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Research Article

Multiple Target Tracking using Kalman Filter in MSN

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Abstract

A wireless sensor network is a collection of nodes organized into a cooperative network. Wireless sensor networks (WSNs) have gained worldwide attention in recent years, particularly with the proliferation in Micro-Electro-Mechanical Systems (MEMS) technology which has facilitated the development of smart sensors. Target Tracking is an important problem in sensor networks, where it dictates how accurate a targets position can be measured. Target tracking in WSNs is an important problem with a large spectrum of applications such as surveillance, natural disaster relief ,traffic monitoring pursuit evasion games, etc Tracking a target as it moves through a sensor network has become an increasingly important application for sensor networks. This work proposes a unique target tracking algorithm where multiple sensor nodes called anchors monitors the position of multiple moving objects and tries to predict the actual position of the nodes based on the data obtained. We simulate the algorithm in matlab and analyze the performances of speed v/s tracking accuracy, number of mobile objects v/s tracking accuracy, number of sensors v/s tracking accuracy.

Keywords: *Mobile sensor network, target tracking, Non GPS , tracking accuracy*

1. Introduction

The Mobile Wireless Sensor Network (MWSN) is an emerging technology with significant applications. Mobile wireless sensor network (MWSN) is a wireless ad hoc network that consists of a very large number of tiny sensor nodes communicating with each other in which sensor nodes are either equipped with motors for active mobility or attached to mobile objects for passive mobility. The MWSN allows the sensor nodes to move freely and they are able to communicate with each other without the need for a fixed infrastructure. These networks are capable of out-performing static wireless sensor networks as they tend to increase the network lifetime, reduce the power consumption, provide more channel capacity and perform better targeting. Multiple-target tracking is a canonical application of sensor networks as it exhibits different aspects of sensor networks such as event detection, sensor information fusion, multi-hop communication, sensor management and decision making. The task of tracking multiple objects in a sensor network is challenging due to constraints on a sensor node such as short communication and sensing ranges, a limited amount of memory and limited computational power.

The paper is organized as follows .Section 2 introduces related works in this area; Section 3 presents the proposed solution .Some simulation results are presented in Section 7 .Section 5 concludes the work.

2. Related Work

Many of the Target tracking techniques have been implemented in the field of mobile sensor network. However, the design of more efficient target tracking techniques with efficient tracking performance still remain a challenge.

Single target tracking in controlled mobility sensor networks is one of the major problem. It thus proposes an original strategy to manage the mobility of sensor nodes, in order to improve the estimation of the positions of the target.(F.Mourad,H.Chehad,H.Snoussi,F.Yalaoui ,2012)
Survey of the state-of-the-art mobile object tracking techniques in WSNs. The authors highlights the advantages and performance issues of the existing tracking methods and make a brief comparison based on the design parameters proposed.(Archana Bharathidasan,Vijay Anand Sai Ponduru, 2012).

The development of a scalable hierarchical multiple-target tracking algorithm that is autonomous and robust against transmission failure, communication delays and sensor localization errors.(Songhwai Oh,Luca Schenato , Shankar sastry, 2005).

Multiple-Target Tracking method using Ant Colony Optimization to satisfy these requirements. In this proposed method, targets current position values are estimated at every time step. Then, predicting the next position Value of each target by using the previous time-step estimated values.(Mourad, Farah, 2012).

The proposed a mathematical model for tracking of a moving target by multiple mobile sensors in the framework of a partially observable Markov decision process is discussed. Applications include the use of a fleet of unmanned aerial vehicles for purposes such as search, surveillance, and target tracking. (Sirin Nitinawarat, George k.Atia, Venugopal V.Veeravalli, 2012).

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Distributed Predictive Tracking, for one of the most likely applications for sensor networks: tracking moving targets. The protocol uses a clustering based approach for scalability and a prediction based tracking mechanism to provide a distributed and energy efficient solution. (H.Yang ,B.Sikdar, 2012)

The performance of a sensor network for tracking multiple targets. The author, begin with geometric arguments that address the problem of counting the number of distinct targets, given a snapshot of the sensor readings. The author provide necessary and sufficient criteria for an accurate target count in a one-dimensional setting, and provide a greedy algorithm that determines the minimum number of targets that is consistent with the sensor readings.(Jaspreet Singh,Rajesh Kumar,Richard Cagley,2011)

The issues of maintaining sensing coverage and connectivity by keeping a minimum number of sensor nodes in the active mode in wireless sensor networks. (Honghai Zhang,Jennifer C.Hou,2005)

3. Proposed Solution

In this section BPSK technique is used in MSN with the Kalman Filter Algorithm. The Mobile Wireless Sensor Network (MWSN) is an emerging technology with significant applications .This MSN network consist of number of target nodes ,number of sensor node, wireless channel ,sensor channel ,sink node .As the target node comes near the one of the sensor node which is already deployed at the particular places ,it sends the signal to the sink node which is deployed at the particular place this sensor node sends the signal till the sensor detects the target node is in its range ,if the target node goes outside the range of this sensor node than the other sensor node which where the target node is in the range of it, it detects this target node and sends signal to the sink node ,if this target node is not in the range of the anyone of the sensor node than this target nodes moving path is calculated using the Kalman filter technique to find the target node's current position where it is located .Here in we have deployed multiple number of sensor nodes which are moving at a particular range i.e. 0-360degree in 100 m for each sensor node and to detect multiple target nodes to obtain accurate tracking performance, here sensor nodes sends signals through wireless channel and the sensor nodes receive the signal ,if the target nodes detected through the sensor channel.

The Kalman filter, also known as linear quadratic estimation (LQE), is an algorithm that uses a series of measurements observed over time, containing noise (random variations) and other inaccuracies, and produces estimates of unknown variables that tend to be more precise than those based on a single measurement alone. More formally, the Kalman filter operates recursively on streams of noisy input data to produce a statistically optimal estimate of the underlying system state. The filter is named for Rudolf (Rudy) E. Kálmán, one of the primary developers of its theory.

The Kalman filter has numerous applications in technology. A common application is for guidance, navigation and control of vehicles, particularly aircraft and spacecraft. Furthermore, the Kalman filter is a widely applied concept in time series analysis used in fields such as signal processing and econometrics. The algorithm works in a two-step process. In the prediction step, the Kalman filter produces estimates of the current state variables, along with their uncertainties. Once the outcome of the next measurement (necessarily corrupted with some amount of error, including random noise) is observed, these estimates are updated using a weighted average, with more weight being given to estimates with higher certainty. Because of the algorithm's recursive nature, it can run in real time using only the present input measurements and the previously calculated state and its uncertainty matrix; no additional past information is required.

The Kalman filter keeps track of the estimated state of the system and the variance or uncertainty of the estimate. The estimate is updated using a state transition model and measurements. $\hat{x}_{k|k-1}$denotes the estimate of the system's state at time step k before the k-th measurement y_k has been taken into account; $P_{k|k-1}$is the corresponding uncertainty.

The Kalman filter model assumes the true state at time k is evolved from the state at $(k-1)$ according to

$$\mathbf{x}_k = \mathbf{F}_k \mathbf{x}_{k-1} + \mathbf{B}_k \mathbf{u}_k + \mathbf{w}_k$$

where

- $\mathbf{F}_k$ is the state transition model which is applied to the previous state $\mathbf{x}_{k-1}$;
- $\mathbf{B}_k$ is the control-input model which is applied to the control vector $\mathbf{u}_k$;
- $\mathbf{w}_k$ is the process noise which is assumed to be drawn from a zero mean multivariate normal distribution with covariance $\mathbf{Q}_k$. The Kalman filtering equations provide an estimate of the state $\hat{\mathbf{x}}_{k|k}$and its error covariance $\mathbf{P}_{k|k}$recursively. The estimate and its quality depend on the system parameters and the noise statistics fed as inputs to the estimator.

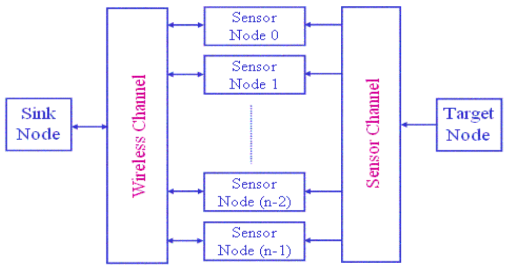


Fig 1

4. Simulation Results

A. Simulation Setup

The proposed protocol is simulated using MATLAB. The network size is 100x100m,with the target nodes ranging, sensor nodes ranging and speed of target. Each node is equipped with an IEEE 802.11 for the MAC layer as shown in Table.1, which list the parameters used in our simulation.

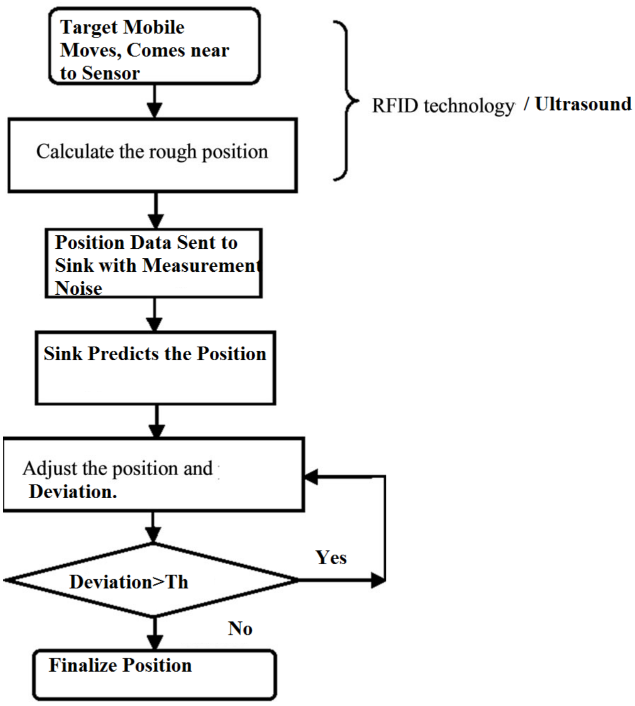


Fig 2 Flowchart of target tracking of object

Table 1 Simulation parameters

Parameters	values
Network area	100 m x100 m
Number of nodes	40
Target speed	1-10m/s
Signal-to-noise ratio(SNR)	-40 db
Initial energy of nodes	0.5 Joules
Target Objects	2-10
Noise power	2-6
Pause Time	1-6
Simulation Time	6-18
MAC layer	IEEE 802.11
Base station location	10-50m

B. Performance Metrics

Four important performance metrics are evaluated. They are used to compare the performance of tracking accuracy in simulation

Sensor nodes: The ratio between the numbers of sensor nodes of the network system by the tracking accuracy.

Target nodes: The ratio between the number of target nodes and tracking accuracy.

Target speed: The ratio between the speed of the target nodes and the tracking accuracy.

C. Results and Discussions

The simulation was carried out using matlab to compare tracking accuracy with the parameters such as number of sensor nodes ,number of target nodes ,pause time ,noise power ,simulation time and target speed .The simulator also provides the flexibility in selectively changing the configuration with different parameters settings including : as number of sensor nodes ,number of target nodes ,pause time, noise power simulation time and target speed.

Fig 3 shows the output of target tracking accuracy where the ,simulation time =10 kept constant ,number of targets are 4,and number of sensor node are varied as 8,10,12,14,16 and poise time=2,noise power=2 and the target speed =10 are kept as constant. As the number of sensor nodes increases, the target tracking accuracy decrease.

Number of Sensor Node Vs Tracking Accuracy

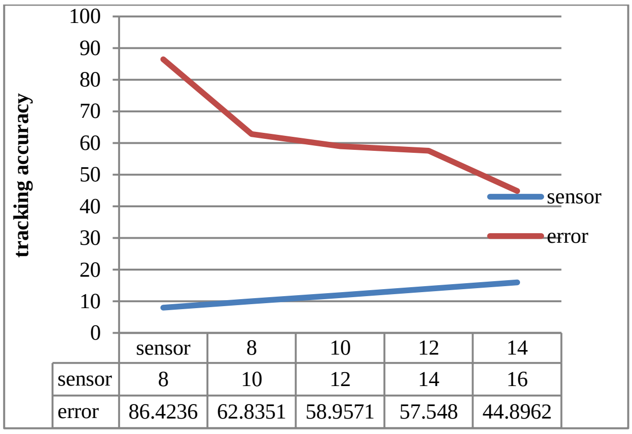


Fig 3

Fig 4 shows the output of target tracking accuracy where the ,simulation time =10 is kept constant ,number of targets are varied as 2,4,6,8,10,and number of mobile nodes =2,poise time=2, noise power=2 and then target speed =10 are kept as constant .As the target objects increases the tracking accuracy also increases.

Number of target node Vs tracking accuracy

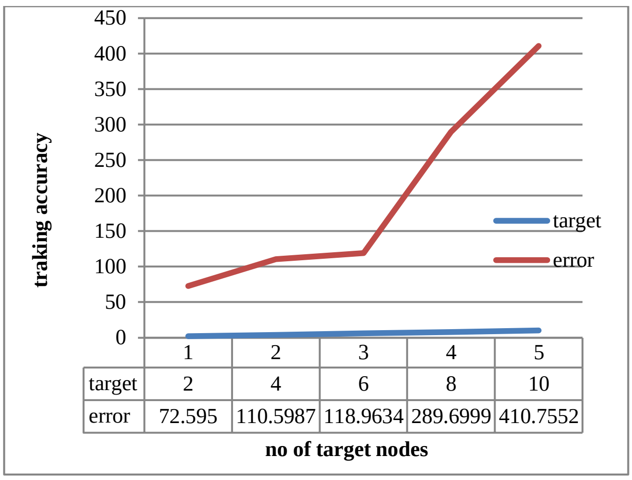
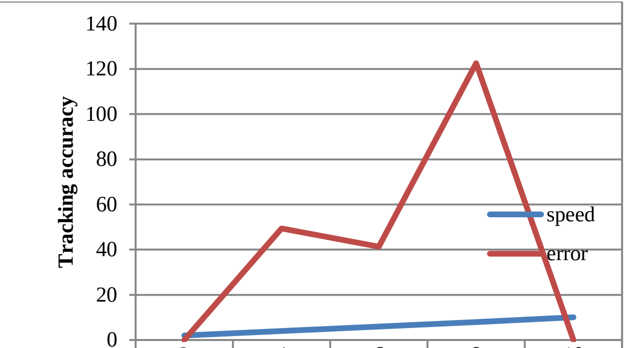


Fig 4

Fig 5 shows the output of target tracking accuracy where the ,simulation time =10 is kept constant ,number of targets =4 and number of mobile nodes =2,poise time=2,noise power=2 and the target speed are varied as 10,12,14,16,18 are kept as constant .As the target objects increases the tracking accuracy also increases.

Target speed Vs Target tracking accuracy



	2	4	6	8	10
speed	2	4	6	8	10
error	0	49.3506	41.3607	122.5171	0

Target speed

Fig 6

Conclusion

In this paper, we have studied the target tracking problem in mobile sensor networks, we introduce performance metrics we investigated the sensor against moving targets, By modeling the dynamic aspects of the target tracking that depends on both sensor and target mobility, we derive the inherent relationship between tracking accuracy and a set of crucial system parameters including no of target nodes, no of sensor nodes, target speed, simulation time.

To refine the sensor mobility model, the network model, and the communication model among sensors in order to enable effective detection and tracking. For example, a practical distributed target tracking and sensing information exchange protocol becomes an interesting future research topic when sensor are required to trace the target pa.

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