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Gait Generation with Smooth Transition for Visualization and Gas Detection in HEXDRAKE Robot

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ABSTRACT: The necessity to utilize the usage of the robot cannot be denied since they are used everywhere around the world.The robot that can be used in any situation may be a remotely controlled by human or moves autonomously.Hexapod robot is one of the robots used in this situation because of its stability and flexibility during the motion on any type of surface.Hexapod robot that has six legs to walk or move. Since the robot has many legs, the robot is easily programmed to move around because it can be configured to many types of gait such as alternating tripod, quadraped and crawl.There are various designs of hexapod robot with certain function and advantages.In this project,a hexapod robot is designed and developed.The decisions for the robot to use legs is based on the sensory devices and the program develops at the controller attached to the robot. The control method on central pattern generator (CPG) for hexdrake robot to achieve gait generation with smooth transition. And also it proposes visual servo hexdrake where the body is designed using 3D printer and it is equipped with embedded system, servo controller, obstacle detector and camera controlled using ZIGBEE.

KEYWORDS: Hexapod Robot, Arduino, ZIGBEE, CPG(Central pattern generator).

I.INTRODUCTION

The automated machines(robots) are present everywhere in today's dailylife.The design of any automated machine will vary according to the applications. The applications decides which components to be incorporated and also it decides the mechanical structure with some constraints such as payload, power supply, cost and so on. A robot is a machine—especially one programmable by a computer—capable of carrying out a complex series of actions automatically.Robots can be guided by an external control device or the control may be embedded within. Robots may be constructed to take on human form but most robots are machines designed to perform a task with no regard to how they look.Robots can be autonomous or semi-autonomous and range from humanoids such as industrial robots, medical operating robots, patentassist robots, dog therapy robots, collectively programmed swarm robots, UAV drones such as General Atomics MQ-1 Predator, and even microscopic nano robots. By mimicking a lifelike appearance or automating movements, a robot may convey a sense of intelligence or thought of its own.In today's technological society, people have accustomed to daily use of several kinds of technology from personal computers to supercomputers, from personal vehicles to commercial airplanes, from mobile phones to communicating through the Internet and everything in between. As such, the use of robots has also become increasingly common. Robots can be used to complete repeated tasks, increase manufacturing production, carry extra weight and many other common tasks that humans do.

Robots can be found everywhere. One of the most important part of a robot is its chassis. There are sev-eral basic chassis types: wheeled, tracked and legged chassises. Wheeled chassises are fast, but not suitable for rough terrain. Tracked chassises are slower, but more suitable to rugged terrain. Legged chassises are quite slow and more difficult to control, but extremely robust in rough terrain. Legged chassises are capable to cross large holes and can operate even after losing a leg. Many researches were performed in this field in past few years, because of its large potential.We

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created a cheap legged platform, which would allow research and testing of walking chassises. Create a system with many sensors that allows the chassis any movement or behavior. The robot should be driven from wirelessly connected computer and should send all available data from sensors, which will be displayed on the computer in the user interface program. This platform should be universal, anyone could connect to the robot and drive it and anyone may connect and send his own data to the user interface program of the control computer.

1.1. What is Robotics?

Robotics is a branch of mechanical engineering, electrical engineering and computer science that deals with the design, construction, operation, and application of robots, as well as computer systems for their control, sensory feedback, and information processing. These technologies deal with automated machines that can take the place of humans in dangerous environments or manufacturing processes, or resemble humans in appearance, behaviour, and or cognition. Many of today's robots are inspired by nature contributing to the field of bio-inspired robotics.

1.2 The Definition of a Robot

The first thing that might come to mind when thinking of a robot is a humanoid machine from the Terminator or Battlestar Galactica series. In reality, we aren't quite at the level that Hollywood likes to project us to be. However, robots today do increase the average quality of life of most people.According to the Merriam-Webster Dictionary, a robot is either "a device that automatically performs complicated often repetitive tasks" or "a mechanism guided by automatic controls." There are several types of robots which will be described in the following sections. Some robots could be described by more than one category.

1.3 TYPES OF ROBOT

There are various types of robots given below

1.3.1Tracked Robots

Tracked robots typically move slower than wheeled robots but are useful in many situations where damage to the wheels is expected. One such example is police bomb disposal robots where a potential explosion could blow the tires. A track system does not require rubber tires and are therefore more robust in these situations.

Fig.1 Tracked Robot

1.3.2Wheeled Robots

Wheeled robots are great for smooth terrain such as asphalt, concrete, or even gravel roads. These are among the fastest mobile robots and the easiest to implement movement. They can be completely electric for smaller scale or even run on combustion engines on a larger scale.

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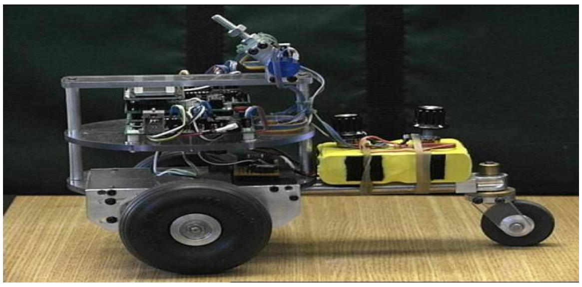

Fig 2 Wheeled Robots

1.3.3 Legged Robots

Legged robots are a type of mobile robot. They are somewhat a recent innovation in robotics. However, many or all bipedal models are not practical because they are cumbersome and slow. Most successful legged robots have four or six legs for further stability. This legs-over-wheels approach lends itself for use in all-terrain purposes because legs are more effective in an uneven environment than wheels.

Fig.3: 4 legged robot

Fig.4: 3 legged robot

Fig.5: 2 legged robot

The **advantages** of legged robots become apparent when terrain becomes uneven and unpredictable. As stated previously, wheeled or tracked robots excel on flat surfaces such as asphalt or concrete roads and can reach much higher velocities than legged ones. However, a legged robot is much more robust in rocky and uneven terrain because it has the ability to climb over obstacles by lifting its legs and pulling itself up.

II. HEXAPOD ROBOT

A six-legged walking robot should not be confused with a Stewart platform, a kind of parallel manipulator used in robotics applications. A hexapood robot is a mechnical vehicle that walks on six legs.Since a robot can be statically sable on three or more legs ,a hexapod robot has a great deal of flexibility in how it can move.If legs become disabled, the robot may still be able to walk. Furthermore,not all of the robot's legs are neede for stability; other legs are free to reach new foot placements or manipulate a payload. Many hexapod robots are biologically inspired by Hexapod locomotion. Hexapods may be used to test biological theories about insect locomotion,motor control and neurobiology.

Fig.6: Hexapod robot

2.1. Body Structure Of Hexapod robot

A robot can be statically stable once there are three legs in contact with the ground and the centre of mass of the robot is with the triangle formed connected the three legs. Therefore, comparing to a quadruple robot, it takes us no work to make a statically stable hexdrake robot, once we moves 3 legs at maximum each time. Moreover, as more legs are available in a hexdrake robot, even one or two legs are temporarily broken, the robot can still move. To enhance the degree of movement and perform more complex motion, we decided to build a hexdrake robot with 2 Servos per leg.

2.2. Hexapod Robot Movement

The robot's legs movement or method of forward motion using hexapod legs is called gait.There are varieties of gaits available and the famous gait used by hexapod robot is the tripod gait. In the tripod gait, three feet of hexapod is always in contact with the ground for the whole time. Method of movement hexapod robot is the locomotion control inspired from the biological paradigm of the Central Pattern Generators (CPG). CPGs are neural networks that produce rhythmic patterned outputs without sensory feedback and biological paradigm means medical model.There are three types of robots motion. Those are walking mode, lifting mode and shifting mode which can be selected by the user. However, only the walking mode is selected in this subchapter to be explained further. The author used tripod gait is used because it is stable compared to other gaits for hexapod robot. The first step in gait control, the initial posture of all legs is decided, and the position of the leg tip is defined as the "reference position". Then, six cylinders of the legs movement are generated so as to be included in the work space with the center of the robotics base is set as the reference position. Thus, the center of rotation of the motion is obtained.The entire system includes battery, electronics, microcontroller, motor driver, sensors and Bluetooth communication module.When the hexapod robot moves, the center of mass follows a roughly sinusoidal trajectory, which is stable sinusoidal motion.Tripod gait is the fastest stable gait with three legs placed on the ground at a time.

2.3 Design Consideration of Hexapod Robot

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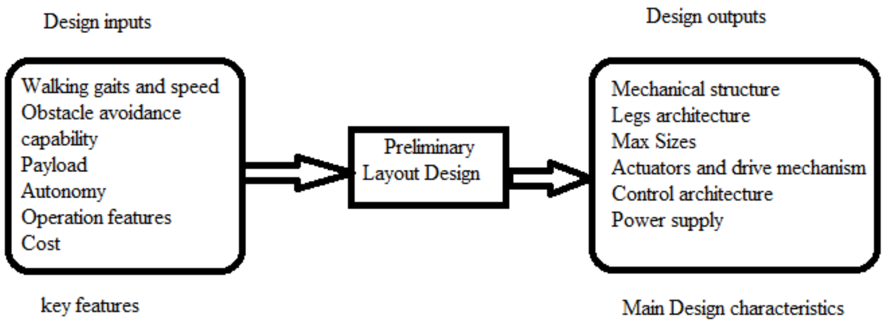

Fig.7: Design consideration

III. MECHANICAL STRUCTURE

The structure of hexdrake robot is designed based on some important consideration such as payload, gait generation, degree of freedom etc. our robot is designed with 2 degree of freedom i.e. 2servo per leg. The gait generation is mainly based on number of servos and degree of stability at various point during leg movement. The coxa, femur and tibia are main joints of an insect which helps in locomotion. At three joints the servo are placed inorder to move the bot. Our bot is designed with 2 servo per leg namely coxa and tibia. It has only 2dof (vertical & horizontal)

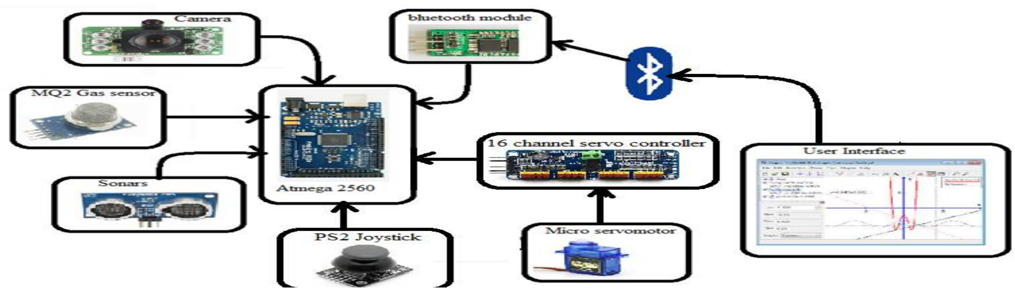

Fig**. 8** Block diagram of Hexadrake robot

3.1. WORKING OF PROPOSED BLOCK DIAGRAM

In our proposed system, our robot has totally six legs and each leg has two servos which means it has two degree of freedom. The two degree of freedom namely called as both horizontal and vertical motion. To supply the power equally to every servos, the servo channel is used. We used totally twelve servos, so 16 channel servo controller is employed in our hexapod robot. Our hexapod robot is mainly employed for mining applications. In mining areas, the major accident is caused mainly due to the leakage harmful gases such as carbondioxide, sulphurdioxide, carbonmonoxide etc.

3.2 NEED OF ROBOTIC SYSTEMS IN UNDERGROUND MINES

Due to safety purpose in underground mines, the need of robotics is very much essential. The followings are highlights the role of robotic application in underground mines. Underground mine navigation or mapping using robotics

1. Position estimation 2. Machinery automation 3. Mine Specific Issues

3.3 WALKING STYLE OF PROPOSED SYSTEM

A simple way to think about this is by how many legs are up in the air during the robot's movement (i.e., gait).Six legs is the most popular number as they allow for a very stable walking gait, the tripod gait . If the same three legs move at a

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time, this is called the alternating tripod gait. If the legs vary, it is called the ripple gait.A hexdrake robot can lift three legs at a time to move forward, and still retain static stability.It uses the so-called alternating tripod gait, a biologically common walking pattern for 6 or more legs.

3.4 GAIT GENERATION:

The gait generation ultimately decides the walking style of the hexdrake robot. Below diagram shows gait generation for the forward motion. The gait generation backward motion is similar with the gait generation of forward motion.

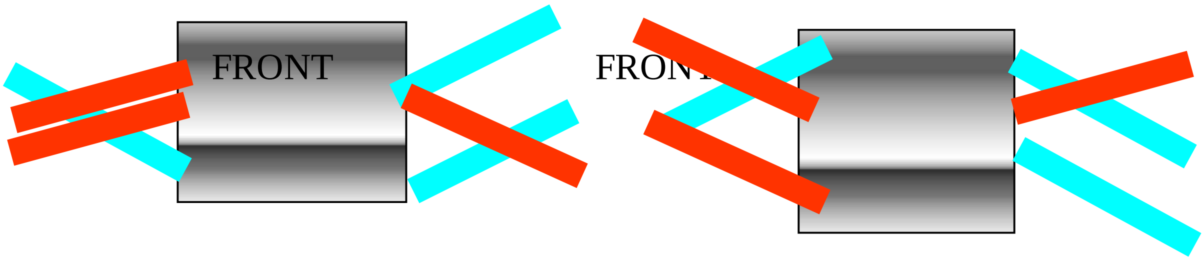

Fig.9 Gait generation for forward motion

RED shows the position of leg at ground
BLUE shows the motion of leg toward front

Characteristic of this gait:

✓ One middle leg on one side and two non-adjacent legs on the other side of the body lift and move forward at the same time.

✓ The other 3 legs remain on the ground and keep the robot statically stable.

3.5 Breadboard setup:

If you don't have a 2.007 carrier board (not for sale as of 24 June 2013, although that may change), put the nano on the breadboard and wire accordingly, with the 5V source in the picture being replaced by your 5v source (e.g. LM7805 with a 4xAA battery pack as described in the first step). You don't want to just put 4xAA into your arduino on "VIN" and then use the "5V" on the arduino because that puts it through a regulator that cannot handle enough current to supply all 18 servos -- your hexapod will be droopy and sleepy as overcurrent protection kicks in on the arduino, unless you just fry your arduino.

3.6 Servo wiring:

Okay, so we have six Y-splitter cables. They will be controlling 12 servos total (2 each). Then we have 6 more independent legs, for 12 servo outputs required total. Now pick a face to be the front of the hexapod, and mentally split the legs evenly down either side. The front and back servos (coxa, femur, tibia) of each side will be wired together, and the middle legs will be independent.

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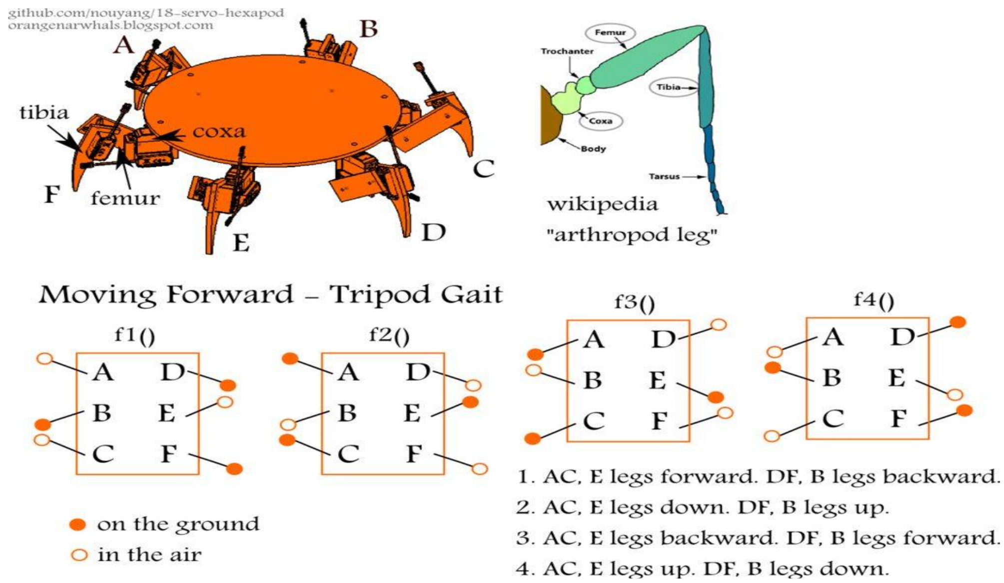

Fig.10 Gait movement

IV. 3-D PRINTING

3D printing, also known as additive manufacturing (AM), refers to processes used to synthesize a three-dimensional object in which successive layers of material are formed under computer control to create an object.Objects can be of almost any shape or geometry and are produced using digital model data from a 3D model or another electronic data source such as an Additive Manufacturing File (AMF) file.It must also be noted that 3D printing drastically reduces the wastage of material, resulting in less pollution, and is therefore safer for environment.

4.1 WORKING OF 3-D PRINTER:

Imagine building a conventional wooden prototype of a car. You'd start off with a block of solid wood and carve inward, like a sculptor, gradually revealing the object "hidden" inside. Or if you wanted to make an architect's model of a house, you'd construct it like a real, prefabricated house, probably by cutting miniature replicas of the walls out of card and gluing them together. Now a laser could easily carve wood into shape and it's not beyond the realms of possibility to train a robot to stick cardboard together—but 3D printers don't work in either of these ways! A typical 3D printer is very much like an inkjet printer operated from a computer. It builds up a 3D model one layer at a time, from the bottom upward, by repeatedly printing over the same area in a method known as**fused depositional modeling (FDM)**. Working entirely automatically, the printer creates a model over a period of hours by turning a 3D CAD drawing into lots of two-dimensional, cross-sectional layers—effectively separate 2D prints that sit one on top of another, but without the paper in between. Instead of using ink, which would never build up to much volume, the printer deposits layers of molten plastic or powder and fuses them together (and to the existing structure) with adhesive or ultraviolet light.

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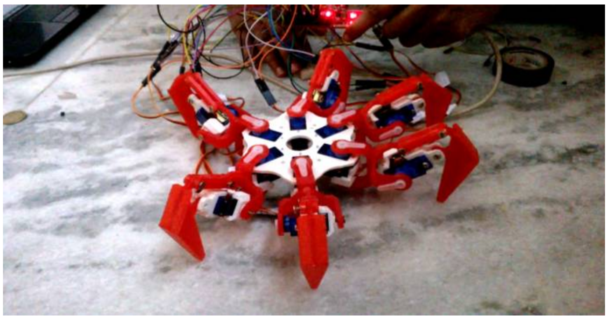

Fig.11. Hardware diagram

V. APPLICATIONS

The application of the proposed system are exploration, mining military, rescue, industrial environments on the earth and beyond. Arduino was basically designes to make the process of using electronics in multidisciplinary projects more accessible. It is intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. Because of these features, arduino finds extensive application in various fields. Legged chassises are especially ideal for space missions. They are used in military research.

VI. CONCLUSION AND FUTURE SCOPE

It can be concluded that the new design of hexadrake has been sucessfully designed and drafted using AUTO CAD.The component selection of the robot has been sucessfully carried out.The robot is actuated using 12 servomotors including the six legs.This project is also implemented by using arduino and programmed with arduino software.The sensors has detected the values and sends the computation to the serial monitor.

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