Design of Graphical User Interface (GUI) for a remote laboratory on programmable logic controller experiments

M I Hambali, E Haritman* and A B Pantjawati

Department of Electrical Engineering Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi 207, Bandung 40154, Indonesia

*erikharitman@upi.edu

Abstract. Remote Laboratory is the use of telecommunications technology to conduct remote experiments. In this study, remote lab operates through the Graphical User Interface (GUI) display, where interactions are carried out online through computer devices. This GUI is designed to support experiments on Programmable Logic Controller (PLC) and must be able to facilitate the user and provide feedback directly to confirm that an action has been taken. This GUI design includes color, image, icon, label, and text navigation to present information to users when needed. This research was carried out through several stages, namely the design of the GUI by using Microsoft Visual Studio software, coding and testing of appearance and function. The results showed that the GUI design met the desired specifications, both in appearance and function. From the users testing, the GUI design get positive responses from all users.

1. Introduction
The 4.0 Industrial Revolution Era has influenced all aspects of human life, including education, especially in the learning process. One of the implications of the industrial revolution on the educational aspect is the development of remote laboratories. Remote laboratory is the use of telecommunications technology to conduct real-distance experiments. Unlike the virtual lab, the remote lab is designed to enable students or researchers to carry out real experiments [1]. By applying the concept of lab management or Digital Laboratory Information System (DLIS), students can access remote lab effectively and efficiently [2].

In this study, the remote lab was designed to run a remote industrial automation laboratory, in this case controlling a programmable Logic Control (PLC). PLC is a special computer that is used to control and operate the manufacturing and machining processes in sequence [3].

Remote lab is a laboratory system that is integrated with remote operation. To make it easier for users to access the object to be controlled, it needs a display interface that connects users and computers. Graphical User Interface (GUI) can meet these needs, which is an interface on a computer operating system that uses a graphical menu. The purpose of using a graphical menu is to provide a display that can make the operating system more responsive, providing convenience and comfort for users in operating the computer. Computer users more easily understand the instructions in the form of images rather than a long description [4]. The main idea of the GUI is to accommodate the user interface with the application intuitively and simply [5]. Software that can be used to create a GUI is Microsoft Visual Studio with Visual Basic, which is software for developing and building applications on the .NET Framework system [6].
In this study, the GUI at a remote laboratory for industrial automation labs was designed using Microsoft Visual Studio as the main software and Visual Basic. NET is used as a programming language that is equipped with design features to create the desired interface.

2. Research methods
The GUI design was conducted using the waterfall method that is described as follows:

2.1. Need analysis
At this stage a needs analysis is done that underlies the determination of the GUI specifications to be designed.

2.2. System design
At this stage the GUI is designed with the following features:
- Splash Screen panel
- Program Menu. In this menu the users can choose which software will be used for doing experiments
- Camera menu. In this menu the users can open the attached camera to see the output from the PLC
- Lamp menu. In this menu the users can turn lights on and off
- Instruction Menu. In this menu the user can see the steps in conducting experiments with this remote lab
- About Menu. In this menu the users can see a brief explanation of the remote laboratory
- Timer
- Notifications

Figure 1 shows the remote laboratory system flow chart.

![Figure 1. The remote laboratory system flow chart.](image-url)

2.3. Coding and testing
This is the most important stage in working on the GUI design, where the system design that has been created will be coded. The results of the coding are tested first to detect and correct errors that occur in the system. Then the GUI is tested on the user.
2.4. **GUI testing**
If the design stage is complete and the GUI meets the desired specifications, the GUI is then tested on a number of users to get a response to the function, appearance and features. Illustration of user testing shown in figure 2.

![GUI system users testing chart](image)

**Figure 2.** GUI system users testing chart.

2.5. **Evaluation**
After all testing is done, the last step is to evaluate and analyse the GUI system that was designed.

3. **Results and discussion**
Graphical User Interface (GUI) design results can be accessed by users using window-based applications on PC or smartphone devices. Figure 3 and 4 show the Splash Screen and the Program menu panels respectively.

![Splash screen panel](image)

**Figure 3.** Splash screen panel.

![Program menu panel](image)

**Figure 4.** Program menu panel.
When the user clicks on RLab.exe, the splash screen panel, as shown in figure 3, will appear for 10 seconds. After the Splash Screen panel disappears, the Program menu panel, as shown in figure 4, will appear and the timer will automatically countdown. In this program menu the user can choose the software that will be used to carry out the desired experiment.

When the user clicks on the Camera menu, a display will appear as shown in figure 5. The user can click on the connect icon to connect to the camera and the control icon to connect to camera controls. On the Lights menu panel, as shown in figure 6, users can click on the lights on the icon to turn lights on or off. While the combo box is used to choose which port is connected to the PC.

![Figure 5. Camera menu panel.](image)

![Figure 6. Lamp menu panel.](image)

Users can see the steps of the experiment in the Instruction menu panel, as shown in Figure 7, and see a brief description of the Remote Laboratory, in the About menu panel, as shown in Figure 8.

If there are only 5 minutes left to conduct the experiment, a notification will appear on the screen as shown in figure 9.
In the final stage, 5 users were asked to test the appearance and function of the GUI. Table 1 shows the feedback given by the users in the trial.
Table 1. Users responses.

| No. | Feature name          | Display that appears when buttons clicked                                                                 | Yes/No answers |
|-----|-----------------------|------------------------------------------------------------------------------------------------------------|----------------|
| 1   | Program menu          | Program panel display, contain GX works button, CX programmer button and reminder                          | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
| 2   | GX works button       | GX works display                                                                                           | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
| 3   | CX programmer button  | CX programmer display                                                                                     | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
| 4   | Camera menu           | Camera panel display, contain connect and control button                                                   | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
| 5   | Connect button        | Logitech webcam camera display                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
| 6   | Control button        | Logitech webcam control display                                                                           | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
| 7   | Lamp menu             | Lamp panel display, contains combo box, Lamp on button and lamp off button                                | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
| 8   | Lamp on button        | Turn on the light                                                                                         | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
| 9   | Lamp off button       | Turn off the light                                                                                        | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
| 10  | Combo box             | Choose the port to use                                                                                    | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
| 11  | Instruction menu      | Instruction display, contains experiment steps                                                           | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
| 12  | About menu            | About display, contains a brief description of the remote lab                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |
|     |                       |                                                                                                            | Yes            |

Table 1 shows that the five users stated that all GUI features function properly. Users are also satisfied with the colors and modern designs of the designed GUI, so it can be concluded that the color aspect has an important role in the appearance design. This is consistent with the results of research which states that color can affect human psychology [7]. The success of the display design, is also determined by how to enter supporting elements such as icons, images, labels, text panels and colors, so that the interface display design can create an attractive and interactive impression [8].

4. Conclusion

The conclusion of this study is that the Graphical User Interface (GUI) for Remote Laboratories in PLC experiments has been successfully created and meets the desired specifications. Users respond very well to the appearance and features provided by the GUI.

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