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Development of artificial intelligence for assessing microprocess plans and metadata models based on ISO 14649 using the Unified HMI platform

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The primary element raising the competitiveness of the manufacturing systems is the machine tool industry, which is the backbone of the industrial sector. To compete in a global competitive society, it is necessary to the smart control system covering with the digital thread from machine control until process planning and data analysis based on the Cyber-Physical System. To implement advanced, or smart, features, an open platform of machine tools that can incorporate with intelligent functions such as data integration, intelligent data processing, and anomaly detection. This paper, based on the unified platform, implements a neutral metadata model required for artificial intelligence data analysis via ISO 14649, as well as an artificial intelligence algorithm that automatically identifies process information-NC data by integrating real-time data of numerical controller and sensor data. The intelligent data processing provides automated data classification and data compressing using deep neural network. Based on the actual processing situation, a metadata model was built from the CAM data, and the processing status, process type, and sensor profile were predicted by applying it to the actual processing real-time data. Chattering detection was implemented through the proposed platform as the proof-of-concept.

1. Introduction

The machine tool industry is the fundamental technology that enhances the competitiveness of other manufacturing industries. In order to be competitive in a global competitive market, it is necessary to reduce dependence on a few specific vendors ofcomputerized numerical control (CNC) and to upgrade the manufacturing capability of each factory by adding intelligent elements based on the Cyber-Physical System based on the digital thread covering with the whole chain from the design phase until production phase. Following the Industry 4.0 paradigm, all components in the manufacturing world possess integrated processing and communication capabilities [1].Meanwhile, as new functionalities are added to machine tools, it eventually gets more complicated [2]. In order to implement advanced technology, that is, smart function, an open human-machine interface (HMI) platform that can be mounted independently on CNC and can add customized Apps developed by machine tool users, tailored to the individual shopfloor, likely smartphone platforms.

In this paper, a neutral meta-data model that can be used for data exchange and analysis such as artificial intelligence based on the Unified HMI platform is implemented using ISO-14649, a STEP-NC standard, and an artificial intelligence algorithm that automatically identifies process information-NC data by integrating real-time NC data and sensor data. Based on actual processing cases, a metadata model was constructed from commercial CAM data, and processing status, process type, and sensor profile were predicted by applying it to the actual processing and real-time information.

2. Methodology and Case Study

2.1 Methodology

2.1.1 ISO Standard Metadata Model

In order to solve the problem of data integration in the data chain, which was the first problem is to design a database with metadata based on a standard data model. Design based on a standard data model ISO (International Standards Organization) has the following advantages: first, when data is stored through a standard metadata model, information from inter-homogeneous or heterogeneous software can be obtained. It can be integrated, which minimizes data loss during data movement and exchange. Second, data storage is

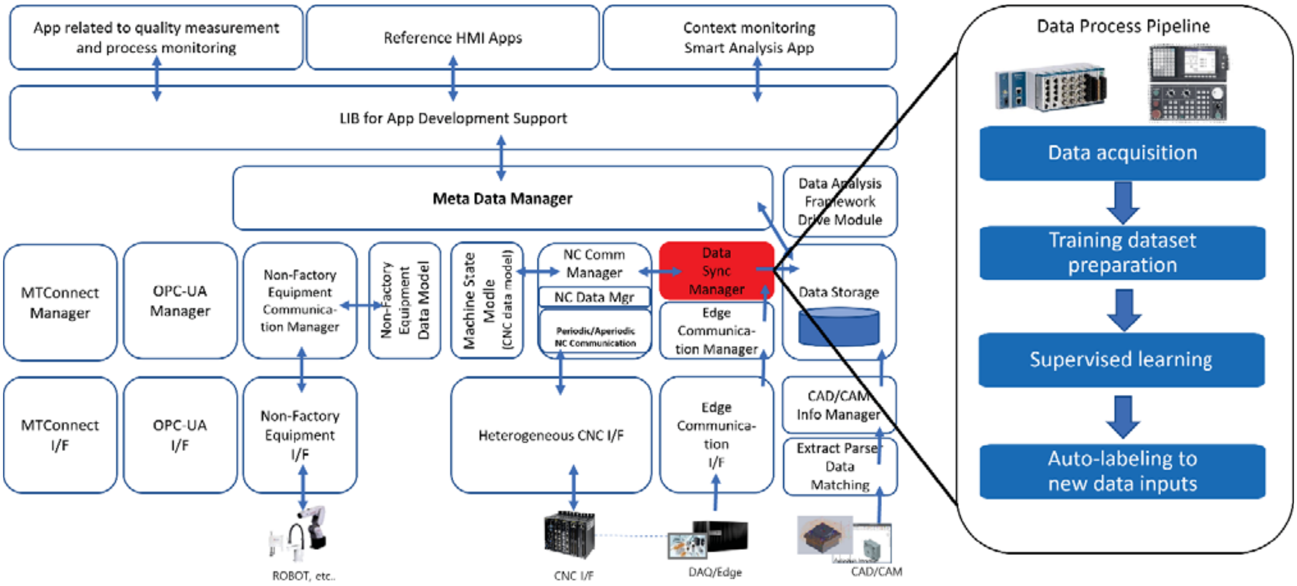

Fig.3. Schematic of data collection and labeling on HMI

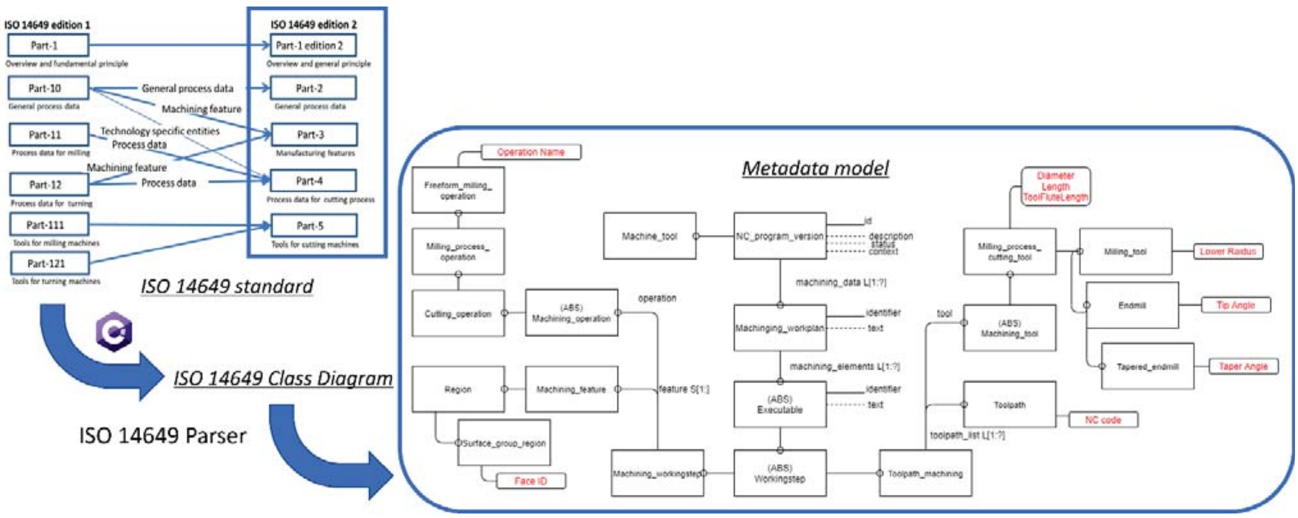

Fig.2. Metadata and Database design based on the standard model

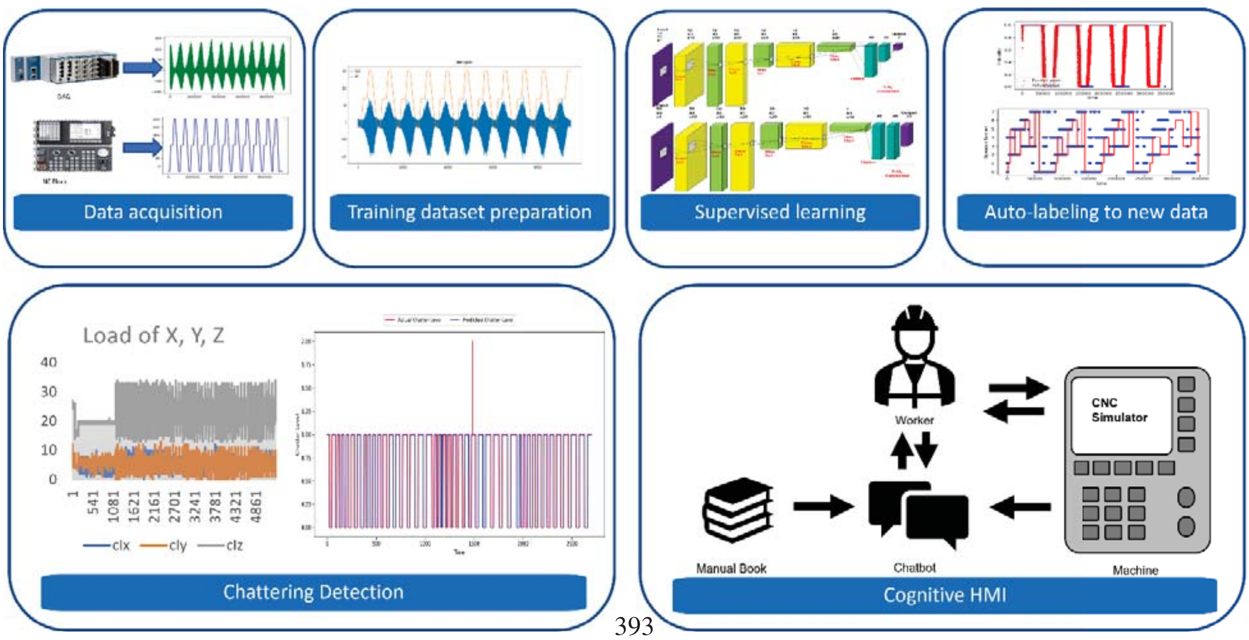

Fig.1. Operation Classification and Data Platform

standardized through standard data models, therefore, when developing apps or using data it can gain the advantage of easy access and access to the data.Standard namely ISO 14649 offers a feature-based programming-integrated object-oriented data model for CNCs with a comprehensive and organized data interface [3].

2.1.2Data Processing

The second problem is the problem-solving methodology for data synchronization. We developed an algorithm that synchronizes data with the Auto-Labeling function through AI. As you can see in figure 1, data comes from various sources. Saving out of sync reduces the value of the data and requires a lot of time and money in preprocessing for use. These data need tobe synchronized through the data process pipelines so that the stored data can be reused later in the data process of the machine learning platform.In the first step of the data processing pipeline, all the data of sensors and controllers are collected in the proposed platform. The second step is to preparethe dataset manually with the representative cases of each operation type. Third, based on that dataset, the platform teachesmachine learning models. Finally, the principle is that data is automatically labeledand synchronized for upcoming newdata.

2.2 Case Study

In this study, we design metadata and databases based on standard models. First, the case study is to store CAM data through a standard metadata model. The first picture that you see in the upper left of figure 2 is the one that shows the change in Edition 1 and Edition 2. As can be seen from the figure, the Parser was constructed by reflecting ISO 14649 Edition2, which is simpler than Edition 1 The second picture is the construction of the Parser in the Class Diagram. The last picture shows a Metadata model based on the parser that was constructed. For theexperiment, we saved the CAM data that can be obtained from NX CAM in MySQL.These CAM data are stored as JSON files across the Metadata model that was previously built.We have completed the experiment of reading this file again. The JSON file printed in this way takes the form of data based on the standard. Benefits include standardized use for data sharing, storage, or reuse.

The nextstep is to resolve data mismatch issues. The experimental dataset was obtained through a Chatter experiment (upper left of figure 3). The data set used is the vibration data of the NC block and DAQ. Synchronization through labeling, NC block data, and DAQ data resolution do not match, so data interpolation is required. Based on the location information of NC information, DAQ data was matched through labeling. Using the labeled DAQ data set, through the artificial intelligence algorithm, even if NC block data does not exist, using only DAQ datasets, it was possible to predict whether the machine was turned on or off or what kind of operation it was doing. These results will allow future incoming data to be automatically labeled and stored in the database.

3. Conclusions

In this study,standard model-based metadata and databases weredesigned to allow data to be stored and utilized in a neutral manner. Secondly, we developed an auto-labeling algorithm through data synchronization. The results of these studies are: It enables seamless information exchange, not only processing data but also analysis and real-time control, regardless of the vendor on CAD-CAM-CNC. Automated data set construction system to effectively analyze real-time data information collected through complex processes. In future research, CAM software and interfaces will be integrated with CNC's own cycle code. Finally, we plan to build real-time prediction conservation by linking with algorithms using artificial intelligence such as failure diagnosis and quality abnormalitiesand also implement a Cognitive HMI in the form of chatbot by using data collected (bottom right of figure 3).

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REFERENCES

1. Gorecky, Dominic, et al. "Human-machine-interaction in the industry 4.0 era." 2014 12th IEEE international conference on industrial informatics (INDIN). Ieee, 2014.
2. Lotti, Giulia, et al. "New trends in the design of human-machine interaction for CNC machines." IFAC-PapersOnLine 52.19 (2019): 31-36.
3. Xu, Xun William, and Stephen T. Newman. "Making CNC machine tools more open, interoperable and intelligent—a review of the technologies." Computers in Industry 57.2 (2006): 141-152.