Anti-jam antenna simulator

Background

Global Navigation Satellite Systems (GNSS) provide both position and time to millions of receivers worldwide. GPS, which is the most widespread variant of GNSS, is deeply integrated into a number of critical infrastructure such as aircrafts, banking, power plants, etc. The signals from the satellites in orbit are weak when they arrive at the GNSS receiver on earth. This means that systems that rely on GNSS are vulnerable to interference, whether intentional or not. Therefore, anti-jam antennas that dynamically attenuates interference signals (nulling) have been developed. These are often called Controlled Reception Pattern Antennas (CRPAs) or nulling-antennas. While nulling the interference, the GNSS signals from the satellites may be amplified using beamforming. Both nulling and beamforming are done using individual phase-shifted signals from multiple antenna elements in an antenna array. Advanced anti-jam antennas can also be used as direction finders of interference signals.

Problem

The thesis consists of developing an understanding for the underlying principles of anti-jam antennas and to present an overview of the different signal processing methods used in such systems. The work should also include programming an anti-jam antenna simulator for a CRPA with a given number of antenna elements. The simulator should be able to distinguish between the directions the signals are coming from and be able to null out one or more unwanted signals. Efforts should be made to simulate realistic situations with regard to signal effect and direction. The simulator must be based on mathematical models and physics. A possible use of the results from this thesis is to build an anti-jam antenna from the ground up.

Proposed workflow

1. Carry out a literature study on anti-jam antennas
2. Describe the operation of anti-jam antennas using both words and mathematics
3. Compare different nulling algorithms like STAP (Signal-Time Adaptive Processing) and SFAP (Signal-Frequency Adaptive Processing)
4. Develop a method for simulating an anti-jam antenna scenario with one or more sources of interference
5. Discuss the strengths and weaknesses of anti-jam antennas
6. Summarize results, give conclusions and identify further work

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