Design of Big Data Platform for Automatic Production Line of Handicraft Structure

Yangzhi Zhang
Nanjing University of Science and Technology, School of Mechanical Engineering, Nanjing 210094, China
Email: 1129710149@qq.com

Abstract. The automation production line of handicraft structural parts are taken as the research object in this paper, and big data platform is constructed through data modeling, data collection, data analysis and data visualization technologies, including data perception layer, communication layer, storage layer and analysis and display layer. The data acquisition layer obtains the multi-source heterogeneous information source at the bottom of the handicraft processing workshop, transmits it to the big data platform based on the OPC UA protocol for the data analysis of equipment status, production efficiency, product quality and other data, and displays the results through the visualization technology in real time to realize the real-time dynamic control of the handicraft processing process.

1. Introduction
At present, most manufacturing enterprises are faced with such problems as complex equipment, serious material accumulation and poor product quality consistency. In order to provide more reasonable production information feedback and production scheduling, the research on big data platform is particularly important. Yang [1] of south China university of technology realized big data acquisition in the plastic machinery industry through the combination of OPC and Kafka technology. Xiao et al. [2] proposed an improved method of fuzzy prediction and comprehensive evaluation of state parameters to evaluate the performance of wind turbine and improve the reliability of unit state evaluation. Xu [3] used the method of extreme learning machine on the Hadoop platform to establish the multi-objective combustion model of the boiler, and verified that the method could improve the boiler's combusion energy use and other problems. Wang[4] used Hadoop and Oracle hybrid architecture solution to improve the timeliness of data collection. In the detection of power equipment, Lu [5] et al. used wavelet packet analysis technology to extract the characteristics of data faults, and built a probabilistic neural network (PNN) to identify the normal, overload and warning states of the equipment. Mahapatra B[6] et al. used the method of data regression to reduce the initial data, and demonstrated the necessity of attribute reduction before data classification. Alexandrov [7] et al. proposed Stratosphere, a deep software stack for analyzing big data, using a high-level scripting language and focusing on providing scalability. Maarala A [8] et al. completed real-time query analysis of logistics data on the basis of Spark, and proposed A big data cloud platform to provide data intake, analysis and storage. Agarwal S [9] et al. introduced the process of real-time data analysis on log flow data, and proposed an advanced streaming data analysis framework for web log flow generation.

In this paper, through the production process analysis of the handicraft structural parts mining the construction demand of the big data platform, based on the data to drive the production optimization of the handicraft structural parts. Through the production data modeling, collection, storage and
analysis design for the large data platform of handicraft structural parts, it provides components such as equipment status monitoring, production efficiency analysis and product quality analysis to provide a basis for intelligent decision-making of enterprises.

2. Demand Analysis
There are many kinds of structural parts in this paper, such as clock structural parts, lamp structural parts, badge structural parts, etc., which have the characteristics of complex processing technology, high detection requirements, high precision and high surface finish. The automatic processing process of handicraft structural parts is shown in figure 1. The core equipment used includes: numerical control machine tool, automatic polishing robot, loading and unloading manipulator, AGV car, three-dimensional warehouse, etc.

![Figure 1. Process flow chart of automatic production line of handicraft structure](image)

At present, the workshop has built an automated production line for the structural parts of handicrafts, which has improved the production efficiency compared with the traditional manual operation method. On the basis of the automated production line, the following goals will be achieved through the application of technologies such as big data and cloud platform:

1. Change the original mode of relying on manual data collection, based on the big data platform to drive the production business through data, and through the data automatic collection technology to get through the data flow of the structural parts of handicrafts.
2. Through the construction of big data platform, integrate the workshop equipment, control system, production line and other factors into the management, real-time monitoring of the operation status of the workshop, and improve the comprehensive utilization efficiency of the equipment.
3. Based on data mining, fully analyze the correlation relationship of workshop equipment, materials, quality and other data, accurately judge the production bottleneck of production line, and dynamically display the data analysis results based on visualization technology, so as to provide data support for intelligent production decision.

3. Data Acquisition Scheme Design
The data collection scheme is designed according to the production data model of the structural parts of handicrafts to provide timely and accurate data sources for the construction of the big data platform. The data collection mainly includes the data collection of equipment and other production process data.

3.1. Production Data Type
The premise of data collection, analysis and management is to master the type and flow direction of production data. As shown in figure 2, the production data is classified into personnel, equipment, materials, methods, environment, quality inspection and other data according to the classification of production data objects. According to the classification of production data attributes, it can be divided into static data of production data and dynamic data of processing process. Static data of production data include personnel, material number, process instruction, quality inspection standard, etc., and dynamic data of processing process include information of equipment operation parameters, production schedule, process schedule, etc.
3.2. Equipment Data Acquisition

Through the customized design of data acquisition main program and each equipment acquisition subroutine to obtain the processing process information of the handicraft structure, including CNC machine tools, AGV, robot, pipeline and other equipment data acquisition.

For CNC machine tools, the method of polling SDK variables is used to obtain the corresponding variables by calling SDK functions and sending them to the main program of acquisition through named pipelines.

For AGV, in order to obtain information such as position, power and load of AGV car, publish/subscribe mode is adopted to obtain data based on OPC UA protocol.

For robot data, data variables are stored in the reading register by polling, including action variables, count, etc., and the data variables are transmitted to the acquisition program through named pipes.

For the automatic pipeline, use the host name to connect the pipeline control system PLC program, polling to obtain the open variable name.

For energy consumption data collection of the device, by installing intelligent air switch with RS485 as the communication module, the serial port server is used to convert RS485 communication into Ethernet communication, and the serial port server network port is connected to the PC network port with the network cable, and the energy consumption data can be read through the browser.

3.3. Production Process Data Collection

Production process data collection mainly includes personnel, materials, environment, product quality and other aspects. Personnel data and product quality data sources of MES system, mainly by XML technology in data acquisition, with XML as the middleware implement collection with MES server one-to-one correspondence, the transmission of data through XML engine to define a standard format to achieve production plan and product quality data loading, browse, modify, and so on. For material data, it is mainly collected through RFID technology, including electronic tags, readers and antennas. The electronic tag records the basic information of the material and attaches to the material. When the material moves to the working range of the reader-driven antenna, the reader reads the data to realize the identification of the item. The collection of environmental data mainly includes the collection of temperature, humidity, smoke and dust concentration through the selection of temperature and humidity sensors, smoke sensors, dust sensors.
4. Design of Big Data Platform for Automatic Production Line of Handicraft Structure Parts

4.1. Big Data Platform Architecture Design

As shown in figure 3, the overall architecture design of big data platform mainly includes four aspects: production process data perception layer, data communication layer, data storage and processing layer, and analysis and display layer.

Figure 3. Overall architecture design of big data platform

(1) Data perception layer
The big data platform automatically obtains a large number of real-time and complex data from the workshop production process, including the data sources of equipment, materials, personnel and quality as the basic platform.

(2) Data communication layer
Based on OPC UA protocol, the workshop network and the internal communication architecture are built. Facing the digital environment of workshop production data acquisition, transmission and production instruction issuing process, the corresponding data acquisition program and interface are provided to realize unified transmission of heterogeneous, highly concurrent, massive and high-noise data.

(3) Handle the storage layer
Access to a large number of multi-source heterogeneous data, from the depth of the workshop in order to solve the problem of data storage and processing, through the establishment of mechanisms, including real-time, timing and relational database cluster will be collecting and processing, the underlying data source defined fields and unified planning, the transformation strategy, remove duplicate fields, through extraction, data cleaning, data import scale data-base, both to ensure uniformity and availability of data, and can eliminate the phenomenon of data island.

(4) Analyze and display layer
Analysis shows the layer is the core part of the big data platform, through the material, equipment, quality of data acquisition, processing and storage, each link related to analysis of data mining is adopted to improve the production efficiency, product quality analysis and equipment condition monitoring, etc, and the data analysis of the abstract and complex results into a more intuitive, more in line with information perception and visual form of logical thinking.
4.2. Core Function Module Design

(1) Equipment status monitoring module
Through start-stop state process of CNC machine tool operation, coordinates, the information such as the spindle speed of real-time acquisition and self awareness, collected for the multi-dimensional real-time data of manufacturing equipment, on the basis of information fusion, using principal component analysis, abnormal means such as pattern recognition, fault diagnosis, implementation to the health of equipment condition assessment, on this basis, using the reliability theory and optimization method, state of equipment comprehensive monitoring, including equipment processing time, processing operation energy consumption, operation time, the processing of the machine quantity, number of idle in the machine, stop the machine number and other information, as shown in figure 4.

![Figure 4. Device status monitoring interface](image)

(2) Production efficiency analysis module
The production efficiency analysis includes the plan completion rate analysis and the production bottleneck analysis. Through the statistical comparison between the production plan data and the real-time execution data, it can judge whether the production plan can be completed normally and the existing problems. By the completion rate of the plan, it can proactively calculate the analysis deviation and feed back the results, so as to provide an accurate remedial decision for the items with relatively lagging schedule. On this basis, the equipment actuation rate analysis of the device monitoring and analysis module of the device association determines the production bottleneck according to the bottleneck theory and orders the production bottleneck according to the influence degree, and finds the best solution according to the direct cause of the bottleneck, as shown in figure 5.

![Figure 5. Productivity Analysis Module Interface](image)

(3) Product quality analysis module
On the one hand, through the analysis of quality based on the history data, implement the quality of raw materials, work in process and finished products, equipment, a comprehensive assessment to find out the key factors influencing the quality problem, the data is divided into several types, quality and technology based on association rule mining, working hours, working procedure, equipment and so on a set of correlation analysis, correlation is used to find the correlative relationship between quantity of
each project, and is usually expressed in the form of rules, and set up the key control points of quality control. Quality, on the other hand, through the real-time data acquisition and the process multidimensional SPC (statistical process control), and other means, to achieve the stability of the production process, process capability indices of evaluation, the workshop parameter adaptive adjustment, optimize the production status, for possible quality abnormal situation, through the analysis of the database product percent of pass, the product can be divided into high qualification rate of product, low qualification rate of products, as shown in figure 6.

![Figure 6. Product quality analysis module interface](image)

5. Conclusion
In this article, through structure in arts and crafts processing demand analysis, on the basis of production data type design data collection scheme, and set up automatic production line for handicraft structural big data platform, including the production data perception, analysis of data communication, data processing and data display, to get through the whole clock structure production process data flow, provide enterprises with intelligent decision making.

6. Acknowledgments
This research work is supported by the intelligent manufacturing demonstration project, No. 2019404124004. Meanwhile, thanks Prof He for his guidance and help.

7. References
[1] Yang da. Research and design of data acquisition system of big data cloud platform for injection molding equipment based on Kafka [D]. Guangzhou: south China University of technology, 2017.
[2] Xiao yunqi et al. Fuzzy comprehensive evaluation of operation status of large wind turbine based on trend prediction [J]. Chinese journal of electrical engineering, 2014, 34 (13): 2132-2139.
[3] Xu chenchen. Modeling and optimization of power station boiler combustion system based on Hadoop big data platform [D], Shanxi: taiyuan university of technology, 2017.
[4] Wang baoyou. Research and implementation of telecom big data integration scheme based on Hadoop [J]. Telecommunications science, 2017, 33 (01):135-142.
[5] Lu xiao, et al.Research on fault diagnosis of power secondary equipment based on big data [J].Electrotechnics, 2018, (21):7-10.
[6] Mahapatra B,Patnaik S. An analysis on data reduction methods for MANETS to reduce incoming data as a preprocessing technique [J].International Journal of Information Technology, 2019, 11 (1):75–88.
[7] A. Alexandrov, R. Bergmann, S. Ewen, et al. The stratosphere platform for big data analytics [J]. The VLDB Journal—The International Journal on Very Large Data Bases, 2014, 23(6):939-964.
[8] Maarala A I, Rautiainen M, Salmi M, et al. Low latency analytics for streaming traffic data with Apache Spark[C]// IEEE International Conference on Big Data. IEEE, 2015:2855-2858.

[9] Agarwal S, Prasad B R. High speed streaming data analysis of web generated log streams[C]// IEEE, International Conference on Industrial and Information Systems. IEEE, 2015:413-418.