

整合嵌入式AI晶片與 先進CNC控制器之系統設計與研發

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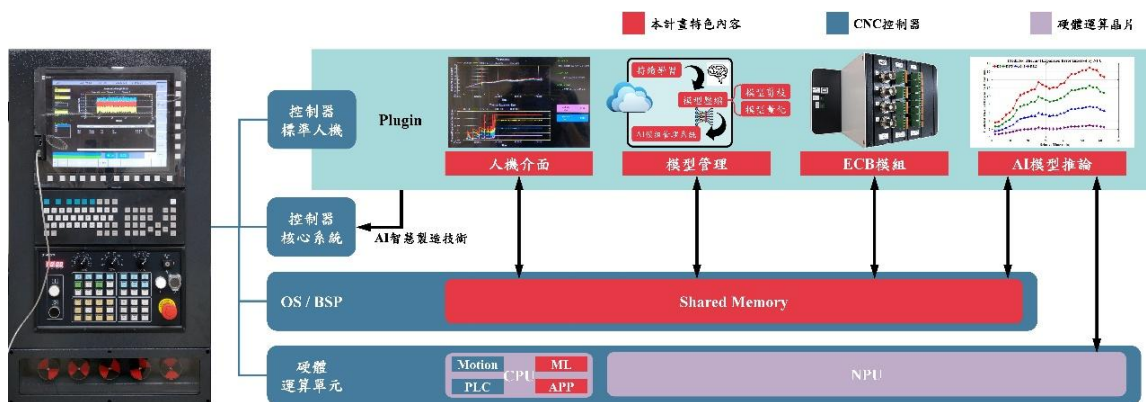
次世代智慧製造



本計畫整合機械、電機與資工背景共四位教授與業界進行跨領域合作，研發一「嵌入式AI晶片與CNC先進控制器」系統，使在商用控制器核心功能上透過AI晶片部署AI智慧製造技術。計畫目標包括：AI晶片與CNC控制器的軟硬體整合與核心參數存取、透過持續學習技術解決AI模型長期失準問題、開發CNC五軸高速高精控制器核心技術、部署AI技術進行熱變位即時補償、參數優化、刀具磨耗估測與表面紋路辨識。藉由多項的技術開發與整合，提升落地應用與產業競爭力。

計畫亮點

- 國內第一套嵌入式AI CNC控制器，透過NPU進行AI模型推論計算，以達到即時回授及補償。
- 開發X軸、Y軸與主軸之整機熱變位補償技術，維持長時間的加工精度。
- 結合感測器擷取模組，於控制器內運行AI熱變位即時補償技術。
- 透過AI模型整合插補、伺服系統、輪廓誤差與加工時間，根據使用者誤差需求，自動搜尋合適之控制器參數。
- 透過模型剪枝壓縮（包含簡化及量化）技術，使AI影像模型可以直接嵌入CNC控制器中運行。
- 建立一雲端AI模型管理系統，方便使用者於控制器端部署、更新與管理AI模型。



產業應用

- 機械產業、自動化產業、資訊產業、自駕車產業

專利資訊：誤差預測方法、工具機控制參數規劃方法以及系統

專利證書號 I845262

專利權期限 2024/06/11 ~ 2043/04/18

本發明專利提出工具機轉角誤差預測方式，透過工具機插補規劃模型計算位置控制資訊，接著藉由伺服馬達模型計算位置回授資訊以及實際移動出的轉角誤差。最後使用多誤差區間機器學習模型根據位置資訊與回授資訊預測轉角輪廓誤差值。

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System Design and Development
on Integrating an Embedded AI Chip
with a 5 Axis CNC Controller

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National Taiwan University
Dr. Meng-Shiun Tsai

Smart
Manufacturing



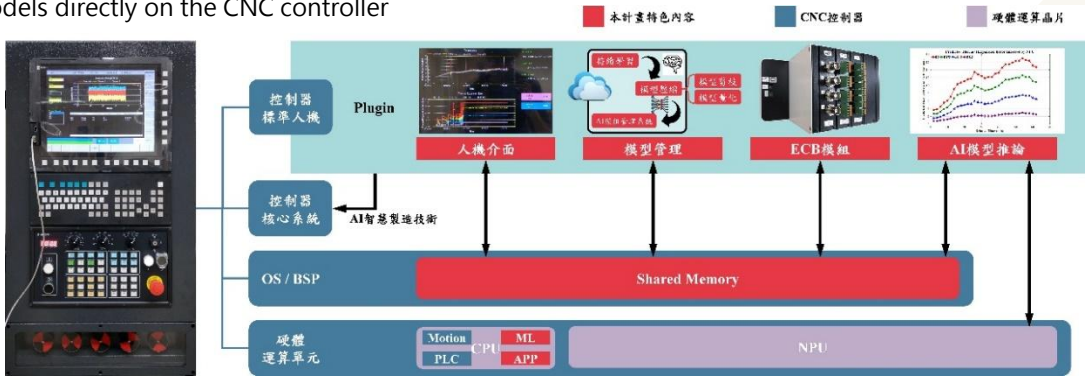
This collaborative project brings together four professors from mechanical engineering, electrical engineering, and computer science together with the CNC controller industry, to build an integrated system that combines an embedded AI chip with an advanced CNC controller. The system brings AI-driven smart manufacturing technique directly into the commercial CNC machine.

This project focuses on hardware-software integration to access core parameters, overcome long-term AI model drift via continuous learning, and develop the core of a high-speed, high-precision five-axis CNC controller. Additionally, this project develops real-time thermal displacement compensation, machining parameter optimization, tool wear recognition and identification using an on-chip neural processing unit (NPU).

By integrating these innovations, the project aims to deliver AI applications for CNC machining and boost the competitiveness of the industry.

Project Highlights

- The first embedded AI CNC controller developed locally, utilizing NPU for AI model inference, real-time feedback and compensation can be achieved.
- Development of comprehensive thermal displacement compensation for x-axis, y-axis, and spindle, maintaining accuracy over long-term processing.
- Connection of sensor acquisition module to enable real-time AI thermal displacement compensation directly within the CNC machine
- Integration of AI models with interpolation, servo systems, contour error analysis, and machining time to automatically optimize controller parameters
- Deployment of model pruning and quantizing techniques to run AI image recognition model natively inside the CNC machine
- Development of a cloud AI model management system, allowing users to deploy, update, and manage AI models directly on the CNC controller



Industrial Applications

- Mechanical industry, automation industry, information technology industry, and autonomous vehicle industry.

Patent :
ERROR PREDICTION METHOD, CONTROL PARAMETER PLANNING METHOD AND SYSTEM FOR CNC MACHINE

Patent Number I845262 Patent Term 2024/06/11 ~ 2043/04/18

This invention patent proposes a method for predicting corner errors in machine tools. It calculates position control information through a machine tool interpolation planning model, then computes position feedback information and the actual corner errors using a servo motor model. Finally, it employs a multi-error interval machine learning model to predict the corner profile error values based on the position information and feedback information.

