# Fuzzy Logic

## *Intelligence, Control, and Information*

**John Yen and Reza Langari**

*Center for Fuzzy Logic, Robotics, and Intelligent Systems*
*Texas A&M University*

PRENTICE HALL
UPPER SADDLE RIVER, NEW JERSEY 07458

Publisher: *Tom Robbins*
Production editor: *Edward DeFelippis*
Editor-in-chief: *Marcia Horton*
Managing editor: *Eileen Clark*
Assistant vice president of production and manufacturing: *David W. Riccardi*
Art director: *Jayne Conte*
Cover designer: *Bruce Kenselaar*
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Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-13-525817-0

Prentice-Hall International (UK) Limited, *London*
Prentice-Hall of Australia Pty. Limited, *Sydney*
Prentice-Hall Canada Inc., *Toronto*
Prentice-Hall Hispanoamericana, S.A., *Mexico*
Prentice-Hall of India Private Limited, *New Delhi*
Prentice-Hall of Japan, Inc., *Tokyo*
Simon & Schuster Asia Pte. Ltd., *Singapore*
Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*

PART I

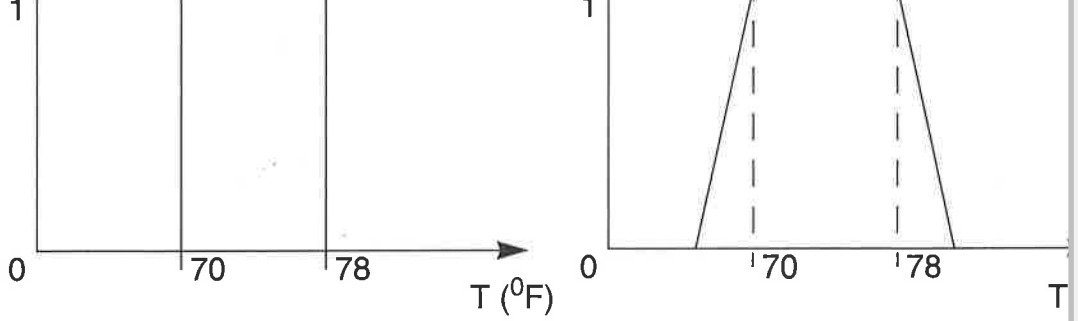
# FUZZY LOGIC

After being mostly viewed as a controversial technology for two decades, fuzzy logic ha finally been accepted as an emerging technology since the late 1980s. This is largely du to a wide array of successful applications ranging from consumer products, to industria process control, to automotive applications. Before we engage in an in-depth discussion c technical issues concerning fuzzy logic, however, we must first place this paradigm in pe spective. For this, we first clarify two meanings of the term "fuzzy logic" and present brief history of the development of fuzzy logic technology and its applications. We wi then discuss the insights that motivated the birth of this technology. This is followed by clarification of some of the common misunderstandings about fuzzy logic.

## 1.1 What Is Fuzzy Logic?

The term fuzzy logic has been used in two different senses. It is thus important to clarif the distinctions between these two different usages of the term. In a narrow sense, fuzz logic refers to a logical system that generalizes classical two-valued logic for reasonin under uncertainty. In a broad sense, fuzzy logic refers to all of the theories and technolo gies that employ fuzzy sets, which are classes with unsharp boundaries.

For instance, the concept of "warm room temperature" may be expressed as an inter val (e.g., [70 $^{\circ}$ F, 78 $^{\circ}$ F]) in classical set theory. However, the concept does not have a well defined natural boundary. A representation of the concept closer to human interpretation i to allow a gradual transition from "not warm" to "warm." In order to achieve this, th notion of membership in a set needs to become a matter of degree. This is the essence o fuzzy sets. An example of a classical set and a fuzzy set is shown in Fig 1.1, where the ver tical axis represents the degree of membership in a set.




The broad sense of fuzzy logic includes the narrow sense of fuzzy logic as a b
Other areas include fuzzy control, fuzzy pattern recognition, fuzzy arithmetic, fuzzy
ematical programming, fuzzy probability theory, fuzzy decision analysis, fuzzy neu
works theory, and fuzzy topology, etc. In all these areas, a conventional black-and
concept is generalized to a matter of degree. By doing this, one accomplishes two
(1) ease of describing human knowledge involving vague concepts, and (2) enhance
ity to develop a cost-effective solution to real-world problems.

The term fuzzy logic in this book is most frequently used in the broad sense.
ever it is used in the narrow sense, we will explicitly state so.

## 1.2 The History of Fuzzy Logic

### 1.2.1 The Birth of Fuzzy Set Theory

The idea of fuzzy sets was born in July 1964. Lofti A. Zadeh is a well-respected pr
in the department of electrical engineering and computer science at University of C
nia, Berkeley. In the fifties, Professor Zadeh believed that all real-world problems c
solved with efficient, analytical methods and/or fast (and big) electronic computers.
direction, he has made significant contributions in the development of system theor
the state variable approach to the solution of simultaneous differential equation
computer science. In early 1960s, however, he began to feel that traditional system
sis techniques were too precise for many complex real-world problems. In a paper
in 1961, he mentioned that a different kind of mathematics was needed:

> *We need a radically different kind of mathematics, the mathematics of fuzzy or cloudy quantities which are not described in terms of probability distributions. Indeed, the need for such mathematics is becoming increasingly apparent..., for in most practical cases the a priori data as well as the criteria by which the performance of a man-made system is judged are far from being precisely specified or having accurately known probability distributions.*

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