An AR-based Wiring Practice for PLC Training

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Abstract – With rapid developments in the manufacturing industry, there has been increasing attention on PLC training for implementing factory automation. In order to meet the increasing demand for PLC training, this paper proposes a method for providing AR-based wiring training. The proposed method involves augmenting virtual wiring guide on the training board to enhance the learning experience for the trainee and to allow even novices to easily acquire the methods and techniques of wiring.

Keywords: PLC, AR-based wiring practice

1. Introduction

Augmented reality (AR) is a technology for presenting real-time overlay of virtual computer graphics image on top of actual image captured by the camera. AR is a compound virtual reality technology that adds computer graphics data to the actual image viewed by the user in real time. Applications of AR include medicine, product processing, construction, game and broadcasting [1,2].

With remarkable advances in science, latest technologies are being incorporated in training and education. The cutting-edge aspect of training is giving rise to demand for new training systems, and there have recently been active studies on training and education based on AR [3][4]. There is a wide range of AR-based training applications from wiring to military equipment maintenance [5][6]. In machine maintenance, it has been confirmed that AR-based maintenance training is much more effective than training performed using computer manual [7].

With rapid developments in the manufacturing industry, there has been increasing attention on PLC training for implementing automated production facilities. PLC training mainly consists of sessions in wiring and programming. Wiring between components become increasingly important as manufacturing facilities become more sophisticated. In the manufacturing industry that uses expensive and latest automated production facilities, incorrect wiring can result in equipment malfunction, mechanical damage, major accidents or significant financial loss. Therefore, it is necessary to pay close attention to providing proper training and practice for wiring.

In order to meet the increasing demand for PLC training, this paper proposes a method for providing AR-based wiring training. The proposed method involves augmenting virtual wiring guide on the training board to enhance the learning experience for the trainee and to allow even novices to easily acquire the methods and techniques of wiring.

2. Main Results

2.1 Conventional Wiring Practice for PLC training

A conventional PLC training is conducted in general frame as following figure.

![Fig. 1. A general frame for PLC wiring practice.](image)
The trainee first learns about the theories related to the training practice session, performs programming based on the acquired theories, and the performs PLC wiring according to programming. However, a novice in PLC experiences difficulty even with the most basic order of wiring. As PLC training becomes more sophisticated and moves into intermediate and advanced levels, wiring becomes complex and the trainee has to rely increasingly on books or web-based manual for the order of wiring.

Fig. 2 displays a conventional(actual) wiring practice for PLC training. The trainee conducts wiring while looking at the manual to verify whether his wiring is correct. If an error is found, the trainee performs wiring again, and if everything is in order, he moves on to the next step. Since this process involves the trainee verifying the correct connection and order of wiring while looking back and forth between wiring and the manual, he cannot focus on wiring practice.

![Image of Conventional Wiring Practice]

**Fig. 2. A snapshot of conventional wiring practice.**

### 2.2 Proposed AR-based Wiring Practice for PLC training

As mentioned above, the method proposed in this paper involves using AR to sequentially augment a virtual wiring guide on the training board like the one shown in Fig.1 or Fig.2, replacing the book or web-based manual for practicing simple basic to complex wiring and helping the trainee to easily acquire wiring techniques. Unlike conventional PLC wiring practice, the proposed AR-based PLC wiring practice system augments a virtual wiring guide on the PLC board, allowing the trainee to perform wiring by looking at the wiring guide. This enables the trainee to focus entirely on wiring and know exactly which contact point or port has to be wired at that particular moment, expediting the practice session.

Regardless of the level of difficulty, PLC wiring practice can be categorized into the following cases [Fig.3].

(Case I) Wiring two adjacent ports (points)
(Case II) Wiring two non-adjacent ports without crossing over an intermediate port.
(Case III) Wiring two non-adjacent ports by crossing over an intermediate port.

![Image of Three Generalized Cases of Wiring Practice]

(a) Wiring two adjacent ports (points) (Case I)
(b) Wiring two non-adjacent ports without crossing over an intermediate port (Case II)
(c) Wiring two non-adjacent ports by crossing over an intermediate port (Case III)

**Fig. 3. Three generalized cases of wiring practice for PLC training.**

A virtual wiring guide of above three cases implemented and augmented on a PLC practice board is shown in Fig.4. The 9 circles on the virtual PLC board indicates the ports that should be wired.
Step 2) Detects whether there is wiring of ports
Step 3) Determines whether port wiring is accurate.
(If ports are wired correctly, move on to the next step in wiring practice.)

Fig. 5. A snapshot of the proposed AR-based PLC wiring practice.

Fig.5 displays the AR-based wiring practice training system proposed in this paper. Wiring practice is performed according to the steps mentioned above. For example, in the case of wiring two adjacent ports (case Ⅰ), points that need to be wired are augmented as a virtual wiring guide (the dotted line) and presented to the trainee. After the trainee performs actual wiring (the solid line) by following the augmented wiring guide, the system verifies the internal link. If wiring is correct, a message is displayed to indicate wiring has been successfully completed, and the next virtual wiring guide is augmented (Fig.6). Cases 2 and 3 are performed with the same procedures. Performing wiring practice with the proposed method for Cases 2 and 3 are shown in Figs 7 and 8, respectively.

3. Conclusion

In this paper, an AR-based wiring practice for PLC training was proposed. The proposed method is to augment virtual wiring guide on the training board to enhance the learning experience for the trainee, which allows even novices to easily acquire the methods and techniques of PLC wiring. By implementing the three basic cases categorized for PLC wiring practice, it is expected that the proposed AR-based wiring practice can provide trainee with more effective learning than training using conventional manuals.
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Fig. 6. Consecutive wiring practice result on Case Ⅰ.

Fig. 7. Consecutive wiring practice result on Case Ⅱ.

Fig. 8. Consecutive wiring practice result on Case Ⅲ.

References


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