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UNMANNED AERIAL VEHICLE AS DATA ACQUISITION SYSTEM

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ABSTRACT
A domestic unmanned aerial vehicle (UAV) was built with the data acquisition capabilities. It is completely based on open-source projects which enables great level of customization. Two different data acquisition systems (DAS) were tested: a proprietary DAS and an in-house developed open platform DAS. Some measurements were presented and possible applications are discussed.
Keywords: unmanned aerial vehicle, data acquisition system, autonomous flight.

1. BUILDING THE UAV
Unmanned aerial vehicles, known in the mainstream as drones, are very popular these days. They are used for aerial photography (mostly), educational purposes or simply as toys. We have built the UAV that can be used for pre-programmed autonomous flights, aerial imaging, and most importantly – data acquisition. Quad-, hexa- and octa-copters were considered. After careful assessment of needs and costs, we chose four motors in this stage. Schematic configuration of motors is illustrated in figure 1 (image courtesy of University of Stuttgart)

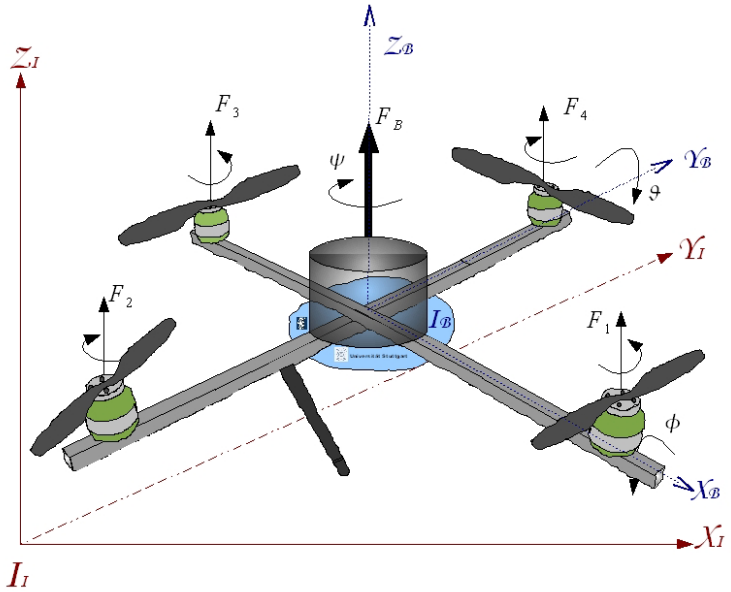

Figure 1: Motors and forces

Some physical properties of various sensors and components are well presented in [1].
Some features of our UAV are:
- brushless motors and programmable electronic speed controllers (ESCs),
- flight controller with the open source software,
- high accuracy GPS for autonomous flights,

- versatile frame with various carrying options,
- various battery configurations for different tasks,
- camera stabilization system,
- full telemetry and two-way communication during the flight.

It is very important to have open source software for flight controller. Only in this case we can have all options and parameters available. The next thing that should be carefully examined is the upgrade path. Some components can be easily upgraded. But the upgrade of the motors, for example, is very difficult and expensive. They must be identical, so you have to upgrade all motors and ESCs together.

2. DATA ACQUISITION SYSTEM

There are two approaches for making the UAV capable for data acquisition: to use proprietary data loggers or two design and built own systems. There are advantages and disadvantages for each, of course. We used proprietary data logger – Pasco Xplorer, but we also designed our own data acquisition system. It is based on open source platform (again). The microcontroller board is powered by an ATmega 2560 8-bit microprocessor clocked at 16 MHz, paired with 4 kB EEPROM and 256 kB flash memory. Secure digital (SD) card slot was added for reading and writing the data. The following sensors are installed onboard directly: BMP085 barometer from Bosch, BMA180 accelerometer, HMC5883L magnetic field sensor and ITG3205 3-axys gyroscope. There is rich set of external sensors (analog, digital, i2c, serial, etc.) that can be connected to our data logger. For example, DHT22 digital sensor (figure 2) of air temperature and relative humidity (RH) with following specifications [3]

- Type: DHT22/AM2302.
- Resolution: 0.1°C.
- Humidity range: 0-100 % RH.
- Temperature range: -40~80°C.
- Humidity measurement precision: +/- 2%RH.
- Temperature measurement precision:+/- 0.5°C.

Figure 2: DHT22 sensor

Our system, consisting of aforementioned board, SD card and DHT22 sensor is quite capable for various atmospheric measurements. Yet, it weights ~30 grams only! That is amazing.

Advantages of custom data logger over proprietary include: less expensive, much lighter (very important for this application), fully configurable. However, there some advantages of the proprietary data acquisition systems as well: even wider range of available sensors and more powerful software (Pasco DataStudio or Capstone).

3. POSSIBLE APPLICATIONS

Our system can be used for various measurements, including but not limited to

- parameters of air, such as pressure, temperature, humidity, concentrations of various substances,
- pollution monitoring. We can send our UAV above industrial chimneys, in the middle of some suspicious clouds above the city, or we can program it to patrol over crowded road. It would be interesting to compare results with another research methods, such as [2],
- landslides and flooding monitoring, etc.

In the cities located in the valley (such as Sarajevo), temperature inversion layers are formed during the winter, acting as the giant lid above the city, keeping all the accumulated pollutants inside. That is

the main reason of strong air pollution in such cities during the certain periods of winter. Our idea was to use this UAV to investigate temperature inversions in Sarajevo and correlations with air pollution in the city. In principle we are able to measure the thickness of the inversion layer, temperature profile across it etc.

4. SOME RESULTS

Our UAV took off for its first mission on 26.01.2015. It was clear and sunny day, so there were no temperature inversions in Sarajevo those days, (un)fortunately. The flight of the UAV was logged using GPS coordinates. To visualize the flight path we used Google Earth (Figure 3.).

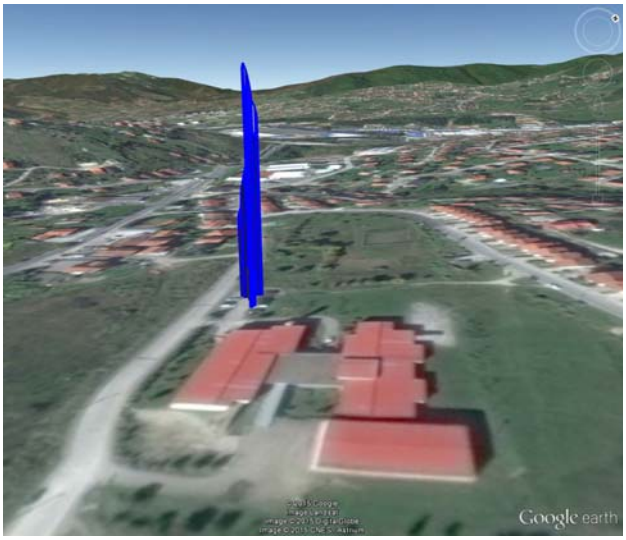

Figure 3: The flight path

On the first flight the UAV was equipped with the proprietary logger Pasco Xplorer. Figure 4 shows the readings from the temperature and pressure sensors during the flight.

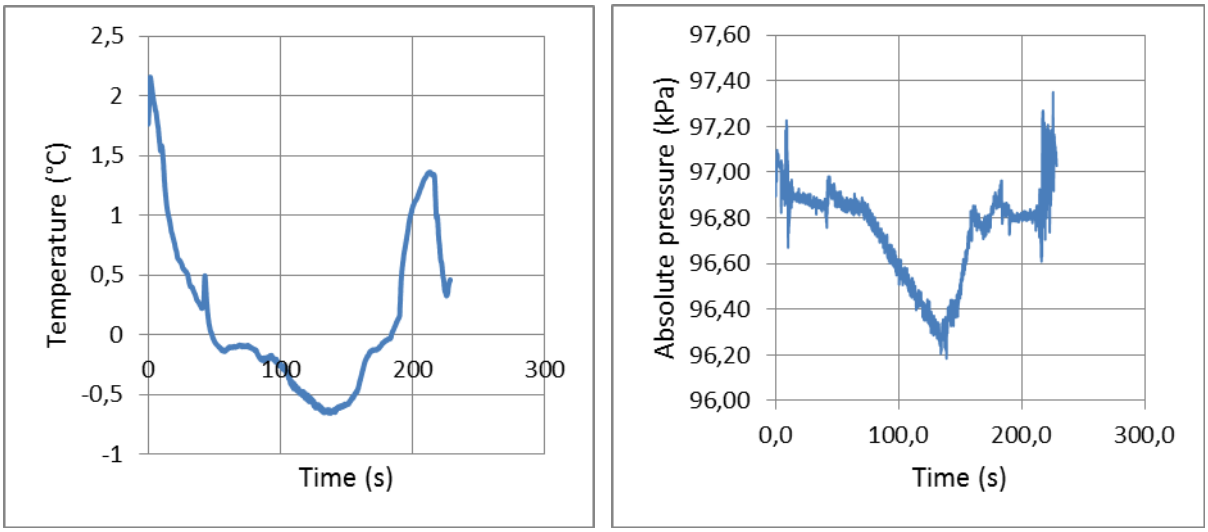

Figure 4: Pressure and temperature readings

On the second flight the UAV was equipped with our own data acquisition system with the DHT22 external sensor. Profiles of the temperature and pressure are almost the same, so we present the third variable – relative humidity (Figure 5.):

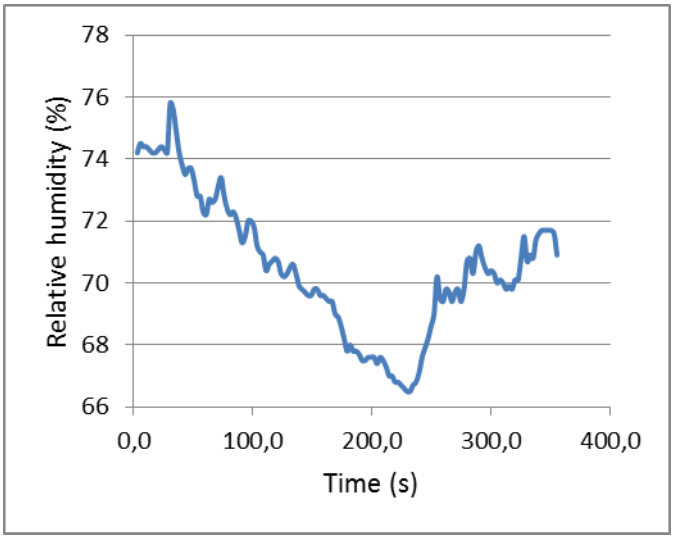

Figure 5: Relative humidity graph

5. CONCLUSION

Unmanned aerial vehicle with data acquisition capabilities was build and successfully tested. Various options for measurements are discussed. We propose open source flight control software and open source custom build data acquisition system. Only that combination gives the full freedom and full control of all relevant parameters. Additionally, (at least in our case) they are less expensive and much lighter. Proprietary data acquisition systems can be used as well. They are usually well tested, accompanied with proprietary but powerful software and the great set of sensors is available.

6. REFERENCES

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