IMAGING WITH
DIFFRACTION TOMOGRAPHY

A Thesis
Submitted to the Faculty

of

Purdue University

by

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In Partial Fulfillment of the
Requirements for the Degree

of

Doctor of Philosophy

May 1985

This work is dedicated to
my family
and friends.

ACKNOWLEDGMENTS

The author would like to thank a number of people who have helped make this thesis possible.

First and foremost I am grateful for the guidance and support of Avi Kak and Mani Azimi. During my graduate years here at Purdue they have been both good friends and colleagues and I am very grateful for the opportunity to work with them.

I would also like to thank Sharon Katz, technical illustrator for the EE department. She has endured innumerable deadlines and garbled instructions and always generated professional graphics.

I would also like to thank Peter Behrens of APUnix, and George Goble, Curt Freeland and Tom Tengdin of the Engineering Computer Network for helping maintain the computer resources that made this thesis possible. They all put in an effort above and beyond the call of duty to help me meet my deadlines.

In addition I would like to thank Kuo-Cheng Li and Herb Schwetman for making a prerelease of the Cyber 205 C compiler available to me for program development.

The financial support of the Walter Reed Army Institute of Research has helped make this work possible. I am very grateful for the opportunity.

And finally, I wish to thank colleagues that have helped me learn about this area of research. These people include Carl Crawford, David Nahamoo, S. X. Pan and Barry Roberts.

PREFACE

We have not succeeded in solving all of your problems. The answers we have found only serve to raise a whole new set of questions. In some ways we are as confused as ever, but we feel that we are confused on a higher level and about more important things.

-- Gary S. Peterson

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ABSTRACT

Slaney, Malcolm Graham. Ph.D., Purdue University. May 1985. Imaging with Diffraction Tomography. Major Professor: Avinash C. Kak.

This work reviews the theory and limits of first order diffraction tomography and studies iterative techniques that can be used to improve the quality of tomographic imaging with diffracting sources. Conventional (straight-ray) tomographic algorithms are not valid when used with acoustic or microwave energy. Thus more sophisticated algorithms are needed.

First order diffraction tomography uses a linearized version of the wave equation and gives an especially simple reconstruction algorithm. This work reviews first order approximations to the scattered field and studies the quality of the reconstructions when the assumptions behind these approximations are violated. It will be shown that the Born approximation is valid when the phase change across the object is less than π and the Rytov approximation is valid when the refractive index changes by less than two or three percent.

Better reconstructions will be based on higher order approximations to the scattered field. This work describes two fixed point algorithms (the Born and the Rytov approximations) and an algebraic approach to more accurately calculate the scattered fields. The limits of each of these approaches is discussed and simulated results are shown.

Finally a review of higher order inversion techniques is presented. Each of these techniques is reviewed and some of their limitations are discussed.