Development of an Embedded IoT Platform for Acoustic Emission Monitoring in Industry 4.0

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Introduction

Industry 4.0 integrates digital technologies into industrial processes, focusing on efficiency and automation, driven by the Internet of Things (IoT), which connects machines, devices, and sensors to collect real-time data and monitor production processes. This technological transformation improves resource utilization and increases precision in critical processes such as milling and drilling[1]. Acoustic Emission (AE) sensors are essential in real-time fault detection, identifying wear and microcracks in materials, especially when combined with IoT technologies, enabling remote monitoring and predictive maintenance[1]. Although efficient, IoT-based AE sensors still face technological challenges for widespread application, as current models require a complex infrastructure[2]. This work proposes a system of integrated hardware and software for collecting acoustic emission signals, utilizing wireless IoT sensors to facilitate fault detection, feature extraction, and integration with cloud storage systems.

Objective

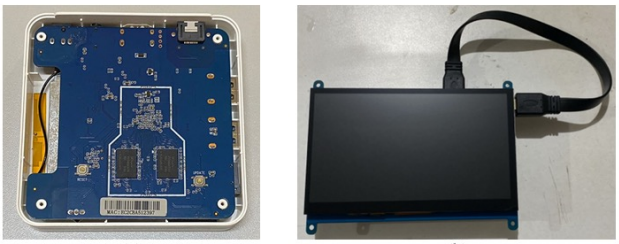
The main objective of this work was to develop an embedded software system that centralizes all functions for collecting, processing, and monitoring IoT acoustic emission sensors, eliminating the need for multiple tools. Additionally, the goal was to create integrated hardware housed in a portable case, equipped with a single-board computer (SBC) and a touchscreen LCD for use in field and laboratory testing.

Methodology

Python was used to develop a GUI with Tkinter for IoT integration, allowing adjustments of parameters like gain and sampling rate, with an algorithm to process raw binary data from AE sensors into real samples, including signal processing and waveform visualization. A single-board computer (SBC) with an AMLOGIC S905 CPU and Linux OS was set up for cloud integration via MQTT, with a touchscreen for interaction and Wi-Fi for communication. After configuring the parameters, the system activates a data link with the AE sensor, allowing signal acquisition, data analysis, and automatic adjustments based on diagnostics. Tests can be registered and stored locally and remotely, confirming the system's efficiency compared to conventional data acquisition.

Results and Discussion

The results of this work include the successful development of a functional portable 4 case equipped with a single-board computer (SBC) and an LCD touchscreen. The system 5 incorporates simple and intuitive embedded software, allowing users to easily adjust the 6 necessary configurations for experiments with the IoT acoustic emission (AE) sensor. Figures 1 to 3 respectively show: Internal components of the implemented hardware: single-board computer (a) and view 2 of the LCD before being integrated into the case (b); IoT acquisition and processing settings window; Waveform of an AE signal collected through a wireless data link



(a) (b)

Figure 1: Internal components of the implemented hardware: single-board computer (a) and view 2 of the LCD before being integrated into the case (b).

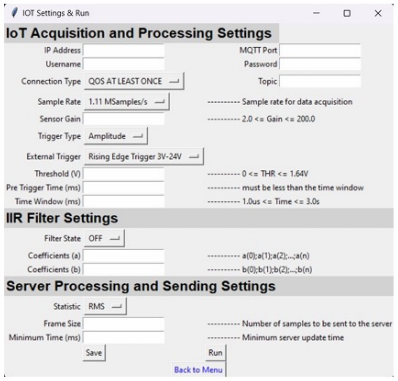


Figure 2: IoT acquisition and processing settings window

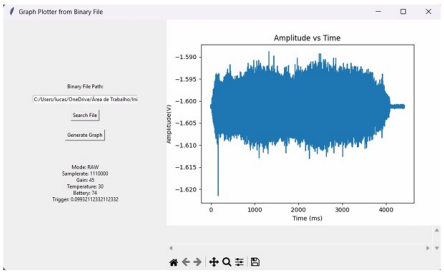


Figure 3: Waveform of an AE signal collected through a wireless data link

Conclusion

This study developed an integrated IoT system for acoustic emission (AE) sensors, simplifying their setup and operation by combining hardware and embedded software into a single, intuitive device. Eliminating the need for auxiliary equipment and complex software, the system enables efficient real-time data processing and predictive maintenance, with cloud connectivity via MQTT for continuous monitoring. Preliminary tests validated the setup, and future field tests will further assess its functionality. This solution enhances AE sensor usability and efficiency, supporting Industry 4.0 advancements and improving long-term data management for industrial monitoring.

References

1. Tran, M.Q.; Doan, H.P.; Vu, V.Q.; Vu, L.T. Machine learning and IoT-based approach for tool condition monitoring: A review 17 and future prospects. Measurement 2023. Available online: https://doi.org/10.1016/j.measurement.2022.112351(accessed on 22 18 September 2024).

2. Dotto, F.R.L.; Aguiar, P.R.; Alexandre, F.A.; Simões, L.; Lopes, W.N.; D'Addona, D.M.; Bianchi, E.C. Acoustic image-based 30 damage identification of oxide aluminum grinding wheel during the dressing operation. Procedia CIRP 2019, 79, 298–302.