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MULTI-AGENT REINFORCEMENT LEARNING SYSTEM OF UAVS FOR RF CHARACTERIZATION FOR SATELLITE COMMUNICATION TERMINAL ANTENNA EVALUATION

Abstract

Along with the growth of the satellite communication industry, the requirement to validate the performance of the terminal antennas is increasing. The validation guarantees that the communication system does not emit unwanted signals, known as "interference", and provides a secured and solid network between satellites and terrestrial terminals. As the number of the terminal antennas to be operated is increasing and new types of antennas are being developed, the time of an antenna under the test (AUT) evaluation process needs to be shortened. Unlike the use of conventional test facilities which is time consuming and expensive, antenna testing is required to be more accessible for anybody, anywhere. In our project so far, an Unmanned Aerial Vehicle (UAV) system has been developed to make the in-situ antenna evaluation possible. One of the challenges of the proposed UAV based antenna testing system is that it is operated in the different local environments by users. Hence, the new antenna test-site planned, needs to be evaluated before initiating the test in order to have valid measurements. The main tasks to evaluate an AUT are to measure its radiation pattern and pointing accuracy. In all scenarios, it is required to identify the direction of the antenna beam precisely. In the proposed test set-up, RF receivers are mounted on multiple UAVs and signal strength can be measured. However, the states of the UAVs in their environment are unknown since the measurement gives the partial and noisy information of the environment, and the RF characteristics of interest (such as local interference and the beam direction) are not known directly. Therefore, a decision-making strategy to guide UAVs to find the intended RF characteristics in the environment where the system no longer sees the true state but receives observation is considered using Partially Observable Markov Decision Processes (POMDPs). In this paper, a deep Multi-Agent Reinforcement-Learning (MARL) algorithm is developed to generate the waypoints for UAVs for RF characterization of AUTs and test-sites, based on measurements from multiple UAVs. The waypoint for each UAVs is generated to minimize the global localization uncertainty calculated by the Fisher information matrix (FIM). A Recurrent Neural Network algorithm is also implemented to capture sequential observations to address the challenge of the partial observability. The effectiveness of the proposed algorithm is discussed with simulated test scenarios.