Verifying UAV Path Planning: A Formal Approach of Choice.

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When deploying multiple UAVs each with its own sensor platform into an unstructured environment, the swarm of these sensor platforms, i.e. the team of UAVs needs to deploy in a manner that will gather information about the local environment, identify and track objects of interest, and act in a co-operative and robust manner. Guidance strategies that result in UAV platforms covering the area of interest whilst avoiding obstacles, and allow UAV platforms to arrive at specific positions at specific times and with specific sensor orientation, is the focus of this presentation. The use of Dudin's sets would provide the framework for guidance and navigation. Coordinated Path Planning of Multiple UAVs for simultaneous arrival with safe flight-paths is described. The simultaneous arrival of all UAVs is guaranteed by paths of equal lengths. Two conditions, namely minimum separation distance and non-intersection of paths at equal length are used/proposed to ensure the safe flight-path of UAVs. These conditions are to avoid inter-UAVs collision. The Dubins paths are used for the path planning. Bisection method is used to find the optimal turning radii of paths. The path planning guarantees design of paths of equal length with shortest paths. This is having advantages in reducing fuel consumption and increasing the durability of UAVs. Furthermore formal modelling techniques are applied to this problem of multi-UAV coordination, decision making and path planning. When UAV teams are called to operate in areas with uncertain information it is impossible to validate every conceivable situation that might arise in operation in such scenarios. By using formal techniques, aspects of the operating model that must necessarily hold true throughout can be mathematically validated. *Kripke models* of "possible" worlds are used to represent formally a multi-UAV scenario, where availability of environment information is to be used by the team to collect, exchange and utilise available information to make a complete survey of the specified area. The ability of our proposed Kripke model to cope with the uncertainties and decision making involved in this process can be verified using an exhaustive proof technique known as *model checking*.

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