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CONCEPTUAL APPROACH TO UTILISATION OF THE UNMANNED AERIAL VEHICLES IN DIVERSE ACTIVITIES

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ABSTRACT

This paper considers current situation and development of software for group of mobile agents applicable on group of unmanned aerial vehicles. Generally, unmanned aerial vehicles are used for transfer of information, mass and energy and their group work enhances their success rate in comparison with the success rate of the use of a single unmanned aerial vehicle. Despite the constant daily use, their potential is realized only in a small portion. It is argued that software development is the natural further step in achieving considerably larger portion of realizations of their potential of groups of unmanned aerial vehicles. Starting requirements that such software must fulfill are rudimentariness of the code, openness regarding number of group members and closeness regarding information exchange. Prospective directions of development of that software are analyzed.

KEY WORDS

software, mobile agents, unmanned aerial vehicle, autonomous group, redundancy

CLASSIFICATION

JEL: L62, L93

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INTRODUCTION

The use of systems of autonomous agents cover numerous applications in a number of activities. While operating, agents in such systems constantly measure certain parameters related to their states or to the state of their environment. A general accompanying characteristic of these measurements is that they are processed with statistical limitations in real time. If the ability of such a system is to be determined empirically, it is necessary to conduct multiple tests with time involved and energy consumed. Ability to assess capabilities of the system would enable the implementation of the system of autonomous agents on a larger number of qualitative various systems. Ability to assess capabilities of the system is defined as the ratio of required and implemented characteristic of system. The system is deemed competent if the ratio is large enough. Therefore, the lack of the method for assessing abilities severely suppresses the possibility of efficient and proper use of a system of autonomous agents.

Examples of the use of autonomous agents are transport of loads and people between multiple locations, non-destructive and irreversible searches of the area, monitoring of natural phenomena, underwater research, traffic control, implementation of communication networks in adverse environments and others. The most commonly used autonomous agents for such tasks are stationary or mobile robots, underwater vehicles, aircraft, agents in a virtual environment, and other types of agents that perform a smaller number of simpler operations, including collecting and processing directly or indirectly measured data on the environment.

GROUP OF MOBILE AGENTS

The concept of controlled group motion was applied onto autonomous group of mobile robots. They prevalently operate in known and unknown interior spaces and have been thoroughly tested in such conditions. Main task for mobile robots is allocating free space and defining mathematical model of movement in observed physical space filled with barriers. Methods that have been widely applied include methods such as are C-space method, equidistant path method, potential field method and fuzzy logic methods [1]. In recent times the majority of use belongs to applications of the cognitive method [2]. That approach is based on collaborative work of independent robots, or in general agents [3, 4].

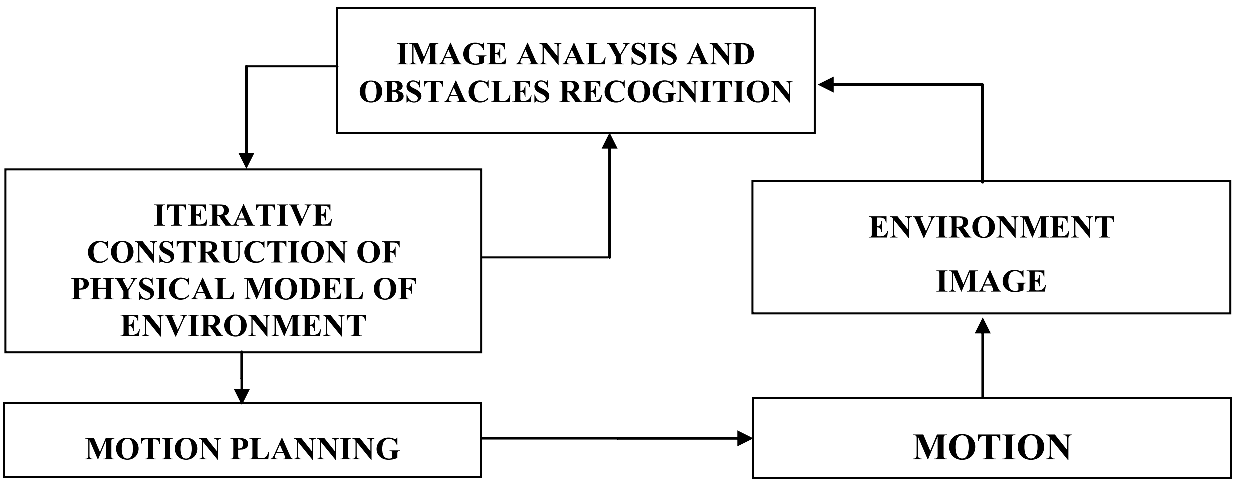

Figure 1. Decision procedure during a typical mobile robot's task performance [6].

An agent is an independent process, which performs a specific task either in collaboration with other agents or individually. All agents work in the same time period. Every agent has initial state, time duration, input and output. Input of one agent can be output from another agent and outputs are the characteristics and events. They can be hierarchically structured and have different priorities, but appears the problem of excessive communication and coordination between them. From the perspective of agents their function can be defined as visual, audio, time, store and memory [5]. In case of movement agent must record the environment, analyze it and in an iterative procedure decide which path is optimal [6]. Figure 1 illustrates a typical mobile robot's decision procedure during task performance.

UAV IMPLEMENTATION

Generally, UAVs are used for transfer of informations, mass and energy. Priority of UAV research must be oriented on software development. That development makes possible realization of most of the capabilities attributed to them by their construction.

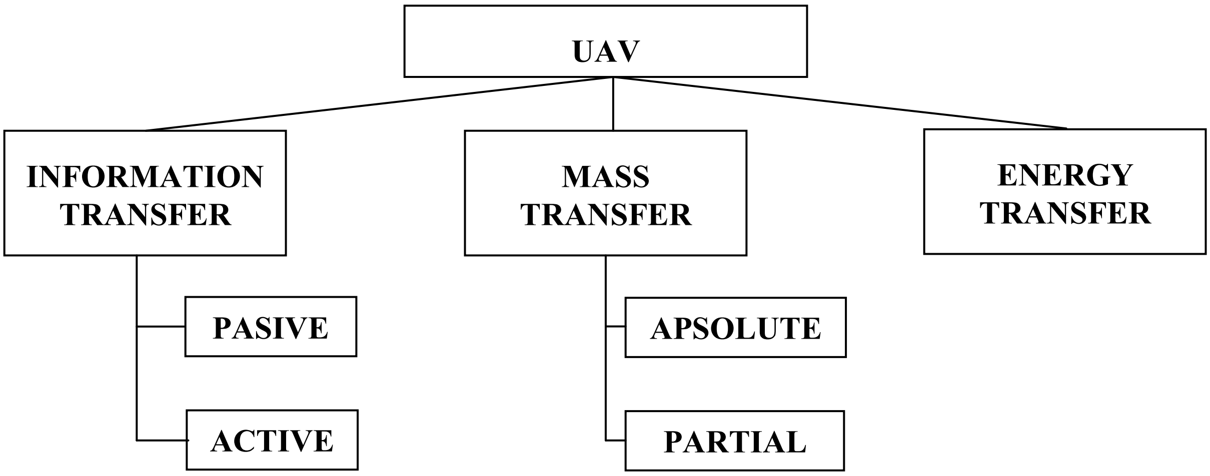

Figure 2. UAV classification.

Let us describe in more details the classification presented in Fig. 2. Information transfer can be passive and active. Passive transfer refers to information collected from the environment during the flight and analyzed after UAVs landing. In the case of active transfer, information is sent from the UAV to station referent for further analysis, usually real time processing. Mass transfer can be absolute and partial. Absolute transfer refers to the weight of the UAV which represents constant load during the flight. Partial transfer refers to the weight of the cargo that UAV lets off during its flight.

Regarding the number of UAVs exploited for a given objective two different classes are introduced (Fig. 3):
- Single unit mission.
- Group of UAVs mission.

These two classes are related to substantially different approaches, regarding relevant criteria for success determination.

In the first class, a single UAV must be equipped with all necessary equipment and instruments, thus as a rule their mass is rather large. Such an UAV is easier for maintenance and control during the flight than the second class UAVs. Major disadvantage is the risk in performing the task because if that UAV crashes or is in other mission fails.

In the second class, a task is subdivided between UAV group members. In that way a redundancy is achieved so failures in one or several UAVs do not bring about automatically failure of the complete mission.

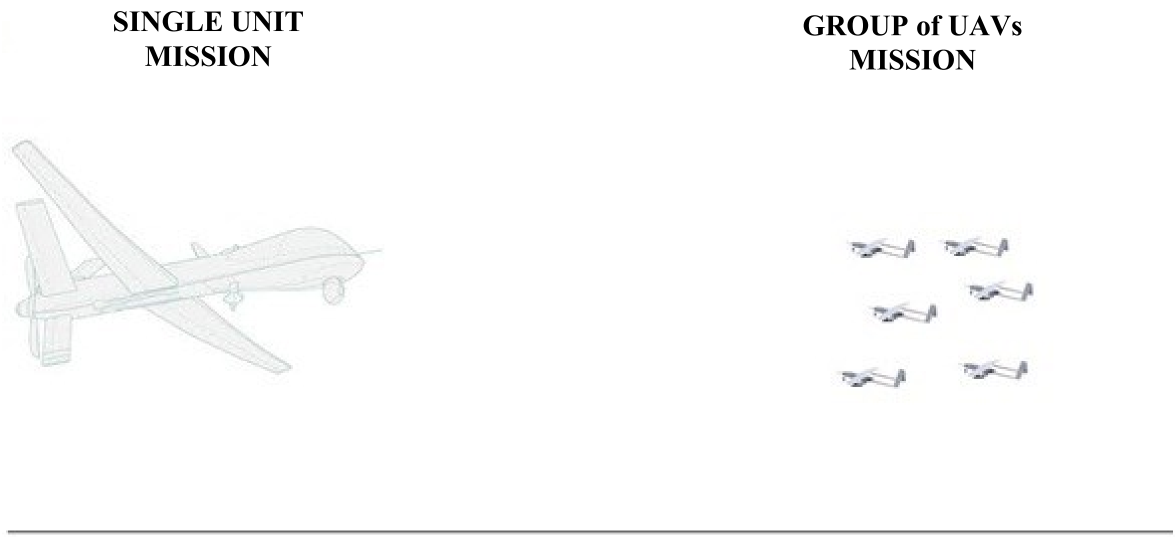

Figure 3. Defined classes regarding the number of UAVs exploited for a mission.

That is major advantage of this approach. Each member of the group collects data from environment and exchanges it with other members. Small part of internal memory is used for exchange of data and the rest is used for flight control. An additional consequence is that each member is in principle cheaper, in a limiting case so cheap that there is no need for but the simplest maintenance, as otherwise UAVs are replaced by new ones. Crucial problem, regarding the second approach, is absence of the software which controls such a group which enables the group to conduct predicted mission in a rather efficient way. Alternatively, if human operator controls UAV group performance, still the nonexistence of described software limits the group efficiency.

SOFTWARE DEVELOPMENT FOR GROUP OF MOBILE AGENTS

Software for autonomous action of a group of mobile agents is not full developed because there is no sufficient level of understand the essence of collective performance which can be effectively formalized and operationalized.

However, the following characteristics are universally present in the basis of their underlying software:

- Rudimentariness,
- openness regarding number of group elements and
- closeness regarding information exchange.

Regarding the code rudimentariness, the software must have as few as possible commands of simpler character and overall as short as possible code. Regarding openness, the software must enable the group to preserve functionality even if one or more elements are missing. On the other hand, openness of the software to the number of elements allows adding new elements which ultimately increases probability of successful task realization and that extends the duration of the group action if requested. The closeness regarding information exchange, puts demand on the software in the sense that if the element in a given time interval does not receive data from other elements of the system he can continue to conduct its subtasks. That characteristic of software resembles the standard software systems of transport aircrafts.

These determinants have several consequences; one of them is a redundancy. More specifically, the possibility of variable total number of agents and variable number of communication links is fail-operational. Fail-operational means that a fault in a system must be detected, localized and the system must be dynamically reconfigured.
Whereas progress in development of the software has a significant and measurable impact on the effectiveness of distributed systems and in general of embedded systems, significant efforts are involved in development of software and related algorithms.

CONCLUSION

A contemporary level of technics makes possible construction of fully operational autonomous groups of UAVs, yet such groups do not exist in practice. The cause for that is insufficient level of developed and embedded software. Consequently, it is opportune to put a priority of UAVs research onto software development. That development makes possible realization of most of the capabilities attributed to by their construction. The basis of such software, like rudimentariness, openness regarding number of group agents and closeness regarding information exchange, must be fulfilled. Progress in development of the software has a significant and measurable impact on the effectiveness of distributed systems and in general embedded systems. Significant efforts are involved for development of the software which would make possible full development of the potential of group of UAVs.

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