Diverse Trajectory Planning for UAV Control Displays (Demonstration)

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ABSTRACT

Current UAV control systems can plan optimal trajectories with respect to predefined constraints (waypoints, no-fly zones). However when the operator is not satisfied with planned trajectories it is usually very complicated to force the system to change the trajectories in desired way. In this demonstration we solve this problem by innovative UAV control display based on diverse planning algorithm.

Categories and Subject Descriptors

I.2.9 [**Artificial Intelligence**]: Robotics—*Operator interfaces*

Keywords

Trajectory Planning, UAV, Human-Machine Interface

1. INTRODUCTION

Current systems for controlling of Unmanned Aerial Vehicles (UAVs) are equipped with sophisticated GUIs providing clear overview of the mission status and efficient way of controlling it by human operator [2]. In cases where autonomous planning systems are involved the operator must be able to define constraints that are taken into account by the planning system. The system then fulfills all defined constraints and calculates the optimal trajectory of an UAV. As the planning system is not aware of all available information about the actual situation it can happen that the calculated trajectory is not optimal from the operator's point of view.

Let us imagine a use case illustrated by Figure 1, where the operator was assigned to supervise an evacuation operation in a village (location B) near a damaged nuclear power plant. He has to fly there from his base station (location A), located in a safe distance from the affected area, while avoiding several no-fly zones. The autonomous planning system calculates a trajectory which goes over the inaccessible river bank as it is the shortest one (solid line). However for the operator it is not an optimal solution as it is impossible to perform emergency landing in such terrain. Other trajectory avoiding the no-fly zones by south (dashed line) would be more preferable.

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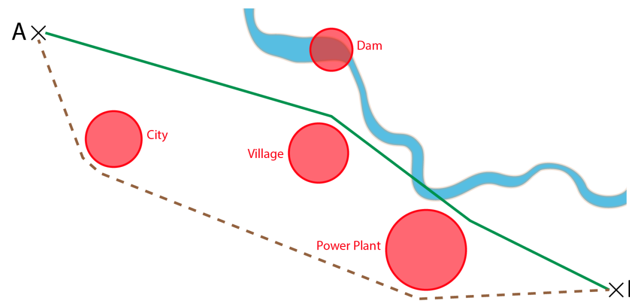

Figure 1: UAV flies from A to B while avoiding no-fly zones. Optimal trajectory (solid) and user preferred (dashed) trajectories are shown.

In our diverse planning system we propose several solutions that should help to solve this situation by means of better presentation of the planning process and ability to influence the selection of the final trajectory by embracing the human-in-the-loop principle.

2. PROBLEMS WITH AUTONOMOUS TRAJECTORY PLANNING

Current systems are able to plan optimal trajectory with respect to given constraints (set of obstacles, different utility functions like fuel consumption, time restrictions, etc.), e.g. A*, or Θ* [3]. A problem arises when the planned trajectory is not optimal from the operator's point of view (see the use case above).

The basic idea is to provide the operator with multiple trajectory alternatives to chose from. This should on one hand increase operator's insight to why particular solution has been chosen and on other hand it allows the operator to change it. This gives the operator higher level of control while not decreasing the level of autonomy of UAVs.

Let us describe two general scenarios when this approach will be beneficial:

Scenario 'Second best'.

The operator may be satisfied with the automatically selected trajectory but still would like to see the 'second best' solution. Obviously his/her perception of the second best solution is different than that of planning system. In some cases the meaning of the difference between two trajectories can be based on some information which is not known to the planning system, e.g. passing rivers or population density.

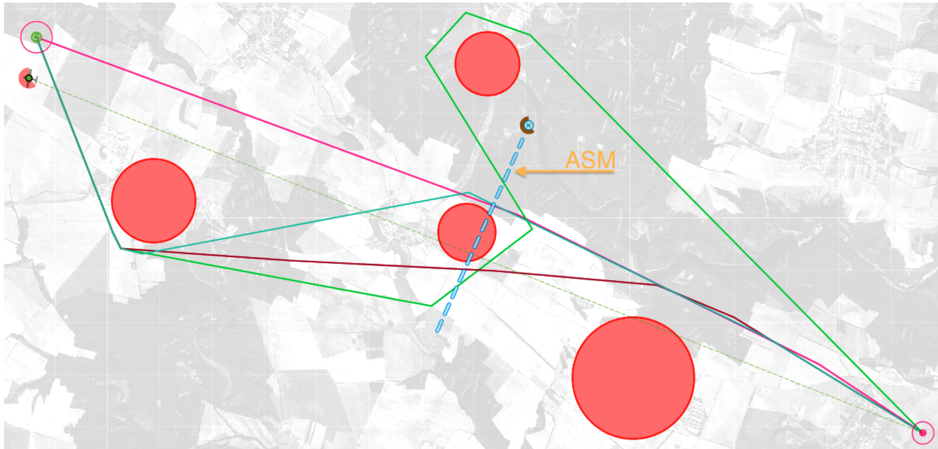

Figure 2: Screenshot of the UAV control display proposing several alternative trajectories. Live demo can be found at: http://agents.cz/arethus/UAV-HMI.avi

Scenario 'Preferred solution'.

Another case is when the operator has already an idea of the optimal trajectory for given UAV and the system proposes optimal, but different solution. The operator will obviously refuse this solution. Using diverse planning we can present several alternatives the operator can choose from.

3. DIVERSE PLANNING

To provide the user with diverse planning feature the planning algorithm should provide alternatives that are significantly different from the operator's perspective and not only from the algorithmic one. We have developed several algorithms that can create diverse trajectories, which were described and experimentally evaluated in the [4]. Several different trajectories are presented in GUI and the operator can choose one or refuse all of them.

The whole system is composed of three main components: *(i)* mission control display, *(ii)* UAV hardware control unit and *(iii)* a planning component. The planning component can be included in any of other component - for different scenarios different implementation can be more preferable. Planning component creates diverse trajectory plans and once the most preferred solution is chosen by the operator, it sends it to the UAV control unit for execution.

3.1 HMI Diverse Planning Presentation

The user interface is optimized for efficient user control in stress situation by means of finger touches. According to Fitt's law [1] all interactive controls are large with stable position and dimension. Location of all necessary information and controls on one spot increases the chance to attract the operator and shorten the time to evaluate the situation.

The blue-white circular controls appear with animation to attract operator's attention and color, shape and size are selected to induce local pop-out effect. Waypoints and no-fly zones menus have stable position and dimension where original size is displayed by dashed line which can be changed.

The operator obtains shortest trajectory along with three alternatives. The shortest trajectory is pre-selected but the operator can select another one. The selection of the alternatives is done by Alternative Selection Menu (ASM, see Figure 2). By clicking on the ASM next three alternatives are displayed and cycle when the operator goes through the whole list. The selection is done by clicking on the desired trajectory. Selected trajectory starts blinking and stays displayed all the time. If the operator moves the pointer over the trajectory a label is displayed with the detailed information (e.g. length, fuel consumption, ETA).

The remaining time to perform the alternative selection is indicated by means of gradually closing arc both on the UAV and ASM. During this time the operator has also the opportunity to refuse all trajectories.

4. CONCLUSION

In this demonstration[1] we present an innovative UAV mission control display enhanced by diverse trajectory planning. Algorithms for diverse trajectory planning have been previously described and experimentally evaluated in [4, 5]. This approach to the human-machine interaction can increase the effectiveness of performed tasks, which is highly important for multi-UAV scenarios, and also the operator's trust in the autonomous system, which is often a barrier preventing its usage in daily tasks.

5. REFERENCES

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