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Pick & Place automated workplace based on CC-Link IE Field basic communication

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Abstract: The article offers a proposal for communication between the collaborative robotic system and the PLC control concerning the CC-LINK IE FIELD BASIC communication protocol. The solution tests the principle of "*Master*" and "*Slave*," where the preferred system is the PLC (from the product company Mitsubishi). In general, there are many possibilities for communication, so this article orients toward Ethernet-type communication. It also includes an innovative interconnection of the components of the different manufacturers (Mitsubishi, VENGLOR, and others) and verification on a real application example of the type "*Pick & Place*."

1 Introduction

At present, collaborative robotics is on the rise. Its deployment is constantly being extended to the already run automated process to reduce costs or the need to implement complex additional safety devices (such as a safety cage, a firewall, etc.). The collaborative robot provides a sufficiently high safety standard for a human operator near (or part of) the running process. In many cases, however, the automated process requires using existing peripheral devices, and thus the communication solution becomes more important [1]. Communication between the robot system and other peripherals (camera, sensors, security features) is necessary for the correct and complete operation of the automated process. The ideal solution, especially in the "Pick & Place" cases, is to install a specific version of the recognition system, e.g., a 2D camera sensor.

Visual systems have an invaluable impact on automation processes and are crucial to their variable use for their many implemented functions and programming capabilities. Applications are found in processes where rapid diagnosis and evaluation of the scanned image are required. The most used parts of the visual systems are the assessment of the quality of the object and the correct dimension [2]. It may lead to a significant increase in the rate of production and control of the products produced. In conjunction with robotic devices, their application increases, particularly when determining the coordinates of scanned objects in cases where it is impossible to precisely define their position. However, to ensure the automated process's correct functionality and the application solution's smooth operation, it is advantageous (and almost always necessary) for raw data collected from the visual system to be modified (aggregation). The ideal device to adjust is the PLC system. In such a case, it plays the role of an "intermediary" and performs the function of a superior system in the visual sensor hierarchy and robotic equipment [3]. Plc not only receives these data from the optical sensor but also sorts them and edits them into the correct data type, according to the camera type and the robotic device control unit, Figure 1.

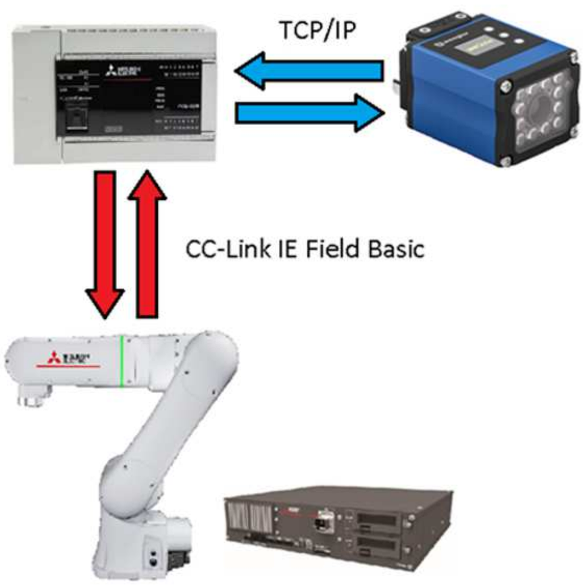


Figure 1 Flow of communication data between the various devices of an automated workstation

2 Hardware components

To ensure the proposed and functional cooperation in an automated workplace, we use a camera sensor (from WENGLOR), a PLC system FX5U (from MITSUBISHI), and a collaborative robot (MELFA ASSISTA, also from MITSUBISHI).

Specifically, the selected camera sensor has several tools to assist and refine the detection result. This device combines a color scanner and visual sensor functions. As a result, it can scan objects of different colors, recognize their shape, and scan and read 1D and 2D codes. In addition, it includes an automatic focus function or object tracking according to the projected pattern. It can also count objects, measure their size, and determine their position [4].

MELFA ASSISTA is a vertical 6-axis collaborative robot with a maximum range of 910 mm, a payload of 5 kg, and repeatability of the position of ± 0.03 mm [5]. It can operate in three basic speed modes, namely:

- Collaborative mode slow (up to 50 mm / s).
- Collaborative standard mode (up to 250 mm / s).
- High-speed mode (up to 1000 mm / s).

An FX5U-type PLC is a compact PLC. Therefore, it is suitable for smaller applications. It is equipped with high-speed 16 digital inputs (24VDC), 16 outputs (relays/transistors), two analog inputs, and one analog output [6]. It also contains a standard error monitoring, LED status indication, or SD card slot. Its most significant advantage is its low price and its small size. The use options are mostly fixed, but thanks to extensions, it offers a degree of variability. The most used extensions are expansion modules to expand inputs and outputs or memory extensions.

3 Communication principle

The basic principle of the proposed communication between the individual Pick & Place workstations is the TCP / IP-based communication protocol, Figure 2. The PLC device (as a preferred system) opens a communication channel and allows the necessary data to be exchanged between the two parties (Master and Slave). The camera sensor retrieved from the inspection sends the information directly to the pre-configured PLC communication port of the device, which is specifically assigned for this type of communication. After a successful data transmission, the communication channel is closed.

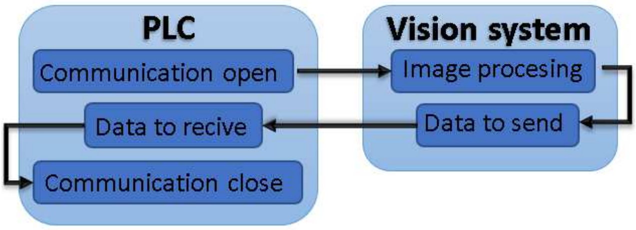
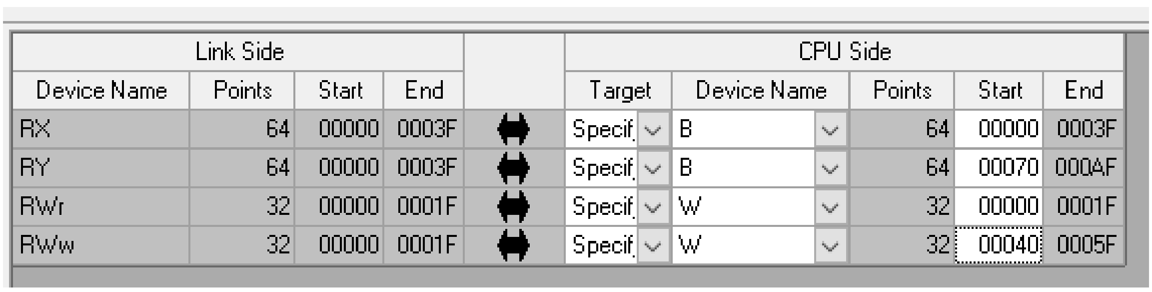


Figure 2 Principle of TCP / IP protocol communication

If we want to understand the principle of communication, it is necessary to explain the CC-Link IE Field Basic communication protocol. CC-Link IE Field Network Basic is a part of CC-Link IE Network and realizes easier network connection of Ethernet devices. Banner communications are achieved by utilizing SLMP, which enables seamless connectivity within all levels of manufacturing [7]. It is a communication protocol that serves specifically and exclusively used for MITSUBISHI facilities. The necessary condition for this communication protocol's setting (opening) is its authorization by the robotic system. The transmission and reception of data by the PLC of the device are secured by defining the bit field length for receiving and transmitting data (Bool type). By analogy, data fields for receiving and sending data in the corresponding (WORD type) are also reserved.



Link Side					CPU Side				
Device Name	Points	Start	End		Target	Device Name	Points	Start	End
RX	64	00000	0003F		Specif	B	64	00000	0003F
RY	64	00000	0003F		Specif	B	64	00070	000AF
RWr	32	00000	0001F		Specif	W	32	00000	0001F
RWw	32	00000	0001F		Specif	W	32	00040	0005F

Figure 3 Range settings for the data fields for the CC-Link IE Field Basic communication protocol

Adjustment (Figure 3) means that the data stored in the PLC storage area (whether of the Bool type or WORD type) correspond to an associated address on the robotic device side (corresponding to 6000 addresses for inputs and outputs in the case of robotic devices from MITSUBISHI).

4 Object detection

Adjustment (Figure 3) means that the data stored in the PLC storage area (whether of the Bool type or WORD type) correspond to an associated address on the robotic device side (corresponding to 6000 addresses for inputs and outputs in the case of robotic devices from MITSUBISHI).

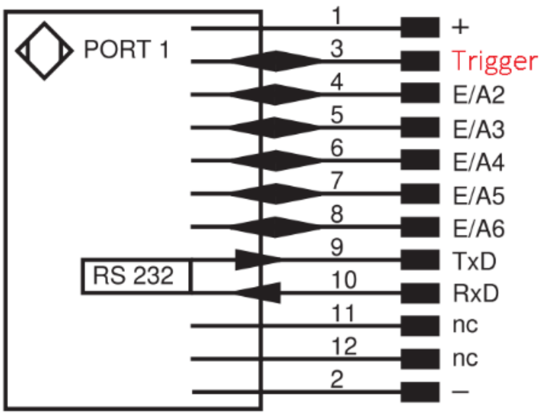


Figure 1 Trigger pin for objects' picture capturing

The PLC device also sends a color change signal to the 2D camera sensor. Since the 2D camera sensor program cannot work with the branch, changing the desired color is achieved by changing the entire 2D camera sensor program by sending a specific signal to the specified output. From the point of view of the use of functionalities, the "*Threshold*" function is an excellent tool. It is a function that filters the color of pixels based on a pre-set filter. Compliant pixels are white, while non-compliant pixels are black, figure 5.

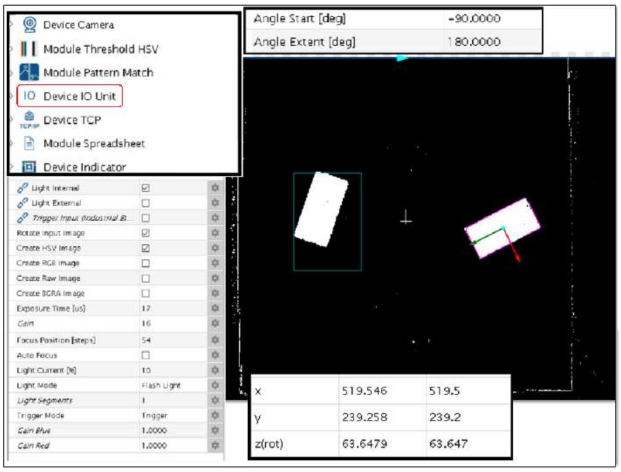


Figure 2 Example of "Threshold" function usage

Another excellent and frequently used functionality is the "pattern match" function. It will be used mainly in detection processes where the shape and size of the object sought are known in advance. The principle of the above procedure is to search for objects that correspond to the set stored (database) pattern. Then, if a match is made and the system finds several compliant objects, the one with the highest percentage match with the pre-set way shall be automatically selected.

At the same time, the function allows the coordinates (x, y) and the rotation of the detected object with the highest percentage of agreement with the pattern to be determined. This information is key to guiding the robotic system into the correct position to grasp the desired object.

5 Application testing

The main task of the "Pick & Place" experimental solution of the automated workstation is to create an application that would sufficiently and effectively test the communication process between the various facilities involved. The application's functionality is based on a camera vision, by which an object is subsequently found in the view field of the 2D camera sensor, Figure 6.

This object's coordinates are subsequently transmitted to the robot (collaborative robot control system) using the PLC device. The robot, thanks to the information received on the position of the object, performs a grasping action on the object. Then is correctly classified according to the attributes defined in the front (e.g., in the corresponding suspending box).

Figure 3 Layout of the automated workplace

The automated process presupposes that the robot system is set to the reference position (depending on the coordinates of the object being sought). The coordinates found are then transmitted in the form of the data type "String" to the PLC device. It is solved by the TCP / IP communication protocol. In the next steps of the PLC, the device processes, adjust and compiles the information obtained so that the information about the coordinates of the object can be understood and correctly read by the robot system. The final step is the movement of the collaborative robotic arm according to the coordinates obtained, grasping the object sought and moving above the stop position where the process ends.

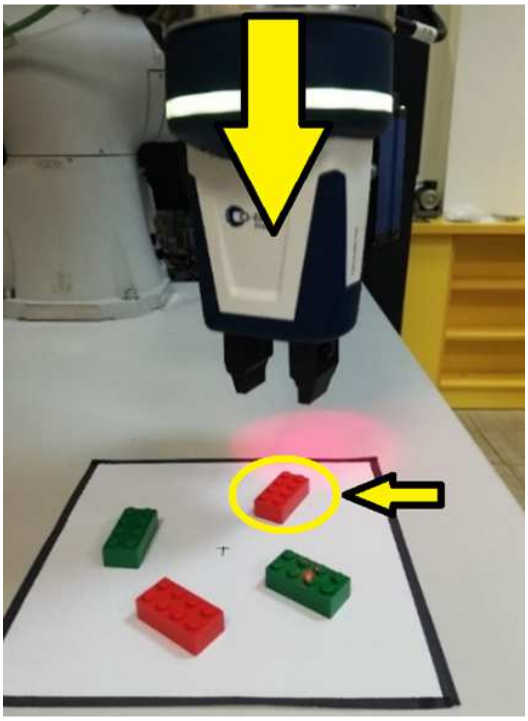


Figure 4 Pick & Place position for a founded object

6 Conclusion

Camera systems are now an essential part of automated workplaces, where the participation of robotic arms is indispensable. Therefore, the solution of the topology for communication, communication protocols, and the nature of the processing (aggregation) of the data offer scope for experimentation, testing, and subsequent verification of the proposed solutions (such as this). Furthermore, they will find their use in the quality control of products and their dimensions and in advanced systems for managing complex automation processes.

Thanks to such application examples, the need to use additional staff for the manual and lengthy work that such a solution offer is no longer needed.

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References

[1] VARGA, M., VAGAŠ, M.: Experimental vision system setup based on the serial configuration interface, *Acta Mechatronica*, Vol. 6, No. 3, pp. 41-44, 2021. https://doi.org/10.22306/am.v6i3.77

[2] VAGAŠ, M., ŠEMINSKÝ, J.: Approaches for the 3D camera system image processing at automated workplaces, *Technical Sciences and Technologies, Chernihiv*, Vol. 22, No. 4, pp. 150-155, 2020.

[3] KURYŁO, P., FRANKOVSKÝ, P., PAPACZ, W., DELYOVÁ, I., SCHURGER, B.: Design of an automated system for measuring car bodies, *Acta Mechatronica*, Vol. 6, No. 1, pp. 11-20, 2021. https://doi.org/10.22306/am.v6i1.74

[4] VIRGALA, I., MIKOVÁ, Ľ., SUKOP, M., VAGAŠ, M, LIPTÁK, T., KELEMEN, M.: *Sensors and transducers, Snímače a prevodníky*, Kosice, TU, 2017.

[5] SEMJON, J., JANOS, R., SUKOP, M., TULEJA, P., HAJDUK, M., JURUS, O., MARCINKO, P., VIRGALA, I., VAGAS, M.: Verification of the UR5 robot's properties after a crash caused by a fall of a transferred load from a crane, *International Journal of Advanced Robotic Systems*, Vol. 17, No. 1, pp. 1-9, 2020. https://doi.org/10.1177/1729881420904209

[6] VAGAŠ, M., GALAJDOVÁ, A., ŠIMŠÍK, D., ONOFREJOVÁ, D.: *Wireless data acquisition from automated workplaces based on RFID technology*, IFAC-PapersOnLine, Vol. 52, No. 27, pp. 299-304, 2019. https://doi.org/10.1016/j.ifacol.2019.12.677

[7] RÁKAY, R., GALAJDOVÁ, A., ŠEMINSKÝ, J., CVITIĆ, I.: Selected wireless communication protocols and their properties for use in IoT systems, *Research papers Faculty of Materials Science and Technology in Trnava, Slovak University of Technology in Bratislava*, Vol. 27, No. 45, pp. 26-32, 2019. https://doi.org/10.2478/rput-2019-0022

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