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Kinematic Analysis And Optimization Of Multi Dof Parallel Manipulator

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ABSTRACT: The role of robotics in society is no longer restricted to assembly and manufacturing. Robots are finding their way into –a wide spectrum of tasks that directly link human and machine. Due to the modelling error or environmental uncertainties, robot motion may present a significant positioning error by using a conventional Computer-Torque Method. To improve tracking capability of robot manipulators, sliding mode control and nonlinear control algorithms have been introduced, but computation is costly, and thus a fast motion execution using simple computer sources is impossible. To resolve this problem, the resolution and position accuracy of magnetically suspended frictionless Hexapod multi DOF manipulator is designed and it will simulate with the help of Adams Software. From Reverse Position Analysis the system joint information can be obtained for a specified operational position. Forward kinematics for a manipulator is the process to calculate the position (or motion) of an end effectors when joint variables are specified. The process is carried out by multiplying sequentially the 4x 4 homogeneous transformation matrix of each joint and finding the transformation matrix *Ti* for the corresponding position The main objective of this Project is to Study the kinematic behavior of the Multi DOF Manipulator mechanism and to control the overall action and to develop a procedure for the optimal design of a redundantly actuated Multi DOF manipulator and to determine the geometric parameters and operating limits.

KEYWORDS: Manipulator, Optimal Design, Operating Limits, Etc.

INTRODUCTION:

A manipulator can produce constrained paths to guide the human along desired trajectories. The advantage of such systems is the ability to actively control and record resistance. A multiple degree of freedom system can facilitate a wide range of exercises. For rehabilitation, measurement of human resistance can assist in the isolation and quantification of injuries as well as gage progress. The first prototypes were mechanically and electronically crude. The evolution of computers and mechanical motion systems has renewed interest in this field. One critical issue currently under investigation is the modelling of human resistance. Material handling is a specialized activity for a modern manufacturing concern. It has been estimated that about 60-70% of the cost production is spent in material handling activities.

MANIPULATOR DESCRIPTION:

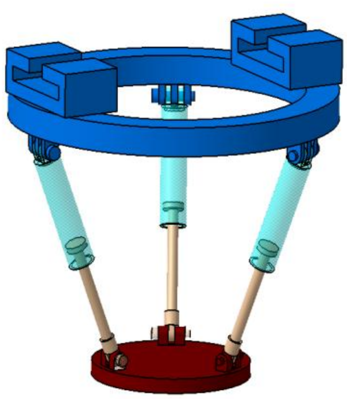

Fig-1 MDOF Manipulator

The Multi-DOF parallel manipulator study in this Project consists of a moving platform that is connected to a fixed base by three legs. Two of the three legs, called the actuated leg, have kinematic ally identical topology. The *i* th actuated leg *i l* (=1, 2) connects point *i B* on the base to point *i b* on the moving platform by a passive revolute joint followed by an active prismatic joint and another passive revolute joint. The third leg *C l* is a passive constraining leg and has architecture different from the other legs, one end of which is fixed perpendicularly at the centre *C* of the moving platform and the other is jointed at the centre *O* of the base by a passive revolute joint followed. Reverse Position Analysis the system joint information can be obtained for a specified operational position. First of all, all the vectors describing the positions of the mechanism will be obtained. The position vectors are the vectors from the origin of the local upper platform reference coordinate to the ball and socket joint, and from the origin of the global lower platform reference coordinate to the gimbal joint, respectively. Forward kinematics for a manipulator is the process to calculate the position (or motion) of an end effectors when joint variables are specified. The process is carried out by multiplying sequentially the 4x 4 homogeneous transformation matrix of each joint and finding the transformation matrix *Ti* for the corresponding position.

PROBLEM DEFINITION

Due to the modelling error or environmental uncertainties, robot motion may present a significant positioning error by using a conventional Computer-Torque Method. To improve tracking capability of robot manipulators, sliding mode control and nonlinear control algorithms have been introduced, but computation is costly, and thus a fast motion execution using simple computer sources is impossible. To resolve this problem, the resolution and position accuracy of magnetically suspended frictionless multi DOF manipulator is designed and it will simulate with the help of Adams Software.

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FORCE ANALYSIS:

A magnetic suspension system uses two magnetic components, one of which must be active if motion control is to be accomplished. We have chosen in our work to use rare earth passive magnets mounted on the micropositioner and air core solenoid electromagnets fixed on the base frame. This particular combination, named as a moving-magnet type manipulator, permits the micro-positioner to work without a power or signal tether to the moving manipulator, improves the positioning accuracy due to the freedom from temperature expansion of the positioned, and uses a drive system which is very linear and thus predictable in behaviour. Air-core solenoid has a few advantages over an iron core in that it has no hysteresis, no eddy current loss, and no saturation of flux density. These characteristics all serve to increase the accuracy which can be achieved. Permanent magnet is being used in many applications of small magnetic systems because it can supply a sufficient force and it is suitable for compact design.

POSITION KINEMATICS:

From Reverse Position Analysis the system joint information can be obtained for a specified operational position. First of all, all the vectors describing the positions of the mechanism will be obtained. The position vectors are the vectors from the origin of the local upper platform reference coordinate to the ball and socket joint, and from the origin of the global lower platform reference coordinate to the gimbal joint, respectively. Forward kinematics for a manipulator is the process to calculate the position (or motion) of an end effectors when joint variables are specified. The process is carried out by multiplying sequentially the 4x 4 homogeneous transformation matrix of each joint and finding the transformation matrix *Ti* for the corresponding position

WORKSPACE ANALYSIS:

The workspace of the presented manipulator is the set of all the output variables *x y* at which the reference point *C* of the moving platform can reach. In this study, in order to disregard the mechanical interferences between the links and joints, especially between the passive leg *C l* and the base joints 1 *B* and 2 *B* , the range of the rotation angle of the moving platform is restricted . In addition, the range of motion of the actuator is given by 1 2 min max *l* , *l* .The geometric algorithm to obtain the boundaries of the workspace for the manipulator studied in this paper. If inputs 1 *l* and 2 *l* are specified, (2) and (3) represent two circles in the frame *O_ xy* , each of which has its radius of *i l* (*i* =1, 2) and its center at *i i x y* . Considering that these centers are given as the function of the dependent variable *θ* yields the following relationships For effectively calculating the workspace size required in the design stage of the presented manipulator, it is necessary to derive the boundaries of the workspace symbolically. The outer boundary represented by *CM x y* is obtained wherever at least one of the actuators reaches at its maximum length max *l* , while the inner boundary represented by *Cm x y* at its minimum length min *l*.

DESIGN OF MAGNETIC LEVITATION SYSTEM

Employing the antagonistic property obtained by using the air core solenoid and magnet in pair a maglev micro positioning manipulator shaped. The box shaped manipulator consists of the top and bottom plates which are 10 em X 10 em flat squares and four connecting bars and two side bars which are 7 em lengths and I em widths. Fourteen magnets are mounted on the manipulator while fourteen coils paired with the magnets are fixed on the base frame. Light weight and rigidity are the two goals of the manipulator design to reduce an amount of current and manipulator structure deformation. Aluminum is used for the material because of its light weight. Several portions of the manipulator are taken away to reduce the weight. The net weight of the manipulator with the magnets is estimated to be about 220 grams. Let's assume that the xyz coordinate system is fixed in the center of the manipulator and the XYZ coordinate system is fixed in the center of the base frame. We describe an arbitrary orientation of the manipulator in terms of Eulerian angles.

OPTIMAL DESIGN:

The robust nonlinear control theory is a widely known strategy for nonlinear systems with uncertainties to guarantee practical stability. It is clear that a practical optimization of the manipulator studied here would require a design index comprising multiple performance indices mentioned above. The values of the three performance indices may be distributed in different ranges. Hence, in order to make a meaningful comparison among them and to prevent simply cancellations between denominators and numerators during the combination process, each of the three indices is normalized by using their maximum and minimum values. The objective of the workspace optimization is to determine the set of the manipulator design parameters leading to the composed design index to be maximized. The design parameters of the presented manipulator include the operating limits of the actuated joint variables, min *l* and max *l* , and the sizes of the base and moving platforms, *r* and *R* .

PERFORMANCE INDICES:

The inverse Jacobian provides information on tile quality of the kinematical structure of a parallel manipulator. In this paper, manipulability, resistivity, and isotropy by using the inverse Jacobian are considered as performance indices of this parallel manipulator. Manipulability, which is the distance from a singularity evaluates the kinematic quality like the particular speed of a manipulator. That is, the farther the configuration of the manipulator is from the singularity, the faster the manipulator moves. Smaller manipulability indicates that there is a singularity near the configuration of the manipulator. Thus, it is better to have maximal manipulability.

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RESULTS

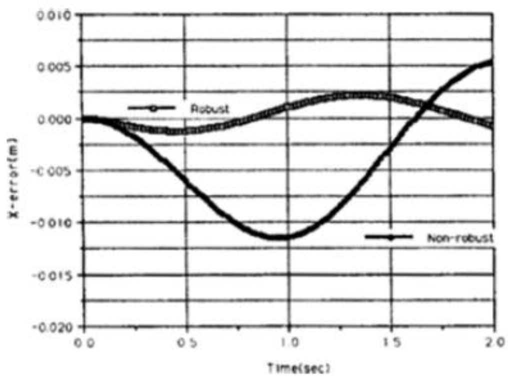

Fig-2 X Direction Error at Manipulator

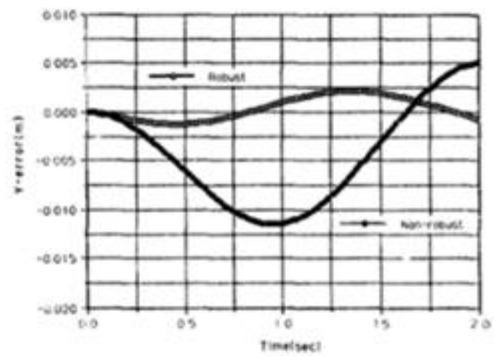

Fig-3 YDirection Errror at manipulator

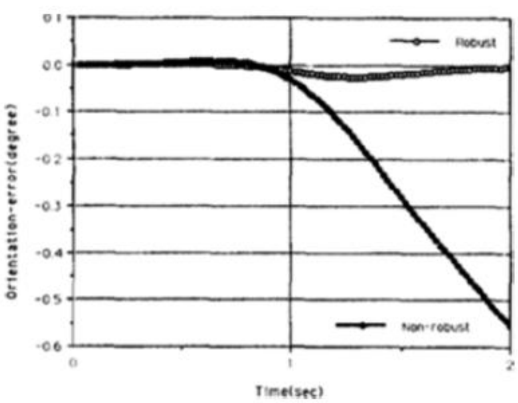

Fig-4 Orientation Error at manipulator

CONCLUSION:

This paper proposes a robotic manipulator system called hybrid type macro-micro system which contains two sub-robotic systems so that a large but coarse motion is generated by macrorobot while a small and accurate motion is created by micro-manipulator. The overall robotic manipulator system with this structure possesses distinct advantage over the conventional one in that high precision motion at end-effector can be achievd while maintaining large overall workspace. However, it is important to realize that the controller for macor-micro robotic system should be very robust. This is because the dynamic interations between two sub-systems must be suppressed properly so that each sub-system can perform its own task without serious dynamic influence from the other. For this purpose, this paper also proposes a robust controller for high precision robotic manipulators of hybrid type. It should also be noted that some concerns to prevent frequent join saturation at small links (i.e., at micor-robotic system) should be made because micro-robot system, which has larger dynamic bandwidth than macro-robotsystem, may be easily saturated for large positon and orientation errors at end-effector. The controller proposed in this paper takes this point into account by predefining nominal home configuration for the micro-robot and preventing large excursions from home configuration.

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