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Design of Smart Home Systems Prototype Using MyRIO

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Abstract. This paper presents the design of smart home systems prototype. It applies MyRIO 1900 embedded device as the main controller of the smart home systems. It includes wireless monitoring systems, email based notifications and data logging. The simulated sensors such as temperature sensor, push button as proximity sensor, and keypad, as well as simulated actuators namely buzzer as alarm system, LED as light and LCD are applied in the prototype. Based on the test and analysis, the smart home systems prototype as well as the wireless monitoring systems have real time responses when input signals are available. The performance of MyRIO controller is excellent and it results in a stable system.

1. Introduction

Smart home systems are designed for a variety of purposes and reasons including safety, security, comfort, and energy efficiency. The smart home systems communicate with the user, whether the user is at home or outside via email [1] as well as web applications. Wireless network plays an important role in the development of smart home systems [2]. By using camera, image processing, and email services which are applied in an embedded controller, the home security can be monitored remotely by the homeowners [1]. In addition to home automation, research on smart home systems has been well developed in the field of medical applications, such as health monitoring systems [3], as well as to assist users with disabilities [4]. Management of power consumption in the smart home systems can be realized by scheduling, such that provides solutions to optimize the use of electrical equipment [5]. As an example is the room temperature control which increases energy efficiency in the home automation system while provides the comfort at home. It applies intelligent controller, which automatically adjusts the temperature set point according to user behaviour as well as environmental conditions. Neural network as temperature controller has a stable performance and is able to adapt to the various environmental conditions [6]. The equipment at home already functions like smart devices, which along with the ability to set up operations when the presence or absence of the user and also learn from the operation of the scheduling pattern that has been received [7].

As the increase in complexity and applications of smart home systems as well as the need for speed, and easy access, this research designed a prototype of smart home systems using NI MyRIO 1900. It has onboard FPGA and microprocessor for ensure the speed of computation processes. It is equipped with a WiFi device that enables communication between devices in the home as well as data communication throught the internet services. The goal of this study is to design the concept of smart home systems using MyRIO 1900 and test the performance while providing the basis for further advanced smart home systems development.

2. Methodology

This research consists some steps as shown in the Figure 1. The smart home systems prototype used MyRIO 1900 as information processing and controller. Besides functioning to monitor the state of the house, the system is designed with the aim to improve the security of the residence. Some features of the smart home system are as follows.

- Remote Monitoring : the state of the home include temperature, state of the lights, electronic equipment and the presence or absence of people in the house can be monitored from a distance as long as the homeowner is connected to the Internet.
- PC monitoring (available at home) which is connected to the smart home systems via a wifi network.
- Security system :
    - Homeowners are asked to enter a password to unlock the gate. If the password is wrong, then the alarm will light and the camera will take a picture of the face of the opening of the gate. Meanwhile, if the password is correct, then the gate will open.
    - If the house is being abandoned by the owner, then there are foreigners who are found in the house, the alarm is on and the system will send a notice to the owner of the house that there was a stranger in the house.
- Data logging: all data (temperature, lighting conditions, the presence or absence of people in the house and faces photograph of the person who opens the gate) to be stored and delivered to the homeowners.

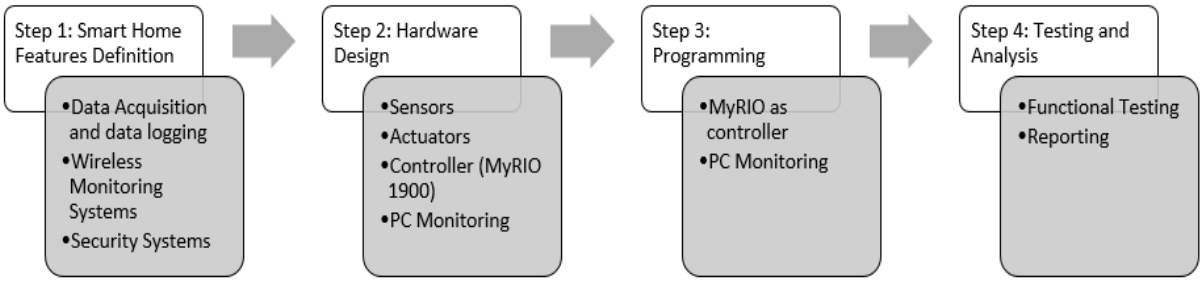


Figure 1. Research methodology

2.1. Hardware Design

Figure 2 shows the block diagram of smart home systems prototype. The input to NI MyRIO are temperature sensors, switches/pushbutton assumed as a proximity sensor, keypad, and camera. MyRIO has outputs namely the buzzer as the alarm, the LCD as a viewer, the LED lights which are assumed as lights control systems.

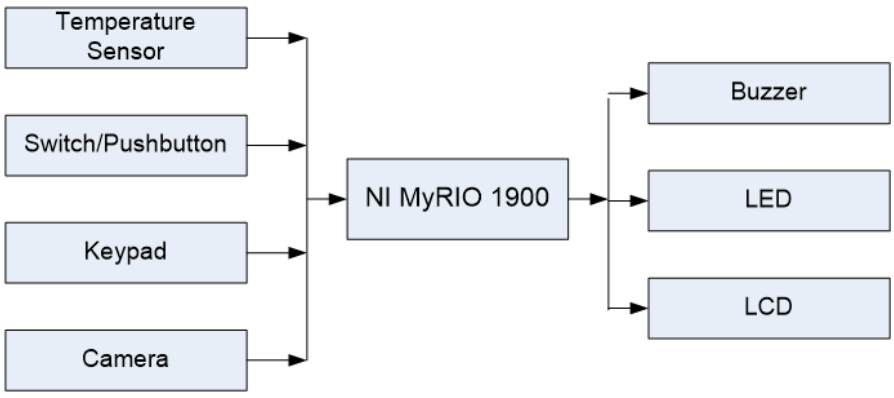


Figure 2. Block diagram of smart home systems prototype

In the Figure 2, it can be seen several sensors and actuators that are used in the design of smart home systems prototype, as follows.

1. Thermistor, to measure the temperature.
2. LED as light controlled.
3. Keypad, enter the homeowner's password.
4. LCD, to display the password.
5. The USB camera, to take pictures of people who type or input the password.
6. Buzzer, as an alarm.
7. MyRIO, as a controller.
8. Switch, as a modifier condition and value assumptions of the proximity sensor in the gate of a house.

2.2. Software Design of Smart Home System in MyRIO

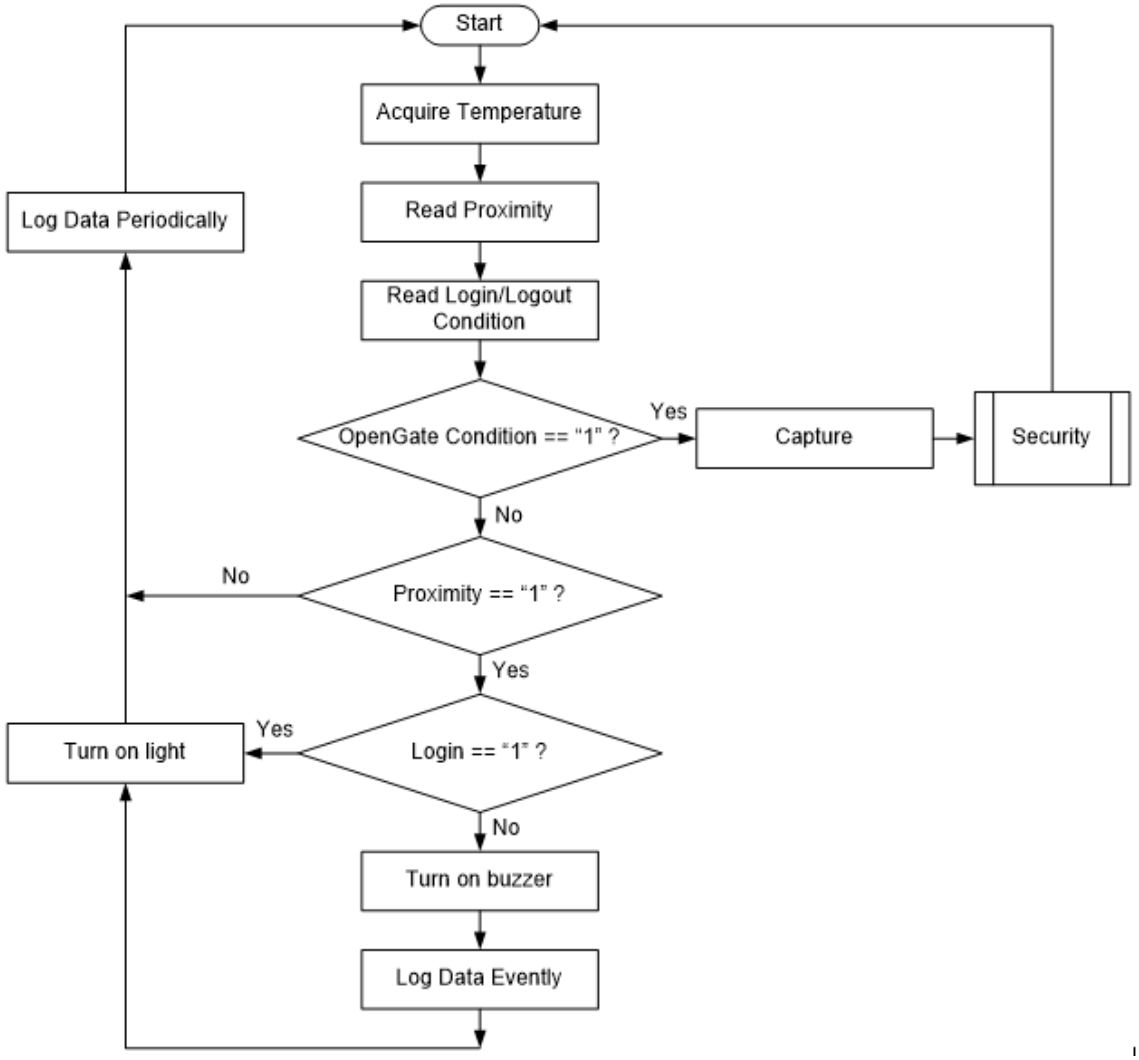


Figure 3. Flowchart of smart home systems prototype

Figure 3 shows the flowchart of main program in MyRIO, while Figure 4 shows a flowchart of security subroutine. The system is continuously read temperature, proximity sensor, login/logout

conditions and the state of the gate. If the gate is open or "1", then the camera will take a picture of the person who enter the house. If else, the user is prompted to enter a password on the keypad. If the password is correct, then the gate will open. However, if the password is incorrect, then the gate is not open and the alarm will turn on.

Then if conditions login/logout is "1" and the proximity change the conditions to "1" which means the homeowner is coming, then the light goes on. Meanwhile, if the conditions login/logout is "0" and the proximity change conditions which means that it is not the homeowner who enter the house, then the light is off, the alarm will be lit and the system will send an alert to the user/homeowner via email. All data (temperature, proximity, conditions login/logout, conditions open the gate and the picture of person who open the gate) will be sent to the user's email once a day, which can be set delivery time.

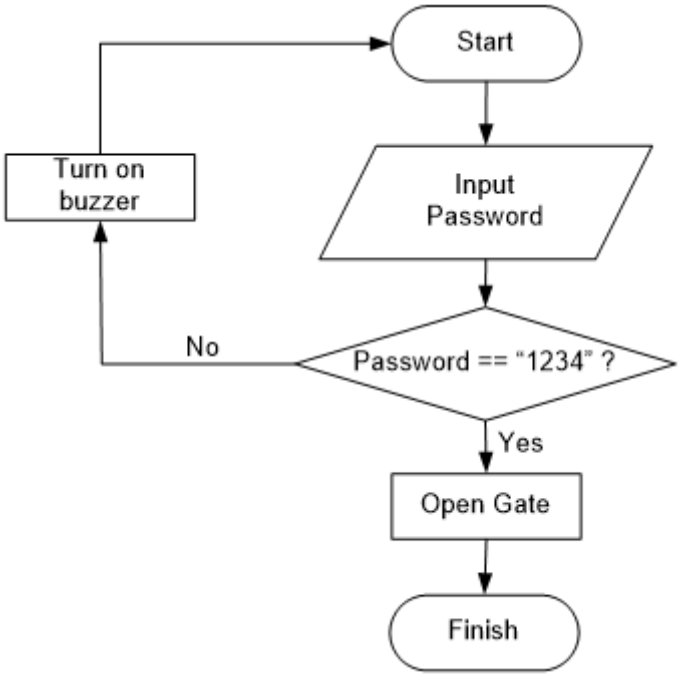


Figure 4. Flowchart of security subroutine

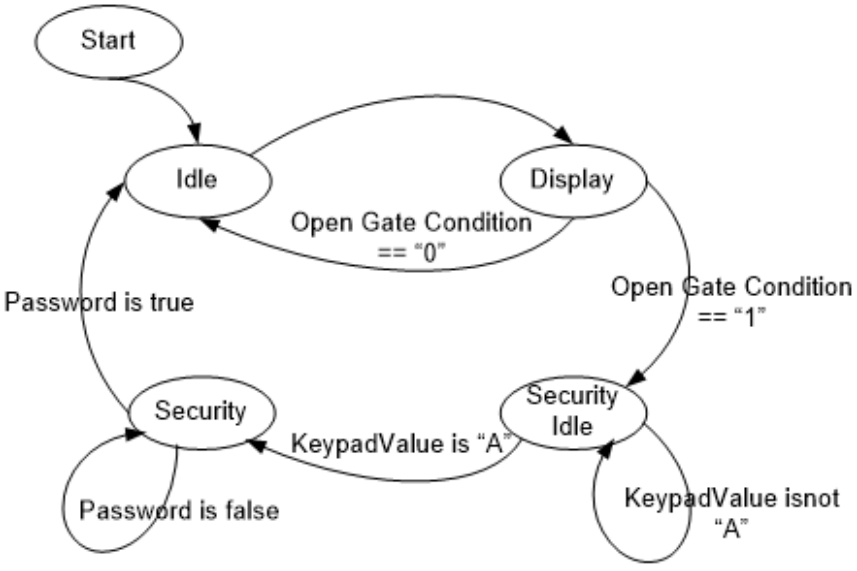


Figure 5. State diagram of smart home systems

Figure 5 shows the state machine diagram of the program. Starting from the *Start* and then jump to *idle*. *Idle* condition is a condition in which MyRIO waiting for input from the user to determine the circumstances which are to be executed next, while *Display* is a subroutin for displaying the sensor and output state. If the value of OpenGateCondition is "1", then the condition to be executed is a condition *SecurityIdle* in which the system will wait for password entered by user. If the value of OpenGateCondition is "0", then the conditions remain in the *Idle* state. When the user press the "A" key means the user has finished entering the password then the *Security* conditions is executed. If the password is correct, then the state will move to the *Idle* state. Meanwhile, if the password is incorrect, then the condition will remain on *security* conditions. The front panel for smart home systems prototype is shown in Figure 6.

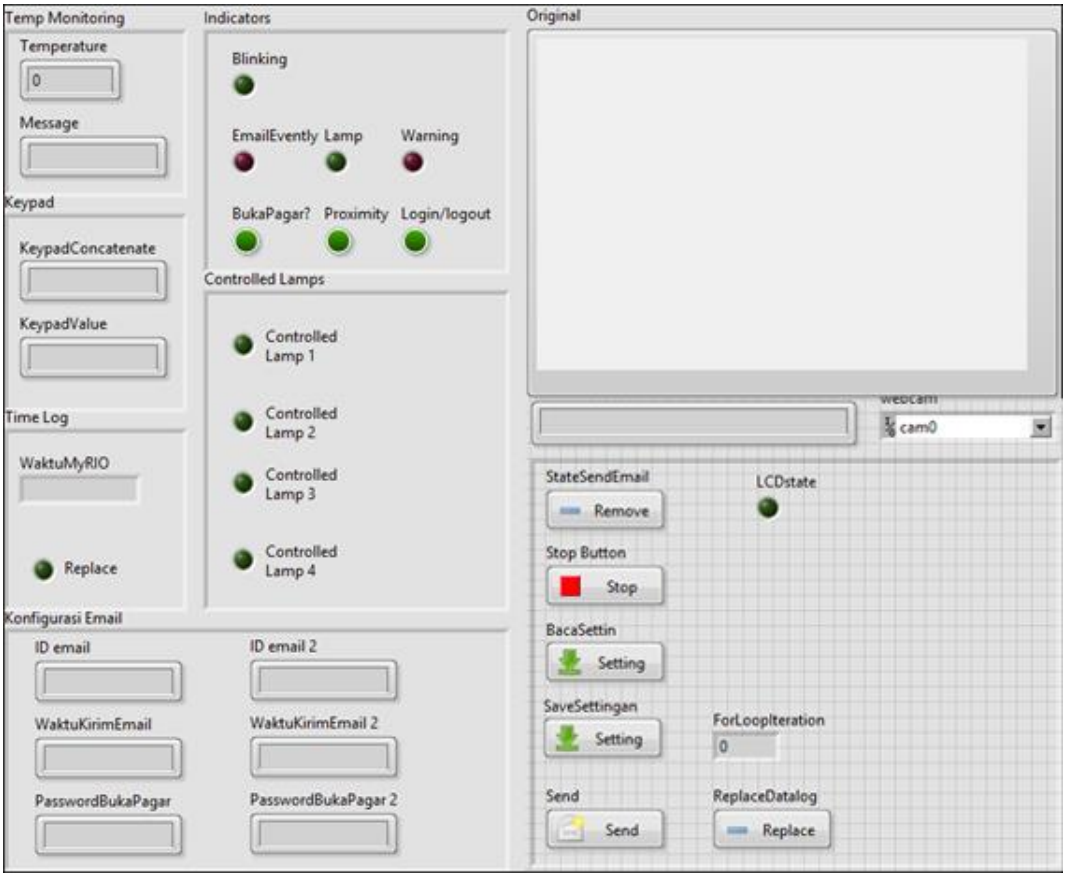


Figure 6. *Smart Home System Front Panel*

2.3. Software Design of Smart Home Wireless Monitoring System

Smart home wireless montoring systems is an application that will be embedded in the PC as the wireless monitoring system. This application can be used to monitor, control and change parameter settings on smart home systems. Figure 7 shows the block diagram of it. It can be seen from the figure that the communication between the PC and MyRIO are using wifi network. The protocol used is User Datagram Protocol (UDP). UDP is a protocol that makes it possible to transmit short data packets to one or more recipients. Unlike TCP (transmitter control protocol), UDP does not guarantee the data sent completely accepted by the recipient. So it is very possible that the data packets are missing or not in order. So that, the UDP should be used for short data transmission and not the transmission of information requiring data accuracy. Limit the maximum size of each packet of approximately 65 thousand.

Figure 7. Block diagram of smart home wireless monitoring systems

The monitoring features are as follows.

1. The condition of the lights. So when users turn on the lights, the lights indicator on the monitoring application will also on.
2. Temperature. The average value of current temperature reading will be displayed on the system monitoring applications in real time.
3. The condition of proximity sensors. Proximity sensors are used to determine whether there is movement of people in the house. If there are changes in the value of the proximity sensor, the indicator will light up on the monitoring application. So that users know that there is someone in the house.
4. The condition of login/logout. If the user wants to leave the house, then the user should tell the system by changing the conditions of switches login/ logout. This condition is also displayed on the monitoring application.
5. The condition of the gate. If a user wants to open the gate, then the user should press the pushbutton to open the gate. This condition will be displayed on the monitoring application. Then the user is required to enter a password through the keypad. If the password is incorrect, then the alarm will sound indicating the house in a state of warning. This condition will also be displayed in the monitoring application.
6. Control light conditions by using monitoring application.
7. Change the settings on the system includes a user's email address, report time and password to open the fence.

Figure 8 shows the state machine diagram of wireless monitoring application. The first state to be executed is *InitSetup*. The next state is the *Startup* state. In this state the user is prompted to press Start on LabVIEW pushbutton to start the application. If the pushbutton is pressed, then the state will be executed next is *Initialize*. But if the pushbutton is not pressed, then the next state is the *Startup* and executed continuously. Then the next state is the *Monitoring*. Then if *configuration* pushbutton is pressed, then the state will be executed next is *Configuration* to display the configuration setting. If the *setting* pushbutton is pressed, then the state will be executed next is state *Configure*. If the *stop* pushbutton is pressed, then the state will be executed next is state *Stop*. Whereas if none pushbutton is pressed, the state executed next is *Manipulated*. Then it backs to the state *Monitoring*. Front panel of the monitoring application is shown by Figure 9.

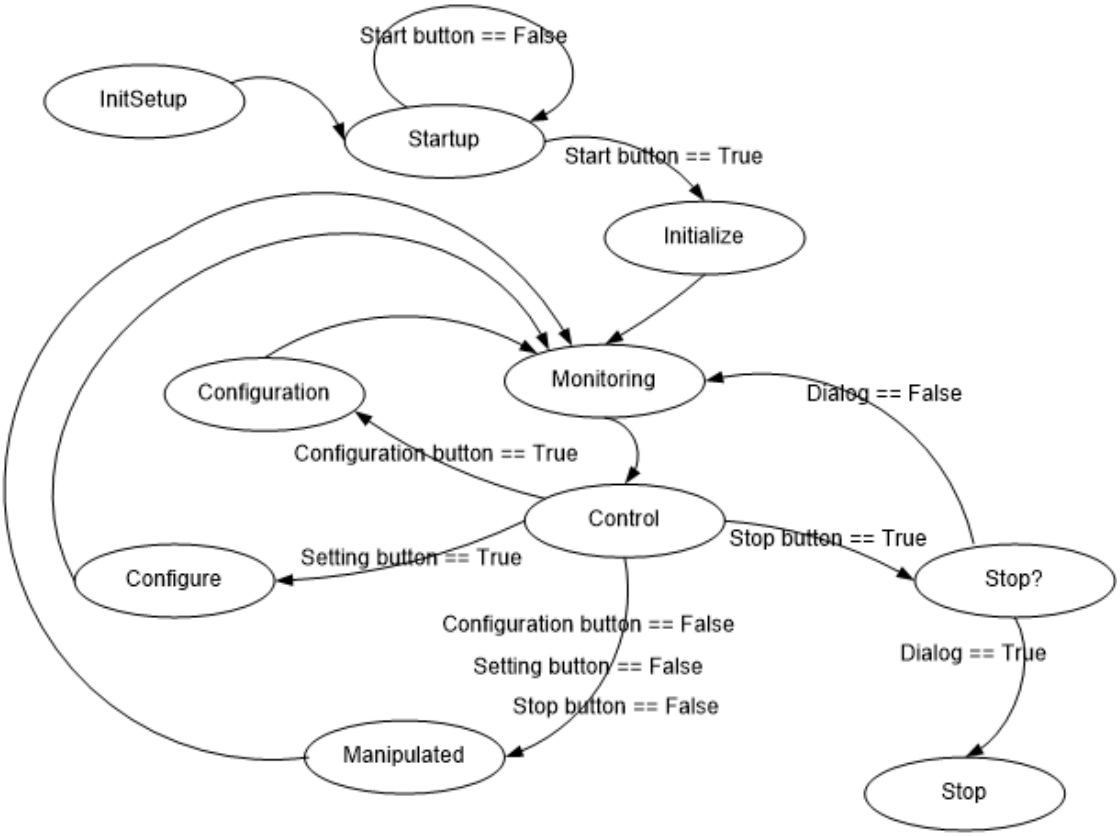


Figure 8. State diagram of wireless monitoring system

Figure 9. Front panel of wireless monitoring system

3. Result and Analysis

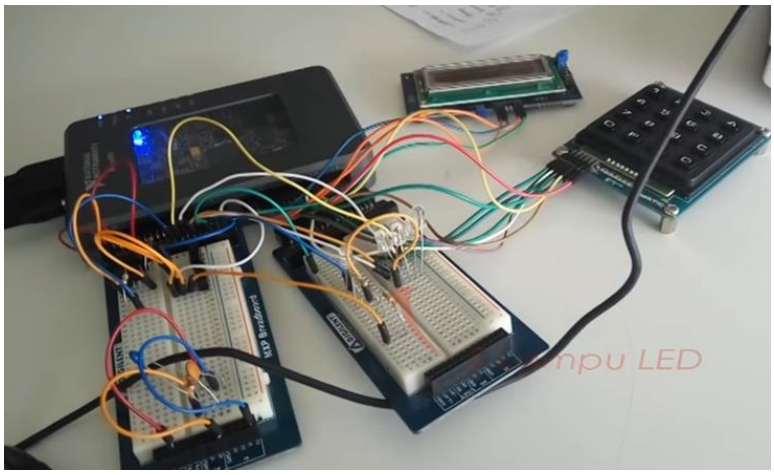


Figure 10. Hardware testing

To determine the performance of the systems, both hardware and software were tested. Figure 10 shows the hardware testing. Testing was conducted on the thermistor for temperature measurement, LED as a light-controlled, the keypad to enter a password, LCD to display the passwords, USB camera to take pictures of people who are entering the password as well as Buzzer as alarm. From these tests, all hardware is working properly as designed. Further testing is functional of wireless monitoring system. Figure 11 shows an example of the monitoring system testing when the room temperature is 25,244 ºC.

Figure 11. Wireless monitoring systems testing

The next test is checking the email notifications which are sent to homeowner. Figure 12 is an example of the display in the email containing the email notificaton of smart home systems. The email includes two attachments namely images of user entering to the house and data monitoring as shown in Figure 13.

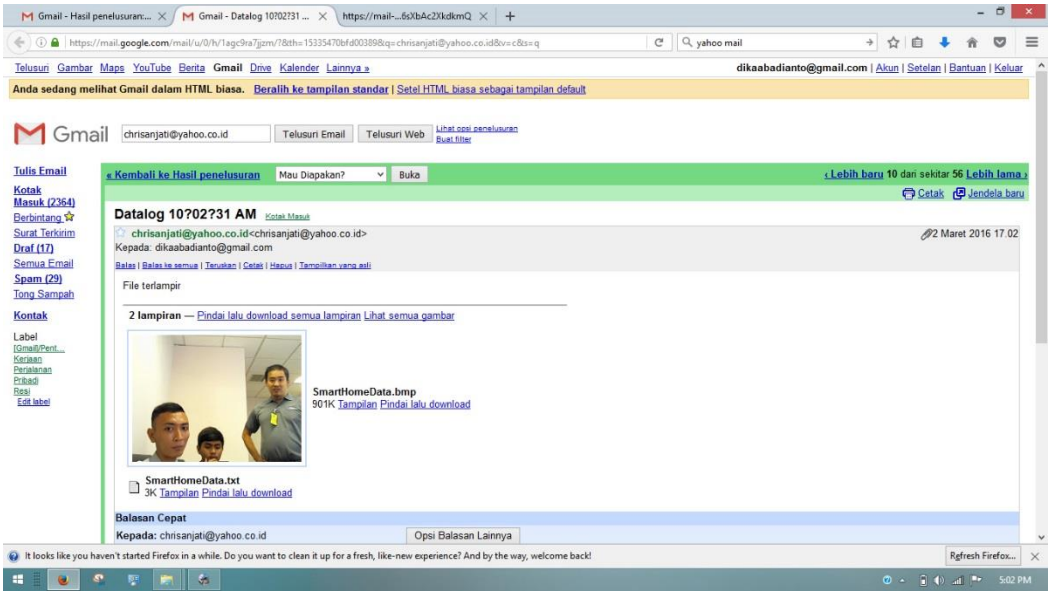
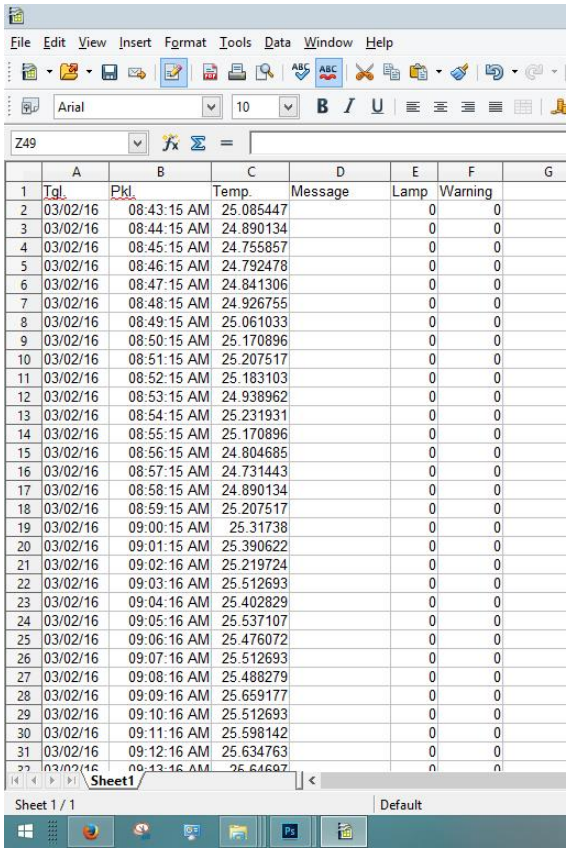


Figure 12. Example of an email notification



	A	B	C	D	E	F	G
1	Tgl.	Pkl.	Temp.	Message	Lamp	Warning	
2	03/02/16	08:43:15 AM	25.085447		0	0	
3	03/02/16	08:44:15 AM	24.890134		0	0	
4	03/02/16	08:45:15 AM	24.755857		0	0	
5	03/02/16	08:46:15 AM	24.792478		0	0	
6	03/02/16	08:47:15 AM	24.841306		0	0	
7	03/02/16	08:48:15 AM	24.926755		0	0	
8	03/02/16	08:49:15 AM	25.061033		0	0	
9	03/02/16	08:50:15 AM	25.170896		0	0	
10	03/02/16	08:51:15 AM	25.207517		0	0	
11	03/02/16	08:52:15 AM	25.183103		0	0	
12	03/02/16	08:53:15 AM	24.938962		0	0	
13	03/02/16	08:54:15 AM	25.231931		0	0	
14	03/02/16	08:55:15 AM	25.170896		0	0	
15	03/02/16	08:56:15 AM	24.804685		0	0	
16	03/02/16	08:57:15 AM	24.731443		0	0	
17	03/02/16	08:58:15 AM	24.890134		0	0	
18	03/02/16	08:59:15 AM	25.207517		0	0	
19	03/02/16	09:00:15 AM	25.31738		0	0	
20	03/02/16	09:01:15 AM	25.390622		0	0	
21	03/02/16	09:02:16 AM	25.219724		0	0	
22	03/02/16	09:03:16 AM	25.512693		0	0	
23	03/02/16	09:04:16 AM	25.402829		0	0	
24	03/02/16	09:05:16 AM	25.537107		0	0	
25	03/02/16	09:06:16 AM	25.476072		0	0	
26	03/02/16	09:07:16 AM	25.512693		0	0	
27	03/02/16	09:08:16 AM	25.488279		0	0	
28	03/02/16	09:09:16 AM	25.659177		0	0	
29	03/02/16	09:10:16 AM	25.512693		0	0	
30	03/02/16	09:11:16 AM	25.598142		0	0	
31	03/02/16	09:12:16 AM	25.634763		0	0	

Figure 13. Sample of data logging

4. Conclusion

This study has been designed the prototype of smart home systems using MyRIO 1900 with simulated sensor devices and actuator. The system is equipped with a wireless monitoring system and email notifications as well as data logging. Based on the results and analysis of the design as well as testing, the smart home system using MyRIO generate real-time output responses when given a particular input. MyRIO performance as the controller is excellent and produces a stable system.

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