Type Stair Climbing Vehicle

ME-362, Instrumentation and Measurement Sessional

Submitted By: Group 10 (ME-08)

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May, 2012

Abstract

MIST Team Seven has designed a stair climbing vehicle that is able to climb stairs, move on flat and rough surface. The purpose of this document is to document the entire job performed in order to design and build the structure of the project. This report also contains the alternative design that could have been built and also presented the logic for selecting this particular design. The project is successfully completed with completion of designing, procurement, construction and final inspection by testing the structure.

This structure was built by the MIST Team Seven group from Military Institute of Science and Technology of Bangladesh. Frequent testing was done on individual components in order to ensure all the components were working before the final construction. The project was completed within the estimated time and under the estimated budget. The structure was tested several times and the results were found to be repeatable. The design has satisfied the entire design requirement set out in the design requirement memo.

Acknowledgement

First of all many thanks to Dr. Engr. Md. Alamgir Hossain sir, Asst. Professor, Department of Mechanical Engineering, Military Institute of Science and Technology, Dhaka, our respected project supervisor, for providing us the opportunity to work on this project. Our team is inspired by his previous effort in development of Stair Climbing vehicle in MIST and we must mention his enormous. His help stimulating suggestions and encouragement helped us all the way through the course. It has definitely challenged our capabilities and given us the chance to broaden our mind.

Heartiest gratitude to our group members for their enormous efforts and contribution.

Then we would also like to express our outmost gratitude to our parents for their love and support affection and inspiration.

Last but not the least; let us not forget the mercy of almighty Allah who empowered us to do all good on Earth.

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December, 2009

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CHAPTER-1

Introduction

1.1 Introduction

The purpose of this report is to conclude the project of stair climbing vehicle designed by Group 10 of ME-08 of Military institute of Science and Technology. This project was built to introduce a completely new design which is different form all the other design of stair climbing vehicle made before. It is a fusion of Tri star wheel mechanism and mars rover robot in order to facilitate the transportation of load over both stair and flat surface. There is lot of buildings where it is difficult to lift loads due to structural congestion in the building. So it is a very useful vehicle which helps to lift loads in small heights in places like industrial sector, hospital, libraries and construction areas etc. Not only this, it may also be used as a stair climbing wheel chair robot or help the physical disabled persons in climbing stairs. This may also come as a useful vehicle to Military purposes where it is impossible for the soldiers to reach. Besides this we have also heard about Mars Exploration robot where the main purpose of the robot is to collect data and move on uneven surfaces present in those planets. So over all it is a multipurpose vehicle which can be used in various fields. The work of our team was to build a mechanism of this type of robot which provides stability, efficient locomotion and use ability in multiple fields

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All design requirements set for the design as described in section 1.3 have been met. The process in which the team followed in designing the vehicle is outlined in chapter 2, as well as the resultant alternative designs. In chapter 3 the components of the final design are described along with their construction and materials. A financial analysis of the project, showing the budgeted money, and the actual funds required can be found in chapter 4. Further discussion of testing results and requirements are discussed in chapter 5.

The designed structure is an 8 wheeled, DC electric motor driven vehicle. The purpose of the vehicle is to climb up and down stairs in one direction (both forward and reverse). If the polarity of voltage source is reversed using a switch then the vehicle can move in both forward and backward directions. The climbing mechanism only functions in the forward direction. The tri wheel support frame, platform, front and rear legs are built from wood creating a robust and light structure. It is powered by standard 220-230 V AC power from main line in household that is sent through a rectifier. The final design of the vehicle is displayed in Figure 1. The project is intended as a proof of concept of the tri-wheel and rover concept used by Mar exploration Robot of NASA.

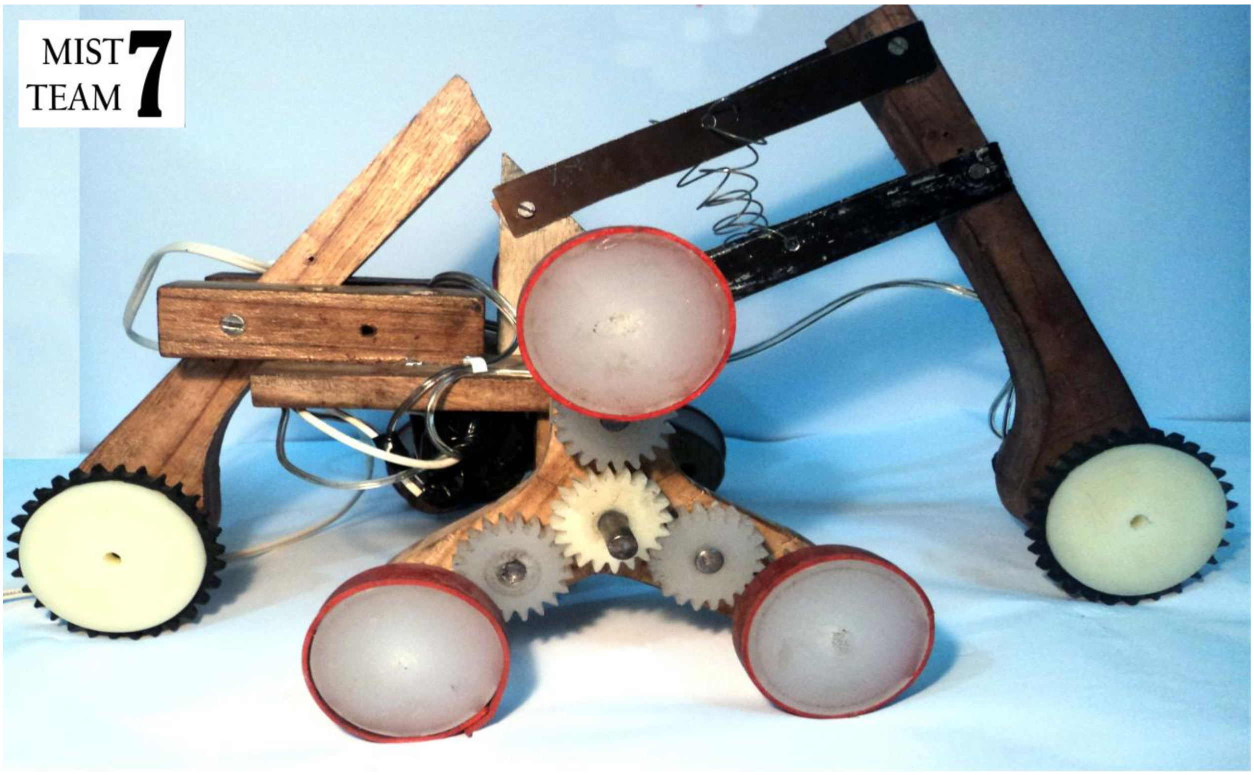


Figure-1: Side view of the Structure

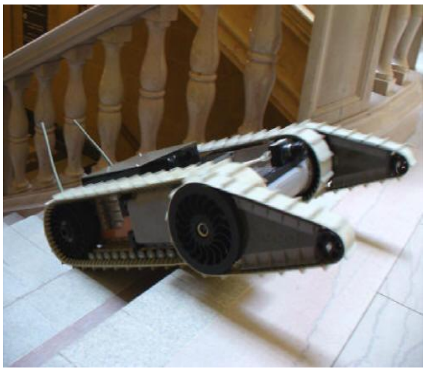
1.2 Application of Stair Climbing Vehicle

1. Can be used as Mars Exploration robot with Autonomous system

Figure-2: Mars Rover Exploration robot

2. Can be used as a stair climbing wheel chair vehicle or most commonly in hospital areas

Figure-3: Wheel Chair Stair Climbing Robot



3. Can be used in Military operations

Figure-4: Robot Used in Military Operation

4. Can be used in lifting loads on stairs.

Figure-5: Lifting Load with Stair climbing Vehicle

1.3 Design Requirement

MIST Team 7 has considered certain design requirement in order to develop a strategy to design and construct the vehicle. These requirements include dimension restrictions, effectiveness and safety. The vehicle is not too heavy to carry by one person. It is a portable vehicle. The target weight of the vehicle was 5 Kg. The combined size of the vehicle is to fit through a standard doorway of width 30 cm and height 25 cm.

It will be powered by standard AC electricity, delivered to the device through an extension cord. The vehicle will be fabricated mainly from wood. Smaller components mainly dealing with the drive system, such as gears, will be made of Nylon 66. Frame assembly components, such a bolts and supports, will be selected based upon cost and weight.

The vehicle will be able to climb and descend stairs at a speed no less than one stair per 6 seconds. The vehicle will climb perpendicular to the stair edge, and will be designed to climb straight stairs without curves or turns. It will be designed to climb stairs with a riser height of 2.5 inches and a tread length of 14 inches.

The drive system will be controlled by a user-operated handheld device. The vehicle should be comfortable for one person to maneuver, and the controls will require minimal input from the operator. As well, the controls will allow for operation from any location around the machine, to prevent a situation where the operator is forced to stand in a dangerous position, i.e. behind the machine.

A basic operations guide will be provided instructing the user on safe and proper usage of the vehicle. We have set a target for the vehicle to last at least one year with minimal maintenance.

CHAPTER-2

Designing

2.1 Design Process and Alternative Designs

Before this there were a lot of researches and experiments on stair climbing vehicles in different parts of the world which was based on project outlines, manufacturing design, technologies, power transmission methods, controlling behaviors of the robot etc. But all of them had the basic objective of climbing the stairs smoothly and precisely.

The following subsections present several designs, each with their pros and cons extensively discussed. Each design consists of a drive module. After the designs are presented, the best choice for each component is determined through the use of design selection matrices.

2.1.1 Design I - Linear Actuator Leveler with Tread Drive

In this design a linear actuator (hydraulic or pneumatic) is attached to the rear of the frame along with a payload. The linear actuator can be controlled by first measuring the tilt angle of the payload base with respect to horizontal direction through an accelerometer, and then feeding back the error signal to form a closed-loop control system.

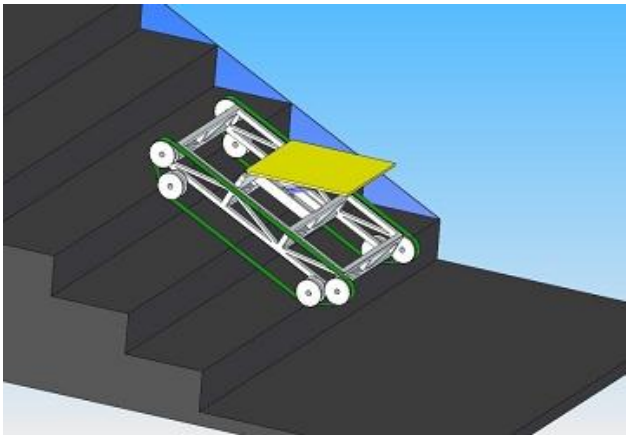


Figure-6: Linear Actuator Leveler with Tread Drive

This system will require a controller and one data acquisition (DAQ) card.

Positive Aspects of the design:

1. Tuning the leveling actuation will be automatically controlled through a computer controlled system, (e.g. using LabView) which is usually easier than tuning a physical system.
2. The design is good for various terrains and there is no additional design necessary to drive from floor to stairs.

Negative Aspects:

1. The electrical actuating system may be hard to troubleshoot; the actuator and DAQ card can be expensive; and the system requires programming.
2. The treads may slip and more power is required to move horizontally compared to using wheels.

2.1.2 Design II - Corkscrew Drive

The cradle leveler uses gravity to continuously balance a payload. The cradle is placed between two triangular frames and rotates about a pin hinge. The pin is damped to reduce oscillatory swinging. The frames are high enough so that the cradle has enough clearance to rotate when climbing a set of stairs as defined in the design requirements.

Positive Aspects:

1. The design is favorable because it will automatically level without pre-programmed software,
2. It is easy to maintain, and is uncomplicated and easy to design.

Negative aspects:

1. It will be difficult to tune the damping as the group will have to build and test different prototypes.
2. The cradle raises the center of gravity making the machine more unstable.

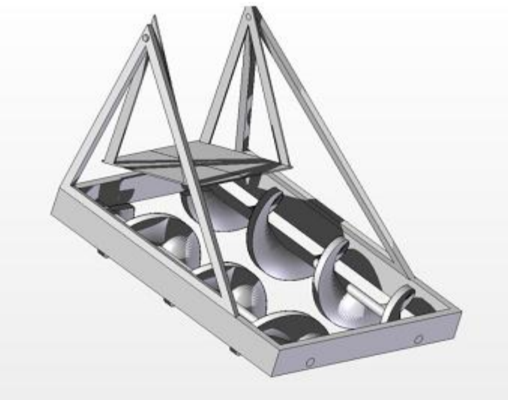


Figure-7: Corkscrew Drive

2.1.3 Design III –Tri-wheel Drive

The chosen design uses the tri-wheel drive system.

Positive Aspects:

1. Smoothness of operation
2. Excellent ability to be sized up for more robust,
3. Higher cost commercial designs

Negative Aspects:

1. It will be difficult to precisely tune the damping.

The tri-wheel stair climbing system has four sets of three driven wheels. Power is transmitted to each of the three wheels in a set by a gearing system, with a central gear connected to the motor, intermediate gears, and one gear directly connected to each wheel, forming a semi-planetary gear set. The whole mechanism rotates the wheel set to climb the stairs, as shown in figure.

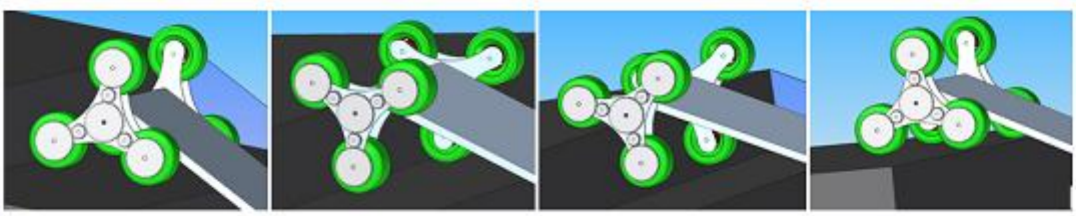
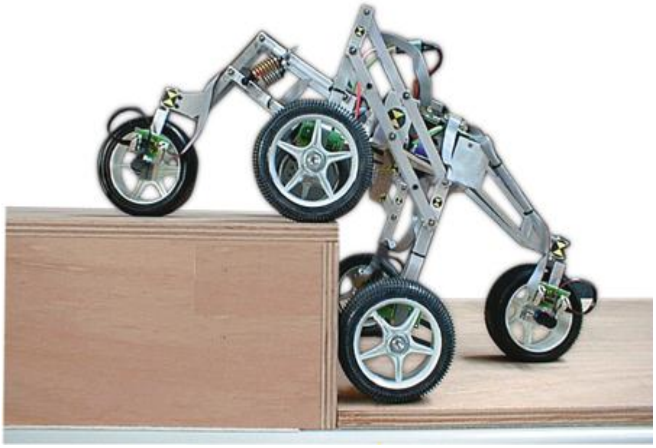


Figure-8: Tri wheel Drive

2.1.4 Design IV – Shrimp Rover Model

In the year 2000 a different type of climbing mechanism was developed based on rover mechanism which was able to run over stepped path. They had used a rhombus configuration rover. This design had a rhombus configuration rover which had one wheel mounted on a fork in the front, one wheel in the rear and two bogies on each side. Although the bogies had a special geometry, it was the same basic principle as used for a train suspension: a couple of two wheels were mounted on a support which could freely rotate around a central pivot. While operating the front fork gets on the step, compressing its spring then the energy accumulated in the spring helps the first wheel of the bogie to climb. When the second bogie wheel is in contact with the stair, the bogie turns around the step.



At this time the center of gravity reached almost its final height. Finally, the last wheel can easily get on the step making the whole structure climbing the stair.

Figure-9: Shrimp Rover Model

Positive aspects:

1. It can climb the stairs twice the wheel diameter.
2. It can be made to move on any type of surface.

Negative aspects of the project:

1. This design showed lower stability over lower steps.
2. The rhombus configuration makes the design clumsier.
3. Limitation of load handling capability and low rigidity of the structure.

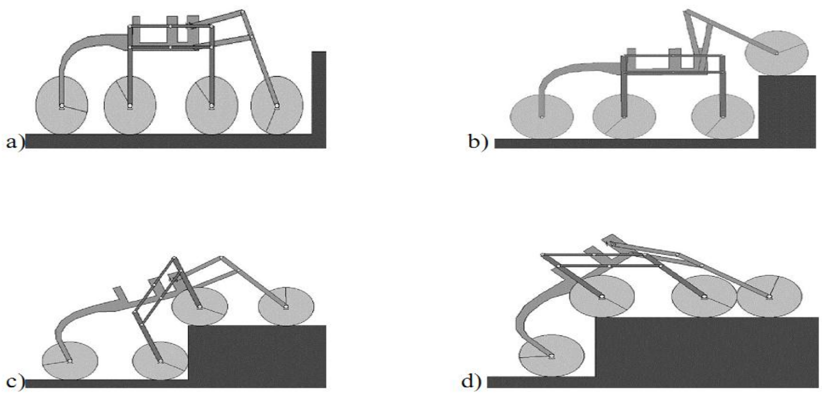


Figure-10: Different orientation of Shrimp Rover Drive

2.2 Designs made previously in MIST

Courtesy: Dr. Engr. Alamgir Hossain, Nafis Ahmed Chowdhury, Rubaiat Islam Linda, Shamimuzzaman Akhtar; “Design And Manufacturing of Stair Climbing Vehicle” Proceedings of the IEOM, International Conference on Industrial Engineering and Operations Management (IEOM), Dhaka, Bangladesh]

Figure-11: Design and Manufacturing of Stair Climbing Vehicle

Courtesy: Dr. Engr. Alamgir Hossain, Mustafa Shafee Saleheen Towfique, Tauhidul Hossain; “Design Modification and Manufacturing of an Intelligent Stair Climbing vehicle with self-controlled system”

Figure-12: Design Modification and Manufacturing of an Intelligent Stair Climbing vehicle with self-controlled system

The main Parts Used in the previous models:

1. **For the Structure:** Design And Manufacturing of Stair Climbing Vehicle

    a) Two electric ac powered motors
    b) Two capacitors
    c) Set of pinions
    d) Chain drive
    e) Journal Baring
    f) Sprockets
    g) Bearing of size 6203
    h) Nuts and Bolts
    i) Electric wiring

2. **For the structure:** Design Modification and Manufacturing of an Intelligent Stair Climbing vehicle with self-controlled system

    Additional Components

    a) Ball clutch
    b) Electromagnetic coil
    c) Photo electric sensor

3. For the Present Structure: Design modification and manufacturing of rover type stair climbing vehicle

    Modification:

    i. No use of sensor
    ii. Use of DC motor
    iii. Use of wooden frame and platform
    iv. Use of front and rear wheel and removing two tri wheel frames
    v. Removing electro magnet
    vi. Intermediate shaft reduced to one

2.3 Selection of the design

After long analysis and discussion among the team members and the supervisor the final design was sought out. The designed structure is shown in the figure below.

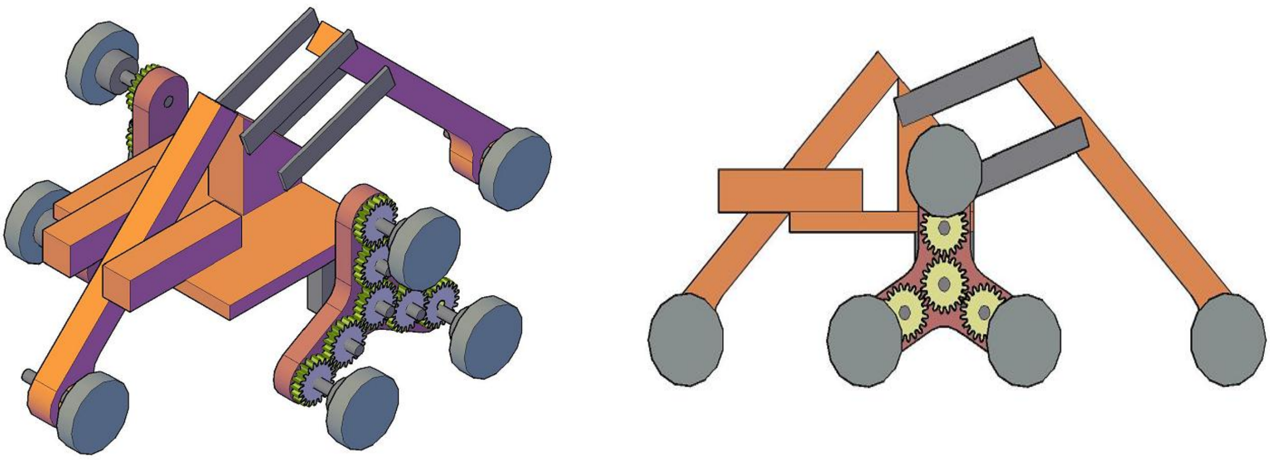


Figure-13: AutoCAD Design of Rough Design

The reason for selecting this design was:

1. To build a completely new design in the field of stair climbing vehicle.
2. It is light and portable.
3. Easy construction. Can be built easily with minimum effort.
4. It provides better stability to the structure due to presence of the tri wheel mechanism. Comparing with the rhombus configuration discussed in the earlier section the tri wheel mechanism provides better stability during locomotion.
5. The electrical circuitry is very simple as it does not require any microcontroller to control the system. It can be operated simply with a handheld on off switch. The switch can reverse the polarity of the DC voltage supplied to motors and hence help the vehicle move in both forward and backward directions.
6. The structure is simple and can provide wide variety of application such as military use, hospitals, lifting loads etc.

CHAPTER 3

Design and Construction

The following subsections outline the detailed design of the major component of drive systems and frame designs are discussed in depth.

3.1 Drive system

The drive system is composed of the tri-wheel assembly, the motors and transmission, and the control system. This section describes the parts of the tri-wheel assembly and the power and torque parameters of the motors. The mounts and drive methods are also presented.

3.1.1 Tri-wheels

The vehicle drives on an assembly of three wheels and a front and rear wheel mounted on a fork. Two wheels from each tri wheel and front and rear wheel are in contact with the ground when the vehicle is driving on flat ground. While operating the front fork gets on the step, compressing its spring then the energy accumulated in the spring helps the tri wheel to be able to rotate about the main axis. The geometry of the entire tri-wheel assembly is designed to ensure no part of the assembly other than the wheels come in contact with the stairs during the climbing process. The components of the tri-wheel assembly are discussed below. A picture of the fully constructed tri-wheel is shown in figure 14.

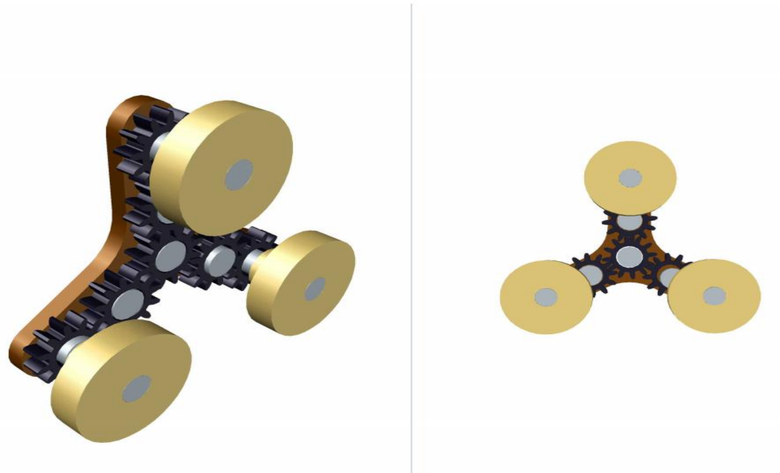


Figure-14: Tri Wheel Frame

3.1.2 Tri-Wheel Faceplates

The tri-wheels require the manufacturing of two faceplates made of 0.5” wood as shown in figure 15. The faceplates have seven seats to hold 8mm bore bearings, which support the wheel axles and gears. These seats, as well as the larger center bearing seat, were machined separate from the faceplates. The faceplates outer shape was produced from a local carpenter shop and the drilling operations were performed in Harun Engineering works Limited in Dhaka.

Figure-15: Tri-Wheel Faceplates

3.1.3 Gears

The tri-wheel’s sun gear on each tri-wheel set is connected to six other gears, 3 idler gears and three wheel gears. This gear arrangement transmits power to the wheels from the sun gear at a 1:1 ratio. The wheel and wheel shaft arrangement are shown in figure 17. The gears were made of Nylon 66 which was processed in the engineering shop. The maximum number of teeth in the gear is 20. A metal pin of diameter slightly greater than the boring diameter of the gear and bearing was made to make the pin fit into the gear and Bearing and hold it together. This technique is used all over the tri wheel star.

Figure-16: Bearing

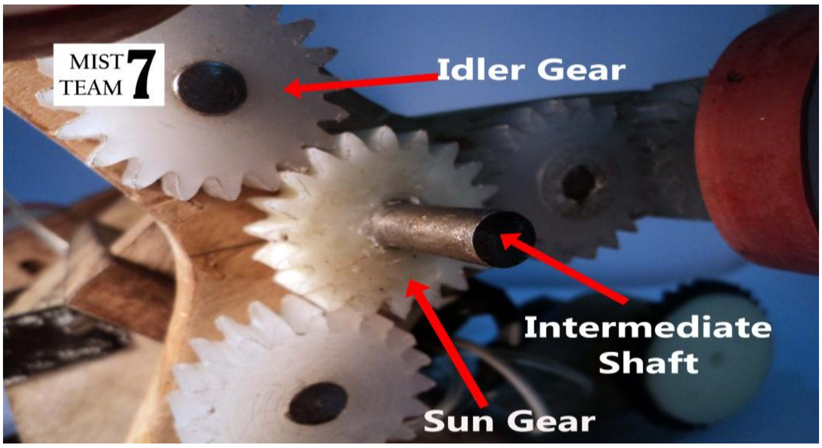


Figure-17: Gear and Shaft Arrangement

3.1.4 Front and Rear Wheel

The main specialty of this structure lies in the front and rear wheel of the structure. There is a front and a rear wheel supported by a fork. The wheels are attached to the motor shaft. The wheels are made of Nylon 66. The motor is also fitted in the fork as shown in the figure 18. While operating the front fork gets on the step, compressing its spring then the energy accumulated in the spring helps the first wheel of the bogie to climb. Besides this the rear wheel also simultaneously provides some thrust which helps the structure to climb easily. In order to get some advantage from friction we also added a studded rubber band wrapped around the circumference of the wheel. This helped us to increase the friction between the surfaces.

Figure-18: Front and Rear Wheel

3.2.1 Motors and Power Transmission

The stair-climber is powered by two 12 V DC motor, purchased and used. This motor is manufactured by Koojae Company according to which it had the following configurations

Specifications

Low rpm dc motor
Voltage: 3 -12v
Speed: 1.1-7200rpm
Long lifespan, quite high torque

Rated volt.v	No load		Load torque				Stall torque	
	Current	Speed	Current	Speed	Torque	Output power	Torque	Gearbox
	mA	r/min	mA	r/min	kg ·cm	W	kg· cm	mm
12	≤20	100	≤110	73	0.8	0.6	2	22

There were three motors in total; one for driving the front wheel, one for driving the shaft and another for driving the rear wheel. The motor shaft carried a small driving gear of 20 teeth which was meshed with another gear of same number of teeth placed in the intermediate shaft of the tri wheel frame.

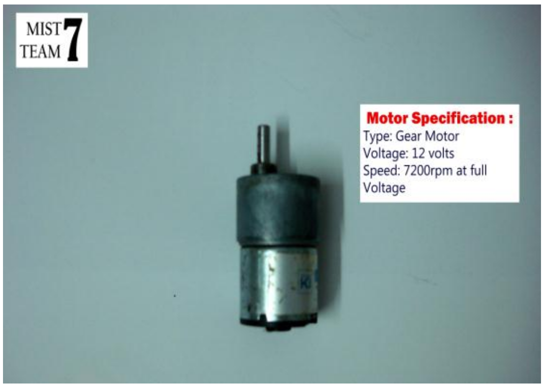
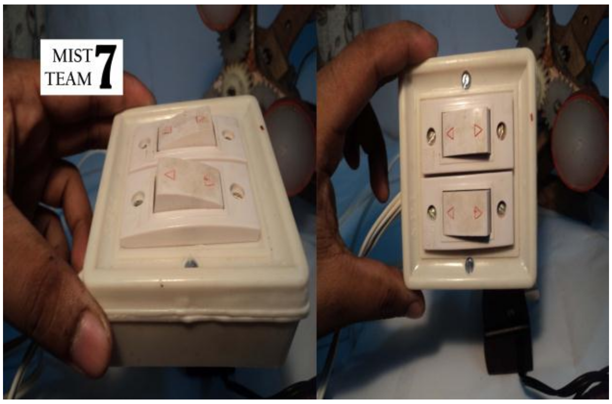


Figure-19: DC Gear Motor

3.2.2 Manual control by switch



The control system of the vehicle is very simple. The whole electrical circuitry has the following components:

1. Connecting wires
2. Adaptor
3. 3 motors as load
4. Two on off switch placed in a switchboard.

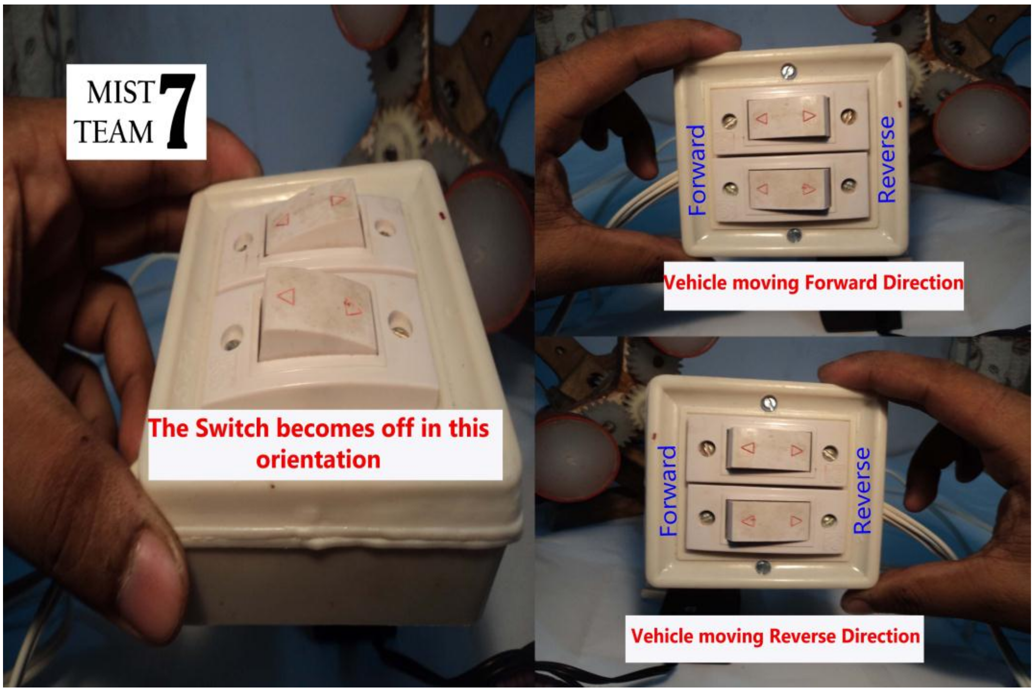


Figure-20: Switch

3.2.3 Adaptor

In this setup the power was given through an adaptor of following ratings:

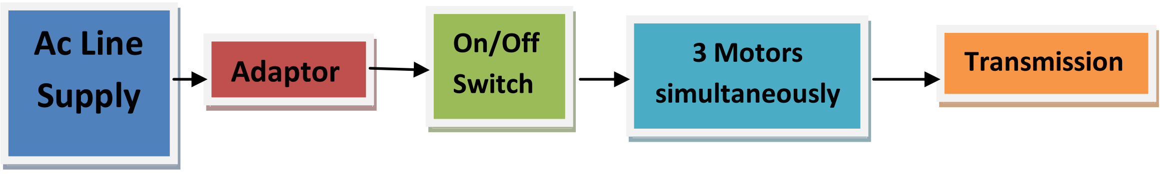
Model Number: LS-600A

Input: AC 110-265V 60/50Hz

Output: DC 12V 1000mA

Figure-21: Adaptor

3.2.4 Block Diagram of modified transmission system



3.3.1 Platform

The platform is a 5” By 5” Wooden plank which supports the front and rear wheel. The motor drives the intermediate shaft is attached to the platform by a clamp attached to the wooden frame by wooden screw. The wooden platform is shown in the figure 22.

Figure-22: Platform

CHAPTER 4

Cost Analysis

All necessary components of the vehicle were researched group has come in under budget by BDT 9,500. Upon completion, the up has come in under budget by BDT 9,500. Upon completion, the final budget for the project is shown in
Table 1.

Table 1 Expenditure on Project

SN	Item	Cost/Unit (BDT)	# Units	Cost (BDT)
1.	Nylon 66	170 Taka per pound	5 pounds	BDT 850
2.	Wooden frame(Including Platform front and rear wheel frame tri wheel frame)	1500 Taka	Overall work	BDT 1500
3.	Wooden Screw	3 taka per piece	20	60
4.	Nuts	3 Taka per piece	20	60
5.	Aluminum frame	80 taka per 10 inch	10 inch	80
6.	Spring	10per piece	2	20
7.	Engineering Shop Processing	3500	Overall work	3500
8.	Motor	350 Per Motor	3	1050

9.	Adaptor	500	1	500
10.	Rubber Grip	100	1	100
11.	Araldite(Adhesive)	50 Per Piece	2	100
12.	Bearing	20 Per Bearing	20	400
13.	Wooden Stair	1200	1 stair	1200
14.	Total			BDT 9420

CHAPTER 5

Device Testing

The device was tested during and after final construction to ensure all design requirements would be met, the descriptions of these tests and the results are described below

Method: Connect the motors individually to a battery to ensure function
Test Status: Upon purchase of the windshield wiper motors, the motors were wired to a 6V torch light battery to ensure they were in working condition.
Results: All motors were found to be operational.

Method: Mount tri-wheels to frame and spin by hand
Test Status: The tri-wheel system involved complex manufacturing and fabrication and construction took a significant amount of project time.

Figure-23: Structure in inverted position

Upon completion of the full tri-wheel system, it was mounted onto the frame and was checked for bearing alignment, bearing friction and clearance. The mounted tri-wheel is shown in Figure 23.
Results: Bearings worked as expected. Negligible bearing friction was encountered. Wheel clearance with the frame was satisfactory.

Method: Electrical Circuit testing
Test Status: The circuit was connected as per the block diagram in 3.2.4.
Results: The circuit worked perfectly without any problem.

Method: Initial full vehicle testing, powering motors with wheels held off of the ground in an inverted position
Test Status: The coupled gear transmitted power to the driving gear in the tri-wheel when kept in an inverted position as shown in figure. The tri-wheel plate did not rotate and all three wheels spun.
Results: The tri wheel system worked properly. The wheels spun as expected.

Method: Straight line motion
Test Status: The device was taken off blocks and set on the floor. The vehicle was tested moving in a straight line at varying speeds.
Results: Operational with slight deviation from straight line, maximum ground speed of 4.367 in/sec.

Method: Ascent/Descent on stairs
Test Status: The vehicle was placed at the bottom and top of the wooden stairs and operated with the switch.
Results: The vehicle drove up/down the stairs adequately. The vehicle climbed the stairs adequately, with minimal input from the operator.

Method: Ascent/Descent on stairs
Test Status: The procedure was the simple by operating the vehicle climbing up and down.
Results: The speed of the vehicle was found to be almost constant.

Figure-24: Stair

Figure-25: Vehicle climbing stair from flat ground

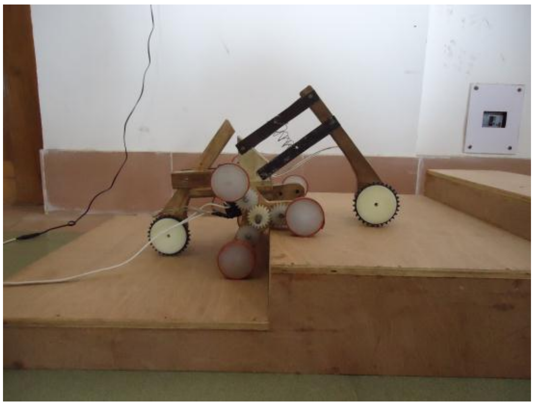


Figure-26: Vehicle climbing stairs

Figure-27: Vehicle coming down from inclined plane

Comparison with the Previous Models (Photographs)

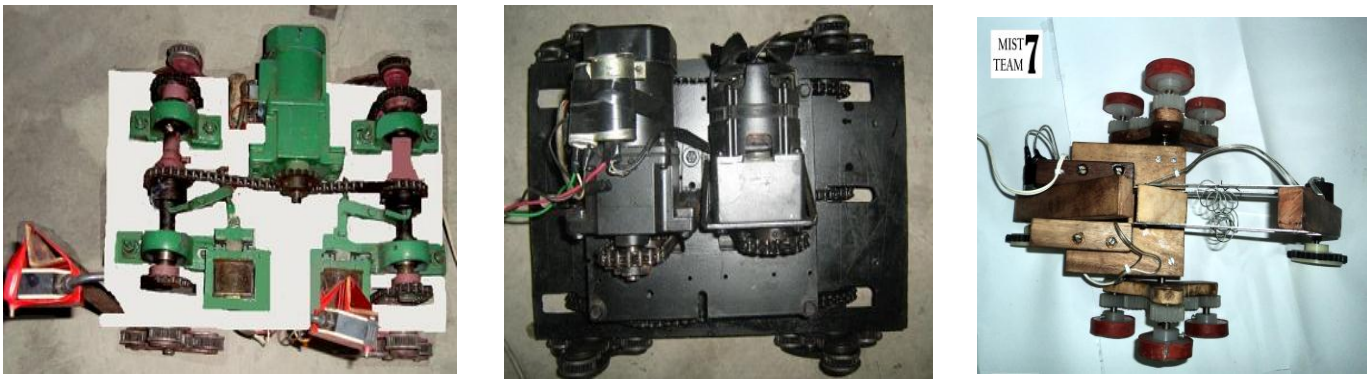


Figure 28: Aerial View of the previous two models and the modified model (From Left to right)

Figure 29: Front view of the previous models and the modified model (from left to right)

Figure 30: Side view of the Previous Models and the modified model. (From left to right)

CHAPTER 6

Measurement of Specifications

6.1 Specifications

a. Length of the vehicle : 42.5 cm
b. Width : 26.7 cm
c. Maximum average speed : 4.367 in/sec (11.09cm/sec)
d. Weight : 4.5 Kg
e. Height : 22.9 cm
f. Inclination angle of step: 15 degree
g. Maximum riding capacity : 3.5 inches
h. Maximum climbing Ramp angle : 45 degree

6.2 Measurement of speed

For maximum speed over flat surface:

First speed =4.5 in/sec

Second speed = 4.3 in/sec

Third speed = 4.3 in/sec

So the maximum average speed = 4.367 in/sec

For maximum speed per stair:

First speed =3.97 in/sec

Second speed = 3.98 in/sec

Third speed = 3.98 in/sec

So the maximum average speed = 3.976 in/sec

Table2: For Maximum Speed over flat Surface

Observation number	Time Taken (Sec)	Distance Covered (Inch)	Speed (Inch/sec)	Average Speed (Inch/sec)
1	1	4.5	4.5	4.367
2	1	4.3	4.3	
3	1	4.3	4.3	

Table 3: For maximum speed over stairs

Observation number	Time Taken (Sec)	Distance Covered (Inch)	Speed(Inch/sec)	Average Speed(Inch/sec)
1.	4.15	16.5	3.97	3.976
2.	4.14	16.5	3.98	
3.	4.14	16.5	3.98	

6.3 Comparisons

Serial Number	Characteristics	Previous Model 1	Previous Model 2	Modified Model
1	Weight	30 kg	22 kg	4.5 Kg
2	Maximum Speed	0.295 in/sec	1.18 in/sec	4.376 in/sec
3	Wheel Frame	Depends on sensor	Depends on sensor	Independent
4	Number of motor	2 AC motor	1 AC motor	3 DC Gear Motor
5	Clutch system	Not available	Available	Not Available
6	Electromagnetic Coil	Not Available	Available	Available
7	Chain System	Complicated	Simple	Not available
9	Sensor	Not Available	Available	Not Available
10	Wheel Frame made of	Mild Steel	Aluminum	Wood
11	Number of intermediate Shaft	03	02	01
12	Gears Mesh between Motor and Shaft	Not Available	Not Available	Available
13	Front and Rear Wheel	Not Available	Not Available	Available
14	DC motor Used	Not Available	Not Available	Available
15	Forward and Reverse movement from same position	Not Available	Not Available	Available

CHAPTER 7

Discussion of the Result

7.1 Outcome of the project

After successful test run we have achieved our design requirements as expected. While operating in normal condition, if the vehicle finds any obstacle then the wheel frame rotates automatically without the help of any kind of sensor. Comparing the previous designs made in MIST, no electromagnetic clutch was used in the structure which helped to reduce the weight of the vehicle. The maximum average speed on flat surface was 4.376 in/sec which around 3.7 times higher than previous model. There was no need of sensor for using the electromagnetic clutch since the particular clutch is absent in the structure. Weight of the vehicle has been reduced from 22kg to 4.5 Kg by eradicating AC motor and one intermediate shaft. For reducing the weight of the vehicle wooden frame and platform were used instead of MS and aluminum. The chain system has been removed and gear system has been introduced. Due to presence of front and rear wheel the climbing mechanism works better that previous structure even though there is certain limitation over stair step size. The maximum height of each step is 2.5 inch and maximum ramp angle is 45 degree. The vehicle can move both in forward and reverse movement which was simple done by the use of DC motor.

7.2 Limitation of the project

Even though the designed structure has a lot of advantage, it has certain limitations as well

1. The vehicle cannot move left or right due to absence of a knuckle joint which can be introduce.
2. The vehicle cannot climb beyond the specified height and below specified tread height. The limitations observer is notable for recommendations. Some limitations can be avoided due to unavailability of the technology.

From the above discussion, it can be summarized that considering some of the limitations the vehicle is proved to be a completely new effective design comparing the previous designs. The vehicle was an effective alternative in transporting load using stairs. Some limitations still remain with the load carrying capacity. This may be improved by further research on improving the load carrying capacity.

7.3 Future Considerations

The stair climbing vehicle was intended as a proof of concept project. The design was kept modular to allow for upgrades. In this section, the scalability of the components will be discussed. There are several major factors in the weight restriction of the device. The foreseeable consequences of device are:

1. Not generating enough torque from the motors to turn over the tri-wheels.
2. Not moving in a perfectly straight line.
3. Cannot climb stairs after certain limitation
4. Can do locomotion in only one direction
5. Failure of the connections and frame as a whole
6. Failure of the tri wheel faceplate.
7. Improper alignment of the front wheel fork.
8. To generate more torque, the motors could be easily replaced with a more robust motor suited for high torque applications. A 24 volt motor could also been used. Due to unavailability of good motors in the local shops, motors with good rating could also be imported from abroad.
9. The alignment of the front wheel fork can be made properly if the fork is made up of aluminum and the nuts and bolts used in it is fastened properly.
10. The obstacle of climbing stair after certain weight limitation can be removed if the motor used in the structure is of good load handling capacity, as well as several structural change can also be brought like shifting the tri wheel position across the platform to an optimum position, setting proper angle of rear wheel.

11. Even though wooden frame and platform were used in the structure, Aluminum could have been better material to be used in the structure. So, in future material selection can increase the efficiency of the structure in terms of weight, strength of the components made from it.

If the device is expected to operate outdoors, the user will set the maximum requirements for the dimensions provided. Expected upgrades to the vehicle may include:

1. A weatherproof casing for the motor driver and associated electronics.
2. Powerful batteries that can be mounted directly to the device.
3. A casing for the gears to prevent water/dirt from impeding the meshing of the tri-wheels.
4. Steering system could have been used to rotate the structure. Besides remote control access can be made in the future design.
5. Programmable microcontroller can be introduced to make the vehicle intelligent.
6. For more precise movement, timer circuit can be used.
7. for sensing purpose several packages can be used which includes gyroscope, accelerometer, compass odometry and differential GPS system etc.

7.4 Conclusion

The design described in this report fulfilled or exceeded all of the design requirements set out in the end.

Since we obtained better result in this new mechanism comparing the previous designs made in MIST , the group is confident that the project was successful as a proof of concept and could be scaled up for larger applications. Future work on the project would involve installing more powerful motors and batteries, reinforcing the frame and joints. Besides furthermore upgrading parts for stronger or thicker material depending on the expected strength and application might give better results

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Appendix A- Operation Guide

Operation Guides

Stair Climbing Vehicle

Read This First

Before operating the unit, please read this manual.

Retain this manual for further use.

Rotating Part Hazard

Electrical Hazard

Rotating Machinary Hazard

Table of Contents

Operating any type of machinery has inherent risks

Please read through this section before operation of the vehicle.

1. Parts of the Vehicle

1.1 Wheels

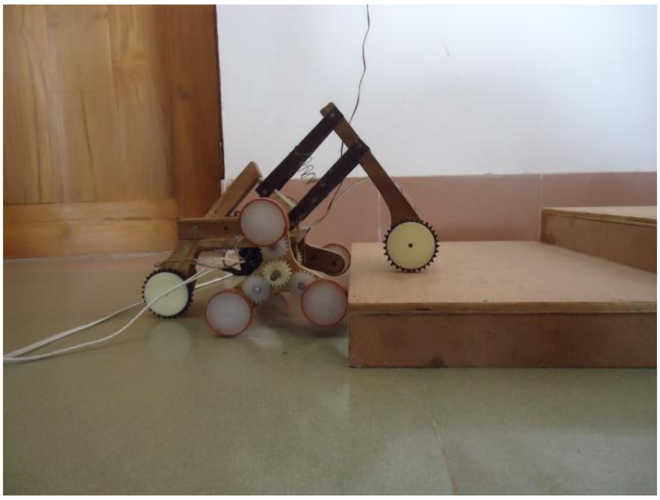
The wheels of the vehicle are 2inch in diameter for tri wheel frame and 2.5 inch diameter wheel for front and rear wheel. This poses a pinch hazard to anything caught in the rotation. Keep any loose clothing or jewelry or away from the tri wheel assembly during operation.

1.2 Gears

Each individual tri wheel assembly contains 7 gears with 6 associated meshing points. These points pose a pinch hazard. Keep loose clothing and jewelry away from the gear assembly.

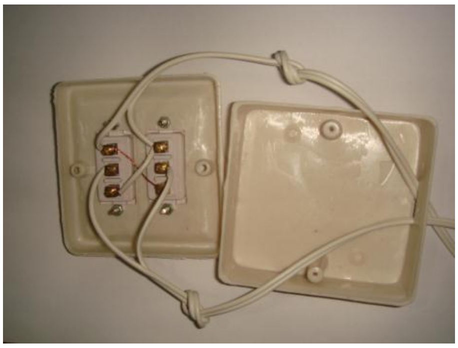
1.3 Movement

The vehicle can move forward, backwards and turn to the left or right. It can also turn on the spot. These movements can pose a threat to an individual caught between the vehicle and another object. Ensure the area is clear of other hazardous objects all individuals stay a safe distance from the device.



1.4 Electric Circuits

Even though we used adaptor for powering the motor, care must be taken for ensuring safety regarding electrical hazards.



2. Getting Started

The vehicle is controlled from a switch. The steps to be taken in setting up the vehicle are as follows:

1. Ensure the electrical wires are properly attached
2. Turn on the Adaptor.
3. The 'status' light should be a red in the adaptor.

4 The vehicle is ready for operation. Ensure that all precautions are taken for safe operation.

3. Configuring the vehicle

The vehicle uses two DC gear motors to power two gear driven tri-wheel assemblies. The motors are controlled with a simple handheld on/off switch, mounted on the switchboard.

4. Controlling the vehicle

The vehicle is controlled by two switches as shown in the figure. When two switches is placed in the same orientation then it shows a particular movement in a particular direction (i.e. Forward or backward direction). The user will be directed by the markings on the switchboard whether to operate in forward or backward direction. But if two switches are placed in opposite orientation then it will switch off the whole system and the vehicle will stop moving.

5. Operation

This section will describe the vehicles two modes of operation: flat ground driving and stair climbing.

5.1 Flat Ground

While moving on flat ground the vehicle will simple move on the plain surface. When an obstacle is faced then the either the front or tri wheel will move over the obstacle depending on which wheel faces it. During operation on flat ground, the device will have 2 sets of wheels on the ground per tri wheel frame and both front and rear wheel. This added friction results in slight vibrations during turning.

5.2 Stair Climbing

The basic operation of the vehicle during stair climbing is for the front wheel to approach the bottom stair and have the first wheel contact the stair wall. This front wheel will cease turning and the other two wheels on the assembly will rotate above the first wheel and reach the flat of the next stair.

The device was designed for optimal operation on a standard stair of 2.5 inch rise and 14 inch tread. The device has the capability to operate on stairs of different dimensions but might need additional arrangement in the structure which is not possible at this moment for this structure.

To operate the device during stair climbing,

1. Drive the vehicle forward until the first wheels contact the stair rise. Allow the vehicle to auto Straighten it by continuing slowly against the rise. Then similarly the tri wheel will climb slowly against the rise. If necessary then the whole tri wheel frame may rotate about the shaft with necessary thrust provided by three motors together.

2. Continue up the steps and do not switch off the switch. This will help to vehicle climb the stairs gradually one by one without any use of sensors or microcontroller.

6. Troubleshooting

a) If the adaptor status LED light does not come on, check the AC power supply

b) If the structure doesn't move after climbing certain steps check

   i. the gears attached in the shafts
   ii. whether the motor is operational or not
   iii. Whether something got stuck with the structure.
   iv. Stair surface. If there is too much dust, the wheels cannot get adequate friction.

The stair dimensions might not match the optimal design. When the rear wheels hit the riser, watch the wheels. There is a possibility that one wheel will try climbing before the other.

If the vehicle no longer responds to control…

i. Check whether the adaptor or the motor is damaged or not.
ii. Check whether the electrical wire is damaged or not.

Appendix B – Draft Drawings

(See attached)

1. Spur Gear
2. Fork-Front and Rear Wheel
3. Front Wheel Support
4. Wooden Platform
5. Shaft Support
6. Tri Wheel Frame
7. Wheel

Authors:

Chapter-1 Introduction –Sub Lt. Zunayed Mahmud
Chapter 2: Designing- Munzarin Morshed
Chapter 3 Design and Construction Al Amin and Sub Lt. Zunayed Mahmud
Chapter 4 Cost Analysis -Ashadullah Hill Galib
Chapter 5 Device Testing - Abid Mahmud Shohel and Ashadullah Hill Galib
Chapter 6 Measurement and Specification Al Amin and Raihan Masud Saquib
Chapter 7 Discussion of the Result-Raihan Masud Saquib and Ashadullah Hill Galib

Appendix A- Operation Guide Al Amin and Munzarin Morshed
Appendix B – Draft Drawings-Al Amin and Raihan Masud Saquib