**Digital Twin Representation of Foliage - Research Proposal**

**Abstract**

The escalating demand for higher bandwidth, increased throughput, and reduced latency driven by the proliferation of connected devices has led to the development of millimeter-wave (mmW) networks. These networks, vital for realizing the potential of 5G technology, face formidable challenges related to mmW propagation, including issues like scattering, atmospheric absorption, and the profound impact of foliage, and building facades. This study focuses on a cost-effective solution that combines Google Street View and satellite images with computer vision and machine learning techniques, offering an accessible means to address these challenges.

By leveraging open-source and low-cost resources, the study aims to create a digital twin (DT) of an environment that encompasses foliage data. This DT holds promise for network operators planning high-frequency network deployments, as it allows for strategic node placement to optimize coverage and user experience. The research emphasizes the importance of foliage in mmW networks, with a particular focus on foliage presence and tree height estimation using Google Street View and satellite images.

Furthermore, the digital twin concept presented here paves the way for future expansions, including data on building facades, traffic signs, road markers, and pedestrian crossings. This comprehensive approach represents a significant advancement in network planning, positioning technology as an enabler of more efficient, adaptive, and cost-conscious mmW network deployment and management.

**Introduction**

In the realm of modern technology and telecommunications, the rapid advancement of millimeter-wave (mmW) networks has become a pivotal component in meeting the escalating demand for higher bandwidth, throughput, and reduced latency. Figure 1 illustrates how 5G wireless networks are keeping pace with mobile market demands. Nonetheless, mmW networks encounter inherent obstacles, including issues like scattering, atmospheric absorption, and notably, the influence of foliage and building facades on the transmission of signals (Figure 2). Addressing these challenges is essential for the successful implementation of 5G networks and ensuring optimal user coverage and throughput.

Figure 1

5G Wireless Networks

A city skyline with a 5g network

Description automatically generated

*Note.* (Scientists Measure Impact, 2022).

Figure 2

Obstacles in 5G Millimeter-Wave Deployment

A diagram of waves and trees

Description automatically generated

*Note.* (Shah, 2018).

Obtaining accurate and comprehensive data on foliage, an element with substantial influence on higher-frequency network deployment, has traditionally relied on labor-intensive and costly methods such as unmanned aerial vehicles (UAVs) and LiDAR (light detection and ranging). Figure 3 shows an Illustration of how data is collected through LiDAR and UAV. The need to repeatedly update this data makes these methods impractical in many cases. However, as technology evolves, a new paradigm is emerging in the form of digital twins.

Figure 3

Illustration of Collection of Data in Lidar and UAV

A diagram of a gps system

Description automatically generated

*Note.* (Airborne Laser Scanning, 2013).

Digital twins have emerged as a transformative technology with applications across various domains, including urban planning, industrial operations, and, most notably, the field of wireless network planning (Qi & Tao, 2018). One intriguing area of application is the representation of foliage or vegetation using digital twin technology. Foliage, such as trees and other plant life, plays a crucial role in the propagation of wireless signals, particularly in high-frequency networks like millimeter-wave (mmW) networks used for technologies such as 5G.

The representation of foliage or vegetation within a digital twin involves the creation of a virtual replica of the natural environment, with a particular focus on the distribution, type, and characteristics of plant life. Figure 4 demonstrates the representation of foliage in Digital Twin. These digital twin models enable network planners, environmental scientists, and other stakeholders to gain a comprehensive understanding of how foliage impacts wireless signal propagation, path loss, and coverage.

Figure 4

Digital Twin Representation of Foliage

A city with trees and buildings

Description automatically generated with medium confidence

*Note.* (MWC23 – Intelligent, 2023).

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