

INTELLIGENT

I

TRANSPORTATION

T

SYSTEMS

S

Vehicle Location and Navigation Systems

Yilin Zhao

VEHICLE LOCATION AND NAVIGATION SYSTEMS

Yilin Zhao

Artech House, Inc.
Boston • London

Library of Congress Cataloging-in-Publication Data
Zhao, Yilin.

Vehicle location and navigation systems /Yilin Zhao.

p. cm.

Includes bibliographical references and index.
ISBN 0-89006-861-5 (alk. paper)

1. Intelligent Vehicle Highway Systems. 2. Motor vehicles—Automatic location systems. 3. Electronics in navigation.

1. Title.

TE228.3Z45 1997
629.2'7—dc21

97-4200
CIP

British Library Cataloguing in Publication Data
Zhao, Yilin

Vehicle location and navigation systems

1. Intelligent Vehicle Highway Systems 2. Motor vehicles—Automatic location systems

I. Title

625.7'94

ISBN 0-89006-861-5

Cover design by Jennifer Makower

© 1997 ARTECH HOUSE, INC.
685 Canton Street
Norwood, MA 02062

All rights reserved. Printed and bound in the United States of America. No part of this book may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher.

All terms mentioned in this book that are known to be trademarks or service marks have been appropriately capitalized. Artech House cannot attest to the accuracy of this information. Use of a term in this book should not be regarded as affecting the validity of any trademark or service mark.

International Standard Book Number: 0-89006-861-5
Library of Congress Catalog Card Number: 97-4200

10 9 8 7 6 5 4 3



CONTENTS

Preface	xiii
Acknowledgments	xvii
Chapter 1 Introduction	1
1.1 Brief History	2
1.2 Modern Vehicle Location and Navigation	6
References	12
Part I Basic Modules	15
Chapter 2 Digital Map Database Module	17
2.1 Introduction	17
2.2 Basic Representations	18
2.3 Reference Coordinate Systems	20
2.4 Standards	28
2.4.1 Geographic Data Files	28
2.4.2 Digital Road Map Association	30
2.4.3 Spatial Data Transfer Standard	31
2.4.4 Truth-in-Labeling Standard	32
2.5 Proprietary Digital Map Databases	33
2.5.1 Etak	33
2.5.2 Navigation Technologies	35

2.6	Digital Map Compilation	
2.6.1	Data Structures	36
2.6.2	Compiler Structure	37
2.6.3	Hierarchical Maps	38
	References	38
Chapter 3	Positioning Module	42
3.1	Introduction	43
3.2	Dead Reckoning	43
3.3	Relative Sensors	45
3.3.1	Transmission Pickups	46
3.3.2	Wheel Sensors	47
3.3.3	Gyroscopes	50
3.4	Absolute Sensors	53
3.4.1	Magnetic Compasses	56
3.4.2	Global Positioning System	56
3.5	Sensor Fusion	63
3.5.1	Simple Filters	75
3.5.2	Kalman Filters	75
3.5.3	Other Fusion Methods	76
	References	78
Chapter 4	Map-Matching Module	79
4.1	Introduction	83
4.2	Conventional Map Matching	83
4.2.1	Semi-Deterministic Algorithms	85
4.2.2	Probabilistic Algorithms	85
4.3	Fuzzy-Logic-Based Map Matching	86
4.3.1	Fuzzy-Logic-Based Algorithms	94
4.4	Other Map-Matching Algorithms	95
4.5	Map-Aided Sensor Calibration	100
	References	101
Chapter 5	Route-Planning Module	102
5.1	Introduction	105
5.2	Shortest Path	105
5.2.1	Dijkstra's Shortest Path Algorithm	107
5.2.2	Modified Shortest Path Algorithm	107
5.3	Heuristic Search	109
5.3.1	A* Algorithm	112
5.4	Bidirectional Search	112
5.5	Hierarchical Search	118

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.