Security Sensor System for Unmanned Aerial System

Krume Andreev[1] and Rumen Arnaudov[2]
[1, 2]Faculty of Telecommunications at Technical University of Sofia
8 Kl. Ohridski Blvd
Sofia 1000, Bulgaria
{andreev.k@abv.bg} {ra@tu-sofia.bg}

ABSTRACT: *Extensive progress has been reported in the unmanned aerial systems recently. Soliciting data and required information from many points is somewhat complex for which we have employed operators and technicians. In the current work, we have to ensure the efficiency of the current plan and offset the varied environmental conditions, we used secured sensor system for in-vehicle implementation. We have analysed the different features of the proposed system. We have developed architecture of the flight control system for unmanned aerial vehicle systems. During testing we found that this model can identify and find failures and violations of safety or performance rules.*

Keywords: UAS, Unmanned Aerial Systems, Flight Safety, Sensor System

Received: 11 March 2021, Revised 7 June 2021, Accepted 21 June 2021

DOI: 10.6025/jisr/2021/12/3/77-83

1. Introduction

The collection of information from difficult access points or in cases where there is a risk for operators and techniques within the boundaries of the ground level between 200 and 500 feet requires the use of special technical devices (Figure 1). One option to solve this problem is the use of unmanned flight systems. They can be classified as "fixed wing" UAS, "rotation wing" UAS and lighter-than-air UAS (airships). They are characterizes by high mobility, unlimited time and space access to information and monitoring of their condition [1]. All of this stimulates the development of the ideas for civil use of UAS, making them one of the fastest growing branch of remote sensing technology. Currently, they can list a number of tasks, the research and solution of which presupposes the use of UAS, each having an operational and / or permanent nature. Unmanned Aerial Systems (UAS) can find the following applications [2]:

• In the event of accidents and disasters, the detection of injured persons, the monitoring of the situation in a distressed region, etc.;

• In agriculture for crop inspection, search for lost animals, view of the farm, damage caused by hail, spills, droughts, diseases, pests, etc.;

• In the ecology for monitoring the status of flora and fauna, monitoring the status of certain areas, etc.;

• In the surveillance systems for ensure large territories;

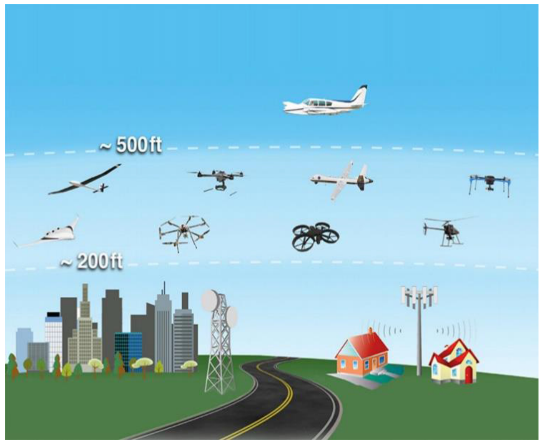

Figure 1. Use of unmanned aerial vehicles for gathering information from difficult access points or where there is a risk to operators and technology

• To assess damage from areas affected by natural disasters: spills and floods, overflow of dams, forest fires, earthquakes, industrial accidents, destroyed bridges / roads, gasses in certain areas, etc.;

• When capturing newly built infrastructure sites and integrating them into a database, monitoring the state of bridges / viaducts, etc.;

• In the energy sector: monitoring and recording of damages / icing on the power grid, recording of damages along the routes of the oil and gas transmission network, etc.

2. Building a Platform for Unmanned System

2.1 Multi-purpose Development Platform for Collecting and Processing Data

Unmanned flight systems can only be used if they can effectively complete their mission and adapt to problematic and precarious environmental conditions [3]. Safety must also be maintained with respect to other aircraft as well as people and land. Currently, there is a regulatory law in the US[4] that distinguishes between the use of UAS for specific missions. In the European Union, including Bulgaria, there are baselines that distinguish and define the use of Unmanned Aerial Systems. They are expected to be completed and published soon.

That is why it is necessary to discuss and develop reliable systems and algorithms for flight safety and monitoring of the technical condition of UAS.

Such a system should be able to perform the following tasks:

• To measure and control multiple sensor and software data in dynamic mode;

• On the basis of the collected measurement information from on-board systems, to be possible of perform and report on the control and diagnosis of defects;

• When UAS left the range coverage of the operator range to be possible automatically switch to autopilot or semi-autopilot mode;

• Electronic systems used in unmanned aeral system must meet the essential electromagnetic compatibility requirements.

2.2. Subsystems for Building of the Flight Sensor Safety System of the Unmanned Aeral System

The first subsystem for the construction of UAS is the choice of a construction solution for the system. As a construction solution may be used "fixed-wing" UAS, "rotation wing" UAS and lighter-than-air UAS (airships). "Fixed-wing" UAS (airplanes, sailplanes ...) have relatively high load-bearing capacity and flight duration, but do not have much maneuverability. "rotation wing" (copters) devices are characterized by great maneuverability but do not have high payload and flight duration. Devices lighter than air (airships) are slow and difficult to maneuverability [5].

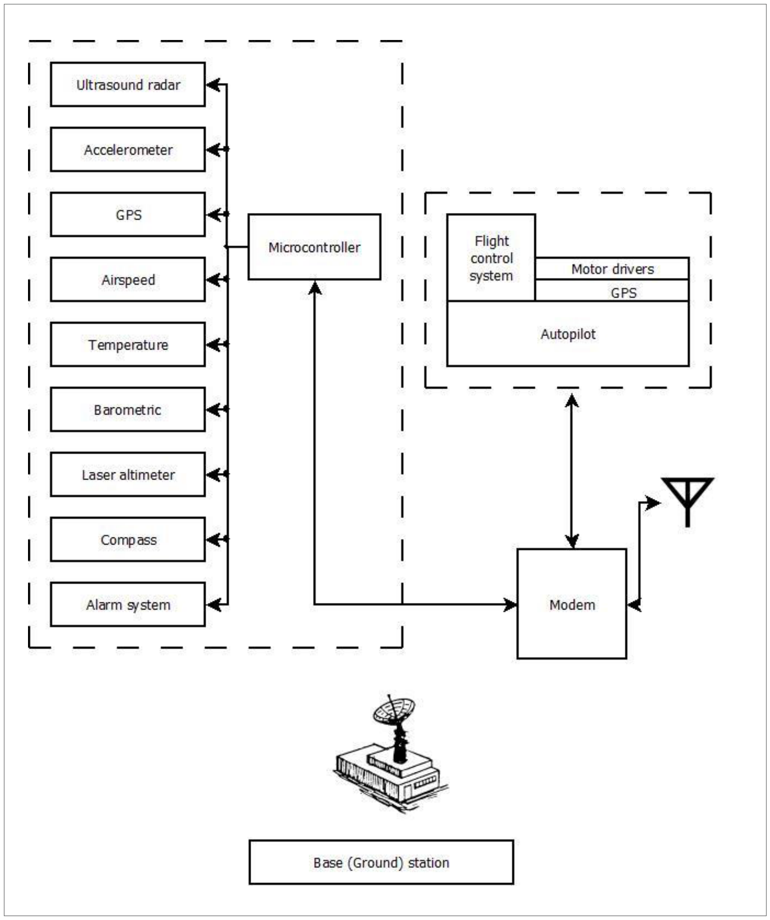

Figure 2. Architecture Platform for Flight Safety Sensor System

The second subsystem of the UAS is the navigation system that allows a single (or assisted) controlled flight to be performed on a predetermined route or route that is constructed at the time of flight. The presence of this subsystem is the basic subsystem that distinguishes BMA from radio-controlled aircraft models used in hobby practice. The navigation subsystem allows a controlled flight to be monitored, captured, measured, enabling the retrieval of scientific information about the presence, condition or condition of the subject or phenomenon being investigated. The navigation subsystem includes: an autopilot controlling the aircraft's controllable planes to conduct a flight along a route consisting of a number of positions in the space, making a closed flight around a point and at a certain height, returning the aircraft to the point from which has started the flight, etc. ; a positioning device (GPS) reporting the reached position along the route as well as the position of the aircraft (height and direction of flight) at the time of capture or measurement; device (s) for assessing the position of the aircraft relative to the horizon, etc [6].

The third subsystem of UAS is made up of different instruments and tools for capturing, recording and measuring, parameters for assessing spatial dimensions, position or state of various objects and phenomena. Depending on the objectives, this subsystem may be deployed only on-board the aircraft or be composed of two segments: an on-board segment and a ground segment. In the latter case, the on-board segment is complemented by a transmitting element, which allows the real-time telemetry information to be transmitted to the receiving segment from the ground segment. In the presence of a transmitting element, the function of the navigation system can also be enriched by providing a feedback allowing visualization of the flight parameters and the operation of the aircraft [7].

It can be seen that the task is very complex in itself, and in ddition it becomes even more complicated when considering the tasks that UAS should perform. This is also the reason for the complexity of compiling standards and norms in the field of trembling.

2.3. Architecture of the Flight Sensor Safety System of the Unmanned Aeral System
Figure 2 shows the architecture of a platform for flight safety sensor system of a UAS using a fixed-wing. It contains: measuring sensors, microcontroller for data processing and measurement system management, flight control system, modem, autopilot, manual control channel for UAS, telemetry for data transmission and ground station. With the help of the measuring sensors, the condition of the aircraft, its coordinates and the environmental parameters are monitored. For this purpose the following sensors are used:

• GPS receiver. It helps determine the location of the aircraft.

• Temperature sensor. In this case, the presence of hot air currents is monitored.

• Air velocity sensor. This parameter is important because it can also control the speed of UAS.

• Barometric pressure sensor. This height and speed can be monitored via the Z axis.

• Laser altimeter for height measurement.

• Ultrasonic radar to prevent the unmanned airplane from colliding with other or other flying objects.

• Accelerator accelerometer for acceleration of unmanned aircraft in case of a sudden loss of lifting force or impact of a UAS on another object.

• A magnetic field sensor that measures the Earth's magnetic field as an inertial navigation signal;

• Alarm system. With this system, in the event of a fall of UAS, it signals the uncontrolled fall of the unmanned flight system.

Knowing the capabilities of different systems allows for proper selection in preparation for a particular task, and the same goes for each task requiring a proper selection of the UAS as a flight system, scientific and navigation equipment. The basic principles for building UAS are [8]:

• Creating a modular, light platform with low power consumption;

• Real-time monitoring of sensors and software signals;

• Analysis of received information and in-flight preprocessing.

Another important feature in the choice of UAS and the flight safety sensor system is the ability of the established platform to comply with the flight rules in the respective country. At this stage in Bulgaria, these rules are being developed. Flight rules are defined by national and international institutions, for example, the US Federal Aviation Administration [9]. Some of the parameters in this policy are the minimum height that aircraft after take-off, maximum flight speed, landing time, etc. have to reach;

2.4. Algorithm of the Flight Safety System for Collecting and Processing Data from Sensors on Board of the Unmanned Aeral System
After starting the device follows an initialization of the MCU [10]. Initialization is performed on the controller, i.e. self initialization. After initialization follows read of the initial settings and initialization on all sensors on board that directly

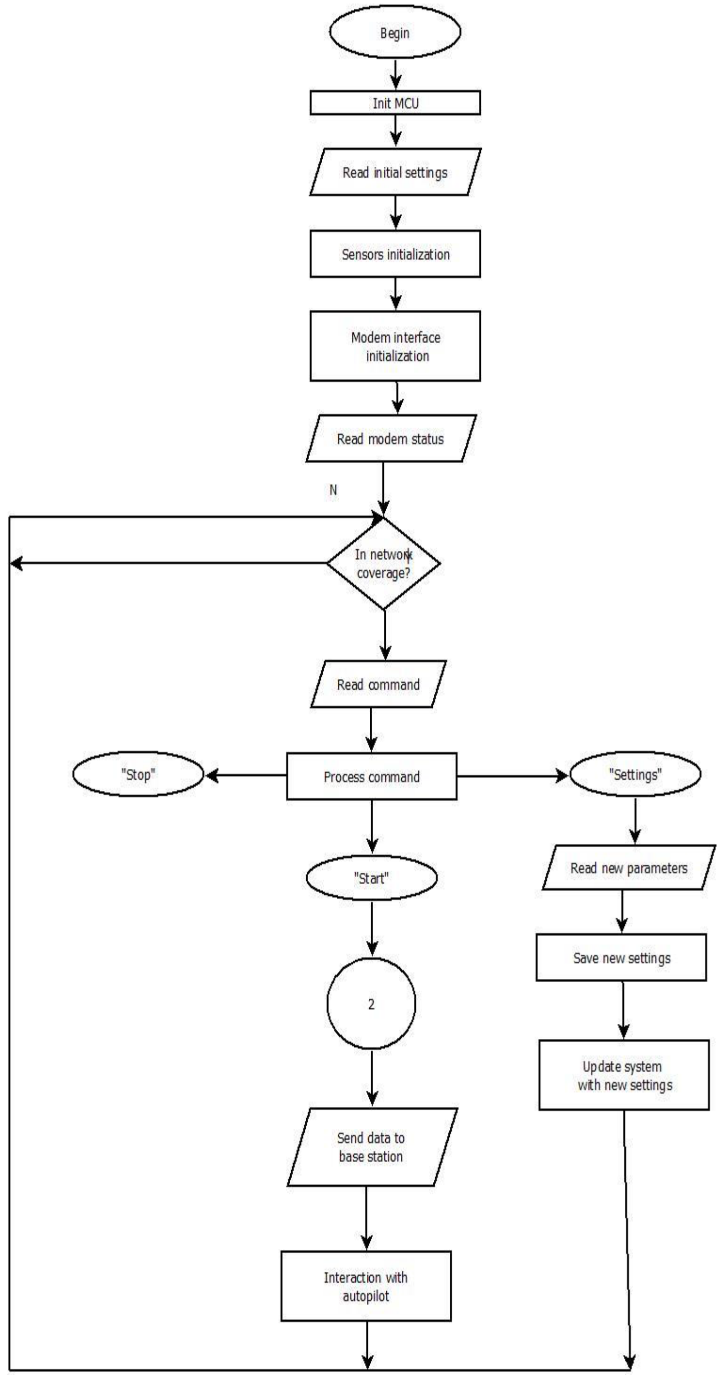

Figure 3. Algorithm for operation of the system for flight control and technical condition for collecting and processing data from sensors onboard the UAS

depend on the system and model interface initialization. Then system proceeds with the modem read status. If the system is in the network coverage the next step is expected acceptance of command. If it's not the system is waiting and checking for the connection with the ground(base) station. Commands are three, as follows, for start, stop and system settings. For a given command start the system begins to read the data sent by sensors on board of the UAS and began to perform the functions of the system (the system functions described above in the text-point section Introduction). After receiving the data from sensors follows the process on the received data and the system makes the right decision. This will be showed on Figure 4 and described in the description for the algorithm. The steps are as follows send data to the base (ground) station and interaction with the other systems on the UAS. In case of need for a interaction of the system for flight control and technical condition of UAS with the other sub-system on board of the UAS i.e. in this case the system for flight control or autopilot. In this case the decision taken in the form of data is sent to the flight control system i.e. to the UAV's autopilot. [11] For a given command stop the system will stop working until the operation will turn it again on. For a given command settings the system will read the new parameters set up by the operator. Save the new set up parameters or save the new settings and will automatically update the system with the new set up parameters.

Figure 3 shows the algorithm of the flight safety sensor system of an unmanned aeral system for collecting and processing data from sensors on board.

For a given command begin system starts working. The first step is reading of the input data. After reading of the data follows the data processing or filtration of the data. Next step is to check if the filtered data is in statistical range, depends on the stored system parameters data. If the data is in the range the system continue working. If the data is not in the range of the stored system parameters data the entire test is repeat until the system reach limit. If the limit is reached the system is sending warning signal data to the base (ground) station for nonfunctional sensor.

Figure 4 shows the algorithm for data processing and decision making algorithm of the system for flight control and technical condition for collecting and processing data from sensors on board.

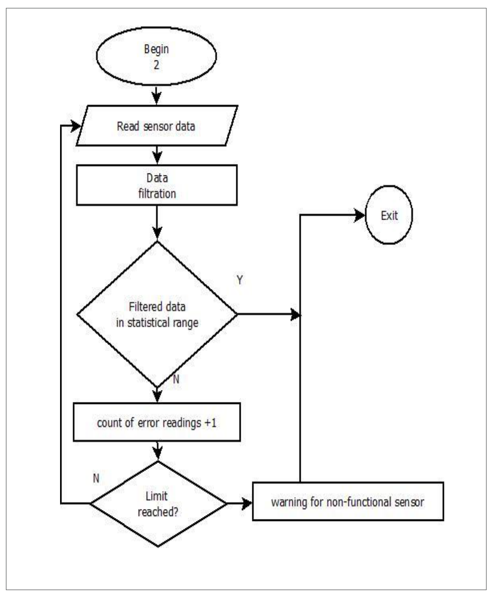

Figure 4. Algorithm for data processing and decision making algorithm of the system for flight control and technical condition for collecting and processing data from sensors on board the UAS

3. Conclusion

This report proposes an architecture and algorithm for flight safety sensor system of an unmanned aeral system for collecting and processing data from sensors on board. They are the basis for the design and development of intelligent UAS and to develop a regulatory framework for standardization and rules for their flight. Such systems may find wide application in other areas, especially where the combine requirements for high operational reliability and service while making quick decisions.

This report introduce a system that meets this requirement with the design of a real-time onboard system for flight safety capability to continuously monitor sensors and hardware components. This system can detect and diagnose failures and violations of safety or performance rules during the flight of a UAS.

Acknowledgement

The proposed architecture and algorithm have been developed with the support of NIS at TU-Sofia, through participation in research projects to help graduate "System for flight control and technical condition of unmanned aerial systems" (session 2018) ! 172—0005-07.

References

[1] Basin, D., Klaedtke, F., ZØalinescu, E. (2017). *Algorithms for monitoring real-time properties*. 220–235.

[2] Latchman, H., Wong, T. (2007). *Software Documentation for Airborne Traffic Surveillance Systems*, 10-17.

[3] Schumann, J., Mengshoel, O.J., Mbaya, T. (2011). Integrated Software and Sensor Health Management for Small Spacecraft, 2011 IEEE Fourth International Conference on Space Mission Challenges for Information Technology, 77-84.

[4] Federal Aviation Administration. (2013). Federal Aviation. Regulation §91.

[5] Basin, D., Klaedtke, F., Zalinescu, E. (2011). Algorithms for Monitoring Real-time Properties, 260-275.

[6] Murphy, D. W. (2004). The Air Mobile Ground Security and Surveillance System, 20-23.

[7] Richard A. Di Lorenzo., Michael A. Bayer. (2009). A Prognostics and Health Management System for an Unmanned Combat Aircraft System – A Defense Acquisition University Case Study, 1- 12.

[8] Schumann, Johann., Kristin Y. Rozier. (2014). Thomas Reinbacher, Ole J. Mengshoel, Timmy Mbaya, and Corey Ippolito, Towards Realtime, On-board, Hardware-supported Sensor and Software Health Management for Unmanned Aerial Systems, 1-27.

[9] Federal Aviation Administration. (2013). Federal Aviation. Regulation §91.

[10] Johann Schumann., Kristin Y. Rozier., Thomas Reinbacher., Ole J. Mengshoel., Timmy Mbaya., Corey Ippolito. (2013). Towards Realtime, *On-board, Hardware-supported Sensor and Software Health Management for Unmanned Aerial Systems*, 1-21.

[11] Reg Austin. (2010). Unmanned Aircraft Systems –UAVS Design, *Development and Deployment*, 16-56 .