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Automated knowledge extraction for smart cognitive Machine tool HMI

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The machine tool market is formed with general-purpose machines and dedicated machines developed by various vendors. Therefore, it is common to use a mix of machine tools from various makers in the single shopfloor. However, diverse manufacturers have their own interfaces, and there are a lot of different versions. Their instructions made of large-size files or heavy paper handbooks are provided to the users, but portability, storage convenience, and visibility are vulnerable. Machine tool users need separate long-term training or trial-and-errors to use the machine without helps. Meanwhile, it is becoming difficult to find technically trained manpower due to population changes in the manufacturing-advanced countries. Automated factories using machine tools is always suffering a shortage of expertized labors, and training courses for new workers are not properly prepared. To address these situations, proposals and use of Digital Intelligent Assistant for factory automation are increasing. In this paper, we propose an automated knowledge extraction process consisted of three interpretation functions. The machine interpretation function uses a machine interface library to read machine status information from the machine. The user Interpretation feature uses the machine simulator image for optical character recognition to identify the user's intention and the operation currently being performed. The manual interpretation function utilizes an information retrieval algorithm that searches text information from large machine instructions. It also uses reinforcement learning to shorten long-term training and replace unnecessary trial-and-errors. New cognitive interface supported by automated knowledge extraction functions can easily interact with humans and provide appropriate answers in intuitive ways. The proposed system will be the basis for integrated cognitive human-machine-interface regardless of the manufacturer. Through this, the efficiency of limited manpower will be maximized in industrial sites where various interfaces are mixed, and human with factory will be realized.

1. Introduction

1.1 Machine Tool Industry

The machine tool industry is an important industry because it is the basic industry of manufacturing. The machine tools are mainly used in the field of factory automation and formed with general-purpose machines and dedicated machines developed by various vendors. Therefore, it is common to use a mix of machine tools with many different interfaces from various makers in the single shopfloor. As equipment becomes more diverse and sophisticated, field workers must master more diverse and challenging interfaces. On the other hand, training course for new field workers is another challenge. Instructions made of large-size files or heavy paper handbooks are provided to the users, but portability, storage convenience, and visibility are vulnerable. Machine tool users need separate long-term training or trial-and-errors to use the machine without helps. Meanwhile, it is becoming difficult to find technically trained manpower due to population changes in the manufacturing-advanced countries and the prolonged pandemic situation. To address these situations, proposals and use of DIA (Digital Intelligent Assistant) for factory automation are increasing. In this paper, we propose an automated knowledge extraction process for the DIA of machine tool.

1.2 Digital Intelligent Assistant

A digital assistant is software support to achieve time-consuming, stressful, or not desirable activities for the users. It interacts with clients with one or more interfaces including conversational interfaces (Wellsandt et al., 2022). The digital assistants can increase the work performance by giving the information related to machine status, operation and quality (Longo et al., 2017). DIAs can be a means of coping with situations where there are insufficient expertized labors and training courses. Recently, the industrial application of DIAs has been actively studied. In order to apply DIAs to industrial sites, it must be based on understanding the data about the environment. But

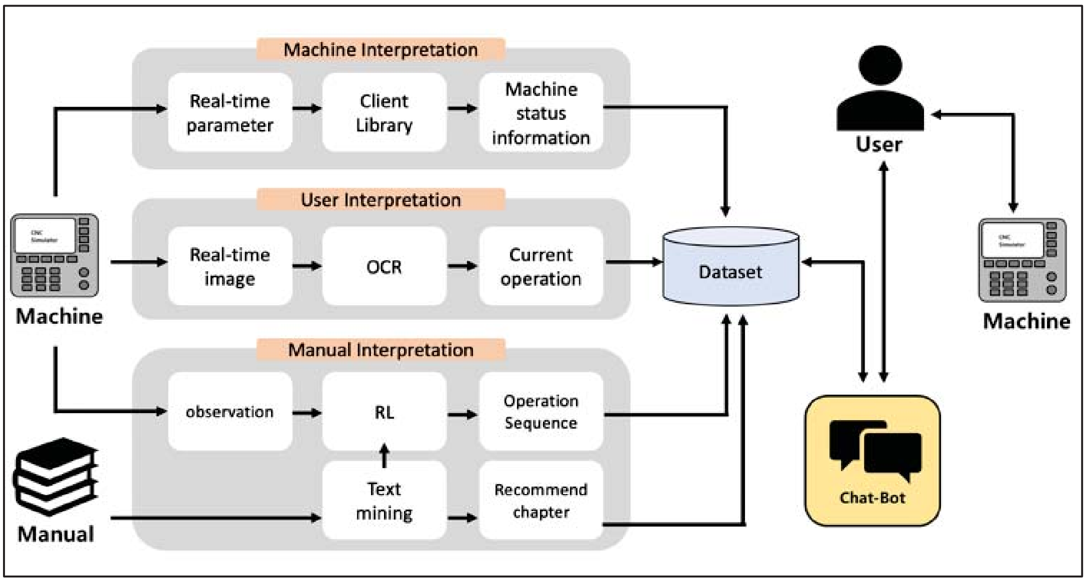

Figure .1 Architecture of smart cognitive HMI

it is stressful work to make and update the dataset for the DIAs. In this paper, we propose automated knowledge extraction process for DIAs interacting between machine tools and workers. New cognitive interface supported by our automated knowledge extraction functions can replace the heavy paper handbooks while using the machine tool and reduce unnecessary time to familiarize with the new machines.

2. Smart Cognitive HMI

2.1 Chatbot for Machine Tool

In industrial sites that use machine tools, it is all too common to use equipment from multiple makers. However, diverse vendors have their own interfaces, and there are a lot of versions with different graphics. This means operators need to take a lot of effort and time to learn and familiarize with new interface each time. It is obvious that it is very stressful time-consuming work especially in the situation where there is a lack of manpower and no curriculum for training.

As a result, we tried to introduce smart cognitive HMI that can be used even if the version and supplier are different. In this system, chatbot is used to interact with users, receive questions from users and identifies users' intentions. It supports users to find a direct way to their desired panel state by giving machine status information, current operation and operation sequence as an answer. Users can use it as an integrated HMI to access machine information and official manual books for machine tool.

2.2 Automated Knowledge Extraction

Proposed chatbot can be used as an integrated, smart cognitive HMI for machine tool. However, a well-made dataset is needed for the chatbot to work smoothly. Thus, we made automated knowledge extraction process to make dataset easily with little effort. As shown in the Fig.1, this process is consisted of the dataset three interpretation functions.

The data in the dataset can be divided into two parts: one is real-time data and the other is accumulated data. Machine status information, current information and other changeable information are saved as real-time data and updated in real-time by interpretation functions. Meanwhile, operation sequence and guidebooks information, that is consistent, are saved as accumulated data. In addition, conversations information emerged from chatbots are saved in accumulated data.

The machine interpretation is the function that reads machine status information from the CNC simulator and update it into the dataset. Using client library, it reads machine parameters contain the information about equipment's current status such as mode, equipped tools, and other information needed.

The user interpretation feature captures the displayed image of machine simulator immediately after the user requests information about the working process. Then, it performs OCR (Optical Character Recognition) algorithm to recognize the text from the image and comprehend the detailed manipulation of the moment.

As soon as the chatbot is asked a question including a keyword that symbolizes the present, the above two functions are triggered to collect each data.

Unlike others, the manual interpretation function was performed in advance to form accumulated data in the dataset. Its goal is to find the most relevant chapter of machine's handbook and button sequence for the desired panel state which is the user's purpose. There are two algorithms in the manual interpretation performance. One is chapter detection algorithm, which performs text-mining in handbooks and find the optimal answers to users' "how" questions. The other is sequence detection algorithm made of reinforcement learning. It uses current-function and softkeys as an observation to trace the pressed button on the CNC. And it finds the optimal click position by trial and errors, which is best action in reinforcement learning (Table.1). So, it can replace the long-term training with less accessible paper manual books.

Table .1 Conditions for reinforcement learning

Observation	[function][mode][soft key1][soft key2]…[soft key9] [soft key10]
Action	[Click position X][Click position Y]

Those three interpretation manipulations are based on the data from machines' displayed graphics and standard parameters, that are regardless of vendors and versions of machines. When applying to new machines, algorithms in each interpretation section can be used with only a few modifications of parameters indicating displaying-area. After that, it extracts data without additional work and create a new dataset suitable for the new machine automatically.

3. Conclusions

Ununiform interfaces of various machine tools and underutilized manuals lead to time-consuming learning and shortage of pre-trained workers. In this paper, we introduced smart cognitive HMI with automated knowledge extraction process to deal with above problem. Proposed information obtaining process are divided into three functions: Machine interpretation, User interpretation and Manual interpretation. Each component is formed with data acquisition algorithm with vision technology and text mining skills. As a result, they can execute their purpose regardless of machine's supplier and interfaces. Supported by these automatically generated dataset, chatbot as a new cognitive interface can easily interact with humans and provide appropriate answers in intuitive ways. The proposed system will be the basis for integrated cognitive human-machine-interface. Through this, the efficiency of limited manpower will be maximized by reducing the pre-training time in industrial sites where various interfaces are mixed. Finally, human with factory will be realized.

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