Identifying Drone Signatures

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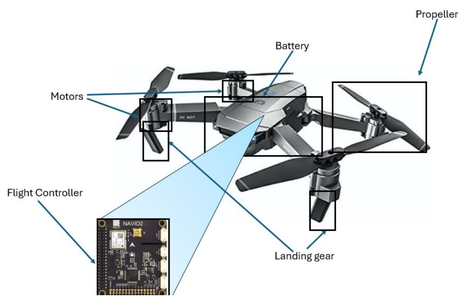
MOTIVATION AND RESEARCH FOCUS

- Drone technologies are now prevalent in applications such as agriculture, environmental, aerial reconaissance and security monitoring
- Drones can be detected through their acoustic, radar and visual characteristics – also known as signatures
- Monitoring drone signatures through ground or air-based sensors is an important problem
  - Allows system malfunction when signatures deviate from expected patterns
  - Enables detection of adversarial drones that may have infiltrated the operating space
- This research will conduct:
  - Experimental studies to record acoustic, optical, and visual signatures representing static and dynamic drone motion
  - Analysis of experimental data to identify types of drones through a combination of acoustic, optical and visual measurements

BACKGROUND INFORMATION



Motion:

- Motors: What moves the drones, coordinated to move the drone in any direction
- Flight controller: Microcontroller that coordinates the motors to move the drone in different directions
- Propellers: Determine the speed, thrust and drag of the drones

Communication:

- RF Antenna: Transmits and receives signals from the base station or other drones in a swarm or adjacent aerial vehicles

Power:

- Battery: Stores power for the drone systems

Other:

- Landing gear: Enables drone to stay intact during landing

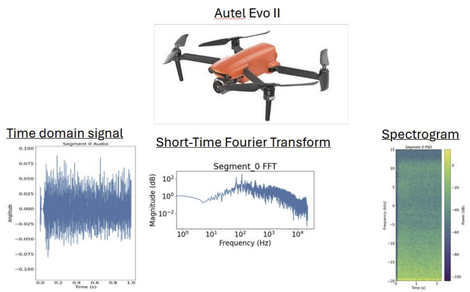
RESEARCH

Acoustic Detection Methods

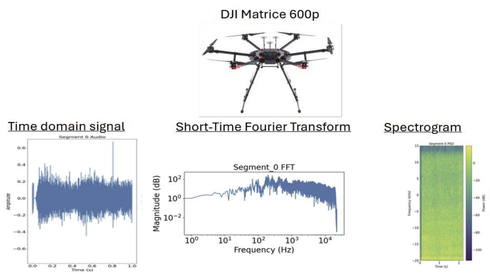
Acoustic Drone Signatures

- Drones can be distinguished by the sounds they emit when in motion
- Propeller noise: Generated by aerodynamics of the propeller colliding with the air when the drone is in motion
- Motor noise: Mechanical vibrations of the motor when the drone is in motion to
- Aerodynamic noise: Noise flowing through the drone's pores when the drone is in motion
- Frame vibration: Drone infrastructure vibrating when in motion

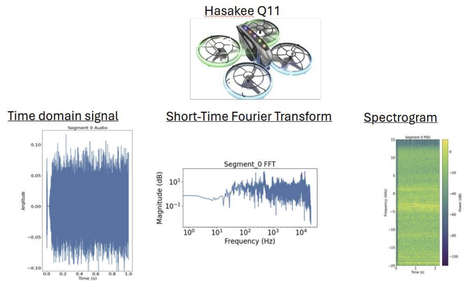
Acoustic Signature from Autel Evo II [1]



Acoustic Signature from DJI Matrice 600p [1]



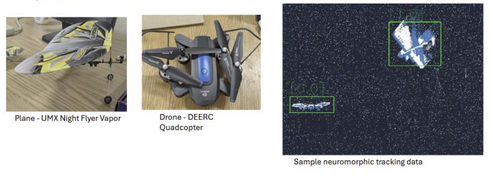
Acoustic Signature from Hasakee Q11 [1]



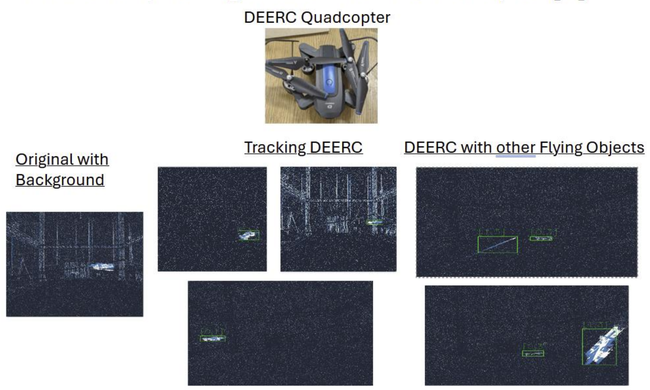
Neuromorphic Vision Sensing

Drone Signatures using Neuromorphic Vision Sensors [4]

- Neuromorphic cameras differ from frame cameras by detecting regions of movement
- Each pixel value is monitored for change in the light intensity – which can signify motion in the scene
- Only the pixels that record changes in light intensity from frame to frame are streamed as output of the camera
- Post-processing of this stream is required to identify objects that exhibited movement during the recording – this leads to a reduced data rate compared to regular cameras when looking for moving objects – such as drones
- Experiments were conducted at the Lowell Advanced Robotics Initiative (LARI) Space



Neuromorphic Signatures from Quadcopter [5]



PRELIMINARY ANALYSIS

- Drone acoustic signatures exhibit a combination of periodic features and band-limited noise
- Spectral analysis show peaks in the 100 – 300 Hz range that may be due to the periodic nature of the propeller dynamics
- Experiments with neuromorphic vision cameras show that structural features may be distinguished between objects in the scene

FUTURE WORK

- Investigate acoustics of a swarm of drones
- Extend analysis to include radar signatures
- Develop statistical and machine learning models with integrated acoustic, visual and radar features
- Identify ways to detect intruding systems

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