ANALYSIS OF LOCOMOTION VERSATILE HEXAPOD ROBOT SYSTEM FOR INDUSTRIAL AUTOMATION

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Abstract: **This paper exhibits the hexapod robot movement performance. We analyze the performance of the DC servo motor in the robotic system and to enhance the function, The Hexapod robot movement analysis was made using Virtual Robot Experimentation Platform (V REP) software. Through this simulation we can analysis the performance of hexapod robot body and legs movement in various parameters. The Robotic system was separately analyzed and the simulation results are given..**

Index Terms— **DC motor, Intelligent Controller, MATLAB, Robots.**

I. INTRODUCTION

Robotics is the science technology of robots and it requires knowledge of Electronics, Mechanics and Software. It‟s mostly used in industrial automation, mechatronics and aerospace systems. The DC servo motor can be used to the robot movement system. Motors are normally used for joint and robot‟s wheel construction because of its small size and easier to control. In this research, to design an electrical and mechanical systems to control the robots, the electrical system (DC Servo motor) is controlled using neuro controller and also the electrical system (DC Servo motor) performance can be analysed with Proportional Integral Derivative (PID) controller and without Proportional Integral Derivative (PID) controller using MATLAB software and the results are compared. Each hexapod robot system‟s legs contain three joints and three links (Joint1, Joint2, Joint3, Link1, Link2, Link3). The performance of hexapod robot system and each joints (1,2,3), links (1,2,3) has been analyzed in various parameters using Virtual Robot Experimentation Platform (V REP) software. Simulation and analysis of the robot movement control system provide how to the intelligent controller effect the output speed of the system.

II. MATERIALS AND METHODS

A. Robotic system

Robotics is the science and technology of robots, their design, manufacture, and application. Robotics requires a working knowledge of electronics, mechanics and software, and is usually

accompanied by a large working knowledge of many subjects. A person working in the field is a roboticist. The appearance and capabilities of robots vary vastly, all robots share the features of a mechanical, movable structure under some form of autonomous control. The structure of a robot is usually mostly mechanical and can be called a kinematic chain (its functionality being similar to the skeleton of the human body). The chain is formed of links (its bones), actuators (its muscles) and joints which can allow one or more degrees of freedom. Most contemporary robots use open serial chains in which each link connects the one before to the one after it. These robots are called serial robots and often resemble the human arm. Some robots, such as the Stewart platform, use closed parallel kinematic chains. Other structures, such as those that mimic the mechanical structure of humans, various animals and insects, are comparatively rare, the development and use of such structures in robots is an active area of research. Robots used as manipulators have an end effector mounted on the last link.

C. Speed Control Method of DC motor

1) DC Motor Modeling

The electrical diagram of the permanent magnet DC motor is shown as Fig. 3. According to the Kirchhoff law, the electrical equation of DC motors can be expressed as in Equation (1).

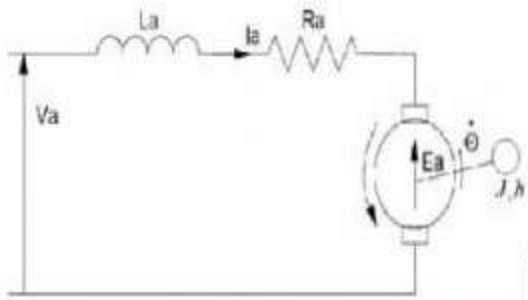


Fig.2.

Electrical diagram of DC motor

By applying the Newton's law and Kirchhoff's law to the DC motor system, we come up with mathematical equation (1) and (2) of DC motors.

$$V=L\ di/dt + Ri+Ea \quad (1)$$

$$J\ddot{\theta} + b\dot{\theta} = \tau m \quad (2)$$

Where, „V" is the supply voltage, „I" the armature current, „Ea" is the back-emf (electromotive force). „L"and"R"arethe electric inductance, and electric resistance respectively. „J" is the moment of inertia of the rotor„b"is the damping ratio of the mechanical part. The motor torque, τm, is related to the armature current, i , b y a constant factor „kt" (In SI units, kt (armature/torque constant) is equal to ke(motor/speed constant)). The back emf, „E" is related to the rotational speed by the equation (3).

$$\tau m = kt.i \quad (3)$$

2) Speed control structure for DC motors

Figure 3 illustrates a speed control structure of DC motor The control scheme consists of an inner current control loop and an outer speed control loop. The output signal of speed controller is the input of the current controller.

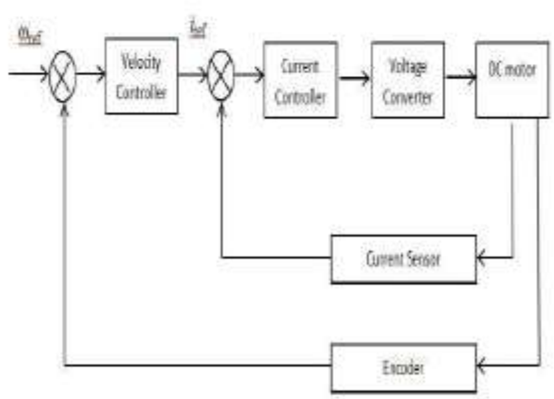


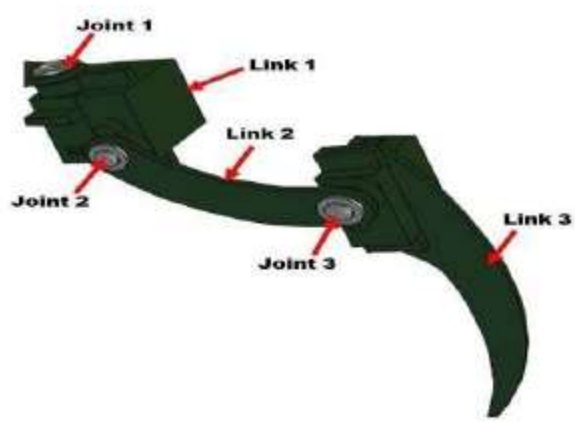
Fig.3. Speed Control Structure for DC motor

Those two controllers can be designed independently because the mechanical dynamics of the system is usually much slower than the dynamics of the armature circuit. Reference speed ωref is the desired speed which the motor should be achieved after a designed time. The controller found in typical industrial systems is PID control algorithm. It can also be included fuzzy, neural network, or adaptive controllers. The current sensor and encoder are usually used as feedback devices in the system.

D. Hexapod Robot System

The hexapod robot is like a six legged insect that enables it to move flexibly in various terrains. This robots are statically stable, therefore they don"t have to depend on balance mechanisms.

(a)



(b)

Fig 4. (a) Hexapod robot model (b) Links and joints of Robot Leg

Though it needs feedback and positive reaction to acquire smoother walk. This type of robot can be used in many ways for real life circumstances such as search and rescue application during disaster environment exploration and also as a CNC machine. Figure 4(a) shows the actual hexapod robot system and figure 4 (b) shows leg of the hexapod robot system, its includes three joints (joint 1, joint 2, joint (3) and three links (link 1, link 2, link 3).

E. Robot movement control system

The robotic movement control system designed for this project is based on few subsystems normally available in most digitally controlled movement design technology. The speed system is the DC motor subsystem. This system can be divided into two parts, the mechanical system and electrical system. Both systems are designed to be controlled by a digital controller subsystem. The sensor subsystem is designed to interact with the digital controller subsystem. The sensor subsystem provides the digital controller subsystem with all information or signals about the environment condition. From this information or signals, the digital controller is expected to be able to control the DC motor subsystem rotation speed. Input switching subsystem is designed to turn on or turn off the motor. Implementation of fuzzy logic based controller system is another approach to this design.

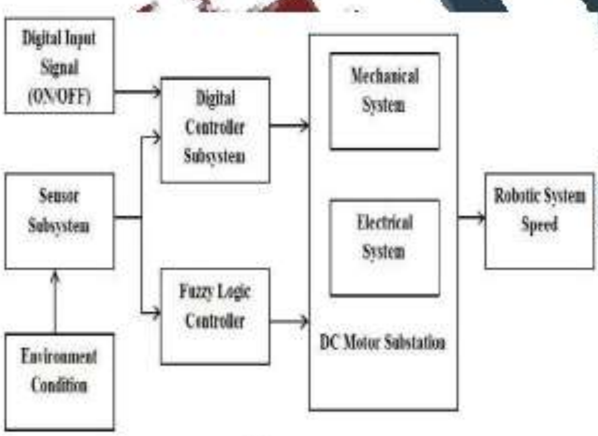


Fig.5. Block diagram of robot movement control system

This controller will interact with the sensor signal and provide additional control to the DC motor subsystem. The designed robotic movement control system block diagram is shown in Fig.5. The DC motor subsystem is the main component that decides how fast the robotic system will move. This subsystem is connected to the mechanical movement system of the designed robot. The main idea in this simulation is to observe how the speed of the robotic system can be controlled and how does a fuzzified controller affect the system. Speed control of a robotic design is always based on how or which type of motor system to be developed. Various types of motor can be used to move the robot joint, robot base system, robot arm and etc. For a simple design, designers normally choose to use either DC servomotor or step motor. In this study, digital controlled DC motor model was chosen for the robotic speed control system design. Basic structure of a DC motor can be divided into two part; voltage controlled circuitry and mechanical rotor. The motor torque provides the movement over inertia for the rotor system. If the motor initially in static condition, it requires larger torque value to start the motor. If the motor initially in moving condition, the inertia of the motor will sum up with the system torque to give a grater rotation which will further increase the moment speed of this system.

III. RESULTS AND DISCUSSION

The results and Tables shows the hexapod Robot Movement (Time vs Distance) and it shows the Position value of hexapod robot legs. The proximity sensor is used in hexapod robotic model to sense the objects, so the robot moves forward, faster and DC servo motor placed in each and every joints in robot legs. The proximity sensor is used in hexapod robot system to sense the nearest objects, so the robot moves quicker to the target. It is used to improve the performance of the DC servo motor in robotic system safely. Figure 6 shows the body position graph of hexapod robot and figure 7 shows the proximity sensor graph of hexapod robot model. These results are used to analyse the performance of hexapod robot movement.

Time (Sec)	Position		
	X	Y	Z
93.35	0.177165	1.265485	0.104299
98.25	-0.02717	1.290485	0.104317
100.00	-0.0881	1.257966	0.104393
105.00	-0.29584	1.344015	0.104438
106.40	-0.40952	1.372836	0.104203

Table 1. Position value of

Hexapod Robot System with sensor

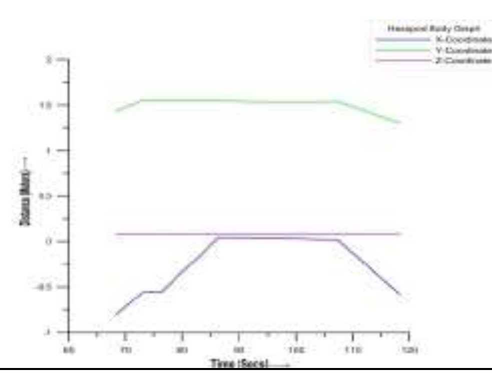
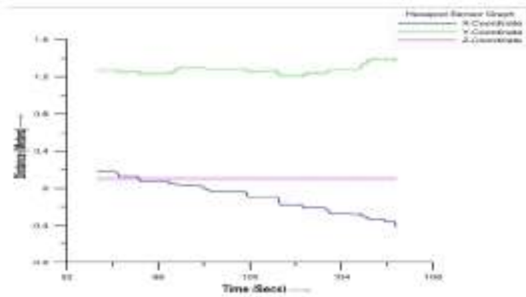


Fig 6. Hexapod Robot body position graph



IV.CONCLUSIONS

The robotic movement control system can improved. The robot body position can analyzed and improve the accuracy of the robot movement, proximity sensor to use sense the object and to avoid the damage, and the robot body position also analyzed using V-Rep software. Finally the robot position and movement can be analyzed for industrial automation.

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