Comparative analysis of two techniques for moving target velocity estimation

Lyubka Doukovska[1], Donka Angelova[2]

[1]*Institute of Information Technologies, Bulgarian Academy of Sciences*
Acad. G. Bonchev Str., bl. 2, 1113 Sofia, Bulgaria
[1]doukovska@iit.bas.bg

[2]*Institute for Parallel Processing, Bulgarian Academy of Sciences*
Acad. G. Bonchev Str., bl. 25A, 1113 Sofia, Bulgaria
[2]donka@bas.bg

***Abstract*—In this paper two different algorithms for target velocity estimation are considered and compared. Traditional approaches for detecting and tracking moving targets typically rely on a multiphase strategy in which target detections are feed to a Kalman-filter-based tracker. In the present paper, two techniques for target velocity estimation in the framework of Hough Transform (HT) detection scheme are considered. The experimental results are obtained by means of numerical analysis. The quality parameter is estimated using the Monte Carlo simulation approach. A comparative analysis of the two velocity estimation techniques is done based on same parameters of the surveillance radar. The research work is performed in MATLAB computational environment. The obtained analytical results can be used in both, radar and communication receiver networks.**

I. INTRODUCTION

Traditional approaches for detecting and tracking moving targets typically rely on a multiphase strategy in which target detections are feed to a Kalman-filter-based tracker. However, the presence of noise and heavy clutter inferences makes difficult the task of consecutive detection and tracking. An improved system concept involves a processing method, which allows preceding data to help in target detection. For example, the Hough transform techniques detect the existence of tracks using a batch of frames. The effectiveness of the Hough transform in achieving improved radar system detection performance is shown in a number of publications [2, 3, 7-11]. Since the information is collected over multiple observation intervals, a target state estimate, including position and velocity, can be obtained during the detection process. In the present paper, two techniques for target velocity estimation in the framework of Hough transform detection scheme are considered.

The Hough transform is a well-known technique used to identify straight lines in a noisy environment. In the context of radar application, the measurements from a straight-line target are collected in stationary bins (or accumulators), which are formed over the Hough parameter space. A track is detected, if the accumulated sum of measurements within each bin exceeds a detection threshold. Then, based on the accumulated measurements, track initiation and confirmation algorithms can be utilized for estimating target kinematics parameters.

The first proposed algorithm is a sequential tracking filter, which is applied to the ordered by time measurements inside detected bins. It is assumed, that the target has a random location, random speed and heading angle in the observed space. Two-point differencing track initiation procedure is implemented, followed by a nearest neighbour Extended Kalman Filter (EKF) [11]. The outputs of this combined HT-EKF algorithm are the estimated target positions and velocity.

An alternative approach for velocity estimation of moving targets towards or down radar can be realized using the Hough Transform proposed by Carlson in [1]. This Hough detector/estimator uses a limited set of preliminary chosen patterns of a linear target trajectory. During the last few years numerous studies consider the application of the Hough Transform in algorithms estimating moving targets velocity under the constraints defined in Carlson, Evans and Wilson's papers [1].

A new two-stage algorithm for target detection and target's radial velocity estimation that exploits the Hough Transform is proposed in paper [4]. This algorithm for detection and velocity estimation of a target moving in straight line in the same azimuth towards or downwards the radar is presented and evaluated. In order to test and study the new algorithm, a simulation algorithm based on the Monte Carlo approach is developed. Graphical and numerical results show that the quality parameters strongly depend on discretization not only of the range-time space but of the Hough parameter space as well. It is also shown that the discretization of both spaces (range-time and Hough) should be optimized in order to meet the requirements for both quality parameters – the probability of target trajectory detection and the accuracy of velocity estimation.

In paper [5] two techniques for radial velocity estimation that use the Doppler and Hough transforms are considered and compared based of the same parameters of surveillance radar. The numerical and graphical results show that the Hough estimator guarantees higher estimation accuracy than the Doppler estimator if the parameter space is sampled with an appropriate sampling step. In order to decrease computational burden of the Hough estimator, the trajectory detection can be done in two stages. At the first stage the Hough parameter is