POSTER: Affordable Automatic Air Quality Monitoring System for At-risk Homes

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ABSTRACT

This research aims to improve indoor environmental justice (EJ) outcomes for elderly individuals residing in historically under-resourced communities of color in Knoxville, TN. To achieve this goal, we have created an autonomous air quality monitoring system that continuously tracks the temperature and CO2 concentrations inside the building. The user interface will display alert messages to remind users to take the essential precautions to ensure their health and safety in the event of hazardous conditions. In addition, the system includes a notification mechanism that alerts loved ones and neighbors to step in when a risk cannot be properly mitigated by a single person. In Knoxville's historically under-resourced communities of color, we successfully implemented and tested our autonomous air quality monitoring system.

KEYWORDS

Indoor air quality, health, well-being, sensors, technology, IOT, affordability, smart thermostats, weather, alerts, safety, Android

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1 Introduction

Poor air quality is associated with numerous health issues, including respiratory diseases, allergies, and headaches, among others. In addition, certain types of poor air quality have been shown to be linked to early-onset dementia in older adults [1]. Recent advancements in internet-of-things technologies have resulted in the development of many networked in-home air quality sensors that offer feasible and affordable solutions to monitor air quality for home use. Despite the availability of these devices, many individuals lack the necessary resources and knowledge to utilize them effectively. The lack of social support systems and awareness of such tools, especially among older adults with higher risk factors, exacerbates this issue. As such, our current experiments focus on homes with at least one adult aged 65 or older, who identifies as Black and resides in designated Environmental Justice communities.

This system provides homes with a central Android-based interface for monitoring real-time air quality via off-the-shelf, affordable AWAIR air sensors, Ecobee smart thermostats, and local weather data. By analyzing data from these sources, when potential safety hazards are detected that can be rectified or mitigated, "air quality alerts" are generated and pushed to our interface. These alerts serve to notify the home of the need to adjust the environment accordingly. If these factors are left unmitigated by the individual, our system notifies family members, neighbors, caretakers, or other authorities to intervene, if necessary. By providing families and their support network with

actionable information and alerts, we hope to empower them to take proactive steps to improve their indoor air quality and ensure a healthy living environment. Further, through this system we aim to both automate and widen the potentially insufficient support networks of at-risk individuals with no one to reach out to in our community.

2 System Design

The system is comprised of many different "parts" that modularly interconnect with each other. The most important component of this project is the Android application, as it is being used directly in the homes by individuals. However, much care was taken in selecting additional physical equipment and creating the centralized backend as well.

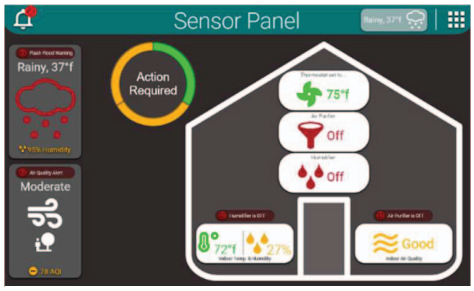

Figure 1: Initial Prototype Interface

Flutter for Mobile App Development

Google's Flutter framework was selected for this project due to its cross-platform compatibility. Applications can be easily developed using only Flutter's system, which can then distribute natively across all platforms with little extra work. Since Flutter relies on Google's open-source Material Design framework, initial user interface prototypes were designed via Adobe XD's prototyping tool. As UX focus groups proceed, features are being implemented in the application itself.

Sensors & Hardware

To allow this system to be flexibly and cost-efficiently distributed, the client-side application is provided to homes with a Samsung Galaxy Tablet. The system measures homes' air metrics via WiFi-connected commercially available AWAIR sensors, which are capable of measuring CO2, temperature, humidity, TVOCs, and particulate. Metrics about the status of homes' AC is collected via an Ecobee smart thermostat. To ensure system stability (being particularly critical given the nature of health-related monitoring), devices are connected to a battery backup power supply and connect to the internet through provided mobile WiFi hotspots.

Backend & Server

Homes' air quality data is periodically processed remotely via our own server. Data is collected through AWAIR and Ecobee's provided APIs, and analyzed on our server while also being distributed to users' tablets for display. When an alert-worthy datapoint is noticed (dangerously high/low temperature/humidity, high pollutants, weather alerts, etc) notifications are generated and sent to a given home. If no action is taken, alerts can be escalated, either increasing in alert frequency to the home itself, or by contacting user-provided family members, neighbors, or local authorities to intervene and ensure any harmful conditions are mitigated as quickly as possible. Through systems like Twilio we are able to automatically send SMS messages and calls to user-designated support systems, meaning there is no external reliance on adoption of our system to ensure community intervention.

3 Preliminary Results

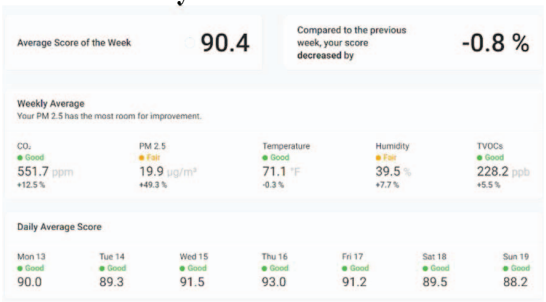

Figure 2: Aggregated results from AWAIR air sensors over one

Initial testing is currently underway as of February 2023. Ten functional systems are currently installed in homes, and UX focus group testing is being conducted to refine the interface of the application itself. The response from in-home users has been very positive, and our team plans to expand to more test homes while improving function and design in the coming weeks.

4 Conclusion

We have developed and rigorously tested a prototype system for the automatic monitoring of air quality in residential homes. The prototype system has been successfully deployed in numerous homes across Knoxville, where we assessed its feasibility and usability. Initial testing showed a positive acceptance of the system, though several issues have been recognized. In a few homes, the system did not function properly due to setup issues. Additionally, one system was rendered inoperable due to a hardware malfunction. However, most homes reported accurate and continuous monitoring of air quality. The initial success of the systems gives us confidence in the potential of the technology to develop a transformative product that is in close conjunction with EJ communities, utilizing connected technologies to advance indoor EJ outcomes.

ACKNOWLEDGMENTS

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REFERENCES

[1] R. Dosunmu, J. Wu, M. R. Basha, and N. H. Zawia, “Environmental and dietary risk factors in alzheimer’s disease,” Expert Review of Neurotherapeutics, vol. 7, no. 7, pp. 887–900, 2007.