Development of Intelligence Automated Robotic Arm Workstation

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***Abstract*—According to industry 4.0 development, many fields not only factories but companies are achieving the goal of intelligence production and going to be transforming to promote their competition. In this paper, we achieved the target of using Internet of things (IOT) in our workstation. It concludes the structure of IOT module, product resume, AOI system, webpage, monitoring module and database. Using IOT module to receive the data from workstation, and then the AOI system detected the products of the defacement and identity of the product. The experiment result is stored in the database and showed on the webpage. All the situation of the workstation's data can be monitored via the monitoring webpage by the users. The progress of the research is that workers could leave the dangerous circumstance and remote via computer to monitor the working process.**

***Index Terms*—IOT module, product resume, AOI system, webpage, monitoring module, database**

I. Introduction

In recent year, automation field [1] emerged and become more popular than the past. Many of the factories improve the conventional system into intelligent one. Therefore, robot is one of the point in industry. Because of the trend, robot industry was more popular. The factory import industry4.0 [2] with big data, database and AI applications. The goal which is upgrading the process line is for the smart factory [3-4]. In this paper, IOT module is used to develop the issue of promoting the processing. It based on automation workstation and then upgrading into industry4.0 which is included database, and monitoring web page. The structures are using RFID, robotic arm and database that is SQL system [5] and establishing the server that Apache remote monitoring webpage on the platform system [6]. It separates into manager and users. Manager could control the products and data via webpage and operate the machine in remote condition.

II. Syatem Structure of Workstation

Robot field is popular in automation industry. the market application of global robots is major in industrial robot. Thus, developing intelligent robot industry is an important part of industrial intellectualization with features of digitization, intellectualization and networking. This means that the development of robots not only replaces manual labor but also replaces mental labor[7]. Take FANUC [8] and ABB [9] for example. FANUC robotic arm was used on Nissan's producing line and it is used for assembling. On the other hand, ABB robotic arm is used for analysis [10]. In this paper, the automation workstation is used FANUC robotic arm. It is common in industry to used robotic arm in producing line. Therefore, the module that was increased is transformed into smart factory.

The system structure was illustrated in Fig. 1. It included seven different parts that are database, PC, webcam, IOT module, webpage, product resume and robot automation workstation. The individual parts are explained as follows:

A. IOT Module

It was consist by Raspberry Pi [11], MCP3008, temperate sensor, air pressure sensor and photo resistance. It was received the data and calculated.

B. Product Resume

The product resume was made up of PC, laser scanner and product. The laser scanner was scanned the barcode of the product and used USB protocol to PC.

C. Web

It was established via Laravel [12] frame and PHP language. It used graphical interface and format to show the relation data.

D. Monitoring Module

It was used Webcam, Logitech C910, for monitoring the multi-function electric meter and deal with AOI via OpenCV [13].

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E. Database

The database was used MySQL to storage the data. This was read from four different sensors via SPI interface.

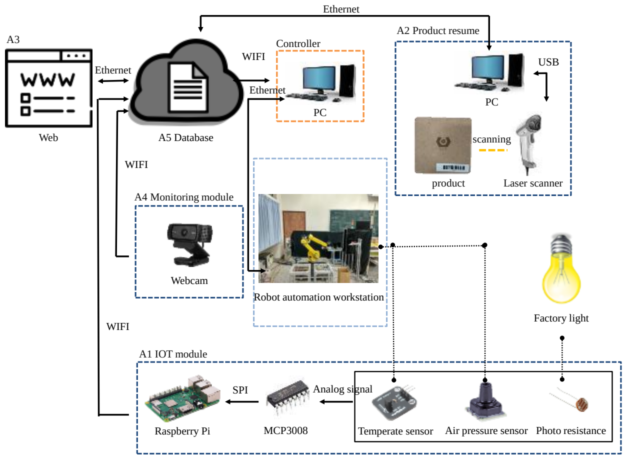


Figure 1. System structure of workstation.

The devices are receiving an order by PC controller. The holding-device was made by vacuum chuck and pneumatic jaw. Using vacuum generator to create negative air pressure for vacuum chuck and solenoid valve controlled pneumatic jaw. Ring lights and camera used in AOI (Automated Optical Inspection) station. Especially the camera, it connected the controller of robotic arm via Camera Link and then cooperated with ring lights. The level of illumination was the best than others to capture. The web was showed the data which was captured from database for users. The database was communicated with PC via WIFI. It used MySQL to be our database. It storage the value which was came from product resume, IOT and monitoring module.

III. Experimental Results

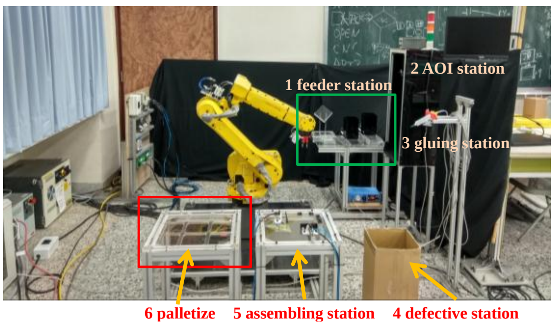


Figure 2. The plot plan of workstation.

The experimental workstation in this study is depicted in Fig. 2. According to the workstation, it illustrated the routine and the application of six axis robotic arm. The station divided into various parts that are storage, checking, AOI, gluing and assembling. Especially the application of air pressure gluing machine, industrial camera and the elements of air pressure, these appeared the entirely automation workstation with detection and gluing active.

This was produced a wooden mirror which showing in Fig. 3. The component of the frame was self-producing with shape of square. The sizes of square element are lens are 95mm×95mm and 78mm×78mm, respectively. It is launched at the green space that is the storage station and end at red space called palletize.

Figure 3. Product material.

The flow chart of workstation is illustrated in Fig. 4. For first, it went on initialization. The robotic arm moved to storage station and sucked the object from feed tray. After that, it went on recognizing at AOI station. In this station, defacement objects will move on defect product station and abandon. Before abandoning, there is a barcode on objects. The camera recognized the barcode and checked. In assembling station, it was made the object at a fix point. At the same time, robotic arm went back feeder station to suck the lens and put into second-position station.

Then moving to gluing station, the arm moved via the path which we set in program and started the air compressor. In the end, robotic arm went on assembling station to combine the lens and frames and then grabbed the finished good to place into palletize. The process can always be repeated.

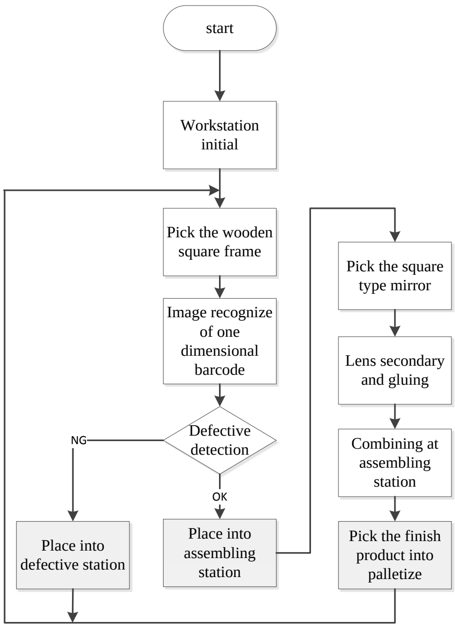


Figure 4. The flow chart of workstation.

A. IOT Application Module

The structure of IOT module is illustrated in Fig. 5. Using Raspberry Pi to be a controller and collect the analog signal by MCP3008 to develop a low cost IOT module. After acquiring the signal, it transmits into

Raspberry Pi by the type of Serial Peripheral Interface. It went on initial calculation when Raspberry Pi receiving the data. This will store in the MySQL database via WIFI transmission module which connect the same film router.

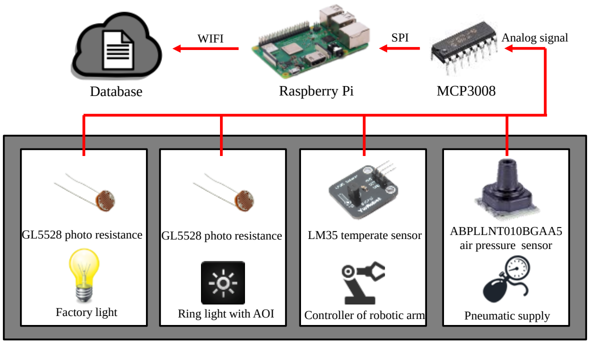


Figure 5. IOT module structure.

The IOT module flow chart is shown in Fig. 6. When the program beginning, it loaded the library and connected the MySQL database to check the value. This is for the feedback of four different sensors. After that, the program will not only launch transformation of data to physical value but judging equipment's condition. In the end, the value will be uploaded to database and stored in the instruction form. Logging out the database to ensure the uploading data should be all connected. After 5 seconds, it will restart the program.

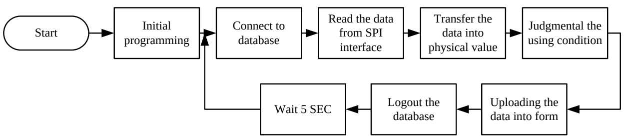


Figure 6. IOT module flow chart.

1) *Result of IOT module data*

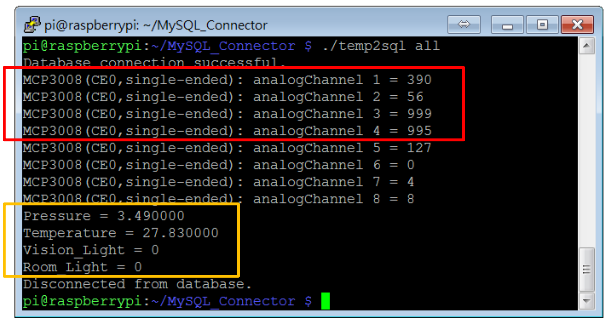


Figure 7. IOT module program.

The circumstance detail and the situation of equipment are showed on the interface by IOT module program in Fig. 7. It was exploited by Raspberry Pi, ADC chip and various sensors. Raspberry Pi gathered the data statue of eight different addresses in MCP3008 via SPI interface. For now, we only used 1 to 4 data address in MCP3008 which was marked in red square to calculate the physical value by transferring senor's formula. The orange square is the practical values which were transferred after calculation. At the end, it had been uploaded into MySQL database through API.

The collecting information from IOT module can be listed in Table I. The data were used to deal with analyze via every control system of workstation. The main purpose of data collecting is to make the system be superior and judging the condition such as, pressure and temperature etc.

TABLE I. LIST OF DATA COLLECTION

Name	*Output*	*Function*
Pressure	Bar	Collecting the air pressure value from workstation
Temperature	℃	Collecting the temperate value from electric cabinet
Vision_light	0 : error 1 : normal	Collecting the light value from AOI station
Room_light	0 : people-no 1 : people-yes	Collecting the light value from factory field

B. *AOI System*

In this paper, it is presented image identification system structure in Fig. 8. The detecting area included barcode scanning and defect detecting with vision inspection function. In order to remove the defacement that use to ensure by quality control. In the image processing flow, determining the object's exterior and choosing not only the appropriate camera but lighting way to stabilize the light. The material's picture was grabbed by camera and via the Camera Link. After dealing with visualization, the value transformed to the controller of robotic arm. Through the PC captured and send the value to database, the identification result showed on the Web page.

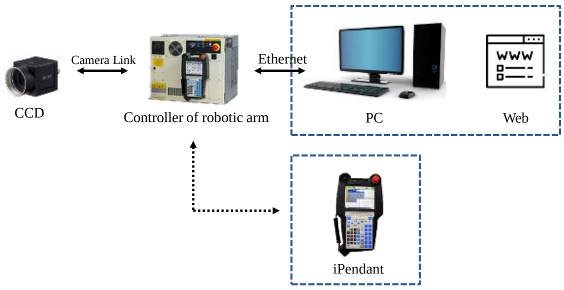


Figure 8. AOI system structure.

The flow chart of OpenCV dealing with image is depicted in Fig. 9. The procedure include four steps, reading training data, capture and crop the image, image process and k-NN(k-Nearest Neighbors) algorithm. First, loading the trained sample to process the calculation via K-Nearest Neighbors algorithm from OpenCV. The sample is included capital vocabularies and numbers. Then, capturing the images to deal with the program in Raspberry Pi by Webcam. The resolution of image is 640(H)*480(V) and using ROI tool to crop the value of power meter that could make smoothly on the process. Then, the images are going to deal with transforming. The first step of the procedure is put the image into gray type because colorful images are not satisfying on processing. The Gaussian filter is used to soft the image which is to deal with threshold and transform into bool image and elude the noise signal to find the contour of the object. At the end, the K-Nearest Neighbor algorithm is based on a practical algorithm. The new and being trained samples are compared and calculated the nearest one.

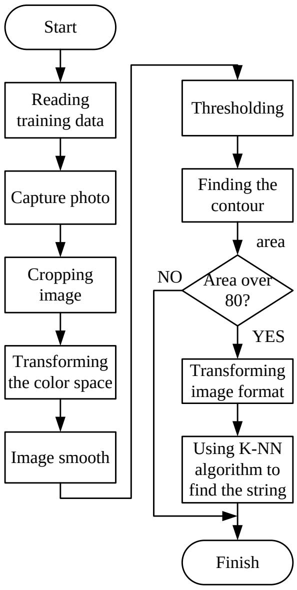


Figure 9. Processing image with OpenCV.

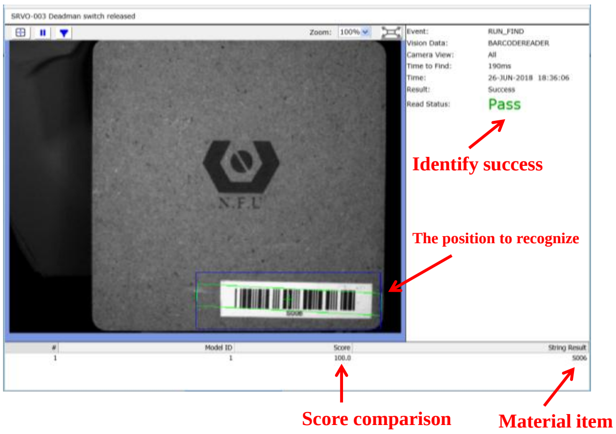


Figure 10. The result of one-dimension comparison.

The picture in Fig. 10 shows the result of one-dimension comparison. There were two steps that is scanning the barcode and detecting the blemishes for frame producing process. It could discriminate the defect condition on item number and back of the frame. Barcode was put to use by iRvision and 1D Barcode Tool. The specification of code39 was used on the finished products coding.

The comparison score is presented in red-square Fig. 11. Acquiring the item number through visualization discriminate system and it detected the interface and LOGO. After detecting, it compared with LOGO and the module which established in the beginning. When finished the comparison, it will obtain a score. Suddenly, visualization system is going to go on detecting discriminate of frame's interface. At the end, it compared LOGO's score and the number of the dots in the same time such as green-square. If it judged in pass, the score need to be more than 95 and the number of the dots should less than 1.

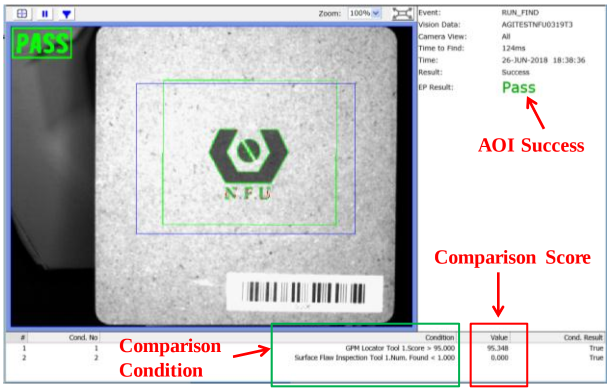


Figure 11. The result of defective detection.

C. *Webpage*

The login webpage is illustrated in Fig. 12. In this section, there is a monitoring website to show the detail of every workstation via chart and form. Adding the monitor in the factory could let users more easily and promptly to acquire the data even they were not in the area. The website used Laravel and PHP programming language to establish and import mysqli expansion kit. Because of mysqli, it could communicate with the cloud database.

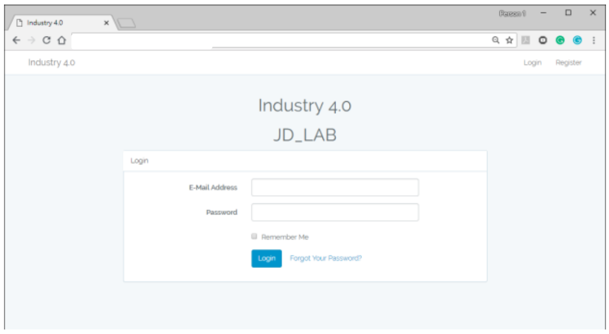


Figure 12. Login webpage.

The flow chart of webpage is presented in Fig. 13. When it opened the website, it must login and wait for certification. After that, it could enter the monitoring page. The design of main list included processing time, IOT monitoring, graphical interface and real-time monitoring four different functions.

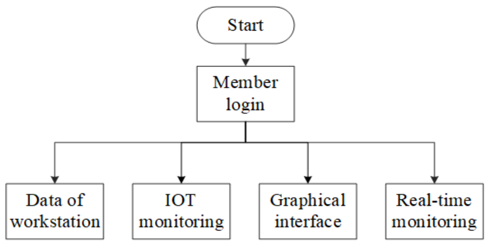
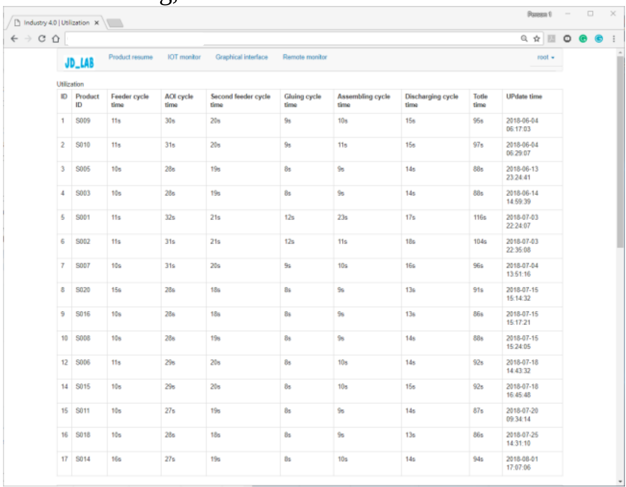


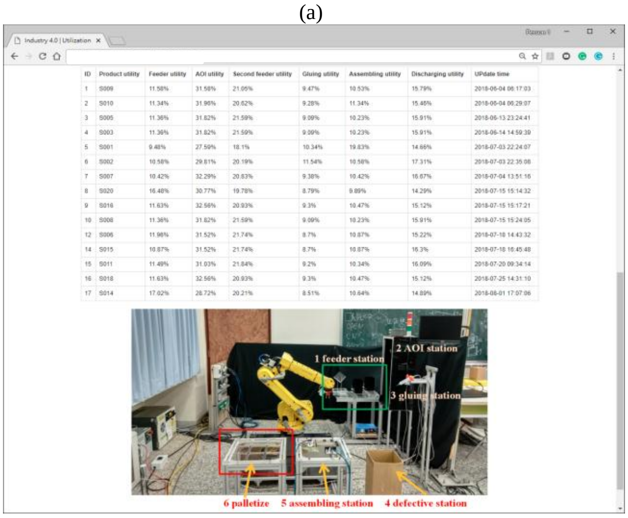
Figure 13. The flow chart of webpage.

1) *Data of workstation*

The webpage shows the receiving data from FAUNC PC interface in Fig. 14. The data included item number, time consuming, total time and utilization.



(a)



(b)

Figure 14. Data of workstation.

2) *IOT monitoring*

The collecting data is showed on the page via IOT module in Fig. 15. This page could do monitor and see the data that collected by IOT module at the same time. It presented the value of air pressure, the temperature of robot controlling, light in detection area and factory using condition.

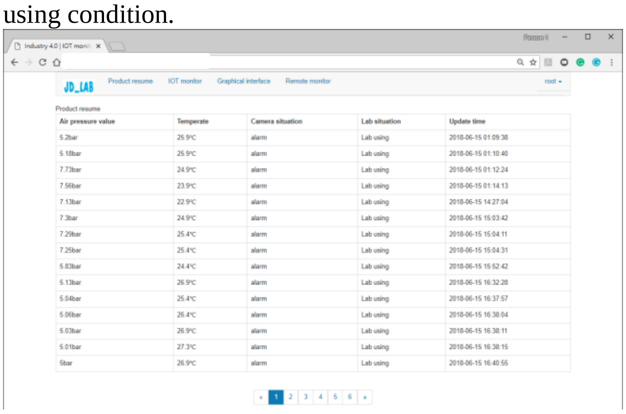


Figure 15. IOT monitoring.

3) *Graphical interface*

The picture shows the air pressure line chart in Fig. 16. The data is collected by the senor of the vacuum chuck on the robotic arm. It is combined in every different period and showed into line graph.

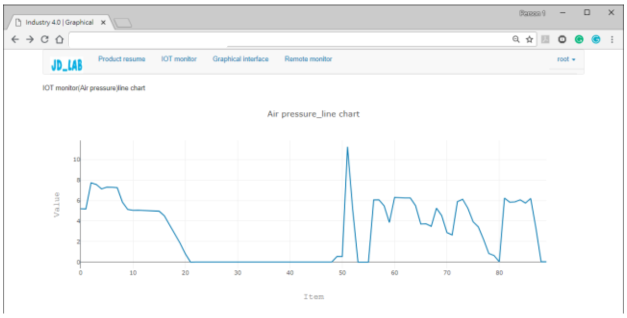


Figure 16. Graphical interface.

4) *Real-time monitoring*

The picture from monitor camera could control the direction and zoom in and out in Fig. 17. The user could select the different images through the direction bottom.

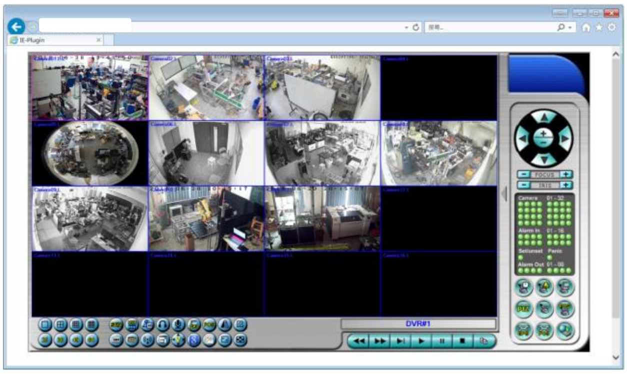


Figure 17. Real-time monitoring.

IV. Conclusion

Many of factories are in transforming steps due to industry 4.0. The promotion and transformation is extremely significant. This study is based on IOT conception and presented a solution of upgrading traditional industry. We not only designed but produced a workstation which could glue and assemble by FAUNC six axis robotic arms. Using visualization system detected quality on raw materials and abandoned defective objects into failure station. At the same time, the identification of product will be read and record the values to the database when the system working. In the end, the goods will be made in traceability. People who work in factory could use bar code machine to scan product's one-dimensional bar code for searching production-inform. In the future, the IOT module will be established in a variety of working task and upgrading the programs such as the analyzing of the data or predicting the problems.

Conflict of Interest

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Jeng-Dao Lee is the corresponding author of this research work. He was in response for conceptual generation, research planning, problem solving, and final editing of the manuscript; Ying-Jie Jhao conducted the research and wrote the paper; Chia Ying Hsieh assisted experiments and paper revision; Chen-Huan Chang modified PC software modification and experimental data collection; Li-Yin Chen was responsible for project management and paper revision; Moreover, all authors had approved the final version.

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REFERENCES

[1] A. Schilling, F. Gabriel, F. Dietrich, K. Dröder "Design of an Automated System to Accelerate the Electrolyte Distribution in Lithium-Ion Batteries," *in Proc. 2019 International Journal of Mechanical Engineering and Robotics Research*, vol. 8, no. 1.

[2] M. O. Gokalp, K. Kayabay, M. A. Akyol, P. E. Eren, "Big data for industry 4.0: A conceptual framework," in *Proc. 2016 International Conference on Computational Science and Computational Intelligence (CSCI), ISBN:978-1-5090-5511-1*, 2016.

[3] D. H. Huang, C. F. Lin, C. Y. Chen, J. R. Sze, "The Internet technology for defect system with deep learning in smart factory," in *Proc. 2018 4th International Conference on Information Management (ICIM)*, 2018.

[4] F. Tao, Q. Qi, "New IT Driven Service-Oriented Smart Manufacturing: Framework and Characteristics", in *2017 IEEE Transactions on System Man and Cybernetics: Systems, PP. 1-11, 2017*

[5] K. I. Satoto, R. R. Isnanto, R. Kridalukmana, K. T. Martono, "Optimizing MySQL database on information systems research, publications and community service," in *Proc. 2016 3rd International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE)*, 2016

[6] M. Dannapfel, T. Wissing, R. Förstmann, P. Burggräf, "Human machine cooperation in smart production: Evaluation of the organizational readiness," *International Journal of Mechanical Engineering and Robotics Research*, vol. 8, no. 2, pp. 327-332, March 2019.

[7] Z. Li, L. Shuhua, W. Siyu "Current situation and future of chinese industrial robot development," *in Proc. 2016 International Journal of Mechanical Engineering and Robotics Research*, vol. 5, no. 4.

[8] FANUC R-2000iA/165F industry robot, https://www.robots.com/robots/fanuc-r-2000ia-165f

[9] Robotics, ABB "Technical reference manual RAPID Instructions, Functions and Data types", 2014.

[10] A. Mandal, R. Jetley, M. D'Souza, S. Nair, "A static analyzer for industrial robotic applications," in *Proc. 2017 IEEE International Symposium on Software Reliability Engineering Workshops, 2017*

[11] Raspberry Pi https://www.raspberrypi.com.tw/

[12] Laravel Frame, [Online]. Available: https://blog.csdn.net/will5451/article/details/52474581

[13] OpenCV library. [Online]. Available: http://opencv.org/

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