ENHANCING THE PERFORMANCE OF ENERGY HARVESTING WIRELESS COMMUNICATIONS USING OPTIMIZATION AND MACHINE LEARNING

ABSTRACT

The motivation behind the work in this thesis is to provide solutions that improve the efficiency of energy harvesting communications systems, and reduce reliance on conventional energy sources. Firstly, an energy harvesting underlay cognitive radio relaying network is investigated. In this context, both the secondary source and relay harvest energy from renewable sources and store it in finite capacity batteries. Closed-form expressions are derived for transmission power of secondary source and relay that maximize the secondary network throughput. Secondly, a practical scenario in terms of information availability about the environment is investigated. We consider an energy harvesting communication system with a source capable of harvesting solar energy. Two cases are considered based on the knowledge availability about the underlying processes. When this knowledge is available, an algorithm is designed to maximize the expected throughput, while reducing the complexity of traditional methods. For the second case, when the knowledge about the underlying processes is unavailable, reinforcement learning is used. Thirdly, a number of learning architectures for reinforcement learning are introduced. They are called selector-actor-critic, tuner-actor-critic, and estimator-selector-actor-critic. The goal of the selector-actor-critic architecture is to increase the speed and the efficiency of learning an optimal policy by approximating the most promising action at the current state. The tuner-actor-critic aims at improving the learning process by providing the actor with a more accurate estimation about the value function. Estimator-selector-actor-critic is introduced to support intelligent agents. This architecture mimics rational humans in the way of analyzing available information, and making decisions. Then, a harvesting communications system working in an unknown environment is evaluated when it is supported by the proposed architectures. Fourthly, we investigated a more realistic energy harvesting communications system. The state and action spaces of the underlying Markov decision process are continuous. Actor-critic is used to optimize the system performance. The critic uses neural networks to approximate the action-value function. The actor uses policy gradient to optimize the policy’s parameters to maximize the throughput.