

What are the different models of beam tracking modules



Overview

This work presents an overview of the different beam-tracking methods used in mmWave communications, focusing on hybrid beamforming techniques.

Key Takeaways

Beam tracking modules can be broadly categorized into traditional model-based, sensor-assisted, and AI/ML-based models, each designed to maintain optimal beam alignment in dynamic wireless environments.

Traditional Model-

Based Beam Tracking

Traditional beam tracking relies on mathematical and linear models to predict and adjust beam directions. Techniques such as Kalman filters (including extended Kalman filters) are commonly used to track the movement of user equipment (UE) and maintain beam alignment in massive MIMO systems. These models are effective for moderate mobility scenarios but may struggle with rapidly time-varying channels or highly nonlinear UE motion, leading to potential beam tracking failures and increased overhead for channel acquisition.

Sensor-



Assisted Beam Tracking Sensor-assisted models incorporate inertial measurement units (IMUs), GPS, or other positioning sensors to aid beam alignment. For example, in UAV mmWave communication, models can use geodetic positions, UAV-BS unit vectors, and height information to predict and track beams. These models improve tracking accuracy by leveraging real-time positional data, which is particularly useful in high-mobility scenarios where traditional models may fail.

AI/ML-Based Beam Tracking Artificial intelligence and machine learning models, especially deep learning (DL) and neural networks, are increasingly used for beam tracking. These models can capture complex nonlinear relationships in high-dimensional data, such as UE motion patterns and environmental scattering effects. AI-based models can predict optimal beam directions and adapt to dynamic channel conditions, reducing the need for exhaustive beam scans and improving throughput in mmWave and terahertz bands.

Examples include deep neural networks (DNNs) for temporal channel modeling and reinforcement learning for adaptive beam selection.

Hybrid Approaches

Some modern beam tracking modules combine traditional, sensor-assisted, and AI-based methods to leverage the strengths of each. For instance, a system may use a Kalman filter for baseline tracking while employing a DNN to refine predictions based on sensor data and environmental context. This hybrid approach enhances robustness and efficiency, especially in high-speed or complex propagation environments.

Summary

In summary, beam tracking modules can be classified into: Traditional model-based: Kalman filters, linear prediction models. Sensor-assisted: GPS, IMU, and UAV positional data integration. AI/ML-based: Deep learning, neural networks, reinforcement learning.

Hybrid models: Combining traditional, sensor, and AI methods for improved performance. These models are essential for maintaining high-quality directional communication in 5G, 6G, and mmWave systems, addressing challenges like narrow beamwidths, rapid UE mobility, and environmental blockages.

Article Content

Beam prediction and tracking mechanism with enhanced LSTM

By combining millimeter wave (mmWave) with abundant spectral resources and advanced directional beamforming technology, mmWave aerial base stations (mAeBSs) can provide

An overview of beam-tracking techniques for mmWave wireless ...

This work presents an overview of the different beam-tracking methods used in mmWave communications, focusing on hybrid beamforming techniques. We also compare the various tracking

Deep learning-based multimodal beam tracking for unmanned aerial ...

In this paper, we propose a multimodal UAV beam tracking model that utilizes both image and GPS sensor data while incorporating sequential information to enable optimal beam tracking,

Beam tracking of a five-dimensional processing system with

In order to meet the processing needs of complex special-shaped microstructures, this paper designed a five-dimensional laser processing system that includes four relatively independent

GPS-Aided Deep Learning for Beam Prediction and Tracking in UAV

This research presents a GPS-aided deep learning (DL) model that simultaneously predicts current and future optimal beams for UAV mmWave communications, maintaining a Top-1 prediction accuracy

Machine Learning for Robust Beam Tracking in Mobile Millimeter

Fig. 4(e) depict the total delivered traffic for different beam tracking algorithms. We observe that MAMBA-X performs better and the total delivered traffic increases by up to 46.8% and 142%

Beam Training and Tracking in MmWave Communication: A Survey

An in-depth and comprehensive analysis of beam training and tracking technologies in terms of training overhead, tracking complexity, tracking error and advantages and disadvantages is

Multi-modal fusion for sensing-aided beam tracking in mmWave ...

The proposed DMBT method includes three designed mechanisms, namely normal prediction process, beam misalignment alert and beam tracking correction. The normal prediction

Beam training and tracking in mmWave communication: A survey

This article provides an overview of the beam training and tracking technologies on mmWave bands and reveals the insights for future research in the 6th Generation (6G) mobile network. Especially, some

Intelligent Beam Prediction and Tracking | part of Artificial ...

In particular, we classify different BPT methods based on the underlying learning techniques and briefly analyze their strengths and weaknesses. Then, we analyze the key challenges of applying machine

Long-short term memory based wideband beam tracking scheme

Massive multiple-input multiple-output (MIMO) systems at millimeter wave have been touted as a possible technology for 5 G wireless communications. The massive MIMO systems,

Beam prediction and tracking mechanism with enhanced LSTM

Consequently, we propose schemes based on deep learning for beam prediction tracking in this paper. On the basis of received signals from both the present and previous beam training, we apply long

Beam Training and Tracking in MmWave Communication: A Survey

Side Information Aided Beam Tracking Machine Learning Position Information Auxiliary Beam Pair Supervised Learning Database

Deep learning-based multimodal beam tracking for unmanned aerial ...

Building on this, we propose a multimodal beam tracking model for UAV communication, integrating image and GPS data to predict UAV movement and optimize beam tracking. The model

Remote Detection of Applications for Improved Beam Tracking in

In , the same authors utilized simplified micromobility models based on diffusion processes to evaluate the performance of on-demand and regular beam-tracking procedures in the

An overview of beam-tracking techniques for mmWave wireless ...

Beam tracking plays a considerable role in 5G communications, especially in vehicular communications, due to the repeated change of the transceiver (Tx, Rx, or both) position. This work

Hybrid LSTM-actor-critic framework for temporal-spatial wideband beam ...

Although employed an LSTM-Actor-Critic scheme for temporal modeling, it was limited to resource allocation in network slicing and did not consider the joint temporal-spatial coupling

A Beam Steering Vector Tracking GNSS Software-Defined Receiver

In this paper, the authors provide algorithms for a beam steering vector tracking software-defined radio (SDR) that is experimentally validated in multipath environments. The

Contact Us

Continue your research online:

Website: <https://bagyou.es>

Technical inquiry: <https://bagyou.es/project-enquiry.html>

This document is for preliminary research. Verify specifications against current standards, product documentation and project requirements.

