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Air Quality Monitoring Systems with Multiple Data Sources for Ho Chi Minh City

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Abstract

In this paper, we present our proposed air quality monitoring system with multiple data sources for smart cities. We deploy our system in one of the biggest cities in Vietnam, Ho Chi Minh City. The proposed system uses data collected by our sensors and extracted from remote sensing images. The system also allows users to contribute by provide alerts through a portal. With data collected from sensors, we can provide exact values of fundamental parameters for calculating air quality index (AQI) while data extracted from remote sensing images help governors estimate the AQI values in surrounding areas without sensors deployed. This estimation although cannot provide exact information as sensors, it helps us to quickly understand AQI in an extremely large area with low cost. Along with these data sources, notifications from users also allow governors to react unawareness problems faster. Experimental results show the error (difference) between our systems and commercial devices is less than 24% for sensoring system and less than 9% for remote sensing images estimation. The sensoring system presented in this paper is low-energy consumption when using only 900mW in average.

Keywords: Air quality index, air pollution, smart city, fine particulate matter, remote sensing images

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1. Introduction

According to World Health Organization, there are about 12.6 millions of people died due to unhealthy environment [1]. In Vietnam, this number is about 52,000 people per year. Therefore, air quality monitoring systems, especially in big cities, have become essential demands due to the high number of inhabitants as well as low air quality index compared to other cities or rural areas.

Although big cities suffer from low quality of air, smart cities provide many benefits for people. According to the Smart City Tracker report, as of Q3/2017 [2] there exist more than 400 smart cities in the world. Along with benefits from smart cities like smart transportation or technology-based applications, inhabitants in smart and big cities need to have a better AQI for their healthy. Therefore, a smart air quality monitoring system that can collect multiple sources of data is an essential demand. The air quality monitoring system can help governors quickly react to air quality hazardous issues to bring a pleasure environment back to inhabitants in the city.

Many countries in the worlds have built and operated air monitoring and air quality forecasting systems. These systems can collect and predict levels of harmful gases such as O3, NO2, or CO and fine particulate matter (PM2.5) [4][5][6]. These parameters are used to announce early alerts to governors and local inhabitants so that they can have reactions to adapt these harmful issues such as idling factories, prohibiting vehicles in the city centers or using green vehicles [7].

		(µg/m3) from images	(µg/m3) from sensors	
LANDSAT 8	14/04/2021	16.4	16.6	1.21%
LANDSAT 8	29/03/2021	15.4	16.0	3.89%
MODIS MOD11A2	17/04/2021	14.3	15.4	7.69%
MODIS MOD11A2	08/04/2021	16.2	15.9	1.85%
MODIS MOD11A2	31/03/2021	15.6	16.1	3.22%

Table 4. Values of land surface temperature from images and from sensors

Images	Date	Temp. (°C) images	Temp. (°C) sensors	Error
LANDSAT 8	14/04/2021	35.22	33.1	6,.01%
LANDSAT 8	29/03/2021	34.28	31.2	8.75%
MODIS MOD11A2	17/04/2021	31.84	30.4	4.52%
MODIS MOD11A2	08/04/2021	28.50	31.0	8.77%
MODIS MOD11A2	31/03/2021	32.72	34.1	4.21%

5.3 Energy consumption measurement

The model in Figure 9 is used to measure the current and the voltage used for our sensoring system. In this model, "Load" means our system. We connect a one-ohm resistor serially with our system to calculate the current used by the system. Oscilloscope is used to measure voltage between A and B then B and C. We supply a power of 5V for the entire system (U_{AC} = 5V).

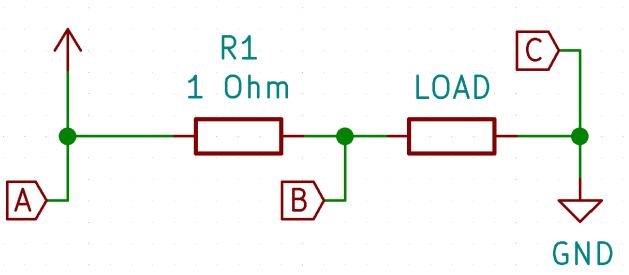

Figure 9. Current used measurement model

Table 5 presents the values of current, and voltage used for our system in 5 different measurement times. According to the table, in average, we need the current of 176 mA and the power supply of 4.88V for the proposed system. Therefore, the system consumes in average 900mV. Compared to other systems reported in the literature, our use is low-energy consumption.

Table 5. Results of current and voltage measurement

Time	1	2	3	4	5	Average
Current (mA)	174	173	176	176	180	176
U_{BC} (V)	4.89	4.89	4.89	4.89	4.85	4.88

6. Conclusion

In this paper, we introduce our air quality monitor system with multiple data sources that can be applied in smart cities like Ho Chi Minh City. We use data collected from sensors and extracted from remote sensing images to monitor the quality index. We build our sensoring systems with sensor nodes and gateway nodes. Based on values collected from sensors, we calibrate the remote sensing images processing models to estimate values of fine particulate matter and land surface temperature. The models can be used to evaluate air quality index in locations where we have not yet deployed sensoring systems. To combine all components to a complete system, we build cloud services including APIs for collecting data as well as database for storing values. The cloud services also provide a graphic user interface portal for users and governors to explore the air quality index. The system is able to receive notifications from users when they aware any hazardous situations at their places. When compared with other commercial devices, values measured by our systems are different up to 24% at most for sensoring while 9% at most with remote sensing images estimation. The proposed system is low-energy consumption when using only 900mW in average.

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