

novel DNN architecture and loss function designs to obtain a single robust network that can work under various configurations. Simulation results demonstrate the good performance, low complexity, and strong robustness of the proposed algorithm. In the future, we will apply the proposed algorithm to more wireless communications problems and prove the convergence property to improve its universality and reliability.

Contributors

Jiabao GAO performed the simulations and drafted the paper. Xiaoming CHEN and Geoffrey Ye LI helped organize, revise, and finalize the paper.

Compliance with ethics guidelines

Xiaoming CHEN is a corresponding expert of Frontiers of Information Technology & Electronic Engineering. Jiabao GAO, Xiaoming CHEN, and Geoffrey Ye LI declare that they have no conflict of interest.

References

- Chen YH, Yan LF, Han C, 2021. Hybrid spherical-and plane-wave modeling and dcnn-powered estimation of terahertz ultra-massive mimo channels. *IEEE Trans Commun*, 69(4):7063-7076. <https://doi.org/10.1109/TCOMM.2021.3098690>
- Cui MY, Dai LL, 2022. Channel estimation for extremely large-scale mimo: Far-field or near-field? *IEEE Trans Commun*, 70(4):2663-2677. <https://doi.org/10.1109/TCOMM.2022.3146400>
- Cui MY, Dai LL, 2023. Near-field wideband channel estimation for extremely large-scale mimo. *Sci China Inf Sci*, 66(7):172303. <https://doi.org/10.1007/s11432-022-3654-y>
- Cui MY, Dai LL, Wang ZC, 2023a. Near-field rainbow: Wideband beam training for xl-mimo. *IEEE Trans Wireless Commun*, 22(6):3899-3912. <https://doi.org/10.1109/TWC.2022.3222198>
- Cui MY, Tan JB, Dai LL, 2023b. Wideband hybrid precoding for thz massive mimo with angular spread. *SCI SIN Inform*, 53(4):772-786. <https://doi.org/10.1360/SSI-2022-0137>
- Elbir AM, Shi W, Papazafeiropoulos AK, et al., 2023. Near-field terahertz communications: Model-based and model-free channel estimation. *IEEE Access*, 11:36409-36420. <https://doi.org/10.1109/ACCESS.2023.3266297>
- Gao JB, Hu M, Zhong CJ, et al., 2022. An attention-aided deep learning framework for massive mimo channel estimation. *IEEE Trans Wireless Commun*, 21(3):1823-1835. <https://doi.org/10.1109/TWC.2021.3107452>
- Gao JB, Zhong CJ, Li GY, et al., 2023a. Deep learning-based channel estimation for wideband hybrid mmwave massive mimo. *IEEE Trans Commun*, 71(6):3679-3693. <https://doi.org/10.1109/TCOMM.2023.3258484>
- Gao JB, Zhong CJ, Li GY, 2023b. Amp-sbl unfolding for wideband mmwave massive mimo channel estimation. *IEEE Int Conf on Communications Workshops*, p.60-65. <https://doi.org/10.1109/ICCWorkshops57953.2023.10283596>
- Hu XL, Liu CX, Peng MG, et al., 2023. Irs-based integrated location sensing and communication for mmwave simo systems. *IEEE Trans Wireless Commun*, 22(6):4132-4145. <https://doi.org/10.1109/TWC.2022.3223428>
- Lu Y, Dai LL, 2023. Near-field channel estimation in mixed los/nlos environments for extremely large-scale mimo systems. *IEEE Trans Commun*, 71(6):3694-3707. <https://doi.org/10.1109/TCOMM.2023.3260242>
- Luo M, Guo QH, Jin M, et al., 2021. Unitary approximate message passing for sparse bayesian learning. *IEEE Trans Signal Process*, 69:6023-6039. <https://doi.org/10.1109/TSP.2021.3114985>
- Nayir H, Karakoca E, Görçin A, et al., 2022. Hybrid-field channel estimation for massive mimo systems based on omp cascaded convolutional autoencoder. *Proc IEEE 96th Vehicular Technology Conf*, p.1-6. <https://doi.org/10.1109/VTC2022-Fall57202.2022.10013010>
- Qin ZJ, Ye H, Li GY, et al., 2019. Deep learning in physical layer communications. *IEEE Wireless Commun*, 26(2):93-99. <https://doi.org/10.1109/MWC.2019.1800601>
- Srivastava S, Mishra A, Raviyaya A, et al., 2019. Quasi-static and time-selective channel estimation for block-sparse millimeter wave hybrid mimo systems: Sparse bayesian learning (sbl) based approaches. *IEEE Trans Signal Process*, 67(5):1251-1266. <https://doi.org/10.1109/TSP.2018.2890058>
- Wan ZW, Gao Z, Gao FF, 2021. Terahertz massive mimo with holographic reconfigurable intelligent surfaces. *IEEE Trans Commun*, 69(7):4732-4750. <https://doi.org/10.1109/TCOMM.2021.3064949>
- Wei XH, Dai LL, 2022. Channel estimation for extremely large-scale massive mimo: far-field, near-field, or hybrid-field? *IEEE Commun Lett*, 26(1):177-181. <https://doi.org/10.1109/LCOMM.2021.3124927>
- Yu WT, Shen YF, He HT, et al., 2022. Hybrid far-and near-field channel estimation for thz ultra-massive mimo via fixed point networks. *IEEE Global Communications Conf*, p.5384-5389. <https://doi.org/10.1109/GLOBECOM48099.2022.10001564>
- Zhang XY, Wang ZN, Zhang HY, et al., 2023. Near-field channel estimation for extremely large-scale array communications: A model-based deep learning approach. *IEEE Commun Lett*, 27(4):1155-1159. <https://doi.org/10.1109/LCOMM.2023.3245084>
- Zhu YF, Guo HY, Lau VKN, 2021. Bayesian channel estimation in multi-user massive mimo with extremely large antenna array. *IEEE Trans Signal Process*, 69:5463-5478. <https://doi.org/10.1109/TSP.2021.3114999>