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Drone Swarm Routing and Scheduling for Off-shore Wind Turbine Blades Inspection

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Abstract : In off-shore wind farms, turbine blade inspection accessibility under various sea states is very challenging and greatly affects the downtime of wind turbines. Maintenance of any offshore system is not an easy task due to the restricted logistics and accessibility. The multirotor unmanned helicopter is of increasing interest in inspection applications due to its manoeuvrability and payload capacity. These advantages increase when many of them are deployed simultaneously in a swarm. Hence this paper proposes a drone swarm framework for inspecting offshore wind turbine blades and nacelles so as to reduce downtime. One of the big challenges of this task is that when operating a drone swarm, an individual drone may not have enough power to fly and communicate during missions and it has no capability of refueling due to its small size. Once the drone power is drained, there are no signals transmitted and the links become intermittent. Vessels equipped with 5G masts and small power units are utilised as platforms for drones to recharge/swap batteries. The research work aims at designing a smart energy management system, which provides automated vessel and drone routing and recharging plans. To achieve this goal, a novel mathematical optimisation model is developed with the main objective of minimising the number of drones and vessels, which carry the charging stations, and the downtime of the wind turbines. There are a number of constraints to be considered, such as each wind turbine must be inspected once and only once by one drone; each drone can inspect at most one wind turbine after recharging, then fly back to the charging station; collision should be avoided during the drone flying; all wind turbines in the wind farm should be inspected within the given time window. We have developed a real-time Ant Colony Optimisation (ACO) algorithm to generate real-time and near-optimal solutions to the drone swarm routing problem. The schedule will generate efficient and real-time solutions to indicate the inspection tasks, time windows, and the optimal routes of the drones to access the turbines. Experiments are conducted to evaluate the quality of the solutions generated by ACO.

Keywords : drone swarm, routing, scheduling, optimisation model, ant colony optimisation
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