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AI智能互動桌球拍

AI Intelligent Interactive Table Tennis Racket

隊伍名稱｜西裝小丑 Clowns in Business Suits
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研究領域

嵌入式系統設計、飛機電控單元設計、智慧機械/農業

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研究領域

科技輔助英語教學、網路輔助英語學習、行動輔助英語學習、英語多元學習評量、英語自主學習與動機及成效相關研究 、VR互動教學研究

作品摘要

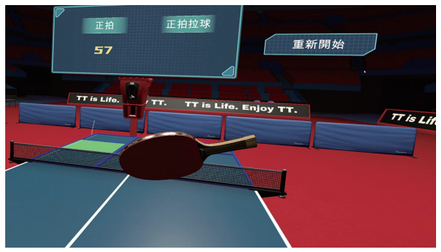
在世界運動的產業趨勢統計中，穿戴式裝置與虛擬訓練已成為主要的發展重點，加上元宇宙的娛樂效應下，整合穿戴式裝置與元宇宙的虛實沉浸體感是本專題創新突破的核心價值。過去的精準運動科技的穿戴式裝置大部分都是以感測資料回傳到雲端或是PC，然後再進行分析與處理。但隨著感測數據的處理分析的即時性需求，整合邊緣運算的技術成為解決的方案之一。

本作品包含硬體與軟體設計等兩部分，其中，硬體開發出AI智能互動桌球拍，以及設計一套VR互動訓練與遊戲軟體。如圖一所示，在AI智能互動桌球拍中，為了達成即時分析與處理，本技術採用AI Micro MCU與9軸IMU感測器，並將自製的電路板嵌入到桌球拍的握把中。其中，透過蒐集桌球選手的揮拍資料特徵分割演算法，實現六種揮拍（正手擊球/拉球/切球與反手擊球/拉球/切球）的姿勢辨識。而經實驗結果顯示，CNN模型有最佳的揮拍波形切割能力及分類準確率，對於桌球選手揮拍之平均分類準確率可達98.2%左右。最後，將此CNN模型以27K位元組的TinyML架構嵌入到Micro Edge AI MCU中，不僅可實現揮拍姿勢的分類，也可修正一般桌球初學者的揮拍姿勢，以達成即時桌球辨識與智慧感測的目的。同時，AI分析後的姿勢判別數據與IMU感測數據可以同步傳輸到PC端，作為進一步的分析處理與調教TinyML。

如圖二所示，在VR互動訓練與遊戲軟體中，將AI智能互動桌球拍所分析的六種姿勢導入，並在桌球拍面上外掛一組VIVE移動定位器，讓玩家透過透過實際的揮拍姿勢，享受沉浸式的遊戲體驗。此外，VR互動訓練與遊戲軟體中包含訓練模式與電競比賽模式。在訓練模式中，以真體感的互動訓練系統，訓練初學者做出六種正確的揮拍姿勢。而電競比賽模式中，嵌入競技桌球3S理論（speed/spin/spot）的智慧運算後，每顆球可以有3種速度參數，5種旋轉參數，9種落點參數等135種變化的可能性，也是聯網時桌球的變化方式，進而實現桌球的真體感VR互動訓練與遊戲系統，達到最佳的訓練方式與娛樂效果，並推廣至虛擬電競比賽中。

此作品的相關技術開發已獲得專利授權—桌球姿勢分類方法及桌球互動系統（I797014），與運動姿勢分析系統（I713890）。而未來的相關成果預計落地且應用在桌球電競的比賽中。

圖一 AI智能互動桌球拍實體圖。



圖二 VR桌球遊戲畫面。

Abstract

In global sports industry trends, wearable devices and virtual training have become major development focuses. Combined with the entertainment effects of the metaverse, the integration of wearable devices with immersive virtual and physical experiences represents the core innovative value of this project. Traditionally, most wearable devices in precision sports technology transmit sensor data to the cloud or PC for analysis and processing. However, with the increasing demand for real-time processing and analysis of sensor data, integrating edge computing has emerged as a viable solution.

This project encompasses both hardware and software design. The hardware involves the development of an AI smart interactive table tennis racket and the design of a VR interactive training and gaming software. As shown in Figure 3, the AI smart interactive table tennis racket employs an AI Micro MCU and a nine-axis IMU sensor to achieve real-time analysis and processing. A custom circuit board is embedded in the handle of the racket. By collecting swing data from table tennis players, the system uses feature segmentation algorithms to recognize six swing postures (forehand hit, forehand loop, forehand chop, backhand hit, backhand loop, and backhand chop). Experimental results demonstrate that the micro CNN model has the best waveform segmentation capability and classification accuracy for swings, achieving an average classification accuracy of approximately 98.2% for players' swings. The CNN model, compressed to 27KB in TinyML architecture, is embedded into the Micro Edge AI MCU. This enables the classification of swing postures and correction of common beginner errors, achieving the goal of real-time table tennis recognition and smart sensing. Furthermore, the postural data analyzed by AI and IMU sensor data are simultaneously transmitted to the PC for further analysis, processing, and TinyML tuning.

In the VR interactive training and gaming software, the six postures analyzed by the AI smart interactive table tennis racket are integrated. Additionally, a VIVE motion tracker is attached to the surface of the racket, allowing players to experience immersive interaction with real swing postures. The software includes training mode and esports competition mode. In training mode, the VR interactive training and gaming system is used to help beginners master the correct six swing postures. In esports competition mode, the system incorporates the competitive table tennis 3S theory (speed/spin/spot), providing each ball with three speed parameters, five spin parameters, and nine spot parameters, resulting in 135 possible variations. This connected table tennis variation system facilitates a true VR interactive training and gaming experience, achieving optimal training and entertainment effects, and promoting virtual table tennis esports competitions.

The technologies developed in this project have been granted patents: Table Tennis Posture Classification Method and Interactive System (I797014), and Sports Posture Analysis System (I713890). Future applications of these results are expected to be implemented in table tennis esports competitions.

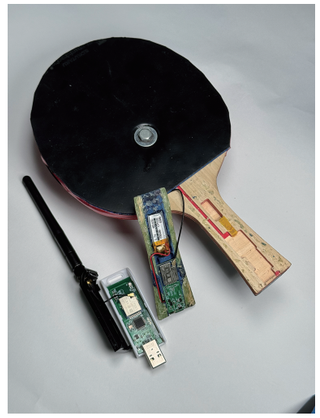


Fig.3 Disassembled view of the AI smart interactive table tennis racket.