Chapter 5
Data Fusion in Underwater Wireless Sensor Networks and Open Research Challenges

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ABSTRACT

Underwater wireless sensor networks consist of numerous devices such as vehicles and sensor nodes, which are positioned underwater, and these devices collaboratively perform data collection, monitoring, and control task. The most critical issues related to underwater wireless sensor networks include limited bandwidth, data aggregation, data fusion, data collection, routing, media access control, higher propagation delay, and higher power consumption. Underwater data fusion is one of the critical issues for underwater military surveillance applications. It is also considered an equally important and challenging aspect for underwater intelligent traffic control and underwater vehicle navigation systems. This chapter provides an insight into basic concepts about multi-sensor data fusion and detailed review of most popular data fusion architectural models available for underwater wireless sensor networks. Finally, the chapter also provides open research directions to researchers for multi-sensor data fusion.

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INTRODUCTION

Recent technological advancements have led to numerous opportunities for underwater explorations using underwater wireless sensor networks (UWSNs) (Goyal et al., 2016, Goyal et al., 2017, Goyal et al., 2020). Major difference between WSN (Guleria and Verma 2018, Guleria and Verma A.K.2019a, Guleria and Verma 2019b) and UWSN is the communication method. The WSN uses radio wave communication whereas UWSN utilizes acoustic signals for communication (Goyal et al., 2018). The most critical issues related to underwater wireless sensor networks include limited bandwidth, data aggregation, data fusion, data collection, routing, media access control, higher propagation delay and higher power consumption.

Ocean, rivers or canals covers almost 75% of earth's surface and various invaluable resources lie underwater which are still unexplored. Due to the significance of underwater target tracking, sonar array based underwater target tracking methods have been proposed (Dalberg et al., 2006; Georgy et al., 2012). Sonar arrays are pulled by a submarine or ship. These sonar array-based algorithms are not adaptive which do not match the highly dynamic nature of underwater environment. Further, if the whole target tracking system may lead to a failure if the submarine or ship is attacked. Underwater Wireless Sensor Networks (UWSNs) provides a very reliable solution in comparison to sonar array. UWSNs offer a better solution with higher reliability, precision and persistence for target tracking because it comprises a varied number of small sized, inexpensive sensor nodes which exhibits self-organized behavior and are deployed in a large geographical area (Lloret, 2013). UWSNs consists of numerous tiny sized sensor nodes spatially deployed underwater in an acoustic medium and collaboratively perform various tasks such as sensing (temperature or pressure), processing, monitoring and control. Underwater communication is possible through acoustic signals since optical communication and radio wave communication is not possible in UWSNs. Acoustic transceivers are utilized for UWSNs communication, which collects the data from underwater sensor nodes and transfers it to their nearest buoyant gateway. Further, the data is transmitted from gateway to the nearest remote station for coastal monitoring and control. Underwater communication is possible through acoustic waves. The acoustic waves exhibit important properties which defines that acoustic waves possess low bandwidth and long wavelength. Hence, acoustic waves can communicate over long distances up to several kilometers (Berger et al., 2008). Major application areas in UWSNs include disaster prevention through underwater monitoring, scientific exploration, coastline surveillance and monitoring, water pollution monitoring and water sports facilitation.

In recent past mobile robots have been used in numerous applications and this concept has got a lot of attention. "Navigation" relates to its multifold aspects which include various tasks related to sensing, mapping, localization and control. Navigation is considered as one of the most challenging tasks for exploratory missions because there is no prior knowledge about the underwater environment about the location of the mission. This relates to the scenario about Unmanned Underwater Vehicles (UUVs) are deployed to carry out missions in a large region however the challenging aspects include highly dynamic and unstructured environment. Hence, it requires an intelligent and reliable navigation and control (liu et al., 2016). In past few years, underwater navigation has got a lot of stimulus since varied variety of numerous sensors have been deployed in underwater for underwater exploration and navigation. Various varieties of underwater navigation sensors include: GPS sensor, acoustic sensor, dead-reckoning sensor, vision and range finder sensor. GPS sensors provide perfect positioning as well as better navigation.