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RESEARCH ON MILLIMETER WAVE RADAR SIMULATION MODEL FOR INTELLIGENT VEHICLE

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ABSTRACT–Radar simulation models can effectively overcome the drawbacks of real vehicle experiment and speed up the development process of intelligent vehicle technologies based on millimeter wave radar via virtual testing. However, there are still many gaps between the radar model using in the virtual driving environment and the real radar. In this paper, a novel simulation model of intelligent vehicle millimeter wave radar is proposed. Based on the analysis of the real radar performance in typical application scenes, the radar model considers the mechanism and characteristics of the vehicle radar synthetically and a systematic radar modeling architecture with innovation is introduced. The highlights of this radar model include the design of the RCS simulation model for radar targets with both high accuracy and real-time performance, the establishment of the quantitative false alarm model, missed detection model and measurement error simulation model. Vast amounts of data collected by real vehicle radar are applied to fetch model parameters and verify the accuracy of the radar model. Simulation results show that the proposed model can reach both high reliability and computational efficiency.

KEY WORDS : Modeling and simulation, Millimeter wave radar, Intelligent vehicles, Virtual testing

NOMENCLATURE

RCS : radar cross section area, m^2

SUBSCRIPTS

max	: maximum value
t	: transmitter
atm	: attenuation
s	: system
omin	: output minimum value
fa	: radar false alarm
fai	: ideal radar false alarm
res	: resolution ratio
IF	: intermediate frequency
SN	: signal and noise

1. INTRODUCTION

The advantage of millimeter wave radar for intelligent vehicles of working in "all-weather" and "all-time" making it becoming one of the most important sensors in the field of intelligent driving (Skolnik, 2010). However, millimeter wave radar is not perfect (Deng *et al*., 2011; Guo *et al*., 2016). Complex traffic scenario elements, such as roads, buildings, vegetation, weather, vehicles, pedestrians and so on (Guo *et al*., 2016), will introduce noise interference in many aspects such as "time domain, space domain, energy domain, polarization domain, frequency domain", which will lead to radar detection capability and measurement accuracy decline or even fail (Nagano *et al*., 2015; Son *et al*., 2018).

In the field of intelligent vehicles based on millimeter wave radar, field testing is one of the main methods on research, development and testing (Etinger *et al*., 2017; Lee *et al*., 2018). However, using real radar to carry out experiments has the disadvantages of high cost, long cycle, high risk, difficulty in repeated testing (Hall, 1997), and it is difficult to guarantee the robustness and reliability of the system (Sobue *et al*., 2009). Virtual radar simulation experiments can overcome the forementioned shortcomings (Jin *et al*., 2014).

The existing research on radar modeling and simulation are mainly conducted for military usage (Runa, 2010), while the research results and conclusions of intelligent vehicle millimeter wave radar modeling and simulation are relatively few (Crispin and Maffett, 1965; Chen *et al*., 2016). Therefore, it is of great research value to study the modeling and simulation for automobile millimeter wave radar (Siegel, 1968; Moon and Yi, 2002).

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