An Efficient Solution for Target Tracking and Node Detection in MWSN

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Abstract
Tracking mobile targets is an important wireless sensor network application in both military and civilian fields. Regularly, it may be necessary for sending additional resources to the vicinity of the mobile target. This work studies the problem of tracking signal-emitting mobile targets using navigated mobile sensors based on signal reception. The mobile target's maneuver is unknown here. In this method delay occurs when mobile sensor's movement to follow the target.Energy consumption is high for the nodes. We propose a min-max approximation approach to estimate the location for tracking which can be solved via semidefinite programming (SDP) relaxation, and apply a cubic function for mobile sensor navigation. The mobile sensor controller utilizes the measurement collected by a wireless sensor network in terms of the mobile target signal's time of arrival (TOA). We estimate the location of the mobile sensor and target jointly to improve the tracking accuracy. To further enhance the system performance, we propose a weighted tracking algorithm by using the measurement information. Our results demonstrate that the proposed algorithm provides good tracking performance and it is used for managing sensors' mobility, aiming at enhancing the tracking of targets.

Kewords
Min -max, Semidefinite programming,TOA, Weighted tracking,Navigation

I. Introduction

In recent years, wireless sensor networks have found rapidly growing applications in areas such as automated data accumulation, surveillance, and natural overseeing.One important use of sensor networks is the tracking of a mobile target (point source) by the network. Typically,target tracking includes two steps. First, it needs to estimate or aniticipate target positions from noisy sensor data estimations.Second, it should control mobile sensor tracker to follow or capture the moving target. The goal is to estimate the target position and to control the mobile sensor for tracking the moving target. In this, chief contributions include a more general TOA measurement model that accounts for the measurement noise due to multipath propagation and sensing error

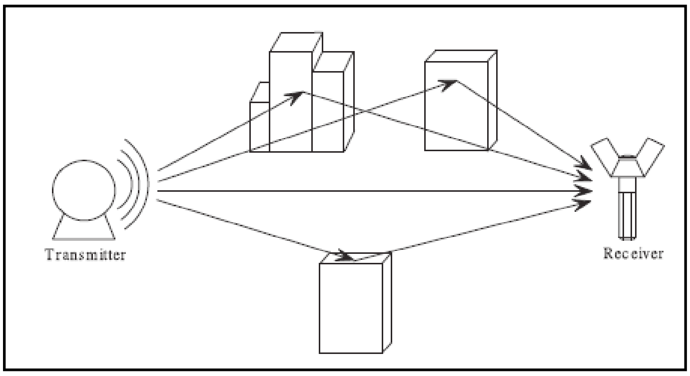

Fig.1: Illustration of the signal transmission path from the transmitter to the receiver.

A min-max approximation approach is used to estimate the location for tracking that can be efficiently and effectively solved by means of semidefinite programming (SDP) relaxation. The cubic functionis applied for navigating the movements of mobile sensors. In addition, the simultaneous localization of the mobile sensor and the target are investigated to improve the tracking accuracy.A weighted tracking algorithm is used in order to exploit the measurement information more efficiently. There are several important reasons for us to utilize the TOA measurement model. First, TOA measurements are easy to procure, as every sensor only needs to distinguish a special signal feature such as a known signal preamble to record its arrival time. Second, our specific utilisation of TOA is a more practical model because we do not need the sensors to know the transmission start time of the signal a priori.As a result,TOA model enables us to directly estimate the source location by processing the TOA measurement data.

II. Motivation and Background

The challenge of target tracking and mobile sensor navigation arises when a mobile target does not follow a predictable path. Successful results require a real-time location estimation algorithm and an effective navigation control technique. Target tracking could be seen as a sequential location estimation problem. Normally, the target is a signal emitter whose transmissions are received by various distributed sensors for location estimation. There exists a number target localization strategies-based different measurement models such as received signal strength (RSS), time of arrival (TOA), time difference of arrival (TDOA), signal angle of arrival (AOA), and their combinations . For target tracking, Kalman filter was proposed in, where a geometric-assisted predictive location tracking algorithm can be effective even without sufficient signal sources. investigated the use of extended Kalman filter in TOA measurement model for target tracking. Particle filtering has additionally been applied with RSS measurement model under correlated noise to achieve high accuracy . In addition to the use of stationary sensors, several different works concentrated on mobility management and control of sensors for better target tracking and location estimation.

III. Wireless Construction and Acquisition

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Every such sensor network node has nomally several parts: a radio transceiver with an internal antenna or connection to an outside reception apparatus, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, generally a battery or an embedded form of energy harvesting. A sensor node may fluctuate in size

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from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created.

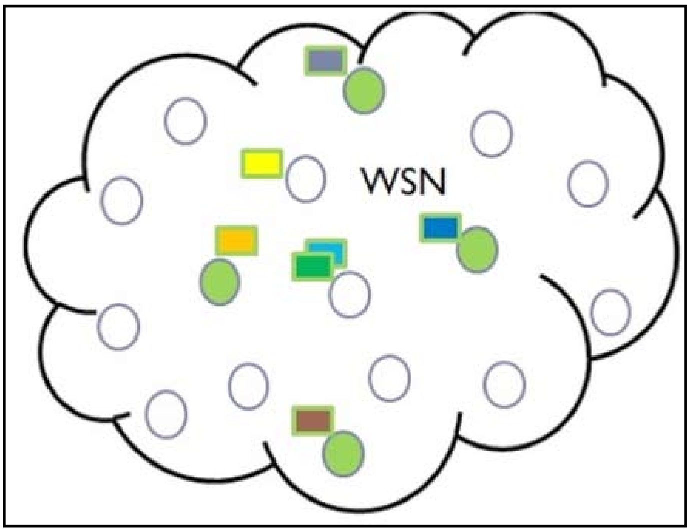

Fig. 2: Node construction in WSN

We think about a sensor network of N anchored nodes at the positions indicated by a set of m-dimensional vectors x1; . . . ; xN (with m ¼ 2 or 3 for 2D or 3D space, respectively). The moving target is a signal emitter whose signal transmission is measured by the N anchor sensor nodes. A mobile sensor additionally emanates signals to permit sensors to gather information necessary to determine its location. The versatile sensor, at the same time,can additionally measure signal from the target. In the data fusion center, a portable sensor controller regulates the mobile sensor to reach and follow the target dependent upon multiple sensor measurements.

We model the time of arrival measurements at the anchor node xi at time instant Tj for the signal from the target (located at yj) and the mobile sensor (located at zj), respectively, as

$$t_{ji} = \frac{1}{c}\|\mathbf{x}_i - \mathbf{y}_j\| + t_{j0} + \frac{1}{c}\|\mathbf{x}_i - \mathbf{y}_j\| n_{ji} + \delta_j,$$

$$\tau_{ji} = \frac{1}{c}\|\mathbf{x}_i - \mathbf{z}_j\| + \tau_{j0} + \frac{1}{c}\|\mathbf{x}_i - \mathbf{z}_j\| \eta_{ji} + \rho_j.$$

Here, c is the signal traveling speed, t_{j0},T_{j0} are, respectively,the time instants that the target and the mobile sensor transmitted their signals.

$\frac{1}{c}\|\mathbf{x}_i - \mathbf{y}_j\| n_{ji}$, $\frac{1}{c}\|\mathbf{x}_i - \mathbf{z}_j\| \eta_{ji}$ with $n_{ji} \geq 0$, $\eta_{ji} \geq 0$
are multipath propagation noise, whereas δ_j and ρ_j are noise from sensing error.

To track a moving target with a mobile sensor, the data fusion center must assess the locations of both the target and the mobile sensor at time instant . The mobile sensor controller receives the TOA measurements regularly from the anchor sensors to estimate the target and mobile sensor locations and to direct the movement of the mobile sensor for target tracking.

IV. Target Localization

The first step of tracking is to estimate positions of both target and mobile sensor. On the other hand, the moving target is a signal emitter whose signal transmission is measured by the anchor sensor nodes. A mobile sensor additionally emamates signals to permit sensors to gather information necessary to determine its location. The mobile sensor, at the same time,can additionally measure signal from the target. In the data fusion center, a mobile sensor controller directs the mobile sensor to reach and follow the target dependent upon multiple sensor measurements.To track a moving target with a mobile sensor, the data fusion center must appraise the locations of both the target and the mobile sensor.

Each anchor sensor node records and sends, to the data fusion sensor, its TOA estimation of target signal and mobile sensor signal. In different words, the mobile sensor controller gains the TOA measurements consistently from the anchor sensors to estimate the target and mobile sensor locations and to direct the movement of the mobile sensor for target tracking.A min-max approximation approach is used to estimate the location for tracking which can be efficiently finds the location of the target.

A. Min-max approximation approach

Minmax is a decision rule utilized as a part of choice hypothesis, game theory, statistics and philosophy for minimizing the possible loss for a worst case (maximum loss) scenario. On the other hand, it might be considered as maximizing the minimum gain. we propose to adopt the min-max criterion for location estimation via

$$\hat{\mathbf{y}}_j = \arg\min_{\mathbf{y}_j} \max_{i=1,\ldots,N} \left| (t_{ji} - t_{j0})^2 - \frac{1}{c^2}\|\mathbf{x}_i - \mathbf{y}_j\|^2 \right|.$$

V. Mobile Sensor Localization

Similar to estimating the location of the target, we can reformulate the portable sensor localization issue into an SDP relaxation problem. All the more particularly, we can estimate the mobile sensor location zj by means of the similar formulation dependent upon the TOA measurements at the anchor nodes from the signal received from the mobile sensor.

A. Semi definite programming

Semi definite programming (SDP) is a subfield of convex optimization concerned with the optimization of a linear objective function (that is, a function to be maximized or minimized) over the intersection of the cone of positive semidefinite matrices with an affine space, i.e., a spectrahedron. Semidefinite programming has been utilized as a part of the optimization of complex systems.

VI. Navigation Identification

A navigator in this case aims to control the mobile sensor to get close to the moving target from any initial position. Since the target moves are not known from the earlier to the controller, taking care of the issue requires a real-time strategy. This also maintains the mobile sensor at a given distance away from the target for surveillance purpose without being discovered. This uses the cubic function to maintain the navigation strategy.

VII. Sequential Tracking

There are two kinds of measurement noises, clamor because of multipath signal propagation and noise due to limited sensing precision of each sensor. Because of the generally complex multipath effects, clamor from multipath propagation in the estimated signal time of arrival is approximately proportional to the actual signal propagation time. In other words, the multipath propagation noise is typically nonnegative. The TOA measurement at the sensor closer to the target will suffer less from the multipath propagation noise. For the particular TOA model , the noise due

to multipath propagation is often much greater than the noise due to sensing error.
Since we have mobile sensors moving towards the target, estimations gathered by mobile sensors are more reliable than other sensing nodes. A weighted tracking error is advocated to improve target tracking performance.
Weighted tracking algorithm implies an iterative approach is utilized by estimating the target and sensor locations before confirming the new weighting factors, which in turn, will be utilized to estimate the target and mobile sensor locations in the next iteration. Regardless, in the first iteration, we set the default weighting variables all to unity, for obtaining initial estimates of target and sensor. By performing iterative weighted tracking, we can receive a better performance.

VIII. Performance Evaluation

The following examples are to illustrate the tracking performance of the proposed algorithm.
This is a graph drawn between number of nodes and coverage range(Fig:3).When number of nodes are increased coverage range are also increased. Eventhough the coverage range is increased the delay and energy of nodes are decreased using min-max approximation approach.

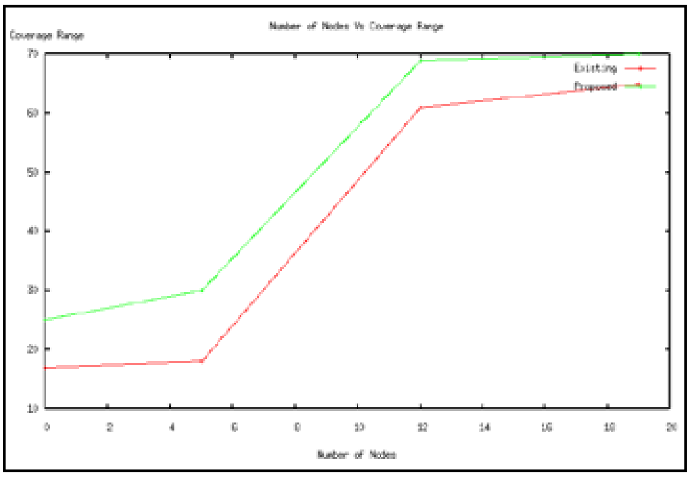

Fig. 3: Coverage range of nodes

This is a graph drawn between number of nodes and delay(Fig:4). When number of nodes are increased delay of nodes are also increased because of traffic between nodes.But using min-max approximation approach it should be decreased.

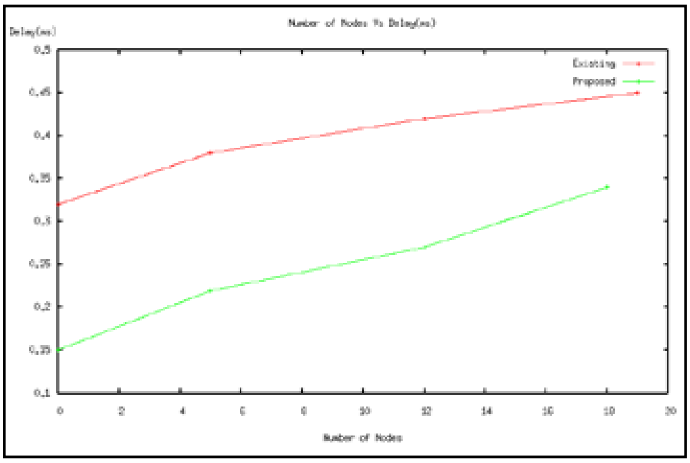

Fig.4: Delay of nodes

This is a graph drawn between number of nodes and energy (Fig:5).When number of nodes are increased energy of nodes are also increased because of delay of nodes. But using min-max approximation approach it should be decreased.When the energy of nodes should be reduced the lifetime of network is increased .

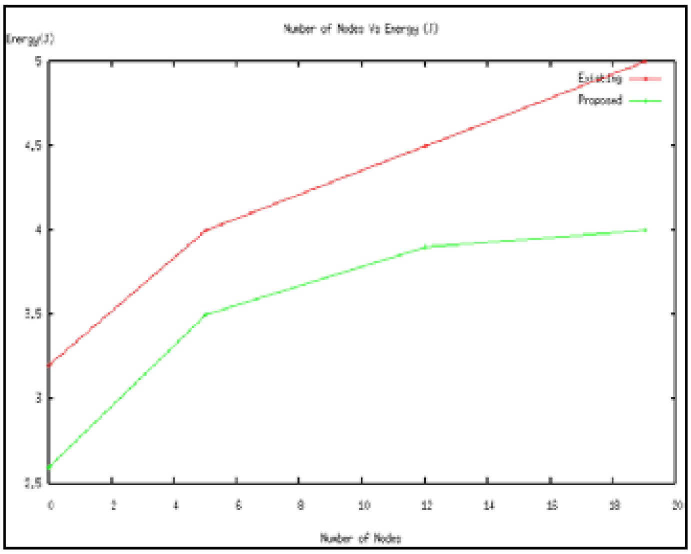

Fig. 5: Energy of Nodes

IX. Conclusion and Future Work

This paper deals with the problem of tracking a moving target using navigated mobile sensors in wireless sensor networks. With obscure target and sensor locations, the locations of the target and the mobile sensors are estimated first. Based on a more general TOA measurement model,convex optimization algorithms through SDP relaxation are developed for localization.A sequential algorithm is provided and a joint weighted localization algorithm before controlling the mobile sensor movement to follow the target. Simulation results illustrate successful tracking and navigation performance for the proposed algorithms under different trajectories and noises.
In future work,ant colony optimization algorithm will be used.It is used for managing sensors' mobility aiming at improving the tracking of targets.One important factor is to reduce the energy consumption of the sensors in order to increase tha lifetime of the network.

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