Near-field Integrated Sensing and Communications with Beamfocusing

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***Abstract*—This paper delves into the complexities of the integrated sensing and communications (ISAC) system situated in the near-field (NF) area. We aim to bring the innovative concept of perceptive mobile networks (PMN) in line with cutting-edge communication technologies. To comprehensively cover the NF area, servicing downlink users and sensing targets, beamfocusing becomes essential. Consequently, we explain the influence of NF beamfocusing on the performance of the ISAC system.**

***Index Terms*—Near-field (NF), Beamfocusing, Integrated Sensing and Communications (ISAC)**

In integrated sensing and communications (ISAC), sensing activities are carried out simultaneously with either downlink (DL) or uplink (UL) communication operation [1]. Prior to transmission, waveform optimization is executed. ISAC employs an orthogonal frequency division multiplexing (OFDM)-based waveform, distinguishing it from the continuous wave (CW)-based waveform typical of traditional radars [2].

The trend in wireless communications is moving towards higher frequencies, spanning from millimeter wave (mmWave) to terahertz (THz), highlighting the significance of ultra-wideband (UWB). In the near-field (NF) region, beamfocusing technologies, supported by extremely large-array (XL-array) and multiple-input multiple-output (MIMO) antennas, are coming to the forefront. This extends the traditional far-field (FF) beamsteering techniques to enhance communication performance in the NF region, as noted in [3]. Although radar research has adjusted for high-frequency NF conditions, ISAC mandates specific alterations, especially concerning waveforms.

The evolution of integrated ISAC is underscored by innovations in beamfocusing, especially within the NF region. A prevailing assumption in traditional hybrid beamforming, especially the analog type, is that array channels are assumed to be planar waves. This assumption guides analog beamforming using a codebook designed for the spatial angle domain. However, in the context of the Fraunhofer distance within the NF region, the FF beamforming experiences diminished gain, as shown in Fig. 1. This discrepancy suggests that relying solely on the existing codebook might impair the efficacy of beamforming for both sensing and communications in the NF domain.

As a result of these insights, the beamfocusing concept was introduced [3]. The NF region expands as center frequency

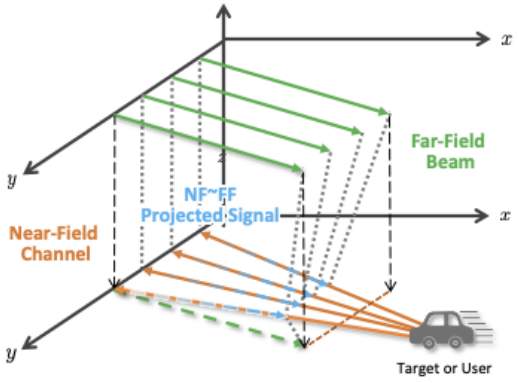

Fig. 1. Effect of far-field beamforming in near-field channel

increases, leading conventional codebook-based beamforming toward decreased sensing accuracy. While self-interference (SI) is already a key aspect of modern ISAC designs, incorporating NF beamfocusing presents additional challenges, from enhancing echoes and signals to handling interference [**?**]. Some research from an ISAC viewpoint has delved into sensing performance in NF settings. However, beamfocusing introduces complications. We can confirm that shifts in the focal point of beamfocusing can impact outcomes, necessitating recalibration.

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