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ERRATUM

Design and analysis of a totally decoupled 3-DOF spherical parallel manipulator – ERRATUM

Dan Zhang†,‡ and Fan Zhang§

†*University of Ontario Institute of Technology, Oshawa, Ontario L1H 7K4, Canada*
‡*Qingdao Technological University, Qingdao 266033, China*
§*Department of Mechanical Engineering, Shanghai University of Engineering Science, Shanghai 201620, China*

The following corrections to the paper by Zhang *et al.*[1] should be noted. The corrected paper follows this notice.

The title of the originally published paper should be corrected to "Design and analysis of a 3-DOF spherical parallel manipulator."

In the whole text from Summary to Section 6 Kinetostatic Analysis, all instances of the word "decoupled" should be removed. Accordingly, some phrases and sentences should be revised as listed below.

In Summary, the second sentence and the last two sentences should be deleted.

In the Introduction section, the whole fourth paragraph should be deleted. In the last paragraph of Introduction, the first line, "fully decoupled" should be deleted. The second sentence should be deleted. The last sentence of this section should be changed into "Overall, this mechanism has a simple structure and is easy to control."

The last two paragraphs of Section 5 should be deleted.

Add the sentence "Gosselin and Gagné[6] analyzed the forward kinematic problem of a spherical 3-DOF parallel mechanism," at the end of third paragraph of the first section. Accordingly, add the following paper in the reference list:

C. Gosselin and M. Gagné, "A Closed-Form Solution for the Direct Kinematics of a Special Class of Spherical Three-Degree-Of-Freedom Parallel Manipulators," *Proceedings of the 2nd Workshop on Computational Kinematics*, Sophia Antipolis, France (1995) pp. 231–240.

The caption of Figure 4 should be changed into "One kinematic chain that affords zero-constraint."

At the end of Section 3.2, Type synthesis of the spherical parallel mechanism, add the following sentence, "It should be noted that the synthesis method of parallel mechanisms are applicable only instantaneously for some specific configurations. Kong and Gosselin[8] investigated more detailed case studies about type synthesis." Accordingly, add the following book in the reference list:

X. Kong and C. M. Gosselin, *Type Synthesis of Parallel Mechanisms* (Springer, Berlin, 2007).

In Section 4.1, "and the Euler angles of the end-effectors are shown as α, ψ φ" should be deleted.

The rotation matrix that appears next to the sentence "the rotation matrix of end-effector is presented as" should be corrected to:

$$
\begin{aligned}
{}^{0}\boldsymbol{T}_2(\theta_x, \theta_y, \theta_z) &= Rot(z, \theta_z)Rot(y, \theta_y)Rot(x, \theta_x) \\
&= \begin{bmatrix} \cos\theta_z\cos\theta_y & \cos\theta_z\sin\theta_y\sin\theta_x - \sin\theta_z\cos\theta_x & \cos\theta_z\sin\theta_y\cos\theta_x + \sin\theta_z\sin\theta_x \\ \sin\theta_z\cos\theta_y & \sin\theta_z\sin\theta_y\sin\theta_x + \cos\theta_z\cos\theta_x & \sin\theta_z\sin\theta_y\cos\theta_x - \cos\theta_z\sin\theta_x \\ -\sin\theta_y & \cos\theta_y\sin\theta_x & \cos\theta_y\cos\theta_x \end{bmatrix},
\end{aligned}
$$

where θ_x, θ_y, and θ_z are the rotation angles with respect to each axis.

The rest part of Section 4.1 between the above rotation matrix and the last paragraph should be corrected to:

For the ith kinematic chain, the unit vectors of the second revolute joints respect to frame $O - XYZ$ can be written as

$$[\boldsymbol{w}_1]_{R0}^{0} = \{0, -1, 0\}, [\boldsymbol{w}_2]_{R0}^{0} = \{0, 0, -1\}, [\boldsymbol{w}_3]_{R0}^{0} = \{-1, 0, 0\}.$$

When the actuator work with angle θ_i, the unit vector of the intermediate revolute joint can be obtained:

$$
\begin{aligned}
&[\boldsymbol{w}_1]_{R0} = Rot(x, \theta_1)[\boldsymbol{w}_1]_{R0}^{0},\ [\boldsymbol{w}_2]_{R0} = Rot(y, \theta_2)[\boldsymbol{w}_2]_{R0}^{0}, \\
&[\boldsymbol{w}_3]_{R0} = Rot(z, \theta_3)[\boldsymbol{w}_3]_{R0}^{0}.
\end{aligned}
$$

Thus,

$$[\boldsymbol{w}_1]_{R0} = \begin{bmatrix} 0 \\ -\cos\theta_1 \\ -\sin\theta_1 \end{bmatrix}, \quad [\boldsymbol{w}_2]_{R0} = \begin{bmatrix} -\sin\theta_2 \\ 0 \\ -\cos\theta_2 \end{bmatrix},$$

$$[\boldsymbol{w}_3]_{R0} = \begin{bmatrix} -\cos\theta_3 \\ -\sin\theta_3 \\ 0 \end{bmatrix}. \tag{7}$$

The unit vector of the third revolute joint can be obtained by inverse kinematics for the parallel mechanism as

$$[\boldsymbol{v}_1]_{R2} = \{0, 0, 1\}, [\boldsymbol{v}_2]_{R2} = \{1, 0, 0\}, [\boldsymbol{v}_3]_{R2} = \{0, 1, 0\}.$$

The vectors of v_i under the frame $O - XYZ$ are obtained:

$$[\boldsymbol{v}_i]_{R0} =^0 \boldsymbol{T}_2[\boldsymbol{v}_i]_{R2}.$$

Thus,

$$[\boldsymbol{v}_1]_{R0} = \begin{bmatrix} \cos\theta_z \sin\theta_y \cos\theta_x + \sin\theta_z \sin\theta_x \\ \sin\theta_z \sin\theta_y \cos\theta_x - \cos\theta_z \sin\theta_x \\ \cos\theta_y \cos\theta_x \end{bmatrix},$$

$$[\boldsymbol{v}_2]_{R0} = \begin{bmatrix} \cos\theta_z \cos\theta_y \\ \sin\theta_z \cos\theta_y \\ -\sin\theta_y \end{bmatrix},$$

$$[\boldsymbol{v}_3]_{R0} = \begin{bmatrix} \cos\theta_z \sin\theta_y \sin\theta_x - \sin\theta_z \cos\theta_x \\ \sin\theta_z \sin\theta_y \sin\theta_x + \cos\theta_z \cos\theta_x \\ \cos\theta_y \sin\theta_x \end{bmatrix}. \tag{8}$$

From the geometry of the kinematic chain, we can find the equation for vectors $\boldsymbol{v}$ and $\boldsymbol{w}$ as

$$\boldsymbol{w} \cdot \boldsymbol{v} = \cos a_i, \tag{9}$$

where $a_i = \frac{\pi}{2}$.

Substituting Eq. (7) and Eq. (8) into Eq. (9) yields

$$\begin{aligned} &-\cos\theta_1(\sin\theta_z \sin\theta_y \cos\theta_x - \cos\theta_z \sin\theta_x) \\ &-\cos\theta_y \cos\theta_x \sin\theta_1 = 0, \\ &-\cos\theta_z \cos\theta_y \sin\theta_2 + \sin\theta_y \cos\theta_2 = 0, \\ &-\cos\theta_3(\cos\theta_z \sin\theta_y \sin\theta_x - \sin\theta_z \cos\theta_x) \\ &-\sin\theta_3(\sin\theta_z \sin\theta_y \sin\theta_x + \cos\theta_z \cos\theta_x) = 0. \end{aligned}$$

Furthermore, we can obtain

$$\theta_1 = \arctan \frac{-(\sin\theta_z \sin\theta_y \cos\theta_x - \cos\theta_z \sin\theta_x)}{\cos\theta_y \cos\theta_x},$$

$$\theta_2 = \arctan \frac{\sin\theta_y}{\cos\theta_z \cos\theta_y},$$

$$\theta_3 = -\arctan \frac{\cos\theta_z \sin\theta_y \sin\theta_x - \sin\theta_z \cos\theta_x}{\sin\theta_z \sin\theta_y \sin\theta_x + \cos\theta_z \cos\theta_x}.$$

The title of Section 4.2 should be corrected to “The extreme roll angle loci of the spherical mechanism.”

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The Figure 5 (c) should be deleted. Thus, the previous Figure 5 (d) should be marked as Figure 5 (c).

The second paragraph together with Figure 9 in Section 4.2 should be deleted. Accordingly, the last figure number of "The prototype of a 3-*RRR* spherical parallel wrist." should be number 9.

In Section 5, all of the phrases of "Full isotropic" and "fully isotropic" should be changed into "isotropic."

The whole Section of "6 Kinetostatic Analysis" should be deleted. Accordingly, the last Section number should be changed into "6. Conclusion." Accordingly, the reference 10 should be deleted.

In the Section of Conclusion, the sentences "The manipulator has some significant advantages; first, the three rotational DOFs are decoupled. Secondly, the Jacobian matrix of manipulator is a unit matrix, indicating that the manipulator is a singularity free and fully isotropic mechanism" should be deleted. In the last paragraph of this Section, "the mechanism is a decoupled mechanism. When the coefficient between the input and output velocity is 1, then the decoupled mechanism is fully isotropic." should be deleted.

We deeply apologize for these errors. The authors sincerely thank Dr. X Kong, Prof. C. Gosselin, and Dr. M. Carricato to provide the helpful comments.

Reference

1. D. Zhang and F. Zhang, "Design and analysis of a totally decoupled 3-DOF spherical parallel manipulator," *Robotica*, doi:10.1017/S0263574710000652 (2010).