History of Fuzzy Logic

• 1964: Lotfi A. Zadeh, UC Berkeley, introduced the paper on fuzzy sets.
  – Idea of grade of membership was born
  – Sharp criticism from academic community
    • Name!
    • Theory’s emphasis on imprecision
  – Waste of government funds!

*Fuzzy Logic: Intelligence, Control, and Information - J. Yen and R. Langari, Prentice Hall 1999*
History of Fuzzy Logic

• 1965-1975: Zadeh continued to broaden the foundation of fuzzy set theory
  – Fuzzy multistage decision-making
  – Fuzzy similarity relations
  – Fuzzy restrictions
  – Linguistic hedges

• 1970s: research groups were form in JAPAN

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History of Fuzzy Logic

• **1974**: Mamdani, United Kingdom, developed the first fuzzy logic controller

• **1977**: Dubois applied fuzzy sets in a comprehensive study of traffic conditions

• **1976-1987**: Industrial application of fuzzy logic in Japan and Europe

• **1987-Present**: Fuzzy Boom

*Fuzzy Logic: Intelligence, Control, and Information - J. Yen and R. Langari, Prentice Hall 1999*
Fuzzy Logic: Motivations

• Alleviate difficulties in developing and analyzing complex systems encountered by conventional mathematical tools.

• Observing that human reasoning can utilize concepts and knowledge that do not have well-defined, sharp boundaries.

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Fuzzy Logic Applications

*Fuzzy Logic: Intelligence, Control, and Information - J. Yen and R. Langari, Prentice Hall 1999*
If all motion vectors are almost parallel and their time differential is small, then the hand jittering is detected and the direction of the hand movement is in the direction of the moving vectors.”

*Fuzzy Logic: Intelligence, Control, and Information - J. Yen and R. Langari, Prentice Hall 1999
Fuzzy Logic Applications

• **Aerospace**
  - Altitude control of spacecraft, satellite altitude control, flow and mixture regulation in aircraft deicing vehicles.

• **Automotive**
  - Trainable fuzzy systems for idle speed control, shift scheduling method for automatic transmission, intelligent highway systems, traffic control, improving efficiency of automatic transmissions
Fuzzy Logic Applications (Cont.)

• Business
  – Decision-making support systems, personnel evaluation in a large company

• Chemical Industry
  – Control of pH, drying, chemical distillation processes, polymer extrusion production, a coke oven gas cooling plant
Fuzzy Logic Applications (Cont.)

• Defense
  - Underwater target recognition, automatic target recognition of thermal infrared images, naval decision support aids, control of a hypervelocity interceptor, fuzzy set modeling of NATO decision making.

• Electronics
  - Control of automatic exposure in video cameras, humidity in a clean room, air conditioning systems, washing machine timing, microwave ovens, vacuum cleaners.
Fuzzy Logic Applications (Cont.)

• **Financial**
  - Banknote transfer control, fund management, stock market predictions.

• **Industrial**
  - Cement kiln controls (dating back to 1982), heat exchanger control, activated sludge wastewater treatment process control, water purification plant control, quantitative pattern analysis for industrial quality assurance, control of constraint satisfaction problems in structural design, control of water purification plants
Fuzzy Logic Applications (Cont.)

- **Manufacturing**
  - Optimization of cheese production.

- **Marine**
  - Autopilot for ships, optimal route selection, control of autonomous underwater vehicles, ship steering.

- **Medical**
  - Medical diagnostic support system, control of arterial pressure during anesthesia, multivariable control of anesthesia, modeling of neuropathological findings in Alzheimer’s patients, radiology diagnoses, fuzzy inference diagnosis of diabetes and prostate cancer.
Fuzzy Logic Applications (Cont.)

- **Mining and Metal Processing**
  - Sinter plant control, decision making in metal forming.

- **Robotics**
  - Fuzzy control for flexible-link manipulators, robot arm control.

- **Securities**
  - Decision systems for securities trading.
Fuzzy Logic Applications (Cont.)

• Signal Processing and Telecommunications
  – Adaptive filter for nonlinear channel equalization control of broadband noise

• Transportation
  – Automatic underground train operation, train schedule control, railway acceleration, braking, and stopping
Chance & Ambiguity

• Suppose you are seated at a table on which rest two glasses of liquid.
  – First glass is described: “having a 95% chance of being healthful and good”
  – Second glass is described: “having a .95 membership in the class of healthful and good”

• Which glass would you select, keeping in mind that the first glass has a 5% chance of being filled with nonhealthful liquids, including poisons [Bezdek 1993]?
Classical Set (Crisp)

- Contain objects that satisfy precise properties of membership.
  - Example: Set of heights from 5 to 7 feet

\[ \chi_A(x) = \begin{cases} 
1 & x \in A \\
0 & \text{else} 
\end{cases} \]

Characteristic Function
Fuzzy Set

- Contain objects that satisfy imprecise properties of membership
  - Example: The set of heights in the region around 6 feet

\[
\mu_A(x) \in \{0-1\}
\]

Membership Function
Fuzzy: Set & Measure

- Fuzzy set provides a basic mathematical framework for dealing with vagueness
- Fuzzy measure provides a general framework for dealing with ambiguity