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Automotive Joint Radar-Communications in mmWave Band

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Extended Abstract

In recent years, various sensing systems sharing the spectrum with wireless communications (radio-frequency/RF, optical or acoustical) and still operate without any performance degradation has begun to capture significant research interest. This extended abstract focusses on the RF spectrum sharing between radar and communications in the emerging automotive scenario.

Combining spectral and hardware resources of various sensors, such as communications and radar, is heralding a new era in intelligent transportation systems. Such a joint radar-communications (JRC) model has advantages of low-cost, compact size, transportation safety due to enhanced mutual information sharing and performance optimization, spectrum sharing, and better management of vehicle-to-vehicle (V2V) interference. Nowadays, millimeter-wave (mmWave) communication has emerged as the preferred technology for short-range V2V links because it provides transmission bandwidth that is several GHz wide (~4GHz from 77-81 GHz band). This band is also promising for automotive radar as large transmit signal bandwidths imply high range resolution

Automotive JRC solutions are usually differentiated by the choice of waveform, which determines the performance of both users. Several JRC works have adopted signaling strategies motivated by either legacy radar or communications waveforms. The most popular communications signal for JRC is orthogonal frequency division multiplexing (OFDM) as demonstrated in multiple prior works based on IEEE 802.11p standard. A stable performance in multipath fading and relative simple synchronization makes OFDM advantageous for a JRC application. While the OFDM users are allocated on only time domain, the OFDM based multiple access (OFDMA) users can be differentiated by both time and frequency.

Other communications waveforms proposed for automotive JRC include spread spectrum noise-OFDM, multiple encoded waveforms and 802.11ad standard But their performance is limited either by the respective communications protocols, inter-vehicular synchronization or infeasible hardware implementations

The commonly used automotive radar waveform is frequency-modulated continuous-wave (FMCW) due to simplicity and low-cost of its receiver. The FMCW provides high range resolution but suffers from range-Doppler coupling. Moreover, it has no modulation to encode the communications data. Lately, there has been interest in using phase-modulated continuous wave (PMCW) as a viable alternative to FMCW for high-resolution automotive radars. Unlike FMCW, the PMCW does not need a linear frequency ramp for range estimation that is instead measured by parallel correlations. This allows for simpler implementations that avoid frequency synthesizers with high speeds, fast settling times or highly linear slopes.

This work will present an overview of the waveforms for automotive JRC considering both the communication and radar centric waveforms. The issues related to the design of such waveforms including the performance metrics and trade-offs will be highlighted. The challenges in utilizing JRC in emerging automotive scenarios with multiple cars equipped with such a functionality will be explored. This leads to a classical decentralized multi-user system and directions on addressing related challenges will be mentioned.