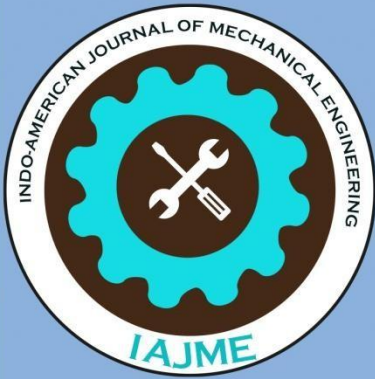


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A STUDY OF THE 8-UPS PARALLEL MANIPULATOR'S EFFICACY

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ABSTRACT

When doing research and designing parallel manipulators, evaluating their performance is a top priority. The manipulators' efficiency is evaluated based on properties like manipulability and minimal singular value. By using the performance indices, the singularity and its surrounding configurations are eradicated. This study examines the 8-UPS spatial parallel manipulator and finds its performance indices for various architectures, including condition number, manipulability, and minimal singular value. The best way to set up the manipulator is decided upon by looking at the performance indicators. The analysis is carried out using MATLAB code that is written. The findings are shown visually.

Key words: Performance Index, Manipulability, Minimum Singular Value.

1. INTRODUCTION

Components are first considered via the lens of the condition number concept of Satisburg and Craig (1). In order to get accurate measurements for the systems with the two revolute joints and the Stanford JPL Articulated hand, they have used the condition number of the Jacobian Matrix as an improvement rule. Tsuneo Yoshikawa conceived up the manipulability measure (2). This is a way to evaluate the mechanical system's ability to regulate the placement and arrangement of the end effectors. This also settles the properties of the manipulability measure.

The city of Yoshikawa. The two planar connections, PUMA and SCARA, were evaluated using this metric to determine their optimal positions. Robots were topics he discussed.

In their third paper, Ming J.Tsai and Yee.H. Chiou (3) investigated controller singularities with respect to manipulability and ruffian screen frameworks. By adjusting the joint settings, singularities may be reduced. In order for the controller to reach several points within the workspace simultaneously without encountering any peculiarities or joint limits, a robot component might be represented as an arrangement of joint variables. A particular angle's workspace is a



subset of the total controller workspace. Compared to a viewpoint's workspace, the aggregate workspace could be much more noticeable. Hyper surfaces, representing the boundaries of the angles, exist inside the aggregate workspace in this way. Surfaces that fall into this category include specific surfaces and joint point of confinement surfaces. The joint's furthest point surface might be a D-surface; this surface could be inaccessible to the robot in one configuration but accessible in another. The difficulty of directing the robot when it is always operating in Cartesian space is increased by both specific surfaces and D-surfaces.

Tsai and Chion provide an accessible capability for the purpose of a shared confinement file. For closed-circle kinematic chains, Gosselin and Angeles (4) provided a generic description of the many kinds of singularities. Three main types of singularities have been identified, and their physical centrality has been shown. They identify the singularities by using Grassmann geometry. For the purpose of improving mechanical controllers' kinematics, Gosselin and Angeles (5) have suggested an alternative execution file. You may use the record they call the global molding index (GCI) to check the delivery of condition numbers throughout the whole office. Similar to other local kinematic or dynamic files, the concept of global record is relevant. Parallel planar and round controllers with three levels of flexibility, a serial wrist with three levels of potential, and a serial two-connection controller are all linked to the GCI. Mama and Angeles (6) investigated the numerical shaping of their

Jacobian Matrix with respect to architectures, which allowed them to study the kinematic execution of planar controllers. By using a distinctive connect length, the dimensional inhomogeneity of the Jacobian lattice is eliminated. Their ideal controller architecture is similar to what is used in pilot training programs. New finesse records, suggested by Gosselin (7), may be linked to spatial and planar controllers. The condition number of the controllers' Jacobian grid determines which lists are relevant. To avoid getting too caught up in the dimensional dependence problem, they provide an alternative formulation of these mathematical claims, because the present lists are affected by controller scaling. They display two records of competence based on a repeating plan of the speed mathematical statements and the minimum amount of factors. Using kineto static execution records in the setup of seven-tomahawks, revolute-jointed controllers was shown by Angeles, Ranjbaran, and Patel (8). They showcased three unique optimum configurations. They proved that controllers with isotropic seven-tomahawks topologies are possible and provided more thoughts on how to design such controllers. Mama and Angeles (9) focused on the best controller architecture outline in element isotropy. It is desirable to take motion into account when choosing controller designs in order to get a better element performance, especially for high-precession controller tasks involving fast movement. Their setup's goal is to choose controller kinematic and inertial characteristics in a way that

they are able to achieve properties as close to isotropy as possible with their combined inactive lattices.



Prof. Y. Zhang According to J. Duffy and Crane (10) the repeated 4-8 parallel controller with a stage of side a will have its base start from a square if the quality file is to be the highest. The investigation of variable movements is carried out using quality lists. These movements include a movable stage that either goes parallel to the base or spins around a focal pivot. Keeping away from concentric ball-and-attachment joints let them get useful design data for the 4-8 repeating parallel controller, which helped them overcome the impedance concerns. A clearly balanced correspondence is essential for the setup of parallel controllers, which is the obvious choice. J. P. Merlet (11) discussed the appropriateness of the various exactness files for parallel robots after reviewing the articles describing them. Important for finding the end effector's positioning accuracy, they have also studied Jacobin and reverse Jacobin grids. They proved that the condition number depends on the network standard's choice. For this reason, the Two-standard and the Frobenius-standard are used. A set of Gough stage stances is studied in order to test the consistency of a condition number and the comparative maximum positioning errors. Octahedral "3-3" parallel controllers were worked on

by J. Lee, J. Duffy, and K. H. Chase (12). On each of its six legs you'll find a straight actuator. Each fully in-parallel six-straight actuator controller resolves a quality list regardless of the arrangement. Its peak performance is associated with a single device with a single focused design, the dimensions of which we establish. A walking robot with sensors to detect and locate humans effectively and efficiently removing landmines was the focus of P. Gonzalez de Santos *, J.A. Cobano, E. Garcia, and J. Estremera (13) in their study. The main system includes a sensor head that can detect specific types of landmines, a controller to move the sensor head over long distances, an imaging system based on a global positioning system, a remote control PC, and the SILO6 walking robot as subsystems. The imaging system is enhanced with a metal identifier. With a focus on robot adaptability and energy productivity in mind, the whole architecture has been developed to operate in a semi-independent manner. A hexapod robot design is more stable than a quadruped, and they proved that a hexapod using an alternative tripod may achieve the highest speed under static stability. As the inverse of the first concept, B. Dasgupta and T. S. Mruthyunjaya (14) have investigated power repetition in parallel controllers.

2. MEASURES OF KINEMATIC PERFORMANCE

2.1. Manipulability

The concept of manipulability of a manipulator was introduced by yoshikawa.

2.1.1. *The manipulability for a redundant or a non-redundant manipulator*

The manipulability is defined as the square root of the determinant of the product of the manipulator jacobian by its transpose, i.e., $w = \sqrt{\det(JJ^T)}$

For a non-square matrix the singular value decomposition of jacobian matrix is to be determined and using the singular values the manipulability can be determined.



are orthogonal matrices and

$$\text{Where } U \in R^{m \times m} \text{ and } V \in R^{n \times n}$$

$$J = U \Sigma V^T \quad \Sigma = \begin{pmatrix} \sigma_1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & \sigma_m \end{pmatrix} \in R^{m \times n}$$

With

$$\sigma_1 \geq \sigma_2 \geq \dots \geq \sigma_m \geq 0$$

Then the measure w can be expressed as the product of the singular values

$$w = \sigma_1 \sigma_2 \dots \sigma_m$$

When $m = n$, i.e., when we consider non redundant manipulators, the measure w reduces to

$$w = |\det J|$$

2.2. Minimum Singular Value

Compared to the other singular values, the lowest singular value varies more drastically near singularities. The implication is that one may gauge dexterity by looking at the minimal single value itself (15). One feature of being close to singularities is the need for very high joint velocities, and the minimal singular value clearly indicates when this is the case. One way to evaluate the parallel manipulator's performance is by looking at its jacobian matrix, specifically its minimal singular value.

chain to the bottom platform. As illustrated in Figure 1, each chain also contains a passive prismatic joint L_i that connects the passive ball joint at P_i to the active universal joint at O_i .

3. 8-UPS PARALLEL MANIPULATOR

Two platforms linked by eight serial chains create the mechanism being discussed (Fig. 1). In contrast to the freestanding second platform, the first one is firmly attached to the floor. There are a grand total of six degrees of freedom in each of the eight serial chains. Through passive spherical joints, each of the eight serial chains is linked to the upper platform (16). Two active perpendicular revolutes create the universal joint that connects each

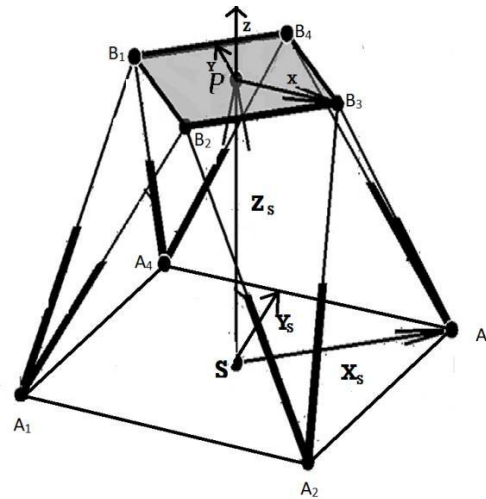


Figure 1 Kinematic model of 8 UPS parallel robot

3.1. Jacobian Analysis

The instantaneous twist, $\$P$, of the moving platform can be expressed as

$$\$P = \theta_1 \hat{\$}_{1,i} + \theta_2 \hat{\$}_{2,i} + d_3 \hat{\$}_{3,i} + \theta_4 \hat{\$}_{4,i} + \theta_5 \hat{\$}_{5,i} + \theta_6 \hat{\$}_{6,i}$$

for $i=1,2,\dots,6$

where

$$\hat{\$}_{1,i} = \begin{pmatrix} s_{1,i} \\ (b-d) \times s \\ i \quad i \quad 1,i \end{pmatrix}$$

$$\hat{\$}_{2,i} = \begin{pmatrix} s_{2,i} \\ (b-d) \times s \\ i \quad i \quad 2,i \end{pmatrix}$$

$$\hat{\$}_{3,i} = \begin{pmatrix} 0 \\ s \\ 3,i \end{pmatrix}$$

$$\hat{\$}_{4,i} = \begin{pmatrix} s_{4,i} \\ b \times s \\ i \quad 4,i \end{pmatrix}$$

$$\hat{\$}_{5,i} = \begin{pmatrix} s_{5,i} \\ b \times s \\ i \quad 5,i \end{pmatrix}$$

$$\hat{\$}_{6,i} = \begin{pmatrix} s_{6,i} \\ b \times s \\ i \quad 6,i \end{pmatrix}$$



$$\hat{\$}_{7,i} = \begin{pmatrix} s_{7,i} \\ b_i \times s_{7,i} \end{pmatrix}$$

$$\hat{\$}_{8,i} = \begin{pmatrix} s_{8,i} \\ b_i \times s_{8,i} \end{pmatrix}$$

Where $s_{j,i}$ is a unit vector along the j^{th} joint axis of the i^{th} limb, $b_i = \overline{PB_i}$ and 1

The reciprocal screw, denoted as $\hat{\$}_{r,1,i}$ is pointing in a direction perpendicular to the joint axes of the universal joint.

$$\hat{\$}_{r,1,i} = \begin{pmatrix} 0 \\ n_i \end{pmatrix}$$

$$\hat{\$}_{r,1,i}^T = 0$$

$$J_c \hat{\$}_p = 0$$

Where

$$J_c = \begin{pmatrix} n_1^T & 0_{1 \times 3} \\ n_2^T & 0_{1 \times 3} \\ n_3^T & 0_{1 \times 3} \\ n_4^T & 0_{1 \times 3} \\ n_5^T & 0_{1 \times 3} \\ n_6^T & 0_{1 \times 3} \\ n_7^T & 0_{1 \times 3} \\ n_8^T & 0_{1 \times 3} \end{pmatrix}$$

Reciprocal to all passive joint screws of the i^{th} limb can be identified as zero pitch screw along the line passing through the two universal joints

$$\hat{\$}_{r,2,i} = \begin{pmatrix} s_{3,i} \\ b_i \times s_{3,i} \end{pmatrix}$$

$$\hat{\$}_{r,2,i}^T \hat{\$}_p = d_{3,i}$$

$$J_x \hat{\$}_p = q$$

Where

$$J_x = \begin{pmatrix} (b \times s_{3,1})^T & s_{3,1}^T \\ (b \times s_{3,2})^T & s_{3,2}^T \\ (b \times s_{3,3})^T & s_{3,3}^T \\ (b \times s_{3,4})^T & s_{3,4}^T \\ (b \times s_{3,5})^T & s_{3,5}^T \\ (b \times s_{3,6})^T & s_{3,6}^T \\ (b \times s_{3,7})^T & s_{3,7}^T \\ (b \times s_{3,8})^T & s_{3,8}^T \end{pmatrix}$$

$$q = [d_{3,1}, d_{3,2}, d_{3,3}, d_{3,4}, d_{3,5}, d_{3,6}, d_{3,7}, d_{3,8}]^T$$

4. RESULTS

Using Matlab the following results have been obtained for 8 UPS spatial manipulators. The results regarding optimum structures based on the performance indices were identified have been presented in this section.

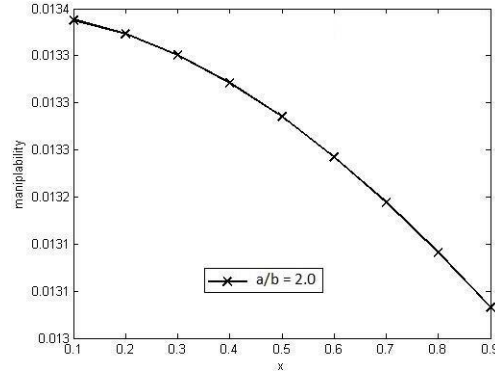


Figure 2 manipulability vs Reach

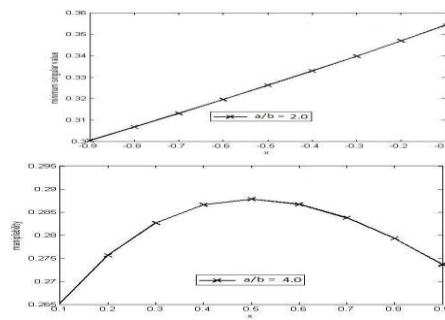


Figure 3 minimum singular value vs Reach

Figure 4 manipulability vs Reach

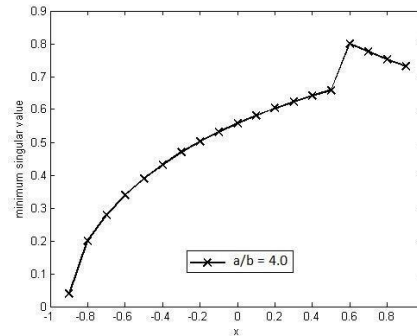


Figure 5 minimum singular value vs Reach

5. CONCLUSION

We have examined the performance indicators of the 8-UPS parallel manipulator. We find the best configurations by looking at the performance indexes. A graphical representation of all the performance index findings is provided.

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