(SD2024-084) Spatio-Temporal Sensing Strategies for Synthesizing Structured Virtual Array Manifolds with Applications to MmWave Systems

Tech ID: 33799 / UC Case 2021-Z08-1

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OTHER INFORMATION

KEYWORDS

Single radio frequency chain, limited radio frequency chains, beam alignment, channel estimation, millimeter wave radar, Bayesian estimation, direction of arrival hierarchical codebook, coherence interval active sensing, manifold synthesis, multi-user detection and transmission

CATEGORIZED AS

- **Communications**
  - Wireless

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ABSTRACT

Researchers from UC San Diego developed a patent-pending novel Synthesis of Virtual Array Manifold (SVAM) sensing approach for the mmWave single RF chain systems. More specifically, this new technology for sensing leads to faster and more robust beam alignment. UCSD believes this contribution will have significant impact on the traditional paradigm for sensing in mmWave systems.

TECHNOLOGY DESCRIPTION

Researchers from UC San Diego have developed a novel sensing approach for millimeter wave systems with limited radio frequency (RF) chains, including the single RF chain system. This technology is inspired from the synthetic aperture radar systems, and presents a paradigm shift. The inventors have provided different design considerations for sensing under the new paradigm that enable rich sensing even with limited RF chains. The measurements collected using the sensing technology opens up myriad options for beam alignment, channel estimation, multi-user detection and transmission. This invention offers novel options for detection (powerbased inference) and estimation, for the beam alignment problem, that this sensing framework enables. Moreover, this sensing technology enables avenues to improve inference by adapting the spatial beamformer. The engineering team refer to this broad framework for sensing as Synthesis of Virtual Array Manifolds (SVAM).

APPLICATIONS

Millimeter wave and 5G (and beyond) technologies are promising and exciting because of the high data rates and many use cases that it enables. The technology is also challenging because of the channel characteristics and the hardware constraints.

The presented sensing methodology impacts the many use cases and addresses the challenges posed by communications in the millimeter wave spectrum.

These include a wide range of applications where signal from multiple antennas is processed e.g., in millimeter wave wireless systems such as UE and gNodeB for beam alignment, channel estimation, multi-user detection and transmission as well as millimeter wave radar systems.

ADVANTAGES

The novel sensing technology provides a systematic mechanism for capturing highly informative measurements. The sensing exploits the millimeter wave channel statistics and the geometry of the antenna array to take measurements that carry information about the unknown angle of arrival and the small-scale fading coefficient. Such emphasis on sensing under the extreme hardware constraints such as a single RF chain system is novel. Moreover this new sensing based measurements can be easily utilized within a broad class of beam

alignment algorithms. A detailed comparison with existing literature is made in the accompanying manuscript.

STATE OF DEVELOPMENT

In their publication, the UC San Diego researchers propose a novel inference scheme that estimates a posterior density on the small-scale fading coefficient and the unknown dominant path angle. Based on the proposed inference procedure, an adaptive beamforming scheme is provided that aims to collect high SNR measure- ments. Finally, the performance of the proposed active sensing scheme is evaluated under different scenarios, and a significant improvement over various benchmarks is demonstrated.

The published empirical study, see ***Pote & Rao, 2024*** (reference below), also reveals the impact of the different design parameters on the beam alignment performance.

INTELLECTUAL PROPERTY INFO

UC San Diego is protecting patent rights on this invention and welcomes enquires from companies interesting in exploring commercialization of the same.

RELATED MATERIALS

- RR Pote, BD Rao. 2024. Novel Active Sensing and Inference for mmWave Beam Alignment Using Single RF Chain Systems arXiv preprint arXiv:2404.07604, 2024 - 04/11/2024

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