Ref: 16/6

NOVEL RECONSTRUCTION TECHNIQUES FOR MAGNETIC RESONANCE IMAGING

A THESIS
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

Yasser Moustafa Ibrahim Kadah

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

Xiaoping Hu, Adviser

June 1997

ABSTRACT

The predominant acquisition and reconstruction technique in magnetic resonance imaging is the Fourier imaging technique. In spite of its success in conventional applications, it has some limitations when applied to unconventional areas such as magnetic resonance angiography and dynamic imaging. Moreover, its sensitivity to subtle non-uniformities in the magnetic field results in severe problem of geometric distortion. In this thesis, three novel reconstruction approaches that can solve some of the problems associated with Fourier imaging are proposed. The first, which is called pseudo-Fourier imaging, is a generalized spatial encoding method based on selective excitations with unconventional slice profiles combined with phase encoding. The classical selective excitation and Fourier encoding techniques are special cases of the new formulation. Examples of using the new technique are described and implemented. The second and third approaches describe two new techniques to solve the geometric distortion problem in the presence of B_0 inhomogeneity. In the first, which is termed simulated phase evolution rewinding, the data is processed with a correction kernel derived from the field map in the domain of the distorted images. The second approach recognizes the nature of the problem as an inverse problem of an ill-posed operator that can in general be estimated. The problem is discretized, and several algebraic methods are introduced to invert the distortion operator in the least-squares sense. These novel reconstruction techniques are important steps toward extending the MRI usage in several unconventional applications such as stereotactic neurosurgery and radiotherapy treatment planning.