EE 367 Project Proposal
Elizabeth Wig
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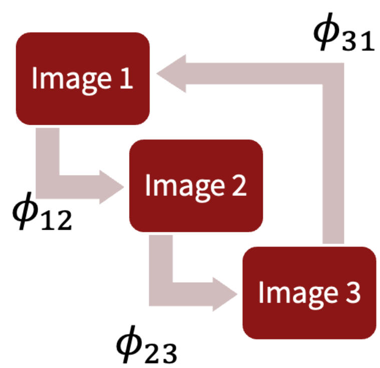
Project Proposal: Denoising of InSAR Phase Closure

InSAR, or interferometric synthetic aperture radar, compares phases between two radar passes over the same area (usually from an aircraft or satellite) to see how the ground is changing. InSAR is frequently used to capture deformation, whether from earthquakes, volcanoes, fracking, or other sources. The phase differences between the two radar passes are used to form an interferogram, which maps how the area is changing in phase across the radar image. The nature of these interferograms is very noisy. To reduce noise (and reduce large file sizes), the standard practice is to do "multilooking" or spatial averaging. For example, taking 4 "looks" each in range and azimuth means averaging every 4 pixels in each direction, which reduces the file size by 16 times. Since original files can be quite large, this reduction does decrease the resolution but increases the SNR, and many applications do not require the high resolution – and in fact find the computational power required to store and process the high-resolution images to be too taxing.

For some applications, a higher resolution is desired. InSAR is a well-established field at this point, and some people have done research into, for example, using CNNs, nonlocal means, and other denoising methods to improve the quality of InSAR images [1-3].

A more novel area within InSAR research is looking at phase closure. While conventional InSAR differences the phase between two radar acquisitions over the same area, phase closure compares three images in a cycle, creating three interferograms and differencing the phase between the three. Figure 1 shows a schematic of the process of calculating phase closure. As shown in the figure, phase closure appears to have some correspondence to soil moisture (as well as vegetation, and other properties on the ground) [4-6].



$$\phi_{cl} = \phi_{12} + \phi_{23} + \phi_{31} \neq 0$$
$$\phi_{cl} \propto \text{ soil moisture}$$

Fig. 1. Diagram showing the concept behind InSAR phase closure. Three acquisitions of radar images (Image 1, Image 2, Image 3), creates three interferograms with phases $\phi_{12}, \phi_{23}, \phi_{31}$. The phase closure sums the phases circularly and has been shown to relate to soil moisture.

My research has looked at using phase closure to track soil moisture. I have found that, under certain circumstances and in certain reasons, a bias-corrected temporal integral of the phase closure can be strongly correlated to soil moisture. However, in order to find this correlation, a very large number of looks is required (at least 10x10, and 30x30 for the best results). At this point, the advantage that InSAR provides in resolution compared to other radar has begun to diminish.

I propose to try other denoising methods to see if the resolution of the image can be improved while still demonstrating a correlation between InSAR phase closure and soil moisture. I will either use simulated data or data with known ground truth (some of what I've previously worked on). If using current data, I will use the 30x30 look data as the ground truth and compare it to a downsampled version of the denoised data (e.g. take one in every 30 pixels of the denoised image to see if it has the same quality). I will look at using the denoising methods we did in class – linear smoothing, nonlinear smoothing, the bilateral filter, and nonlocal means – to see how each is able to process InSAR phase closure data. I will be trying to determine whether any of these methods could be used to increase the resolution or the SNR of the image. If time, I may also look into denoising with a neural net, although there is no exact training data on phase closure, so the net may be trained on something else and less accurate as a result.

References:

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