Contribution

- New way of utilizing SAR data in the sensor fusion framework
- Possibility of obtaining good images and good navigation solution simultaneously

Background

The method for creating high resolution Synthetic Aperture Radar (SAR) images is to integrate all the low resolution Real Aperture Radar images taken along the synthetic aperture by the flying platforms, such as aircraft or satellites. In order for this operation to produce high quality images, it is crucial that the flown path is known, otherwise the images will be distorted. One of the most common distortions is the image defocus. This is illustrated in the figures to the left where SAR images of two point targets are simulated, one with linear unperturbed track and the other with a linear perturbed track.

Problem Formulation

Many methods for autofocus of SAR images are present today and they are usually based on phase error estimation or image processing type methods. Since the computational systems and SAR processing algorithms are getting better, on-line, real time SAR image creation is becoming possible. Then it becomes natural to use SAR data in the sensor fusion framework. The information from the raw radar data and navigation system can be fused and utilised to obtain the best solution to both image focusing and navigation simultaneously.

Given the platform’s dynamic and measurement model

\[
x_{t+1} = f(x_t, u_t), \quad w_t \sim \mathcal{N}(0, Q_t),
\]

\[
y_t = h(x_t) + e_t, \quad e_t \sim \mathcal{N}(0, R_t),
\]

where \(y_t\) contains measurements from inertial system and radar data, any nonlinear filter, like Extended Kalman Filter (EKF), can be applied to estimate the navigation states.

Measuring the Range Derivative

\[
y_t^R = -\frac{\lambda}{4\pi MF} \sum_{i \neq j} \text{Im} \left\{ \ln P_i^j - \ln P_j^i \right\}, \quad i = 1, \ldots, M, \quad j = 1, \ldots, M
\]

and expressed analytically as a function of the platform’s states

\[
h_t^R(x_t) = \frac{-\left( X_m - X_t \right) v_t^X + Y_t v_t^Y - R_N \sin(\Psi) v_t^v + \sum_{i=1}^{M} \text{sin}(\Psi)_{X_t} X_m - \text{sin}(\Psi)_{X_t} X_t}{R_N^2 + Y_t^2 - 2R_N Y_t \sin(\Psi)}
\]

Future Work

- Finding a better way to estimate the range gradient
- Applying different filters, e.g. Particle Filter
- Use real SAR measurements and images