Volume 5, Issue 3, March 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

A Survey of Target Tracking Methods in Wireless Sensor Networks

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Abstract— Wireless sensor networks are spatially distributed sensors that cooperatively monitor some physical or environmental conditions. One of the key application of WSN is target tracking. In which tracking a target as it moves through a sensor network. This paper examines some of the target tracking methods in use today. During the recent years many target tracking approaches are proposed in the area of Wireless Sensor Network. For further researches, understanding of these approaches is essential.

Keywords— Wireless sensor networks, target tracking, tree based, prediction based, facetracking.

I. INTRODUCTION

Wireless Sensor network (WSN) is an emerging technology and has great potential to be employed in critical situations. The development of wireless sensor networks was originally motivated by military applications like battlefield surveillance. However, Wireless Sensor Networks are also used in many areas such as Industrial, Civilian, Health, Habitat Monitoring, Environmental, Military, Home and Office application areas, tracking targets of intrest [1],[2]. Detection and tracking of targets (eg. animal, vehicle) as it moves through a sensor network has become an increasingly important application for sensor networks. The continuous evolution in wireless sensor network technology make it possible to implement the wireless sensor network (WSNs) in a variety of scenarios. WSNs consist of thousands of tiny sensor nodes deployed in a physical environment for observation of an event of interest. The sensors in the vicinity of an event must be able to monitor it and report back to the sink. A sink sensor node has capability to communicate with outside world such as laptop, base station. Sensor nodes have been deployed to play significant roles in traffic control, battlefield, habitat monitoring and intruder tracking in recent years. The traditional target tracking methods for Wireless Sensor Networks make use of a centralized approach. As the number of sensors rise in the network, more messages are passed on towards the sink and will consume additional bandwidth. Thus this approach is not fault tolerant as there is single point of failure and lacks scalability. Moreover in traditional target tracking methods, sensing task is usually performed by one node at a time resulting in less accuracy and heavy computation burden on that node. In WSNs each node has very limited power; consequently traditional tracking methods based on complex signal processing algorithms are not useful.

In a target tracking application, the sensor nodes which can sense the target at a particular time are kept in active mode while the remaining nodes are to be retained in inactive mode so as to conserve energy until the target approaches them. To continuously monitor mobile target, a group of sensors must be turned in active mode just before target reaches to them. Active sensors varies depending on the velocity of moving target and schedule from cluster head. Ultimately, target tracking in course of maintaining the balance between network resources like energy, bandwidth, and overheads is challenging.

The purpose of this paper is to introduce, summarize and compare some of the target tracking algorithms currently used in sensor networks.

II. TARGET TRACKING METHODS

Target tracking algorithms usually focus on the aspect of the sensor nodes' interaction with a target after the target has already been detected within the area the sensor nodes cover. Once the object has been detected, the nodes collect information and then use one of many different types of algorithms to calculate the current location of the object relative to the sensor nodes' locations. From here it is the goal of the sensor network to track the object as it moves through the network. This may or may not involve predicting the next location the object will move to in order to forewarn those nodes it will be heading towards to prepare to capture data.

In WSNs Moving object tracking has received Considerable attention in recent years and the solutions can be mainly classified into Three schemes, such as

- Tree - based tracking
- Cluster-based tracking
- Prediction-based tracking.

a) Tree based tracking method

In Tree-Based Target Tracking, nodes in a network may be organized in a hierarchical tree structure or represented as a graph. The vertices in the structure represent sensor nodes and edges are links between nodes that can directly communicate with each other. While tracking a target the nodes that detect the target communicates with each other and selects a root node. The root node collects information from all the nodes via a distributed spanning tree. If the root node is far away from the target, then the tree will be reconfigured. Although the spanning tree based approaches track the moving objects more accurately, tree organizations result in high-energy consumptions.

The centralized target tracking approaches are both time and energy consuming; to avoid this limitation tree-based tracking methods are proposed.

- Dynamic Convoy Tree-Based Collaboration (DCTC):

It is a Tree-based tracking method. Dynamic convey Tree-Based collaboration [3],[4] first detects the target and monitors it by tracking the surrounding area of the target. It relies on a tree structure called convoy tree, that include sensor nodes around the moving object, and the tree is configured to add some nodes and prune some nodes as the target moves. The target first enters the detection region, sensor nodes that can detect the target collaborate with each other to select a root and construct an initial convoy tree. Root node collects information from the sensor nodes and refines this information to obtain more complete and accurate information about the target using some classification algorithms. A big challenge of implementing the DCTC framework is reconfiguration of the convoy tree in an energy efficient way, when the target is moving. Some of the schemes optimize the energy consumption but those are not practical [4]. Some of the practical solutions to implement the DCTC framework are constructing the Initial Tree, Tree Expansion and Pruning, Tree Reconfiguration. This is the main concept involved in DCTC target tracking method.

b) Cluster based methods:

Cluster-based method divides the network into clusters to support collaborative data processing. A cluster consists of cluster head and member sensor nodes. When a sensor detects an object it volunteers to act as a CH(Cluster Head). There is No need of explicit election of leader. So message exchanges are not incurred. If more than one powerful sensor may detect the signal, multiple volunteer nodes may exist. So a decentralized approach has to be applied to ensure that only one Cluster Head is active in the vicinity of a target to be tracked with high probability. Cluster based method is divided into three types. Static Clustering and Dynamic Clustering.

- Low-Energy Adaptive Clustering Hierarchy (LEACH):

Low-Energy Adaptive Clustering Hierarchy [5] is used to reduce energy consumption. In LEACH method sensor nodes formed as clusters and choose one of them as cluster-head. Sensor node first detects the target and sends the data to its cluster-head. Then the cluster head aggregates and compresses the data collected from all the nodes and sends it to the base station. The Cluster head requires more energy than other nodes in the network. So LEACH uses random rotation of the nodes required to be the cluster-heads to evenly distribute energy consumption in the network. LEACH operations can be divided into two phases one is Setup phase and another one is Steady phase. In the setup phase clusters are formed and a cluster head is chosen for each cluster. In the steady phase, data is sensed and sent to the central base station. This is the main concept involved in LEACH concept to track a target.

- Static clustering :

In Static Clustering [6] clusters are formed statically at the time of network deployment. The attributes of each cluster, such as the size of a cluster, the area it covers, and the members it possesses, are static. In spite of its simplicity, the static cluster architecture suffers from several drawbacks. First, fixed membership is not robust from the perspective of fault tolerance. If a Cluster Head dies of power depletion, all the sensors in the cluster render useless. Second, fixed membership prevents sensor nodes in different clusters from sharing information and collaborating on data processing. Finally, fixed membership cannot adapt to highly dynamic scenarios in which sensors in the region of high event concentration may be instrumented to stay awake.

- Dynamic clustering:

Dynamic cluster architecture has several desirable features. When a sensor with sufficient battery and computational power detects signals of interest, it volunteers to act as a CH. Compared with the static clustering approaches, dynamic clustering networked sensors do not statically belong to a cluster and may support different clusters at different times. Moreover, as only one cluster is active in the vicinity of a target with high probability, redundant data is suppressed and potential interference and contention at the MAC level is mitigated.

The biggest problem with this algorithm is that it will not work with mobile nodes. The network calculates the sensor node's locations at start-up. Since these locations need to be known by the cluster head and are calculated only once, this prevents any nodes from moving or even being added to the network. This problem could be easily fixed by periodically refreshing the locations of the sensor nodes, although this will decrease the network's life- time. So it is better to use a detection algorithm and constantly refreshing the nodes' location isn't an optimal solution is better in this case.

c) Prediction based methods:

Prediction-based methods are used to predict the Future movement locations of the moving objects. In which predict movements of target in future. Main predicting methods are given below.

- Scalable information driven sensor querying and routing :

It is prediction based scheme [7], which describes two novel techniques, information-driven sensor querying (IDSQ) and constrained anisotropic diffusion routing (CADR), for energy-efficient data querying and routing in ad hoc sensor networks for a range of collaborative signal processing tasks. This approach allows sensors to become activated when there are "interesting" events to report, and only those parts of the network with the most useful information balanced by the communication cost need to be active. The type of networks can be stealthy and is advantageous for security reasons. The networks could also actively seek out information, based on predictions of when and where "interesting" events will be. An entire sensor network, with its in network processing power for processing, routing, and combining distributed sensor data, is an extremely powerful distributed computing system. One notable feature of this distribute "supercomputer" is that its I/O is also distributed and can match well with the impedance of the sensing application domain by design.

- Prediction-based tracking technique using sequential pattern (PTSP):

Prediction-based tracking technique using sequential pattern [8] is one of the object tracking technique that predict the future movements of the objects that track with the minimum number of sensor nodes. PTSP is based on two stages: Sequential pattern generation, Object tracking and monitoring. In the sequential pattern generation stage, the prediction model is built based on a huge log of data collected from the sensor network and aggregated at the sink in a database, producing the inherited behavioral patterns of object movement in the monitored area. Depending upon this data the sink will be able to generate the sequential patterns that will be deployed to the sensor nodes in the network. So the sensor nodes that can predict the future movements of moving objects in their detection area. In the second stage, the actual tracking of moving objects starts. This stage has two parts: Activation Mechanism and Missing Object Recovery Mechanism. The use of the Activation Mechanism is to predict which node should be activated continually to keep track of the moving object. The missing object recovery mechanism is used to find the missing object in case of the activated node is not able to locate an object in its detection area.

d) Other tracking methods

- MOBICAST Based Method:

A new multicast communication paradigm called a "spatiotemporal multicast" or "Mobicast" [9] was investigated to support spatiotemporal coordination in applications over wireless sensor networks.The distinctive feature of multicast is the delivery of information to all nodes that happen to be in a geographic zone at a particular point in time. The set of multicast message recipients is specified by a forwarding zone which continuously moves and evolves over time. When continuously monitoring an entity, forwarding zones at different time intervals greatly differ. This provides a mechanism for application developers to express their needs for spatial and temporal information dissemination directly to the multicast communication layer. It also offers a new just-in-time multicast delivery paradigm.

While conceptually simple, this mobicast protocol is useful for coordination scenarios where the mobile coordination event does not change its velocity and spatial confinement very often, and is very challenging to implement.

- Polygon based Face tracking:

It is method different from other tracking method. FaceTrack [11], a tracking framework that detects the movements of a target using polygon face tracking. Here the term face represent a polygon that construct to track the target. Here uses a brink detection algorithm that enables the Wireless sensor network to be aware of a target entering the polygon a bit earlier, and to work in a timely fashion. In Brink Detection Algorithm[10], the common edge across which the target is about to cross is called a brink. The end nodes of brink are the couple nodes. If a Target reaches the location near to the brink, the edge node broadcast the message which will wake up the sensors in next polygon. An Optimal Selection Algorithm is also used to select couple nodes on the target's moving path to keep the number of active sensors to a minimum. In case of failure in any node, the possible node to detect the target in the same face will sense the Target. This concept will reduce the Data Redundancy and Energy Consumption of the network.

III. CONCLUSIONS

In wireless sensor networks, several researches are going based on tracking targets in an area. Most of them based on finding energy efficient tracking method. This paper has examined some of the target tracking algorithms in use today. An overview of each algorithm type was presented along with an analysis of its problems, benefits and possible improvements.

ACKNOWLEDGMENT

I express my deepest thanks to Mrs.Jucy Vareed (Asst. Professor, CSE Department) for taking part in discussions and giving necessary advices and guidance, facilitating preparation of this paper.

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