Journal of Computer Science and Digital Technology, 2025, 1(2), 1-7
https://doi.org/10.71204/atp0rz33

Editorial: Research Topic on Intelligent Industrial Sensing, Embedded Measurement Systems, and Precision Motion-Control Technologies in Digital Manufacturing Environments

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Received: 27 December 2025/Accepted: 28 December 2025/Published online: 29 December 2025

Abstract

The rapid evolution of intelligent manufacturing, industrial automation, digital production systems, and embedded sensing technologies is reshaping the global industrial landscape. As modern manufacturing systems continue to advance toward higher precision, stronger intelligence, and deeper digital integration, industrial sensing systems, motion-control platforms, intelligent measurement technologies, and automated quality-control architectures have become fundamental technological pillars supporting the next generation of industrial transformation. In this issue of the Journal of Computer Science and Digital Technology, we are honored to invite the research and engineering team from Hopo Technology (Ningbo) Co., Ltd. to present a series of specialized studies focusing on intelligent sensing systems, industrial automation technologies, embedded signal processing, precision measurement platforms, and industrial reliability optimization. The five research articles included in this research topic systematically investigate key technical challenges and engineering implementation methods related to magnetic grid manufacturing, precision grating measurement systems, industrial instrument optimization, intelligent encoder systems, and embedded industrial sensing architectures. These studies not only reflect practical industrial engineering experience, but also demonstrate the interdisciplinary integration of computer science, embedded systems, intelligent control, industrial communication, automation engineering, and digital manufacturing technologies. Through a combination of theoretical analysis, embedded algorithm development, system architecture optimization, industrial deployment validation, and mass-production engineering verification, the published works provide valuable technical references for intelligent manufacturing applications, industrial digitalization, and high-precision motion-control systems. This research topic highlights the increasing importance of software–hardware collaborative systems, intelligent sensing technologies, embedded signal-processing algorithms, and industrial reliability verification within the broader context of digital industrial transformation.

Keywords: Intelligent Manufacturing; Industrial Automation; Embedded Signal Processing; Precision Measurement; Industrial Sensing Systems; Motion Control

1. Introduction

The global manufacturing industry is currently undergoing a profound transformation driven by intelligent manufacturing, industrial Internet technologies, edge computing, artificial intelligence, and digital production systems. Traditional industrial production models based primarily on mechanical automation are rapidly evolving toward intelligent cyber-physical systems integrating embedded sensing, real-time data acquisition, adaptive control, and digital decision-making capabilities. Within this transformation process, industrial sensing systems, intelligent measurement technologies, and precision motion-control architectures have emerged as key enabling technologies for modern high-end manufacturing systems.

As the complexity and precision requirements of industrial equipment continue to increase, conventional industrial sensing and control technologies are facing unprecedented technical challenges. Modern intelligent manufacturing systems demand not only high measurement accuracy and rapid dynamic response, but also strong environmental adaptability, real-time communication capability, long-term operational reliability, and intelligent diagnostic functionality. Industrial environments involving electromagnetic interference, vibration, oil contamination, temperature fluctuation, and high-speed automated operation further increase the engineering difficulty of precision sensing systems.

Against this technological background, the current issue of the Journal of Computer Science and Digital Technology focuses on the interdisciplinary integration of computer science, industrial automation, embedded systems, intelligent sensing technologies, and digital manufacturing architectures. We are particularly pleased to present a special collection of engineering-oriented research contributions from the research team of Hopo Technology (Ningbo) Co., Ltd., whose work reflects substantial practical experience in industrial sensing system development, embedded control architectures, precision measurement technologies, and intelligent manufacturing deployment.

The selected studies emphasize not only theoretical optimization methods but also engineering implementation strategies, industrial deployment experiences, reliability verification frameworks, and mass-production process optimization. This engineering-oriented perspective aligns closely with the mission of the journal to promote the integration of computer science and digital technologies into practical industrial applications.

2. Overview of the Research Topic

This research topic includes five research articles covering several important research directions related to intelligent sensing systems and digital industrial technologies. The topics span precision magnetic grid manufacturing, optical grating measurement systems, intelligent industrial instrument optimization, embedded signal-processing architectures, and intelligent encoder technologies.

Collectively, these papers demonstrate how embedded computing, adaptive signal processing, industrial communication architectures, and intelligent manufacturing technologies are transforming conventional industrial sensing systems into intelligent digital industrial platforms.

3. Intelligent Motion Control and Automatic Detection for Magnetic Grid Manufacturing

The first article, "Design and Implementation of an Intelligent Motion Control and Automatic Detection System for Magnetic Grid Manufacturing" investigates intelligent automation technologies for magnetic grid production systems.

Magnetic grid sensors are increasingly employed in industrial robots, CNC machine tools, precision transmission mechanisms, and intelligent manufacturing equipment because of their high environmental adaptability and stable measurement capability. However, traditional magnetic grid manufacturing processes still heavily rely on semi-manual assembly and inspection methods, resulting in low assembly consistency, unstable inspection quality, and poor digital process traceability.

The authors propose a comprehensive intelligent production framework integrating motion-control algorithms, automatic detection technologies, software–hardware collaborative systems, and digital quality-management architectures. A layered system architecture consisting of equipment execution modules, embedded control systems, and industrial data-management platforms is established to realize automated assembly positioning, precision calibration, and real-time production monitoring.

Particularly noteworthy is the integration of feedforward compensation strategies and friction compensation algorithms into the motion-control framework, which significantly improves positioning repeatability and trajectory stability under industrial operating conditions. The proposed system further incorporates intelligent quality-control mechanisms capable of performing real-time defect analysis and production traceability.

Experimental deployment results demonstrate substantial engineering benefits, including significant reductions in inspection time and defect rate, while greatly improving assembly consistency and manufacturing efficiency. The study provides a representative example of how embedded motion-control systems and intelligent manufacturing technologies can be effectively integrated within precision industrial production environments.

4. High-Precision Grating Measurement Systems Based on Optical Signal Processing

The second article, "Design and Implementation of a High-Precision Grating Measurement System Based on Optical Signal Processing and Absolute Coding Algorithms" focuses on precision optical measurement technologies and embedded coding algorithms for industrial motion-control systems.

Precision grating sensors play critical roles in CNC systems, industrial robots, servo systems, and automated manufacturing equipment. However, conventional grating systems often suffer from signal instability, environmental sensitivity, optical interference, and long-term operational drift under harsh industrial conditions.

This study presents a comprehensive engineering framework integrating optical sensing architectures, anti-interference optimization, digital signal processing, interpolation subdivision algorithms, and absolute coding technologies. The authors systematically investigate key technical challenges involving grating scribing accuracy, optical-path optimization, electromagnetic compatibility, and temperature compensation.

A major contribution of the study lies in the development of high-resolution absolute coding algorithms based on Gray-code and segmented coding strategies. These algorithms improve both measurement resolution and power-off position retention capability while maintaining compatibility with embedded MCU and ASIC platforms.

The paper further demonstrates the increasing importance of embedded digital signal-processing techniques in modern industrial sensing systems. Through multi-stage digital filtering, adaptive gain control, and real-time error compensation, the proposed measurement framework achieves high-resolution stable operation under complex industrial environments involving vibration, contamination, and thermal fluctuation.

This work highlights the growing convergence between embedded computing technologies, intelligent signal processing, and high-precision industrial sensing systems.

5. Intelligent Process Iteration and Industrial Instrument Optimization

The third article, "Design Optimization and Intelligent Process Iteration for Industrial Instrument Systems in Intelligent Manufacturing Environments" investigates optimization strategies for industrial instrument systems operating under intelligent manufacturing conditions.

Industrial instruments constitute the foundational sensing infrastructure for digital manufacturing systems, industrial automation platforms, and process-control architectures. The performance of industrial instruments directly influences production stability, operational reliability, and manufacturing efficiency.

The authors propose a unified optimization framework integrating modular embedded circuit architectures, adaptive sensing technologies, automated calibration methods, process parameter optimization, and industrial reliability verification. The study pays particular attention to engineering challenges involving electromagnetic interference, environmental adaptability, production consistency, and long-term operational stability.

One of the most important aspects of this work is its emphasis on process-oriented engineering optimization rather than isolated hardware improvement. The proposed framework combines low-noise circuit architectures, adaptive sensor interface optimization, and embedded signal-processing technologies to improve industrial measurement stability under harsh environmental conditions.

Furthermore, the paper demonstrates how automated production management systems and intelligent calibration architectures can improve manufacturing consistency and reduce dependence on manual process adjustment. This reflects the broader industrial trend toward digitalized and intelligent production management systems.

6. Intelligent Absolute Magnetic Grating and Rotary Encoder Technologies

The fourth article, "Intelligent Absolute Magnetic Grating and Rotary Encoder System Based on TMR Sensing and Embedded Signal Processing for Industrial Automation Applications" explores advanced magnetic sensing technologies and embedded encoder architectures for industrial automation systems.

Absolute rotary encoders and magnetic grating systems are critical components in industrial robots, servo drives, automated logistics equipment, and intelligent production systems. Compared with optical encoder systems, magnetic sensing technologies provide superior environmental adaptability under conditions involving vibration, dust contamination, moisture, and oil exposure.

The authors introduce a comprehensive engineering framework integrating tunnel magnetoresistance (TMR) sensing technology, magnetic circuit optimization, adaptive signal processing, interpolation algorithms, and embedded decoding architectures. The proposed system further supports multiple industrial communication interfaces including RS422, SSI, and CANopen communication protocols.

An important contribution of this study is the integration of multi-turn power-off memory capability with adaptive embedded decoding algorithms. This significantly improves operational reliability and startup efficiency for industrial motion-control applications.

The research also demonstrates the growing importance of intelligent embedded sensing systems within industrial automation environments. By integrating magnetic sensing technologies with embedded processing architectures and industrial communication platforms, the proposed system represents a practical example of next-generation intelligent industrial sensing technology.

7. Embedded Signal Processing and Reliability Verification for Industrial Instruments

The fifth article, "Intelligent Industrial Instrument Accuracy Enhancement and Process Optimization System Based on Embedded Signal Processing and Reliability Verification" investigates embedded industrial sensing systems integrating adaptive signal processing, automated calibration, and industrial reliability optimization.

The study emphasizes the increasing role of embedded processing architectures in industrial sensing systems. Conventional industrial instruments frequently experience signal distortion, thermal drift, electromagnetic interference, and inconsistent manufacturing quality during long-term industrial deployment.

To address these challenges, the authors propose a comprehensive engineering framework combining modular circuit architectures, adaptive sensing technologies, Kalman-filter-based signal processing, automated production systems, and reliability verification technologies.

The proposed framework demonstrates how embedded algorithms and intelligent calibration methods can improve both measurement precision and industrial deployment stability. Reliability evaluation involving vibration testing, thermal cycling, and electromagnetic compatibility verification further confirms the engineering robustness of the developed system.

This study reflects an important research trend within modern industrial automation: the transition from isolated industrial measurement devices toward intelligent embedded sensing platforms integrating communication, adaptive processing, and reliability management functions.

8. Academic and Engineering Significance of the Research Topic

The research contributions included in this research topic collectively demonstrate several important technological development trends within intelligent industrial systems.

First, embedded signal processing and intelligent sensing technologies are becoming central components of modern industrial automation systems. Industrial instruments are no longer limited to simple parameter acquisition devices but are evolving into intelligent digital platforms integrating sensing, communication, adaptive processing, and reliability management.

Second, software–hardware collaborative integration has become increasingly important in industrial engineering systems. The studies emphasize the close interaction among embedded algorithms, sensing architectures, communication protocols, and manufacturing process optimization.

Third, industrial reliability verification and process standardization are emerging as critical engineering requirements for intelligent manufacturing deployment. The included works systematically address environmental adaptability, long-term operational stability, electromagnetic compatibility, and automated quality management.

Fourth, the integration of digital manufacturing technologies with industrial automation platforms is accelerating the transformation of industrial production systems toward intelligent, networked, and data-driven operational architectures.

From the perspective of computer science and digital technologies, these studies highlight the interdisciplinary convergence of embedded systems, intelligent algorithms, industrial communication architectures, adaptive signal processing, and industrial data management within intelligent manufacturing environments.

9. Conclusion

The editorial board of the Journal of Computer Science and Digital Technology sincerely appreciates the valuable contributions provided by the research team from Hopo Technology (Ningbo) Co., Ltd.. The five studies presented in this research topic provide important academic and engineering insights into intelligent sensing systems, embedded measurement technologies, industrial automation architectures, and digital manufacturing platforms. These works not only demonstrate strong practical engineering value but also reflect the broader technological evolution of intelligent industrial systems toward higher precision, stronger intelligence, deeper digitalization, and greater system integration. We believe that this research topic will provide meaningful references for researchers, engineers, industrial developers, and practitioners working in the fields of industrial automation, embedded systems, intelligent sensing, digital manufacturing, and precision motion-control technologies.

Author Contributions:

All authors have read and agreed to the published version of the manuscript.

Funding:

This research received no external funding.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Conflict of Interest:

The authors declare no conflict of interest.