Abstract

Tomographic reconstruction from incomplete, limited, and noisy projection data is an ill-posed problem having a numerically sensitive or noisy solution and the conventional reconstruction techniques such as convolution back projection (CBP) and filtered back-projection (FBP) do not yield good results in such a situation. Numerous techniques have been proposed in the recent past for the reconstruction from such limited, noisy projection data, in which *a priori* knowledge about the image has been used to improve the reconstruction quality.

This dissertation deals with the tomographic reconstruction from severely limited and noisy projection data, where the reconstruction problem has been formulated as the detection and estimation of the objects in the image. The problem is approached from an optimization view-point and several randomized search and optimization techniques, namely, genetic algorithm (GA), evolutionary programming (EP), and simulated annealing (SA) have been used to obtain a near optimum maximum-likelihood estimate of the images being reconstructed. A model-based approach has been used here, in which an image model is assumed based on the *a priori* knowledge about the type of objects in the image, their geometries, and intensities along with the background intensity.

Several modifications have been proposed in GA, EP, and SA framework to adapt them to the problem of model-based tomographic reconstruction and extensive results have been presented to demonstrate the suitability of these techniques for the detection and estimation of 2-D images containing circular, elliptical, polygonal, or irregular shaped objects and 3-D images containing spherical or ellipsoidal objects.

A novel optimization approach has been proposed for a class of problems, in which the problem can be subdivided into several subproblems such that the objective function of the original problem (or the required computation) can be expressed as a function of the objective functions (or the required computation) of the subproblems. In this approach, multiple GA (MGA), multiple EP (MEP), or multiple SA (MSA)

algorithms have been used to obtain the solution of the original problem with each GA, EP, or SA working on a separate subproblem. The proposed MGA, MEP, and MSA approaches have been applied for the model-based reconstruction of 2-D as well as 3-D images. These techniques have been demonstrated to be much faster than their conventional implementations and they also yield more accurate results.

Finally, an application of the proposed model-based reconstruction techniques implemented using GA, EP, and SA has been presented in geotomographic reconstruction for the detection of high contrast subsurface anomalies in cross-hole seismic tomography. An alternative cell-based approach using GA has also been presented for the reconstruction of such anomalies. In addition, a faster ray tracing technique has been suggested.