Machine Learning For Radar Tracking In Urban Environments

Jiarui Zhang, Kaiyi Yang, Weixian Liu, Hongchuan Feng, Bihan Wen

School of Electrical and Electronic Engineering
Nanyang Technological University

Multiple target tracking in urban environments is extremely challenging due to effects such as target shadowing, limited angle resolution and multipath reflections. In addition, range and angle estimations obtained from classical radar processing system result scattered points in a noisy environment and lead to that the final formation of tracks matches neither the number of true targets of interest nor their true characteristics. Previously, Multipath Exploitation Radar (MER), which utilizes urban multipath to maintain track of non-line-of-sight (NLOS) targets, has been proposed to improve the detectability for urban radar. However, a big challenge for MER implementation is target positioning/relocating, which is based on appropriate ray tracing approaches with a priori knowledge of the urban environment or building geometry. Hence, manual parameter tuning and data processing are required. Moreover, conventional ray tracing models are not accurate for radar working at low frequencies.

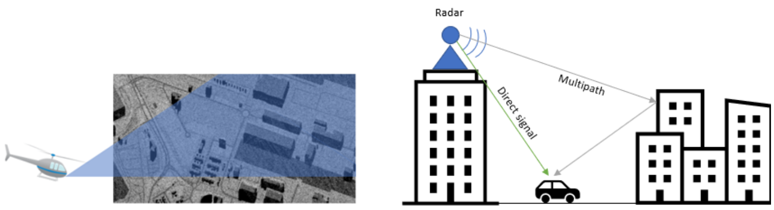

Figure 1: Urban environment and multipath propagation

Inspired by the extremely powerful Deep Learning (DL) methodologies, we hope to use DL to solve the urban radar target localization problem. It has shown great potential in object detection tasks in a Range-Doppler map and achieves similar accuracy as conventional beamforming but with faster processing time. On the other hand, deep learning is well-known for its data driven ability, that is, it can automatically and repetitively learn and discover certain pattern given sufficient data. In this work, we will investigate the feasibility of DL applications for target tracking, especially, to understand the radar data under the urban environment geometry and thus find the true location of targets automatically.

Multipath signals usually arrive later and are out of phase. Previous study introduced Time Reversal (TR) technology, which considered multipath as beneficial information to focus the transmitted energy on the real target to improve Signal-to-Noise Ratio (SNR). The finding of TR provides possibility for Deep Neural Networks (DNN) to learn the environment geometry and multipath formation rule in a certain particular environment given sufficient data. Therefore, DL can help classify true targets of interest and mirror images caused by multipath propagation. Through the insertion of a trained classification model, the whole radar processing system is expected to track only true targets of interest and improve the target localization in azimuth angle.

Our solution relies on a modified Convolutional Neural Network (CNN) based on multiple frame radar signals, as research has shown CNNs have excellent performance on time series classification tasks and a deep CNN can usually extract very informative features. In this work, 77GHz automotive radar is used to collect raw data to prove the concept and ease the data collection. The raw data is processed through classical radar processing techniques and then passed for training as illustrated in Figure 2.

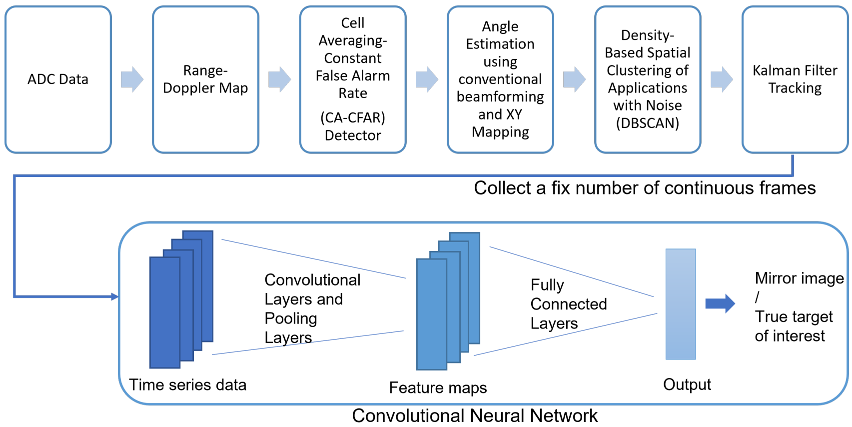

Figure 2: The model training data is obtained through classical radar processing techniques. Sufficient time series of processed data is passed to CNN for learning the formation rule of mirror images.

The experiment data is collected indoor (see Figure 3) with various reflective laboratory equipment, which is similar to the urban environment. By applying the classical radar processing techniques, the multipath propagation is obvious in the Range-Doppler map and causes mirror images in the final tracking result as shown in Figure 3. The experiment is in progress and we will demonstrate the results in near future.

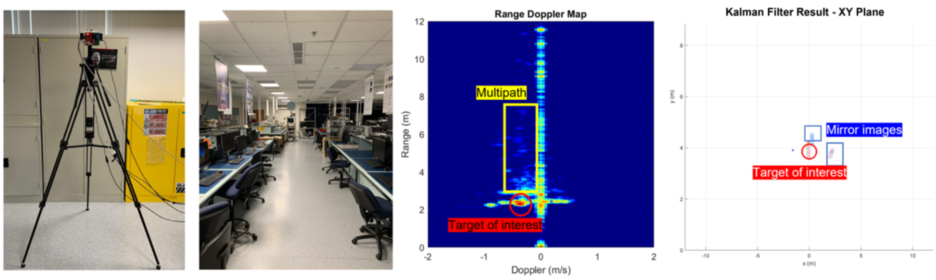

Figure 3: Experiment environment and setup; Under this environment, classical radar processing system results: multipath propagation causes false detections of non existing targets.