Evaluation of Elevation Angle Representation Methods for Clustered Detections in Multi-Beam Radar

Thanh Tran Thi, Khuong Nguyen Van, Kien Tran Trung, Quynh Le Thuy, Hoa Nguyen Thi

*R*adar Center, Viettel High Technology and Industries Corporation, Viettel Group, Hanoi, Viet Nam

tranthithanhbg1995@gmail.com, khuongnv2@viettel.com.vn, kientt9@viettel.com.vn, quynhlt18@viettel.com.vn, hoant248@viettel.com.vn

Abstract— **In radar data processing systems, determining the representative value of a detection cluster is a crucial step following the clustering process. Most existing systems employ the centroid-based method to compute the cluster representative. However, field evaluations on operational multi-beam air-defence surveillance radars have revealed several limitations of this approach, particularly in estimating the elevation angle of clustered detections. This paper presents a comprehensive analysis and evaluation of multiple alternative solutions for determining the representative elevation angle of clusters in multi-beam radar systems. A three-step clustering-based framework is introduced, encompassing hit-level, plot-level, and group-level processing to improve the stability and accuracy of elevation estimation. A total of 32 method configurations are systematically examined using real-world data collected from a 3D air-defence surveillance radar. Experimental results demonstrate that the proposed method achieves up to 47% improvement in Root Mean Square Error (RMSE) and 45% enhancement in trajectory smoothness (Roughness) compared with the conventional centroid-based approach. The findings provide practical insights and an effective framework for enhancing elevation-angle representation in multi-beam radar data processing, thereby contributing to more accurate and reliable 3D target tracking.**

Keyword— **multi-beam radar, elevation angle estimation, cluster representation, radar signal processing, target detection, centroid method, air-defence surveillance radar**

Thanh Tran Thi, born in 1995, is a senior engineer at Radar Center, Viettel High Tech, Viettel Group. Her research interests include radar signal and data processing. In particular, she focuses on multi-target tracking algorithms for radar systems.

Kien Tran Trung, born in 1987, is a master of engineering. He has over 15 years of experience in radar design and manufacturing at Radar Center, Viettel High Tech, Viettel Group.

Khuong Nguyen Van, born in 1996, is a senior engineer at Radar Center, Viettel High Tech, Viettel Group. His research interests include radar signal and data processing.

Hoa Nguyen Thi, born in 1998, is a master of engineering. She is working at Radar Center, Viettel High Tech, Viettel Group. Her research interests include signal processing and noise filtering in wave propagation and radar systems.

Quynh Le Thuy, born in 2001, is an Engineer in Applied Mathematics and Informatics. She is working at Radar Center, Viettel High Tech, Viettel Group. Her research interests include the study of algorithms for radar signal processing.