Development of Energy Monitoring System based on Human Behavior by using Arduino Microcontroller

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Abstract— **This paper presents the development of energy monitoring system based on human behavior by integrating Arduino Microcontroller and MATLAB. The goal of this research is to develop an efficient energy monitoring system based on human behavior especially for workers during daytime in workplace. A prototype of this system is constructed, using an Arduino ATMega2560 electronics platform as an interface to dekstop PC. Then, structured programmed is develop in MATLAB software to observe and analyzed the system output. There are three types of sensors that has been used to detect a human behavior which are Passive Infrared Sensor (PIR sensor), touch sensor and push button sensor. Finally, the process of the system and observation of human behavior towards power saving by using the developed system is presented.**

Keywords—energy saving; time spent; human behavior

I. Introduction

Wireless Enabled Electricity Manager (WEEMAN) is an intelligent control device reported in [1]. This system can monitor the energy consumption of a single device or a set of devices. Smart meter acts as the central control node in which availability based management algorithm. This algorithm learns about the usage patterns of the appliances, collects the information such as the real time average power of appliances from WEEMAN to generate efficient energy load patterns. The algorithm will provide a unique attribute for the user to set the expected monthly electricity bill amount and proactively control the operation of the all appliances according to the amount [1]. The smart grid delivers electricity from suppliers to the consumers by using digital technologies to save energy, reduce cost and increase reliability of the system [2-5].

Typical human behaviors are described with logical sensors which are defined through data fusion processes spatially and temporally with the physical sensors of the mobile robot and those in the environment. The system can be utilized to make human-robot communication and interaction friendlier and smarter. It is necessary to detect the presence of the human in advance before processing the human activities such as falling, standing or walking.The inhabitant's behavior possesses a unique pattern that can be classified into distinct episodes. Unlike other information sources, the patterns consist of an explicit initial point and an ending point. The pattern also possesses another significant property, which is related to natural facts [6].

Human habit cannot be controlled because it changes according to our life. Human activity has been critical information since knowing what activities are undertaken is well important for judging if energy consumed by appliances is well spent by users [7]. Besides that, an estimation of the occupant's location can be modelled as the belief in the fact that he/she is located at position, x at the instant, t. This depends on the time to reflect the changes in activities during the day or week. The information from human activity is an important clue for providing an energy saving service.

This paper will discussed about the development of energy monitoring system using Arduino platform. The developed prototype will be used to justify the human behavior factors and the effect of recorded time data on the power consumption and saving.

II. System Development

The proposed monitoring system will be used to observe the human behavior and relation on electrical appliances usage. The useful information in term of usage time duration is recorded for specific period of time. This system is developed based on the scenarios and cases which are created by referred to the survey that has been done before [8]. The survey has been done on workers in the office sector to know their behavior in the workplace. There are three type of working behavior is characterized based on survey which are: Person A is referring to worker, which is like to do his work in an office. Person B is referring to workers, which like to do his work in an office and outside of the office. While, Person C refers to the worker, which is like to do his work at outside of the office for most of the time.

Fig. 1 shows the flowchart for the algorithm adopted in this system. Once, system in working condition, the input signal from each sensors will provide the information to the system. Then, developed programmed in MATLAB will start

to capture the signal and displayed. This signal then will be analyzed and recorded. Further process on recorded data will be done to inform the user or electrical appliances to switch 'ON' or 'OFF'.
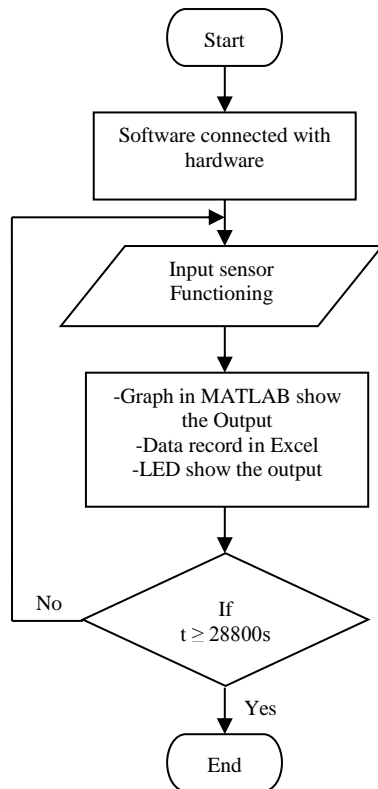
Start

↓

Software connected with hardware

↓

Input sensor Functioning

↓

-Graph in MATLAB show the Output
-Data record in Excel
-LED show the output

↓

If t ≥ 28800s

No → / Yes ↓

End

Fig.1. System process

The block diagram of the component use in system design is shown in Fig. 2. In practical, different type of input sensor can be used in order to provide the information signal to the system. However, in this project, the PIR sensors, touch sensor and push button sensor has been used as the input sensor to the Arduino.

Sensor as Input

↓

MATLAB ↔ Computer ↔ Arduino Microcontroller

↓   ↓

*Graph is use to show the Output
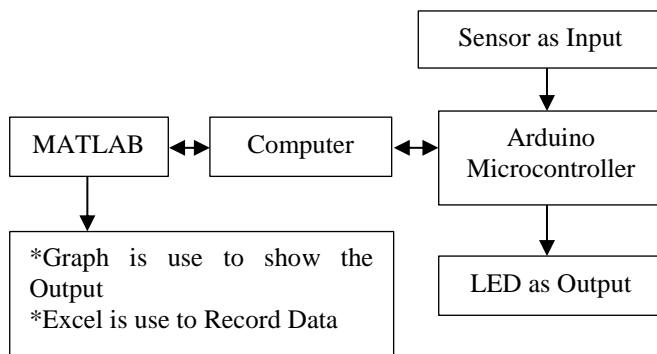*Excel is use to Record Data

LED as Output

Fig. 2. Block diagram for system

The Arduino microcontroller is new type of controlller which use simpler C language. The Arduino ATMega2560 board is provided with a low-cost and simple technology in order to create the project. Arduino is a small microcontroller board with a USB plug to enable connection with computer

and a number of connection sockets that can be wired up to external electronics. This microcontroller can either be powered through the USB connection from the computer or a 9V battery [9]. Microcontroller is the CPU (Central Processing Unit) of the system. Microcontroller will receives and process data based on the specific developed language program. Algorithms need to be design for the process of microcontroller to read the input signal and respond accordingly.

Fig. 3 shows the Arduino Microcontroller board used in this system. Sketch software is used to write the coding for Arduino microcontroller. Fig. 4 shows the example of sketch software's interface.

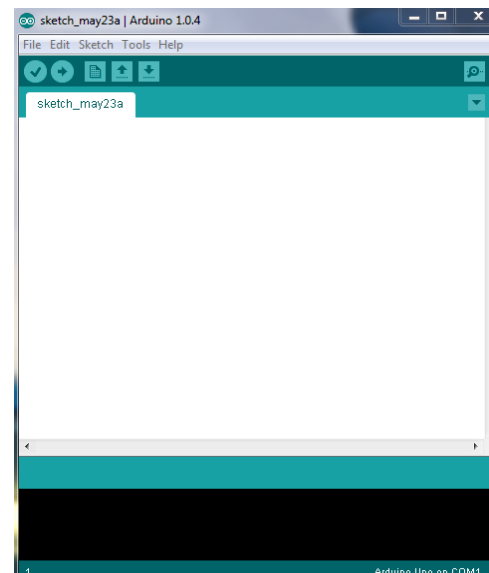
Fig. 3. Arduino ATMega2560 board

Fig. 4. Sketch software for coding

Furthermore, there are several units of sensors are placed in selected position in order to provide accurate information about the inhabitant's location. PIR Sensor can be used to turn lights 'on' or 'off' based detection of person in the coverage zone. The flexibility of the working hours can be realized by using automatic detection and recorded system. Furthermore, the integrations of detection system and control system can control the electrical appliance and other's electrical facilities usage.

Besides that, touch sensor is used to detect the human body so that the system will be acknowledge whether there is person on the chair or not. While, push button is used as a switch mechanism to provide more accurate detection system during monitoring process. When the push button is unpressed there is no connection between the two legs of the push button. Therefore, the output will be turn to 'off' state. When the push button is pressed, the connection between two legs of the push button will be connected and the output will be turn to 'on' state.

All sensors that are shown in Fig. 5, 6, and 7 will be used and integrated in the system to detect and monitor the human behavior.

Fig. 5. PIR sensor

Fig. 6. Touch sensor

Fig. 7. Push button

Light Emitting Diode (LED) is a semiconductor device that emits visible light when an electric current passes through it [10]. Three LED are used as output indicators in this project. Fig. 8 shows the LED and its schematic diagram.
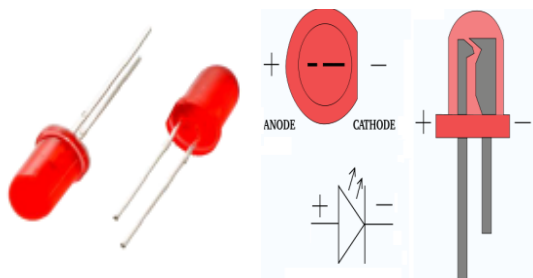
Fig. 8. LED and its schematic diagram

MATLAB software is used in this system to acquire and analyze the input data from Arduino board. Therefore, the M-File programmed code has been developed in MATLAB to interface with the Aduino. This programmed code will simulate the integration process, data recording, simulation and analyzing the input data. The input signal from the sensors at Arduino will be capture and plot real time in MATLAB. Each sensor's signal will be plot on separate graph for better visualization.
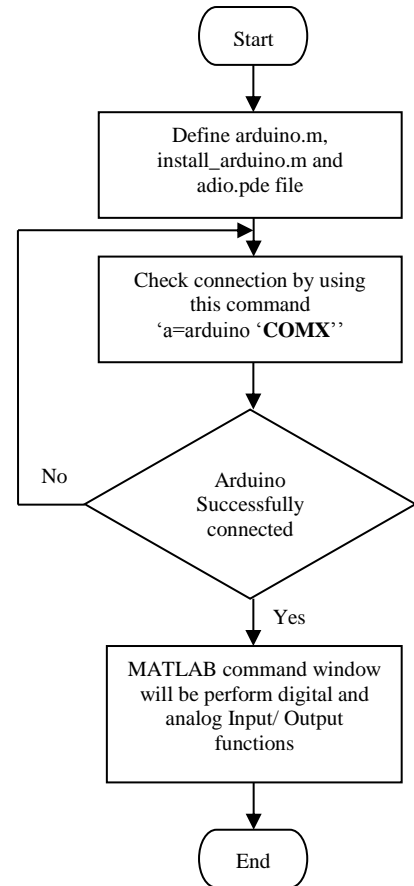
Fig. 9. Interface Arduino in MATLAB

The connection and interfacing process between MATLAB and the Arduino is done by using Arduino IDE file. Then, the 'adio. pde' file will be uploaded in Sketch software before the interfacing process can be done. There is notification will be appeared in MATLAB command windows once the connection between COM port and Arduino successful connected. Fig. 10 show the example of connection notification in MATLAB command window.

Attempting connection...............

Basic I/O Script detected !

Arduino successfully connected !

Fig. 10. Arduino successfully connected

The LED is used to indicate the output controll signal from the Arduino in physical view. Each sensors will send the signal to the system when there are human are detected. This signal will be recorded and ploted in real time for further analysis. The plotted data will be analyzed in term of the sensor's duration in 'on' state. This durations of time will be used to represent to behaviour of dedicated human.

Later, the consumed electrical power energy will be calculated based on time spent that has been recorded before. Therefore, the energy power saving plan can be proposed for next monitoring period. Equations (1-4) are used to calculate the energy performance, the energy consumption and power saving in this system.

Total Power, kWh = Total Time Spent for each room   (1)
(hour) x Total Power per day, kWh [11]

Power Consumption, kWh = Time Spent (hour) x   (2)
Total Power use per hour, kWh for each room [11]

Power Saving, kWh = Total Power, kWh – Power   (3)
Consumption, kWh [11]

Saving in cost (RM) = Power Saving, kWh x RM   (4)
0.218 per unit (tariff rate in Malaysia) [12]

III. PROTOTYPE DEVELOPMENT

Fig. 11 show the developed prototype by using Arduino platform and input sensors. In order to increase the system efficiency, the wired connection can be replaced with the wireless connection. This is due to the speccification of Arduino microcontroller that can support the Zigbee wireless connection.
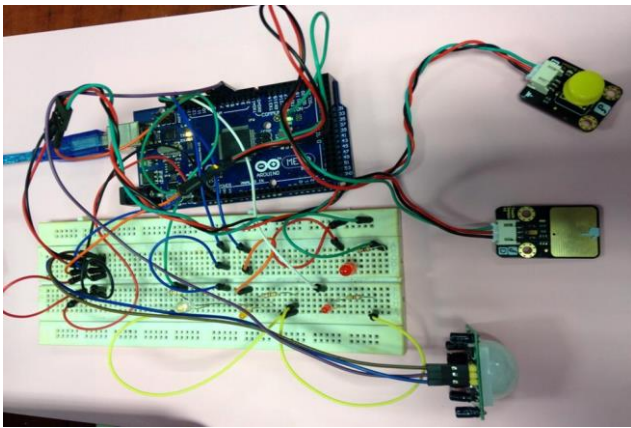

Fig. 11. Arduino microcontroller with the sensors

Fig. 12, 13 and 14 show the real time plot of input signal from each sensor. The y-axis for each graph is representing the output signal from sensors while x-axis is show the duration time in second. The system monitoring is set to operate for 3600s which equivalent to 1 hour. Fig. 12 shows the signal from PIR sensor. The signal represent HIGH (1) when there are movement are detected. While, the signal is presented OFF (0) when no movement detected in coverage area. The PIR

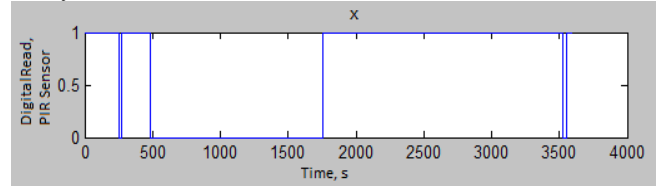sensor is the main sensors in human movement detections in this system.

Fig. 12. Output from PIR sensor

Fig. 13 shows the detected signal from touch sensor. This sensor will be used to detect the pressure of human body on the chair. Therefore, the system able to identify the existing of human body on the specific chairs. The output signal represent HIGH once the pressure on the chair detected and OFF when no detection of pressure.
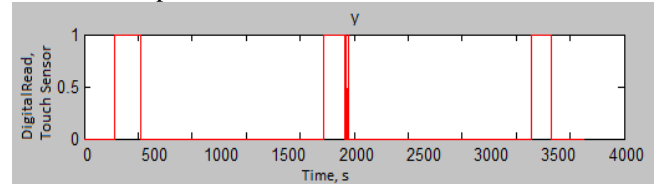

Fig. 13. Output from touch sensor

Fig. 14 shows the signal from push button sensor. Push button is considered to be as a switch. This sensor will be used when there is needs to switch on the light manually. The output signal is represent HIGH once push button turn ON, and maintain the ON state after the push button is released. Push button requires another depress to turn it to OFF state.
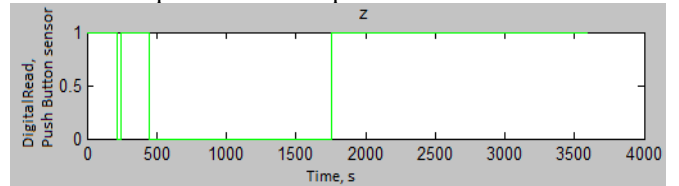

Fig. 14. Output from a push button sensor

CONCLUSION

This monitoring system is developed based on Arduino microcontroller and MATLAB software. The Arduino has been interfaced with MATLAB. Three type of sensors used in this project is PIR sensor, touch sensor and push button. Besides, the LED also been used as output indicators. The developed prototype shows the output signal of each sensor can be used to detect an existing of human in coverage area. The recorded time spent from MATLAB then is used to calculate the power energy consumption and energy saving. The proposed time consume for each electrical appliance can be proposed based on recorded data. Further analysis on the system implementation will be done to verify the system performance.

ACKNOWLEDGMENT

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