Fuzzy Mixed Integer Linear Programming for Air Vehicles Operations Optimization

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Abstract. Multiple Air Vehicles (AVs) to prosecute geographically dispersed targets is an important optimization problem. Associated multiple tasks viz., target classification, attack and verification are successively performed on each target. The optimal minimum time performance of these tasks requires cooperation among vehicles such that critical time constraints are satisfied i.e. target must be classified before it can be attacked and AV is sent to target area to verify its destruction after target has been attacked. Here, optimal task scheduling problem from Indian Air Force is formulated as Fuzzy Mixed Integer Linear Programming (FMILP) problem. The solution assigns all tasks to vehicles and performs scheduling in an optimal manner including scheduled staged departure times. Coupled tasks involving time and task order constraints are addressed. When AVs have sufficient endurance, existence of optimal solution is guaranteed. The solution developed can serve as an effective heuristic for different categories of AV optimization problems.

Keywords: Fuzzy Mixed Integer Linear Programming, Air Vehicles, Planning, Scheduling

1 Introduction

Unmanned Air Vehicle (UAV) is an aircraft with no onboard pilot which can be remote controlled or fly autonomously based on pre-programmed flight plans with complex dynamic automation systems. Optimizing air to ground operations of such air vehicles is an important decision making problem [7]. A more challenging scenario is multiple UAVs required to service geographically dispersed targets. Multiple tasks are required to be successively performed on each target, viz. targets to be classified, attacked and damage inflicted on targets must be assessed. The floating time constraints are critical. A target cannot be attacked before it is classified and UAV sent to target area only after target attack has been executed. Multi role UAVs are considered such that each UAV can perform all tasks. Small UAVs such as autonomous Wide Area Search Munitions (WASM) are deployed in groups from aircraft flying at higher altitudes. They are individually capable of autonomous searching, recognizing and attacking targets. The ability to network involving communication of target information to one another and consequent co-operation greatly improves effectiveness of future UAV teams. The problem comprises of planning performance of UAVs' tasks such that critical timing constraints are satisfied. This calls for optimal assignment and scheduling [1].

In a time phased network optimization model was used to perform task allocation for team of UAVs [9]. The model is run simultaneously on all air vehicles at discrete points in time and assigns each vehicle one or more tasks each time it is executed. The network optimization model is iteratively implemented such