Application of the Tikhonov regularization method in image restoration problems

Duong Thi An

Abstract: This thesis investigates the application of Tikhonov regularization for the ill-posed problem of image restoration. Image degradation, caused by factors such as blur and noise, often results in an inverse problem that is highly sensitive to perturbations in the observed data. Direct inversion of the degradation model amplifies noise, yielding unstable and meaningless results. To address this, Tikhonov regularization introduces a penalty term that stabilizes the solution by imposing a smoothness constraint. This study formulates the restoration problem as a minimization of a cost function combining a data fidelity term and a regularization term, controlled by a regularization parameter. The selection of this parameter is critical for balancing noise suppression against the preservation of fine image details. Various methods for parameter choice, including the L-curve criterion and generalized cross-validation, are evaluated. Experimental results on degraded images demonstrate that the Tikhonov method effectively reduces noise and restores image structures, though it may introduce oversmoothing at edges. The findings confirm that Tikhonov regularization is a robust and practical approach for image restoration, with performance heavily dependent on optimal parameter selection.

Keywords: Tikhonov regularization, image restoration, inverse problem, regularization parameter