A Survey on Design And Control of Hexapod Robot

Prof. Vinutha R[1], Srinatha K N[2], Tejas B R[3], Sampath N[4], Srihari S S [5]
[1, 2, 3, 4, 5] Dept of Electronics and Communication Engineering
[1, 2, 3, 4, 5] Atria Institute of Technology Visvesvaraya Technological University, Belgaum, Karnataka, India

Abstract- *Humans cannot be deployed in all the terrains during a search and rescue mission. Navigating in hazardous areas like mine fields, archaeological expedition or entering disaster-prone areas can be done with the help of robots. This paper reviews survivor robot model inspired by the physique of spider which can be used in the cases of search and rescue operation. The six-legged design helps the robot transverse uneven, unpredictable terrain from stair climbing to non-structured environments. The limbs of the robot are structured to have 3-dimensional degree of freedom and additional sensory components can be added for autonomous navigation on rugged surfaces. The technological advancement in the field of robotics is moving at a rapid pace starting from a light weight chassis' design making the robot to be more rigid, flexible and durable. With the development of cloud computing, the robotic locomotion, transmission of data can be controlled and monitored from any place.*

Keywords- Embedded design, hexapod, image acquisition, locomotion, robot

I. INTRODUCTION

Robots can be found everywhere. One of the most important parts of a robot is its chassis. There are several basic chassis types: wheeled, tracked and legged chassis. Legged chassis are quite slow and more difficult to control, but extremely robust in rough terrain. Legged chassis are capable to cross large holes and can operate even after losing a leg. Legged hexapod robots are programmable robots with six legs attached to the robot body. The legs are controlled with a degree of autonomy so that the robot can move within its environments, to perform intended tasks. Hexapod robots can be suitable for terrestrial and space applications.

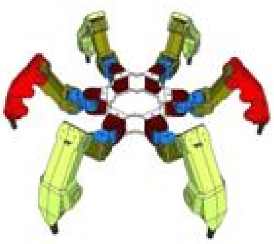

Figure 1. Hexagonal design of the hexapod robot.

We present a narrative followed by a review of various themes. The paper is divided into the following section:

Section I introduces types of chassis and its difference, Section II gives the historical perspective on legged robots. Section III explains the literature survey on hexapod robot Section IV is the conclusion for the paper followed by the references.

II. HISTORICAL PERSPECTIVE

The research inspiration of most hexapod walking robots comes from the natural insect.

The Bio-bot was introduced by Delcomyn[1] in 2000, which referred to the American cockroach show in Fig. 1. The whole size of this robot was 58cm x 14cm x 23cm, it's body and the leg size are 12 to 17 times as large as the true cockroach.

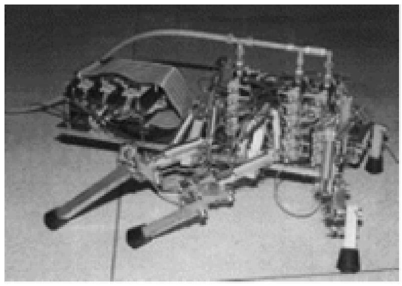

Figure 2.Biobot

Jie Zhu [2] proposed the SMA (Shape Memory Alloy) robot, which has two degrees of freedom in each leg. This robot only can move along the straight line and cannot make a turn. In order to realize the turning, researchers improved the main body of this robot.

Axel Schneider [3] introduced a new hexapod robot, HECTOR (Hexapod Cognitive autonomously Operating Robot), which combines a rich sensors; compliant joint drives and decentral control approaches [4].

In an attempt to explore the irregular surface of plant and other dangerous places, hexapods were developed with vision technology, functional algorithms and loaded with sensors that can be used to know kinds of information about outside and itself which was possible with advancement in the field of electronics.

III. LITERATURE SURVEY

Xiyu Li; Chao Wei et al proposed Research on wheeled Robot [5]. As a kind of robots which is based on the Inverted pendulum control method, two-wheeled self-balancing mobile robot draws people's attention because of its flexible movement. However, due to the dynamic system has the features of nonlinear, multivariable, strong coupling, time varying and parameter uncertainty, it has been much limited in the application.

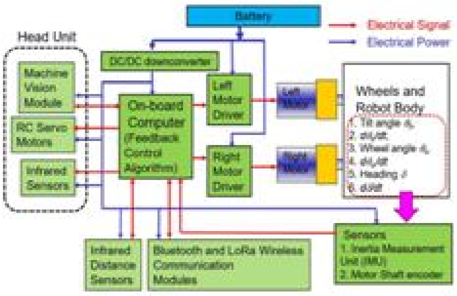

Figure 3.Wiring diagram of the components on the two-wheeled robot

Fabian Kung proposed a design of agile two-wheeled robot with machine vision[6]. This is a self-balancing robot used to navigate in unstructured environment with multiple on-board sensors and machine vision to detect obstacles and wireless communication capabilities. Wheeled chassis are fast, but not suitable for rough terrain. The major disadvantage is the usage of Bluetooth module which does not have sufficient throughput for continuous video transmission.

Jie Ma, Jun Luo et al proposed Design, Simulation and Manufacturing of a Tracked Robot for Nuclear Accidents [7]. To avoid human lives and properties after disasters such as earthquakes, tsunamis, nuclear accidents and so on, the robots can be deployed for search and rescue tasks. Here the robot is designed using aluminum tracked chassis and driving motors consists of driving roller and spring-loaded suspension, which provides advanced mobility and off-road capabilities to the robot. The designed chassis had to undergo radiation test. Most of the devices could work under a total dose of 200 Gy, but the camera we used failed to show images right after the radiation appeared. Lead glass may be used to be the shield of the cameras to protect it from radiation.

Figure 4. 3D model of the tracked robot chassis

Manuel Fernando Silva and JA Tenreiro Machado et al review A literature on the optimization of legged robots [8].it talks about advantages over wheeled and tracked vehicles because they allow locomotion in terrain inaccessible to these traditional vehicles, since they do not need a continuous support surface. Also this paper has presented a survey of several strategies, namely the mechatronic mimic of biological animals characteristics, the use of evolutionary computation for the optimization of the legged structure parameters, the adoption of good mechanical project rules, the optimization of power and energy-based indices and other complementary approaches.

M. Luneckas; T. Luneckas et al talks about Hexapod Robot Energy Consumption Dependency on Body Elevation and Step Height [9], in this paper. Tripod, tetra pod and wave gaits were used. Five different body elevation and step heights were selected. It is observed that, when measuring power dependence on body elevation, short delay was incorporated between leg transfer phases to understand the beginning of each transfer phase. Energy values were calculated for particular movement distance. For example L = 10 m what is logical for hexapod robot model. Results show that energy consumption does not depend on body elevation or gait. Current diagrams with delay showed that most power is used when legs are being raised and feet are pressed against the ground. However, energy consumption does depend on step height. The higher legs are raised, the more power robot consumes. Energy calculations showed that the most energetically inefficient gait is wave and the most energetically efficient is tripod gait. However this paper couldn’t observes energy consumption on more parameters such as speed or payload.

James Fang; Dinesh Parimi et al proposed Decentralized Control of a Hexapod Robot Using a Wireless Time Synchronized Network [10], this paper shows that, Decentralized control can be used to successfully coordinate actions in robotic systems. However, as the results show, success depends on keeping the various controllers time synchronized. Thus, the controllers need to be connected via a network to share a common time reference. So Open WSN network is used in this paper to ensure each controller’s time reference remains synchronized with respect to the DAGroot’s clock by usage of the ASN variable implemented by OpenWSN.

Abhilash Krishna; Krishna Nandanan et al proposed Design and Fabrication of a Hexapod Robot [11],in which the hexapod robot is designed, fabricated and Programmed to execute autonomous navigation. The control of leg actuators is done by the microcontroller via the servo controller. The decision making is aided by the accelerometer, ultrasonic and infrared sensors. however, the walking of the hexapod robot doesn't contain force resistive sensors at the base of each leg. That can help for finding the type of surface it moving on which further used for power optimization.

Mohiuddin Ahmed; Md. Raisuddin Khan et al proposed A Novel Navigation Algorithm for Hexagonal Hexapod Robot [12], this paper talks about a novel navigation algorithm which is developed for a hexagonal hexapod robot that uses optimal gait for locomotion. The algorithm generates near maximal stroke tripod gait for walking on regular terrain. The problem of optimal gait generation for a six legged walking machine, the hexapod, is addressed in this paper.it also includes, Limits on minimum stability margin, maximum foot force, foot motion and collision between adjacent legs are considered for generating the gait. The algorithm can be used with minor modifications, for generating a regular gait like wave gait for walking on inclined planes as well as steps.

Marek Zak et al designed a hexapod robot [13], which can walk using tripod, wave and ripple gaits, can rotate and it is equipped with sonar's, force-sensitive resistors, encoders and LCD display. The foot sensors on the legs allow ground detection, thus the robot can walk in rugged terrain. I also designed an user interface program in C++ and Qt, which allows to control and monitor the robot. The program visualizes the position of legs, displays data from the sensors and allows sending commands to the robot. But the paper doesn't have user interface with a custom gait wizard.

S.Rathnaprabha; S.Nivetha et al proposed Designing of Hexapod Robot [14], in which every parts of hexapod robot has to be analyzed to find out either it is strong enough to hold some force or pressure before the overall parts are assembled. A body of hexapod moves independently of its ground contact points. This paper doesn't shown control of 16 servo motors rather they implemented for 8 servo motors.

Julien Dupeyroux; Julien Diperi et al proposed a bio-inspired celestial compass applied to an ant-inspired robot for Autonomous navigation [15], In this paper, a novel insect-inspired celestial compass was introduced. Performances analysis of this compass can be used in all weather conditions, including high and low UV-index, clear and covered sky. The sensor was then embedded onto an ant-inspired walking robot to maintain the robot's heading direction constant while walking. However there was slightly less reliable due to the high variability of meteorological conditions. This paper doesn't contain focus on the impact of the turning uncertainty of the robot on the heading direction.

IV. CONCLUSION

After extensive study of papers based on robot architecture, electronic control systems, software design, we conclude that the legged robot have so much benefits and more flexibility compared to other types of robots. They also are capable of moving in rough terrain. Furthermore, for risky and dangerous tasks. The implemented hexapod must be energy efficient and reliable. The content like flexibility of the structure design must be further investigated to avoid friction and poor stability.Overall, we must ensure that all the above said criteria are met in the implementation of our prototype.

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