Investigating 77 GHz Automotive Radar Corner Cases using High Fidelity Full-Physics Simulations

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The need for fully autonomous vehicles with active safety systems has led to accelerated growth in the development of advanced driver assistance systems (ADAS). At the core of autonomous vehicles and active safety systems are various sensor technologies that equip the vehicle with a highly dynamic picture of the surrounding operating environment. Specifically, vehicles must be able to map the relative position, velocity and angle of arrival of multiple targets such as vehicles, pedestrians and road infrastructure before fully autonomous operation can be achieved. Light detection and ranging (Lidar), radio detection and ranging (Radar), optical cameras and ultrasonic sensors are some of the most widely used sensors in active safety and autonomous vehicles. Radar has emerged as the robust backbone sensor technology as it can simultaneously provide range, velocity and angle of arrival of multiple targets without being adversely affected by visibility or inclement weather. Automotive radar finds application in adaptive cruise control (ACC), pre-crash warning, blind spot detection (BSD) and cross traffic alert systems.

Although radar is a mature technology, its implementation in fully autonomous vehicles still needs to be extensively tested and validated for reliability. Specifically, automotive radar systems must be extremely reliable as they evolve from merely providing information to the driver to supplying critical data for fully autonomous operation. This provides a huge challenge to automotive makers as it is time consuming, expensive and impractical to physically build and test radar systems for different corner cases. Simulation is the only practical way to test the multitude of corner cases that need to be investigated before fully autonomous vehicles are deemed safe and reliable.

The high frequency structure simulator shooting and bouncing ray solver (HFSS SBR+) is a physical-optics based, asymptotic ray-tracing electromagnetic solver that can efficiently solve for electrically large problems. In this presentation, HFSS SBR+ is used to model various 77 GHz automotive radar corner cases. Specifically, a full scale traffic radar scene was modelled and analyzed using transmitting and receiving 77 GHz antennas designed in HFSS. Radar-return reduction for critical targets such as pedestrians due to terrain inclines will be presented. A method for improving pedestrian radar returns by over 16 dB is also proposed. Ghost targets emanating from road-covering construction plates will also be investigated along with a technique for realizing a 27 dB reduction in their radar-returns. In addition, the reduction of on-coming target radar-returns experienced by vehicles when negotiating a curve will be investigated along with a beam steering technique that can be used to improve radar-returns by 26 dB. Finally, the impact of highly reflective road guardrails on Doppler-range maps will be investigated and shown to potentially obfuscate low velocity targets such as pedestrians or stationary vehicles. Recommendations from this study can be used to aid in early target detection which can in turn reduce accidents while potentially saving lives.