Robust Drone Detection and Tracking in harsh Environment

Degree programme: Master of Science in Engineering | Specialisation: Information and Communication Technologies
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Drones are multi-talents of the skies. They allow unprecedented possibilities for private and professional applications. However, the technical and economical potential involve danger of unauthorized use or even abuse. Within the scope of this thesis, a modular sensor network has been developed to protect sensitive airspace and areas, such as the approach corridor of an airport, against unauthorized drone intrusions.

Background

Despite clearly defined no-fly zones and airspace regulations, violations of the current regulations are increasing. Equipped with explosive payloads, drones are even used in modern warfare by terrorists to target buildings and crowds of people. To avoid incidents with injured- or even dead ones, these shady sides of the steadily growing drone market must be countered with anti-drone systems.

Methods

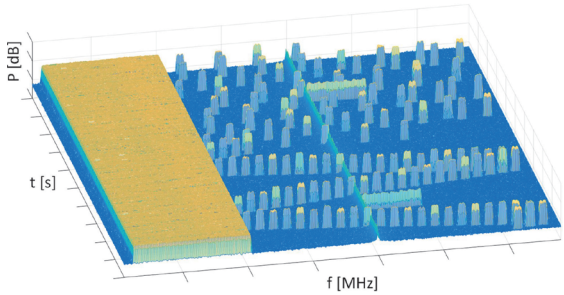
Most drones are equipped with a First Person View (FPV) transmission to the remote control to allow controlling the drone in FPV and taking aerial photos or videos. These electromagnetic signals are exploited for a Radio Frequency (RF) based detection and tracking of an intruding drone into a pre-defined security area. A sensor network, built on several spatial distributed sensor nodes, has been developed. Each sensor node is equipped with a detection triggered Direction of Arrival (DoA) estimation. To ensure a robust detection, morphological filtering in the frequency domain is used to separate drone- from interference signals. The DoA estimation is performed using modern beamforming techniques that simultaneously exploit signals from multiple antennas (antenna arrays).

By conjoint data processing on a central unit, taking into account information from all sensor nodes, the position of an intruding drone is estimated in real-time and visualized in a Graphical User Interface (GUI). To guarantee a reliable position estimation even with missing DoA data over a short time, a flight path prediction system has been implemented using an autoregressive model for linear prediction.

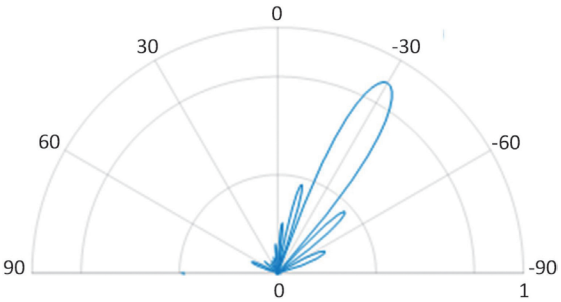
Results and Outlook

The performance of the developed sensor network has been validated on synthetic signals and confirmed in field tests by means of a sensor network, built on two sensor nodes. With a detection and tracking range of up to 3 km, a detection sensitivity of 85%, a standard deviation of 1° in the estimated DoA and no false alarms, promising results have been obtained. After an upcoming optimization phase, a competitive and smart drone detection and tracking system can be realized. Equipped with features such as early detection, high sensitivity at a low false alarm rate, high tracking accuracy and modular and expandable structure with minimized system overall costs, allows the system to prevail in the highly competitive anti-drone market.

Bernhard Matthias Nyffenegger



Power Spectral Densitiy (PSD) of FPV Transmission- (l) and Remote Control Drone Communication Signals (r)



Estimated Spatial Spectrum with Beam of detected Drone at Direction of Arrival (DoA) of –30°