MITSUBISHI Project B:

Title

Optimization of wireless base station placement as an essential foundation for our future IoT society

Industrial Partner: Information Technology R&D Center of Mitsubishi Electric Corp.

Mitsubishi Electric is a world leader in the manufacture and sales of electrical and electronic products and systems used in a broad range of fields and applications. As a global leader among green companies, our technologies are being applied to contribute to and support society and daily life around the world. The Information Technology R&D Center is actively creating new businesses through basic research and development in the fields of information technology, media intelligence, electro-optics microwaves, and communication technologies. We are also seeking technologies that reinforce our position on the leading edge of progress, with work to renew existing businesses through the fruits of our R&D in the field of IT.

Industry Mentors

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Introduction

Continuous development of wireless communication technologies has led to creation of various IoT applications [1]. Among them, 5G technology [2] is the most promising. The generation of a mobile communication standard has been upgraded almost every decade. Now, the 5G wireless communication standard has been launched with numerous attractive features: enhanced mobile broadband (eMBB), massive machine type communications (mMTC), and ultra-reliable and low latency communications (URLLC). These features will establish 5G technology as a firm foundation for future IoT society.

For 5G, the radio frequency band is to be licensed not only to mobile operators but also to private system developers such as manufacturers. That transformation will alter the industry structure, creating a wide range of business opportunities in automobiles, industrial equipment, home security, and smart meters. That is one reason why we are keenly developing wireless technology.

Construction of an efficient system demands the smooth and rapid development and deployment of new wireless systems. The basic requirements of wireless systems are fewer base stations, complete coverage, and broad band throughput. Most importantly, to use limited radio frequency resources efficiently, such systems must not interfere with other systems. Accurate placement design is important, but the coverage evaluation of a real environment requires great costs and time.

Expectations

The purpose of the project is creation of an efficient and reliable optimization algorithm to ascertain the positions and directions of wireless base stations to reduce the costs and time for designing wireless systems. The optimization algorithm accepts the spatial distribution of radio signal strength (RSS) to evaluate the cost function. Therefore, we provide a propagation model that can predict the RSS. Participants can change the propagation model input parameters such as the base station position, direction, transmitting power, and the design environment geometry. Then, the propagation model predicts RSS considering the transmission loss which occurs when radio waves pass through walls and when multiple reflections of radio waves occur on the wall.

The design dimensions largely determine the problem difficulty. Base stations are restricted in a one-dimensional space in wireless train control systems [3,4], whereas the positions are in two- or three-dimensional space for general placement design [5]. Typically, the target number of base stations is a few hundred for train control systems, or a few dozen for general placement design. Because of the curse of dimensionality, solving optimization problems becomes extremely difficult as the parameter space increases. We encourage participants to create an algorithm for two- or three-dimensional design space, which is more challenging and worth trying in terms of larger parameter space. For example, the resulting method can be applicable to wireless design for large indoor areas (e.g. factories) or for outdoor areas (e.g. urban environments).

Conventional methods have typically used combinational optimization. In recent years, several studies have examined analytical methods using topology (e.g. persistent homology) [6] or graph theory [7]. We encourage participants to propose formulation using these mathematical structures of coverage and interference and efficient optimization algorithms that are applicable to larger parameter spaces.

Requirements

We welcome students who are motivated to tackle application-oriented and practical problems encountered by manufacturers. Students must have knowledge of optimization. In addition, it is desirable that they have the following knowledge.

- Programming (e.g. Python, MATLAB)
- Topology
- Graph theory

References

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[7] M. Lin, Q. Ye and Y. Ye, "Graph theory based mobile network insight analysis framework," 2016 IEEE 7th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON), New York, NY, 2016, pp. 1-7.