Joint Multiple Target Tracking and Classification in Collaborative Sensor Networks

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Abstract — **We address the problem of jointly tracking and classifying several targets within a sensor network where false detections are present. A collaborative signal processing algorithm where multiple targets are dynamically associated with leader nodes is presented. It is assumed that each target belongs to one of several classes and that the class information leads to the motion model of a target. We propose an algorithm based on sequential Monte Carlo (SMC) filtering of jump Markov systems to jointly track the system dynamic and classify the targets. Furthermore, an optimal sensor selection scheme based on the maximization of the expected mutual information is integrated naturally within the SMC tracking framework. Simulation results have illustrated the excellent performance of the proposed scheme.**

I. Introduction

We focus on the problem of jointly tracking and classifying several targets evolving within densely scattered sensor nodes. Multiple target tracking tackles the issue of sequentially estimating the state of a possibly varying number of objects; whereas classification deals with the identification of those objects down to a given class. Because the number of targets can vary, we are handling three closely coupled subjects: target detection, tracking and classification. Considering the strong interrelations existing between those, it is natural to address them jointly. Indeed, information about the class of a target provides very useful knowledge about its motion characteristics and thus allow the tracking to be more accurate. Besides, the observed target dynamic allows us to distinguish the type of the tracked object. And naturally, a change in the number of targets implies a modification of the tracking and classification procedures.

II. Multi-Target Tracking and Classification

We consider a leader-based tracking scheme in which, for each target and at each time step, only one sensor - the leader node - is active [3]. Each leader node is thus focused on the tracking and classification of a single target. However, unless the other targets are far away, the leader cannot consider them as noise [1]. We thus need to take those targets into account as soon as they appear in the field covered by the leader node. At each time step the leader node update the belief, chooses a next leader node, hands over this belief and then goes back to an idle state. Moreover if a previously untracked target appears, we need to be able to generate a new leader node for this appeared object. Given the posterior probability that a target has appeared and some information from neighboring sensors, it is possible to decide whether the second target should be associated to a new leader-node or not. From now on the discussion will concern only a specific leader-node.

In order to track and classify the targets, we consider a model-based target tracking method where the target motions and the observations can be represented by state-space models. The possible variation in the number of target is modeled by a markovian indicator. The system at time t is thus characterized by a vector containing the number of targets within the field as well as the position, velocity and class of each target. We make the common assumption that each target moves independently from the other and according to a non-linear markovian class-dependent transition dynamic.

The resulting jump Markov system is solved by SMC techniques [2]. This allows us to take into account the non-linearities and the uncertainty arising from the false measurements. With this methodology, all the necessary information is contained in the posterior distribution which is approximated by a set of random samples and weights. It is well known that common SMC techniques can perform badly in the presence of static parameters such as the class. To cope with this problem we developed a class-based resampling scheme so as to keep a sufficient number of particles per class.

Because our tracking scheme relies on a leader-based algorithm, the sensor selection step is essential. We proposed a Bayesian sensor selection criterion maximizing the expected information gain measured by mutual information. This criterion is approximated by Monte Carlo integration based on the available samples.

III. Conclusion

We have considered the application of sequential Monte Carlo methodology to the problem of joint multiple target tracking and classification in sensor networks. The requirements of those networks have lead us to the use of a leader-based scheme so as to solve this complex problem by collaboration among the sensors. Within this framework, a robust classification scheme has been developed. We have also presented an SMC method for dealing with the problem of information-driven sensor selection. Furthermore we have used jump Markov systems to deal with a varying number of targets. Our simulations have shown that our algorithm is able to detect newly appeared targets, to generate a new leader-node for those targets and to accurately track and classify them.

References

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