ECE1528 Term Project

Smart Kitchen Air Quality Monitoring and Controlling Ventilation System

Divya Sivakumaran

Adam Pietrewicz

Introduction

According to the World Health Organization, approximately 3.2 million people face premature death annually due to household air pollution caused by cooking [1]. Additionally, in Taiwan women have a higher risk of lung cancer than men, even though their smoking rate is 10% [2]. This study has shown that women that spend a longer time cooking, increased their risk of cancer. With the right ventilation in the kitchen, the concentration of harmful gases can be reduced which can decrease the risks of smoke inhalation. This project aims to address this issue by creating an IoT system that can monitor the air quality in the kitchen and control the ventilation system to increase airflow. This real-time monitoring can decrease the smoke inhalation risks and allow for a safer cooking environment.

Project Description

The proposed project is a smart kitchen air quality system that a user can install in their home kitchen and monitor the air quality status wirelessly through a computer. The system comprises portable air quality sensor modules that can be placed around the desired room (even installed on an oven air vent) that connect to a cloud server and upload their air quality readings. This data will be analyzed and displayed to the user on a computer application where they can read their air quality status. In addition, the system includes fans that are placed within the kitchen and automatically controlled by the system depending on the detection of harmful gases or smoke. The user may also manually control the fans as well.

Requirements

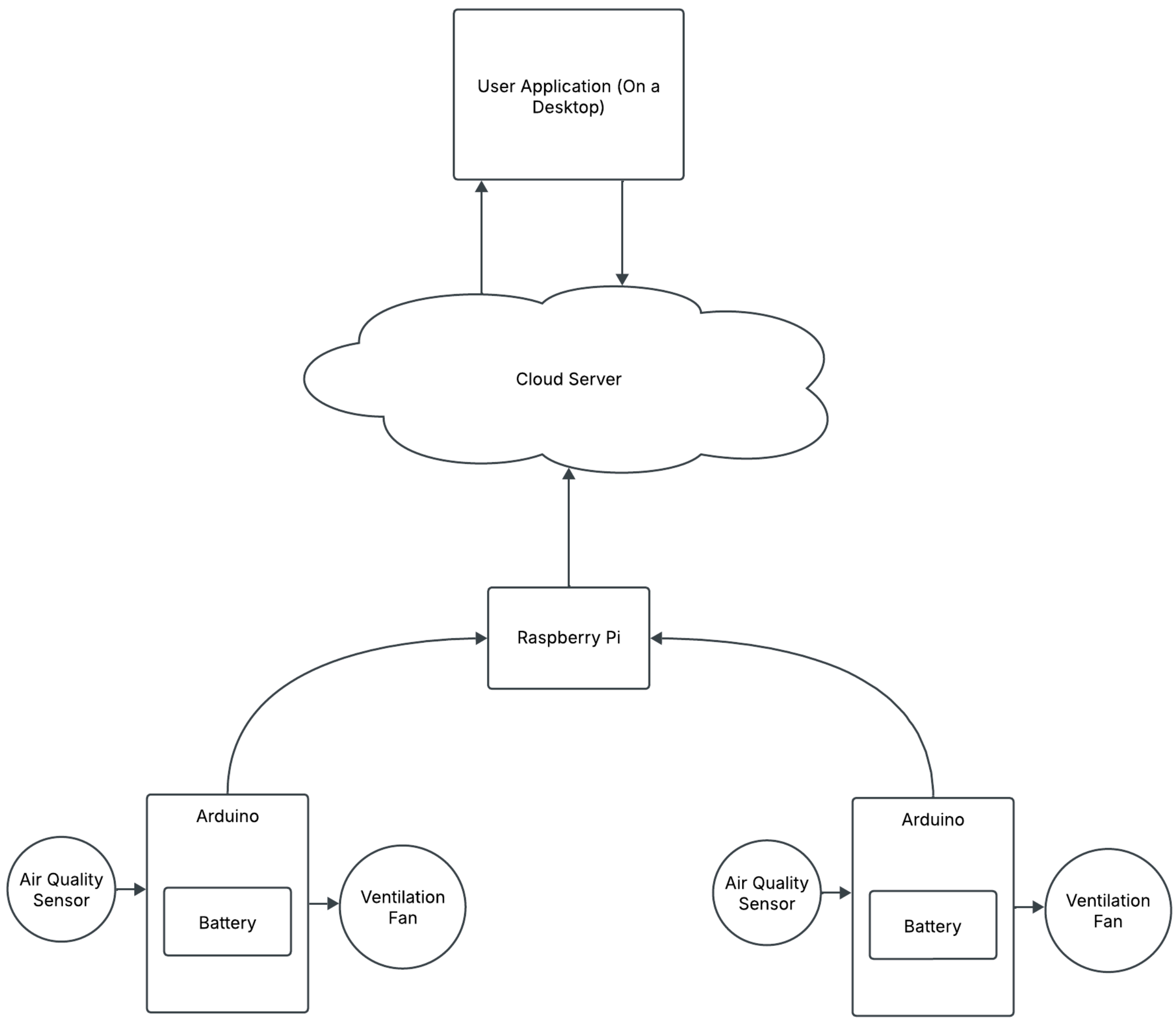
<u>Functional Requirements:</u>

1) Monitor and detect the air quality metrics such as gas levels of carbon monoxide, carbon dioxide, methane, volatile organic compounds (VOCs), smoke, and other harmful gases using an air quality sensor
2) Send air quality readings to cloud
3) Access historical readings and measurements of air sensors from the cloud
4) Operate fan ventilation automatically based on detected gas levels, and manually through the user application
5) Receive notifications on the user application when there are threatening gas levels or an error with the ventilation system

<u>Non-Functional Requirements:</u>

1) The air sensor system must be energy efficient (battery powered?)
2) Securely store sensor data on cloud to prevent unauthorized access
3) User application must be easy to operate and interact with

System Block Diagram



System Components

1. Air quality sensors:
    a. MQ135 Air Quality sensor [3]
    b. DHT11 Temperature & Humidity Sensor [4]
2. Arduino:
    a. WeMos D1 ESP8266 WiFi Board [5]
3. DC Power Supply:
    a. LiPo Batteries
4. Ventilation Fan:
    a. Adafruit Miniature 5V Cooling Fan [6]
5. Cloud Server:

        a. Google Kubernetes Engine on Google Cloud
6. Raspberry Pi:
    a. Raspberry Pi 3B+
7. User Interface:
    a. Streamlit Python Library

High-Level Workflow

1) Sensors will make air quality readings every minute and it will be displayed on an LCD display.
2) The measurements will be sent to the cloud, which will be responsible for sending out a notification if the air quality surpasses the safe threshold.
3) The kitchen fans and ventilation will be adjusted according to the reading to minimize smoke inhalation.
4) Users will have access to a dashboard that can display the historic readings.

Software Tools for Development

1. Arduino IDE:
    a. Will develop software for the WeMos D1 ESP8266 WiFi Boards to interface with our sensors and actuators (air sensor, ventilation fan, LCD screen) and to connect to the Raspberry Pi MQTT broker.
2. Raspberry MQTT Broker:
    a. Will run the MQTT broker Docker image on the Raspberry Pi and send the readings to the cloud server
3. Google Kubernetes Engine (Google Cloud Platform):
    a. Will have a server that will receive the measurements and host the Steamlit User Interface.
    b. Will create a Docker Image that can be used by GKE which will contain the required artifacts.
4. Any preferred software IDE:
    a. Will use Python and Streamlit library to develop the front-end application.

Limitations

Given the limited budget and resources, the sensors used for this project may not provide the most accurate readings. This can decrease the overall reliability of the data. Additionally for portability and demo purposes, a miniature fan will be used rather than a complete HVAC or kitchen range hood.

Feasibility and Risks

Our project integrates the key concepts and configurations explored in our lab assignments so far. While additional learning may be required to develop the cloud infrastructure and user interface software, these tasks can be efficiently divided among team members to ensure the successful implementation of a working demo. The project's components (air sensors, cloud, and user interface) are well defined and align with its objectives: developing an IoT prototype system that addresses the smart home and safety industry while functioning as a distributed system. This project presents a practical and well-structured approach to distributed system design, making it both feasible for initial development and scalable into a polished, high-quality solution.

Conclusion

This project will aim to reduce health risks and improve kitchen safety for Canadians. Unknowingly, many Canadians are exposed to dangerous gas, so with an affordable product that can be easily integrated into kitchens, we can help mitigate this. After completing the initial scope, some future ideas of development can be to expand this functionality beyond the kitchen and integrate with AI for more detailed findings. These action items are not feasible in the current timeline, but will be improvements to consider down the road.

References

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