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Workspace of a Planar Robotic Guiding Device with Parallel Topology of FP_3+3×RTR+MP_3 Type

For a parallel topology robotic guiding device, the workspace frontier can be determined by the topological analysis of its partial frontiers. The principle of method is to determine the workspace of the characteristic point P (referring to robot) on the basis of the geometrical constraints imposed by every connexion introduced between the two platforms (the fixed and the mobile one) and on the basis of the geometrical constraints imposed by the platforms.

1. Introduction

A parallel topology robotic guiding device consists of a mobile platform MP_n linked with a fixed one FP_n by means of „n" connexions.

The concept „connexion" was introduced in Mechanism Theory by Professor F.V. Kovacs. According to [1], [2], a "connexion" is an open linkage interposed between two links, aiming the change of the number of their relative degrees of freedom (DOF).

In the case of a planar robotic guiding device mechanism, the partial frontiers and the entire workspace frontier are curves.

In the case of a spatial robotic guiding device mechanism, the partial frontiers and the entire workspace frontier are surfaces.

The characteristic point P is placed on the mobile platform MP_n.

2. The Kinematical Scheme and the 2D Model of a Planar Robotic Guiding Device Mechanism of FP_3+3×RTR+MP_3 Type

Between the fixed platform FP_3 and the mobile one MP_3 there were interposed 3 identical connexions RTR (every connexion containing two binary links, two rotational joints "R" and a translational one "T"); "j" is the connexion's number (j = 1, 2, 3).

The kinematical scheme of a FP_3+3×RTR+MP_3 type parallel topology robotic guiding device mechanism is presented in figure 1.

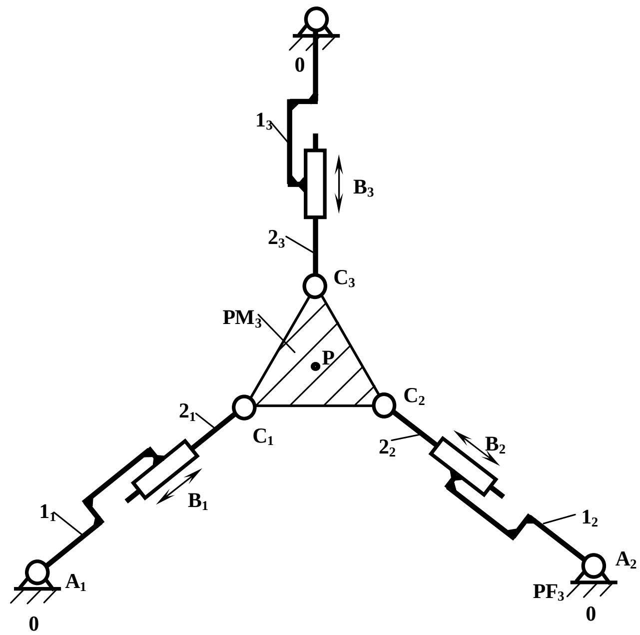

Figure 1. The kinematical scheme of a FP_3+3×RTR+MP_3 type mechanism.

The elements dimensions are given:

- the fixed platform: equilateral triangle having the sides $\overline{A_1A_2} = \overline{A_2A_3} = \overline{A_3A_1} = 200\,[mm]$;
- the mobile platform: equilateral triangle having the sides $\overline{C_1C_2} = \overline{C_2C_3} = \overline{C_3C_1} = 50\,[mm]$;
- link's lenghts 1_j: $\overline{A_1B_1} = \overline{A_2B_2} = \overline{A_3B_3} = 50\,[mm]$;
- link's lenghts 2_j: $\overline{B_1C_1} = \overline{B_2C_2} = \overline{B_3C_3} = 70\,[mm]$.

The points A_j, B_j, C_j were considered in the geometrical centers of the kinematical joints; for the stroke ends, the $\overline{A_jC_j}$ segments lenghts can achieve the extreme values $\left(\overline{A_jC_j}\right)_{min} = 70\ [mm]$, $\left(\overline{A_jC_j}\right)_{max} = 110\ [mm]$.

The characteristic point P is placed in the geometrical center of the mobile platform MP_3.

In figure 2 is presented the 2D model of the $FP_3+3\times RTR+MP_3$ type parallel topology robotic guiding device mechanism.

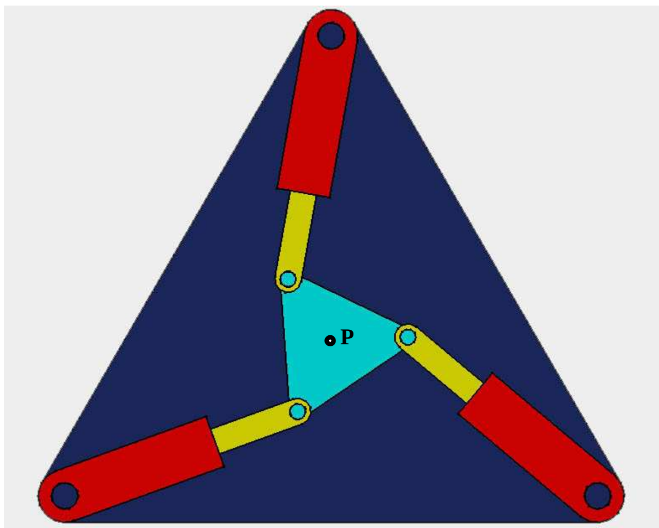

Figure 2. The 2D model of the $FP_3+3\times RTR+MP_3$ type parallel topology robotic guiding device mechanism.

3. The Determination of the Workspace of a $FP_3+3\times RTR+MP_3$ Type Parallel Topology Robotic Guiding Device

For the planar mechanism with $PF_3+3xRTR+PM_3$ structure, the workspace is a plane surface and its frontier is a curve.

For determining the frontier of this surface, the geometrical locus of the possible positions of the characteristic point is determined, taking the geometrical constraints of the connexion into account; finally the geometrical constraints imposed by all the connexions and by the platforms are are simultanously applied.

The maximum position of the characteristic point P versus A_j point is realized in the case of the maximum stroke of the translational joint, when the points A_j, B_j, C_j and P are collinear.

The minimum position of the characteristic point P versus A_j point is realized in the case of the minimum stroke of the translational joint, when the points A_j, B_j, P and C_j are collinear.

The geometrical locus of the characteristic point P, taking into account only the constraints imposed by a connexion, is the surface between two concentric circles having the radius:

$$R = \left(l_{A_jP}\right)_{max} = \left(l_{A_jB_j} + l_{B_jC_j}\right)_{\max} + l_{C_jP} = (90 + 20) + 28{,}868 =$$
$$= 138{,}868\ [mm] \tag{1}$$

and

$$r = \left(l_{A_jP}\right)_{min} = \left(l_{A_jB_j} + l_{B_jC_j}\right)_{\min} - l_{C_jP} = (90 - 20) - 28{,}868 =$$
$$= 41{,}132\ [mm], \tag{2}$$

as shown in figure 3.

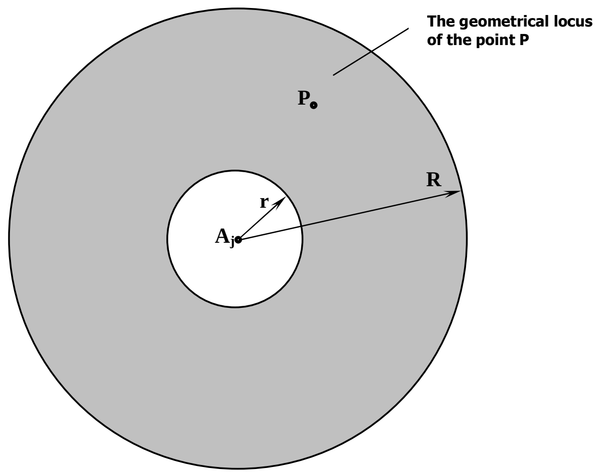

Figure 3. The geometrical locus of the characteristic point P, taking into account the geometrical constraints imposed by a $A_jB_jC_j$ (RTR) connexion.

Taking into account the constraints of all connexions, the geometrical locus of the point P (the workspace) is the intersection of 3 surfaces likewise the one presented in figure 3, as shown in figures 4 and 5.

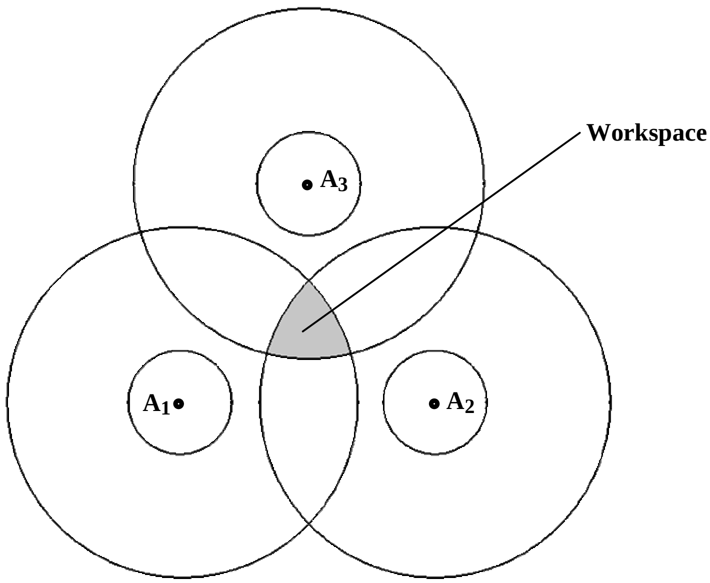

Figure 4. The geometrical locus of the characteristic point P, taking into account the constraints imposed by the connexions.

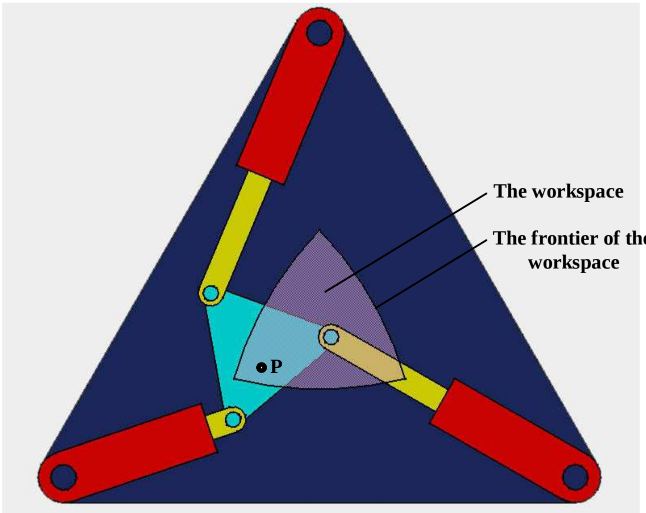

Figure 5. The workspace, taking into account the constraints imposed by the connexions.

In figure 6 are shown the dimensions of the workspace, taking into account the constraints imposed by the connexions.

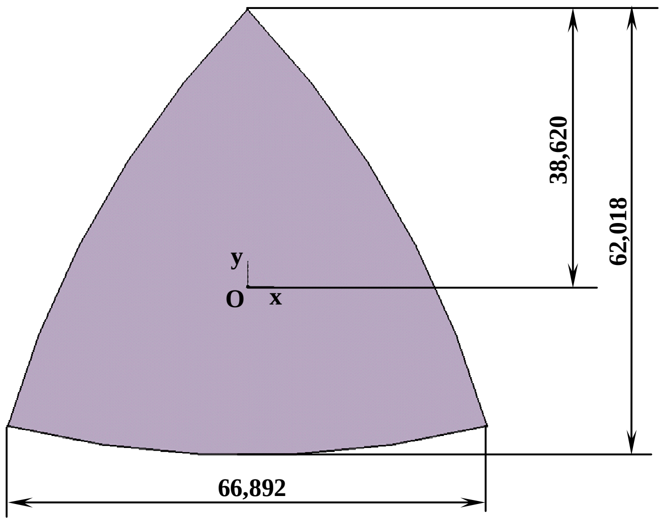

Figure 6. The dimensions of the workspace, taking into account the constraints imposed by the connexions.

If the costraints imposed by the mobile platform are taken into account, the workspace is restrained, as shown in figure 7.

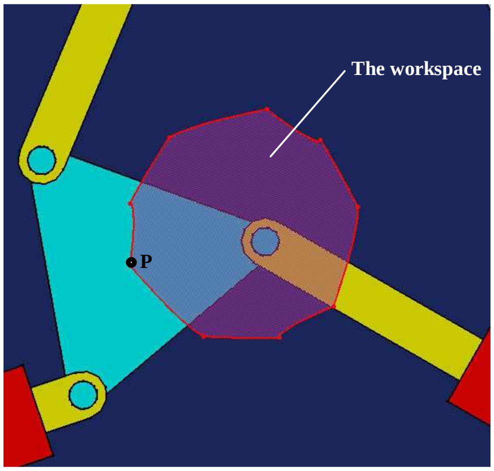

Figure 7. The workspace, taking into account the constraints imposed by the connexions and by the mobile platform.

If the mobile platform exceeds the singularities, the workspace becomes as shown in figure 8.

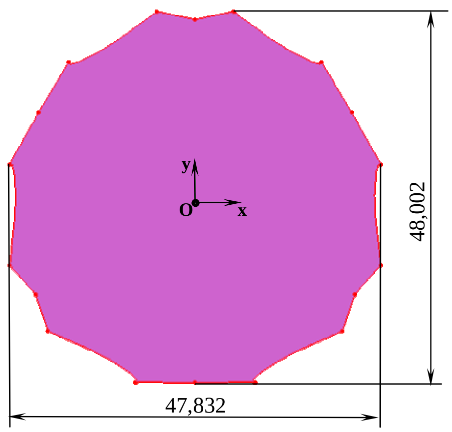

Figure 8. The workspace, taking into account the constraints imposed by the connexions, by the mobile platform and the exceedments of the singularities.

4. Conclusions

The workspace of a planar robotic guiding device with parallel topology of $FP_3+3\times RTR+MP_3$ type is a plane surface, as shown in the paper.

The factors which influence the shape and the dimensions of the workspace are: the elements dimensions, the minimum and maximum strokes of the kinematical joints, the geometrical constraints of the connexions and of the mobile platform, the exceedments of the singularities.

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