

Object Oriented Design and Implementation of HMI GUI Design Tool

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Abstract: Nowadays a large number of PLCs are being used in automatic machines for factory automation in industry, and HMI is essential for the effective and convenient operation of PLCs. Each screen displayed in actual HMI equipment should be created, modified and deleted using a PC-based editor and it should be composed of necessary display components to express desired GUI. Based object-oriented development methodology, this study designed screen objects representing a editing screen, display components forming the UI of screens and data management objects necessary for data exchange with HMI system and, based on the objects, implemented a HMI screen editor.

Keyword : PLC, HMI, Object Oriented Design, GUI Design Tool, Computer Application

1. INTRODUCTION

Now, PLC (Programmable Logic Controller) is the part essential to our daily lives and manufacturing plants to control all sorts of equipments. The PLCs widely used like this are getting miniaturized and having better performances owing to rapid progress in electrical, electronic, and digital techniques. In order to effectively control authorized modules consisting of a lot of PLCs or finished authorized equipment made up of a great number of authorized modules, the user-interface should be provided so that operators of those equipments can easily recognize motions of those PLCs used inside the machines. The operators also should be able to convey the motion that they want to the equipment through the interface.

The HMI(Human Machine Interface), where these equipments and humans meet, became an essential factor in the interactions between authorized equipments and operators. These HMI systems are mostly provided with HMI hardware and software by PLC manufacturers to effectively control their own PLCs or include functions of controlling even the PLCs manufactured by other companies.

The HMI system, consisting of an embedded system, is made up of hardware, the HMI machine, and software for the HMI and provided with various product families. The HMI software, loaded on the HMI machine, can be divided into the HMI machine operating software including system software function to operate the equipment on limited hardware base of the HMI machine, and application software to deliver the information of GUI design for the HMI to the HMI equipment, although it isn't necessary for its actual operation.

However, it is impossible to execute control and monitor through PLCs and communication unless we know PLC communication protocol to make sure that

the HMI system can communicate with a specific PLC, since there are various PLC manufacturers and product families on the market and a communication protocol capable of communicating only with the PLC manufactured by each company is available. Of course, manufacturers won't abandon their own communication protocol, although they propose standard communication protocol and its details.

This paper intended to examine considerations required for the relevant software necessary for a specific environment called HMI system by designing GUI design software necessary for HMI system through object oriented methodology and implementing it. First of all, Chapter 2 dealt with structure of the HMI system, Chapter 3 design of the object necessary for GUI Design Tool, Chapter 4 its implementation, and Chapter 5 concluded the paper..

2. HMI SYSTEM COMPOSITION

2.1 HMI Equipment

Since the hardware of HMI Equipment consists of an embedded system with only required hardware resources at minimum level, the function of loadable software also should be limited.

Since the memory for HMI equipment, where HMI software is loaded on non-volatile memory, has the circuit constructed to make sure that the software jumps to where the routine necessary for initialization of HMI equipment exists as soon as the power is on, the software executes the routine indicating HMI GUI data on screen through display module by referencing the data area, when basic initializing routine is done. Then, it updates the information necessary for the GUI data area while executing communication with a PLC. It can execute necessary routine when interruption occurs from an Input Device.

Fig-1 shows such interactions and the blocks indicate the software or libraries interacting with required devices.

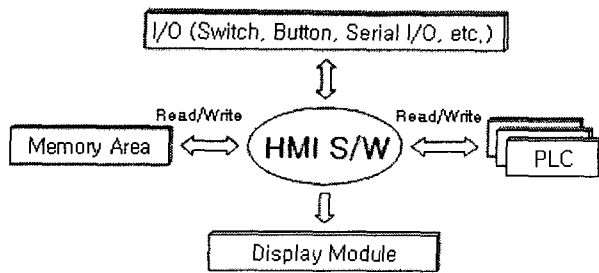


Fig-1 Structure of HMI Software

2.2 HMI GUI Design Tool Software

A HMI GUI Design Tool is application software designed to edit the GUI in PC-based environment and transmit the GUI data to HMI equipments in order to represent desired GUI on the equipments. It should have the data structure loadable on the memory of HMI equipment, include communication protocol information according to kinds of PLC when HMI equipment communicates with the PLC, and minimize the waste of resources by using string data or image data that should appear on the screen communally when those data are identical. That is, tasks required on background as well as simple editing function should be added to it.

3. DESIGN AND IMPLEMENTATION

3.1 Application Design

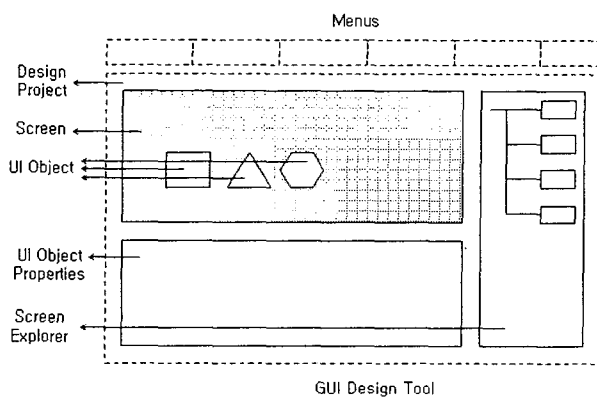


Fig-2 GUI Design Tool User Interface Environment

The unit consisting of HMI GUI is screen, and GUI Design edits the screen. It can edit several screens at the same time, and users can arrange the UI Objects that they want on each screen because all sorts of UI object consisting of the screen are provided, and edit their properties.

Fig-2 is required specifications, and, based on these, the objects consisting of the screen were designed and the ones in charge of managing data in the background were designed.

3.2 Object Design of HMI GUI Elements

The GUI Design Tool was designed so that the project with GUI data can manage the list of screen objects capable of adding or deleting the screen objects dynamically in order to give it the ability to edit a lot of screens into one project simultaneously.

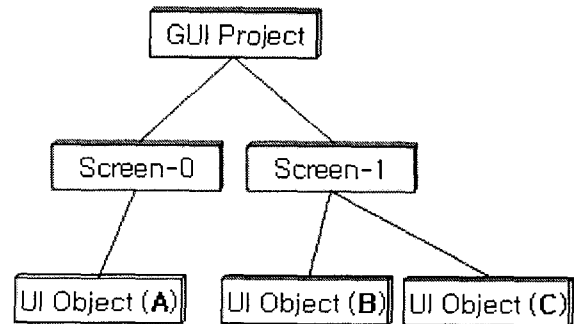


Fig-3 Object Relation of GUI Elements

3.2.1 Screen

A screen is a unit consisting of GUI, and each screen belongs to the GUI data in the shape of list with its own ID and name. In addition, a screen object, which includes a list of UI objects with various types, was organized that it can add the UI object that a user added to the screen to the list and then display it on the screen.

3.2.2 UI Object

There are various types of UI objects according to what graphical presentations a screen, the minimal unit consisting of GUI, should have on it, and in what ways it should present the data from a PLC.

There are various kinds of properties of UI objects, and if a user alters its properties, the altered properties are displayed on the screen.

The presentation forms are broadly divided into two: text and image types. It was designed to make sure that the size of resources to be used could be minimized by defining common management object so that it can use the strings used for text type and images for image type together.

3.2.3 UI Object Properties and Screen Explorer

As shown in Fig-3, the objects with the shape of user dialog appropriate to the type of UI object are required to alter the UI object properties. This object is an object with UI object properties, and relevant object with UI object properties should appear on the screen if a user selects the UI object when editing GUI.

Additionally, a screen explorer is required to be able to trace several screens. Each node of an explorer becomes a pointer designating one screen, and corresponding screen should appear on the area when selecting relevant node.

3.3 Object Design of GUI Data Managers

The GUI Design Tool is a tool editing the things appearing on the screen, and requires data managers for effective management of the data edited with the data presented on the screen in background.

3.3.1 PLC Protocol Manager

Among a lot of UI Object properties, the one accessing to a particular domain of memory is very important. These information-managing objects are required since there are differences in domains of PLC memory according to the kind of PLC, which is connected to HMI equipment and performs controlling and monitoring.

When the PLC is manufactured by different companies, this information should be processed since the protocol to communicate with the PLC as well as the domain of memory is totally different from each other.

3.3.2 Shared Resource Manager

As briefly mentioned in section 3.2.2, an additional communal resource manager should be provided so that the UI objects can use the communal resources like strings and images. Communally used strings and images should be managed by giving them IDs.

3.3.3 GUI Data Manager

The edited data using the UI objects as the screen units for GUI are transmitted to HMI equipment and stored in its memory, and they are data manager object functioning as transformer of the data edited into usable forms by the HMI software in HMI equipment.

3.3.4 GUI Data Transfer Manager

The RS232 serial communication should be executed through Com ports of a PC and HMI equipment to exchange edited, transformed and stored GUI data with HMI equipment in GUI Degin Tool. The transmission should be done by building a frame data, which the GUI data with alteration was cut into fixed size and appropriate header was added to. For example, when transmitting the GUI data to HMI equipment, its software writes the data on suitable location of memory domain by referencing the header of relevant frame.

3.4 Implementation

Based on designed objects, the implementation was based on the MFC framework to implement the application software on the basis of the PC with a Windows operating system.

3.4.1 Classes Table

Table 1 Classes for implementation

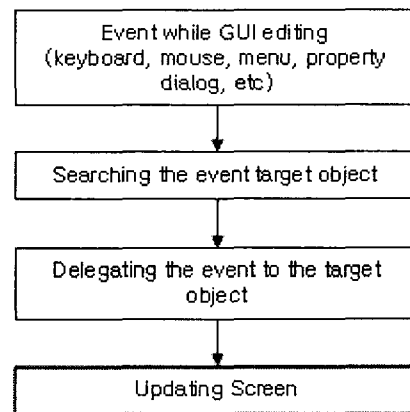
| | |
|---|---|
| Application View | CHMIView |
| Application Document(Data) and GUI Data Manager | CHMIDoc |
| Screen | CScreen (Screen View) |
| | CScreenData(Screen Data) |
| UI Object | Ctag |
| | CTextTag, CMessageTag, CLampTag, CImageTag, CLineGraphTag, CDigitTag... |
| UI Object Properties | CTextDlg, CMessageDlg, CLampDlg, CImageDlg, CLineGraphDlg, CDigitDlg... |
| | CpicInfo |
| Shared Resource Manager | CTextResManager CimgResManager |
| GUI Data Transfer Manager | CcommThread |

3.4.2 Object Creation

It is data managing-objects that should be generated when executing the application software, and it is screen and UI related objects that are generated dynamically while a user edits.

3.4.3 Screen Drawing and Event Handling

In order to edit GUI, a screen is generated, UI objects are generated and aligned, and their properties are edited when an empty screen appears. Those objects are moved using a mouse or keyboard for the alignment of UI objects.

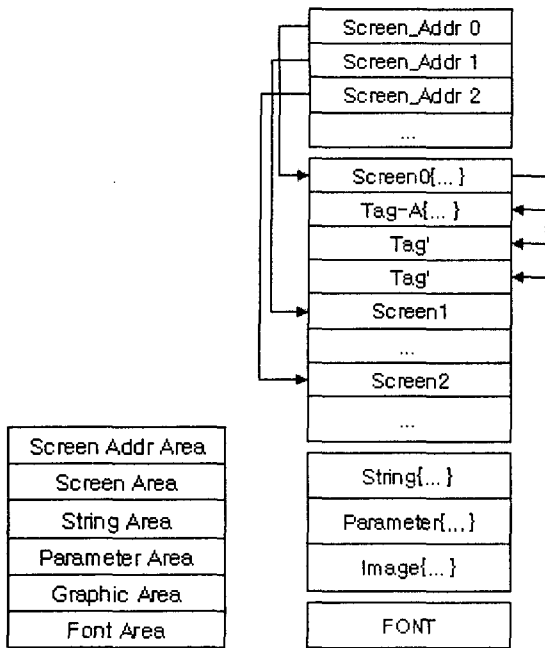


<Fig-4 Event Handling Flow to Update Screen >

<Fig-4>shows the process routine executing a drawing reflecting the event that was generated for the process like this by processing the event suitably.

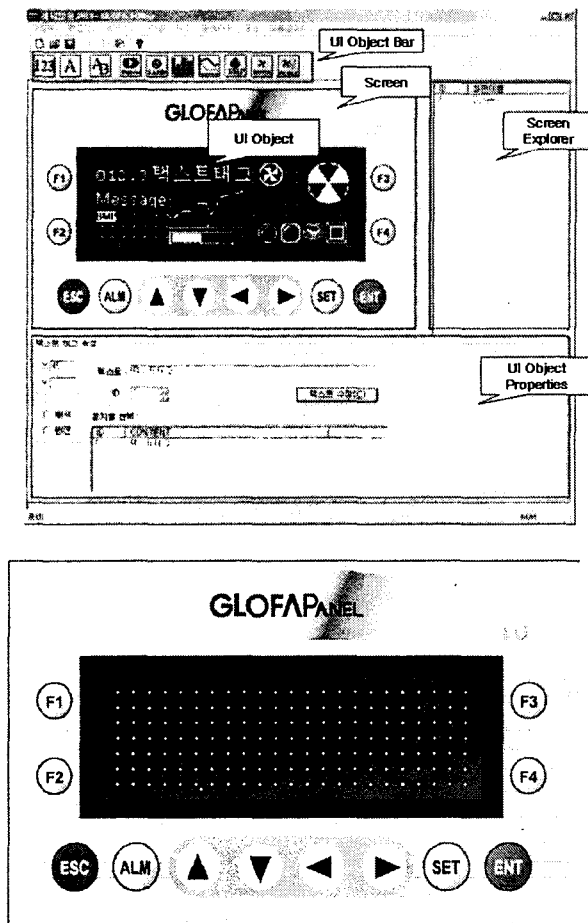
3.4.4 Transformation of GUI Data

The left side of<Fig-5>indicates memory domain where HMI software used for GUI, and its right side represents that the data alteration was done before the GUI data was transmitted to the memory domain of HMI equipment



<Fig-5 HMI Memory Map and GUI Data Build>

3.4.5 GUI Design Tool and HMI Equipment



<Fig-6 GUI Design Tool and HMI Equipment>

The picture lying on top in<Fig-6>is the screen showing the implementation of GUI Design Tool, the

one at lower part of the figure shows the HMI equipment where edited GUI is operated.

4. CONCLUSION

The GUI Design Tool Application Software for HMI equipment was designed through object-oriented methodology and implemented in this paper. In designing and implementing the software like this, only a few specific PLCs are controllable for now, since understanding of HMI equipments and PLCs is required and through this understanding, the knowledge of communication protocols and memory domains for communication with PLCs is also necessary for controlling and monitoring this kind of PLCs. The researches on protocol analysis methods of communicating with this kind of PLC through various PLC protocol analysis and libraries capable of using analyzed protocol in GUI Design Tool with ease are required from now on.

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