World Academy of Science, Engineering and Technology
International Journal of Electronics and Communication Engineering
Vol:14, No:06, 2020

Multi-Agent Searching Adaptation Using Levy Flight and Inferential Reasoning

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Abstract : In this paper, we describe how to achieve knowledge understanding and prediction (Situation Awareness (SA)) for multiple-agents conducting searching activity using Bayesian inferential reasoning and learning. Bayesian Belief Network was used to monitor agents' knowledge about their environment, and cases are recorded for the network training using expectation-maximisation or gradient descent algorithm. The well trained network will be used for decision making and environmental situation prediction. Forest fire searching by multiple UAVs was the use case. UAVs are tasked to explore a forest and find a fire for urgent actions by the fire wardens. The paper focused on two problems: (i) effective agents’ path planning strategy and (ii) knowledge understanding and prediction (SA). The path planning problem by inspiring animal mode of foraging using Lévy distribution augmented with Bayesian reasoning was fully described in this paper. Results proof that the Lévy flight strategy performs better than the previous fixed-pattern (e.g., parallel sweeps) approaches in terms of energy and time utilisation. We also introduced a waypoint assessment strategy called k-previous waypoints assessment. It improves the performance of the ordinary levy flight by saving agent’s resources and mission time through redundant search avoidance. The agents (UAVs) are to report their mission knowledge at the central server for interpretation and prediction purposes. Bayesian reasoning and learning were used for the SA and results proof effectiveness in different environments scenario in terms of prediction and effective knowledge representation. The prediction accuracy was measured using learning error rate, logarithm loss, and Brier score and the result proves that little agents mission that can be used for prediction within the same or different environment. Finally, we described a situation-based knowledge visualization and prediction technique for heterogeneous multi-UAV mission. While this paper proves linkage of Bayesian reasoning and learning with SA and effective searching strategy, future works is focusing on simplifying the architecture.

Keywords : Levy flight, distributed constraint optimization problem, multi-agent system, multi-robot coordination, autonomous system, swarm intelligence
Conference Title : ICMASR 2020 : International Conference on Multi-Agent Systems and Robotics
Conference Location : London, United Kingdom
Conference Dates : June 29-30, 2020