Physics-based Statistical Models of Traffic Targets for Automotive Radar Scene Simulations

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Autonomous vehicles technology is fast developing and recently has drawn significant attention from both academia and industry. Such technology is promising to revolutionize transportation by providing much higher safety, and efficiency both in fuel consumption and reducing traffic congestions. Millimeter wave automotive radar system (77 GHz) serves as an essential part of the autonomous vehicle. Traditionally automotive radars are used to provide range and relative speed information of target of interest, and our research shows they can be used for much wider range applications including road surface assessment, accurate lane positioning, imaging in inclement weather condition, and long range target detection. To study full potential of automotive radars, phenomenological study of scattering from traffic environment is necessary. Accurate information regarding the statistical radar cross section of target can help to improve the reliability and performance of the sensing system of autonomous vehicles. As different objects have different shapes, sizes and materials, their radar cross section (RCS) could be quite different. Also because of the industrialized standards for many objects like vehicles and traffic signs, the RCS for one types of objects could be very similar. This research is to find the similarity and uniqueness in RCS for different types of targets in traffic environments. Because of the complexity of electromagnetic wave scattering from arbitrary target shapes with large dimensions, highly randomized RCS as a function of range, directions and frequencies can be observed, but their statistical features are well-behaved and consistent within a certain ranges, directions and frequency band. Therefore, those statistical features can be categorized for different targets and it should be consistent regarding different environments and time.

To obtain such statistical features accurately, a large amount of data is required. In this paper we perform Monte-Carlo simulations on various targets on traffic scene including many different vehicles, pedestrians, traffic signs, lamp post, and etc. Because the dimensions of scatters are much larger than the wavelength and the radii of the curvature for most part of the surface of the scatterers are also greater than the wavelength, physical optics (PO) method is applied for scattering simulations. The statistical distribution and parameters of each target from different directions and ranges are categorized and compared. Previously we presented a limited statistical model of RCS of vehicles and pedestrians in the far-field range at a single frequency 77 GHz, and to improve the reliability and generality of the model, in this presentation, the RCS many targets are simulated and summarized for different ranges and a wideband of frequencies.