D-STOP

Technical Report 137

Virtual Waveform Design for Millimeter-Wave Vehicular Joint Communication-Radar

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Project Title: Joint Millimeter-Wave Communication and Radar for Automotive Applications

May 2019

Data-Supported Transportation Operations & Planning Center (D-STOP)

A Tier 1 USDOT University Transportation Center at The University of Texas at Austin

D-STOP is a collaborative initiative by researchers at the Center for Transportation Research and the Wireless Networking and Communications Group at The University of Texas at Austin.

Technical Report Documentation Page

1. Report No. D-STOP/2019/137	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle Virtual Waveform Design for Millimeter-Wave Vehicular Joint Communication-Radar	5. Report Date May 2019 6. Performing Organization Code
7. Author(s) Preeti Kumari and Robert W. Heath Jr. (WNCG, University of Texas at Austin); Sergiy A. Vorobyov (Aalto University, Finland)	8. Performing Organization Report No. Report 137
9. Performing Organization Name and Address Data-Supported Transportation Operations & Planning Center (D-STOP) The University of Texas at Austin 3925 W. Braker Lane, 4th Floor Austin, Texas 78701	10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTRT13-G-UTC58
12. Sponsoring Agency Name and Address United States Department of Transportation University Transportation Centers 1200 New Jersey Avenue, SE Washington, DC 20590	13. Type of Report and Period Covered 14. Sponsoring Agency Code

15. Supplementary Notes

Supported by a grant from the U.S. Department of Transportation, University Transportation Centers Program.

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16. Abstract

Automotive joint communication and radar (JCR) waveforms with fully digital baseband generation and processing can now be realized at the millimeter-wave (mmWave) band. Prior work has developed a mmWave wireless local area network (WLAN)-based automotive JCR that exploits the WLAN preamble for radars. The performance of target velocity estimation, however, was limited. In this paper, we propose an adaptive virtual JCR waveform design for automotive applications at the mmWave band. The proposed system transmits a few non-uniformly placed preambles to construct several receive virtual preambles for enhancing velocity estimation accuracy, at the cost of only a small reduction in the communication data rate. We evaluate JCR performance trade-offs using the Cramer-Rao Bound (CRB) metric for radar estimation and a novel distortion minimum mean square error (MMSE) metric for data communication. Additionally, we develop three different MMSE-based optimization problems for the adaptive JCR waveform design. Simulations show that an optimal virtual (non-uniform) waveform achieves a significant performance improvement as compared to a uniform waveform. For a radar CRB constrained optimization, the optimal radar range of operation and the optimal communication distortion MMSE (DMMSE) are improved. For a communication DMMSE constrained optimization with a high DMMSE constraint, the optimal radar CRB is enhanced. For a weighted MMSE average optimization, the advantage of the virtual waveform over the uniform waveform is increased with decreased communication weighting. Comparison of MMSE-based optimization with traditional virtual preamble count-based optimization indicated that the conventional solution converges to the MMSE- based one only for a small number of targets and a high signal-to-noise ratio.

17. Key Words wireless local area network, WLAN, mmWave, joint communication and radar, JCR, minimum mean square error, MMSE	18. Distribution Statement No restrictions. This document is available to the public through NTIS (http://www.ntis.gov): National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report) Unclassified	20. Security Classif.(of this page) Unclassified	21. No. of Pages 42	22. Price

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Acknowledgements

The authors recognize that support for this research was provided by a grant from the U.S. Department of Transportation, University Transportation Centers.