REVIEW AND ANALYSIS OF GOUGH-STEWART PLATFORM

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***Abstract*:** This paper represents the literature review of the 6 degrees-of-freedom parallel manipulator commonly known as Gough-Stewart platform by closely analyzing its mechanism. Comprehensively, it also shines light on numerous implementations in various applications. The Gough-Stewart platform was originally found to establish a suitable mechanism for flight simulation. It has been modified over the years for applications ranging from stabilization of loads in cranes to vibration isolators. This paper takes a review of modifications done to the original design for respective applications.

Keywords: Gough-Stewart, 6-DoF, 6-Axis.

I. INTRODUCTION

A Gough-Stewart platform(D. Stewart Et al. [1]) is a type of parallel robot that has six prismatic actuators, commonly hydraulic jacks or electric actuators, attached in pairs to three positions on the platform's base plate, crossing over to three mounting points on a top plate. Devices placed on the top plate can be moved in the six degrees of freedom in which it is possible for a freely-suspended body to move. These are the three linear movements lateral, longitudinal and vertical, and the three rotations pitch, roll, & yaw.

The Stewart Platform was originally designed in 1965 as a flight simulator, and it is still commonly used for that purpose. Since then, a wide variety of applications have benefited from this design. A few of the industries using the Stewart Platform design include aerospace and defence, automotive, transportation, and machine tool technology, who use the platform to perform flight simulation, handle vehicle maintenance, and design crane hoist mechanisms. The Stewart Platform design is also used for the positioning of satellite communication dishes and telescopes and in applications such as shipbuilding, bridge construction, transportation, and as a drilling platform on the Lunar Rover.

II. FRAMEWORK DESIGN

The Stewart Platform is a classic example of a mechanical design that is used for position control. It is a parallel mechanism that consists of a rigid body top plate, or mobile plate, connected to a fixed base plate and is defined by at least three stationary points on the grounded base connected to six independent kinematic legs. Typically, the six legs are connected to both the base plate and the top plate by universal joints in parallel located at both ends of each leg. The legs are designed with an upper body and lower body that can be adjusted, allowing each leg to be varied in length.

The position and orientation of the mobile platform varies depending on the lengths to which the six legs are adjusted. The Stewart Platform can be used to position the platform in six degrees of freedom. In general, the top plate is triangularly shaped and is rotated 60 degrees from the bottom plate, allowing all legs to be equidistant from one another and each leg to move independently of the others.

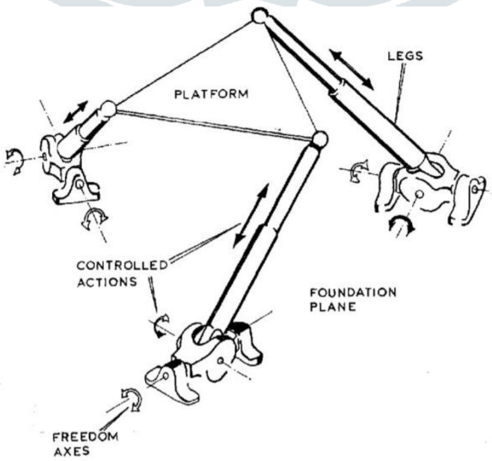

Figure 1: General Representation

III. APPLICATIONS OF GOUGH-STEWART PLATFORM

3.1 Implementation of Stewart Platform in cranes

Existing cranes of many different types from many manufacturers are able to lift comparable loads, but cannot stabilize the loads in rotation or sway and have no means of controlling forces or torques on the load. Under ideal conditions, a highly skilled crane operator can provide some degree of oscillation damping. However, for precision orientation, crew of riggers is needed to manually stabilize the load from rotating and swinging and to manually guide the load into its desired position with adverse conditions such as winds. An expert operator cannot prevent perturbations such as wind from causing load to sway. Novice operators of conventional cranes might have difficulty in preventing heavy loads from colliding with objects in its surroundings.

Principal advantage of the SPIDER(Roger Bostleman Et al. [2]) is that it provides sufficient control to allow even a novice operator to position a load without sway to within a few millimeters in x, y and z directions, and to control orientation without oscillation to within one degree in roll, pitch and yaw. Force sensors on SPIDER mechanism could also allow the operator (with computer assistance) to control forces and torques on a load after it comes into contact with the environment. The control provided by the SPIDER could thus reduce the size of crew needed to manually position loads. An additional advantage of SPIDER is its high lift-to-weight ratio. Due to its octahedron geometry, the SPIDER requires no counter weight and experiences no twisting or bending moments. As a result, it can lift at least five times its own weight. This is another important advantage.

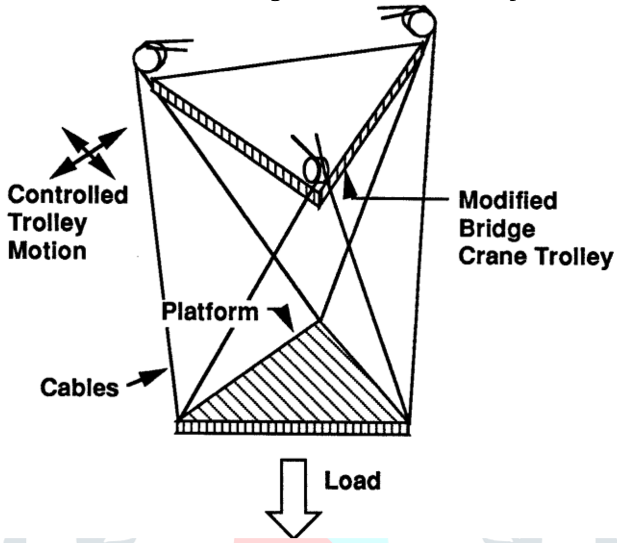

Figure 2: Stewart Platform in Cranes

3.2 Implementation of Stewart Platform as Flight Simulator

The development of flight simulators bears close relation to the advance of modern aircraft(Wu Dongsu Et al. [3]). A flight simulator has two most important functions, one is flight training, the other is research and development. In flight training, it is used mainly to reduce cost and increase safety, while in research and development, it performs flight simulation to evaluate the controllability of a new airplane or the performances of a newly devised component prior to its flight testing. Another kind of flight simulator is used to determine the causal factors in an accident and replicate the accident scenario. In order to fulfill the above-mentioned functions, flight simulation must imitate flight and provide realistic information that indicates a vehicle motion in three ways: (1) from visual system with naked eyes; (2) from vestibular system; (3) from tactile system, in which, for instance, the acceleration of a vehicle is perceived from the force that the seat exerts on a pilot's back.

As an important element of a flight simulator, the motion platform serves to simulate the motion of aircraft and provides the pilot with realistic vestibular feelings and a part of tactile feelings.

3.3 Implementation of Stewart Platform in Helipad

The invention relates generally to the field of aircraft access to floating structures. More particularly, the invention(Vidar Hovland Et al. [4]) relates to helicopter landing pads or platforms associated with floating structures such as seismic Survey vessels.

As with any marine seismic vessel, at least Some personnel are required to navigate the seismic vessel, and operate the various seismic data acquisition equipment on board the Seismic vessel. Typically, seismic Survey seismic vessels include a helicopter landing pad to facilitate movement of personnel onto and from the seismic vessel while the vessel is at Sea. As a matter of personnel safety, however, there are limits to the amount of seismic vessel movement, other than in the direction of travel of the seismic vessel, for which helicopter landing and takeoff can be safely performed. Such movement has three components known as pitch, roll and heave.

One aspect of the invention is a motion compensator for a helipad on a vessel. A motion compensator according to this aspect of the invention includes a sensor for measuring a parameter related to at least one or pitch and roll of the vessel. The system includes a first actuator functionally coupled to the helipad to move the helipad translationally with respect to the vessel in response to the measured at least one of pitch and roll of the vessel. A controller operates the actuator in response to the sensor measurements to provide the required compensatory motion. Another aspect of the invention is a method for compensating motion of a helipad on a vessel for effects of at least one of pitch and roll motion of the vessel. A method according to this aspect of the invention includes measuring a parameter related to at least one or pitch and roll of the vessel, and moving the helipad by an equivalent translational displacement thereof caused by the at least one or pitch and roll motion. The equivalent displacement is determined from the measured parameter.

3.4 Implementation of Stewart Platform as Vibration Isolator

In this work, we investigate the active vibration isolation and damping of sensitive equipment(Ahmed Abu Hanieh [5]). Several single-axis isolation techniques are analyzed and tested. A comparison between the sky-hook damper, integral force feedback, inertial velocity feedback and Lag Lead control techniques is conducted using several practical examples.

The study of single-axis systems has been developed and used to build a six-axis isolator. A six degrees of freedom active isolator based on Stewart platform has been designed manufactured and tested for the purpose of active vibration isolation of sensitive payloads in space applications. This six-axis hexapod is designed according to the cubic configuration; it consists of two triangular parallel plates connected to each other by six active legs orthogonal to each other; each leg consists of a voice coil actuator, a force sensor and two flexible joints. Two different control techniques have been tested to control this isolator: integral force feedback and Lag-Lead compensator, the two techniques are based on force feedback and are applied in a decentralized manner. A micro-gravity parabolic flight test has been done to test the isolator in micro-gravity environment.

In the context of this research, another hexapod has been produced; a generic active damping and precision pointing interface based on Stewart platform. This hexapod consists of two parallel plates connected to each other by six active legs configured according to the cubic architecture. Each leg consists of an amplified piezoelectric actuator, a force sensor and two flexible joints. This Stewart platform is addressed to space applications where it aims at controlling the vibrations of space structures while connecting them rigidly. The control technique used here is the decentralized integral force feedback.

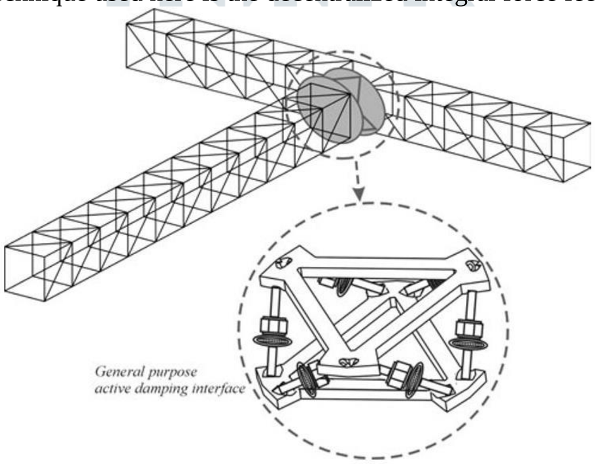

Figure 3: Vibration Isolator

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