Research on dynamic target tracking algorithm in mobile sensor networks

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Abstract. With the increasing complexity of networked cooperative detection environment, new targets appear and leave in the detection area, and the mobility of targets is increasing. The emergence of sensors makes the sensors in the sensor network have certain motion characteristics. These uncertainties increase the complexity of the problem. At the same time, the dynamic selection of sensor resources needs to consider the needs of different priority tasks, platform survival risk, sensor cost and other factors. In view of these problems to be solved, based on the qualitative synthesis theory of predictive control and stochastic dynamic programming optimization theory, the dynamic sensor selection decision theory and method based on multi-step forward decision are explored. This paper studies the dynamic sensor strategy based on multi-step forward decision scheduling, and carries out the research on the optimization decomposition method of sensor selection under different structural characteristics, the dynamic optimization method of sensor selection under complex and uncertain environment, and the multi-objective optimization method of dynamic sensor selection under heterogeneous targets, so as to explore a new way of dynamic sensor selection algorithm design and performance analysis under networked collaborative tracking. The research of dynamic target tracking algorithm in mobile sensor networks has important theoretical and engineering significance to improve the resource efficient utilization and the overall target tracking performance of sensor networks.

Keywords: dynamic target, mobile sensor networks, tracking algorithm

1. Introduction
With the rapid development of sensors, computers, networks and electronic equipment, a large number of multi-sensor networks for complex application background emerge. Multiple sensors of the same or different types can obtain information from different angles and fields of vision. Effective fusion of multiple sensor information is an effective way to improve the accuracy of target detection and tracking. Multi sensor network has broad application prospects in many fields, such as remote battlefield early warning detection, environmental monitoring, intelligent transportation, public security and so on.

In multi-sensor networks, the diversity of information forms, the mass of information data, the complexity of information relations, and the timeliness, reliability and accuracy of information
requirements promote the rapid development of multi-sensor data fusion technology. At present, the research of multi-sensor information fusion mainly focuses on the selection and optimization of information fusion structure, criteria and algorithms. This open-loop fusion method is information driven processing method, which is easy to cause information redundancy and waste of resources. More importantly, it can meet the needs of different tasks in the dynamic environment. Taking sensor management as feedback link, a closed-loop fusion system is constructed. Through effective cooperation and management of multi-sensor, the quality and robustness of information can be increased, and the overall efficiency of the system can be improved. Considering the constraints of sensor resources, capacity and communication bandwidth, sensor management dynamically selects the sensors participating in the task to drive multi-sensor cooperative work to complete the corresponding tasks, so as to achieve the optimal performance of the task. As a key problem of sensor management, dynamic sensor selection has become a hot topic at home and abroad in recent years.

2. Mobile wireless sensor networks
Mobile wireless sensor network can be simply defined as a wireless sensor network, in which sensor nodes are mobile. Compared with their predecessors, mobile wireless sensor network is a small emerging research area. Mobile wireless sensor networks have more versatility than static sensor networks because they can be deployed in any situation and cope with rapid topology changes. However, many of their applications are similar, such as environment monitoring or monitoring. Usually, the node consists of a radio transceiver and a battery powered microcontroller, as well as some kind of sensor used to detect light, heat, humidity, temperature, etc.

Since there is no fixed topology in these networks, one of the challenges is to route data from its source to its destination. In general, these routing protocols draw inspiration from two areas. WSN routing protocol provides the required functions, but it cannot handle frequent topology changes. Although MANET Routing protocols can deal with mobility in the network, they are designed for two-way communication and are usually not needed in sensor networks.

Protocols designed specifically for mobile wireless sensor networks are almost always multi hop, sometimes adapted from existing protocols. For example, angle based dynamic source routing (ADSR) is an adaptation of the wireless mesh network protocol dynamic source routing (DSR) for mobile wireless sensor networks. ADSR uses location information to calculate the angle between the potential forwarding node and the destination. This can then be used to ensure that packets are always forwarded to the receiver. In addition, LEACH protocol for WSN has been adapted to leach-m (leach mobile) for MWSN. The main problem of hierarchical protocol is that mobile nodes are easy to switch frequently between clusters, which may cause a lot of overhead for nodes that have to reassociate themselves with different cluster heads on a regular basis.

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Another popular routing technique is to utilize the location information from the GPS module.
attached to the node. This can be seen in protocols such as zone based routing (ZBR), which
geographically cap clusters and use the location information to keep updating nodes with their clusters.
In contrast, this divides the network area into grids, and then uses location information to forward data
opportunistically in each hop as much as possible.

Multipath protocol provides a reliable mechanism for routing, so it seems to be a promising direction
for mobile wireless sensor network routing protocol. One such protocol is query based data center
weaving multipath.

In addition, powerful temporary sensor routing and location aware sensor routing have two protocols
specially designed for high-speed mobile wireless sensor network applications, such as the protocol
combined with UAV. They all use multi-path routing, which is realized by blind forwarding technology.
Blind forwarding only allows the sending node to broadcast packets to its neighbors, and then the
receiving node is responsible for deciding whether to forward or discard the packets. The network wide
gradient metric is used to determine whether to forward packets, so as to compare the values of sending
and receiving nodes to determine which is closer to the receiver. The main difference between RASEr
and laser is the way they maintain the gradient metric. RASEr uses the conventional transmission of
small beacon packets, where the node broadcasts its current gradient.

3. General target tracking algorithm

Generally, target tracking is divided into two parts: feature extraction and target tracking algorithm. The
extracted target features can be divided into the following categories

1) The color histogram of the target region is used as the feature, and the color feature is rotation
invariant, and is not affected by the size and shape of the target, and its distribution in the color space is
roughly the same.
2) The algorithm speed is fast, and it also has good effect when the target has a small part of
occlusion.
3) The tracking effect of texture feature is better than that of contour feature.

There are four kinds of target tracking algorithms

1) Mean shift algorithm, namely mean shift algorithm, this method can quickly find the most similar
position with the target through less iterations, and the effect is also very good. But it can't solve the
problem of occlusion, and can't adapt to the change of the shape and size of the moving object. The
improved algorithm is CAMSHIFT algorithm, which can adapt to the change of the size and shape of
the moving target, and has good tracking effect. But when the background color is close to the target
color, it is easy to make the target area larger, which may eventually lead to the loss of target tracking.
2) Target tracking based on Kalman filter, this method considers that the object motion model obeys
Gaussian model to predict the target motion state, and then compares with the observation model to
update the state of the moving target according to the error. The accuracy of this algorithm is not very
high.
3) Target tracking based on particle filter, resampling the distribution of particles each time through
the current tracking results, and then diffusing the particles according to the distribution of particles,
and then re observing the state of the target through the diffusion results, finally normalizing and
updating the state of the target. The characteristic of this algorithm is that the tracking speed is very fast,
and it can solve the problem of partial occlusion of the target, so it is more and more used in practical
engineering applications.
4) Based on the method of modeling the moving object. This method needs to know what the target
object is in advance through prior knowledge, such as vehicles, pedestrians, faces and so on. By
modeling the target to be tracked, and then using the model to track the actual target. This method must
know in advance what the object to be tracked is, and then track the specified target, which is its
limitation, so its generalization is relatively poor.

4. Moving object tracking based on particle filter
The algorithm consists of four steps: 1) particle filter initialization; 2) motion feature extraction. The following three processes in turn realize the tracking of moving objects.

1) Feature extraction of moving object
   In this stage, we need to select the target to be tracked through human-computer interaction, and calculate the characteristics of the target to be tracked, such as the color characteristics of the target, and calculate the histogram of the color space of the region, which is used to describe the characteristics of the target.

2) Feature search phase
   After extracting the features of the target in initialization, we can scatter particles around the target to search for the target. There are many ways to sprinkle particles, such as: a) evenly distributed: that is, evenly sprinkle particles in the whole video. b) Gaussian distribution is used to scatter particles near the target, that is, more particles are scattered near the target and less particles are scattered far away from the target. Each particle calculates the color feature of its position according to the target feature obtained during initialization, and calculates the similarity between the histogram vector and the target histogram vector. Then the calculated similarity between each particle and the target is normalized, so that the sum of the similarity of all particles is equal to 1.

3) Decision making stage
   The weighted average is made according to the similarity between each particle and the target. Let the coordinates of the ith particle be, and its similarity to the target be, then the most likely position of the target is, and N is the number of particles.

4) Particle resampling
   Particle resampling is to redistribute the number of particles according to the size of similarity, that is, to put more particles in the particles with the highest similarity, and to put fewer particles in the particles with low similarity. The core idea of particle filter algorithm is random sampling and importance resampling of particles. Because we don't know where the target is, we randomly scatter particles. After scattering particles, the similarity of each particle is calculated according to the similarity of the features describing the target, and then more particles are scattered in the place with high similarity, and less particles are scattered in the place with low similarity, which is the idea of particle filtering.

5. Summary
With the increasing complexity of networked cooperative detection environment, new targets appear and leave in the detection area, and the mobility of targets is increasing. The solution of dynamic sensor selection problem based on multi-step forward decision-making is a typical NP hard problem. Due to the high computational complexity, its practical application is limited. Efficient optimization algorithm is a problem to be solved. The uncertainty of target motion and environment makes it difficult to estimate the impact of current local decision on future tracking performance and to establish a multi-step forward decision scheduling model. It is an effective way to study the dynamic sensor selection strategy in uncertain environment by using the idea of predictive control to deal with uncertain problems. In the multi-sensor network target tracking system, different targets have their own tracking requirements. The research of dynamic target tracking algorithm in mobile sensor networks has important theoretical and engineering significance to improve the resource efficient utilization and the overall target tracking performance of sensor networks.

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