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SPECIAL ISSUE

Hyper-parameter tuned deep Q network for area estimation of oil spills: a meta-heuristic approach

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Abstract

Oil Spills near shoreline are a major environmental hazard. Rapid estimation of spill perimeter provides a quick estimate of its area extent thus facilitating its quick removal. In this study; a meta-heuristic algorithm; *"Gamma-Levy Hybrid Meta-heuristic with Conditional Evolution (GLHM-CE)"* is proposed. The proposed algorithm is then used to evolve a distributed control strategy for a swarm of unmanned aerial vehicles for rapid confinement and estimation of spill perimeter. Every agent is controlled by a Deep Q Network whose Hyper-Parameters are tuned by GLHM-CE. Evaluation of GLHM-CE over 28 Blackbox Problems of CEC-2013,Special Session on Real-Parameter Optimization and its comparison with evolutionary algorithms like SHADE,Co-DE and JADE reveals that GLHM-CE successfully evades local minima and has a fast convergence. The effectiveness in hyper-parameter tuning of a Deep Q Network by GLHM-CE was evaluated over the quintessential CartPole problem from OpenAI Gym framework.

Keywords GLHM-CE · MetaHeuristics · Evolutionary Algorithms · DQN · Hyper PArameters · Oil Spill · UAV

1 Introduction

For a successful removal of oil spill near shoreline, time is of paramount importance. The more time lost in predicting oil spill extent and trajectory prediction, the more we endanger marine biology [27]. Professions relying on marine biology like that of a fisherman is temporarily and in extreme cases permanently destroyed by such a catastrophic event. In 2013 alone two oil spills in Malaysia and Ecuador contaminated drinking water of 300,000 and 80,000 people respectively. Shoreline spills create the most havoc followed by deep water spills by oil-rigs and oil tankers. Studies reflect that a rapid perimeter estimation of these spills reduces the damage considerably both in financial and environmental aspect [1].

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Oil Spill perimeter estimation by SAR imagery has been the focus of research. Nirchio et al. [19], Karantzalos et al. [15] and Jha et al. [14] has provided significant insight in perimeter detection of spills from SAR imagery a decade ago. Recent approaches in SAR image analysis for spill detection such as that of Saeed et al. [7] and Yang et al. [31] has provided accuracy rates more than 90% in spill detection. Though SAR imagery approach is of importance, it can noway be considered inexpensive and rapid with the time lag between images involved. Rapid estimation of spills can only be achieved by active agents or robots (both aerial and surface) deployed in vicinity of the spill following a distributed control algorithm for optimized trajectory. Studies by Gonzalez and Yu reflects both the importance and effectiveness of multiagent systems in dealing oil spill perimeter estimation and tracking. Yu et al. [32] incorporates homogenous buoys for long term oil spill tracking. Though the argument by Yu against that of unmanned aerial vehicles is its lack of endurance in foul weather, the same also goes for the deployment of buoys by ships and air planes which will suffer the same endurance issues as that of the UAVs. A late deployment costs more time. Works of Fingas and Brown [10] provides useful insights in aerial imagery by laser fluorosensors for oil detection by UAVs. Hybrid control algorithms for multiagent perimeter estimation without