What is the comprehensive model of Surface Effects (SE) on multirotor performance, with a focus on ground effect and wall effects, and how can this model be leveraged to develop energy-efficient navigation algorithms for unmanned aerial vehicles in close-proximity flights near surfaces?

Methodology

- Utilized UR5 robot with an inbuilt force-torque sensor.
- Collected data from the multirotor at various distances from surfaces.
- Gathered 10 sets of 1-minute-long flight data for each effect (ground and wall) and in free space as a control.
- Recorded force-torque data for analysis.
- Logged RPM data from each of the six motors for thrust calculations.
- Total thrust (T) determined by the equation:
  \[ T = T_c \cdot (\omega_1^2 + \omega_2^2 + \omega_3^2 + \omega_4^2 + \omega_5^2 + \omega_6^2) \]
  \( T_c \) is a constant related to motor and propeller characteristics and was calculated using the control dataset.
- \( \omega_1, \omega_2, \omega_3, \omega_4, \omega_5, \) and \( \omega_6 \) represent motor angular velocities.

Data Processing

- Initial raw data: High noise, sensor drift offsets.
- Sensor offset removal: Subtract average of first 50 points with motors off.
- Noise reduction: Apply lowpass filter, followed by 250-point moving average.

Results

- The model does not align with the expected results for ground effect as per [1]. Instead of observing an increase in thrust, we are experiencing a decrease.
- Noted a substantial sensor drift of up to 25% (4N) in observed values. This drift in sensor readings can explain the discrepancy, where forces are decreasing by 4 percent at 0.2 m instead of increasing by the expected 3 percent.
- To address this issue, we plan to adopt more accurate and less-drifting sensors for improved data reliability and alignment with expected results.

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