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Design Exploration & Optimization Interactive Gimbal Design

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Abstract

Gimbal can be any support that can pivot around an axis; most Gimbal systems look like a series of concentric rings. The outermost ring mounts to a larger surface, like a boat's instrument panel. The next largest ring connects to the outermost ring at two points that are perpendicular to the outer ring's surface mount. Then, the third largest ring mounts to the second largest one at two points' perpendicular to the connection between the first and second ring, and so on. Sound confusing. Aero plane system posses Gimbal. In this Gimbal attached vision system. This paper deals how to eliminate friction between Gimbal system and vision system while yaw, pitch and role movement of auto plane.

Key words:
ADAMS, AML, PATRAN, NASTRAN, Matrix-X, ACCOS-V, FEM, M-Vision, Oracle, DADS, and PV-Wave.

1. Introduction

The basic concept of the DEO-IGD program, titled "Development of an Adaptive Modelling Language (AML) for Mechatronics -based Engineering with application to Interactive Gimbal Design (IGD)", is the development of a system that will allow for the efficient integration of overall gimbal system requirements, sensor models, optical designs, mechanical designs, structural analyses, stabilization models and manufacturing processes and design optimization.

The IGD system will capture previous successful gimbal designs and interactive data base available a database of gimbal subcomponents to aid in the design of vibration isolation of gimbals. The IGD System will offer a significant Productivity increase in the ability to design and evaluate gimbal systems. The design, analysis,

optimization and manufacturing of gimbals and integrated optical systems. It is a complex, highly interactive, and time-consuming process that contributes significantly to the overall product cost of electro-optical systems. This task must address cost, technical performance, vehicle specification considerations, weight, dynamic performance, accuracy, environment and a host of other aspects in order to bring about an effective design. Significantly contributing to this design optimization process is the use of bearings, gyros, resolvers, and torquers. Whose operational and physical properties, environmental limits and interfacing requirements are critical to the design process. The IGD program requires the integration of software products.

2. General gimbals and vision control problem

2.1 Theoretical Foundation

As described in the previous section, the problem of servo control of a flexible, multi-degree of freedom kinematic chain, or flexible gimbal system must be treated as a non-linear control problem. That is, the control of such a system is a controlled process, the dynamics of which has the following form

$$\dot{\underline{x}} = f(\underline{x}, \underline{u}, t)$$

Where u is the vector input to the system, x is the; State vector of the system, f is a non-linear and possibly time variant function, and "t" represents

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time. If a performance criteria having the general form And a reference signal, r(t), which signifies

$$S = \int_{T_1}^{T_2} G\ (\underline{c}(t), \underline{u}(t), \underline{r}(t), t)\ dt$$

the desired output response and G represents a loss function or measure of instantaneous change from ideal performance, is given, then an optimal control problem is specified. The problem of optimal control is the determination of the control input, g, that minimizes the performance criteria, S , subject to certain constraints on p and x. Before proceeding with this problem, let us pose a reasonable question about the applicability of an optimal control approach to servo control of flexible manipulators. Why has optimal design not yet been discovered?

2.2 Reasons

One reason is that gimbal developed from vision oriented system. Whose prime focus was developing a useful system rather than a complete theory. Gimbal system though highly non-linear and strongly coupled could be built with controls based on linearized or otherwise simplified models. This approach has resulted in a generation of gimbal system. Which are useful, but whose performance may be orders of magnitude less versatile than could be obtained. Most of the gimbal and vision systems move at velocities of less than one meter/second. However, by paying careful attention to control and error minimization, and by using direct drive.

2.3 Problems with gimbal and Vision systems

Another problem preventing optimal design is that only a limited number of performance criteria can be written in a closed analytical form. However, many criteria such as position, force, accuracy, energy, path length, etc. can be easily described. Also, in some cases it may appear that multiple criteria must be satisfied. In some cases such as system rings reaching for the same object, the individual criteria will conflict resulting in a winner and a loser or a tie. Solutions in optimal control involve the solution of non-linear two-point boundary value problems. These may be difficult to solve either analytically or computationally. Thus, the computational burden for an optimal solution may be large that it prevents real time state of affairs. Suggestion given by Shinners is stress the state-space approach for problems involving non-linearities, time varying characteristics, and multi-variable inputs and outputs.

3. Assumptions of gimbal and vision systems

A basic assumption in Centaur pilot system simulation is that friction exist the system. This phenomenon has been modelled as classical coulomb friction. With level of friction chosen from information gathered from test firings of the part. The effect of Coulomb friction has been documented for oscillating pendulums. The system has been modelled. Time responses showed that, for level of Coulomb friction used in analysis, unacceptably large altitude error.

3.1 Model for Gimbal System

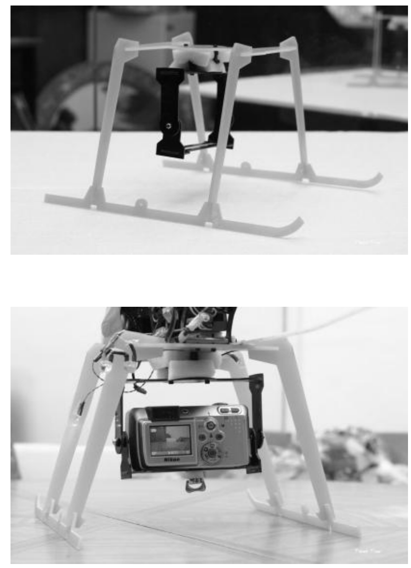

Fig 3.1 Gimbal vibration isolation system

A gimbal vibration isolation system suitable for use with an inertial platform to enable accurate positioning of the platform independently of a presence of vibratory translational movement upon a gimbal housing enclosing the platform employs a frame assembly centrally located within platform for pivoting the platform and for isolating the platform from vibration. The gimbal housing includes a drive ring rotatable about a central axis and encircling the frame assembly which is connected to the drive ring. A central portion of the frame assembly carries a pivot which pivotally supports the platform. An electromagnetic actuator is located at each of a plurality of positions located circumferentially around the central axis wherein each actuator has a first part connecting with the frame and a second part connecting with of the platform to accomplish a pivoting between platform and frame assembly upon activation of each actuator. The frame assembly further includes a plurality of vibration isolation elements of resilient material disposed symmetrically about the central axis and being connected between the first parts of respective ones of the actuators and the drive ring to allow operation of the actuators in an environment substantially free of translatory vibrational movement.

3.2 Two axis gimbal suspension with wireless signal and power transfer

A suspension system permits fine angular adjustment of a gimbal-mounted platform and, in combination with a wireless power and communications transfer system, eliminates the unwanted forces associated with systems which rely upon cables to transfer power and signals between a gimbal platform and its support structure.

3.3 Flexure mounted gimbal support assembly

A flexure mounted gimbal support assembly for limited angular rotation hag a flexure assembly of an open web construction mounted between a platform and a gimbal assembly via a ball bearing assembly. The flexure assembly has a plurality of flexure elements having a high flexibility so that the flexure assembly provides less resistance to rotational motion than the static ball-bearing friction over the limited angular rotation. A slip-ring assembly is mounted inboard of the flexure assembly to provide direct connection to angle measuring resolvers and direct-drive dc torque motors, which eliminates slip-ring brush-on-ring effects and torque motor brush friction effects.

3.4 Antifriction bearing with compensating flexural pivot in a free axis gyroscope

An antifriction bearing with compensating flexure pivot, including a shaft supporting a load and mounted in a suitable ball bearing arrangement with a flexural pivot device operatively connected in the shaft intermediate the load and the bearing so as to provide a free axis of a gyroscope. Thus one operative part of the flexural pivot is secured with an inner race of the bearing so as to permit large angular freedom of movement of one gimbal of the gyroscope relative to another gimbal of the gyroscope about the free axis provided by attaching the other operative part of the flexural pivot to one gimbal of the gyroscope, and an outer race of the bearing arrangement to the other gimbal of the gyroscope so that the deflection of the flexural pivot may in effect be always kept nearly at null so that torque transmitted to the load due to friction at the bearing may be considered of a negligible effect and the bearing substantially frictionless.

4. Conclusion and recommendations

This brief overview of the wide angle vision system for vision servo control of a gimbal system has started from general theoretical principles and followed by a specific example. The general gimbal control problem is difficult due to the non-linear, coupled nature of a multi-degree of freedom device. In specific cases, clever methods are required to uncouple the various degrees of freedom and simplify the non-linear elements. The use of a specific test vehicle, a gimbal lawn mower, has provided a research tool with which to test new concepts and approaches. A great deal has been learned about gimbal design and optimization. More theoretical research and demonstration devices are needed to apply the full power of control theory to the great variety of useful applications of gimbal vision systems.

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