International Journal of Internet, Broadcasting and Communication Vol.12 No.4 48-54 (2020)
http://dx.doi.org/10.7236/IJIBC.2020.12.4.48

IJIBC 20-4-7

A Study on the Design and Implementation of Fine Dust Measurement LED Using Drone

Jong-Youel Park†, Chang-Bae Ko ††

† *Assistant Professor, Department of Smart IT, Baewha Women's University, Korea*
†† *Professor, Department of Business Administration, Kyungdong University, Korea*
pjy@baewha.ac.kr, kcb2013@kduniv.ac.kr

Abstract

Researchers recognized air pollution changes causing diseases and difficulties in living due to environmental pollution following various human activities, and have studied how to avoid fine dust harmful to the human respiratory system to be healthy. To this end, Arduino is used to equip fine dust level sensors in drones to measure the fine dust levels, visualize the measurements with LED indicator colors depending on the measurements to inform users of the danger of fine dust, and use the benefits of drones to specify dangerous fine dust zones and measure the fine dust levels. Users can see the changes depending on the fine dust levels in real time with the LED indicators. This will contributes to measuring fine dust levels easily in dangerous areas. Mission Planner (ArduPilot) is used to set up the GPS of drone, and store the data from the dust sensor as contents. This study aims to establish a method for improving the environment to measure fine dust levels with drones with LED indicators for fine dust, and reduce fine dust.

Keywords: *Fine dust, Drone, OPS, LED, Mission Planner, Arduino*

1. Introduction

A recent emerging serious social concern is air pollution caused by fine dust. In many cases, fine dust particles are rather artificially created following development of industrial facilities than a natural phenomenon. Korea has also experienced serious damage by both fine dust coming from China, and created in Korea. At present, Korea collects fine dust level information only under a specific altitude, and it is thus necessary to collect it from an even wider range.

The maximum size of micro particles specified as fine dust is 10μm which is 1/10 the hair thickness [1].

Because most fine dust is not filtered through the respiratory system, the heavy metals therein are accumulated in human bodies, and smaller fine dust particles are 2.5μm in their size which is 1/4 the fine dust particles. The volume of fine dust and ultra-fine dust shows a steady increase every year, and they are very harmful to the respiratory system and human bodies, and a great threat to human health [2].

Ansan where the Banwol National Industrial Complex is based with many businesses discharging air pollutants discharges the most fine dust in Korea, and Seoul of a high population density discharges fugitive dust the most [3]. Drones, the Fourth Industrial Revolution technology, have been studied mainly about storing high-resolution images and verifying their accuracy [4][5].

The recent drone technology is generally used for collecting fine dust data in required locations, and another

Manuscript Received: August. 10, 2020 / Revised: August. 14, 2020 / Accepted: August. 18, 2020
Corresponding Author: kcb2013@kduniv.ac.kr(Chang-Bae Ko)
Tel: +82-10-2367-1304, Fax: +82-31-869-9909
Professor, Department of Business Administration, Kyungdong University, Korea

popular technology is to combine various sensors required to collect the data [6].

This study suggests a strategy for designing a drone combined with sensors for measuring fine dust by using drones, the technology element of the Fourth Industrial Revolution and equipping cameras, fine dust sensors and communication systems to measure fine dust levels in order to measure fine dust and ultra-fine dust levels; and equipping various sensors in the drones to measure the dust levels in required areas and showing the collected data in visualized LED indicators to allow humans to recognize the fine dust and ultra-fine dust fast.

2. Related Studies

2.1 Open Source Arduino and Breadboard

Arduino with simple hardware based on the open source is a microcontroller based on hardware and software easy to use.

It is easy to use the breadboard to implement LED circuits. Interworking with the Arduino board by using the fine dust sensor and the LED sensor, writing and rewriting programs in the integrated development environment by making the various sensors interwork with the Arduino board [7].

Figure 1 shows a program developed in the integrated development environment with a basic Arduino Uno architecture used the most and a breadboard with LEDs indicators. Using the integrated development environment allows developers to use the library provided in the open source easily, and upload the compiled source onto the firmware in the Uno board through a USB for development. The Arduino Uno uses LED sensors, fine dust sensors, GPS sensors and the like to develop fine dust measurement methods.

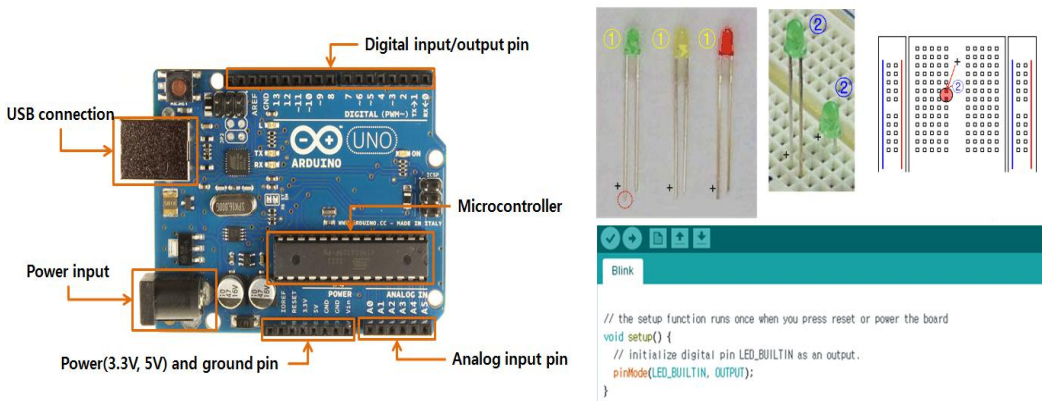


Figure 1. Arduino Uno Basic Structure and Breadboard

2.2 Drone Flight Path

Although many technologies are required to control drones directly, drones can go to a destination by using GPS information. A recent study is to set up a specific flight zone to design a program enabling drones to continue to fly the flight zone autonomously. Moreover, a platform has been studied to enable drones based on path optimization, GPS and image sensors to which machine learning is applied to autonomous flight. Autonomous drone flight requires communication, the technology to avoid obstacles, accurate and high speed, and control technology [8][9]. Figure 2 shows an exemplary development of a platform system for autonomous flight [9].

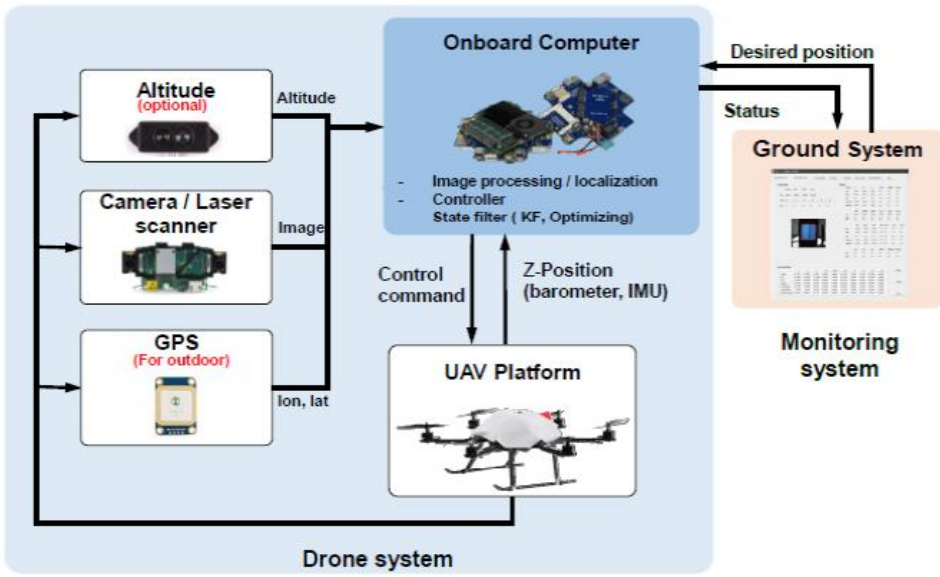


Figure 2. Autonomous Flight Platform System Configuration Diagram

3. Designing LED Drone for Measuring Fine Dust Levels

3.1 System Configuration

This study aims to suggest a method for measuring fine dust levels at an ideal altitude by combining drones with the Arduino system.

Figure 3. Drone configuration diagram for fine dust measurement

Figure 3 shows a drone suggested in this study for measuring fine dust levels. The Arduino system equipped with the sensor and the GPS module for measuring fine dust and ultra-fine dust levels sets up the GPS of drone and specifies a flight zone, or controls them to measure the fine dust levels of a desired altitude and zone. LED colors change depending on the real-time measurement of fine dust levels collected by the fine dust sensor of Arduino system to allow users to know the fine dust levels.

The fine dust level measurement data collected by the fine dust sensor of Arduino system equipped in the drone is sent to the analysis server to enable the data control system to use the analysis data. The system configuration suggested in this study aims to interwork between the drone and the GPS module to set up the flight zone and locations, and use the sensor and the communication module measuring fine dust levels in the

Arduino board to measure the levels and send the result to the analysis server. Furthermore, an LED indicator is designed to examine the fine dust levels in real time.

3.2 Designing Fine Dust Sensor

The fine dust sensor uses GP2Y1010AU0F PM2.5 PM10 connected to Arduino to detect dust. The circuit has an architecture connecting the 150ohm resistor to the 220uF capacitor to discharge the current stored in the capacitor.

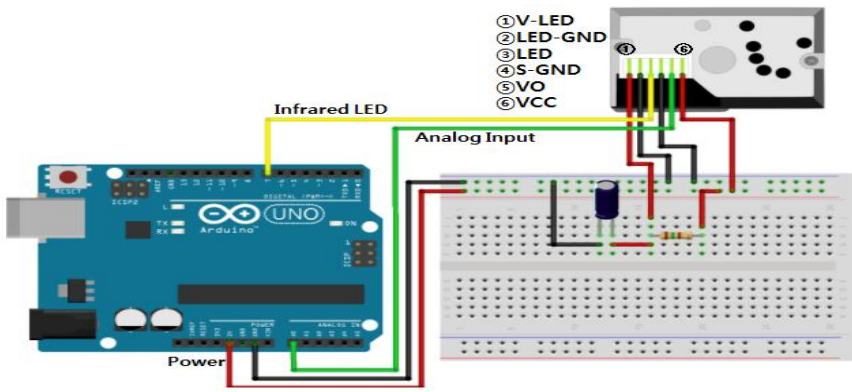


Figure 4. Arduino board fine dust sensor design

Figure 4 shows the configuration of the fine dust sensor, the Arduino board and the breadboard. The fine dust sensor can detect dust of PM2.5, and uses the infrared LED indicator in the round hole in the center of the sensor to examine dust levels. In the Arduino board, power is supplied through pin Nos 1 and 2 of the fine dust sensor. The fine dust levels are measured through pin Nos 4 and 6.

3.3 Designing LED Circuit

Figure 5 shows a breadboard circuit in which an LED indicator is connected to show different colors depending on fine dust level data measured in the Arduino board.

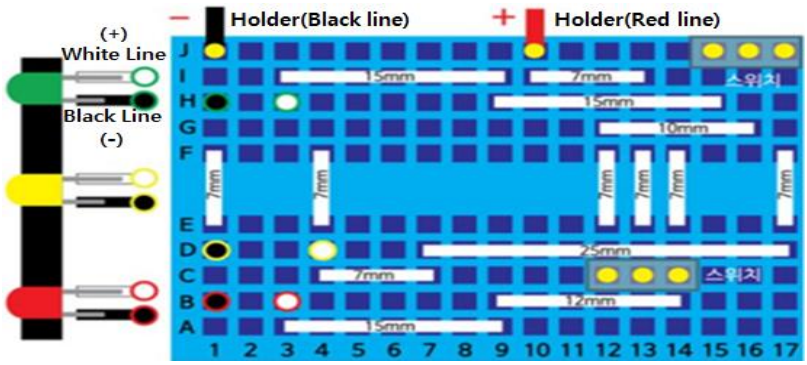


Figure 5. LED circuit diagram according to fine dust measurement

3.4 Designing Software

Figure 6 is a process flow of collecting and measuring fine dust levels. The program is designed to change the LED colors depending on the measurements by the fine dust sensor.

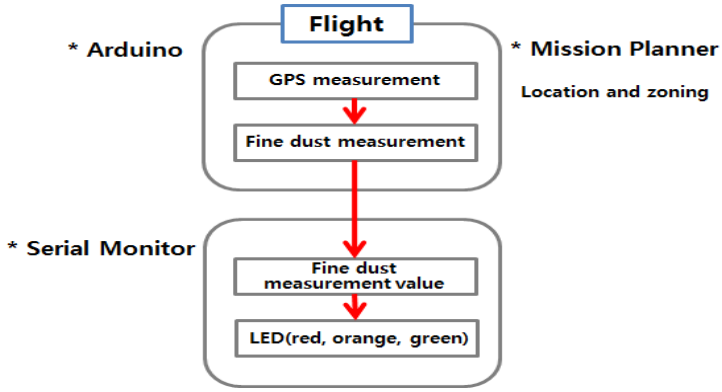


Figure 6. Fine dust collection and measurement process

The drone controls the GPS module to set up the locations and zones, and uses the fine dust sensor in the Arduino board to measure fine dust levels. The measured fine dust measurement data is sent by means of the communication module and the data sent and received is displayed on the serial monitor.

The fine dust measurements are classified into 0~30 Good (green), 30~60 Moderate (orange) and 60~ Bad (red) in μg/m3 for the levels.

4. Implementing LED Drone for Measuring Fine Dust Levels

4.1 Setting up Drone and Specifying Zone

The drone equipped with the GPS module measures fine dust levels according to the specified flight locations and flight time. The drone conducts the process required for the initial setup of the GPS and the drone firmware, and specifies the altitude in 20m. When the step of setting up the GPS module and the drone is completed, the current drone is shown in real time in the format of drone location, time and altitude as shown in Figure 7.

Figure 7. Initial drone setup and zoning

4.2 Implementing System

Figure 8 shows LED changes depending on the measured fine dust levels. An experiment is conduced through serial communication before using the drone, and the measurements by the sensor are displayed on the screen Whenever the measurement changes, the LED colors change into “Good (green), Moderate (orange), and Bad (red)”.

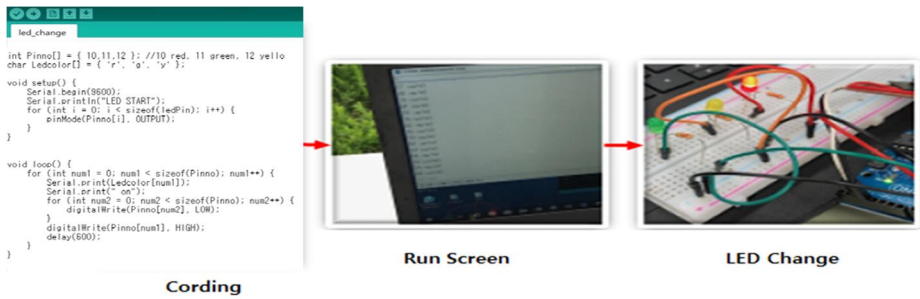
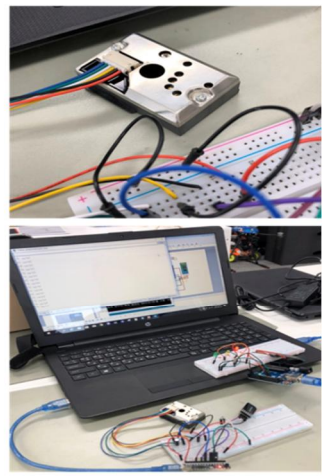


Figure 8. LED change result according to the result of fine dust

Figure 9 shows fine dust sensor operation and the developed program. It is required to configure the circuit to operate the fine dust sensor. The time for receiving the data values of fine dust sensor is important. The infrared LED operation cycle is 10ms, and the time of infrared LED On and Off is specified as 0.32ms and 9.68ms, respectively. The analog data values are the data measured after the infrared LED is On.

```
float vo_value=0;
float sensor_voltage=0;
float dust_density=0;

void setup()
{
 Serial.begin(9600);
 pinMode(v_led,OUTPUT);
}

void loop()
{
 digitalWrite(v_led,LOW); // 적외선 LED ON
 delayMicroseconds(280); // 280us동안 딜레이
 vo_value=analogRead(dustout); // 데이터를 읽음
 delayMicroseconds(40); // 320us - 280us
 digitalWrite(v_led,HIGH); // 적외선 LED OFF
 delayMicroseconds(9680); // 10ms(주기) -320us(펄스 폭) 한 값

 sensor_voltage=get_voltage(vo_value);
 dust_density=get_dust_density(sensor_voltage);

  Serial.print("value = ");
  Serial.println(vo_value);
  Serial.print("Voltage = ");
  Serial.print(sensor_voltage);
  Serial.println(" [V]");
  Serial.print("Dust Density = ");
  Serial.print(dust_density);
  Serial.println(" [ug/m^3]");

  delay(1000);
}

float get_voltage(float value)
{
 float V= value * 5.0 / 1024;
 return V;
}

float get_dust_density(float voltage)
{
 float dust=(voltage-no_dust) / 0.005;
 return dust;
}
```



Parameter	Symbol	Value	Unit
Pulse Cycle	T	10 ± 1	ms
Pulse Width	P_W	0.32 ± 0.02	ms
Operating Supply voltage	V_{CC}	5 ± 0.5	V

Figure 9. Arduino fine dust sensor program

Important variables include the values from the sensor, the variables measured with voltage, and fine dust level variables. The repetition function loop() operates the fine dust sensor, reads the data depending on the infrared LED operation cycle, stops the infrared LED sensor, and continues to repeat the part for sending data. The important functions include delayMicrosecond() used for delay in micro seconds, get_dust_density() for changing the fine dust detected in voltage (V) into fine dust levels, and get_voltage() for changing analog values into values (voltage).

5. Conclusion

This study aims to design and make the process of equipping a fine dust sensor and LED indicators in the Arduino board of drones to change LED indicator colors depending on fine dust level measurements(Figure 10).

The Mission Planner program was used to examine drone locations. The zones where the drone can fly are specified to measure fine dust levels in the specified altitudes and locations, and a controller is used to measure fine dust levels in the desired locations. In locations, for example, industrial complexes, discharging much fine

dust and ultra-fine dust and polluting the air, the drone suggested in this study can be used to measure fine dust levels, and users can see the changes depending on the fine dust levels in real time with the LED indicators. This will contributes to measuring fine dust levels easily in dangerous areas.

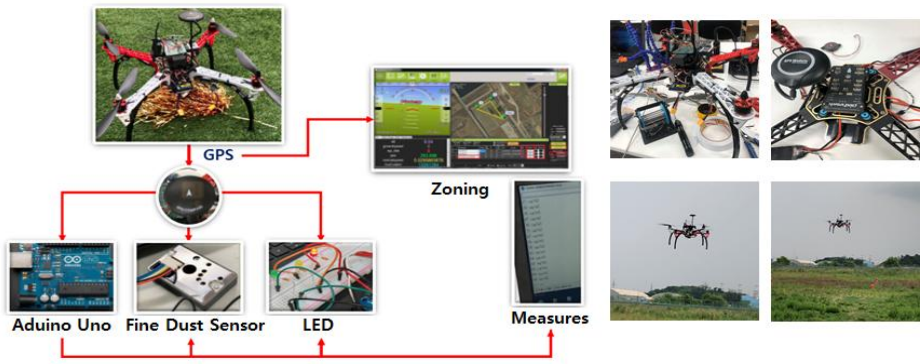


Figure 10. Fine dust collection and measurement process

It is necessary further to study how to use the artificial intelligence to analyze the fine dust levels in more details.

Acknowledgement

This research was supported by Kyungdong University Research Fund, 2020.

References

[1] World most polluted countries 2018 (PM2.5). *https://www.airvisual.com/world-most-polluted-countries*

[2] Hyoung-Ji Seo, Jong-Yeoul Park, Young-Hyun Chang, "LED Drone for Fine Dust Measurement Using Arduino," The Journal of the Convergence on Culture Technology, 2020.

[3] Dong Young Kim, Minae Choi, Bomi Yoon, "Analysis of PM Hot-spot Emission Zone in Seoul Metropolitan Area, " Journal of Korean Society for Atmospheric Environment, Vol. 35, No. 4, August 2019, pp. 476-501. DOI: https://doi.org/10.5572/KOSAE.2019.35.4.476

[4] N. Pineux, J. Lisein, G. Swerts, C.L. Bielders, P.Lejeune, G. Colinet, A. Degre, "Can DEM time series produced by UAV be used to quantify diffuse erosion in an agricultural watershed?," Geomorphology , Vol.280, pp.122-136, 2017.
DOI: https://doi.org/10.1016/j.geomorph.2016.12.003

[5] O. G. Ajayi, A. A. Salubi, A. F. Angbas, M. G. Odigure, "Generation of accurate digital elevation models from UAV acquired low percentage overlapping images," International Journal of Remote Sensing , Vol.38, No.8-10, pp.3113-3134, 2017.
DOI: https://doi.org/10.1080/01431161.2017.1285085

[6] J. Wivou, L. Udawatta, A. Alshehhi, E. Alzaabi, A.Albeloshi, S. Alfalasi, "Air Quality Monitoring for Sustainable Systems via Drone Based Technology," 2016 IEEE International Conference on Information and Automation for stainability(ICIAfS) , IEEE, Galle, Sri Lanka, pp.1-5, Dec. 2016.
DOI: https://doi.org/10.1109/ICIAFS.20166.7946542

[7] Jong-Youel Park, Young-Hyun Chang, "Study on Arduino Kit VR contents modularization based on virtualization technology in software education field", Journal of the convergence on culture technology, v.4 no.3, pp.293 – 298, 2018.
DOI : http://dx.doi.org/10.17703/JCCT.2018.4.3.293

[8] Don-gu Lee, Do-wan Cha, "Path optimization of a single agent for a drone using machine learning," Institute of Control, Robotics and Systems, 2018.5, 516-517(2pages). URL:http://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE07450057

[9] Hyun-beom Lee, "Autonomous drone technology trend," Institute of Control, Robotics and Systems, 2019.12, 37-46(10 pages). URL:http://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE09286725