EVALUATING VHF-BAND SAR AUTOFOCUS ALGORITHMS USING A FOREST BACKSCATTER MODEL

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1. INTRODUCTION

SAR image formation can be performed in frequency domain with Fast Fourier Transform techniques or in time domain with back projection techniques. The strength of the Back-Projection algorithm in time domain is that the range variations to every scatterer in the scene can be handled as long as the geometry is known or determinable, even for wide aperture angles like in low frequency SAR. In frequency domain the image formation often include an autofocus method to remove or compensate for range distortions caused by an unknown flight track and algorithm approximations. Existing autofocus algorithms work in the frequency domain which makes it difficult to use them in time domain. The same range compensation is applied for all azimuth angles which will suffice in a case with a narrow aperture angle. In the low frequency SAR case, where a large aperture angle is used, the range error due to a misplaced aperture position will be different for different azimuth angles [1]. At the moment Back-Projection algorithms are thus dependent on an accurate positioning system, such as GPS. To avoid being dependent on an external system it is desirable to develop a new autofocus method which is able to estimate range distortions in the radar data itself. A method is required that estimates the correct geometry by analyzing the distortions caused by an incorrect geometry in the image data.

Fast Factorized Back Projection [2], FFBP, is a computationally efficient time domain technique which uses the same approach as Fast Fourier Transform compared to Discrete Fourier Transform. The computational burden is reduced by recursively dividing the signal into parts which can be transformed with lower bandwidth. In the time domain SAR case this signal dividing is the same as dividing the synthetic aperture in smaller parts, subapertures, which are processed independently and then merged to larger and larger subapertures in steps. An autofocus method is suitable to be integrated with the FFBP algorithm since the image processing is divided in smaller parts, each processed independently. The correct geometry for each merging step is estimated by maximizing the correlation between the subaperture data, i.e. we choose the merging geometry that gives the most focused subimage in each merging step. When the merging is performed with an incorrect geometry the two subimages will locally be translated relatively to each other so if we find the geometry that gives us zero translation every where we have found the correct geometry [3].

2. PROBLEM

The geometry estimation in each subaperture merging is based on correlation measurements to find a translation. The accuracy of the translation measurement between the corresponding subimages will be dependent on used image size, resolution, scene content and system noise, such as thermal noise and sidelobe effects. We want to make the correlation measurements as efficient as possible in terms of accuracy and computational cost. The objective in this paper is to estimate the accuracy of the translation measurements in each merging step and for different scenarios and also to evaluate if and when the translation measurements will suffice to focus the subapertures in one arbitrary merging step. We could determine this in real measured data but then the results would be valid for that data only and it is not possible to collect data for every type of scene. If we want to fully understand what effects the parameters mentioned previously have on the accuracy we must simulate the process using an accurate model.

3. METHODS

To give a fair estimation of the translation measurement accuracy we use a model where the parameters of interest are included and can be varied. The model consists of three parts, a physical forest model, the SAR impulse response for each subaperture and the correlation measurement. The forest model includes Rayleigh distributed background scattering and trees which are placed according to a Poisson process with an arbitrary tree density and with a log-normal distributed backscattering magnitude [4]. The values of the distribution parameters are calculated in terms of the Radar Cross Section per unit area of the background and the forest respectively, to make it easy to compare with real data. The forest image is then convolved with the SAR impulse response corresponding to each subaperture. The impulse response is created in frequency domain and the spectra will have the shape like a piece of a donut. The size and orientation of the spectra depends on aperture size, aperture look angle and system bandwidth. The SAR subimages are then translated both in range and azimuth to find the translation where the correlation between the two images is maximized. This is performed a number of realizations and for different scenes to statistically find the accuracy of the subimage fitting for different subaperture sizes.

4. RESULTS

The results of the simulation will be presented in the full paper. It is shown that the accuracy of the translation is poor in the beginning when the subapertures are small and the resolution is poor. The accuracy will improve with resolution and with image size used in the correlation measurement but will also depend on the number of trees in one resolution cell.

5. REFERENCES

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