Development and Implementation of Human Machine Interface for Environmental Monitoring Network

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Program Information:
National Science Foundation
Grant EEC-1359476

Research Experience for Undergraduates
Summer 2016

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1. Abstract

Human Machine Interfaces (HMIs) are a very useful way to compress a large amount of information and many controls into a compact space. They can be set up to display simple information and complex data sets. Most interestingly, HMIs can change configurations that provide both the inexperienced users access to the basic information for daily operations and the experienced users the more detailed and nuanced data sets. In this project, we design a user friendly HMI for power consumption monitoring. While this project is specifically about monitoring power consumption, the applications of HMIs are perfect for monitoring high importance statistics like temperature, power consumption, or even health data. Being able to have a compact and dynamic control panel can accommodated constant updates as often as the relevant system is updated.

2. Introduction

A Human Machine Interface (HMI) is a combination of a display and control panel where the controls can be set to influence both the operation of the hardware it controls as well as the appearance of the HMI panel itself. They are useful because they make it feasible to fit a large amount of information on a small display and can easily be reconfigured throughout the process of development. The focus of this project is to devise an efficient and preferably modular way to present data from a variable number of sensors.

3. Broader Impact

Human Machine Interfaces and the knowledge to design them are useful in broad applications from every field. These are useful as they can be constructed in every size and a large number of sensors and indicator configurations. Utilizing a HMI to control Programmable Logic Controller (PLC) allows the measuring and displaying of both Boolean and analog input signals. This system has nearly infinite applications as monitoring data and controls in a compact and efficient way and is useful in a wide range of fields. HMI technology could mean the difference between life and death in critical situations like spacecraft or undersea vehicles where both air and power are finite and very valuable resources that should be closely monitored and regulated. Advances in medical technology will soon allow us to utilize small medical sensors to constantly measure blood sugar, oxygen content and heartrate. This sensor data could be displayed on a HMI to aid decisions about when to take emergency medical actions.

4. Procedure

4.1. Selection and Evaluation

The first step in the process of designing the HMI was to assess which existing hardware and software most closely meets the requirements for this project.

4.1.1. Hardware Selection and Evaluation

The primary requirements for which hardware is most appropriate for this project included being as inexpensive as possible, compatible with software that passes the evaluation and will accommodate both analog and digital I/O. My first consideration was the DirectLogic 05 PLC from AutomationDirect. This device was highly considered because the base PLC had already been purchased by the student working on the project before me. That being said, the base PLC only had analog I/O capabilities and would require an upgrade module to accommodate digital I/O as well [1]. Another considered piece of hardware was one of a selection of LabView DAQs. I considered multiple different inexpensive DAQs that each had analog and digital capabilities [2]. These were more expensive than the system from AutomationDirect but not obscenely so. This system garnered some extra consideration because I am most familiar with this hardware, having done several similar projects in the past. Rockwell Automation's Micro850 PLC was considered and accepted based upon the comparably small price tag as well as its modularity This system was also superior to the former two as the PLC supported a standalone touchscreen HMI panel which is lighter and more user friendly than a desktop with a monitor [3].

Figure 1: Panelview 800 (top) and Micro 850 PLC (bottom)

4.1.2. Software Selection and Evaluation

The major requirements for this project's software was to be inexpensive, easy to use, compatible with hardware that passed the evaluation, and able to create a clean and versatile HMI. My first consideration was AutomationDirect's Point of View. This software looked appealing because it was free with the purchase of one of their PLCs which we already owned. One drawback of this setup would be that it requires a computer to run the executable. This means that we would have to acquire an expensive touchscreen monitor and the end user would have to lug around the desktop tower to run said monitor. LabView was also considered but it had the same issues as Point of View in requiring a computer to run as well as being prohibitively expensive for anything but the watermarked student version. The only advantage LabView had was that I am proficient in its use in calculations, managing I/O, and designing versatile user interfaces. I finally settled on Rockwell Automation's Connected Components Workbench as it was compatible with the best hardware option and has the ability to create versatile multi-panel HMIs.

4.2. Layout Design

When designing the HMI's layout, several factors had to be kept in mind. Most importantly, information had to be displayed simply and cleanly all while maintaining a large amount of versatility. The way I decided to accomplish this was by dividing the controls and indicators into three different panels. The home panel shows a brief overview of all the most basic information like the most recent alarm messages and a simplified power consumption graph. This panel will be the default and most often used panel because most people won't need any more detailed information than that. The other two panels show more detailed versions of the alarm and power consumption parts of the home panel. This will be useful to more high level users who would care about the breakdown of power consumption and a longer list of alarm messages.

4.2.1. Home Panel

The Home panel is set as the default screen that will show up when the HMI is booted up. It has a compressed version of all of the information all in one place so many users will never have to use anything other than the Home panel. In the top left corner under the navigation buttons, there is a graph which will show both the real past power consumption for a period as well as what the algorithm predicted the consumption would be for that time and for a small period into the future. The box to the right of the graph shows a breakdown by percentage of the current power consumption of three categories of devices: the ECU, Personal devices, and the Lights. The bottom left corner of the panel houses an abridged alarm display and the bottom right corner holds a Boolean indicator that tells the user if an alarm condition is currently active. Below in figure 2 is the final draft for the Home panel.

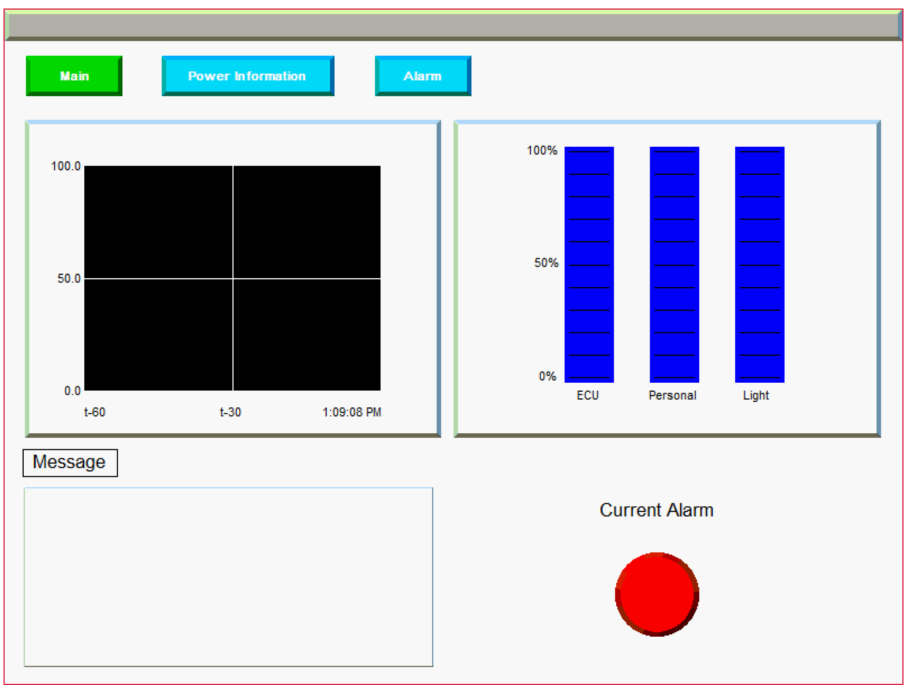

Figure 2: Home Panel

4.2.2. Power Consumption Panel

The Power Consumption panel is a more detailed view of the top half of the Home panel. The panel shown below in figure 3 shows a period of past power consumption selected by date and time in the options below the graph. The graph on this panel includes the past total power, categories of power (ECU, personal, and lights), and an algorithmically generated predicted power consumption. This allows users to see how different categories of power consumption changed and how accurate the predictive algorithm was over the selected period.

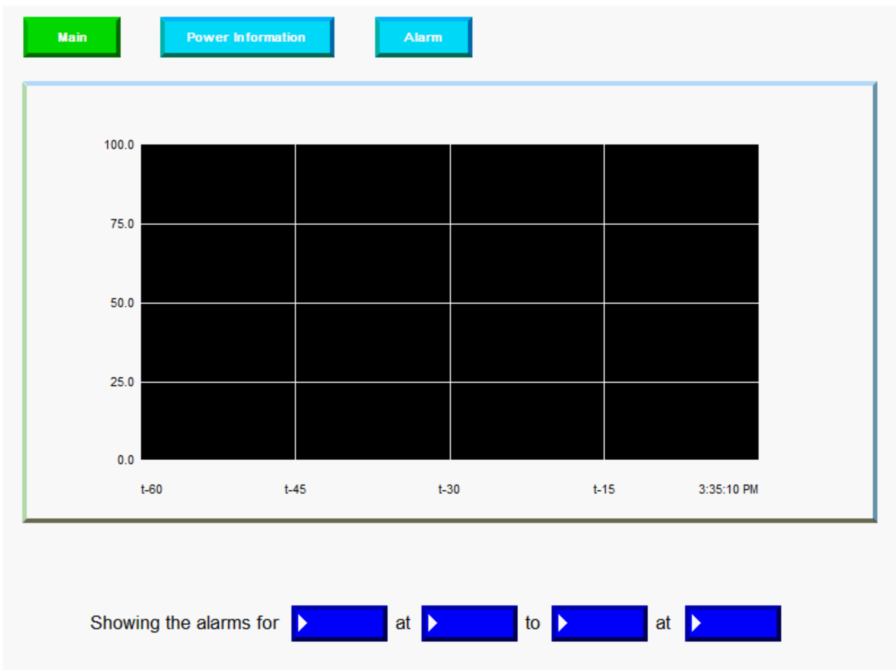

Figure 3: Power Consumption Panel

4.2.3. Alarm Panel

The Alarm panel is a more detailed version of the bottom of the home panel. Like the Power Consumption panel, the Alarm panel also has a period control using dates and times at the bottom of the screen. Alarm conditions shown include the door of the room being left open and any of the power consumption categories getting out of control. The final draft of the Alarm panel can be seen below in figure 4.

Figure 4: Alarm Panel

4.3. Program Data Inputs and Outputs

The final step of the process of this project was to program the HMI indicators and controls. This part of the process was the hardest as at the beginning of this project because I was not familiar with tag-based PLC programming. Many of the inputs to the system to be displayed on the HMI are being provided by another group in the form of text and Boolean signals so most of the work in this step is just connecting the indicators to the corresponding data.

5. Results

As of the completion of this project time period, I have nearly completed all of the objectives I set out to complete from the beginning. I have analyzed the hardware and software options from multiple different companies and determined that Rockwell Automation's systems have everything necessary for this project. Several drafts to HMI layout designs have been completed and refined into a simple utilitarian design that contains all relevant information. Most indicators and controls are connected to their respective inputs and outputs but further information from other project groups must be acquired to fully finish this step.

6. Conclusion

6.1. Summary

In conclusion, a Human Machine Interface is an efficient and compact way of displaying a large amount of information. This project is utilized this technology to create a user friendly display to show data about the energy consumption of the room in question. The final draft of the HMI includes three panels; a Home panel that offers an abridged version of all the information and both Power Consumption and Alarm pages to offer more detailed information about each of their titles.

6.2. Future Work

There is still some work to do to integrate the system with the data collection done by other teams. More work needs to be done to establish this connection between systems and be tested further.

7. References

[1] DirectLogic 05 (micro brick PLC). (1999). Retrieved July 27, 2016, from AutomationDirect, http://www.automationdirect.com/adc/Shopping/Catalog/Programmable_Controllers/DirectLogic_Series_PLCs_(Micro_to_Small,_Brick_-a-_Modular)/DirectLogic_05_(Micro_Brick_PLC)

[2] Data Acquisition (DAQ). (n.d.). Retrieved June 21, 2016, from http://www.ni.com/data-acquisition/

[3] Graphic Terminals. (n.d.). Retrieved June 21, 2016, from http://ab.rockwellautomation.com/Graphic-Terminals

8. Acknowledgements

The funding for this research came from the National Science Foundation award number EEC-1359476. Thanks to advisors Dr. Yanxiao Zhao and REU Site Director Dr. Thomas Montoya for their guidance, Dr. Alfred Boysen for his help in critiquing my reports and speeches and finally thanks to the entire Electrical and Computer Engineering Department for the use of the Wireless Communications and Networking Lab and the equipment therein.