**Gaussian Markov Random Field Based Phase Locked Loop for Phase Unwrapping of Two Dimensional Interferograms**

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Phase unwrapping (PU) is the reconstruction, or estimation, of the absolute phase signal from its observed noisy wrapped samples. Based on the fact that phase locked loop (PLL) output can be considered as a MAP estimate, it has already been proposed to be used for phase unwrapping of two dimensional (2D) interferometric phase. On the other hand, the Gaussian Markov Random Field (GMRF) is well known to be an appropriate statistical model for parameter estimation of images. In this work, GMRF-based second order PLL is proposed for 2D phase unwrapping. As opposed to common PU methods dealing with the wrapped phase obtained by the arg(.) operator, PLL operates on the complex interferogram directly. Considering the neighboring pixels as the past based on the GMRF model, error measures, i.e., the phase detector outputs, from neighboring samples are averaged to estimate the phase for the current pixel. The performance of the proposed approach is evaluated for both simulated fractal Brownian surface, which is considered to be a proper model for 2D absolute phase, and real TerraSAR-X / TanDEM-X interferometric pairs. For both simulated and real data, the phase singularity points (residue points) are detected and the residue maps are extracted. Residues due to phase noise are successfully reduced / removed by means of phase noise filtering, and the results show that the proposed method performs quite well under proper sampling condition, i.e., no aliasing. In case of aliasing, the residues arising from undersampling can be masked and the proposed GMRF-based PLL approach can still be applied.