

Dynamic Analysis and Control for a HEXAPOD Parallel Platform

鄧琪曄、陳俊達

E-mail: 9224499@mail.dyu.edu.tw

ABSTRACT

The robot types of nowadays almost open up machine of series connection mode, for all to have advantages of nice working property and larger working space, but have some defect : (1) because of the cantilever structure the static rigidity is so bad. (2) because of the series connection mode, the drive in back to change into the front driver ' s load, so the structure load to increase, make the turn-inertia to be higher , therefore the error to accumulate at the back. (3) inertia-quality and turn-inertia are more higher, therefore the accelerate is so bad when the same thrust. Consequently, our laboratory to bring up based on Stewart parallel connection mode mechanism, to set up HEXAPOD parallel connection mode platform, to conquer the defects of the series connection mode. Therefore, the paper is aimed at HEXAPOD parallel connection mode platform, to use Larange method of the absolute coordinates system to pour out motion equation, in order to carry movement analysis. Finial, design the PD control rule to control the HEXAPOD parallel connection mode platform.

Keywords : Stewart、 parallel connection mode mechanism 、 HEXAPOD、 parallel connection mode platform、 PD control rule.

Table of Contents

目錄 封面內頁 簽名頁 授權書.....	iii	中文摘要.....	iii
.....v 英文摘要.....	v	.....vi 誌謝.....	vi
.....vii 目錄.....	vii	.....viii 圖目錄.....	viii
.....xi 表目錄.....	xi	.....xiii 符號說明.....	xiii
.....xiv 第一章 緒論.....	xiv	.....1 1.1並聯式運動平台簡介.....	1
.....1 1.2文獻回顧.....	1	.....5 1.3研究動機與目的...	5
.....7 第二章 HEXAPOD並聯式平台之設計.....	7	.....8 2.1 HEXAPOD並聯式平台之外觀.....	8
.....8 第三章HEXAPOD並聯式平台之動態方程式.....	8	.....11 3.1 座標系統定義...	11
.....11 3.2 座標轉換.....	11	.....12 3.3 位置向量.....	12
.....13 3.4 動能及位能.....	13	.....14 3.4.1動能.....	14
.....14 3.4.2位能.....	14	.....16 3.5 拘束方程式.....	16
.....17 3.6 虛功原理.....	17	.....18 3.6.1馬達所做的虛功.....	18
.....19 3.6.2 拘束力所做的虛功.....	19	.....19 3.7 HEXAPOD並聯式平台之運動方程式.....	19
.....21 3.8 真座標之運動方程式.....	21	.....24 3.8.1速度轉換矩陣.....	24
.....27 3.9 討論.....	27	.....26 3.8.2 真座標之運動方程式.....	26
.....27 第四章 模擬分析.....	27	.....27 3.9 討論.....	27
.....28 4.1 模擬結果.....	28	.....30 4.1.1 例子一,	30
.....31 4.1.2 例子二,	31	.....34 4.1.3 例子三,	34
.....37 4.1.4 例子四,	37	.....40 4.2 討論.....	40
.....43 第五章 控制器的設計.....	43	.....44 5.1 PD控制器.....	44
.....44 5.2 控制器的設計.....	44	.....45 5.3 討論.....	45
.....46 第六章 結論與未來研究方向.....	46	.....47 6.1 結論.....	47
.....47 6.2未來研究方向.....	47	.....47 參考文獻.....	47
.....48 附錄.....	48	.....51 圖目錄 圖1.1 典型的6-6 Stewart platform	51
1 圖1.2串聯機構示意圖 3 圖1.3並聯機構示意圖 3 圖1.4 Ingersoll 公司所生產之並聯式工具機, 型號HOH600 4 圖1.5 Toyoda 公司所生產之並聯式工具機, 型號HexaM 5 圖2.1 HEXAPOD工作平台之設計 8 圖2.2伺服馬達與Z軸滑台 9 圖2.3活動平台及球接頭 10 圖4.1 HEXAPOD工作平台尺寸設計圖 28 圖4.2萬向接頭及球接頭位置圖 29 圖4.3 活動平台的位置變化圖 31 圖4.4活動平台的線速度變化圖 31 圖4.5 活動平台的角位移變化圖 32 圖4.6 活動平台角速度變化圖 32 圖4.7 螺帽滑座位置變化圖 33 圖4.8螺帽滑座的線速度變化圖.....	34	.....33 圖4.9活動平台位置變化圖.....	33
.....34 圖4.10 活動平台速度變化圖 34 圖4.11 活動平台角位移變化圖 35 圖4.12 活動平台角速度變化圖 35 圖4.13 螺帽滑座位置變化圖 36 圖4.14 螺帽滑座線速度變化圖 36 圖4.15活動平台位置變化圖 37 圖4.16 活動平台線速度變化圖 37 圖4.17活動平台角位移變化圖.....	38	.....38 圖4.18活動平台角速度變化圖.....	38
.....38 圖4.19 螺帽滑座位置變化圖 39 圖4.20 螺帽滑座線速度變化圖 39 圖4.21 活動平台位置變化圖 40 圖4.22活動平台線	39	.....40 圖4.22活動平台線	40

速度變化圖.....	40	圖4.23活動平台角位移變化圖.....	41	圖4.24活動平台角速度變化圖.....	42
圖4.26 螺帽滑座線速度變化圖	42	圖5.1 PD控制器結構圖	44	圖5.2 活動平台運動軌跡與時間關係圖	46
HEXAPOD工作平台尺寸規格表	29	表5.1 控制器參數的特性	44		

REFERENCES

- [1] D. Stewart, "A Platform with Six Degrees of Freedom" Proceedings of the Institution of Mechanical Engineering.vol.180,part1,pp.371-386 ,1965.
- [2] J.E McInroy., J.C. Hamann, "Design and control of flexure jointed hexapods", pp.372-381, IEEE Aug 2000.
- [3] U. Saranli, M. Buehler, D.E. Koditschek, "Design, modeling and preliminary control of a compliant hexapod robot", pp.2589-2596, [4] N. Koyachi, T. Arai, H. Adachi, K. Asami, Y. Itoh, "Geometric design of hexapod with integrated limb mechanism of leg and arm", pp.291-296, IEEE Aug 1995.
- [5] G.M. Nelson,Quinn R.D.,Bachmann R.J.,W.C. Flannigan, R.E. Ritzmann ,"Design and simulation of a cockroach-like hexapod robot",pp.1106-1111,IEEE Apr. 1997.
- [6] T. Donald Greenwood, "Principles of Dynamics",1988.
- [7] F. Behi, "Kinematic Analysis for Six-Degree-of-Freedom 3-PRPSParallel Mechanism ",pp.561-565,IEEE 1988.
- [8] J.D. Geng, Z. Lee, R.L.Carroll, L.H.Haynes, "Learning Control System Design Based on 2-D Theory – an Application to parallel Link Manipulator",pp.1510-1515 IEEE 1990.
- [9] A.Codourey, E.Burdet, "A Body-oriented Method for Finding a Form of the Dynamic Equation of Fully Parallel Robots",pp.1612-1618 IEEE 1997.
- [10] M.Honegger, A.Codourey, E.Bourdet, "Adaptive Control of the Hexapod a 6 dof Parallel Manipulator"pp.543-548 IEEE 1997.
- [11] Wang,Jian,Masory,Oren, "On the Accuracy of a StewartPlatform-Part 1 The Effect of Manufacturing Tolerances",pp.114-120 IEEE 1993.
- [12] Takanori MASUDA, Motoyoshi FUJIWARA and Tatsuo ARAI,"Kinematics Analysis of the Parallel Mechanism with Vertically Fixed Linear Actuators", Series C, Vol.44,pp.731-739 NO. 3, 2001.
- [13] 羅華強, MATLAB 5.3 範例入門SIMULINK3.0, 全華科技圖書股份有限公司,2001.
- [14] Haim Baruh "ANALYTICAL Dynamics ",1989.
- [15] Chun-Ta Chen,Chieh-Chuan Feng "Inverse Dynamics of the General 6-6 Stewart Platform",2002.
- [16] B. Dasgupta, T.S. Mruthyunajaya, "Closed-Form Dynamic Equation of the General Stewart Platform Through the Newton-Euler Approach",pp.993-1012 ,1998.
- [17] K. Sugimoto, "Kinematic and Dynamic Analysis of Parallel Manipulators by means of Motor Algebra ",ASME PaperNo.86-DET-139 1986.
- [18] 王世明、康淵, "六自由度SPBM 工具機之設計應用原理與誤差分析", 機械月刊, Vol.29, No.3 , pp.75-83 , 2003.
- [19] 張道弘編譯, PID 控制理論與實務, 全華科技股份有限公司,1995.
- [20] 陳朝光、陳介力、楊錫凱編著, 自動控制, 高立圖書有限公司,2001.
- [21] C.KUO BENJAMIC, " Automatic Control Systems",1995.
- [22] 鄭永福編譯, 自動控制系統, 文笙書局, 1983.