IoT-HOME SYSTEM: a WATER PRESSURE, GAS LEAKAGE, and LOAD MONITORING and CONTROL

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ABSTRACT: IoT-Home System utilizes the technology of Internet of Things. The system is composed of three subsystems, namely Emergency Water Supply System, Gas Leakage Monitoring System, and Electrical Load Control System. The main concept of the system is to monitor and automate the components connected to every subsystem through mobile application using the internet. The Emergency Water Supply System includes the monitoring of the main water line pressure and determines through machine-learning algorithm if water shortage or outage will occur. If the probability of having a water interruption is high, the subsystem will open the emergency water tank to fill up for storage. When the interruption occurs, it automatically opens the storage tank to provide the water source of the household The Gas Leakage Monitoring System detects the presence of gas in the area and the automatic opening of the exhaust fan when the measured concentration of the gas detected is above the reference value. The Electrical Load Control System allows the monitoring and control of the appliances and electronic devices in the household. The system uses different types of sensors in order to collect data that will be processed as the needed information and will be sent to the mobile application through the internet in real time.The whole system showed accuracy and good reaction time.

KEYWORDS:*Internet of Things, Home Automation, Emergency Water Supply, Gas Leakage, Electrical Load Control*

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1.0 INTRODUCTION

Home Automation, also called "Smart Home" is a technology that provides the control of devices or appliances in a household from mobile devices with an appropriate application anytime, anywhere.[7] Home automation utilizes the "Internet of Things" in which all the devices and the appliances are networked together and offers monitoring and remote control.[8] The benefits of a functional home automation system may include energy conservation, remote home monitoring, automatic device or appliance control, comfort and convenience, and safety and security to the owners.[7] An example of these benefits is the smart lighting system. This technology allows the householder or the owner of the house to remotely control the lightings to minimize and save power consumption. This lighting system also automatically turns on and turns off outdoor lighting based on the current time and the ambient light.

IoT Home System incorporates the Electrical Load Control. The system has the capability to control the electrical loads which are limited to low power ones like electrical fans and lights. It also turns the lighting system on or off based from the time set or the sensed lighting surrounding the area. Another system incorporated in the IoT-Home System is the Gas Leakage Monitoring System this system detects the presence of gas leakage or gas concentration and has pre-emptive measures to address the problem. Based from the threshold value and the amount of gas concentration sensed by the gas sensor, the system controls the exhaust fan's on or off function in order to dissipate the gas. The Emergency Water Supply System has the capability to monitor the water pressure of the main water line of the household and determines the probability of having a water shortage or outage using the machine learning algorithm [10]. The system automatically stores and fills up water in the storage tank if the probability of water interruption is high and sets this emergency storage tank as the source of water when the water outage happens.

All the functionalities of the IoT-Home System are done using the mobile phone and the IoT technology. The concept of the Internet of Things is basically interfacing any gadget with an on and off switch to the Internet. This includes everything from cell phones, clothes washers and driers, coffee makers, lights, wearable gadgets and nearly whatever else you can consider[8].

Internet of Things for Home Automation is an approach for smart home automation using Internet of Things (IoT) integration with computer vision, web services and cross-platform mobile services. The said project aims to increase home security [1]. Design and Implementation of a Wi-Fi Based

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Home Automation System is another paper that presents a design and prototype implementation of new home automation system that uses Wi-Fi technology as a medium to connect its components. It uses a web server to manage, control and monitor the home [2][7]. Designing of Lighting Automation System Based on Arduino Bluetooth Interface is another design that uses the Bluetooth technology. The design permits trading information over short separation utilizing short wavelength radio transmission, giving comfort, knowledge and controllability. In this design, a home lighting control framework utilizes Arduino Bluetooth interface with android cell phone. Android application is downloaded to the android smartphone to monitor and control the operation of the lighting system remotely [3].

IoT based Water Management is a project that focuses on monitoring of the use of water. Water management implies to maximize the use of water and minimize the wastage of water. The sensors sense the flow of water to each pipe which ultimately tells the usage of water at one area. This water usage data would be sent to the cloud using the IoT (Internet of things)[4]. Smart Tank Water Monitoring System using IOT Cloud Server at Home/Office is a project that aims to monitor the quality of water in real-time to ensure safe supply of drinking water. The system consists of some sensors which measure the water quality parameter such as pH, turbidity, hazardous Gas, dissolved oxygen, water Level. The measured values from the sensors are processed by the microcontroller and these processed values are transmitted remotely to the core controller that is PIC Microcontroller using IOT protocol [5][6].

From the review of related literatures and studies, there are many technologies that enable the user to control devices wirelessly and remotely. In the present day, Internet of Things is widely used since it offers great distance coverage in wireless communication. It only needs the device and the controller to be connected to internet. Connectivity to the internet is very crucial in home automation because the internet serves as the medium between the user and the devices to be controlled.

2.0 METHODOLOGY

2.1 Machine Learning Algorithm

The Emergency Water Supply System uses the Machine-Learning Algorithm (MLA). MLA is an algorithm where a certain machine accepts input data to calibrate its parameters without human intervention. MLA concludes and makes decisions based on the trend of the successive input data. Some data are used to make training models to observe its patterns and the remaining data will be used to evaluate the predictive quality of the trained model. The design uses the Naïve Bayes Theorem [10] in predicting the

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probability that a future water interruption will occur. Naïve Bayes Theorem is a supervised learning algorithm that computes the probability that an event will occur. Given some parameters, the Naïve Bayes Theorem calculates the probability of a hypothesis to be true given a prior event.

$$P\left(\frac{h}{d}\right)=\frac{P\left(\frac{d}{h}\right)P(h)}{P(d)} \qquad (1)$$

In the formula of Bayes Theorem, posterior probability the probability of hypothesis h being true given the data d, likelihood probability is the probability of data d given that the hypothesis h was true, class prior probability is the probability the hypothesis h was true, and predictor prior probability is the probability of the data d.

2.2 System Block Diagram

The figure below illustrates the system block diagram that describes the overall control function of the system. The projected system works using the smartphone application. The smartphone application is implemented on an android device, which receives data and sends command through the web server.

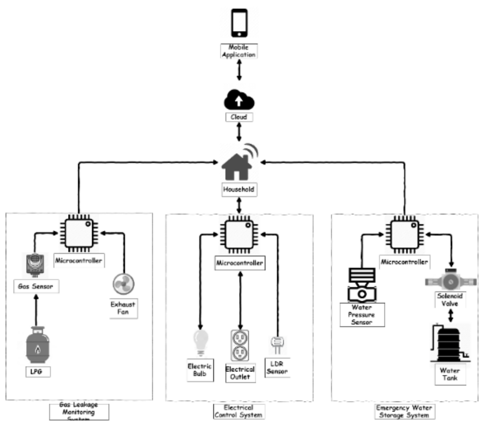

Figure 1: System Block Diagram

The system block diagram is composed of different devices and components that are used for the development of the design.

1. Microcontroller

A microcontroller is a single-chip computer that is dedicated to performing a single task and execute one specific application. It has a memory, a programmable input/output peripheral, and a processor as well.The proponents have used several microcontrollers for the development of the project namely: ESP32[12], ESP8266[13], and Arduino Mega [14].

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2. Sensors

Devices that are used to respond and detect electrical or optical signals are called sensors. It converts physical parameter (i.e. light, speed, temperature, water pressure etc.) into a signal which can be measured electrically[18].

a. Water Pressure Sensor

   Pressure sensors can also be used to indirectly measure other variables such as fluid/gas flow, speed, water level, and altitude. The proponents used the water pressure sensor to measure the amount of pressure present in the main water line of the household and in the pressure tank used as the emergency water storage tank.

b. Gas Sensor

   A gas sensor or a gas detector is a type of chemical sensor which detects/measures the concentration of gas in its vicinity. The proponents used the MQ6 gas sensor to detect if there is a gas leakage in the area of the prototype created by them.

c. Light Dependent Resistor

   Light Dependent Resistors or photoresistors are often used to detect light intensityto change the operation of a circuit. The proponents used this sensor for the Electrical Load Control System to detect the light sensitivity in the area.

3. Relays

Relays are electromagnetic switches that are operated by small electric currents. The proponents used relays in the Electrical Load Control System and in the gas leakage monitoring system of the project.

4. Solenoid Valve

This is a type of valve that uses an electriccurrent to regulate the opening of fluid flow in a valve. The proponents used solenoid valves as inlet and outlet gates of the emergency water tank.

5. Mobile Phone/Device

A mobile device was used by the proponents as the medium between the user and the 3 systems that are to be controlled and monitored by the user.

6. Micro-SD Card Module

The micro- SD Card Module is a simple solution for transferring data to and from a standard SD card. The proponents used this module to store data in a comma separated value (CSV) format so that the data would be easy to analyze and interpret.

7. Bi-directional Logic Level Converter

The proponents used a bi-directional logic level converter so that the two microcontrollers (Arduino Mega and ESP8266) can be compatible and can communicate through serial communication.

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8. Interfaces Used

a. Broker (MQTT Broker)

MQTT stands for Message Queuing Telemetry Transport. This protocol is ideal for "Internet of Things" connected devices, and for mobile applications where an internet connection and battery power are at a premium. The proponents used the Mosquitto MQTT Broker for the lightweight communication between the microcontrollers and the mobile phone. Mosquitto is a lightweight open-source message broker that implements MQTT versions 3.1 and 3.1.1 [16].

b. Web Service using Node.js

The proponents used Node.js to create a web service that gets the current time and date in JavaScript Object Notation (JSON) format. Node.js is a platform built on Chrome's JavaScript runtime for building fast and scalable network applications easily[17].

This system block diagram can be broken down into numerous smaller flowcharts that clearly defines the operation of the subsystems.

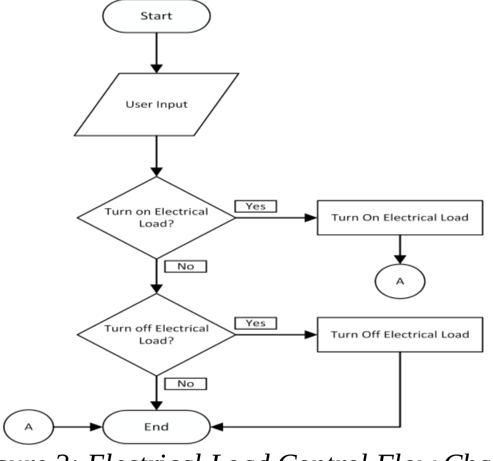

Figure 2: Electrical Load Control Flow Chart

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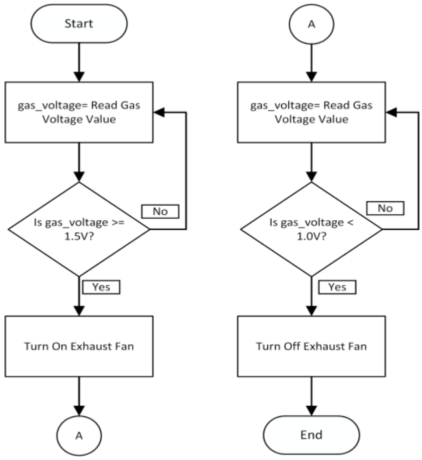

Figure 3: Gas Leakage Monitoring Flow Chart

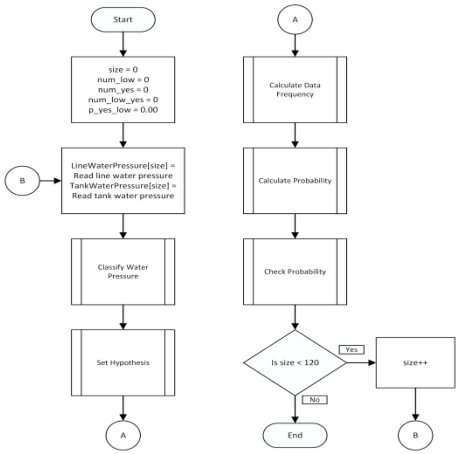

Figure 4: Emergency Water Supply System Flow Chart

3.0 RESULTS AND DISCUSSION

The proponents evaluated and tested the functionality of the system created, in responding to the user's input on the mobile application to the response time of the prototype.Table 1 shows the data collected in several trials to see the response time of the Electrical Load Control System in turning "on" the light bulbs.

Table 1:Response Time for Lightbulb to Turn On

Trial Number	Response Time for Lightbulb to Turn On
1	0.28 s
2	0.21 s
3	0.19 s

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4	0.20 s
5	0.26 s

The mean indicates the average response time of the light bulb being controlled through the mobile application. Getting the mean (average of the given data), the average response time is

$$Mean = \frac{Sum\ of\ all\ data\ values}{Number\ of\ data\ values} \qquad (2)$$

$$Mean = \frac{0.28 + 0.21 + 0.19 + 0.20 + 0.26}{5}$$

$$Mean = 0.23s\ (response\ time)$$

Table 2 shows the data collected in several trials to see the response time of the Gas Leakage System in opening the exhaust fan and notifying the mobile application the status of the presence of gas. The proponents tested the Gas Leakage System by spraying butane gas in the gas box.

Table 2:Difference in Time between the Mobile App and the Opening of Exhaust Fan

Trial Number	Actual Opening of Exhaust Fan after applying gas	Notification in mobile application after applying gas	Difference in time between mobile app and the opening of exhaust fan
1	5.53s	10.09 s	4.56 s
2	6.64 s	9.23 s	2.59 s
3	7.04 s	11.57 s	4.53 s
4	2.78 s	4.05 s	1.27 s
5	2.29 s	4.15 s	1.86 s

The value of the mean indicates the average difference when the exhaust fan was turned on upon sensing the presence of concentrated gas and the time the mobile phone received the notification.

$$Mean = \frac{Sum\ of\ the\ difference\ values}{Number\ of\ data\ values} \qquad (3)$$

$$Mean = \frac{4.56 + 2.59 + 4.53 + 1.27 + 1.86}{5}$$

$$Mean = 2.962s\ (average\ difference\ in\ response\ time)$$

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For the emergency water storage system, the tables show data about pressure collected every second through the water pressure sensor. The proponents were able to gather different sets of data points in which water pressure is given in psi, and through the proponents' classification and hypothesis, they were able to get the probability of water outage using the Naive Bayes' Theorem. Once the probability of water outage goes above 0.50 or 50%, the system will automatically check the pressure inside the storage tank to determine whether the tank is full or not. If the tank is not in the 'full' state, the inlet solenoid valve of the storage tank will be opened, thus, storing water from the main line in case the probability of water outage reaches a much higher level. When the probability of water outage reaches 0.90 or 90% up to 1.00 or 100%, and the water pressure from the main line is at a dangerously low level, the outlet solenoid valve of the water tank will be opened which means that the water which will be used by the household will be that from the storage tank. We classify the water pressure by: HIGH (16 onward), MEDIUM (7.01 to 15.99) and LOW (below 7).

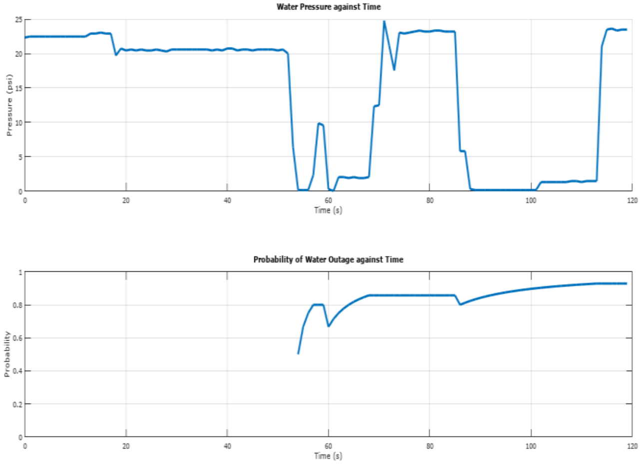

Figure 5: Probability and Water Pressure vs. Time - Trial 1

There are no instances where there is a probability of water outage at the first set of data points. This is because the water pressure in the main line from the first data point up to the 50th or so data point did not go down to a 'low' level, so applying Naïve Bayes' Theorem and using the proponents' assumptions on the formula, the result would be Not a Number (NaN). By the time the pressure went down, the graph for the probability of water outage started.

4.0 CONCLUSION

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The IoT-Home System: A Water Pressure, Gas Leakage and Load Monitoring and Control can benefit every household. This system allows and enables people to control their electrical loads and monitor if there are any gas leakages in their house using the Electrical Load Control System and Gas Leakage System respectively. It also allows them to monitor and check the water pressure in their main water line if there will be possible water interruptions. If the probability of having a water interruption is high, the Emergency Water Storage System will automatically store water for future purposes. The proponents created and developed a mobile application that serves as the controller of the Electrical Load Control System. For the monitoring, the mobile application displays the current status of the Gas Leakage System, and for the Emergency Water Storage System it will display the water pressure, and the probability of water interruption on the mobile application in real time. The following findings were observed after several trials and validations:The main objective of the project to develop a mobile application that controls the Electrical Load Control System, and monitors the Gas Leakage System, and Emergency Water Storage System were achieved because it had a quick response time in controlling and displaying information about the whole system.The whole system showed accuracy and good reaction time.

Thus, the proponents came up with following conclusion based on the findings obtained from the testing procedures conducted to attain the objectives of the study.The mobile application developed can be used to control the electrical load and can monitor the water pressure in the household.The system developed for the gas leakage can monitor the area near the gas tank and has pre-emptive measure if there will be a gas leak and will alarm the mobile application in real time.The system created for the water interruption can detect if there is a change in water pressure and will store water in the storage tank if there is at least a 51% chance of water interruption, and if the storage tank is not full. The water pressure versus time graph can be viewed in the mobile application in real time.

The following recommendations are possible improvement for the system.To obtain better response time between the mobile application and the actual prototypes, it is recommended to have better internet connection.For the Gas Leakage Monitoring System: If it is to be applied in a real kitchen, it is recommended that the exhaust fan to be used must have higher power so that dissipation of gas would be quicker.For the Emergency Water Supply System: The tank should be bigger for the system to be able to store large amounts of water in case of long-time water shortage.The proponents recommend adding a notification feature in case the appliances and/or lights are left turned on.

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