Method and Algorithm for Automatically Targeting of Unmanned Aerial Vehicle with Vertical Landing on Mobile Landing Site

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Abstract – **The article provides a method and algorithm for automatically targeting of unmanned aerial vehicles with a vertical landing on a mobile landing site commensurate with its dimensions, using GPS for civilian free use and a modified radio navigation system for pseudo-conical scanning.**

Keywords – **Automatic landing of UAV; pseudo-conical scanning; radio-navigation and radiolocation.**

I. INTRODUCTION

The landing of unmanned aerial vehicles (UAVs), and in particular those of a lower category, is carried out under the supervision of a qualified operator. The landing site is usually commensurate with the dimensions of the UAVs and GPS accuracy of the GPS for civilian purposes is not sufficient to target it directly. This is done using a differential GPS, the cost of which is significant [1]. In patents [2,3], the landing is conducted by a image recognition of the mobile landing site. After the landing, a protective enclosure is erected at the end of the landing site, which is a very precarious means of stably restraining UAVs. A solution is also available which is based on the automatic targeting of UAVs to the center of the stationary landing site through a modified pseudo-scanning method [4].

The functional scheme and operation of a vertical landing gearless landing system on a mobile landing site in which the present method can be implemented is described in [5]. This article presents the method and algorithms for its realization.

II. STAGED IMPLEMENTATION OF THE AUTOMATIC LANDING METHOD ON A MOBILE OBJECT

The landing method on a mobile object is realized by a series of operations, whose interrelationship is also presented in the form of algorithms (Figure 1).

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A. STAGE 1 - Positioning of the UAS over the pseudo-conical scan zone

Block 1. Sending the UAVs command to the moving landing site by an operator or automatically after the task has been performed and transmitting the coordinates of the erroneously positioning cylinder as defined in [4,5].

Block 2. The on-board communication-information module directs the UAVs to it, driven by continually updated GPS coordinates of the erroneously positioning cylinder.

Block 3. Intrusion of the UAVs into an area for close communication and connection between the UAVs and the landing site through their wireless interfaces for close communication. If there is no communication - it cyclically searches and continues to fly to the coordinates.

Block 4. Switch on the microwave receiver on the UAVs and the microwave transmitter at the landing mobile site. The transmitter, via an electronically pseudo-conical scanning antenna mounted at the center of the landing site, radiates continuously sequentially the four modulated signals in four beams. The modulated signals carry the landing site identification number, the identification code of each beam (left, right, forward, backward), the current GPS coordinates of the erroneously positioning cylinder, the speed and the change of motion direction vector, based on the gyro. The latter contributes to a faster response to the movement of the landfill site. After this data, each beam emits a constant signal to measure its level.

Block 5. There is a check. Are these signals accepted by UASs? If NO continues cyclical searching + emergency procedure. If YES, follows:

B. STAGE 2 - Signal processing and positioning of the UAS at the center of the pseudo-conical scanning zone

Block 6. Processing of the level of signals received by pseudo-conical scanning rays (described in Block 4) from an information microcontroller by algorithm from [6].

The position of the UAV is determined by processing the measured power of the received signal from the four beams of the antenna by pseudo-conical scanning. For this purpose, different algorithms can be used, as in the [6], the classical conical scan method, the least mean square (LMS) estimator, the Kalman filter (KF) based on the classical conical scan method and others. They are adapted to pseudo-conical scanning, the specificity of the controled object, the landing conditions and the instrumental error in measuring the received power.

Block 7. Targeting the UAVs to the central axis 0Z above the landing site as a result of the data and processing in Block

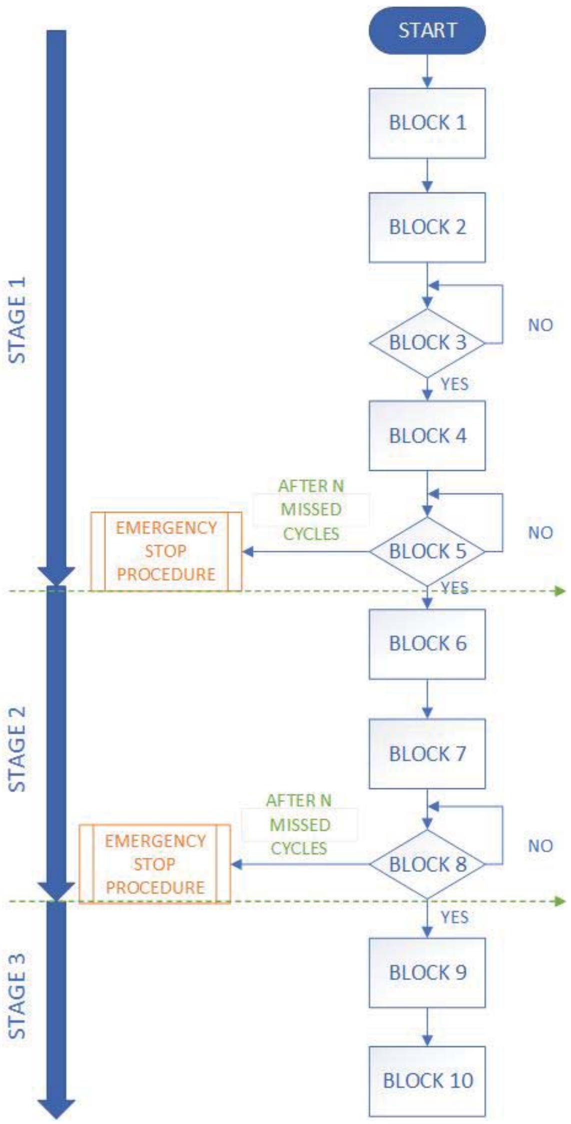

Fig. 1. Algorithm for realization of the method

5, the result of which is fed to the onboard dashboard communication-information module. The on-board communication-information module receives information in which direction to move. It directs and positions just above the center of the landing site, where the signal levels of all four beams are equal. The gyroscope signal helps for a very fast flight direction correction to follow the wrong positioning cylinder and correspondingly the pseudo-conical scan range.

Block 8. Aligning speeds, turning on the altimeter and sending a landing permission request (automatically from the mobile station of landing site or from the operator). If no permission is given, action is made on the plan and flies to a landing or landing site of the mobile object or eventual manual landing control.

C. STAGE 3 - Downgrading the UAS and landing on the site

Block 9. After receiving permission, the UAVs shall descend downward to the center of the landing site, driven by the data and processed pseudo-conical scan signals, in accordance with Block 6 and the altimeter. Communication is routed through proximity communication interfaces.

Block 10. Upon reaching a few centimeters above the landing site, command is sent to turn the electro-magnetic or electro-mechanical gripping device on the landing site, depending on its inertia. A landing sensing sensor can also be set up to automatically engage the landing. Successful landing message is sent. With the UAVs landing, it must be firmly engaged on the site, especially at higher speeds on the mobile object. Electro-mechanical clamping can be done with two side-clips relative to the landing site driven by micro-electric motors.

III. Additional Remarks

The algorithms to perform the individual stages are autonomous and run sequentially, each ending with an emergency signal to the landing site if problems arise. In this case, its movement must be stopped to ensure a safe landing and, if necessary, stopping the movement of the object and moving to manual control.

IV. Conclusion

The proposed method, based on pseudo-radio scanning in radio navigation, is suitable for targeting and controlling the landing of plumbing aircraft on a mobile landing site commensurate with their gauges using civil GPS systems.

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