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ULES: Underwater Localization Evaluation Scheme Under Beacon Node Drift Scenes

ZHAOHUI CHEN, QINGSONG HU, HAO LI, RONG FAN, AND DING DING
School of Information and Control Engineering, China University of Mining and Technology, Xuzhou 221116, China

Corresponding author: Qingsong Hu (hqsong722@163.com)

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ABSTRACT In underwater sensor localization scenes, beacon nodes (BNs) with known coordinates are deployed to localize unknown nodes (UNs). However, the BNs are likely to drift due to undercurrents, geological changes, and marine biological activities, which will lead to localization failure. This paper proposes underwater localization evaluation scheme (ULES) to improve localization accuracy under drift scenes. Reliability of BN is evaluated based on underwater drift, underwater environment, and underwater acoustic channel using an analytic hierarchy process and a grey correlation method. For each UN, four BNs in its communication range with high reliability are selected for underwater localization. This process can iterate for several times, and newly localized nodes act as temporary BNs in the next iteration. Simulations are performed for different localization schemes under different BN deployment schemes and scenarios. Results show that about a quarter more UNs obtain accurate localization comparing with the conventional schemes under beacon node drift scenes, which fully shows that ULES reduces average localization error under BN drift scenes.

INDEX TERMS Beacon node drift, position measurement, reliability evaluation, underwater wireless sensor networks.

I. INTRODUCTION

Underwater localization technology is the basis of marine technology. As the Global Positioning System (GPS) cannot be directly used there, underwater wireless sensor networks (UWSNs) become promising solutions, which can significantly improve the localization accuracy and speed in large geographical areas [1], [2]. Besides, UWSNs-based methods are at least an order of magnitude cheaper than conventional oceanographic research vessels [3]. For these reasons, UWSNs have been widely used in aquaculture [4], disaster forecast, deep-sea exploration [5], [6], military navigation and localization [7], tsunami warning system [8]. However, accurate coordinates of beacon nodes (BNs) is the prerequisite of UWSNs-based localization. Traditional methods such as the Received Signal Strength Indication (RSSI), Time of Arrival (ToA), Time Difference of Arrival (TDoA), and Angle of Arrival (AoA) [9], [10] assume that the position of BNs are ideal static. These methods would get bad results or even fail completely if the BNs deviate from the original places, which is called BN drift scenes.

This paper proposes a novel localization scheme making use of four BNs to mitigate the negative impact of BN drift, which includes three steps. (1) Each unknown node (UN) chooses four BNs with high reliability in its communication range. To do that, some indexes are proposed and their weights are evaluated using the analytic hierarchy process (AHP) method. Then calculate the grey correlation grades representing the reliability of each BN. BNs in the communication range of each UN are ranked according to reliability, and the four BNs with highest reliability are chosen. Here we call them A, B, C and D. (2) The three BNs (e.g., A, B, C) are used to determine two candidate coordinates as shown in Fig. 1, and the candidate coordinates with relatively small distance error to D are selected as final localization result. (3) For the UNs with BN neighbors less than 4 in its communication range, the localized UNs act as temporary BNs. Once there are enough number of BNs with the help of temporary ones, the localization process continues with the same method stated before. It's important to note that the method can also be used in the third or even more iterations.