THE INVERSE POSITIONAL PROBLEM OF THE PARALLEL ROBOT

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Abstract

In this paper we present the inverse positional problem of the RT(RRR)R type parallel robot. Between the extreme positions of the mobile platform, the lengths, of the active couplers, they have the time variation laws. Analyzing all the possible final positions of the mobile platform, it can be established the working space for the parallel robot with two cylindrical hinges, noted R, one translation joint, noted T, and one ball-and-socket joint, noted RRR, on each kinematic chain. The robot has both platforms as hexagon with equal sides.

1. Introduction

A parallel robot represents a mechanism with closed kinematic chains, composed by a mobile platform with "n" degrees of freedom and by a fix platform. The link between the two platforms is made by closed kinematic chains, each kinematic chain being actuated independently. The current papers solve the inverse positioning problem in the case of the parallel robot with guiding in six points, whose structural scheme is presented in figure 1.

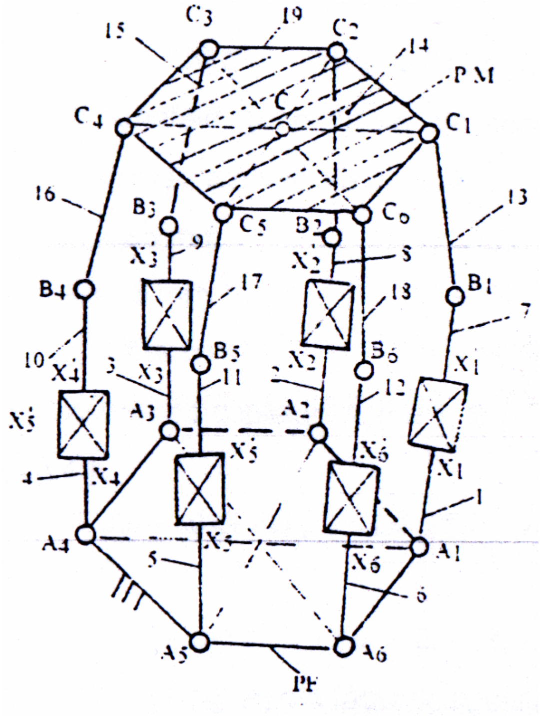

Fig 1. The robot is of type RT(RRR)R

The robot is of type RT(RRR)R. Analyzing the structural scheme from figure 1, the following correspondence exists:

A_1 – cylindrical joint whose rotational axis is perpendicular at the platform's base, with one degree of freedom, assimilated to a rotational joint (R);

`A_1B_1 – unidirectional guiding, with one degree of freedom, assimilated to a translation joint (T);

B_1 – spherical joint, with three degrees of freedom, assimilated to a spatial rotation joint (RRR);

C_1 – whose rotational axis is radial on the mobile platform’s radius, assimilated to a rotational joint (R);

2. The kinematics of the RT(RRR)R type parallel robots with platforms – each one being a hexagon

The parallel robot with guiding in six points, of type RT(RRR)R with platforms – hexagon (Fig. 2) is in the category of parallel robots with guiding in six points, the kinematic of these robots was solved from the theoretical point of view, in the case of the inverse positioning problem in the paper: “ The solving of the inverse positioning problem at the RT(RRR) type parallel robot.

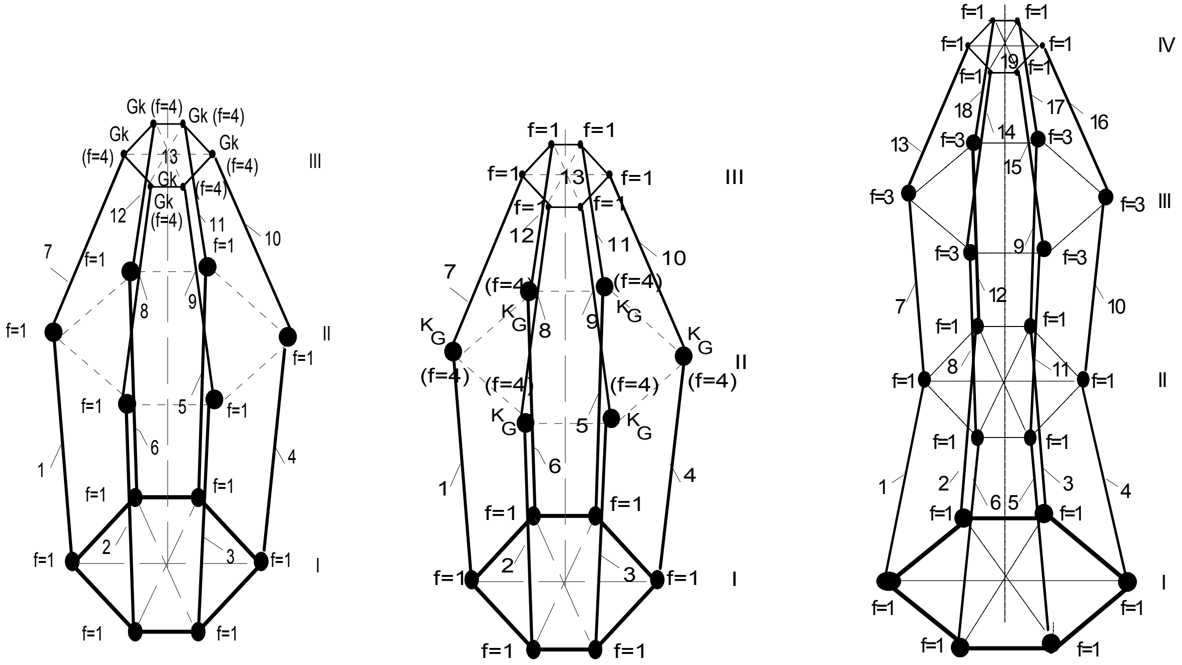

Fig 2

In accordance with the presented theoretical study, for analyzing the inverse positioning problem it is necessary to know the time variation law of the displacements from the translational joints. In accordance with the specifications:

$$BiCi = l = li = \sqrt{(x_{Bi} - x_{Ci})^2 + (y_{Bi} - y_{Ci})^2 + (z_{Bi} - z_{Ci})^2}$$

$$i = 1, 2, \ldots, 6;$$

Where: x_{Bi}, y_{Bi}, z_{Bi} are the ordinates of the spherical joint in relation with the mobile reference system, united with the end effector, for which the solution is being calculated with the relations (14) , -(19) from the first part of the paper preceding this paper.

3. Determining the working space

The working space is considered as being the space which is used by the end effector, united with the mobile platform, actually, the space in which center of the masses of the mobile platform performs, for which the time variation laws of the length of the translations joints are determined.

For establishing the working space, we start from the general basic relations, established in the first part of this paper, relations which where particularized as it follows:

R = 120 mm – the radius of the base (the fix platform);

r = 65 mm – the radius of the mobile platform;

$l = B_iC_i =$ 100 mm – the distance between the joints (RRR) and (R);

The generalized coordinates of the center of the masses of the mobile platform, initially those are considered as being the starting values of the program;

$X_{CEN} = 25$ mm $\qquad \psi = 10^{o}$
$Y_{CEN} = 5$ mm $\qquad \varphi = 10^{o}$
$Z_{CEN} = 110$ mm $\qquad \theta = 10^{o}$

The positioning of the A_i ($i = 1, 2, \ldots, 6$) joints from the plane of the base in relation with the fix reference system [4 fig. 4]

$$\delta_{i1} = \delta_{i1} + 60 \cdot (i-1), \qquad i = 1, 2, \ldots, 6$$

$$\delta_{i1} = 0$$

and the positioning of the C_i ($i = 1, 2, \ldots, 6$) joints from the plane of the mobile platform in relation with the mobile reference system [4 fig. 4] was made with the relations:

$$\delta_{j1} = \delta_{j1} + 60 \cdot (i-1), \qquad i = 1, 2, \ldots, 6$$

$$\delta_{j1} = 0$$

The working space was obtained by processing the specifying relations using a number of programs written in PASCAL programming language. For the parallel robot with hexagonal platforms, of unequal dimensions (R different from r), more possibilities where analyzed, from which we present the variant from figure 2.

For numerical approximation, we had to make some restrictions, considered useful by us, but these restrictions had no major disturbance in determining the working space of the robot, they just helped to reduce the processing time of the computer. The IBM PC 486 computer was used.

The imposed restrictions are:

- in the inferior cylindrical joint the value of the rotation angle must be less than 80°;
- in the spherical joint, the value of the rotation angle is considered to be between 35° and 70°;
- in the superior cylindrical joint the value of the rotation angle must be less than 90°;
- the maximum admissible value of the translation is 200 mm.

Related to the mobile reference system Cxyz, keeping the "z" coordinate constant, there were drawn plane curves. In this paper we present only two of them:

- in figure 3, for $z_{cen} = 180$ mm;
- in figure 4, for $z_{cen} = 190$ mm;

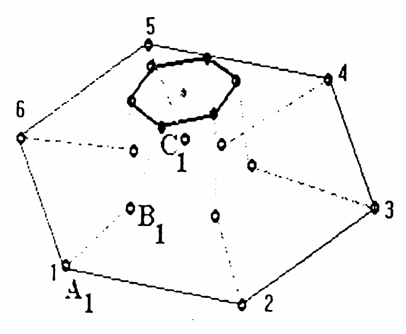

fig 3.

Note: The generalized coordinates values obtained represents the current point on the plane curve, at grid level.

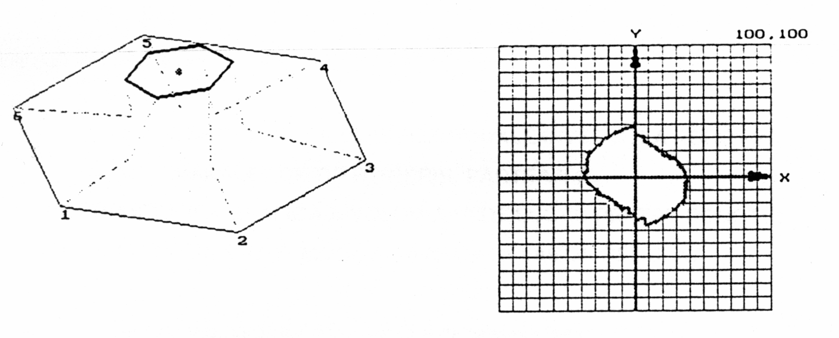

Fig 4

There were drawn all the curves that delimitates the working space at different levels. By supposing these, it is obtained the robot working space, presented in figure 5.

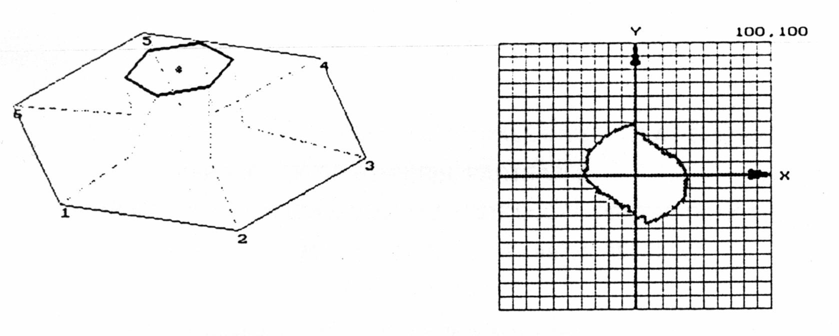

Fig 5.

4. Conclusion

The present paper shows its contribution to the study of the robots with guiding in six points of RT(RRR)R type with platforms: regular hexagons.

1. Working space (fig. 5) represents the entire volume that can be accessed by the end-effector. Actually, the paper establishes the possible positions of the masses center of the mobile platform, by actuating it with the six kinematic closed chains, actuated independently.

2. The distance between the masses center of the mobile platform and the end-effector is constant. Thus, the obtained representation of the working space must be translated at a real distance to obtain the working space in which the end-effector can operate.

3. The working space - suggestive - shows that the end-effector cannot have access in any place. If the evolution - displacement - is made in the working space limits, the curve that delimitates it has multiple angular points, which disturbs the continuous (without shocks) functioning of the robot.

4. The functioning of a robot, with the appropriate working space, can be considered continuous if the end-effector id moving to the interior wrapping of the same level curves.

5. REFERENCE

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