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Locomotion of Hexapod Robot

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Abstract: A hexapod robot is a recent innovation in the field of robotics which has a great deal of flexibility. This paper describes the locomotion of a power autonomous, six-legged hexapod robot. The robot has six limbs-one motor located at each limb that is robust and has operation in real-world tasks. Stable and highly maneuvrable locomotion arises from a simple open-loop tripod gait. The robot achieves fast and robust forward locomotion traveling at speeds up to one body length per second and walks with a continuum of statically stable insect like gaits in response to a single, scalar user input that controls the speed of locomotion.

Keywords: power autonomous, six-legged hexapod robot, maneuvrable locomotion.

I. INTRODUCTION

The locomotion of hexapod robot comes under mobile robotics. Often hexapods are controlled by gaits, which allow the robot to move forward, backward and rotate. Some of the common gaits are as follows:

- Alternating tripod: 3 legs on the ground at a time.
- Quadruped.
- Crawl: move just one leg at a time.

Gaits for hexapods are often stable, even in slightly rocky and uneven terrain. Motion may also be non gaited, which means the sequence of leg motions is not fixed. This may be most helpful in very rocky terrain, but existing techniques for motion planning are computationally expensive. Many kinds of actuators may be used for the robot to move around like legs, wheels, arms and flippers. Stability is a main factor for locomotion. For working and exploring in unknown and rough terrain, the use of legged robots is advantageous because their movement is less constrained by the shape of the surface on which they have to travel. In the industries, movements on a straight path normally are done on automatic guided vehicles with sensors on touch/no touch. In natural terrains, legs are often superior to wheels; they avoid undesirable footholds and make discrete contacts where wheels must propel with continuous rolling contact. Walking machines only require continuous spots of solid ground for moving; whereas wheeled vehicles normally need large continuous extensions of relatively flat surface to move. There are a number of simple legged robots whose foot trajectories are fixed to follow a certain route for swing (or return stroke) and stance (or power stroke). These types of vehicles are not so different from wheeled vehicles, as the behaviour of their legs could be interpreted as a special type of the wheel. But, when the wheels fail to function properly, legs become the more suitable solution for moving in more demanding terrains. The legged robots are built to improve the speed and to climb the obstacle’s height easily.

II. ARDUINO PROGRAM FOR ROBOTIC MOVEMENT

```
#include<avr/io.h>
#include<util/delay.h>
int main(void)
{
ddrd=0xf0;  //setting the data direction of portd where motors are connected
while(1)
{
portd=0x60;  //moving the robot forward
_delay_ms(1000);
portd=0x90;  //moving the robot backward
_delay_ms(1000);
}
}
```

III. SENSORS FOR MOBILITY

Joint velocity sensors: the joint angle sensors are differentiated in analog for each dof of the leg.

Ground contact sensor: this is a linear potentiometer mounted on the ankle that measures the detection of the foot as it presses against the ground.

Inclinometer: this sensing unit is made up of a degree roll sensor and a degree pitch sensor.

IV. INSECT LOCOMOTION

Definition of terms

Protraction: The leg moves towards the front of the body
Retraction: The leg moves towards the rear of the body
Power stroke: The leg is on the ground where it supports and propels the body. Forward walking the leg retracts during this phase. Also called the stance phase or the support phase.
Return stroke : The leg lifts and swings to the starting position of the next power stroke in forward walking the legs protracts during this phase also called the swing phase or the recovery phase.
Anterior extreme position (AEP): In forward walking this is the target position of the advance degree of freedom during the return stroke.
Posterior extreme position (PEP): In forward walking this is the target position of the swing degree of freedom during the power stroke.

Fig.1: leg components

V. STATICALLY STABLE PLATFORMS

The first walking robots were statically stable. A statically stable robot can be controlled gradually and will work just fine without any sort of balance sensors. As early as the late 1800 century people tried to mimic animal walking with machines. The walking robots had a great advantage over wheeled robots. To control every leg separately and to choose its hold up is called to use a free gait. An example of this sort of machine was built in the mid-1960 by Ralph Mosher .It was called the "walking truck" and was a close to 3.5 meters tall hydraulically powered beast. Weighing almost 1400 kg, this machine with its human operator could push cars out of the way and climb piles of rail road ties. The most incredible feature was that its legs had advanced force feedback that allowed the operator to control them with great accuracy. The drawback with this robot was that it was tiring and needed keen concentration of the operator. The solution came with enhanced computers. When a computer could take care of the exhausting problem of coordinating the legs, the science of walking machines got to a new milestone in history. In the 1970's Robert McGhee's group at the Ohio State University constructed the first successful computer controlled hexapod robot. The main task of the computers was to coordinate the 18 motors, making a number of different types of gaits possible while always keeping the center of mass in a stable position. The problem with this approach is it was power and time consuming as well as expensive. Though there were 18 engines mounted in the leg joints, it was needed to solve advanced calculations for every progress.

VI. DYNAMICALLY STABLE ROBOTS

The main problems that the crawler has are that they are heavy, slow, and have many moving parts. A robot that can actively balance itself does not need to have a lot of legs. This makes the robots lighter and more practical. Faster and smaller computers have made the early problems with balance much easier to solve. This also opens up for the possibility of a robot to perform short states of ballistic flight such as jumping or running. With balance the reach of the legs can be extended and it is possible to compensate for acceleration by moving the center of mass relative to the support area. Balance makes it possible to jump over obstacles or to use a very narrow support area. The first kind of running robots were one legged. The definition of running is that the object should perform a period of ballistic flight. The idea was that if this problem could be solved for a one legged jumping robot the solution could be transferred to a multiple legged machine.

ASIMO (example of legged robot): Even though robots that use balance are rare in everyday life today, they do exist and actually work rather well. One of the best two legged robots today is ASIMO, made by Honda Motor Co. This humanoid robot has 34 servos and can climb stairs, run, walk and maintain balance if pushed or impacted to a certain degree. It has stored motion patterns of walking, turning, running and start/stop that it can combine with sensor data in real time. It also shifts its center of mass in real time to be able to turn while walking. When the robot moves it is influenced by gravity, and forces from acceleration and deceleration. Together these forces make a resulting force vector that is called the total inertial force. To maintain balance the robot has to sustain its center of gravity in the opposite direction of this force at all time, this opposite force is called the ground reaction force. When these two forces do not align, the robot is out of balance and needs to realign these vectors before it falls. The point that the total inertial force intersect is called the zero moment point (ZMP) and the point where the floor reaction force operates is called the floor reaction point. The computer calculates a theoretical walking pattern and the servo motors. Target ZMP control accelerates the upper torso in the direction that the robot threatens to fall. If the object under the foot is big enough, or the floor reaction point and ZMP for some other reason is so much misaligned that the floor reaction control cannot compensate enough to realign them this function kicks in. If the robot for example is about to fall forward this control would accelerate the center of mass forward and thereby creating an opposite force to the fall. The originally planned position for the next step is adjusted to catch the new position of the center of mass so that stability is regained. ASIMO is also extremely expensive due to its many servos and costly materials needed to keep its weight low.

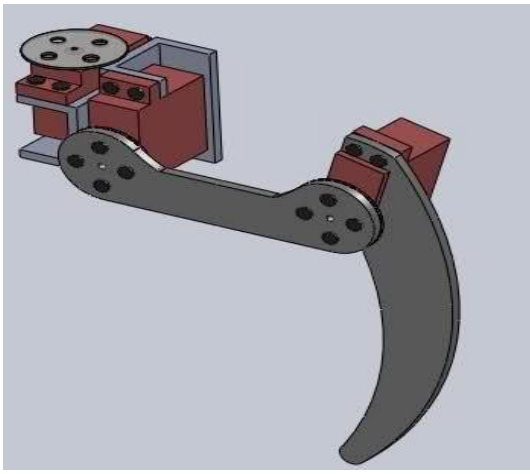

Fig.2: Robotic leg

VII. ADVANTAGES AND DISADVANTAGES OF LEGGED ROBOTS

To have a platform with legs that are able to strategically choose contact points on the ground is a vast advantage over wheels in many ways. Not only because of the previously mentioned reason that it can step move smoothly over terrain. Consider a statically stable robot that moves one leg at the time and gently places it at a new stable position, the main body of such a robot would oat forward smoothly like a boat, even on really rough terrain like in a forest. Another advantage is the ability to change direction of movement without changing the direction the body is facing. This is useful in tight spaces and creates a faster and more natural movement in places with a lot of obstacles. Wheels also have a tendency to slip on the ground when they lose traction. A leg on the other hand is much kinder to the surface it moves over. It can distribute its weight and even move its center of mass without changing the positions of its supports. This advantage is desirable in cases like moving up or down a slope or stairs, or where there is a long distance between supporting objects to step on.

The advantages are not just noticeable in rural environments. The urban society of today is in many ways adapted for legs: Ask anyone in a wheelchair. Urban obstacles like stairs and doorsteps are often a problem for wheeled platforms. All these possible advantages come at a price though; the design will be more complicated and will have more moving parts. While a robot with wheels could work just fine with only two motors, one for forward trust and one for steering for example, a robot with legs needs at least tree actuators for each leg if one wants it to be more useful than a wheel. The actuators used today are still heavy compared to their power output. . Control of the leg actuators and execution of the leg control and gait generation models, is performed by controller boards. This often makes legged robots very heavy or weak, especially if they have many legs.

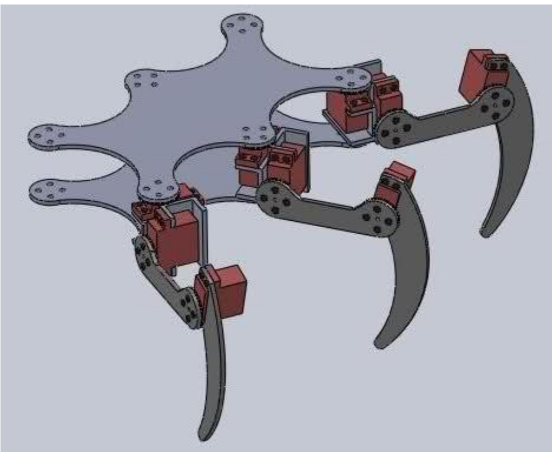

Fig.3: Structure of chassis with legs

VIII. RESULT & CONCLUSION

To make a robot that is capable of working outdoors it must have some kind of protection of its sensitive parts from foreign objects, dirt, moisture, etc. The internal temperature of the robot in accordance with the surroundings has to be regulated to protect its sensitive parts. The vital part in hexapod design is the interface of robot with the software and its movement. The legged robot has the advantage of moving in any kind of terrain and harsh surface areas with ease and flexibility than wheeled robots. Some of the examples of legged robots are Asimo, Bigdog, runbot, HUBO 2, Toyata partner robot and so on. The maneuverable locomotion of the power autonomous hexapod robot navigation is based on the static and dynamic stable response.

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