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ROBOTIC TECHNOLOGY

PRINCIPLES AND PRACTICE

Werner G. Holzbock, M.S.M.E., P.E.

with a Foreword by
Professor Jack D. Lane

E8761596

VAN NOSTRAND REINHOLD COMPANY
New York

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Library of Congress Catalog Card Number 85-15634
ISBN 0-442-23154-7

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Manufactured in the United States of America

Published by Van Nostrand Reinhold Company Inc.
135 West 50th Street
New York, New York 10020

Van Nostrand Reinhold Company Limited
Molly Millars Lane
Wokingham, Berkshire RG11 2PY, England

Van Nostrand Reinhold
480 LaTrobe Street
Melbourne, Victoria 3000, Australia

Macmillan of Canada
Division of Gage Publishing Limited
164 Commander Boulevard
Agincourt, Ontario M15 3C7, Canada

16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging in Publication Data

Holzbock, Werner G.
Robotic technology, principles and practice.

Includes bibliographies and index.
1. Robotics—Handbooks, manuals, etc. I. Title.
TJ211.H65 1986 629.8'92 85-15634
ISBN 0-442-23154-7

8761596

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In memory of my friend Boris B. Bodelm

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FOREWORD

Because of the spectacular growth of the robotics industry and the significance this holds for future industrial growth, there must be textbooks and courses on all levels to teach the technological principles involved. Among the significant publications that have already appeared, none so far has described the structural elements of robots in their totality. This book makes an important contribution to filling the need for such a comprehensive book.

At the GMI Engineering & Management Institute in Flint, Michigan, we have given courses and workshops on robotics for several years. Werner Holzbock was one of my students. He has followed to a large extent the general outline of such a course. His coverage of the subject is excellent. It can be expected that this text will find widespread use in the robotic community and become the basis for the study of the subject in coming years.

JACK D. LANE

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Training Division and Member of
the Technical Council of
Robotics International of SME.

PREFACE

Robotic technology refers to the design and application of robots, and specifically of industrial robots that are used for manufacturing or construction purposes with the intent of handling, processing, assembly, and inspection of materials and parts.

Robotic technology embraces mechanics, hydraulics, pneumatics, electronics, and so on. This is an exceptionally wide spread for any specialized technology. A total treatment of all aspects of these various categories could never be given in a single book, and that is not the object of this book. The aim is rather to describe the principles that control behavior, operation, selection, and development of robotic technology.

Robots are a kind of automation. There are many automatic devices in factories; a bottling plant, for example, is a miracle of interacting, automated mechanical devices. However, they differ from robots in that they are not easily reprogrammable; and, hence, such automation is usually referred to as hard automation as compared with the soft, flexible automation of the robot.

Another kind of industrial automation is a machining center under computer control, which may hardly need human attention. The robot differs from this type of automation too because the robot is capable of working in relation to other production machinery and is capable of bringing about the coordination of various pieces of production equipment in a way that is readily reprogrammable. Thus, it is either the easy programming or the coordinating ability or both that mark the robot as a very particular automation tool. Robots are *not* humanoids. They are practical mechanisms designed to grasp and move objects; that is, they are manipulators. But they are manipulators of a special kind because they can be programmed to operate in a specific manner to execute repetitive tasks. They are designed to move in a variety of ways and to be capable of carrying workpieces as well as tools, such as welding torches and paint spray guns and other implements. In other words, they are flexible enough to be truly multifunctional.

If all this is considered, one arrives at the "official" definition, as for-

mulated by The Robot Institute of America (now the Robotic Industries Association):

> A robot is a programmable, multifunctional manipulator designed to move material, parts, tools, or specialized devices, through variable programmed motions for the performance of a variety of tasks.

The definition speaks of a "programmable, multifunctional manipulator." Many manipulators, like the robot, have sliding and rotating joints for the purpose of grasping and moving objects. But it should be well understood that the robot is a *programmable, multifunctional* manipulator, and that not every manipulator can be considered a robot.

Note also the concept of "variety of tasks." If only a single task is involved, a robot is hardly required. There are plenty of mechanisms that fall under the category of hard automation and that can perform the task more efficiently than any robot, even when reprogramming from time to time may be required. As always in life, it is paramount to consider the *simplest* approach for the performance of the specific task or tasks. Only when a variety of tasks is involved should the robot be considered.

H. R. Leep and D. K. Hagan[1] made a random survey of 24 companies and found that fewer than one-third of the robots discussed used more than one computer program, an indication that they were applied in repetitive operations that do not necessarily require a robot.

They also stated that since "robots are not assigned flexible tasks . . . they relieve people from hazardous or repetitive work." This is correct, but it leaves unresolved whether these are tasks for a robot or for a mechanism with suitable linkages to perform this work.

Furthermore, the variety of tasks to be performed determines structure and complexity of robots. Again utmost simplicity—and that spells economy—is the goal.

The judgment about which robot is the most suitable for a given job requires a knowledge of the capabilities of the many ways in which robots can be built, a knowledge of their principle and their transformation into practice. If this knowledge is the task of our endeavors, then the logical first question is: What does a robot consist of? How do the parts work by themselves? And then how do they operate as an integrated whole? It is this kind of analytical approach to the subject matter of robotic technology that is applied in this text.

An attempt has been made to illustrate as many concepts of robotic technology as possible by actual products of a variety of manufacturers. The selection has been arbitrary. Many manufacturers should have been included, and the author extends his apologies to those that were overlooked.

In some subject areas (vision, touch sensors, etc.), developments are in such flux that it was necessary to include some of the ongoing research to give a wider spectrum of the potential offered by these techniques.

Many manufacturers, institutions, and researchers have given their active support to the preparation of this text. The author can only hope to have done justice to all the advanced technology they represent. It is hoped that no misrepresentations have occurred. However, if mistaken statements of published data have been made, they are the author's sole responsibility.

International licensing and agreements between robot manufacturers can lead to confusion: Unimation is now part of Westinghouse, which also is involved with Olivetti, Kawasaki, Mitsubishi, and Kamatsu; General Electric has license agreements with Hitachi, Volkswagen, and DEA; GMF Robotics Corp. is a combined venture of General Motors and Fujitsu Fanuc; IBM is associated with Sankyo Seiki, and so on. Little or no attention has been given in this book to where the different technologies were originally developed. Robotic technology is, at least for the engineer, a welcome example of international coordination and cooperation.

Customary U.S. units have been used throughout this book, wherever feasible. This means inches, pounds, and so forth. In some isolated case, however, use of the metric system seemed preferable.

With regard to terminology, extensive use has been made of the glossary for robotic terms of the National Bureau of Standards,[2] the dictionary of electronics by Graf,[3] and the microcomputer dictionary by Sippl.[4]

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Bloomfield Hills, Michigan — WERNER G. HOLZBOCK

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