

Wifi CSI data interpretation - Phase.

What is WiFi CSI:

Wifi CSI involves sending a signal into a room and observing the signal in another location, by figuring out which signals are changing you can identify dynamic objects in the room, such as a person.

What can Wifi CSI do?

Localisation:

By utilising the propagation characteristics of radio waves, it's possible to triangulate a person's position within a room accurately. This method primarily relies on analysing variations in signal strength and the phase information collected from multiple antennas, such as the three-receiver antenna configuration described in the dataset. Each antenna receives the radio waves that have travelled from the transmitter, but these waves are subject to alterations caused by obstacles, movement, and the inherent properties of the environment.

The complex data captured by each antenna includes variations in amplitude and phase that occur as the environment changes, such as when a person moves within the room. By comparing the differences in how each antenna receives the signal, one can derive spatial information about the location of objects or people causing these disturbances. This comparison can involve techniques like phase difference of arrival (PDOA) and time difference of arrival (TDOA), which help pinpoint the exact location by measuring the time or phase shift differences as signals reach different antennas at slightly different times or phases.

Machine learning models can also be used to identify the location of people in rooms using this set up.

Activity recognition:

Each human activity affects the radio waves differently. Walking might cause periodic disruptions in the signal as the body repeatedly passes through the line of sight between the transmitter and receiver while sitting could result in a sudden but stable change in the signal pattern as the person remains relatively static. Applying machine learning algorithms to these data points makes it possible to classify these patterns into recognisable activities.

The process involves training these algorithms on a dataset where multiple instances of human activities have been recorded along with the corresponding changes they induce in the signal characteristics. The trained model can then identify activities in real time by matching incoming signal data to the learned patterns. This technique not only enhances a system's capability to interact intelligently with its environment but also opens up possibilities for non-intrusive health monitoring, where specific gestures or movements associated with health issues can be detected and addressed promptly.

What does Phase represent:

Phase indicates the timing of the signal as it reaches the receiver. It provides critical information on how the signal has been altered by the environment, such as through reflections, diffractions, or other changes in the path from transmitter to receiver. This phase information is essential for understanding signal integrity, directionality, and the environmental impact on the signal's propagation. Feeding this data into the machine learning model as a separate feature would likely greatly improve the quality of the model.

How can these imaginary numbers be used in machine learning?

Feature Extraction from complex numbers:

Separate Features: The real and imaginary parts of complex numbers can be treated as separate features in a machine-learning model. This approach maintains the distinction between amplitude and phase information.

Polar Coordinates: Convert the complex numbers from Cartesian (real and imaginary) to polar coordinates (magnitude and phase). This transformation makes the phase information (related to the imaginary part) more explicit and directly usable.

Standard preprocessing and handling non-linearity

Normal preprocessing should still be done on this data before moving on to making the data linear, either using phase wrapping or using the sine/cosine of the wave.

Sinusoidal Encoding:

Sinusoidal encoding should be used as it is well-suited for this type of data. It makes it easier for the data to be used in machine learning models by ignoring the discontinuities in the data due to how the phase data is likely to appear.

Info about machine learning networks and CSI data: <https://www.mdpi.com/2079-9292/12/18/3935>