Effective mission planning for fixed-wing Unmanned Aerial Vehicle

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Abstract

Today Unmanned Aerial Vehicles (UAV) are integrated into the different duties of human activity. Multiple advantages of UAV stimulate continuous growing number of practical applications in industry 4.0. Precision level of modern onboard positioning sensors supports accurate trajectory maintaining in a fully automatic mode for most short-length missions. Effective trajectory planning is a key element of mission success. In the paper, we study mission planning stage with a focus on UAV navigation. Flight phase classification is used for lateral UAV navigation and safe altitude is calculated based on a digital elevation model. Trajectory calculation for effective UAV missions includes estimation of true and magnetic heading angles; pitch angle; ground speed; time of flight and safe altitude. Forecasted weather data of wind speed and direction are used for ground speed estimation and effective mission planning. In numerical demonstration, we use specially developed software for effective mission planning of power lines exploration with UAV of airplane type.

Keywords

flight planning, UAV, air navigation, trajectory calculation, aerospace

1. Introduction

Nowadays Unmanned Aerial Vehicles (UAV) play an important part in the global economy [1, 2]. Commercially available UAVs are presented in small, medium, and large types. It is widely used in vary of applications: video filming (remote camera), agriculture, remote sensing (sensing digital surface model with Lidar), building (construction observation), power lines inspection, etc [3, 4]. UAV is a unified platform for different tool placement, which makes it welcome in any sector of the economy. Mostly performance of UAV is defined by their construction. UAVs of copter, airplane, and combinations are mostly used today.

UAV could use copter structures with any number of engines. Copter structure provides the possibility of holding in a particular point of airspace, changing direction of flight in any side, vertical take-off, and landing. Most commercially available copter UAVs are electrical engine lift generation that significantly limits time and range of system use.

UAV of airplane type is a high speed and long range of operation. Commercially available small and medium UAVs of this type provide about 50kg of payload for ranges in 300-500 km. Most airplane types of UAVs require a runway or specially developed launch system. Also, it highly uses a parachute recovery system for landing due to required runway and specific skills of flight technique to landing successfully [5, 6].

Any commercial UAV application requires maintaining a defined trajectory in the airspace [7, 8, 9]. Trajectory of upcoming flight is specified at the pre-fright (mission planning) stage. Trajectory is defined as a sequence of waypoints, altitudes, and defined times of its reaching. Many commercially available UAVs include autopilot mode and remote payload control for mission support. Remote UAV

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pilot deals with take-off, landing, and payload control during en-route phase of mission. In this case, a person using UAV is a remote pilot for UAV deployment stage only and a payload operator for the rest. Therefore, a well-planned trajectory for UAV is important for results of payload use and mission success.

UAV operates in the atmosphere, actually, most UAVs use a lower troposphere, where most weather phenomena are concentrated. Unfortunately, commercially available autopilots deal with normal weather conditions only. Excessive wind speed, precipitation, drizzling, rain, snow, fog, and other weather phenomena degrade UAV performance and create a high risk of mission fault that may be result of particular failures in UAV systems [10, 11, 12].

Many studies in aviation focus on trajectory correction due to avoidance of entering part of airspace with dangerous weather phenomena action [13, 14]. In this case, actual weather data is used to compare planned trajectory and areas with abnormal weather action [15, 16, 17]. Also, different math algorithms could be used to calculate an optimal trajectory to avoid entering dangerous areas and complete mission successfully [18, 19]. In civil aviation, specific software is used to dynamically evolve flight plan to follow trends in wind and weather.

In the paper, we study a process of UAV trajectory calculation for upcoming flight that is a main part of mission planning. Also, we consider the positive impact of wind side and speed on UAV mission performance based on weather forecasts.

2. UAV mission planning

Mission planning is an important stage of UAV flight preparation which includes: trajectory planning of upcoming flight, considering weather forecasts, planning settings of payload use, planning take-off and landing, prepare UAV and payload for mission. Each of these tasks is critical for mission completion success. For example well-planned trajectory and ideally tuned on-board systems of UAV don't make sense in case of payload fault. Accurately moved airframe is not effective due to fault in the main task of the mission. UAV mission is successfully completed only in case the main goal of mission is reached. Another important component is the technical state of each system component [20, 21].

In this paper, we are mostly focused on trajectory planning and calculation in order to guarantee safe UAV operation. Trajectory planning for upcoming flight requires selection of waypoints passing UAV through which makes it possible to use payload to reach the main goal of mission (Figure 1). Trajectory is specified as a sequence of waypoints through which UAV should fly. Waypoints usually are specified in geodetic coordinates of latitude and longitude. Also, most applications require linear moved UAV between waypoints. For each waypoint, an altitude is specified. Based on flight mode altitude could be specified as a range from WGS-84 ellipsoidal model in case of using GNSS, or could be a pressure altitude calculated by a barometrical sensor and counted from isobaric line of constant pressure (760 mmHg).

Vertical plane planning for UAV mission should take into account relief altitude, natural and artificial constructions. Specified waypoints and altitude of its reaching form a flight plan for upcoming mission. Flightplan is coded by a particular data format and is loaded to autopilot module to launch a mission.

2.1. 2D Trajectory Planning

Commercially available UAVs usually include flight planning software in the general packet. Such software uses a graphical interface for interaction with a particular mapping tool for the selection of waypoints for planned trajectory. In most cases, waypoints are selected manually "on the map" by specifying coordinates based on required mission. Flight plan could be segregated into seven main phases, based on mission criteria (except transportation mission):

- Take-off and climbing;
- En-route (moving to point of payload use);
- Maintaining to initial point of payload use;

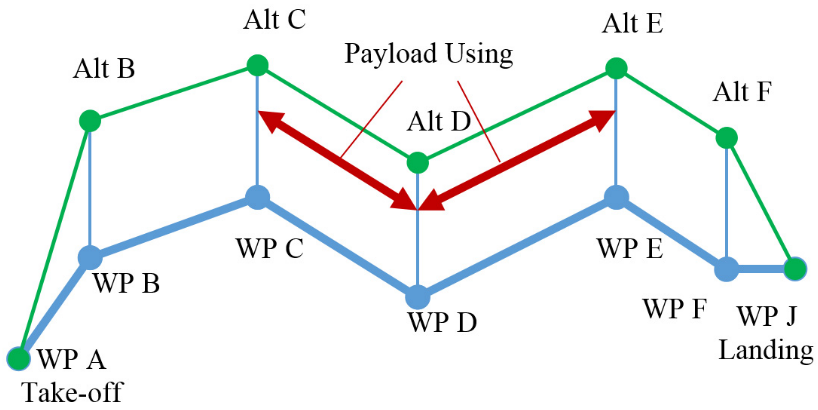

Figure 1: UAV trajectory planning.

- Payload usage;
- Back to en-route;
- Descending;
- Landing.

During mission planning a point of take-off could be selected based on requirements of UAV [22]. For example for quadrotor UAV, take-off places should be selected based on criteria of human safety and minimum risk of collision with nature. In most cases, a place of payload use is located in areas that are hard to reach in person. Therefore, after take-off, UAV has to travel along en-route phase to place where payload will be used. At the end of payload use, UAV has to follow en-route to landing zone. Each of trajectory phases could include several (or more) waypoints.

Trajectory planning should be taken in accordance with rules of airspace use. Most countries limit maximum altitude to use UAV by 500 m, however, in particular conditions altitude limit could be extended up to 1000 m about ground level (AGL). Many commercially available UAVs have built-in protection system to limit their use near airports and airplanes. Flight planning software avoids trajectory creation through prohibited areas in which UAV could be dangerous. As an example, airports are covered by prohibited areas which are approximately in a 5 km radius. Runways and areas of airplanes moving at low altitudes are also specified as restricted. Using waypoints or trajectories through these areas is prohibited. As an example, a configuration of prohibited areas of four airports (UKBB, UKKK, UKMM, UKKT) in Kyiv's vicinity is shown in Figure 2. Waypoints of flight plan are selected taking into account uncertainty area of on-board positioning system. On-board positioning system measures UAV coordinates with particular precision [23]. Precision of positioning system should be taken into account during planning of flight operations near restricted areas. GNSS provides a basic positioning capability which could be improved by using a ground-based augmentation system. Heavy UAVs could use conventional navigational aids to identify their position in case of a primary positioning system lock [24, 25].

Many commercially available UAVs are equipped with ADS-B-in modules to receive digital data about location of closed airplanes. Autopilot has a simple algorithm to compare UAV coordinates and air traffic around. In case if UAV became close to the airplane, autopilot informs pilot about restricted zone around airplane and initiates engine stop mode. The common safety range is 60 meters of a direct range around airplane position.

Trajectory planning takes into account performance of UAV which is limited by the maximum range of operation [26]. Maximum operational range is estimated by capacity of battery (for electronic propulsion) or fuel tank (for fuel engine). Maximum range is significantly affected by total take-off mass of UAV and wind distribution over the planned trajectory. Also, factors of interference of intentional jamming should be taken into account in the case of manual piloting mode [27, 28].

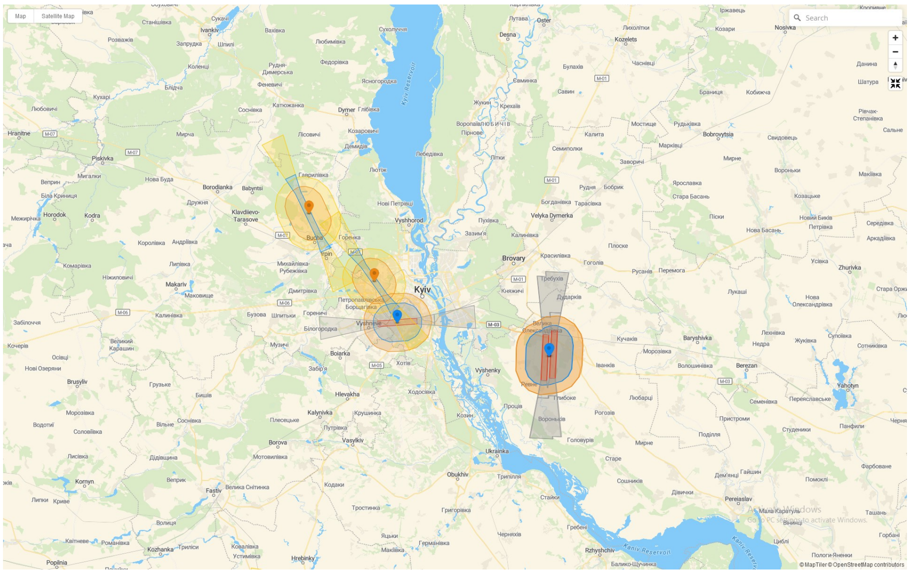

Figure 2: Restricted areas for UAV usage in Kyiv's vicinity.

Calculation of total trajectory length (D) is mostly done by the assumption of a small operational range and linear legs that connect waypoints:

$$l_i = \sqrt{(x_{i-1} - x_i)^2 + (y_{i-1} - y_i)^2 + (z_{i-1} - z_i)^2} \tag{1}$$

$$D = \sum_{i=1}^{n} l_i \tag{2}$$

where D is the total trajectory length; l_i is a leg length; x_i, y_i, z_i are coordinates of i-th waypoint in ECEF; n is the number of legs.

2.2. Vertical profile planning for UAV mission

Trajectory planning requires setting an altitude for each waypoint. An altitude could be specified as pressure altitude or WGS-84. The WGS-84 altitude provides a hard-fix UAV-to-Earth ellipsoidal model. Static pressure fluctuates based on weather action that makes pressure altitude in relation to the place and time. During vertical profile planning of upcoming flight it is important to use minimum descending altitude, which could be called safe altitude. Safe altitude marks an altitude range from the ground which is dangerous to operation due to the high risk of collision with nature or artificial constructions.

A digital elevation model could be used to specify terrain [29] with a safety buffer for natural elements. As an example, SRTM (Shuttle Radar Topography Mission) global terrain model could be used to calculate minimum descent point for each waypoint [30]. SRTM includes terrain altitude specified in meters from WGS-84 ellipsoidal model. SRTM makes easy safe altitude calculation during mission planning with GNSS. Pressure altitude fluctuates together with isobaric surface used to point initial callout level [31]. For the case of a small UAV and a short range of planned missions, static pressure on the take-off point could be used for simple recalculation of pressure altitude to WGS-84.

Artificial constructions and nature (stones, trees, bushes, etc.) could be taken into account by personal image study along the planning trajectory. Some UAVs may use LIDAR, imaginary, or ultrasonic sensors for virtual environment study in-flight to maintain a safe distance from dangerous elements of nature. In the case of manual control remote pilot could make a decision on a minimal descent point for each point of planned trajectory based on visual data from on-board cameras.

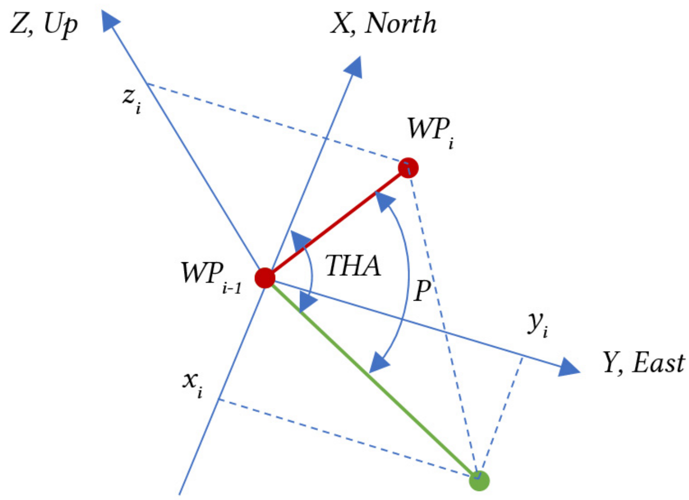

Figure 3: Orientation of North-East-Up reference frame.

3. UAV trajectory calculation

A sequence of waypoints for upcoming UAV mission has to be used for navigation data calculation. Navigation data is required for manual piloting mode as well as for autopilot initial data setting. These data include:

- Length of each flight plan leg;
- True and magnetic heading angles;
- Pitch angle (important for airplane type of UAV);
- Ground speed;
- Time to fly between waypoints (ETE);
- Estimated time of arrival at each waypoint (ETA);
- Getting relief data.

Heading is an angle in a horizontal plane between the North direction and the direction of UAV movement along the flight plan leg counted clockwise in the point of UAV location. Heading could be True or Magnetic. True heading is based on using True poles of Earth in which rotation axis is passing through. Magnetic heading uses Earth's magnetic field configuration. Magnetic heading helps to predict magnetic compass readings along a particular flight plan leg. Actually, the shortest line between two waypoints results in a constant heading angle. Therefore, each leg corresponds to a particular true heading angle and a small variation of magnetic heading.

True heading angle could be calculated based on leg orientation in the space of local cartesian frame with a reference point in waypoint coordinates. Local North-East-Up cartesian reference frame is useful for true heading angle (THA) calculation (Figure 3). True Heading Angle (THA) could be calculated as follows:

$$\mathrm{THA}_i = \begin{cases} \arctan\left(\frac{y_i}{x_i}\right), & \text{if } x_i > 0 \text{ and } y_i \geq 0 \\ \pi + \arctan\left(\frac{y_i}{x_i}\right), & \text{if } x_i < 0 \\ 2\pi + \arctan\left(\frac{y_i}{x_i}\right), & \text{if } x_i > 0 \text{ and } y_i < 0 \\ \frac{3\pi}{2}, & \text{if } x_i = 0 \text{ and } y_i < 0 \\ \frac{\pi}{2}, & \text{if } x_i = 0 \text{ and } y_i > 0 \end{cases} \tag{3}$$

where x_i and y_i are coordinates of i-th waypoint in the North-East-Up cartesian reference frame.

Magnetic heading angle (MHA) could be estimated based on the world magnetic model [32] which is available in the function library of various software languages. MHA is calculated based on declination angle which indicates magnetic field variation from Earth True poles. Declination angle (D) is calculated based on the world magnetic model for a specific time frame:

$$\mathrm{MHA}_i = \mathrm{THA}_i + D_i \tag{4}$$

where D_i is a declination angle at i-th waypoint.

In case of fault in primary positioning with GNSS, a simple magnetic heading reading could be used to navigate UAV to the next waypoint, based on the dead reckoning method.

The pitch angle could be calculated based on geometry of a particular trajectory leg. Pitch angle indicates vertical UAV inclination during climbing or descending for airplane type of UAV:

$$P_i = \arctan\left(\frac{z_i}{\sqrt{x_i^2 + y_i^2}}\right) \tag{5}$$

where P_i is a pitch angle of trajectory at i-th leg.

Time to flight between waypoints (ETE) is calculated based on initial settings of airspeed. In case wind data is available, airspeed could be recalculated to ground speed. Obtained values of ground speed are used for estimation of the time to flight at each leg of flight plan:

$$ETE_i = \frac{li}{GSi} \tag{6}$$

where GS_i is the ground speed of UAV at i-th leg of a flight plan.

Estimated time of arrival at the waypoint (ETA) is calculated as a cumulative sum at each waypoint:

$$ETA_i = \sum_{j=1}^{i} ETE_j \tag{7}$$

Flight profile calculation is another important element of mission planning. A digital relief elevation model (DEM) has to be used to get terrain distribution along the planed trajectory. Most DEMs use a grid of a particular cell size. Relief altitude is assumed equal along cell space. Getting relief distribution along planed trajectory means detection of grid cell numbers based on input geodetic coordinates of each point. Precision of SRTM data is specified as cell size. Since 2014 global DEM from SRTM has been available with one arcsecond which is 30 meters cell size.

A safe altitude is calculated as relief altitude plus safety buffer:

$$ALT_k = DEMk + h \tag{8}$$

where k is number of considered points of planned trajectory; DEM_k is a relief altitude by SRTM; h is a safety buffer for a particular environment.

In case of wind action along the flight path, ground speed (GS) could be calculated from forecasted wind direction (WA) and wind speed (W):

$$GS = \sqrt{V^2 + W^2 - 2VWcos(THA + \pi - WA)} \tag{9}$$

During trajectory selection, it should be noted that wind speed and wind direction should be taken into account. Actually, part of trajectory in which expect to use payload could not be changed. However, a side of payload use and approaching schemes should be selected based on positive input for tailwind.

4. Efficient trajectory planning based on wind input

Weather plays an important role in the operation of UAVs. Weather conditions affect many aspects of UAV operations and functionality. Poor visibility greatly complicates the operation of a UAV, as most UAVs use cameras to collect information about the environment, and fog or rain can interfere with their observation capabilities. One of the reasons for this may be air safety, as low visibility increases the risk of collision with other airspace users. Rain, snow, and fog can become intense and impair visibility. Due to precipitation, there may be high humidity, which has a negative impact on the operation of sensors and electronics in UAVs and can cause short circuits or malfunctions

Humidity is measured by a hygrometer or weather station. It has a great impact on radio signal propagation. The higher the humidity, the worse the quality of communication and thus the shorter the range of the total system.

Icing of UAV in the air leads to many problems in their operation. Icing occurs at temperatures between +1 C° and -50 C°. The main types of icing are ice, frost, and frost. Ice that accumulates on the surface of the vehicle increases its weight, which leads to changes in flight characteristics and recalculation of control parameters.

There may be changes in the aerodynamic characteristics of the UAV, increasing air resistance, which leads to a decrease in speed. Ice accumulated on sensors and cameras can damage their operation. In order to have a chance of successfully completing a UAV mission, you need to know the air temperature near the ground, the dew point temperature, the UAV altitude, and the air speed.

Icing occurs due to uneven distribution of atmospheric pressure and is directed from areas with high pressure to areas with low pressure. Due to constant changes in atmospheric pressure, wind direction, and speed are constantly changing. At high altitudes, the wind may increase due to reduced air friction on the ground.

The Earth's surface has different terrain and humidity levels, which leads to uneven heating under the influence of sunlight. Darker and drier areas warm up faster than lighter and more humid areas, releasing more heat into the air. In addition, slopes and elevations also affect heating: southern slopes are warmer than northern ones, and eastern slopes warm-up earlier than western ones. These factors create conditions for the thermal activity of air. Warm, heated air rises upward, creating upward heat flows or thermals, while cold air from colder areas replaces it, forming a local or thermal wind. This leads to an increase or decrease in the wind in the ground layer in the presence of a background wind. Without a background wind, the local wind blows in different directions and not periodically.

The effect of wind on UAVs is quite important to consider when flying. Strong winds affect flight stability. Under the influence of a strong side wind, the aircraft begins to roll unstably or change direction. Wind affects the speed of an unmanned aerial vehicle. When flying against the wind, the aircraft moves more slowly and this increases the flight time. When flying into the wind, the flight speed increases.

Flying against strong winds increases the energy consumption of the batteries, which reduces the flight time and limits the range. Wind causes a loss of control over the aircraft. The stronger the wind blows, the stronger and larger the rotor behind the obstacle can be. It is important to understand that the length of the rotor behind an obstacle depends on the square of the height of the obstacle. When landing, it is advisable to land on the windward side in front of an obstacle, such as a forest belt, rather than behind it, given the wind direction.

Before flying, the crew needs to study the weather conditions. Pilot can obtain this information from National or regional weather services, aviation weather services, and they can also use various websites or mobile applications. In general, many factors can affect UAVs, but the most important ones that operators should consider when planning their route and making preliminary calculations have been highlighted. Also, when choosing a route, it is imperative to take into account the radius of application, maximum flight range, the most favorable flight duration speed, the most economical flight speed, and the speed per wind direction at altitudes.

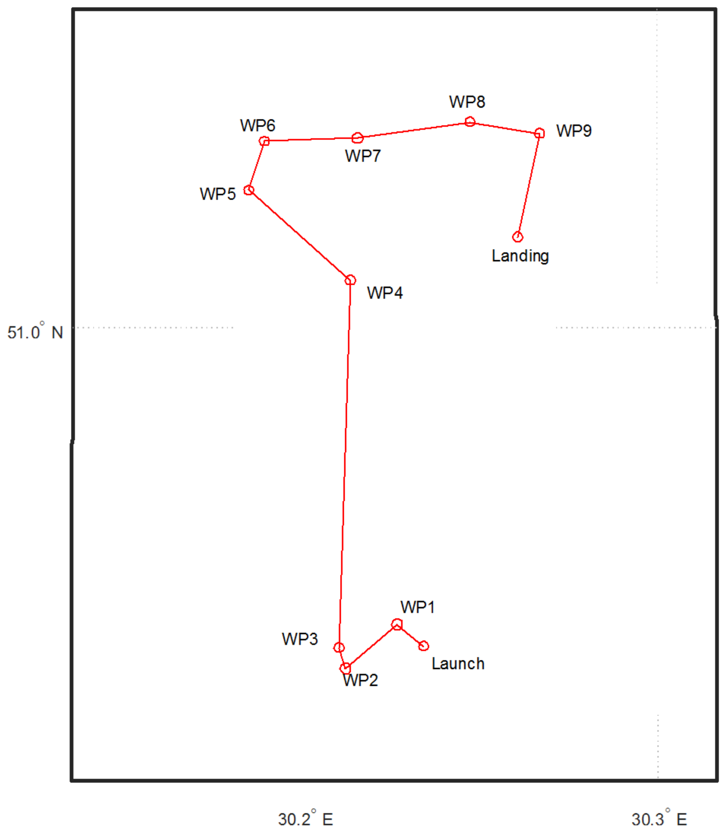

Figure 4: Planned trajectory for the mission.

5. Numerical demonstration

In numerical demonstration, we consider as an example of flight trajectory planning for automatic power lines checking mission. We use UAV -10 for detailed power lines filming with post-flight picture analysis to identify deterioration of technical condition of mechanical constructions. UAV performance is following:

- Propulsion: one electric engine;
- Take-off mass 4.5 kg;
- Max mission duration: 0.6 hours;
- Cruise airspeed: 72 km/h;
- Max barometrical altitude: 2000 m.

UAV requires a special runway or a launch pad. Landing is provided with a parachute system. Payload will be automatically pointed to power line construction. Exploared part of the power line is approximately 5 km placed in wild nature. Team members are going to launch UAV from a launch pad located in 3 km from the power lines location and expect UAV to land with a parachute in an area with no trees or brushes. An appropriate place for landing is approximately 11.6 km from the final point of payload use. The configuration of flight flight-planned trajectory of the upcoming flight is represented in Figure 4. It will include take-off, landing, and 9 waypoints of en-route (WP 1-WP 9). The main task is using a payload at legs WP3-WP4 and WP4-WP5 to explore derogative state of a power line construction. During the planning coordinates of WP3-WP5 a sun location was taken into account and harmful action of electromagnetic field closed to power lines. Landing area is selected based on smallest nature configuration. Therefore after finishing use payload UAV has to travel to landing area located far away from the active area. Mission start has been planned at 11:23:02 UTC. Results of planned trajectory

Table 1
Results of Planned Trajectory Calculation

Waypoint	Length km	THA,[°]	D,[°]	MHA,[°]	GS, m/s	DEM, m, WGS84
Launch	0	309	6.25	302	20.8	134
WP 1	0.92	229	6.25	223	19.1	134
WP 2	1.77	342	6.24	336	21.2	135
WP 3	0.40	1.7	6.24	-4	21.2	135
WP 4	6.29	311	6.26	305	20.8	114
WP 5	3.53	17	6.26	11	21.2	110
WP 6	0.95	88	6.26	82	20.1	101
WP 7	2.93	81	6.27	75	20.2	101
WP 8	3.53	99	6.28	93	19.8	100
WP 9	2.19	192	6.28	186	18.7	101
Landing	1.91	192	6.27	186	18.7	108

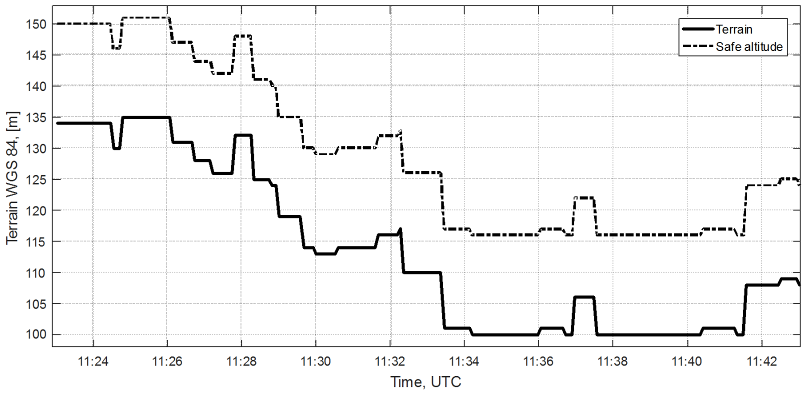

Figure 5: Terrain altitude ans safe altitudes.

calculation are presented in Table 1. For calculation GS we use actual weather data for each waypoint. Due to the low length of total trajectory, wind data could be constant for each waypoint. We use a wind speed is 1.3 m/s which is applied with wind direction at 270°. Also, we expect to use constant cruise speed along the whole trajectory. Total trajectory length is 27 km which takes more than 20 min to meet the main mission goal. The mission is planned to be in fully automatic mode. The team is used only for launch equipment deployment, then launch and UAV maintenance after parachute landing.

Terrain altitude calculated for each point of trajectory based on SRTM is shown in Figure 5. Also, we use a 30 m safe altitude above relief to avoid collision with nature. At the legs of payload use, we descend UAV to 16 m to move payload close to observed construction.

6. Conclusions

Trajectory planning of upcoming UAV mission should be based on lateral flight path selection and correct safe altitude. Trajectory should be set up with a sequence of waypoints and a specified altitude for each of them. Configuration of waypoints should be selected with criteria of meeting the main goal of the mission, which means moving a payload along a specified trajectory. Weather can significantly influence a mission, thus actual weather parameters should be compared with peril values to meet performance of UAV. Trajectory of up-coming mission should be selected considering wind direction. Approach to a leg of payload use should be wind-effective to make additional lift force input produced by a tailwind. Effectively selected trajectory could significantly improve performance of UAV used, mostly in total trajectory length and time of system use.

Effectively planned mission could be fully performed in automatic mode in rural areas in various applications. As an example exploitation of pipeline and power lines in rural areas. UAV could use high-resolution camera payloads for imaging (as well as other payload types) with geolocation and camera orientation logging. Collected during the mission data could be used for further data analysis.

Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

References

[1] N. Mohamed, J. Al-Jaroodi, I. Jawhar, A. Idries, F. Mohammed, Unmanned aerial vehicles applications in future smart cities, Technological forecasting and social change 153 (2020). doi:10.1016/j.techfore.2018.05.004.

[2] A. Molina, Y. Huang, Y.Jiang, A review of unmanned aerial vehicle applications in construction management: 2016–2021, Standards 3 (2023) 95–109. doi:10.3390/standards3020009.

[3] R. Avtar, T. Watanabe, Unmanned aerial vehicle: Applications in agriculture and environment, Springer-Verlag, Cham, Switzerland, 20201.

[4] S. Park, Y. Choi, Applications of unmanned aerial vehicles in mining from exploration to reclamation: A review, Minerals 10 (2020) 663. doi:10.3390/min10080663.

[5] P. Paul, L. Paul, An overview on the parachute recovery systems with additive manufacturing for uav landing, Materials Today 72 (2023) 3158–3162. doi:10.1016/j.matpr.2022.10.229.

[6] R. Kumar, J. Singh, P. Yadav, N. Semwal, S. Yadav, A. Bhorey, H. Dhawan, Parachute deployment system for safe recovery of a drone, Materials Today 72 (2023) 114. doi:10.1016/j.matpr.2023.04.114.

[7] V. Kharchenko, N. Kuzmenko, I. Ostroumov, Identification of unmanned aerial vehicle flight situation, in: Proceedings of the IEEE 5st International Conference on Actual problems of Unmanned Aerial Vehicles Development (APUAVD-2017), IEEE, Kyiv, Ukraine, 2017, pp. 116–120.

[8] I. Ostroumov, N. Kuzmenko, Risk analysis of positioning by navigational aids, in: Proceedings of the IEEE Signal Processing Symposium (SPSympo), IEEE, Krakow, Poland, 2019, pp. 92–95.

[9] M. Zaliskyi, O. Solomentsev, O. Holubnychyi, I. Ostroumov, O. Sushchenko, Y. Averyanova, Y. Bezkorovainyi, K. Cherednichenko, O. Sokolova, V. Ivannikova, R. Voliansky, B. Kuznetsov, I. Bovdui, T. Nikitina, Methodology for substantiating the infrastructure of aviation radio equipment repair centers, CEUR Workshop Proceedings 3732 (2024) 136–148.

[10] H. Jayaweera, S. Hanoun, Path planning of unmanned aerial vehicles (uavs) in windy environments, Drones 6 (2022) 101. doi:10.3390/drones6050101.

[11] D. Vural, R. Dell, E. Kose, Locating unmanned aircraft systems for multiple missions under different weather conditions, Operational Research 21 (2021) 725–744. doi:10.1007/s12351-019-00455-7.

[12] O. Solomentsev, M. Zaliskyi, O. Holubnychyi, I. Ostroumov, O. Sushchenko, Y. Bezkorovainyi, et al., Efficiency analysis of current repair procedures for aviation radio equipment, in: I. Ostroumov, M. Zaliskyi (Eds.), Proceedings of the 2nd International Workshop on Advances in Civil Aviation Systems Development. ACASD 2024. Lecture Notes in Networks and Systems, vol. 992, Springer Nature Switzerland, Cham, 2024, pp. 281–295. doi:10.1007/978-3-031-60196-5_21.

[13] C. Duan, J. Feng, H. Chang, Meteorology-aware path planning for the uav based on the improved intelligent water drops algorithm, IEEE Access 9 (2021) 49844–49856.

[14] C. Deng, W. Sribunma, S. Brunswicker, J. M. Goppert, I. Hwang, 3d path planning with weather forecasts, ground risks, and airspace information for uav mid-mile delivery, in: AIAA SCITECH 2025 Forum, 2025, p. 1806.

[15] J. Zhang, Y. An, J. Cao, S. Ouyang, L. Wang, Uav trajectory planning for complex open storage environments based on an improved rrt algorithm, IEEE Access 11 (2023) 23189–23204.

[16] H. Huang, A. V. Savkin, W. Ni, Online uav trajectory planning for covert video surveillance of mobile targets, IEEE Transactions on Automation Science and Engineering 19 (2021) 735–746.

[17] H. Liu, Y. P. Tsang, C. K. Lee, C. H. Wu, Uav trajectory planning via viewpoint resampling for autonomous remote inspection of industrial facilities, IEEE Transactions on Industrial Informatics (2024).

[18] I. Ostroumov, O. Ivashchuk, N. Kuzmenko, Preliminary estimation of war impact in ukraine on the global air transportation, in: 2022 12th International Conference on Advanced Computer Information Technologies (ACIT), 2022, pp. 281–284. doi:10.1109/ACIT54803.2022.9913092.

[19] I. Ostroumov, V. Ivannikova, N. Kuzmenko, M. Zaliskyi, Impact analysis of russian-ukrainian war on airspace, Journal of Air Transport Management 124 (2025) 102742. doi:https://doi.org/10.1016/j.jairtraman.2025.102742.

[20] O. Solomentsev, M. Zaliskyi, Y. Nemyrovets, M. Asanov, Signal processing in case of radio equipment technical state deterioration, in: Proceedings of the IEEE Signal Processing Symposium (SPS 2015), IEEE, Debe, Poland, 2015, pp. 1–5. doi:10.1109/SPS.2015.7168312.

[21] O. Solomentsev, M. Zaliskyi, O. Zuiev, Estimation of quality parameters in the radio flight support operational system, Aviation 20 (2016) 123–128. doi:10.3846/16487788.2016.1227541.

[22] M. Alam, J. Oluoch, A survey of safe landing zone detection techniques for autonomous unmanned aerial vehicles (uavs), Expert Systems with Applications 179 (2021) 115091.

[23] I. Ostroumov, N. Kuzmenko, Compatibility analysis of multi signal processing in apnt with current navigation infrastructure, Telecommunications and Radio Engineering 77 (2018) 211–223. doi:10.1615/TelecomRadEng.v77.i3.30.

[24] I. Ostroumov, N. Kuzmenko, Accuracy improvement of vor/vor navigation with angle extrapolation by linear regression, Telecommunications and Radio Engineering 78 (2019) 1399–1412. doi:10.1615/TelecomRadEng.v78.i15.90.

[25] I. Ostroumov, N. Kuzmenko, Accuracy assessment of aircraft positioning by multiple radio navigational aids, Telecommunications and Radio Engineering 77 (2018) 705–715. doi:10.1615/TelecomRadEng.v77.i8.40.

[26] O. Solomentsev, M. Zaliskyi, O. Zuiev, Radioelectronic equipment availability factor models, in: Proceedings of the IEEE Signal Processing Symposium (SPS 2013), IEEE, Serock, Poland, 2013, pp. 1–4. doi:10.1109/SPS.2013.6623616.

[27] O. Holubnychyi, M. Zaliskyi, O. Sushchenko, O. Solomentsev, Y. Averyanova, Y. Bezkorovainyi, et al., Self-organization technique with a norm transformation based filtering for sustainable infocommunications within cns/atm systems, in: I. Ostroumov, M. Zaliskyi (Eds.), Proceedings of the 2nd International Workshop on Advances in Civil Aviation Systems Development. ACASD 2024. Lecture Notes in Networks and Systems, vol. 992, Springer Nature Switzerland, Cham, 2024, pp. 262–278. doi:10.1007/978-3-031-60196-5_20.

[28] O. Solomentsev, M. Zaliskyi, Method of sequential estimation of statistical distribution parameters in control systems design, in: IEEE 3rd International Conference on Methods and Systems of Navigation and Motion Control, 2014, pp. 135–138. doi:10.1109/MSNMC.2014.6979752.

[29] M. Habib, Y. Alzubi, A. Malkawi, Impact of interpolation techniques on the accuracy of large-scale digital elevation model, Open Geosciences 12 (2020) 190–202. doi:10.1515/geo-2020-0012.

[30] K. Preety, A. K. Prasad, A. K. Varma, H. El-Askary, Accuracy assessment, comparative performance, and enhancement of public domain digital elevation models (aster 30 m, srtm 30 m, cartosat 30 m, srtm 90 m, merit 90 m, and tandem-x 90 m) using dgps, Remote Sensing 14 (2022) 1334. doi:10.3390/rs14061334.

[31] M. Simonetti, O. G. Crespillo, Robust modeling of geodetic altitude from barometric altimeter and weather data, in: Proceedings of 34th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2021), IONS, 2021, p. 1176–1189. doi:10.33012/2021.18054.

[32] WMM2020, World magnetic model 2020 released, 2020. URL: https://www.ncei.noaa.gov/news/world-magnetic-model-2020-released.