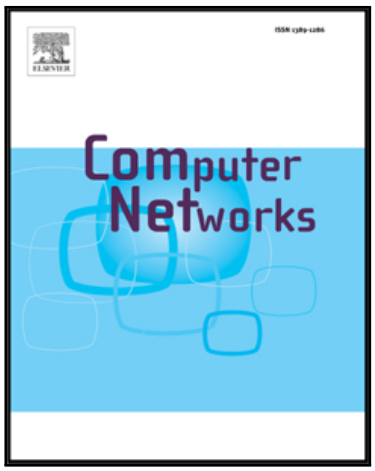

Advances on Localization Techniques for Wireless Sensor Networks: A Survey

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Advances on Localization Techniques for Wireless Sensor Networks: A Survey

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***Abstract*—Localization in Wireless Sensor Networks (WSNs) is regarded as an emerging technology for numerous cyber-physical system applications, which equips wireless sensors with the capability to report data that is geographically meaningful for location based services and applications. However, due to the increasingly pervasive existence of smart sensors in WSN, a single localization technique that affects the overall performance is not sufficient for all applications. Thus, there have been many significant advances on localization techniques in WSNs in the past few years. The main goal in this paper is to present the state-of-the-art research results and approaches proposed for localization in WSNs. Specifically, we present the recent advances on localization techniques in WSNs by considering a wide variety of factors and categorizing them in terms of data processing (centralized vs. distributed), transmission range (range free vs. range based), mobility (static vs. mobile), operating environments (indoor vs. outdoor), node density (sparse vs dense), routing, algorithms, etc. The recent localization techniques in WSNs are also summarized in the form of tables. With this paper, readers can have a more thorough understanding of localization in sensor networks, as well as research trends and future research directions in this area.**

***Index Terms*—Localization, WSN, algorithms, application, indoor localization, static nodes, mobile nodes.**

I. Introduction

Localization in wireless sensor networks (WSNs) is one of the central components of a variety of emerging applications including cyber-physical systems, military [1], [2], eHealth [3], [4], [5], [6], environment monitoring [7], home and office automation [8], [9], weather forecasting [10] and so on. Many of these applications need location based services. Although GPS is a direct solution to the localization problem, the high cost, high power consumption, and poor performance of GPS inside an indoor environment have necessitated the research on localization algorithms [11]. Over the past few years, the scientific world has observed a lot of research efforts on this topic. Note that the localization is defined as the determination of the position of an unknown node, sometimes with the help of nodes with known position, and at other times using the connectivity information between the unknown nodes. Recent studies have investigated the effect of mobility in localization [12], [13], [14], real world applications [15], [16], [17], "Anchor Based" and "Anchor Free" localization methods [18], "Range Based" localization algorithm (distance measurement technique to calculate the location of unknown nodes) and "Range Free" localization algorithm (connectivity rather than distance) [19], "Cooperative" (communication exists among all nodes) and "Non-Cooperative" (unknown nodes communicate only with the anchor nodes) algorithms [20], "Centralized" algorithm based localization (aka network-centric positioning [21]) and "Distributed" algorithm (no central control on the determination of the node's position and each node estimates its location based on the locally gathered information $-$ aka "self-positioning" algorithm [21]) [22].

In this paper, localization techniques/algorithms in WSN are divided into "Sparse vs. Dense", "Anchor based vs. Anchor free", "Indoor vs. Outdoor", "Cooperative vs. Non-Cooperative" and "Static vs. Mobile" categories as shown in Fig. 1. Furthermore "Anchor Based" and "Anchor Free" localization algorithms are further classified into "Range Based" and "Range Free" algorithms. The above classification is made considering the network size (sparse vs dense) and specific application of certain type of algorithms (indoor). Furthermore, they are classified based on their mobility (static vs mobile) and usage of anchor nodes (anchor based vs anchor free). Also, at the end of anchor based and anchor free localization algorithm sections, comparison tables are included to characterize each algorithm based on different factors such as whether they are centralized or distributed and whether they are cooperative or non-cooperative. Thus any reader who wants to find a specific algorithm that needs to fulfill some special requirements can use this vast classification will help him to find recently proposed algorithms that suit the demands.

Although there are survey papers that provide information about the localization in WSNs, more up to date activities

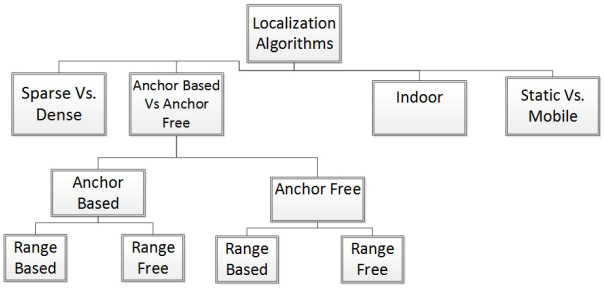

Fig. 1. A typical classification of localization techniques in WSNs.

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