A Path Planning of Mobile Beacon-Assisted Localization Based on Scanning by Unit Square for Wireless Sensor Networks

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***Abstract*—In this paper, we will discuss on the problem of mobile -beacon-assisted localization which have been unsolved in decades, and we propos e a path planning conserving more path length of mobile beacon than others with out ambiguous localization, incomplete coverage, and flooding situation.**

***Index Terms*—localization, WSN, mobile beacon, path planning.**

I. Introduction

In the architecture of wireless sensor network (WSN), Global Positioning System (GPS) are the most general method for localization, and the localizing architecture of static beacon is the second most localization technique. GPS is the most accuracy and also the most ubiquitous localizing technology, which attained the absolute positions of the GPS chips by the satellites above them; In the architecture of static beacon, beacons deployed before the localization process at least three of them, do not have any mobility themselves, broadcasting localization package to sensors around them. A sensor should receive at least three localization package to start calculating the own position.

The path planning proposed by this paper use the range-based ranging technology called Received Signal Strength (RSS) to implement Accuracy Priority Triangulation (APT), Time Priority Triangulation (TPT), and Weighted Centroid Localization (WCL) with our path planning algorithm for replacing GPS technology and the architecture of static beacon which is the most common method in WSN. In following paragraph, we will mention the reason why we use mobile beacon-assisted localization instead of those two technologies we just introduced above.

First of all, GPS has some drawbacks such as high cost, high power consumption, and disability of localizing without satellite connection. In the architecture of WSN, sensors are usually up to hundreds or thousands of them. If we use GPS on every sensors, this architecture would be a really high cost architecture, and the problem of high power consumption would directly decrease the lifetime of the system. Moreover, the applications of WSN are not necessarily in the spacious environment which has possibility of missing GPS signals, like household, commercial, industrial, and military areas. That is the reason why this paper use APT, TPT, and WCL with RSS instead of GPS.

Second, due to a sensor need at least three non-collinear localization package to localize itself, the accuracy and coverage of static beacon-assisted localization depends on the numbers and the deployment of static beacons. Because of the high cost of beacons, the architecture of static beacon cost a lot more than the architecture of mobile beacon in th aspect of physical facilities to guarantee the localization results. Furthermore, after the deployment of environment, it takes a tremendous cost and time to reallocate the beacons; however, the accuracy and coverage of mobile beacon-assisted localization can be adjust to whatever the quality that the system want just by changing the path planning and the localization algorithm of the mobile beacon, and the mobile beacons can go back to charge themselves spontaneously. As the results, the method of this paper will not take static beacon-assisted localization as an architecture. Instead, we choose the architecture of mobile beacon which has more efficiency and lower cost under the WSN.

There are severals difficulties that not a path planning can deal with all of them well within an algorithm so far, such as the ambiguity of localization results, the length of the path, coverage percentage, flooding situation, and the synchronization of sensors. The contribution of this paper is the novel path planning of mobile beacon we proposed, which has a shorter path length compared with every well designed path in most circumstances.

The rest of the paper is organized as follows: Section II will state most of the path planning of mobile beacon so far and point out their advantages and disadvantages. Our path planning will be presented in detail in Section III. Section IV will show the comparison to each path planning by our simulation results. At last section, Section V will conclude this paper and mention our future work.

II. Related Work

The path planning of mobile beacon nowadays can be classified into two different kinds of algorithm which are static and dynamic path planning. There are a lot of static path planning proposed from then until now, and static paths can also be furthermore classified into two various emphases, one of which is to improve the accuracy of localization result as high as possible, such as double scan, S-curve, LMAT, and Z-curve, for optimizing the path of mobile beacon, and the other is to achieve the shortest path, such as Scan and Hilbert. Among the static paths emphasizing the accuracy evaluation, Double Scan, which travels twice of the length that Scan does perpendicularly to exclude the wrong coordinates, was designed to solve the ambiguous localization problem of Scan. Although Double Scan can fix the weakness of Scan, it double the length of path, which Scan does, and also the accuracy of Double Scan is not good enough due to the characteristics of Scan. S-curves, which is designed by the thought that there is no three collinear point on a semicircular arc so that it can solve the ambiguous localization, is a path consisting of several semicircles; however, it still costs lots of redundant path without high accuracy. In recent years, LMAT and Z-curve are two notable and highly accurate static path planning of mobile beacon. LMAT, taking advantage of the characteristics of equilateral triangles, solves the problems of ambiguous localization and non-full coverage, but LMAT still not good enough compared with Z-curve, proposed after a few years. Z-curve took Hilbert as reference and proposed a recursive path planning in the order of $2^n.(n \in Z^+)$ Z-curve performs better accuracy and shorter path than LMAT does, and Z-curve is the most accurate static path planning of mobile beacon in certain circumstances to our knowledge. Scan is known as the shortest path planning of mobile beacon but with a critical defect which is known as ambiguous localization because the points broadcasting the localization packages are mostly collinear. Hence, Hilbert, which remains the shortest length as same as Scan and solves the ambiguous problem at the same time, is considered to be the best shortest path planning of mobile beacon so far. However, the restriction of Hilbert, which requires the regions of interest have to be a square whose length of side is $2^n * s(n \in Z^+, s \leq \sqrt{2/5} \times \text{communication range})$, is very unpractical. If the region of interest do not correspond to the restriction of Hilbert, it will use the method mentioned in this paper called minimum bounding rectangle, which take the Hilbert path of smallest but bigger square of $2^n \times s$ side length to be the path of mobile beacon. Therefore, in this occasion, Hilbert would waste a lot of path just because the region does not meet its requirement, and that is the reason why Hilbert is still a path planning leaving much room for improvement. Consequently, this paper propose a path planning which will achieve shortest path length in most conditions. As for dynamic path planning of mobile beacon, DeteRministic dynamic bEAcon Mobility Scheduling (DREAMS) was first proposed in [Xu Li], the paper mentioned that it can reach full coverage and higher accuracy of localization than static path planning. However, we do not agree with that DREAMS has full coverage mentioned itself. DREAMS did not consider the possibility that there are several tree in the region of interest. In addition, although DREAMS can solve the ranging inaccuracy dynamically, the path length of DREAMS is a lot longer than each the path length of static path planning; moreover, the path length of DREAMS lengthens tremendously while the degree of node increases, and there is no restriction of whether the sensor are connected or not in static path planning and no unpredictable situation in static path planning. Therefore, we choose the idea of static path planning instead of the idea of dynamic path planning. In the field of mobile beacon-assisted localization, there is always a trade-off between the accuracy of localization and the length of path planning, this paper will not only pursue the shortest path traveled by the mobile beacon in the localization procedure but also solve the ambiguity of localization, non-full coverage, and flooding problems. In the chapter IV, we will present the simulation results showing that our path planning is shorter than the path planning without ambiguous localization nowadays with the random size of the region in most of the circumstances.

III. method

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IV. Simulation

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V. Conclusion

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