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HEXAPOD: A SPIDER FOR TERRAIN AND OBSTACLE SHUNNING BY ARDUINO

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Abstract—Robots are controlling today's tech-machines scenario and world is ready to accept the new trends the for useful operations. In some industries, a part of work which signify threat and consequently, very strict security rules e.g. some of the work in nuclear plant, where human can't go or its should be avoided as well as such condition such as underwater exploration even on terrain surface too where human can't go on defined destination or somehow it's difficult to reach on defined destination even in surface such as rock, mud, natural water flow, sometimes it's impossible to move for any human

Here we come up with the solution for this type of problem to develop a Spider robot i.e. hexapod , so that it will overcome not only above examples but it will be a spider robot base system which will be used anywhere in the similar type of situations. Gravitational Search Algorithm would be utilized for gravity search and to run the same system like insects. We would explore the parameters from Gravity algorithm for stabilization of body of the Spider system

We will implement artificial intelligence part into the same system as well as GSA algorithm so that spider's locomotion will be like insects and dew to AI, avoidance of obstacle is possible. The physical spider robot system controlled by arduino technology and motors with fabricated body. For development of spider robot we are in planning to use Insects as source of inspiration because the characteristics from the insects such as gaits based on traveling high speed, avoiding obstacles very fast, ability to easily navigate on uneven terrain surface.

Index Terms—Spider robot, Gravity algorithm, gravity search algorithm, biological robot

I INTRODUCTION

Since from the development of the machine, so many engineers and researchers has done the study of nature and these were interested to implement it in to machine made by man. Researchers got so many innovative ideas from the nature its self, sometimes these ideas were easy to implement sometimes these were so hard to implement by taking lots of effort .The most famous prime locomotion is walking. First walking machine is developed by Russian mathematician P. Chebyshev in 1870.It was quadruple leg machine. The first patent was given by US Patent office for walking machine in 1893to L.A.rygg . To develop biological inspired spider we can use GA (genetic algorithm) and GSA (Gravitational search algorithm). By these algorithms we can initialize the gait for various locomotion's. Filipp Seljanko(2011)

The locomotion of bio-inspired robots can be controlled as well as modeled more in aspect of the robot designed by using wheel. For more running speed and direction control in fast speed wheeled robots are preferred, while in case of motion planning however to reach an equivalent functionality with a legged robot, aspects such as gait generation, turning strategies, leg coordination, path planning etc considered. Robots developed by using legs are better suits for travelling terrain uneven surface .If we are interested to move our robot in complex environment the robot habe have abilities to work in kinematic as well as static stability creation. So gait generation is very important in to run effectively use of legged robots in live worlds. Proper gait should be generated for right stability control Umar Asif,Javaid Iqbal and M. Ajmal Khan (2011)

A FTP (Force Threshold-based Position) is one of the controllers which separate all the legs from one to another leg. The joint force for locomotion of one leg does not rely on other status of leg.Each leg controlled separately so each leg will achieve certain performance .The same criteria of the performance can be preprogrammed for different locomotion of gaits. By this algorithm we can reach potential for running, climbing and jumping legged systems Mayur Palankar1 and Luther Palmer (2012)

We should know the state of the robot i.e. acceleration, velocity and global position of the same, is important to get better performance for legged locomotion and its gait clout May be its effortless to measure acceleration and position but measuring velocity of the robot is bit of difficult task We should know the velocity of each leg of effective control of the same leg. However estimation of the velocity is difficult task but it's possible by Kalman filter, initial force Sensor and supporting dynamic legs .This method is developed by readouts of IMU (Initial Measurement Units) Paweł Wawrzy´nski, Jakub Mo˙zaryn and Jan Klimaszewski (2013)

Sometimes biological inspired robots may fail but these failed robots should be reconfigured by them self. Robots should have switching ability from one leg to another leg and should work well and fine. By pressure and force sensor it's possible to get an analog data about the failure of the system. In some cases leg may damage, so in this condition system should reconfigure to produce and control 18 DOF Ammar Akhlaq, Ayesha Umber, Jameel Ahmad (2014)

Locomotion of Hexapod can be controlled by artificial CPG (central pattern generators).CPG based microcontrollers can be able to flourish allocation arrangements in open loop system of gait-joints of the legs. CPG-based microcontrollers are able to developing allocated patterns in open loops and rhythmic activities in certain joints. Here we integrate the biological observations as well as CPG designing in the controller by finding real date of cockroaches Blaptica Dubia as well as whole date analysis by using digital image processing. Even we utilize three dimensional trace of insect such as cockroach for kinematic analysis. Dong Liu, Weihai Chen, Zhongcai Pei, Jianhua Wang, and Zhifeng Li (2014)

Arduino UNO is one of the embedded boards are developed by using with AVR at mega 328 microcontroller. Nowadays controllers are developed by using CMOS integration technology to integrate lots of embedded components.

Arduino board uses harward architecture. Arduino have some advantages over the other development board:

- Economical: We can develop lower version of the arduino at least cost or even buying a

- arduino Mega cost is less than 1000 Rs.
- Ease of use of programming : .ino is the one the language of combination of C++ and python ,so its ease of use for beginners
- Open source.: so many libraries are available free of cost on the internet as well as we can edit these libraries and make changes as per our requirement Mănoiu – Olaru Sorin, Mircea Niţulescu (2011).

II DESIGN METHOD

For an insect to walk, only signal of navigation is not enough it must maintain its stability as well as continuously monitor gravitation of earth.

- Spider first decide where to go [i.e. navigation signal]
- Then it monitor the fluid behind the ears to sense gravitation [i.e. gravity signal]
- Finally it walk on rough terrain by keeping themselves stable by adjusting the angles of their legs [i.e. stability control]

A. Block Diagram:

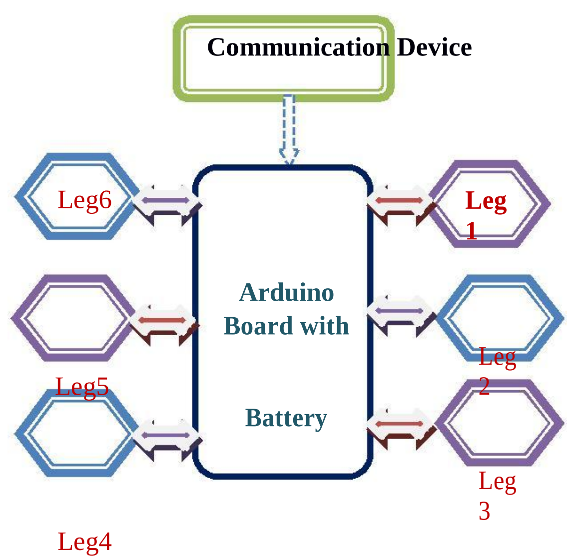

Fig.1. Block diagram of proposed Spider.

Hardware requirement: Arduino At mega,
Servo Motors, Sony PS2

Software: Arduino: 1.0.6 IDE and NX3 & Proteus

B. Hexapod Locomotion

For the spider Locomotion we will use two types of gait generation. Spider will move in any direction as well as on uneven terrain surface .so on terrain surface also spider should moves very fast of in defined speed or on uneven surface also it should run in defined speed. Sensor will Help to find the obstacle like ditch or hill which may occur in plane surface. Here if the obstacle is less in size then we can call it's a uneven terrain surface. Md. Masum Billah, Mohiuddin Ahmed, and Soheli Farhana (2008)

Two gaits are used for hazardaoud and uneven terrain surface these are

1. Tripod gait
2. Wave gait

C. Tripod Gait for Even Terrain

The Tripod Gait is the best-known hexapod gait. A tripod consists of the front-back legs on one side and the middle leg on the opposite side. For each tripod, the legs are lifted, lowered, and moved forwards and backwards in unison.
During walking, a hexapod uses its 2 tripods not unlike a bipad stepping from one foot to the other - the weight is simply shifted alternately from one tripod to the other. Since 3 legs are on the ground at all times, this gait is both "statically" and "dynamically" stable. The numbers adjacent to the legs in the body diagram correspond to time points on the graph. The leg coordination of walking spiders appears to be quite regular too, and is described by the so-called tripod gait In the tripod gait three legs, front and rear leg of one side and the middle leg of the other side, perform their swing movements at the same time.

D. Wave Gait for Uneven Terrain

In the Wave Gait, all legs on one side are moved forward in succession, starting with the rear most leg. This is then repeated on the other side. Since only one leg is ever lifted at a time, with the other five being down, the animal is always in a highly-stable posture. One conjecture is that the wave gait cannot be speeded up very much. Wave gaits are a group of gaits in which a wave motion of foot falls and foot lifting's on either side of the body move from the rear

to the front, one after another with constant intervals, and in which the laterally opposing legs differ in

phase exactly half of a leg cycle. Each wave gait is characterized by a forward wave of stepping actions from the back to the front on each side of the body. The wave gait pattern is chosen in this system because it provides the maximum stability margin for uneven terrain navigation. The control algorithm is used for the control action of wave gait locomotion with an angular position input and torque command output. The foot is commanded to move forward a constant length as viewed from the main body at each integration time interval. The numbers adjacent to the legs in the body diagram correspond to time points for the wave gait. Md. Masum Billah, Mohiuddin Ahmed, and Soheli Farhana (2008)

E. Algorithm for Movement of Spider

Table1. Set of elementary reactions

Sr No	Behavior	Reaction
1	Behavior 1	Go Forward
2	Behavior 2	Rotate Right
3	Behavior 3	Rotate Left
4	Behavior 4	Go Backward

From the Table I, the steps of hexapod movement control system with elementary behaviors are summed up as follows-

Steps of progress:

1. The Spider stands for forward movement with tripod gait until grasps obstacle.

2. If perceive obstacles then wave gait with

a) Timer on for t seconds

b) Terrain consider as uneven

c) Go backward in the terms of behavior4, and then it

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uses its behavior 3 & 2 to rotate left or right (90 angles) according to the opposite direction of the obstacle.

d) Use behavior1 until grasp obstacle

3. Else tripod gait with behavior 1.

F. Obstacle and Collision Avoidance

We have designed two types of obstacle for the hexapod robot, such as 'hill' & 'ditch' type. Thus the hexapod robot will detect these obstacles during the navigation period. Sensor1 is used for the detection of 'hill 'obstacles and Sensor 2 is used for 'ditch' obstacles. Table II shows the method of different types of action during obstacle detection.

Table2. Different operations

Sr No	Behavior	Obstacle Status
1	Behavior 1	No Obstacle
2	Behavior 2	Left Obstacle
3	Behavior 3	Right Obstacle
4	Behavior 4	Front Obstacle

G. Robot gait generation:

The process of gait generation for a walking legged robot. The development of gaits for a walking robot requires control and coordination of a set of simultaneously moving legs. Walking gait can be defined as a sequence of consequent steps where every following step is a derivative of states of legs from the previous step. This sequence should be looped in order to lessen the complexity of computational tasks and ensure stable transfer from the last step to the first step of the gait without compromising stability of a moving robot. Further details will be given in sections below. Filipp Seljanko(2011)

H. Initial Step Generation

Initial step generation procedure generates first step of the gait based on random leg state selection, but in compliance with certain predefined rules. Every leg can have five different states. Three support states, when leg touches the ground and supports weight of the robot, and two transfer states, when leg is lifted and is being transferred to a new position.

- DR – (Down Rear) leg is on the ground in rearward position
- DF – (Down Forward) leg is on the ground in forward position

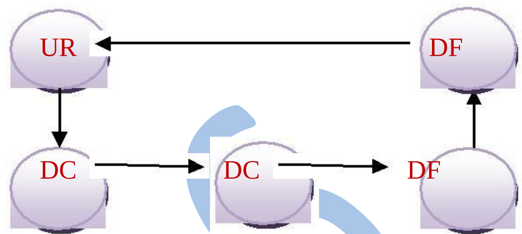

Fig2. Transfer diagram of the leg states.

- DC – (Down Center) leg is on the ground in central position
- UF – (Up Forward) leg is in the air in forward position
- UR – (Up Rear) leg is in the air in rearward

I. Leg Control

The system proposed by the authors (Fig. 3) is similar with the system xPC-Target component of Arduino1.0.6 IDE and Proteus 8.0. The Software that make possible the communication between Arduino board and proteus has been released with the last Version of proteus. Proteus8.0 has also developed support for Arduino in simulation. A part of the communication software i.e. Arduino library is uploaded on the Arduino board and plays the server role. There is one program that can be uploaded on the board: i.e. vilsservo..pde designed exclusively for motor control via PWM specially for angle and various motor control

Arduino1.0.6 & Proteus8.0

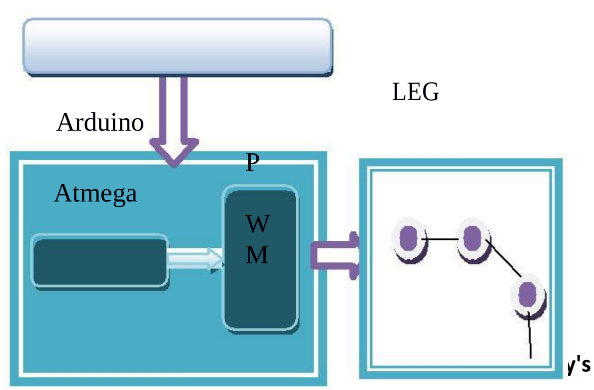

Fig 3. Leg control System

J. Walking Algorithm

During walking or running the leg move cyclically and in order to facilitate analysis or control, the motion of the leg is often partitioned in two parts:

- Support phase or stance when the robot uses the leg to support and propel.
- Transfer phase or swing when the leg is moved from one foothold to the next.

The stance part of the walking algorithm is supposed to move the leg in a straight line.

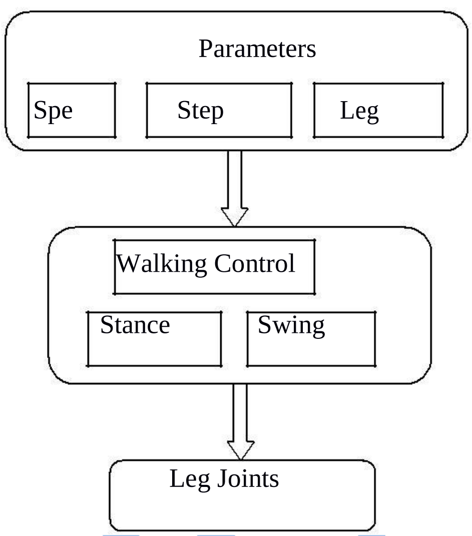

Fig.4. Transfer diagram of the leg states.

The swing part of the Algorithm must lift the leg off the ground, move it back to the starting position and lower it down to the ground again. The walking algorithm is based on the kinematical model of the leg. Mănoiu – Olaru Sorin, Mircea Niţulescu (2011)

Parameters introduce in the algorithm (Fig. 4) are:

- Speed; define the speed of the leg tip,
- Step length; define the length of the step,
- Leg lift; this defines how high the leg is

III RESULTS AND SIMULATION

GA algorithm have been used generate the gait of the motors in various angles of the respective legs Filipp Seljanko(2011)12 Motor has been interfaced to arduino

Mega and done the simulation on proteus 8.0
Code of program is done is .ino. This arduino language is developed by C++ and python. Code compilation is done by arduino 1.0.6 IDE and >hex file has been generated. The newly created >hex file has downloaded in Arduino MEGA which is interfaced to the 12 servo Motors.

In the table3, we have shown that positions and behaviors of motors in change in angle as per our requirement.

Table 3. Angle positions for 12 motors

Sr No	Position	Behavior
1	Position A	M1-M5-M9=> will rotate in 90 Degree direction remaining motors will be in rest position
2	Position B	M2-M6-M10 => will rotate in 90 Degree direction remaining motors will be in rest position
3	Position C	M1-M5-M9=> M3-M7-M11==> will rotate in 90 Degree direction remaining motors will be in rest position
4	Position D	M1-M5-M9=> will rotate in 90 Degree direction remaining motors will be in rest position

5	Position E	M1-M5-M9=> All motors will be in rest position

Proteus simulation

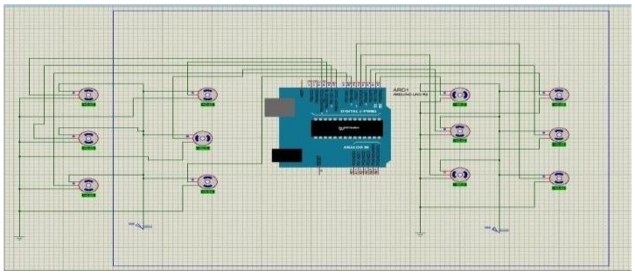

Fig 5. M1-M5-M9in position A

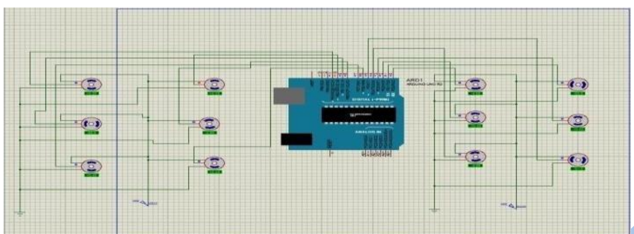

Fig.5. M2-M6-M10 in position B

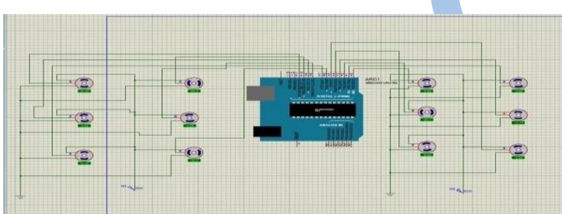

Fig.6. M3-M7-M11 in position C

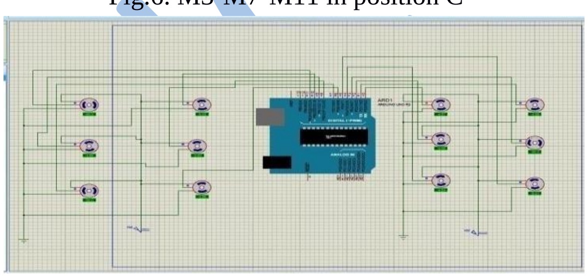

Fig.7. M4-M8-M12 in Position D

IV CONCLUSIONS

In the Spider development, in first stage we did simulation by proteus8.0 by genetic algorithm for locomotion control and Gravity search algorithm for stability control. Experiments showed that additional mechanisms for compensation of deviation of the robot path from preset trajectory are required.

Development of actual physical system for avoidance mechanisms and development of gait generation algorithm will be the subject of future work as well as development of actual hardware of spider with reconfiguration of leg with wireless control mechanism

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