無人自行車動態平衡控制之研究

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摘 要

本論文主旨在發展無人自行車平穩行駛控制系統的設計與實現技術。首先建立自行車動態資料量測系統，其包含的元件有側傾角感知器、編碼器等，對自行車的側傾角、前叉轉向角度、車速等進行量測，設計以伺服馬達作為驅動器的轉向機構，用來模擬騎士騎乘操控狀態。最後進行無人自行車操控實驗。無人自行車控制系統是以工業電腦作為控制器的平台，使用PID控制理論作為控制器的主要核心，分別控制側傾角、前叉轉向角與車體速度，車體速度控制以編碼器量測訊號以參考車速比較後，再經由LabVIEW程式中控制器產生一PWM訊號至MOSFET後對馬達進行開關控制，以達到穩定車速行速，側傾角控制則以側傾角的回授訊號和參考信號比較後，經由PID控制器產生一前叉轉向角之參考訊號後再經由另一PID控制器產生一電壓訊號，而對伺服馬達產生轉矩進而使自行車進行前叉轉向角與側傾角之控制。本論文中所使用的資料擷取程式與控制法則程式，皆使用虛擬儀控軟體LabVIEW所撰寫，在實驗上所得到之數據，可以驗證本論文所設計的系統與控制器的可行性。

關鍵詞 : 無人自行車、PID控制、工業電腦

目錄

參考文獻

[1]Alleyne, A., De Poorter. M.,“ Lateral displacement sensor placement and forward velocity effects on stability of lateral control of vehicles, ” American Control Conference, Vol.3, pp.1593~1597, 1997.

[2]Brown, H. B., Jr. and Xu, Y.,“ A Single-wheel, gyroscopically stabilized robot, ” Robotics and Automation, IEEE, 1996.

[3]Brown, H. B., Jr. and Xu, Y.,“ A Single-wheel, gyroscopically stabilized robot, ” Robotics & Automation Magazine, IEEE, Vol. 4, pp. 39~44, 1997.

[4]Beznos, A. V., Formal, A. M. ’ sky, Gurfinkel, E. V., Jicharev, D. N., Lensky, A. V., Savitsky and L. S. Tchesalin, K. V.,“ Control of Autonomous Motion of Two-Wheel Bicycle with Gyroscopic Stabilization, ” Robotics & Automation, IEEE, Vol.3, pp. 2670~2675, 1998.

[5]Chen, C., and Tan, H. S.,“ Steering Control of High Speed Vehicles :Dynamic Look Ahead and Yaw Rate Feedback, ” Proceedings of the 37th IEEE Conference on Decision & Control, Tampa, December 1998.

[6]Getz, Neil H.,“ Control of Nonholonomic Systems With Dynamically Decoupled Actuators, ” Proceedings of the 32nd Conference on Decision and Control San Antonio, December 1993.
[7]Getz, Neil H.,“ Control of Balance for a Nonlinear Nonholonomic Non-minimum Phase Model of a Bicycle, ” Proceedings of the American Control Conference Baltimore, Maryland June 1994.
[8]Getz, Neil H.,“ Internal Equilibrium control of a Bicycle, ” Proceedings of the 34th Conference Decision & Control New Orleans, LA-December, Vol.4, pp. 4286~4287, 1995.
[9]Getz, Neil H., and Hedrick, J. Karl,“ An Internal Equilibrium Manifold Method of Tracking for Nonlinear Nonminimum Phase Systems, ” Proceedings of the American Control Conference Seattle, Washington June 1995.
[10]Getz, Neil H. and Marsden, Jerrold E.,“ Control for an Autonomous Bicycle, ” IEEE International Conference on Robotics and Automation, Vol.2, pp. 1397~1402, 1995.
[11]Kawamura, S., Kubo, K., and Li, Z.,“ Effect of internal force on rotational stiffness of a bicycle handle, ” Systems, Man, and Cybernetics, IEEE International Conference, Vol.4, pp.2839~2844, 1996.
[12]Klein, R. E.,“ Using Bicycles to Teach System Dynamics, ” IEEE Control Systems Magazine, pp. 4~9, 1989.
[13]Yao, Y. S. and Chellappa, Rama,“ Estimation of Unstabilized components in vehicular motion, ” Computer Vision & Image Processing., Proceedings of the 12th IAPR International Conference, Vol.1, pp.641~644, 1994.
[14]Suryanarayanan, S., Tomizuka, M. and Weaver, M.,“ System dynamics and control of bicycles at high speeds, ” American Control Conference, Vol.2, pp. 845~850, 2002.
[15]Yavin, Y.,“ Navigation and control of the motion of a riderless bicycle, ” Compute. Methods Apply. , pp. 193~202, 1998.
[16]Yavin, Y.,“ Stabilization and control of the motion of an autonomous bicycle by using a rotor for the tilting moment, ” Computer Methods in Applied Mechanics and Engineering, Vol.178, pp. 233~243, 1999.
[17]Ou,Y., and Xu, Y.,“ Balance control of a single wheel robot, ” IEEE/RSJ International Conference on Intelligent Robots and System, Vol. 2, pp. 2043~2048, 2002.
[18]Lee, S., and Ham, W.,“ Self stabilizing strategy in tracking control of unmanned electric bicycle with mass balance, ” IEEE/RSJ International Conference on Intelligent Robots and System, Vol. 3, pp. 2200-2205, 2002.
[19]Feng, K. T., Tan, H. S., and Tomizuka, M.,“ Automatic Steering Control of Vehicle Lateral Motion with the Effect of Roll Dynamics, ” Proceedings of the American Control Conference, Philadelphia, Pennsylvania June 1998.
[20]Yasuhito Tanaka,“ Self Sustaining Bicycle Robot with steering controller ” IEEE/RSJ International Conference on AMC, pp.193~197. 2004.
[21]Zadeh, L. A.,“ Fuzzy Set, ” Information Control, Vo1.8, pp.338~353, 1965.
[22]Sharp. R. S., Evangelou, S. and Limebeer, D. J. N.,“ Advances in the modelling of motorcycle dynamics ”, Multibody System Dynamics, 12(3), pp.251-283, 2004.
[23]Sharp. R. S.,“ Optimal linear time-invariant preview steering control for motorcycles ”, The Dynamics of Vehicles on Roads and on Tracks (S. Bruni and G. Mastinu eds), supplement to VSD 44(1), Taylor and Francis (London), 2006.
[24]Sharp. R. S.,“ Motorcycle steering control by road preview, ” Trans. ASME, Journal of Dynamic Systems, Measurement and Control, Vol 129, pp. 373-381, 2007.
[25]Sharp. R. S.,“ On the Stability and Control of the Bicycle, ” Applied Mechanics Reviews, Vol. 61, No. 6., 2008.
[26]陳志達,“ 無人自行車之駕駛控制系統設計與實現, ” 國立中興大學電機工程研究所碩士論文, 2001.
[27]楊智凱,“ 無人自行車操控動態建立與控制, ” 大葉大學碩士論文, 2004.
[28]游富雄,“ 具有平衡質量塊之無人自行車系統設計與控制, ” 國立中興大學電機工程研究所碩士論文, 2004.
[29]劉育江,“ 無人自行車系統設計與操控實驗, ” 大葉大學碩士論文,2006.
[30]楊可農,“ 無人騎乘自行車系統設計與穩定行駛之研究, ” 大葉大學碩士論文,2007.
[31]蕭子健、儲昭偉、王智昱,“ LabVIEW 進階篇, ” 高立圖書有限公司.
[32]LabVIEW Software help, PID Control Toolset User Manual.
[33]鄭皓文,“ 無人自行車運動控制之研究, ” 大葉大學碩士論文,2008.
[34]童景賢、陳育堂、藍天雄、許桂樹, ” 自動控制概論, ” 全威圖書有限公司.