Chapter 12

Multi-Object Tracking in Wireless Sensor Networks Using Swarm Intelligence

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ABSTRACT

Wireless sensor networks (WSNs) may be described as a self-configured wireless networks that can be used to track physical objects or monitor environmental features, such as temperature or motion. The sensed data is then passed across the network to the main location or sink node, where the data can be processed and analyzed. Sensor nodes in WSN are fundamentally resource-constrained: they have restricted processing power, computing, space, and transmission bandwidth. Object tracking is considered as one of the major applications. However, many of the recent articles focused on object localization. In this chapter, the authors suggest an effective approach for tracking objects in WSNs. The aim is to achieve both minimal energy consumption in reporting activity and balanced energy consumption across the WSN lifetime extension of sensor nodes. Furthermore, data reliability is considered in our model. The chapter starts by formulating the multi-object tracking problem using 0/1 Integer Linear programming. In addition, the authors adopted the swarm intelligence technique to solve the optimization problem.

I. INTRODUCTION

Wireless Sensor Network (WSN) is a vast network of low-cost, battery driven, multipurpose, and tiny nodes. Nodes in this network can monitor physical conditions in the real world, such as temperature and humidity, carry out computations, and communicate via wireless media. They notify a base station named sink node of the data that has been gathered (Ilyas & Mahgoub, 2004). The design of WSN faces

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various challenges where energy efficiency is one of the main challenges. Nonetheless, sensor nodes are subject to resource constraints such as battery power (or energy), bandwidth and storage. The most important resource is energy, because not only the quality of the sensor nodes that is affected by the limited energy, but also of the whole network (Ammari, 2009) . Communication energy consumption has been identified as the main energy source and costs significantly greater than sensing and data processing in WSNs (Pottie & Kaiser, 2000). Thus, energy conservation is considered as the most important performance objective when designing WSN routing protocols (Dahane & Berrached, 2019). Reliability in WSNs is a key aspect, which is always taken into account where multi-hop routing strategies are always used in WSNs and data packets are sent from one node to another (intermediate nodes) before reaching the sink node. Unexpected node loss or unreliable wireless connection (the action of radio links differs unpredictably over time and space) is normal at each hop (Tran-Thanh & Levendovszky, 2009) Baccour et al., 2009); this might lead to packet drop. By contrast, the loss of important information prevents the sensor network from achieving its primary purpose of data transfer (Xu & Wang, 2010). Therefore, routing strategies would emphasize effective transmission. Simultaneously, reducing the number of dropped packets in WSNs is important, and would increase network performance and energy consumption.

In the last decade, swarm-inspired optimization techniques have become more and more common (Shahin et al., 2014). Our research is autonomous and represents the behavior of swarms of collective insects like bees, flocks of birds or fish schools(Shi, 2018). Swarm smart systems are versatile, flexible, adaptable through basic behavior (McCune & Madey, 2014) like the shortest path finding that can solve complicated problems effectively. Ant Colony System (ACS) (El-Fouly & Ramadan, 2020) is one of the most relevant swarm intelligence systems to provide tentative solutions for problems of optimization in a fair period of time.

ACS (Gunes et al., 2002) (El-Fouly & Ramadan, 2020) has been influenced by the food finding behavior of real ants and can be used to find the shortest route in WSNs. This chapter concentrate on ACS which uses two artificial ant agents that is, Forward ant agent which moves from source to destination and find out details about quality of the road. Backward ant agent travel from target to source and gather knowledge regarding pheromone storage. In comparison to other routing strategies (Rocca et al., 2009), the ant colony optimization meta-heuristic suggested in the literature for WSNs is focused only on local knowledge of sensor nodes. That is, no routing tables or other information blocks must be transmitted to neighbors or other network nodes (Gunes et al., 2002) .

The potential implementations of WSNs include object detection, which have been one of the main use of WSNs. The target tracking has multiple real-life purposes such as forest animal control and combat field intrusion detection (Eswari & Vanitha, 2013). However, there are plenty of activities in this field (Vadakkan, & Raghavanpilla, 2015). The target detection method consists of two essential processes. The first is tracking, where sensor nodes are used to identify and control the movement conditions of the mobile object. The second process is monitoring, where nodes observing the target send their findings to the sink node (Chen et al., 2013) . Many object tracking researches concentrate on how to map the location of objects accurately and do not recognize several other criteria such as reliable data reporting (Chen & Liao, 2010) (Liu et al., 2010) (Mahboubi et al., 2012) (Liu et al., 2012) (Chen et al., 2013), nodes energy usage, and nodes energy balance. Therefore, in this chapter, we take these parameters collectively into consideration. We assume that considering these parameters would improve the overall efficiency of the WSNs as well as advance the object tracking process. To do so, our contributions in this chapter concentrate on: 1) formulating the object tracking problem into 0/1 integer programming with previously listed parameters, 2) the energy consumption in reporting activity for WSN lifetime