A22-154

用於工業物聯網故障檢測與通知的無線智慧機上盒

Wireless Smart Machine Box for Industrial IoT Fault Detection and Notification

隊伍名稱　神奇小盒
Magical Box
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臺灣大學電子工程博士，現為中山大學資訊工程學系副教授。曾於英特爾 - 臺大創新研究中心（Intel-NTU Connected Context Computing Center）擔任博士後研究員，亦曾任教於逢甲大學電子工程學系。曾獲得中國電機工程師學會「優秀青年電機工程師獎」、臺灣積體電路設計學會「傑出年輕學者獎」，以及 IEEE 臺南分會「最佳年輕專業會員獎」等殊榮。目前亦為亞太信號與信息處理協會中華民國分會（APSIPA Taiwan Chapter）理事兼財務長。

研究領域

多核心系統晶片設計、類神經網路學習演算法設計、可靠度系統設計、超大型積體電路架構與電腦輔助系統設計

作品摘要

在現今工廠中，零件會因為經常性的碰撞及振動，導致零件的損耗、老化進而導致整體系統運作故障和輸出結果錯誤。當機械出現故障會造成生產者的成本增加且影響工廠生產品質。因此，機械零件的預測性維護（Predictive Maintenance，PdM）系統也漸漸被業界所重視。

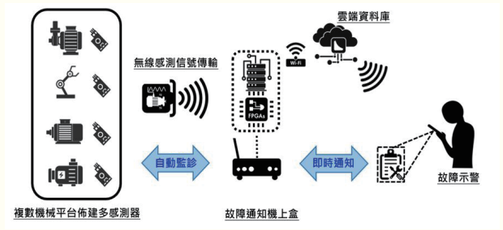
在機械故障診斷方面，傳統會透過複雜的訊號處理機制，來分析所收集到的故障零件之振動訊號，藉此來判斷故障類型。然而，這樣的方式通常需透過富有相關經驗的專家來執行，由於需花費較多的人力以及時間成本，對於一般中小型規模的企業來說，將是一個不可忽視的成本負擔。

基於上述原因，本作品開發了一套用於工業物聯網系統的無線檢測與故障通知機上盒，其特色為：

1. 支援複數個機械之故障診斷技術：透過人工智慧技術來化簡複雜的診斷過程。便可以在不需要太多先備知識的條件下，來達到同時支援複數個機械平台故障診斷的目標，藉此來降低診斷成本。
2. 支援無線感測診斷技術：本作品以Xilinx Pynq FPGA作為診斷平台之母板，並搭載所開發之機器學習診斷運算模組。同時，本作品將ADI Voyager無線CbM感測接收模組與Xilinx Pynq FPGA進行整合，使所接收到的感測信號能更即時的被擷取並進行診斷運算。
3. 支援即時故障通知之工業物聯網技術：本作品也將無線網路傳收模組與Xilinx Pynq FPGA進行整合，除了可即時的將所接受到的感測信號上傳至雲端資料庫外，當診斷結果為故障時，也可以即時的將診斷結果透過電子郵件來通知機械維修人員。

圖一為本作品的系統運作圖，ADI Voyager無線CbM感測器首先佈建於多部馬達中，以收集各部馬達的運作振動信號。接著，透過ADI Dust Network來進行資料的抗噪性傳輸，將感測資訊傳至機器學習運算平台中。Dust Network使用2.4GHz頻段，並可與不同的ADI Voyager無線CbM感測器建立起一套SmartMesh，意即每顆無線感測器既可用來感測振動資訊，也可以作為用來協助傳輸從別顆無線感測器所傳來之訊號的中繼站。如此一來，便可以在非常惡劣的傳輸環境中，達到99.999%以上的傳輸可靠度，以達到準確的遠端感測需求。

透過本團隊所開發之工業物聯網系統的無線檢測與故障通知機上盒，可以協助企業透過較低廉的檢修成本來同時診斷並監控多部機械的健康狀態，來大幅降低整體企業對於機械維保的成本負擔。



圖一 本作品馬達軸承齒輪故障診斷工業物聯網系統

Abstract

In terms of traditional mechanical fault diagnosis, the type of fault is determined by applying complex signal processing mechanisms to analyze the collected vibration signals. However, the time and labor costs are considerable because sophisticated experts are required to perform this kind of signal-processing-based methods. For medium-sized enterprises, the high time and labor costs become huge cost burden. Because of the abovementioned reasons, this work had developed a wireless smart machine box for industrial IoT fault detection and notification, which features:

1. Support fault diagnosis to multiple types of machinery simultaneously: We first use an artificial intelligence technique to simplify a complex diagnosis process. In this way, this work can support the fault diagnosis to multiple machineries without any prior knowledge, thereby reducing the diagnosis cost.
2. Support wireless sensing diagnosis technology: This work uses Xilinx Pynq FPGA to develop the diagnosis platform used to perform the machine learning diagnosis operation module. Besides, this work integrates the ADI Voyager wireless CbM sensor receiver module and Xilinx Pynq FPGA. Therefore, this work can process the received sensing signal and perform the diagnosis in real time.
3. Support real-time fault diagnosis notification in an IIoT environment: This work also integrate the wireless transceiver module with Xilinx Pynq FPGA, which is used to upload the sensing signals to the cloud database. When the fault is detected, the diagnosis results will be notified to the mechanical maintainer via email.

Fig. 2 shows the software-hardware collaboration architecture of the work. The ADI Voyager wireless CbM sensor is first deployed in multiple motors to collect the operating vibration signals of each motor. Afterward, the ADI Dust Network is employed to perform anti-noise data transmission. The Dust Network uses the 2.4GHz frequency band and can establish a SmartMesh with different ADI Voyager wireless CbM sensors. In other words, each wireless sensor can not only be used to sense vibration information but also be used to assist in transmission from other wireless sensors. In this way, it can achieve a more than 99.999% transmission reliability in a very harsh transmission environment and achieve accurate remote sensing requirements.

The proposed wireless smart machine box for industrial IoT fault detection and notification can help enterprises diagnose and monitor the health status of multiple machines simultaneously with lower maintenance costs. Therefore, this work can greatly reduce the enterprise's cost burden for machinery maintenance.

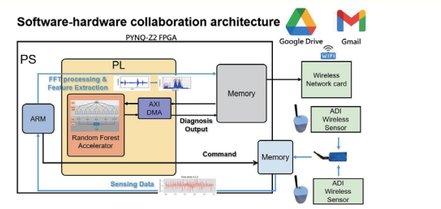


Fig. 2 Architecture diagram of fault detection platform applied to multi-component vibration data