Simultaneous SAR Auto-focusing and Navigation

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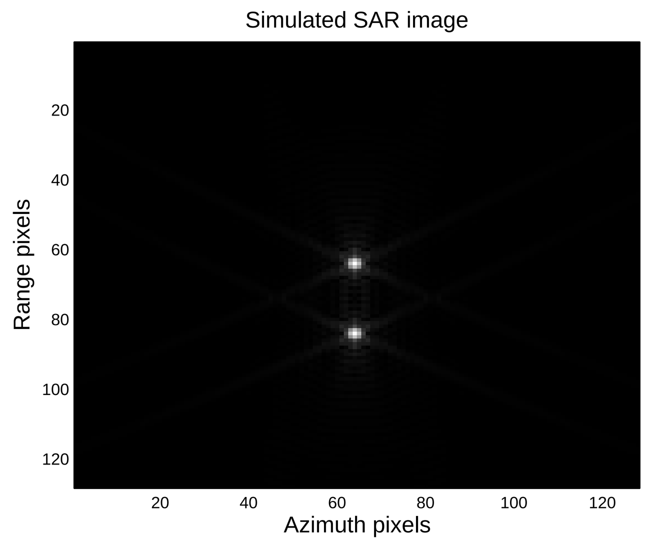
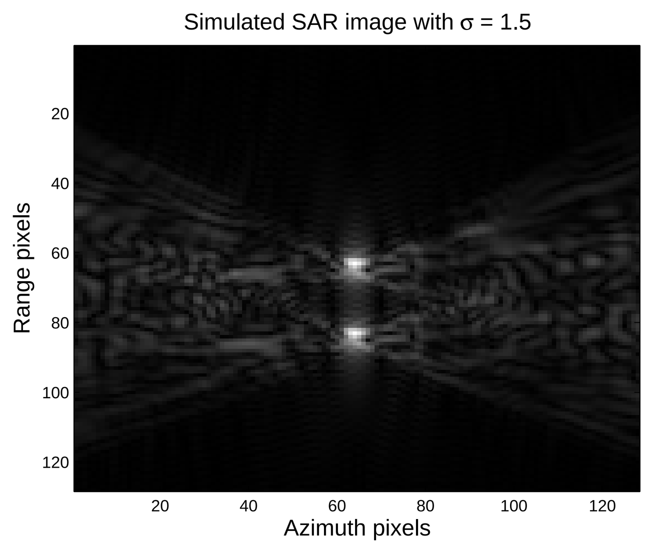
Contribution

- Possibility of obtaining good images and good navigation solution
- New way of utilizing SAR in Sensor Fusion

Background

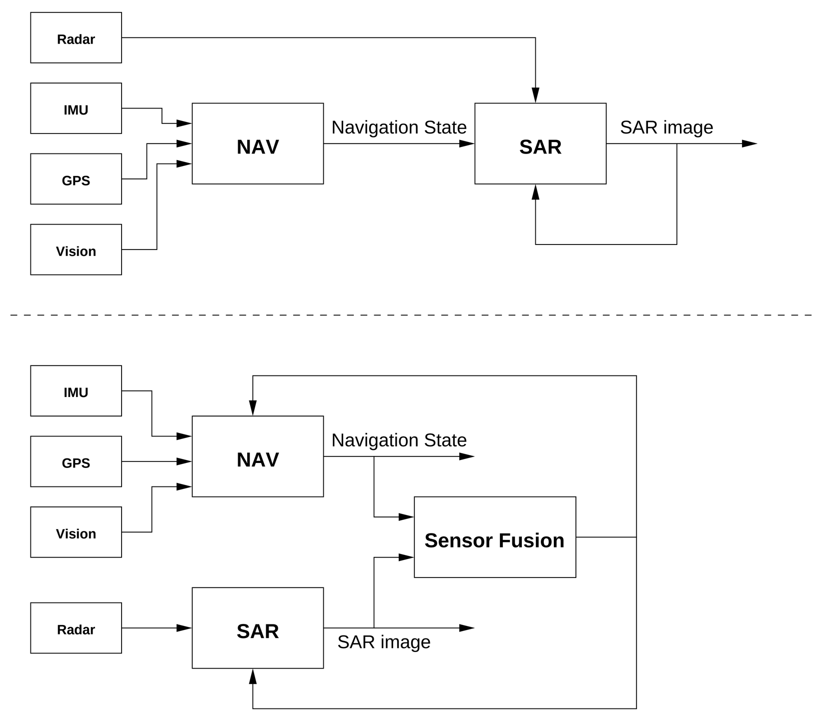




The method for creating high resolution Synthetic Aperture Radar (SAR) images is to integrate all the low resolution Real Aperture Radar images taken along the synthetic aperture by the flying platforms, such as aircraft or satellites. In order for this operation to produce high quality images, it is crucial that the flown path is known, otherwise the images will be distorded. One of the most common distortions is 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 auto-focusing 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 images in the sensor fusion framework. The information from the image defocusing and navigation system can be fused and utilised to obtain the best solution to both focusing and navigation simultaneously.



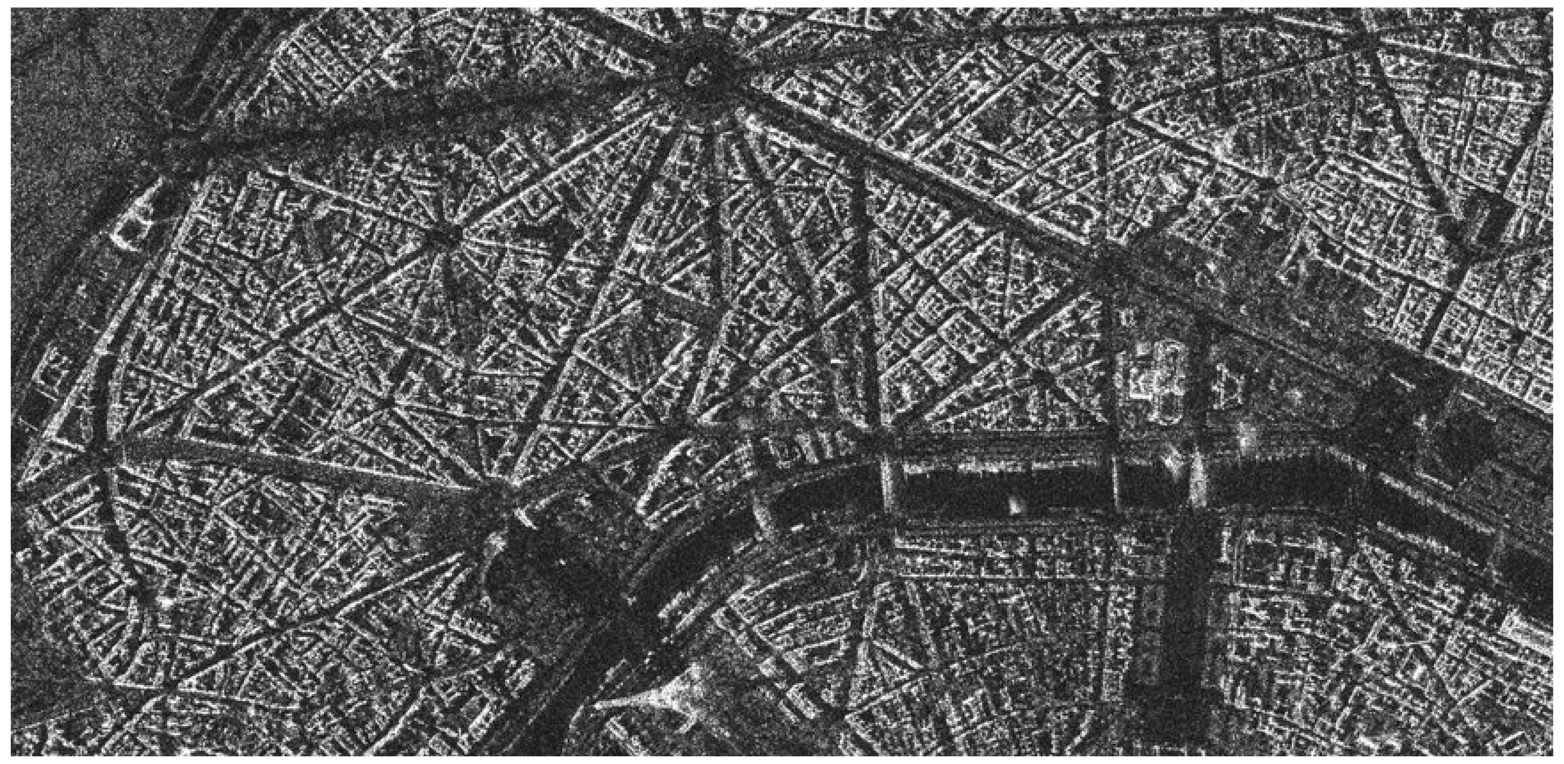
The following minimisation problem can be formulated

$$\min_{x_0} F(x_{0:t}) + \sum_{k=1}^{t} ||y_k - h(x_k, u_k)||^2_{R_k}$$

subject to

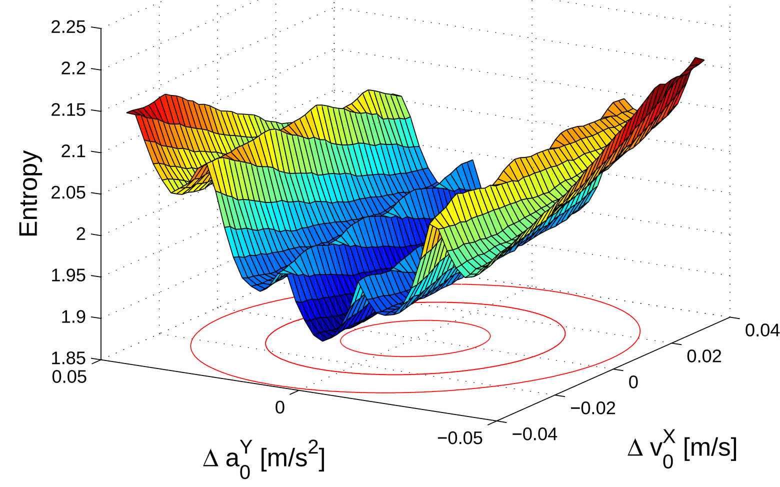
$$x_{t+1} = f(x_t, u_t, w_t), \qquad w_t \sim \mathcal{N}(0, Q_t)$$
$$y_t = h(x_t, u_t) + e_t, \qquad e_t \sim \mathcal{N}(0, R_t)$$

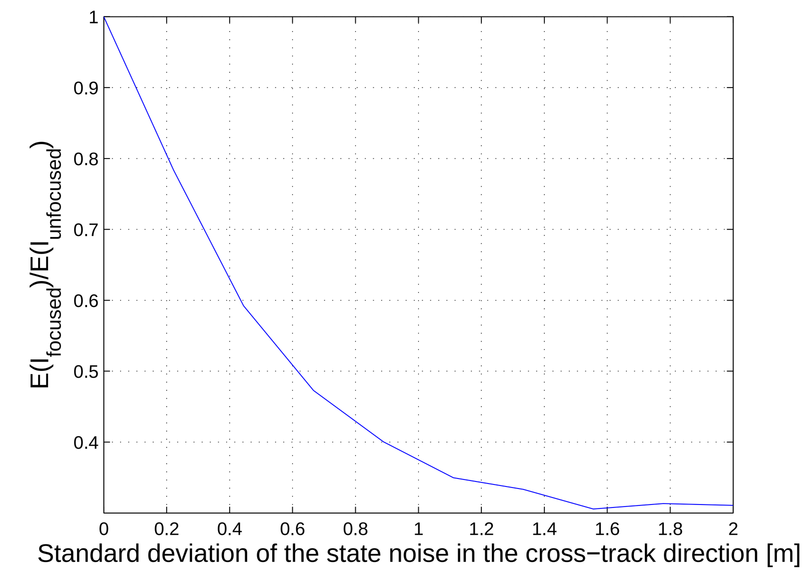
where the scalar function $F(x_{0:t})$ is a measure of how focused the image is and it depends on the whole trajectory $x_{0:t}$, and in particular on the velocity in the along-track direction, v_t^X, and the acceleration in the cross-track direction, a_t^Y.



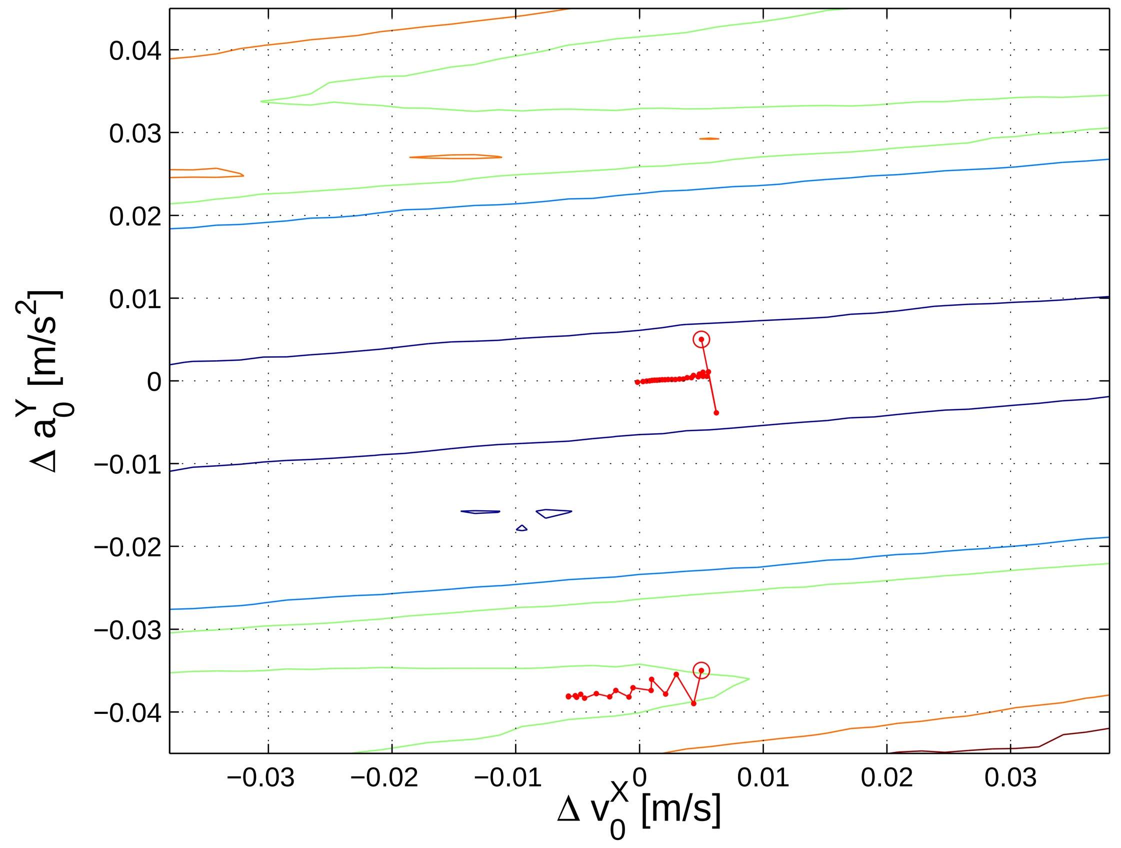
Evaluation of Focus Measures

Several popular focus measures, for example Tenengrad and entropy, representing $F(x_{0:t})$ have been evaluated and compared for some different cases, like error in initial values and different position jitter noise w_t. As an illustration, the entropy focus measure is depicted for these two cases. To the left as a fuction of error in initial values together with standard deviations. To the right as a ratio of entropies for focused and unfocused images due to variation of the position jitter noise.





Gradient Search



- Non-convex objective function
- Usual methods will get stuck in local minima
- More advanced algorithms are needed

Future Work

- Finding good methods for solving the minimisation problem
- Use more relistic scenes
- Use real SAR measurements and images