Safety Monitoring in Restaurants based on IoT

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Abstract. In the recent years, food and its connectivity with restaurants are inseparable. Kitchen plays the important role in restaurants. At the same time, it is more prone to accidents and hence safety in kitchen is a critical issue. The main reasons for accidents include cooking fires, flammable materials and gas leaks which should be addressed immediately. The purpose of this project is to monitor kitchen safety using Internet of Things (IoT). So, a smart safety monitoring system is proposed which mainly aims at ensuring safety in kitchen by monitoring the outbreak of fire, gas leaks and air quality(concentration of CO2). In addition to safety, the system also aids in comfort by notifying status and booking of new cylinder and maintaining the room temperature constant involving warming or cooling compared to outside temperature.

Keywords: Internet of Things(IoT) · Gas Leakage · CO2.

1 System Introduction

The annual report of National Fire Protection Association states that, in 2009, 784 people died of unintentional injuries due to non-fire exposure to gases [7]. The article about Why monitoring indoor air quality is important? by Nirvana expresses that exposure to the toxic air can lead to acute and chronic respiratory illnesses including asthma, lung cancer, pneumonia, systemic hypertension, chronic obstructive pulmonary disease (COPD), Legionnaires' disease, and humidifier fever [2]. Research from the Lawrence Berkeley National Laboratory indicates that performance of the brain's cognitive function declines by 2% for each degree above 25°C and by 4.7% for each degree below 21°C [3]. This proves that there are still many safety critical issues which should be addressed immediately, although there is no place without the footprint of technology nowadays. One of the major issues is accidents occurring in food industries especially in Hotels and Restaurants. Apart from cooking flames, gas leakage and its resulting explosions also contribute towards the restaurant fires.

Thus, the purpose of the project is to develop an efficient, smart safety monitoring system in restaurants to prevent accidents and enhance comfort in the working environment. Hence, the goal of the project is to that maintain safety and comfort in the kitchens by preventing and taking necessary actions in case of sudden fire, gas leakage and abnormality in air quality.

2 System Analysis

The user needs a system that mainly focuses on maintaining safety and comfort for better enhancement in the working environment.

2.1 Functional requirements

The following is the list of requirements that will fulfil the system goals.

R1 When the concentration of LPG gas and smoke level exceeds the threshold, the kitchen is ventilated (by opening the window and switching on the exhaust), alarm is turned on and an alert message is sent to the security officer, owner and fire department.
R2 Once the nominal indoor air quality starts degrading, an alert message is sent to the security officer and owner. and staffs are immediately evacuated from the kitchen until the quality is improved.
R3 If the room temperature is low i.e., below the absolute value, heater is increased, else decreased.
R4 If the weight of the cylinder is lower than certain limit, a notification is sent to the kitchen staff and the owner.

2.2 Non-functional requirements

R5 In case of power failure, the system should function properly.
R6 The system must work efficiently continuous, even in the absence of people.

For this system, both functional and non-functional requirements fall under mandatory requirements.

2.3 Use case diagram

The requirements of the smart safety monitoring system are expressed in the use case diagram as shown in Fig. 1.

3 System Architecture Design

The system monitors fire and gas leakage in the kitchen and upon increasing beyond the threshold value, ventilation process is started, an alarm is turned on. It also attempts to alert the concerned personnel through text message, notifying the situation even in their absence. Additionally, the system records the details of the sensor readings continuously, which could be later accessed by an authorised person or the management itself.

Another feature is that it reads the level of substances (concentration of gases) in the air like CO2, SO2, Particulate Matter (PM), NO2 and CO. Even a slight increase is communicated to the officials and staffs are immediately evacuated from the kitchen until the level of substances in air are maintained properly.

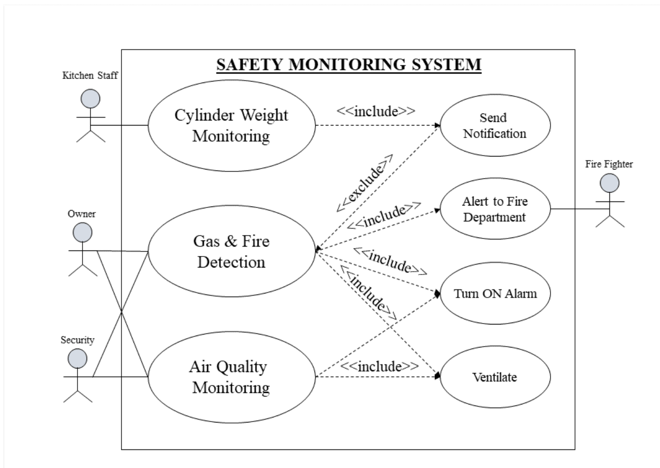

Fig. 1. Use case diagram for Smart Kitchen Safety Monitoring System.

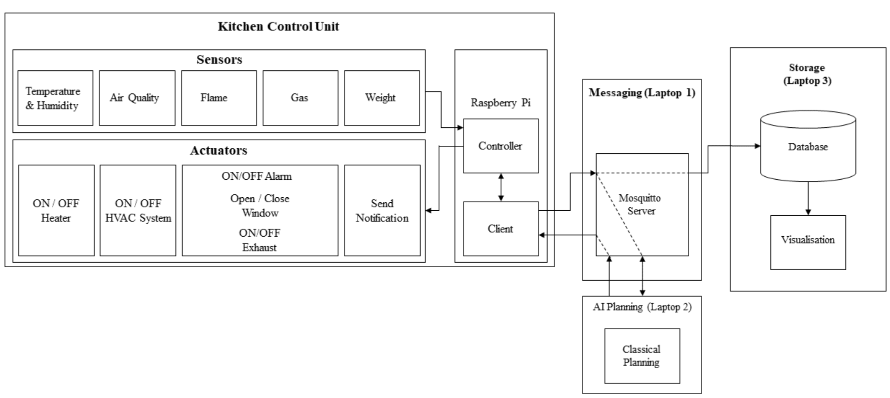

Fig. 2. System Implementation.

The temperature of the kitchen is also maintained at a constant level, where the heater is adjusted accordingly. The weight of the gas cylinder is measured at regular intervals and a message is sent to the kitchen staff regarding the status of the cylinder and cylinder booking. Moreover, Fig. 2 shows how the system can be remotely monitored via internet or through an app from laptops or smart phones.

3.1 System modelling

The system is distributed in the following layers: Physical, Ubiquitous, Reasoning and Presentation. The physical layers consists of sensors and actuators. The sensing devices deployed for the system implementation are as shown in Table 1.

Table 1. List of sensors and their functionality.

Sensor list	Functionality
Temperature	Determines the temperature of the room
Humidity	Quantifies the moisture content in air
Gas	Inspect the concentration of LPG
Flame	Detects the presence of fire
Air quality	Measure concentration of CO2 in air
Weight	Monitor the weight of the gas cylinder

In the ubiquitous layer, the system receives raw data from sensors related to the context of the physical environment (restaurant) especially physical conditions like temperature, humidity, air quality and hazardous gas concentration. The raw data is stored in a database to provide consistent view of the restaurant's status. The raw data is then forwarded to the reasoning layer, where decision making takes place to match the restaurant's adaptive configuration. In this system, decision making is handled by Artificial Intelligence (AI) planning. The generated plan is then executed using general device commands in the ubiquitous layer to trigger the actuators. The last layer is the presentation or application or user layer which helps the user to visualise the system status as shown in Fig. 3.

4 System Implementation

Raspberry Pi 4 Model B is used as an IoT for implementation. The sensors like temperature, humidity, LPG(gas), load cell, flame and air quality are deployed in the restaurant kitchen and dining room to facilitate the safety monitoring system. The behaviour of the sensors are simulated using simulatediot and the values are sent by the raspberry Pi over MQTT publish-subscribe protocol. The raw data is subscribed by the MQTT client and the data is used to generate the problem instance, which is fed as input to the Artificial Intelligence (AI)

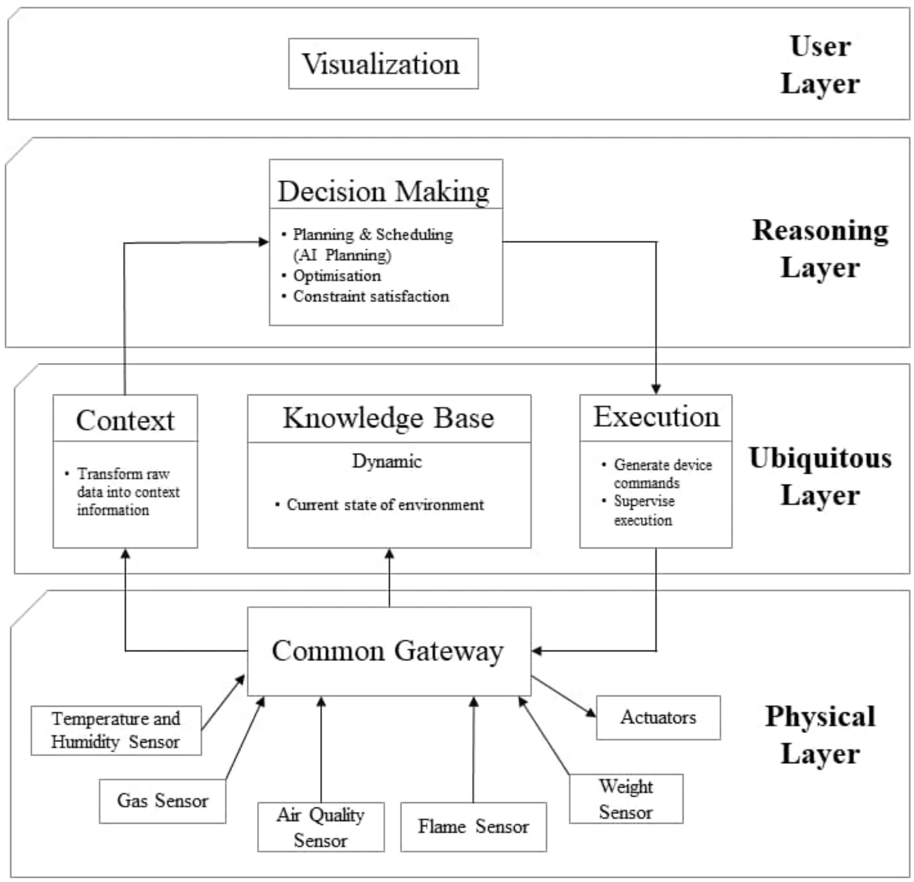

Fig. 3. System Architecture.

planner. The plan generated by the AI planner is subscribed by the raspberry Pi. The necessary actuation is done by the raspberry Pi based on the received plan. Simple LEDs are used to facilitate the behaviour of actuators. In addition, the sensed data is stored time to time for the purpose of further reference and visualization.

4.1 SimulatedIoT

The sensors listed in the Fig. 4 are custom simulated to match the actual sensor functionalities and system needs.

Sensors	Min. Value	Avg. Value	Max. Value	Threshold	Condition
Temperature	16	25	35	26	Uncomfortable
Humidity	55	65	75	70	Uncomfortable
Gas	200	250	2500	700	Leads to cold burns and life threat
Air Quality	350	400	2000	500	Affects health conditions
Flame	0	-	1	1	Life threat
Weight	15,3	25	29,5	27	Inconvenience

Fig. 4. Simulated sensor list.

4.2 Indirect Communication

In order to avoid direct coupling between the sender and the receiver over communication network indirect communication is preferred. This also aids scalability of the system without affecting the existing functionality of the system. Message queuing Telemetric Transport (MQTT) protocol is used for this application since our system requires only minimum network bandwidth and also it is light weight. MQTT utilizes publish-subscribe mechanism. It consists of a broker which acts as a hub for sending and receiving messages. Broker also aids in filtering the messages based on the topic of the message. Mosquitto MQTT broker is used in this project [4]. Certain features of MQTT protocol like topic of the message, payload (data) and the Quality of Service (QoS) are used for accomplishing the indirect communication.

Topic: Topic of the message acts as a filtering criteria using which the message can be redirected by the broker to the respective mqtt client.

Payload: It is the actual data to be sent/received. In this application, json dictionary format is preferred for sending the payload.

QoS: Quality of service (QoS) level “2” is used which indicates exactly one. This is because it ensures that only one copy of the message will get delivered.

A brief overview of indirect communication using MQTT publish-subscribe protocol is described in Fig. 5. In our case, the raspberry Pi controller and the systems in control room are configured with paho MQTT client [5]. The

Mosquitto broker is also hosted in control room. The raspberry Pi controller which is a MQTT client acts as a publisher in the kitchen environment initially. It publishes various simulated sensor values from the kitchen on appropriate topics. The paho MQTT clients in control room subscribes to all the sensor data using wildcard method. One Client is used for storing the data and visualizing it using matplotlib for real time plotting. Another Client, which is the AI planner will use the subscribed data as input to the problem instance generator and gives the problem file with sensor values and goal description. Once the plan is generated by the AI planner, plan data is published via mosquito MQTT host. The raspberry Pi in the kitchen environment subscribes to the plan data and uses it for actuating purpose.

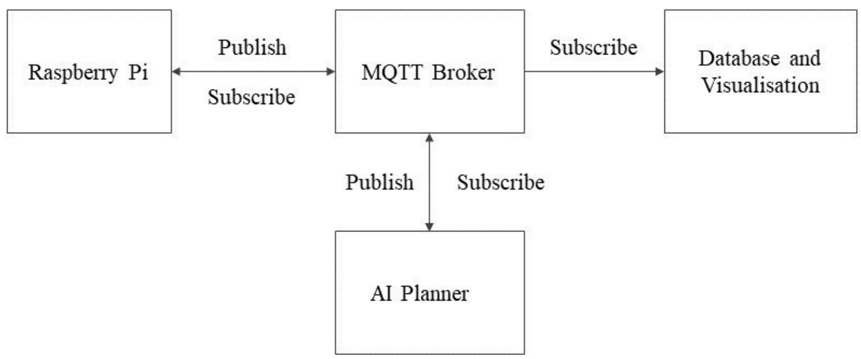

Fig. 5. Indirect Communication.

4.3 AI Planning

The system achieves maximum potential when its interaction with objects is made more powerful. This can be realised through Artificial Intelligence (AI) planning. The goal of AI planning is to develop autonomous intelligent machines, to perform tasks without human intervention, based on the surrounding environment.

There are two types of planners namely Domain-independent and Domain-specific planners. Domain-specific planners use specific knowledge about the problem to find a solution efficiently. They are used for a specific problem. If the problem is different and unrelated to the planning domain, these planners may be inefficient at finding a plan [6]. Generally, domain-specific planning is a good option for planning with efficient solutions. Domain-independent planners use generic techniques without any knowledge of the planning domain. It is not necessary to develop new plan for every problem, as it will work for any planning domain. In theory, it is a bit slower than domain-specific planning [6].

PDDL Planning Domain Definition Language is a standard language for classical planning tasks. The five important sections in PDDL are: Objects, Predicates, Initial state, Goal Specification and Actions. The system must achieve four goals. The actions to be executed to attain the goals are: switch on/off heater, on/off ventilation, on/off hvac system, send notification.

4.4 Visualization

There involves another MQTT client which will subscribe for the sensor data published from the Pi and it is stored time to time in a database, which is a .csv file.

And using the matplotlib library, the collected sensor information is visualized as plots. The Fig. 6 shows the graph of different sensor values and its variations.

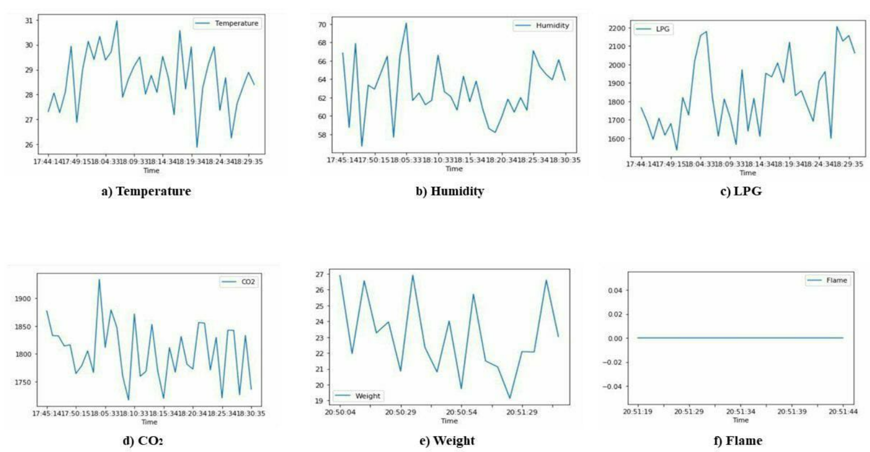

Fig. 6. Output graph of sensor data.

5 Results and Conclusions

The application– Safety Monitoring in Restaurants using IoT aims at ensuring safety in the kitchen by automation and control of the kitchen atmosphere in restaurants. This application aids in controlling fire break out, inhalation of harmful gases and air quality in the dining environment. Further it provides ease of monitoring, by providing graphs to visualise the sensor statistics and also does necessary actuation in case of emergencies. The system can be extended to maintain the room air quality and cooking gas leakage protection in residential as well other non-residential buildings and also it ensures high levels of hygiene and low human interaction. It also senses and notifies the responsible person about the change of a new gas cylinder as add-on.

GitHub link of our project: [1]

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All links were last followed on July 13, 2020.