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RECENT APPROACHES AND ALGORITHMS TO SOLUTIONS OF THE PROBLEMS OF COLLISION AVOIDANCE OF UNMANNED AERIAL VEHICLES

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ABSTRACT: - An unmanned aerial vehicle (UAV) is an aircraft that is remotely piloted or flown autonomously, without pilot assistance. Historically, UAVs were originally used as military devices: weapons and reconnaissance tools. However, since the early 2000s, UAVs developed for purely civilian purposes rather than military ones have become increasingly important. The civilian application of UAVs is very broad: from the agricultural and entertainment sectors to the oil and gas and security sectors. "Civilian drones can be used by emergency services (fire safety control); law enforcement (patrolling areas, detecting violations); agriculture (crop surveillance), forestry and fishing (forest protection and fishery control); geodesy companies (mapping); geography and geology institutes; oil and gas companies (monitoring of oil and gas facilities); construction companies (inspecting construction.

KEYWORDS: An unmanned aerial vehicle (UAV), algorithm, reconnaissance, collision avoidance.

INTRODUCTION

At the beginning of the twentieth century new unmanned devices appeared: boats, cars, planes. In the nineties, these devices began to actively develop, stimulated by the traditional military application for all pioneering systems. Initially UAVs were used as reconnaissance vehicles. Since the beginning of the 21st century, UAVs have been actively used for civilian purposes [8]. Currently, the number of possible applications of UAVs is approaching two hundred [8, 1, 7]. The volume of UAV production and sales is growing exponentially [1, 6]. According to various estimates, by 2025, UAVs will be produced at a cost of 10 to 15 billion dollars per year. Accordingly, the number of UAVs will steadily increase (up to a million per year), and by 2030 there will be a serious problem of their interaction in a single airspace [9, 7].

From the theoretical point of view, the relevance of the research topic is determined by the insufficient level of research concerning the algorithmic support of interaction of different-type UAVs belonging to different owners. Modern UAV control systems, as a rule, do not contain developed automated tools for evaluating the surrounding air environment and preventing air collisions.

All UAVs are divided into two large classes: "wing" and "helicopter", a variety of copters (quadcopters, octocopters, and so on) belong to the helicopter type. And if helicopter-type UAVs can "hover" in some point of space, the UAV type "wing" must necessarily move at some minimum speed. In addition, the mass-energy characteristics of UAVs limit the possibilities for their maneuvering. To implement interaction control in a group of different-type UAVs, it is necessary to develop specialized software for issuing commands to the standard autopilot of the UAV, including:

- analysis of information coming from the "alien" objects position estimation module to estimate supposed trajectories of objects movement in the potentially dangerous zone of airspace surrounding UAVs;
- formation of information for selection of one or another algorithm of UAV behavior depending on position and behavior of potentially dangerous objects in the airspace zone surrounding the UAV;
- formation, if necessary, of command information for autopilot to correct UAV trajectory.

The ultimate goal of the research is to develop algorithms and design special software based on them, improving the efficiency of control of different types of civil UAVs in conditions of interaction in common airspace.

To achieve the intermediate goal, namely to identify the relevance of developing these algorithms [99, 101], it is necessary to solve problems:

1. identify the most demanded functions of UAVs by regional and municipal governments.

Determine, on the basis of the identified functions, the most popular types of UAVs used and expected to be used by regional and municipal governments.

Determine a standard list of hardware for the most popular types of UAVs. 4.

Determine algorithms for solving UAV interaction management tasks in common airspace.

5. Identify the least developed, but most promising direction for building UAV interaction algorithms.

6. To form algorithmic problems of UAV interaction control, which solution allows to achieve the goal in an optimal way, from the point of view of achieving the goal with minimal use of resources.

The solution of the presented tasks makes it possible to reveal the degree of relevance, as well as to parameterize the groups of civilian UAVs with a high probability of involved in interaction (in some cases with collisions) in a single airspace.

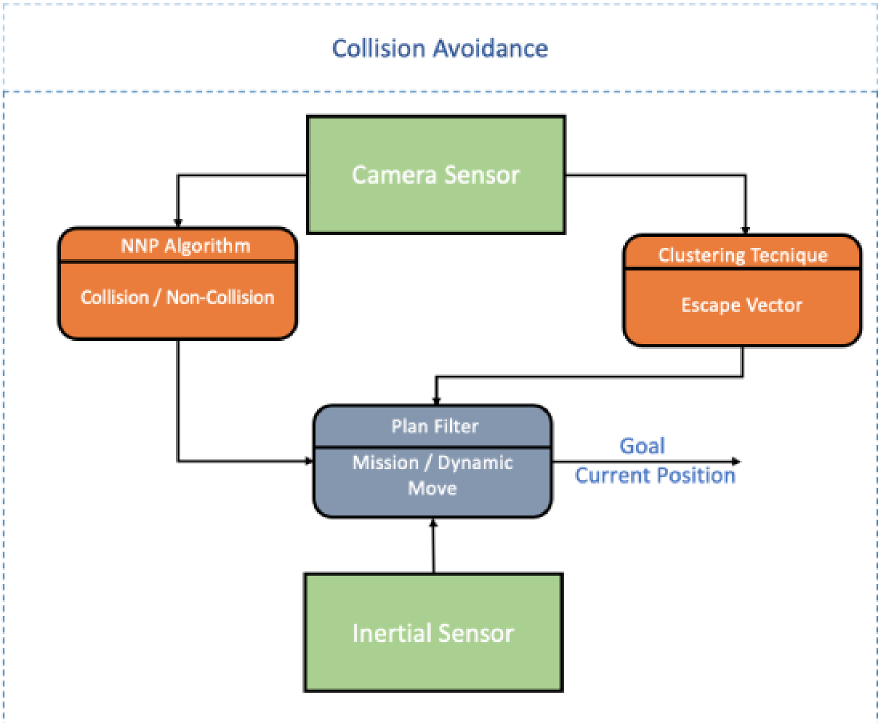

Fig 1. Suggested collision avoidance approach for UAV

METHODS AND DISCUSSION

The aim of this research work is to develop a computational method for preventing collisions of unmanned aerial vehicles with each other, based on a velocity approach.

To achieve the goal, the following tasks should be accomplished:

1. Perform an analysis of existing UAV collision avoidance methods.
2. Develop a mathematical model for detecting potentially dangerous dynamic-moving objects, based on a velocity approach.
3. Develop an algorithm for collision probability assessment, based on the features and behavior characteristics of these objects.
4. Develop algorithms to calculate UAV parameters for collision avoidance.
5. To implement the developed algorithms in the software complex for simulation of UAV movement and their visual representation.
6. To check the adequacy of the developed algorithms by direct mathematical modeling.

The object of research - UAV collision avoidance system.

Subject of research - collision avoidance algorithms based on the velocity approach.

The research methods are based on the general methodology of mathematical modeling of the processes under study, object-oriented programming. The theory of inventive problem solving was used to solve the problems. Visual Studio integrated environment for C# programming language was used.

Scientific novelty of the results:

1. A new mathematical model of dynamically changing interpositioning of unmanned aerial vehicles has been proposed, which makes it possible to estimate the parameters preventing the collision of unmanned aerial vehicles, distinguished by the possibility of obtaining adequate results in analytical form.
2. A new algorithm for determining the boundaries of the critical velocity range based on the velocity approach, distinguished by the possibility of obtaining the values of these boundaries in analytical form, has been proposed.
3. A new algorithm for determining the linear acceleration of the UAV to prevent collision in a high-speed manner is proposed, distinguished by the fact that the values of the boundaries of the critical velocity range calculated on the basis of the velocity approach are used to calculate the linear acceleration.
4. A new approach to improve the efficiency of the Monte Carlo method for constructing the boundaries of the interaction zone is proposed and implemented in the program, differing from the existing contextual narrowing of the boundary search area.
5. An algorithm is developed and a software package is created for realization of collision avoidance system with a large number, up to fifty, of unmanned aerial vehicles, differing from the existing ones by the possibility of realization of a velocity approach for collision avoidance.

CONCLUSION

A safer architecture for UAV navigation was given in this paper. A block in this design is responsible for avoiding collisions with dynamic objects (such as a thrown ball). An escape vector is calculated by a parallel OME algorithm whenever this NNP outputs an incoming collision. To predict the trajectory of the incoming object, the OME uses the optical flow between the previous and current frames, as well as a clustering method. For this use-case, a new OF clustering algorithm termed OFC was devised, which outperformed state-of-the-art algorithms. This research will focus on relatively recently developed autopilots, in which the operator is relieved of the burden of detailed control of the UAV. The operator has the task of plotting the route of the UAV, although in some cases this task is at least partially shifted to the autopilot.

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