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Workshop on Inverse Problems (Canberra, February 3–7, 1986)

Edited by R.S. Anderssen
and G.N. Newsam

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PREFACE

In the first week of February, 1986, the Centre for Mathematical Analysis hosted a workshop on inverse problems as part of the 26th Summer Research Institute run by the Australian Mathematical Society. The workshop was organized to bring together a group of people with experience in the area of inverse problems to consider a number of practical inverse problems encountered by other researchers in various fields. The hope was that presentations and discussions of these problems both would help progress towards their solution in particular, and would encourage interest and collaboration among participants in general.

Three particular practical problems were presented in detail; the determination of flaws in castings by inverse scattering, the determination of coefficients governing flow in aquifers, and the determination of geological structures from aeromagnetic surveys. Since all are difficult problems and are the subjects of concerted research efforts both in Australia and elsewhere, the presentations have been gathered together in these proceedings to provide a clear statement of the problems and of research being carried out on them.

The first paper, authored by Noel Barton of the Division of Mathematics and Statistics (DMS), CSIRO, considers the use of ultrasound to locate flaws in metal castings. This leads to problem in inverse scattering with the shape and position of the flaws to be determined from measurements of the scattering they induce when the casting is irradiated by ultrasound. The work described is part of an ongoing project being undertaken by the Division of Applied Physics, CSIRO.

The second presentation by Claude Dietrich, Fred Ghassemi and Tony Jakeman of the Centre for Resource and Environmental Studies, the Australian National University (ANU), considers the problem of determining the transmissivity and storage coefficients governing flow through an aquifer, given data on the pressure distribution across the

aquifer together with measurements of inflows and outflows. This work is part of a larger project being carried out with the aim of determining optimal water management strategies in the Murray river basin.

The third paper, presented by Ingeborg Koch of DMS, CSIRO and Chris Tarlowski of the Bureau of Mineral Resources considers the problem of determining major rock structures at depths of 100m ~ 10km below the surface from surface measurements of the anomalies in the earth's magnetic field induced by these structure. A number of organizations both public and private have carried out aeromagnetic surveys over most of Australia, and there is naturally considerable interest in using such data in mineral exploration.

In addition to these three problems a number of other speakers kindly presented talks. Two of these, by Malcolm Sambridge and Paul Williamson of the Research School of Earth Sciences, ANU, are included here as they are very much in the spirit of the previous presentations. Malcolm Sambridge considers the problem of locating earthquake epicentres in space and time from data on the arrival time of the seismic waves generated by the shock. Paul Williamson considers the related question of inferring the density of the earth from measured travel times of seismic waves.

While the discussions held during the workshop are not reported separately here, one particular point emerged that is worth noting: inverse problems require special care in their formulation and solution. There are a number reasons for this. Perhaps the principal one is that all the problems considered here are nonlinear and the only method of solution appears to be by iterative solution of appropriate discretizations. Such methods are expensive both to set up and to run; so it is important to get it right the first time. This is compounded by the ill-posedness of the mathematical models; they are far more sensitive to discretization and other errors than are the associated direct problems.

A further reason for careful formulation is that the degree to which a problem is ill-posed, and therefore the difficulty of solving it, depends very much on the amount of detail about the solution that is sought. For instance determination of the exact shape of a flaw in a casting by inverse scattering techniques is a highly ill-posed problem, but the problem of finding only the location and volume of the flaw is likely to be a much better posed problem.

In conclusion, the editors would like to thank the participants in the workshop for their contributions, and in particular the speakers and authors of the papers in this proceedings. The editors also wish to acknowledge the support and assistance of the Centre for Mathematical Analysis and the Australian Mathematical Society. Finally a special thanks to Marilyn Gray and Joyce Heinz for their efforts in bringing the proceedings to press.

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