Journal of Young Scientist, Volume VII, 2019
ISSN 2344 - 1283; ISSN CD-ROM 2344 - 1291; ISSN Online 2344 - 1305; ISSN-L 2344 – 1283

MOBILE AIR QUALITY MEASUREMENT USING UNMANNED AERIAL VEHICLE AROUND CITY CENTER

Senanur SAMUR, Fadime Hazal GÜNEŞ

Scientific coordinators: Assoc. Prof. PhD Ergin YILMAZ, Prof. PhD Yılmaz YILDIRIM

Zonguldak Bulent Ecevit University, İncivez Mahallesi, Üniversite Cd., 67100 Merkez, Zonguldak, Turkey, Phone: +90 372 291 11 00, Fax: +90 372 257 21 40

Corresponding author email: senaaasmr@gmail.com

Abstract

The aim of this study is to determine the air pollution occurring in city centers or it's around by means of Unmanned Aerial Vehicle (UAV) equipped with some of the sensors. Today, the air quality in the city centers is realized via stationary air measuring stations located at the determined points of the city. This method provides very safe data depending on the number of stations that make measurement. However, when the city centre is rugged and the measurement period is considered, it is clear that it is not an efficient method. In this study, a more useful measurement method will be produced by using an UAV which is also a practical method to solve this problem. It is planned to measure some of the air pollutants such as CO_2, CO, NO_2, CH_4, and some meteorological parameters such as temperature and pressure, using a modular UAV system to be designed in the study. Due to the advantages of the modular design system, a practical measurement can be carried out for different gases if required.

Keywords: *Air quality, city center, mobile, UAV, vertical temperature.*

INTRODUCTION

UAVs are used in the field of agriculture, mining, media, search and rescue operations, military, health, transportation, engineering, and environmental. If they are used in the field of agriculture for civil goal, UAVs can be used for diseases detection in plant, weed flora detection, sensitive chemical practice, check of animals, water stress, and growing crops-maturity detection. Thanks to the advantages provided by UAVs, their usage in agriculture is increasing day by day (Türkseven et al., 2016). The UAV system can carry a high-resolution camera. The camera is used for taking photos of forestland sources, ways, flow canals and provide to evaluate these photos (Gülci et al., 2017).

In search and rescue operations, fast coverage of problematic field in the disaster area, the detection of casualty and provide assistance are very important issues. Methods are developed for mapping of disaster area via UAVs. The image map is used for detection of people. According to experimental results, UAV can be used in research and rescue operations (Yavuz et al., 2016).

The target identification and diagnosis in real time is one of the most important skills required for security forces in order to achieve success in the military operations (Ergün and Sönmez). In a military application, the UAVs can be sent to dangerous areas before soldiers and the danger or the enemy can be detected. At the same time, target detection can be made by night vision and thermal cameras carried by UAVs.

In the field of the health sector, UAVs are used for blood and pathology samples transportation between two hospitals. This method was developed by the EOC hospital group in Switzerland (Mion, 2018). The other use of UAVs is to transfer devices for first-aid to reduce delay occurring due to traffic density.

UAVs are used in many areas of engineering, for example, in the field of civil engineering, UAVsare used for conducting bridge inspections by optimizing an unmanned aerial system (Cho, 2018).

One of the areas where UAVs are used is environmental studies. In areas such as the detection, sampling, and analysis of environmental pollution that occur by natural and unnatural means, the regions where people cannot reach physically can be reached with UAVs.

For example, the extent of the environmental disaster caused by volcanic eruptions and the detection of pollutants in the resultant gas and particle structure can be made with UAVs. Again, the volcanic activity, seismic tremor and gas emissions, the impending explosive activities occur in the peak crater area of the volcano, and the new technology UAVs are used to understand the mobility of these events.
Air pollution results from the combination of high emissions and unfavourable weather. Air quality has hazardous effects on health, ecosystems, heritage, and climate. Due to sensitive to climate change, air quality is strongly dependent on weather (Holman, 1999; Akimoto, 2003; Patric, 2008; Frumkinand Hess, 2008; Carvallo et al., 2009).
Air pollutants such as nitrogen oxides (NOx), Sulphur dioxide (SO2), volatile organic compounds (VOCs), methane, ozone, particulate matter (PM) have both natural and anthropogenic sources. Particulate matter (PM) includes sulfate, nitrate, organic carbon, elemental carbon, soil dust, and sea salt. The first four components are mostly present as fine particles less than 2.5 mm diameter (PM2.5), and these are of most concern for human health. Sulfate, nitrate, and organic carbon are produced within the atmosphere by oxidation of SO2, NOx, and NMVOCs. Ozone is produced in the troposphere by photochemical oxidation of CO, methane, and NMVOCs. Carbon particles are also emitted directly by combustion (Jacob and Winner, 2009).
Although air pollution in major cities tends to increase during the build-up phase due to levels of sulfur dioxide and soot, in recent decades, however, the increasing traffic in the cities has switched the attention to CO, nitrogen oxides, organic compounds and small particles (Fenger, 1999).
Air quality instruments for quantitative measurements of gas pollutants can be separated into sensors and measurement systems. Some of the gas or particle analyser methods for real-time measurements include UV fluorescent, chemiluminescent, IR techniques and Beta gauge absorbing. Devices for measurement systems are usually very bulky, cost-intensive and require long warm-up time (several minutes to an hour) and long response time. Sensors' detection is mainly based on electrochemical measurement principles. Although sensors have typically a limited response time, limited accuracy, often show signal drift and a limited lifetime, they are more practical than the measurement systems (Winegar and Keith, 1993; Bucholtz, 1997; Degner and Ewald, 2018).
Air quality standards for health protection for some of the pollutants are given in Table 1 (EU, 2017).

Table 1. Air Quality Standards for The Protection of Health of The EU Ambient Air Quality Directions for NO_2,SO_2, O_3

Pollutant Averaging Period	µg/m^3	ppb$_v$
NO_2 1 hour average	200	105
annual average	40	21
Alert (3h, 100km^2)	400	209
SO_2 1 hour average	350	131
1 day average	125	47
Alert (3h, 100km^2)	500	188
O_3 1 hour average	180	90
8 hour average	120	60
Alert threshold	240	120

In this study some of the gases (CO, NH_3, NO_2, CH_4, CO_2, vb.) that cause air quality problem or cause greenhouse gas effects can be detected or sampled by using an UAV carrying sensors at the background, at the stack or at the stack level dispersion area, at the area that is not easy to sample the air or the area that is harmful to human health.

MATERIALS AND METHODS

A) Properties of UAV

Figure 1. A prototype of the UAVe

The designed UAV prototype is shown in Figure 1. Due to its ability, the UAV will have 2 km coverage and it also stays approximately 15 minutes in the air without power supply. Image around the city area will be taken with the camera and will be saved to the SD card. The UAV also has a GPS that detects the location. The load carrying capacity of the UAV will be approximately 2.8 kilograms. It will be used Li-Po battery and this battery property: 11.1volt, 5200 mAh etc. It will be used brushless motor (4 pieces and peace of 52 g) at UAV. Revolutions per minute of this motors 960KV and have long lived. It was preferred to "Naza m lite" as a flight control card. The data will be saved to SD card while UAV is flying. Graphics will be analyzed when UAV land down. The UAV's block diagram is shown in Figure 2.

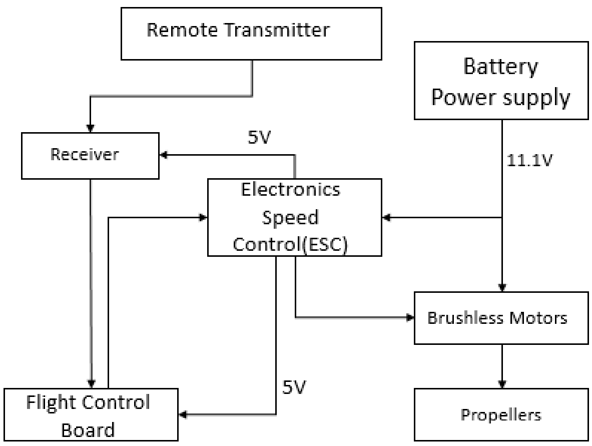

Figure 2. UAV block diagram

B) Multichannel Gas Sensor Components for Air Sampling (MGSC)

The block diagram of gas sensing is given in Figure 3.

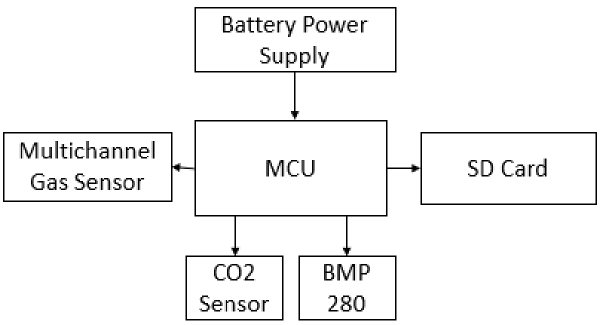

Figure 3. The system of gas sensing block diagram

"Grove Multichannel Gas Sensor (GMGS)" will be used for pollutant gases in the air and "Ccs811 Sensor Module" will be used for CO_2 with the UAV. In addition, BMP 280 sensor module will be used for vertical pressure and temperature measurement with the UAV. GMGS can detect many types of harmful gases and thanks to 3 channels three gases can be detected simultaneously. Therefore, with this sensor, the concentration of more than one gas will be analysed at the ambient air. With this multiple channels of the sensor, the detectable gases include Carbon monoxide (CO) 1-1000 ppm, Nitrogen dioxide (NO_2) 0.05-10 ppm, Hydrogen (H_2) 1-1000 ppm, Ammonia (NH_3) 1-500 ppm, Methane (CH_4) >1000 ppm. GMGS's sensitivity is between 1.2-50 ppm (URL(1)) and BMP 280 sensor, for temperature between -40 and +85 ◦C with an accuracy between +/- 1 ◦C URL(2).

C) Methods

Many different methods have been developed for ambient air quality measurement. One of the methods developed for mobile air quality measurement application is the mobile vehicle measurement method. Due to the advantages of this method, air pollution measurement is carried out with the aid of gas sensors placed on buses and cars travelling to different points of the city. The data collected from different points in the city are transmitted to a single centre and the air quality maps of the cities are produced using the data (Carvalho and Lopes, 2009).

Another method for air quality measurement is the fixed point measurement method that the most used traditional air quality measurement method. The data can be obtained by means of air quality measurement stations or the sensors placed in a fixed point station (Liu et al., 2011).

The aim of this project is to determine the air quality of the region by measuring the concentration of some of the air pollutant using a UAV equipped with the sensors. The UAVs provide excellent potential for air quality data collected at elevated height with a spatial and temporal resolution. It is also aimed to reduce the measurement process and costs for air quality studies in cities or its surrounds. As the system is modular, different analyses can be made by using different sensors.

In the measurements that will be made using an UAV, the data will be produced for both air quality and some meteorological parameters.

The data will be recorded to the SD card on the system and the air quality levels of the measured areas will be analysed.

RESULTS AND DISCUSSIONS

In this study, real studies could not be done in the field. However, preliminary experimental studies have been carried out for some gas measurements. The results are given in Table 2. For gas measurements, the unit is in ppm. The last two columns of the table show the average and standard deviation of the measurements. When the results are examined, the mean and standard deviation are very low. This shows that the accuracy of the measurement is high, and the sensor has the feature to be used in the gas measurements in the field.
The temperature and pressure values are shown in the Table 3. They were obtained at different altitude without sensor not being placed in the drone.

Table 2. Preliminary results

H2	**CH4**	**CO**	**NO2**
1,96	6885,45	8,36	0,06
1,96	6885,45	8,36	0,06
1,96	6606,61	8,27	0,06
1,92	6606,61	8,27	0,06
1,92	6606,61	8,27	0,06
1,944	**6718,146**	**8,306**	**0,06***
0,019596	**136,6031**	**0,044091**	**0****

*: Arithmetical average **: Standard deviation

Table 3. Measurement results: Temperature, Pressure

ApproxAltitude	0 m	11.23 m
Temperature	11.08 ◦C	12.90 ◦C
Pressure	101679.75 Pa	101573.63 Pa

CONCLUSIONS

Pollutant gases and some of the meteorological parameters will be measured using a UAV equipped with the sensors for an air quality study. The main point of this study is to measure air quality with some meteorological parameters spatially and temporarily using the UAV in a mobile manner. The method can be used not only in city centres or its surrounds but also in the areas where heavy traffic occurs and the environment that is dangerous for human health. It might also be used for air pollution sampling, measurement of stack gases in industrial areas, or gas detection in forest fires.

ACKNOWLEDGMENTS

This project was carried out with the supported of Biomedical Engineering Department Staff Dr. Ergin YILMAZ and Environmental Engineering Department Staff Dr. Yilmaz YILDIRIM.

REFERENCES

Akimoto H., 2003. Global Air Quality and Pollution: State of The Planet, p. 1716-1719.

Bucholtz, F., Ed., 1997. Environmental Monitoring and Instrumentation, Optical Society of America, Washington, D.C.

Carvalho V., Lopes J.G., 2009. City-Wide Mobile Air Quality Measurement System: IEEE SENSORS 2009 Conference, p.546-551.

Cho A., 2018. Taking A Closer Look at Bridges: Cover Story Inspection Technology, p. 22-26.

Degner M., Ewald H., 2018. Mobile gas sensing system for detection of combustion pollutants – suitable for UAVe based measurements, 2018 Twelfth International Conference on Sensing Technology (ICST), Limerick, Ireland.

Ergün S., Sönmez S., The Integration and Usage of New Security Related Technologies in Counter Terrorism: The Usage Model of Terahertz Imaging on UAVs. P.1-29.

EU, 2017. Air quality in Europe — 2017 report, European Environment Agency, Report No 13/2017, ISBN 978-92-9213-920-9

Fenger J., 1999. Urban air quality, Atmospheric Environment 33, 4877-4900.

Frumkin H., Hess J., 2008. Matters, p. 435-445.

Gülci S., Akgül M., Akay A. E., Taş İ., 2017. Usıng Ready-to-Use UAVe Images in Forestry Actıvıtıes: Case Study of Çınarpınar İn Kahramanmaras, TURKEY; The International Archives Of The Photogrammetry, Remote Sensing And Spatial Information Sciences, Volume XLII-4/W6, 2017 4th International Geoadvances Workshop, 14–15 October 2017, Safranbolu, Karabuk, TURKEY, p. 51-53.

Holman C., 1999. Sources of Air Pollution, Air Pollution and Health, Ed. S.T. Holgate, J.M. Samet, H.S. Koren, R.L. Maynard, Academic Pres, U.S.A..

Jacob D. J., Winner D.A., 2009. Effect of climate change on air quality, Atmospheric Environment 43, 51–63.

Liu H., Kim M., Kang O., Sankararao B., Kim J., Yoo J.K., 2011. Sensor Validation for Monitoring Indoor Air Quality in A Subway Station: Indoor And Built Environment, p. 205-221.

Mion F.U., 2018. Flying UAVes to Exchange Lab Samples: Services Innovation by The Swiss Multisite Hospital EOC: Service Design and Service Thinking

in Healthcare and Hospital Management, p. 463-479.
Patric L., 2008. Climate change, Air Quality, and Human Health: 2008 American Journal of Preventive Medicine, p. 459-467.
Türkseven S., Kızmaz M.Z., Tekin A.B., Urkan E., Serim A.T., 2016. Digital Conversion in Agriculture; Unmanned Air Vehicle Use. Journal of Agricultural Machinery Science 12(4), p.267-271.
Winegar E.D., Keith L.H., Eds., 1993. Sampling and Analysis of Airborne Pollutants, Lewis Publishers/CRC Press, Boca Raton, FL
Yavuz D., Akbıyık H., Bostancı E., 2016. Intelligent UAVe Navigation for Search and Rescue Operations; 2016 24th Signal Processing and Communication Application Conference (SIU).
www.sciencemag.org.
URL(1),http://cdn-reichelt.de/documents/datenblatt/A300/101020088_01.pdf, 03 march 2019.
URL (2),https://cdn-shop.adafruit.com/datasheets/BST-BMP280-DS001-11.pdf ,03March 2019