Bayesian Inference for Phase Unwrapping using Statistical Mechanical Informatics

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In this study[1],[2], on the basis of statistical mechanical informatics, we investigated a problem of phase unwrapping in remote sensing using synthetic aperture radar (SAR) interferometry. In this method, we first removed residues in observed interferogram searching a ground state of the 3-state Q-Ising model under a constraint of surface-consistency condition and then reduced noises from the reconstructed wave-front based on a method of maximum entropy. Then, in order to clarify performance of the present method, we carried out Monte Carlo simulations both for artificial and realistic wave-fronts corresponding to digital elevation models which represented Japanese volcanos. First, we described a phase diagram in hyper-parameter space to clarify a PU phase in which the present method succeeded in phase unwrapping with high degree of accuracy. We clarified that the maximizer of the posterior marginal (MPM) estimate using the 3-state Q-Ising model was successful in phase unwrapping under the constraint of the surface-consistency condition, and also that prior information on original wave-fronts succeeded in extending the PU phase in the hyper-parameter space. In addition, we found that the Bethe approximation almost realized phase unwrapping with the same accuracy as the MPM estimate for the artificial models representing wave-fronts in the SAR interferometry. Next, we investigated performance of the present method for phase unwrapping for realistic wave-fronts representing the digital elevation models, such as "Mt. Asama" and "Mt. Iwaki". We found that the present method realizes phase unwrapping with high degree of accuracy by making use both of the MPM estimate using the 3-state Q-Ising model and the method of maximum entropy, if we assumed hyper-parameters appropriately.

References
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