

4. Advanced Technology of Socio CA Wireless Network

Progress until FY2024

1. Outline of the project

We are developing wireless communication optimization technologies to enable reliable and stable teleoperation of Socio-CAs. Specifically, we aim to construct an intelligent local network (ILN) in Fig. 1 by interconnecting and dynamically controlling multiple smart spot cells (SSCs) composed of Local 5G and Wi-Fi. This architecture allows us to maintain optimal wireless connections and coverage areas for CA operations, thereby ensuring high-quality and uninterrupted teleoperation of Socio-CAs.

Flexibly adjust SSC coverage based on CA movement and density

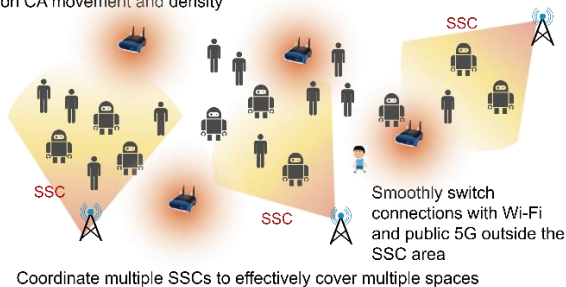


Figure 1: Concept of the Intelligent Local Network (ILN).

2. Outcome so far

We have developed a Socio-CA wireless communication reliability evaluation simulator (Fig. 2) that enables pre-assessment of communication quality for multiple CAs operated via an ILN composed of Wi-Fi and Local 5G base stations. By separately simulating the effects of reflection from static objects and obstruction from moving objects such as humans and CAs, the simulator significantly reduces the computational load of radio propagation simulations. This allows us to determine, in advance, the optimal number of Wi-Fi access points and Local 5G base stations to meet the communication quality requirements in environments with up to 100 CAs.

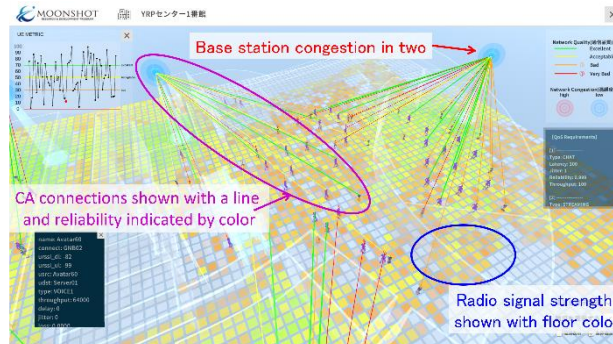


Figure 2: Socio-CA Wireless Communication Reliability Evaluation Simulator.

We also developed a CA terminal (Fig. 3) capable of switching between heterogeneous wireless systems within a SSC composed of Wi-Fi and Local 5G. To fully utilize the performance of the installed infrastructure and terminals, we developed deployed base stations and terminals, we build the optimal CA communication area computing database (OCAC DB), which collects and stores status data about each communication node and CA communication.

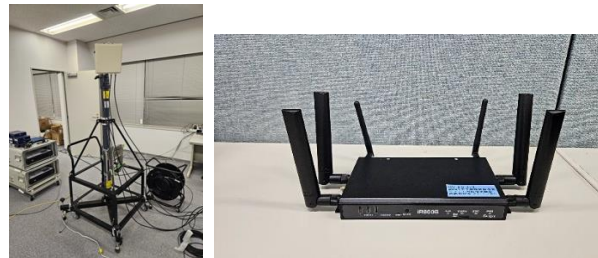


Figure 3: Portable Base Station (left) and CA Terminal Capable of Heterogeneous Wireless Connections (right).

Based on the data stored in the OCAC DB, we developed a technology called “NeuroRAT” (Fig. 4), which employs a Deep Neural Network (DNN) to model and estimate communication quality and derive optimal parameter settings

to maximize the performance of existing wireless infrastructure. The DNN is trained using communication data generated in the virtual environment built by the simulator and applied in real-world setting to select optimal communication parameters in real-time.

Furthermore, for 5G base stations equipped with numerous antenna elements utilizing MIMO technology, we proposed a beamforming algorithm that dynamically tracks the movement of CAs, enabling responsive direction control of transmission beams [Accepted in IEEE Trans. Quantum Engineering].

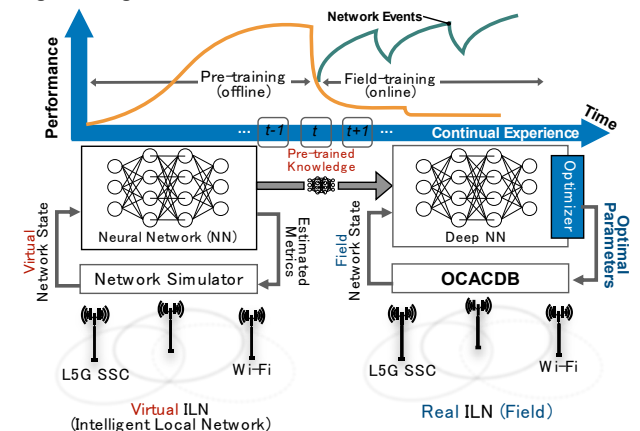


Figure 4: NeuroRAT Wireless Environment Optimization Algorithm.

3. Future plans

By integrating the Socio-CA wireless communication reliability evaluation simulator, base stations, terminals, the OCAC DB, and the NeuroRAT algorithm, we aim to optimize wireless communication for multiple Socio-CAs and demonstrate stable teleoperation of CAs. This integrated system enables seamless teleoperation and maintains communication quality under diverse network conditions.