This invaluable book presents an unbiased framework for modelling and using sensors to aid mobile robot navigation. It addresses the problem of accurate and reliable sensing in confined environments and makes a detailed analysis of the design and construction of a low-cost optical range finder. This is followed by a quantitative model for determining the sources and propagation of noise within the sensor. The physics behind the causes of erroneous data is also used to derive a model for detecting and labelling such data as false. In addition, the author's data processing algorithms are applied to the problem of environmental feature extraction. This forms the basis of a solution to the problem of mobile robot localisation. The book develops a relationship between the kinematics of a mobile robot during the execution of successive manoeuvres and the sensed features. Results which update a mobile vehicle's position using features from 2D and 3D scans are presented.

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Sensor Modelling, Design and Data Processing for Autonomous Navigation

Martin David Adams

*European Semiconductor Equipment Centre
Cham, Switzerland*

World Scientific

Singapore • New Jersey • London • Hong Kong

Published by

World Scientific Publishing Co. Pte. Ltd.

P O Box 128, Farrer Road, Singapore 912805

USA office: Suite 1B, 1060 Main Street, River Edge, NJ 07661

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

Library of Congress Cataloging-in-Publication Data

Adams, Martin David.

Sensor modelling, design and data processing for autonomous navigation / Martin David Adams.

p. cm. -- (World Scientific series in robotics and intelligent systems ; vol. 13)

Includes bibliographical references.

ISBN 9810234961 (alk. paper)

1. Mobile robots. 2. Robots -- Control systems. I. Title.

II. Series.

TJ211.415.A33 1999

629.8'92--dc21

98-36913

CIP

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

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Printed in Singapore by Uto-Print

Preface

As any living being traverses its environment, information via the senses is weighted, in terms of its importance, and processed to attain some reasonable level of navigation. The ease with which animals integrate with, and travel through, the vast assortment of differing environments is still considered to be the benchmark of an automatic system to the mobile robotics researcher. Interesting experiments in which real indoor environments are scanned and the resulting data is analysed for use in navigational exercises, are used as illustrative examples throughout this book. Indeed the aim of this monograph is twofold. Firstly the problems of active sensor design, data interpretation and processing for reliable feature extraction are addressed and secondly the developed theories are applied to the problems of target tracking and navigation.

Various methods aimed at correctly interpreting real sensor data and finding algorithms for extracting useful information from this data have been documented. A survey on the vast literature assortment relating to sensor data processing and scene interpretation shows that particular subsets of the overall problem have been addressed. A coherent framework for the *application oriented modelling of sensors* and subsequent data processing appears to be lacking in the available literature. This book explains in detail methods for the correct interpretation of *light detection and ranging* sensors with the specific aim of aiding mobile robot navigation. The methods and algorithms presented are indeed applicable to a number of diverse applications, not necessarily limited to the field of autonomously guided vehicle research and the text is written to address the *general* problem of sensor data interpretation. Concentrating on a single application however, allows consideration to be given to actual implementations and results in some detail.

In **chapter 2**, the problem of accurate and reliable sensing in confined environments is addressed and the qualities of different sensors for range estimation are compared. A key requirement in mobile robotics is high band-width, high quality sensor data as a fuel source for higher level reasoning. A detailed analysis of the electronic design of a low cost optical range finder to meet this requirement is therefore the subject of **chapter 3**. The minimisation of noise sources and optimal signal processing for the production of reliable range information at the electronic level, is essential for the integration of a sensor into an autonomous navigating system. **Chapter 4** presents solutions for actively scanning an environment in 3D, from a mobile vehicle. Here the mechanical

and optical aspects involved in the construction of a robust sensing node for autonomous navigation is discussed.

A quantitative model is examined in **chapter 5** which determines the sources of noise within, and the propagation of noise through, the chosen sensing strategy. The device is theoretically modelled, to predict the type of noise distribution which can be expected under certain operating conditions. A noise model is presented and the benefits of this model are demonstrated with real 2D and 3D range scans.

Chapter 6 examines the physics behind the causes of erroneous data, which is used to derive a model to detect and label this data as false. The reliability of the model in correctly finding bad data is quantified in terms of environmental reflectance and range discontinuities. The data processing algorithms are applied to the problem of environmental feature extraction in **chapter 7**. A feature is defined as a pattern or event in the sensor's output data which is expected to be observable in the future, if the sensor is moved. In particular the range information and range variances, derived from the sensor noise model, are combined within an optimal filtering algorithm, capable of segmenting the range data to form edges.

Another fundamental issue from the problem of mobile robot navigation is *localisation*. In a further application, **chapter 8** develops a relationship between the kinematics of a mobile robot, when executing successive manoeuvres, and the sensed features (edges) from the sensor. Results which update a mobile vehicle's position using features from 2D and 3D scans will be presented along with a discussion of the type of *a priori* information necessary for reliable localisation.

As a final application, the coordinates of detected edges are used in a local path planning algorithm in **chapter 9**. These coordinates, relative to those of the mobile robot, are tested to examine whether they can be used to attract a mobile robot towards territory which cannot be visualised or extracted from the present sensor data. Results using a real mobile vehicle and real optical range data will be presented.

Finally **chapter 10** discusses the future of sensor data processing for the application of mobile robot navigation. In particular an alternative approach to mobile robot localisation is outlined. This offers a potentially, computationally economic solution which allows a moving sensor to track a single feature. The notion of a moving scanning mechanism locking onto a fixed target presents an interesting and an extant research issue and the possibility of a fully instantaneous tracking algorithm will be discussed.

Researchers in academic institutions and industry will find the sensor modelling and data processing framework useful for developing sensing systems in general. Readers at the undergraduate and graduate level interested in sensing and navigation in mobile robotics will also find the text particularly valuable.

Acknowledgments

“Seeing is believing, Sensing can be deceiving”

During the course of the studies and experiments carried out to make this book possible, the author was greatly indebted to many colleagues for their time and cooperation.

The manuscript is based upon work carried out at the Robotics Research Group, Department of Engineering Science, University of Oxford, U.K. and at the Institute of Robotics, Swiss Federal Institute of Technology, Zurich, Switzerland.

In particular, during the doctoral dissertation work at Oxford, the author would like to thank Penny Probert, Hugh Durrant-Whyte and John Leonard for their academic and practical help and support in mobile robotics. Mike Brownlow provided invaluable inspiration from his initial electronic design work on lidar sensing.

In Zurich, this work was further supported by Prof. G. Schweitzer and major contributions to the mechanical lidar construction were provided by Matteo Camani, Stefan Mathis and Lorenz Ruf. The author further gratefully acknowledges the assistance of Daniel von Flüe with the experimental work on sonar and André Kerstens for the presented localisation and tracking algorithms with lidar. The assistance and cooperation of Philipp Bühler, Marco Fumagalli and René Schöni during many of the electronic hardware implementations and data retrieval experiments is also gratefully acknowledged.

The late night work on this book would not have been possible without McVities Hob-Nobs.

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