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DESIGN AND FABRICATION OF PROTOTYPE OF STEWART PLATFORM USING SIX DEGREE OF FREEDOM

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ABSTRACT

This paper gives information about linear actuators which is to be used in a six-degrees-of-freedom dynamic test system using Stewart device application intended for simulation/space technology. The paper reacts to recent calls in the space application. The Stewart platform is frequently used in simulation technology to simulate motion effects in vehicle or airplane simulators. This paper looks at the design and optimal control of an electromechanical linear actuator to be used in a simulation of a 6 D.O.F motion platform. By using this type of platform we can replace the hydraulic system with electro-mechanical system as in linear actuator without affecting kinematic as well as dynamic parameters. The paper provides a comparison of both types of system having a detailed description of the design of optimal control for electromechanical actuators.

KEYWORDS: Electromechanical linear actuator, Stewart platform, simulation technology, optimal control.

1. INTRODUCTION

A platform having six degree of freedom is known as hexapods. In this era of simulation, robotics manipulator is generally used now days alternative manipulator is being designed so that they can over come the drawbacks of previous design.

Parallel manipulator has several advantages over series on either in terms of greater structural rigidity, accuracy as the arrangement consist of three major parts: first one is top frame which is in a hexagonal shape, second one is bottom frame which is 1.5 times larger in size as of top one and the third one is linear actuators as they are electro-mechanical. Here with the help of high torque DC motors these actuators can be run easily to sustain the load. Moreover in this type of platform we are not operating the movement of actuator manually instead we are equipping PCB in which a program is written on the board hence interfacing is easily achievable.

Six degree of freedom refers to the activity of a solid state / rigid body in a 3D space. Last 2 decades six degree of freedom mechanism has received great attention due to several features such as high rigidity, low inertia effect, compact size and very high local dexterity. According to the area of use there exist various configuration: Stewart platform and variation in the top and bottom platform and connecting joint so the mechanism discussed in this paper is used for following -

1) Position device for high precision
2) Surgical tools as a platform for simulation
3) As a basis of design for new type of machine tools manufacturers CNC machines
4) As basis of design for automatic assembly transferred machine
5) As a vibration isolator and damping vibration in machines
6) As a mechanism for docking and berthing in space craft
7) Prosthetic leg – Assistive foot
8) Automatic satellite disc positioning system
9) Stationary platform

The main focus of paper is to bring attention towards Docking & berthing application.
Docking is in simple terms can be explained as joining of two different space capsule in space which is generally manned.

Berthing is when two different inactive modules start separating which is done with a help of an robotics action as in these two operation the vibration and chattering produced a lot so to overcame or reduced up to a certain limit.

This mechanism is firstly used in LIDS that stands for Low impact docking system in 1980.

Fig. 1.

In 1965[1] D. Stewart had proposed the six degrees of freedom mechanism for the first time from the last decade many of the researches had put their effort to sort out the problem which are enrol with forward and reverse kinematics.[1] To make it simple or the trial done to enhance its simplicity, most of them tried to solve for forward and inverse kinematics.

In 1988 [1], Lee and Shah solved the forward and inverse kinematic of 3 – D.O.F mechanism (two for orientation and one for translation), where the base fixed plate is connected to the upper mobile plate through 3legs (actuators) only. The equations of motion have been formulated in joints pace using Lagrangian approach. However it was suggested to be a part of manipulation systems for limited applications.

In 2002,[2] Song and kwon with the help of tetrahedron approach a new direct kinematic formulation of 6 D.O.F Stewart platform is developed. The approved model was 3-6 platform, where the author used a new formulation approach to easily derive a single constraint equation of the direct kinematics. According to the author it's still a challenge due to the complicated formulation in the forward kinematic problem of the 6-6 type and heavy computational burden.

In 2004,[2] Merlet solved the forward kinematics of 6 degree of freedom Stewart mechanism of the type 6-6, where the mobile platform is connected the fixed plate through 6 extensible links. However, the author did not fully solve for forward kinematics, but solved for all then possible poses of the platform, given the six leg lengths of the extensible links. The author declared that this step is accepted as soon as some method will allow determining which solution among n solutions is the current pose of the robot. According to him, no such method is known to date, even for planar parallel mechanisms.

In 2005,[2] Roll and introduced a method for solving the forward kinematics problem with an exact algebraic method for the general parallel manipulator. In this method the parallel manipulator kinematics is formulated as polynomial equations system where the number of equations is equal to the number of unknowns. As the author mentioned, solving the most general case (6-6 Stewart platform), the rational representation comprised a univariate equation of degree 40 and 8 to12 real solutions were computed.

In 2011, Gonzalez and Lengerke they solved inverse as well as direct kinematics of Stewart platform applied to cargo transportation which are at off shore.

2. SIMULATION TECHNOLOGY

The Stewart platform is generally used in simulation technology just to simulating the effect on aircraft and simulators, by using these technologies we can actually simulate all the forces which are acting on it. Without any physical damage we can actually check / the ultimate limit to what extent it can bare the forces can bear and can sort out the errors. It plays a vital role in modern training; here all the crucial exercise which can't be done in actual practice can be done easily.

3. AIM OF DESIGN

There are various configuration of stewart platform depending on the area & purpose and the use but in all cases we have to keep in mind that design have to very simple and easy to run. There are certain consideration we have to keep in mind,

1. It must have high pay load / structure weight ratio to achieve maximum performance from available power
2. Low frictional motion to reduce power losses & to obtain high response.
3. Each motor has a specified motion with simplified control.
4. Basic Component of Platform

- Lead screw – Electro-mechanical actuator

Length –500 mm

Diameter -16 mm

Thread – V- type

Pitch – 2mm

- **Bush**

Material – Mild steel

Pitch- 2.05 mm

Width – 15 mm

- **DC Motors**

RPM - 60

Torque – 35 kgf cm

- **Pulley & belts –**

Material-Inner dia-16 mm

Outer dia – 60mm Belt – A15

- Universal joint- Material – stainless steel.

½" CV 1773

We are using two kind of sensors

1. Ultrasonic sensor - so as to locate the target object which is at a certain range or distance in the space we require this sensor to determine the location so that it can easily mate the target body
2. Infrared sensor - we are using six sensors over the hexagonal frame and when the mating body is near to the target body infrared sense the distance and mate with the target body completely.

4. CONTROL MEANS

In order to arrange the platform to be operated in a pre-determined programme involving linear & angular motions or combination of both, necessary signals are given to different motors in accordance with input requirement to control the platform in required direction

5. WORKING MECHANISM

The 6 D.O.F platforms capable of moving in all 3- linear directions and 3 angular orientation single or in combination it has a hexagonal fixed bottom frame connected to top frame with the help of 6 arms called linear actuators. The translation movement of the actuators is operated by DC motor in a controlled manner so as to achieve desired motion. The motor has a low R.P.M as a result it has a high torque due to which load sustaining capacity is very high. The rotatry motion of motor is transferred to lead screw with the help of pulley belt

mechanism due to which the hollow cylindrical cap attached to the bush as a result desired motion can be achievable. With the help of universal joint the 6 D.O.F can be achievable the number of universal joints are twelve, though 6 are attached to the top frame and remaining are in bottom frame.

6. FUTURE SCOPE

Six degree of freedom stewart platform can be modified by using positioning sensors for proper alignment in hospitality sector (The wheel chair can be modified by using these linear actuator) second in gaming application

7. CONCLUSION

As the desired result can be achievable with in a specified duration of time by mating the top frame with the target body which is at a certain orientation .With the help of linear electro-mechanical actuator we can alterate the position of top frame hence mating can be achievable.

8. REFERENCES

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