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Name of Supervisor: Mr. MOHD RUZI BIN HJ HARUN

Date: 7/5/2007

HIGH FLEXIBILITY MULTI TERRAIN ROVER

NG ENG SIA

This Report Is Submitted In Partial Fulfillment of Requirements For the Bachelor Degree of Mechanical Engineering (Design and Innovation)

Fakulti Kejuruteraan Mekanikal

Universiti Teknikal Malaysia Melaka

March 2007

DECLARATION

I hereby declare that this project report entitled

HIGH FLEXIBILITY MULTI TERRAIN ROVER

is written by me and is my own effort and that no part has been plagiarized without citations.

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Name of author : Ng Eng Sia

Date : 7/ 5/ 2007

DEDICATION

Dedicated to my beloved family Father (Mr Ng Sung Chin), Mother (Mrs Lim Tiang Hoa), Brother (Ng Shin Cheang), Sisters (Ng Eng Chew and Ng Eng Eng) and also my friends which always be my side

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ABSTRAK

Projek ini menbentangkan pergerakkan kendaraan berinnovasi di kawasan tidak rata yang berkonsepkan enam buah roda. Dengan menggunakan bentuk rombus, kenderaan ini mempunyai roda pemandu di depan dan belakang serta dua roda lagi yang terletak di kedua-dua belah badannya. Di depan roda mempunyai spring penangguhan untuk memastikan sentuhan antara tanah dilakukan secara maksimum setiap masa. Panduan arah kendaraan ini dapat diberangan oleh panduan roda pertama dan belakang dan laju yang berbeza pada roda di tengah. Ini dapat memastikan ketepatan pergerakan kenderaan ini walaupun pergerakannya minimum. Tujuan reka bentuk artikulasi selari antara roda depan dan badan adalah untuk setkan pusat putaran searas atau bawah daripada paksi roda. Ini dapat memastikan kestabilan yang masimum dan keupayaan pendakian walaupun dengan geseran yang rendah antara roda dengan tanah. Satu struktur model telah direka dan dihasilkan. Robot ini mempunyai panjang 66 cm dan tinggi sebanyak 23 cm boleh mengatasi halangan secara pasif sehingga dua kali ganda diamenter rofa dan dapat memanjat tangga yang mempunyai langkah setinggi 10cm.

ABSTRACT

This project present an innovative locomotion concept for rough terrain based on six motorized wheels. Using rhombus configuration, this terrain rover has a steering wheel in the front and the rear, and two wheels arranged on a bogie on each side. The front wheel has a spring suspension to guarantee optimal ground contact of all wheels at any time. The steering of the rover is realized by synchronizing the steering of the front and rear wheels and the speed difference of the bogie wheels. This allows for precision maneuvers and even turning on the spot with minimum slippage. The use of parallel articulations for the front wheel and the bogies enables to set a center of rotation at the level of or below the wheel axis. This insures maximum stability and climbing abilities even for very low friction coefficients between the wheel and the ground. A well structure prototype has been designed and manufactured. The robot, measuring only about 66 cm in length and 23 cm in height, is able to passively overcome obstacles of up to two times its wheel diameter and can climb stairs with steps of over 10 cm.

CONTENTS

LIST OF TABLES

ABREVIATIONS

2d	2 Dimensional
3d	3 Dimensional
AC	Alternating Current
Al	Aluminum
CAD	Computer Aided Design
CAE	Computer Aided Engineering
COG	Central of Gravity
DC	Direct Current
FEA	Finite Element Analysis
PLC	Programmable Logical Control
ROV	Remotely Operated Vehicle
RMS	Remote Manipulator System

LIST OF SYMBOLS

SYMBOLS	DEFINITION
D	Wheels Diameter
e/r	Rolling resistance parameter
E	Elasticity module
F, N	Tangential/normal force
F', N'	Ground reaction forces
l	Length of rectangular contact pitch
kg	Kilogram
h	hours
T_r	Friction torque
T	Motor torque
N	Angular Speed
mm	millimeter
R	Wheel's radius
r.p.m	Round per Minute
s	Movement of the wheel
V	Velocity
°	Degree

HURUF GREEK	DEFINISI
μ_o	Static friction coefficient
μ	Dynamic friction coefficient

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Robot is a reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks can category into many types. The modern uses of robot are for exploration, industry, medicine, and entertainment.

Robots can be found in the real world usually in Robot Facts, where the majority of robots are found in factories. Some interesting places robots have traveled include space, the depths of the ocean, inside volcanoes, into buildings containing bombs, and others. Robots are sent out when the "mission" may be too dangerous for a human. Robots are regularly used by police forces around the world to disarm bombs, and by scientists to venture inside volcanoes to gather important data.

Inline with mission to achieve developed country, designer should create something that can be very useful to the engineer firm and at indirectly can convince them to use a latest sophisticated technology. To make it a reality terrain rover which is the robots which manipulate an important role in robotic world need to be implemented. This rover is one type of robot which it can move freely in the multi terrain and can overcome obstacle as allegation above. This terrain rover will be used by either police forces or explorer to archive the mission which is too dangerous for a human.

The aim of this project is to generate a design, analysis and fabricates the mechanical structure of terrain rover. This terrain rover has high flexibility to be traveled at Malaysia's terrain. This project will be designed by advanced CAD (Computer Aided Design) software named Autodesk inventor. Simulation and analysis on this multi terrain rover will be done by advance CAE (Computer Aided Engineering) software. There are several important roles should be considered for this project and they included:

a) Machine design
b) Modeling
c) Process manufacturing of the machine parts and components

During involve this project, knowledge on mechanical and manufacturing should be applied. During design and develop the terrain rover, many factors will affect the functionality of it. Alignment, mechanism and strength of material of machine are the main factors that need to be considered. These factors must be detected and eliminated to make sure the terrain rover function well.

1.2 Problem Statements

In our country, most of the designers just focus on the robot that use in industries only. Terrain rover is seldom manufactured by any automotive company. However, people are interested in places that are sometimes full of danger, like outer space, inside volcanoes or the deep ocean. But when human can not go into that place by their own because that places are too danger for human. Thus, as a designer, we need to design a robot which can overcome this obstacle as a human replacement to do such dangerous activity.

In this epoch world, police is one type of dangerous job since they need to disarm bombs and others dangerous activity until their live will be threatened. As a result, police also need to certain types of robots for bomb-disposal and for bringing video cameras and microphones into dangerous areas, where a human policeman might get hurt or killed. The military also uses robots for locating and destroying mines on land and in water, entering enemy bases to gather information, and spying on enemy troops. All of these activities need to use a robot that can overcome obstacle. Thus, design of mobile robot over is a need to help human in this dangerous activity.

Recent research in mobile robotics has mainly concentrated on autonomous navigation. These new technologies allow for reliable localization, obstacle avoidance and even autonomous map building in dynamically changing environment. However, mobility in very rough terrain is often very limited due to the absence of adequate locomotion concepts. Most of the existing surface locomotion concepts are based on wheels, caterpillars or legs and have not much evolved lately.

Since there is still less of this type of robot that able to overcome specific obstacle on moment a terrain rover that have good off-road ability is necessary to develop in order to fulfill any requirements from industry or military areas. This terrain rover can be widely used in factory, or construct area. It also can be used as education equipments for high education institute for lab session and provide opportunity for students learn on analysis the structure of this terrain rover.

1.3 Objectives of project

This project will be started with the goal to build a wheeled robot:

a) To design a terrain rover that can overcome obstacle (step, stair, and off-road) while moving.

b) To design at terrain rover that able to passively overcome steps of 1.25 times its wheel diameter.

c) To analysis structure and movement of terrain rover.

1.4 Scopes of project

A structure of terrain rover will be generated at the end of this project. It was design base on the concept that adapted to unstructured environment. On a plane surface, it demonstrates low speed motion. Here below are some scopes of the terrain rover:

- To study the mechanical design that aid in the design of terrain rover.
- To do the finite element analysis (FEA) on critical part of terrain rover.
- To simulate the movement of terrain rover in uneven terrain with the software of 3d studio max.
- To present the structure of terrain rover

1.5 Thesis Outline

Thesis outline is a summary of every chapter was described to introduce about the chapter. Chapter one introduced about the basic theory, problem encounter, and the content of the thesis and also the main objective of doing the thesis. Next is Chapter two where all information about robot, the design consideration of terrain rover and introduction of motor and type of bearing. Beside than, this chapter also include the information of Computer-Aided Design (CAD) and Finite Element Analysis (FEA). In Chapter three, it will describe the project implementation from collect data and information until the design was verified. Chapter four will perform all steps to design the terrain rover by using Autodesk Inventor. The phase of design will showing in this chapter. In Chapter five, the results from terrain rover design will be performed. Its include summary of case study from the analysis of kinematics motion and function of terrain rover. Discussion, recommendation and conclusion will explain in the end of this report.

1.6 Summary

High flexibility multi terrain rover will design in order to overcome the specific obstacle which has good off-road ability passively. In order to complete the design an analysis structure and movement of terrain rover will be done by using different CAE software. First of foremost, the mechanical design study need to be done. Then, Finite element analysis on critical part will conduct in order to make sure that this terrain rover able to perform well in the structure and unstructured environment. After analysis had done, simulation about motion of terrain rover at unstructured terrain will be done by using 3d studio max software. This simulation will give a clear view about how the terrain rover moves. Finally, a structure model will be presented.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of robot

A robot can be defined as a programmable, self-controlled device consisting of electronic, electrical, or mechanical units. More generally, it is a machine that functions in place of a living agent. Robots are especially desirable for certain work functions because, unlike humans, they never get tired; they can endure physical conditions that are uncomfortable or even dangerous; they can operate in airless conditions; they do not get bored by repetition; and they cannot be distracted from the task at hand [1].

The concept of robots is a very old one yet the actual word robot was invented in the 20th century from the Czechoslovakian word 'robota' or 'robotnik' meaning slave, servant, or forced labor. Robots don't have to look or act like humans but they do need to be flexible so they can perform different tasks [1].

Early industrial robots handled radioactive material in atomic labs and were called master/slave manipulators. They were connected together with mechanical linkages and steel cables. Remote arm manipulators can now be moved by push buttons, switches or joysticks [1].

Current robots have advanced sensory systems that process information and appear to function as if they have brains. Their "brain" is actually a form of computerized artificial intelligence (AI). AI allows a robot to perceive conditions and decide upon a course of action based on those conditions [1].

A robot can include any of the following components:

- effectors - "arms", "legs", "hands", "feet"
- sensors - parts that act like senses and can detect objects or things like heat and light and convert the object information into symbols that computers understand
- computer - the brain that contains instructions called algorithms to control the robot
- equipment - this includes tools and mechanical fixtures
- Characteristics that make robots different from regular machinery are that robots usually function by themselves, are sensitive to their environment, adapt to variations in the environment or to errors in prior performance, are task oriented and often have the ability to try different methods to accomplish a task.

Common industrial robots are generally heavy rigid devices limited to manufacturing. They operate in precisely structured environments and perform single highly repetitive tasks under preprogrammed control. There were an estimated 720,000 industrial robots in 1998 [1].

Tele operated robots are used in semi-structured environments such as undersea and nuclear facilities. They perform non-repetitive tasks and have limited real-time control [1].

2.1.1 Robot History

The word "*robot*," a Czech term for forced labour or serf, was also introduced by a Capek. Karl was wondering what to call the "artificial workers" in his play, and he thought they should be called "labori." His brother didn't like that idea, and muttered that they should be called "*robots*." Then, the term "*robot*" was born. Below is the timeline of robot from the built of first robot until nowadays [2]:

- ~270BC an ancient Greek engineer named Ctesibus made organs and water clocks with movable figures.
- 1818 - Mary Shelley wrote "Frankenstein" which was about a frightening artificial life form created by Dr. Frankenstein.
- 1921 - The term "robot" was first used in a play called "R.U.R." or "Rossum's Universal Robots" by the Czech writer Karel Capek. The plot was simple: man makes robot then robot kills man!
- 1941 - Science fiction writer Isaac Asimov first used the word "robotics" to describe the technology of robots and predicted the rise of a powerful robot industry.
- 1942 - Asimov wrote "Runaround", a story about robots which contained the "Three Laws of Robotics":
- 1948 - "Cybernetics", an influence on artificial intelligence research was published by Norbert Wiener
- 1956 - George Devol and Joseph Engelberger formed the world's first robot company.
- 1959 - Computer-assisted manufacturing was demonstrated at the Servomechanisms Lab at MIT.
- 1961 - The first industrial robot was online in a General Motors automobile factory in New Jersey. It was called UNIMATE.
- 1963 - The first artificial robotic arm to be controlled by a computer was designed. The Rancho Arm was designed as a tool for the handicapped and it's six joints gave it the flexibility of a human arm.
- 1965 - DENDRAL was the first expert system or program designed to execute the accumulated knowledge of subject experts.