Hindawi Publishing Corporation
Mathematical Problems in Engineering
Volume 2011, Article ID 638565, 9 pages
doi:10.1155/2011/638565

Research Article

Relation between Press Intensity and Angular Velocity at a RPPP Mechanism

Şenay Baydaş[1] and Bülent Karakaş[2]

[1] *Department of Mathematics, Faculty of Science and Arts, Yüzüncü Yıl University, 65080 Van, Turkey*
[2] *Department of Business Administration, Faculty of Economics and Administrative Science, Yüzüncü Yıl University, 65080 Van, Turkey*

Correspondence should be addressed to Şenay Baydaş, senay.baydas@gmail.com

Received 9 June 2010; Accepted 3 February 2011

Academic Editor: Bin Liu

We study some properties of RPPP. RPPP is discussed by rising with constant velocity along a given axis. The constant pressure which it stresses on a constant axis is defined by the increasing PPP. Some relations between the increase at PPP and angular velocity at R are analyzed and relations of correlation are investigated at Matlab.

1. Introduction

Mechanisms may have different types of joints, such as linear, rotary, sliding, or spherical. Although spherical joints are common in many systems, since they posses multiple degrees of freedom, and thus, are difficult to control, spherical joints are not common in robotics, except in research. Most robots have either a linear (prismatic) joint or a rotary (revolute) joint [1]. To describe the translational and rotational relationships between adjacent links, Denavit and Hartenberg proposed a matrix method of systematically establishing a coordinate system to each link of an articulated chain. The Denavit-Hartenberg (D-H) representation results in a 4×4 homogeneous transformation matrix representing each link's coordinate system at the joint with respect to the previous link's coordinate system. Thus, through sequential transformations, the end effector expressed in the hand coordinates can be transformed and expressed in the base coordinates which make up the inertial frame of this dynamic system [2].

Calculating the position and orientation of the hand of robot is called forward kinematic analysis. In other words, if all robot joint variables are known, using forward kinematic equations, one can calculate where the robot is at any instant [1].

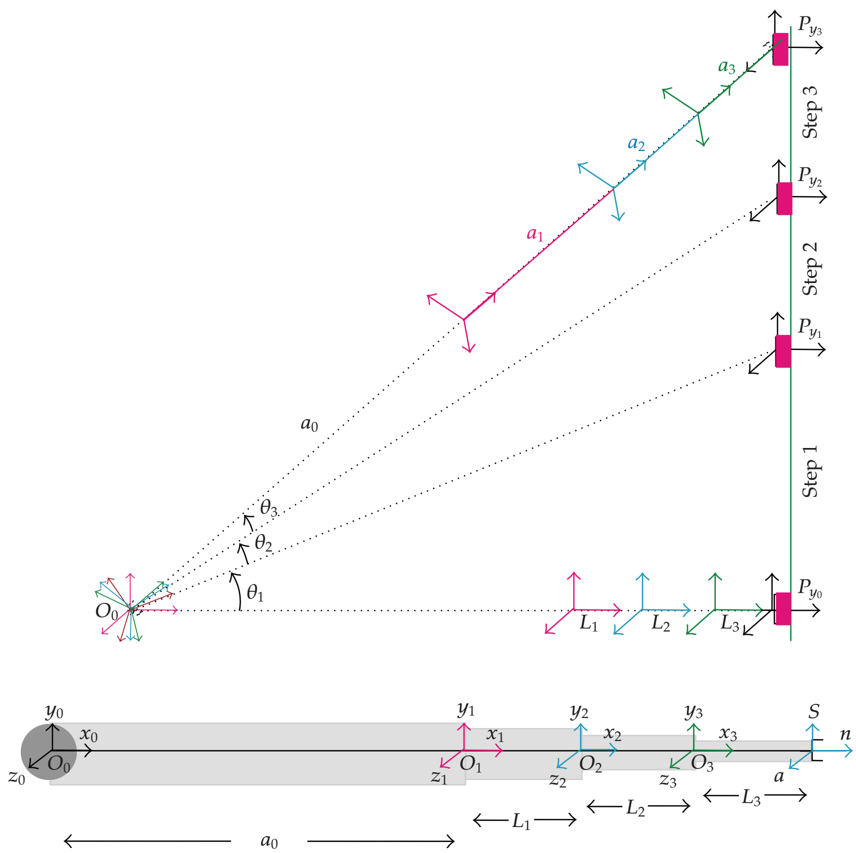


Figure 1: Settle of frames and end effector according to steps.

A robot manipulator is often designed as spatial open chain in which each joint is actuated. The kinematics equations of the open chain define the position of the end effector for a given set of values for the joint parameters. It is also necessary to be able to compute the joint parameter values that provide a desired position for end effector. This is known as the inverse kinematics problem in robotics [3].

Three serial chains with 3-dof each connect the fixed link to the end effector link [4, 5].

Mechanism of RPPP robot is studied in this paper. This mechanism is used for rising with constant velocity along fixed axis at screw plane. Design and equations of matrix of mechanisms are given in Section 2.

2. Presentation of RPPP

RPPP mechanism and its special tasks are dealt with in this paper. The first main function is to rise with a constant velocity of the end effector at a constant direction. Its other functions are to come back and to displace the constant axis (Figures 1 and 2).

At the rising and returning time, a constant pressure is done to the constant axis. The pressure is fixed if pistons have an expressed pressure at any time. Firstly let us write kinematic equations for RPPP.

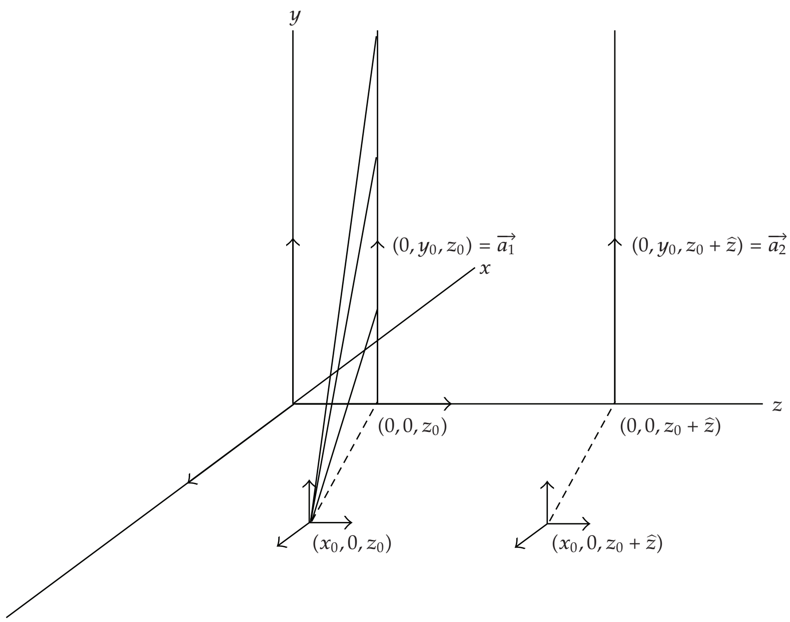


Figure 2: Skid motion.

The frames of mechanism which we investigated can be seen in Figure 1, where

$$L = a_0 + L_1 + L_2 + L_3. \tag{2.1}$$

a_1, a_2, and a_3 are latest lengths of L_1, L_2, L_3. a_1, a_2, and a_3 are known as

$$\begin{aligned} a_1 &= L\left(\sqrt{1+\tan^2\theta_1} - 1\right), \\ a_2 &= L\left(\sqrt{1+\tan^2(\theta_1+\theta_2)} - 1\right) - a_1, \\ a_3 &= L\left(\sqrt{1+\tan^2(\theta_1+\theta_2+\theta_3)} - 1\right) - (a_1 + a_2). \end{aligned} \tag{2.2}$$

a_i is a function of θ_i and θ_i is a function of a_i too, in Figure 3. Point values at the constant axis for θ_i are as follows.

$$\begin{gathered} M_i = \left\| O'Py_i \right\| = L\tan\left(\sum_{j=1}^{i}\theta_j\right), \quad 1 \le i \le 3, \\ M_1 = \left\| O'Py_0 \right\| = L\tan(\theta_1), \\ M_2 = L\tan(\theta_1+\theta_2), \\ M_3 = L\tan(\theta_1+\theta_2+\theta_3). \end{gathered} \tag{2.3}$$

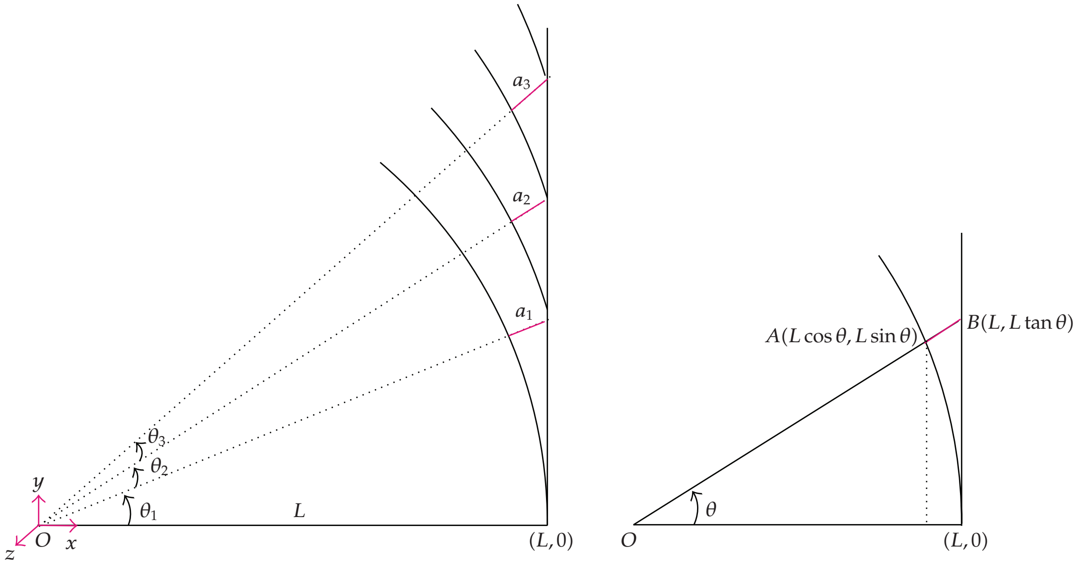


Figure 3: Relation between θ_i and a_i.

Table 1: D-H parameters.

θ_i	d_i	a_i	α_i
θ_1	0	a_1	0
θ_2	0	a_2	0
θ_3	0	a_3	0

The end effector rises with fixed speed along vector $\overrightarrow{a} = (0, y, z_0)$ when the base frame is at point $(0, 0, 0)$.

The turning back motion is an inverse of rising. The skid motion is a displacement of fixed frame from $(x_0, 0, z_0)$ to $(x_0, 0, z_o + \hat{z})$.

Now we can define the general procedure, based on Denavit-Hartenberg representation, to assign frames to each joint.

D-H parameters belonging to mechanism RPPP are calculated as in Table 1.

We wrote the motion matrix with a different method, instead of using the D-H parameters.

A translation vector according to Figure 4 is

$$\overrightarrow{AB} = B - A = (L - L2\cos\theta, L\ \cos\theta - L\ \tan\theta\ ). \tag{2.4}$$

Consequently we obtained the motion matrix as

$$T = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & L - L\cos\theta \\ \sin\theta & \cos\theta & 0 & L(\cos 2\theta - \tan\theta) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}. \tag{2.5}$$

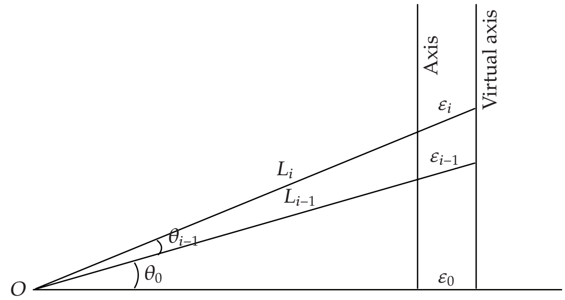


Figure 4: Relation between L and ε at any t time.

```
clear all, close all, clc
axis([-5 110 -5 300])
hold on
L=100
a=square((L-L*cosd(50))^2+((L*cosd(50)-tand(50)))^2)
for t=0:5:65
for u=50:5:65
t
R=[cosd(t) -sind(t) L-L*cosd(t)
sind(t) cosd(t) L*(tand(t)-sind(t))
0 0 1]
A=[L;0;1]
M=R*A
line([0, M(1)], [0, M(2)], 'Marker', '.', 'LineStyle', '-')
plot(L*cosd(t), L*sind(t), 'Marker', '.', 'LineStyle', '-')
pause(0.1)
cla
end
line([0, M(1)], [0, M(2)], 'Marker', '.', 'LineStyle', '-')
plot(L*cosd(t), L*sind(t), 'Marker', '.', 'LineStyle', '-')
end
```

Algorithm 1

There is not any pressure to vertical axis in this machine as it is. If the machine is used with different purposes, such as painting, sandpaper, it must make a press to vertical axis.

While the output lengths of pistons are L_i, if the output of pistons are $L_i + \varepsilon_i$, the pistons make a pressure to a barrier. The fixed pressure belongs to the initial value which we determined. So

$$\frac{L_{i-1}}{L_{i-1} + \varepsilon_{i-1}} = \frac{L_i}{L_i + \varepsilon_i} \tag{2.6}$$

is obtained with Thales theorem and from Figure 4.

Table 2: Correlation relation among L_i, ω_i, and ε_i.

	L_i	ω_i	ε_i
			$\varepsilon_0 = 5$
1	100	0, 1	5, 00076
2	100, 0152	0, 1	5, 00305
3	100, 061	0, 0999	5, 00686
4	100, 1372	0, 0999	5, 01221
5	100, 2442	0, 0998	5, 0191
6	100, 382	0, 0996	5, 02754
7	100, 5508	0, 0995	5, 03755
8	100, 751	0, 0993	5, 04914
9	100, 9828	0, 099	5, 062325
10	101, 2465	0, 0988	5, 077135
11	101, 5427	0, 0985	5, 093585
12	101, 8717	0, 0982	5, 111705
13	102, 2341	0, 0978	5, 13152
14	102, 6304	0, 0974	5, 15307
15	103, 0614	0, 097	5, 17638
16	103, 5276	0, 0966	5, 201495
17	104, 0299	0, 0961	5, 22846
18	104, 5692	0, 0956	5, 25731
19	105, 1462	0, 0951	5, 288105
20	105, 7621	0, 0946	5, 32089
21	106, 4178	0, 094	5, 355725
22	107, 1145	0, 0934	5, 392675
23	107, 8535	0, 0927	5, 4318
24	108, 636	0, 0921	5, 47318
25	109, 4636	0, 0914	5, 51689
26	110, 3378	0, 0906	5, 56301
27	111, 2602	0, 0899	5, 61163
28	112, 2326	0, 0891	5, 66285
29	113, 257	0, 0883	5, 71677
30	114, 3354	0, 0875	5, 773505
31	115, 4701	0, 0866	5, 833165
32	116, 6633	0, 0857	5, 89589
33	117, 9178	0, 0848	5, 961815
34	119, 2363	0, 0839	6, 03109
35	120, 6218	0, 0829	6, 103875
36	122, 0775	0, 0819	6, 18034
37	123, 6068	0, 0809	6, 26068
38	125, 2136	0, 0799	6, 34509
39	126, 9018	0, 0788	6, 4338
40	128, 676	0, 0777	6, 527035
41	130, 5407	0, 0766	6, 625065
42	132, 5013	0, 0755	6, 728165

Table 2: Continued.

	L_i	ω_i	ε_i
43	134, 5633	0, 0743	6, 836635
44	136, 7327	0, 0731	6, 95082
45	139, 0164	0, 0719	7, 07107
46	141, 4214	0, 0707	7, 197785
47	143, 9557	0, 0695	7, 331395
48	146, 6279	0, 0682	7, 472385
49	149, 4477	0, 0669	7, 621265
50	152, 4253	0, 0656	7, 77862
51	155, 5724	0, 0643	7, 94508
52	158, 9016	0, 0629	8, 121345
53	162, 4269	0, 0616	8, 3082
54	166, 164	0, 0602	8, 50651
55	170, 1302	0, 0588	8, 717235
56	174, 3447	0, 0574	8, 94146
57	178, 8292	0, 0559	9, 18039
58	183, 6078	0, 0545	9, 4354
59	188, 708	0, 053	9, 70802
60	194, 1604	0, 0515	10
61	200	0, 05	10, 313325
62	206, 2665	0, 0485	10, 65027
63	213, 0054	0, 0469	11, 013445
64	220, 2689	0, 0454	11, 40586
65	228, 1172	0, 0438	11, 83101
66	236, 6202	0, 0423	11, 83101

At the same time, the following equalities are obtained with information from Figure 4.

$$\begin{aligned}
L_i &= \frac{L_0}{\cos\theta_i}, \\
\left\|\overrightarrow{OP_{y_i}}\right\| &= L\tan\theta_i, \\
w_i &= \frac{v}{L_i}, \\
\varepsilon_i &= \frac{L_i}{L_{i-1}}\varepsilon_i - 1, \\
L_i w_i &= v : \text{constant}, \\
\varepsilon_i &= \frac{w_i - 1}{w_i}\varepsilon_{i-1}.
\end{aligned} \tag{2.7}$$

These equalities are used at correlation between L, w and ε.

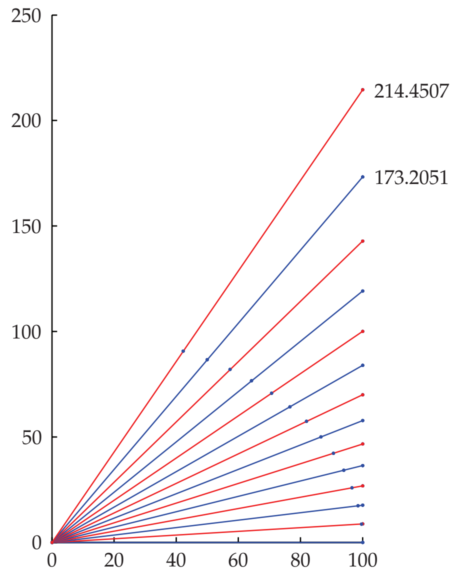


Figure 5

cor(ε, w) approaches to -1 from

$$\varepsilon_i w_i = w_{i-1}\varepsilon_{i-1}. \tag{2.8}$$

cor(ε, L) approaches to 1 because

$$\frac{\varepsilon_i}{\varepsilon_{i-1}} = \frac{L_i}{L_{i-1}}. \tag{2.9}$$

cor(L, w) approaches to -1 because

$$L_i w_i : \text{constant}. \tag{2.10}$$

3. Experimental Result and Discussions

For $L = 100$, $\varepsilon_0 = 5$, $0 \leq \theta \leq 65^0$, we calculate L, ε_i, and w_i at Matlab. The programme at Matlab and its figure (Figure 5) are as Algorithm 1.

If correlation is calculated between ε, w, and L values,

$$\begin{aligned} \operatorname{cor}(\varepsilon, \omega) &= -0,976350874, \\ \operatorname{cor}(\varepsilon, L) &= 0,999677409, \\ \operatorname{cor}(L, \omega) &= -0,975049457 \end{aligned} \tag{3.1}$$

are obtained. This is a desired result.

4. Conclusions

In this paper, RPPP mechanism, in which we used kinematical equations and we gave a design and a numeric sampling, is a prototype for a pressing. The machine is apt for being used especially in the specialized aims.

The pistons conducting translation are of hydraulic structure and should be considered to be controlled with double sensors. And finally, if we add ε to L, then we can make a little press to fixed axis. Results of significance tests between L, ε and w are appropriate for the expectations. While ε and w have positive correlation, both (ε, L) and (L, w) have negative correlation but significant.

References

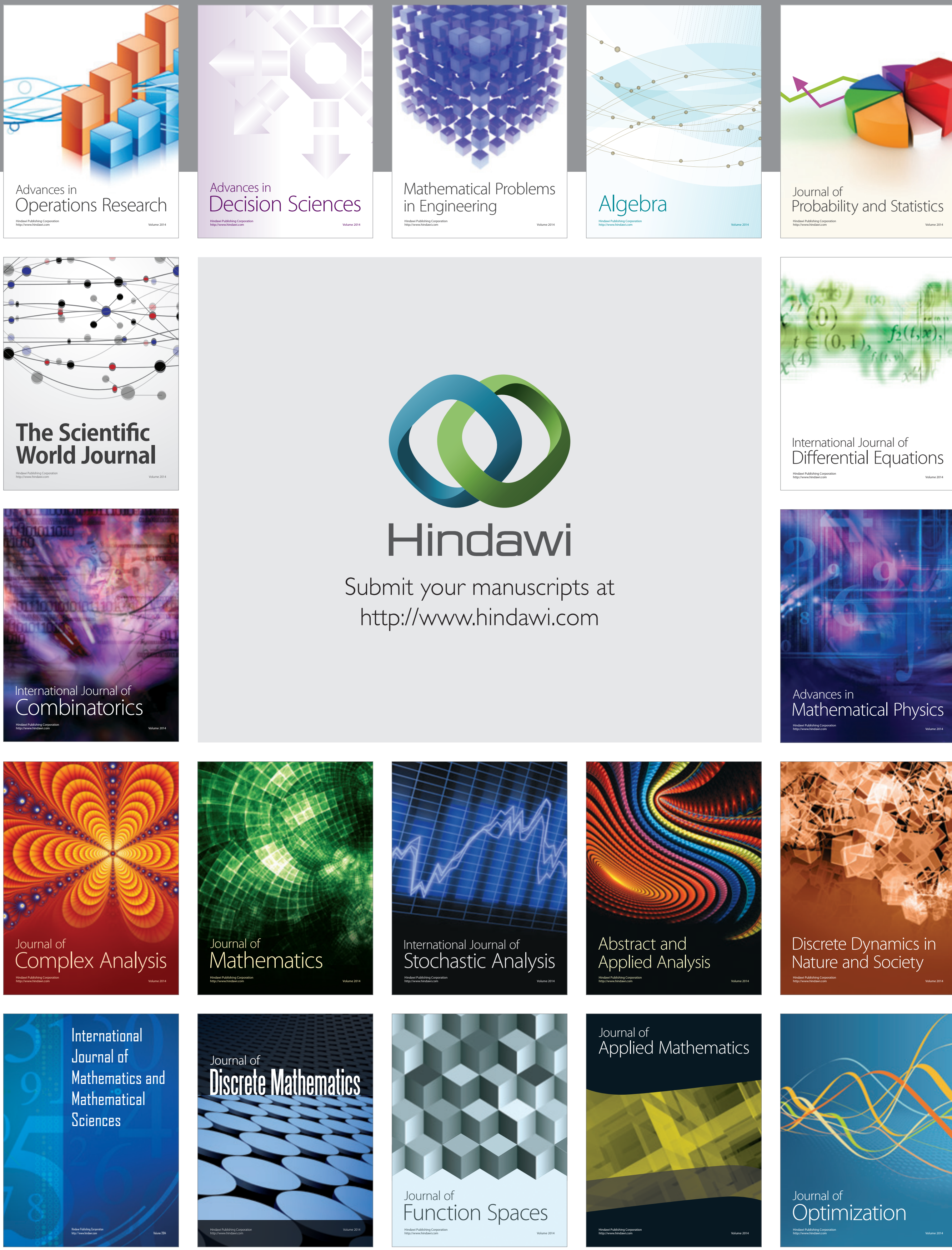
[1] S. B. Niku, *Introduction to Robotics*, Prentice Hall, Upper Saddle River, NJ, USA, 2001.

[2] K. S. Fu, R. C. Gonzalez, and C. S. G. Lee, *Robotics*, Mc Graw-Hill, Singapore, 1987.

[3] J. M. McCarthy, *Geometric Design of Linkages*, vol. 11 of *Interdisciplinary Applied Mathematics*, Springer, New York, NY, USA, 2000.

[4] R. L. Williams and B. H. Shelley, "Inverse kinematics for planar parallel manipulators," in *Proceedings of the ASME Design Technical Conferences*, Sacramento, Calif, USA, September 1997.

[5] J. Gadek, "3-parametric robot manipulator with intersecting axes," *Applications of Mathematics*, vol. 40, no. 2, pp. 131–145, 1995.


Advances in Operations Research
Advances in Decision Sciences
Mathematical Problems in Engineering
Algebra
Journal of Probability and Statistics
The Scientific World Journal
Hindawi
Submit your manuscripts at
http://www.hindawi.com
International Journal of Differential Equations
International Journal of Combinatorics
Advances in Mathematical Physics
Journal of Complex Analysis
Journal of Mathematics
International Journal of Stochastic Analysis
Abstract and Applied Analysis
Discrete Dynamics in Nature and Society
International Journal of Mathematics and Mathematical Sciences
Journal of Discrete Mathematics
Journal of Function Spaces
Journal of Applied Mathematics
Journal of Optimization