Introducing Vehicle Dynamic Models in Dynamic Networks for Navigation in UAVs

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Objective

- Trajectory of the UAV is estimated by fusing the measurements from various sensors
- For the project Dynamic Network is used for sensor fusion
- The aim of the project is to integrate the control input to the motors of UAV as an additional measurement in Dynamic Network

Observation Model

- UAV is equipped with various types of sensors (a)
- Each sensor has a backward augmented state estimator for each measurement (c)
- The terms in backward augmented state estimator are expressed in terms of the unknown position and orientation of the robot with the help of lever-arm and bore-sight of the sensor
- For higher order terms, finite differences is used
- Each type of sensor has an observation model (c), which is a non-linear function that calculates the difference between the measured value of the sensor and the estimated value from the backward augmented state estimator

Dynamic Network Structure

- An initial guess is given to the unknown position and orientation (pose)
- The backward augmented state estimator is calculated for each sensor from the unknown poses
- The observation model is used to calculated the errors in the measured and estimated value
- Non-linear least square is performed to find poses

Vehicle Dynamic Equations

\[ a^b(z, \xi) = \frac{1}{m} \begin{bmatrix} 0 \\ 0 \\ \sum_{i=1}^{N} b_i \omega_i^2 \end{bmatrix} - \frac{1}{m} C_0 (V_0^p)^2 \text{sn}(V_0^p) + R^b_w \begin{bmatrix} 0 \\ 0 \end{bmatrix} \] (1)

\[ M^b(z, \xi) = \begin{bmatrix} \frac{\alpha Z b}{(\alpha - \omega_1^2 + \omega_2^2 + \omega_3^2 - \omega_4^2)} \\ \frac{\alpha Z b}{(\alpha - \omega_1^2 + \omega_2^2 - \omega_3^2 + \omega_4^2)} \\ \frac{\alpha Z b}{(\omega_1^2 - \omega_2^2 + \omega_3^2 + \omega_4^2)} \end{bmatrix} \] (2)

\[ a^b_{\text{cm}}(z, \xi) = \text{Sgn}(\alpha) (M^b_{\text{cm}} - \omega \times (\omega_1 \omega_2 \omega_3 \omega_4)) \] (3)

Results

- The inputs to the motors $\omega_1, \omega_2, \omega_3, \omega_4$ is used to calculate the linear and angular acceleration of UAV (Equations (1), (2), (3))
- The observation model (Equation (4)) is used to input the measurement into the dynamic network

Conclusions

- Using VDM measurements decreases the variance of error in the pose estimates
- The variance of the error in the bias estimate only gets better with fixed VDM sensor parameters
- Parameter estimation depends on the correlation between the parameters