A14-064

Ghost Rider

幽靈騎士

隊伍名稱
飛輪海 / Flywheel Boy

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作品摘要 Abstract

本作品為一輛可以自動導引的自行車。無須有人在上面騎乘操控，即可自動平衡，且機動性高，外界的干擾對它的影響很小。未來可應用於自動化物流運輸、輔助騎乘、醫療復健與休閒娛樂上。從設計、製作、評估到應用的所有階段，都可作為機電工程教育很好的教材與平台，不但可以結合理論與實務，也可激發學生自主學習的動機與熱情。

此自動導引自行車系統之設計與整合的想法與步驟如下。首先設計一陀螺儀平衡器產生力矩使得自行車即使在不動的情況下亦能平衡，如同騎士藉著身體的移動來平衡自行車一般；設計模糊滑動模式控制器（Fuzzy sliding-mode control，FSMC）用於自行車的平衡控制，如同騎士的大腦；於龍頭、平衡器與後輪動力系統分別改裝馬達上，產生動力使系統作動，如同騎士的肌肉骨骼；於自行車與平衡器重心處裝上感測器，接收姿態量測資料，如同騎士的感官；自動導引自行車系統藉由以上各子系統的整合與溝通，達到無人騎乘、自動平衡並能抵達目的地的功能。

此作品亦利用Lagrange這種數學方程式推導陀螺儀平衡器及自行車的動力學模型，模擬結果證實系統足夠穩定與強健。為了驗證實體系統的可行性與強健性，故設計以下實驗: 利用2公升PE水瓶由90度角自由落下撞擊自行車，給予衝擊干擾。實驗結果中，FSMC控制器在自行車系統受到劇烈撞擊後仍可維持自行車平衡，且於靜止時可使自行車持續維持穩定而不傾倒。

In this work, we developed an autonomous bicycle with a gyroscopic balancer controlled by fuzzy sliding mode control (FSMC). The autonomous bicycle with the gyroscopic balancer and FSMC controller has the advantages of fast system response and relatively high robustness to disturbances. Even when the bicycle is hit by a bottle filled with two liters of water, hung on a rope with a length of 50 cm and sway away from an angle of 90 degrees, the bicycle is still highly stabilized. The gyroscopic balancer is the balancer with the least mass ratio of balancer to bicycle among various bicycle balancers, and it can effectively produce a moment to prevent the bicycle from falling down. Moreover, the bicycle with the gyroscopic balancer controlled by FSMC can outperform the one with PID under highly uncertain environment. The FSMC is suitable for manipulating a bicycle which is already successfully performed by humans. It can significantly reduce the design complexity of a controller for the autonomous bicycle.

The design concept of FSMC is creating a sliding surface served as a balancing index which incorporates three factors, the lean angle of the bicycle, the lean angular velocity of the bicycle, and the rotation angle of the gyroscopic balancer. The bicycle dynamics model with the gyroscopic balancer was proposed to simulate and validate the design concept on the balancing performance of the bicycle with FSMC.

Finally, experiments are designed to demonstrate that the autonomous bicycle system is still highly stable even when the bicycle doesn't move forward and is under impact disturbance.

Furthermore, since the results of simulation are consistent with ones of the experiments, it validates the derived bicycle dynamics model with the gyroscopic balancer and proves its robustness.

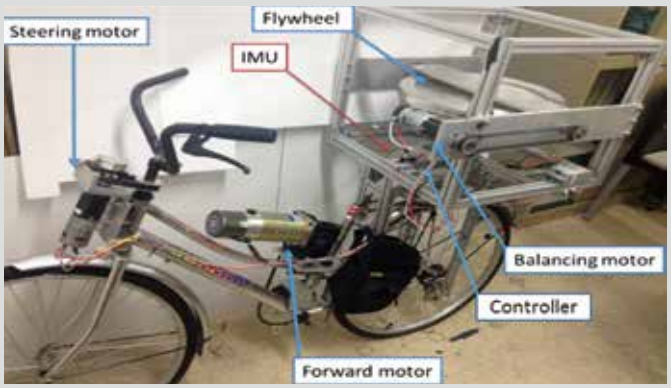

Fig.1 > Bicycle system structure