Chapter 18: Neural Computing Applications, Genetic Algorithms, Fuzzy Logic and

Hybrid Intelligent Systems

- **Several Real-world Applications of ANN Technology**

- **Two Decision Support Technologies:**
  - **Genetic Algorithms**
  - **Fuzzy Logic**

- **Integration of these Cutting Edge Technologies**
  - **Among Themselves**
  - **With Expert Systems**

18.1 Opening Vignette: Applying Neural Computing to Marketing

The Problem

- **Veratex Corp. - Distributor of medical and dental products**

- **Deployed neural-network- and expert-system-based sales-support systems**

- **Veratex's Unique Approach to Marketing Products**

    - **Mail unsolicited catalogs to physicians and dentists**

    - **When a customer buys from catalog, name added to customer database**

    - **Telemarketers call the names regularly for reorders**

Decision Support Systems and Intelligent Systems, Efraim Turban and Jay E. Aronson
Copyright 1998, Prentice Hall, Upper Saddle River, NJ

- **Huge numbers of "dormants" accumulate**
- **Creditability of older data questionable**

The Company Had to

- **Verify older data**
- **Decide to which members of the dormant pool to assign limited telemarketing time**

The Solution

- **Back-propagation neural network**
- **Helps identify dormants who are most likely to be "best" customers**
- **Weed out potentially bad customers**
- **Inputs: Statistical and demographic data**
- **Output: Customer rating**
- **Customers are rated and ordered**

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Three Additional Applications

- **Expert System Resets Credit Limits Monthly**
  - **Mimics credit manager's decision making**
  - **Scheduler prioritizes tasks: Staff handles delinquent accounts**

- **Veratex Benefits**
  - **More specialized and personalized customer service**
  - **Efficient credit department**
  - **Increased sales**
  - **Happy customers**
  - **Happy customer service representatives**

18.2 Areas of ANN Applications: An Overview

Representative Business ANN Applications

- **Accounting**
- **Finance**
- **Human Resources**
- **Human Resources**
- **Management**
- **Marketing**
- **Operations Airline Crew Scheduling**

Accounting

- **Identify tax fraud**
- **Enhance auditing by finding irregularities**

Finance

- **Signatures and bank note verifications**
- **Mortgage underwriting**
- **Foreign exchange rate forecasting**
- **Country risk rating**
- **Bankruptcy prediction**
- **Customer credit scoring**
- **Credit card approval and fraud detection**
- **Corporate merger and take over predictions**
- **Currency trading**
- **Stock and commodity selection and trading**

Finance 2

- **Credit card profitability**
- **Forecasting economic turning points**
- **Foreign exchange trading**
- **Bond rating and trading**
- **Pricing initial public offerings**
- **Load approvals**
- **Economic and financial forecasting Risk management**
- **Signature validation**

Human Resources

- **Predicting employees' performance and behavior**

- **Determining personnel resource requirements**

Management

- **Corporate merger prediction**
- **Takeover target prediction**
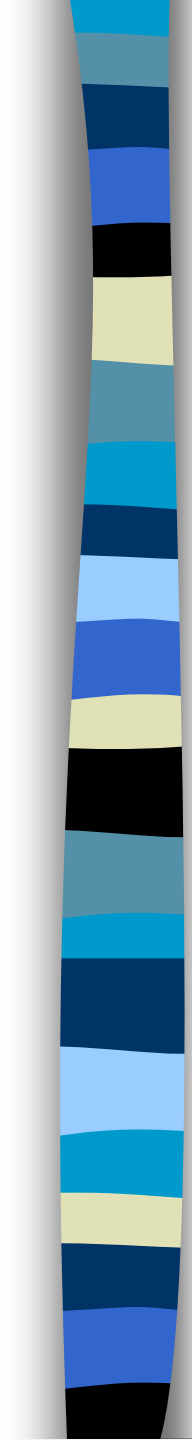- **Country risk rating**

Marketing

- **Consumer spending pattern classification**
- **New product analysis**
- **Customers' characteristics**
- **Sales forecasts**
- **Data mining**
- **Airline fare management**
- **Direct mail optimization**
- **Targeted marketing**

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Operations Airline Crew Scheduling

- **Predicting airline seat demand**
- **Vehicle routing**
- **Assembly and packaged goods inspection**
- **Fruit and fish grading**
- **Matching jobs to candidates**
- **Production/job scheduling**

And Many More

18.3 Using ANNs for Credit Approval

- **Increases loan processor productivity by 25 to 35 % over other computerized tools**

- **Also detects credit card fraud**

The ANN Method

- **Data from the application and into a database**

- **Database definition (Figure 18.2)**

- **Preprocess applications manually**

- **Neural network trained in advance with many good and bad risk cases**

Neural Network Credit Authorizer Construction Process

- **Step 1: Collect data**

- **Step 2: Separate data into training and test sets**

- **Step 3: Transform data into network inputs**

- **Step 4: Select, train and test network**

- **Step 5: Deploy developed network application**

18.4 Using ANNs for Bankruptcy Prediction
Concept Phase

- **Paradigm: Three-layer network, back-propagation**

- **Training data: Small set of well-known financial ratios**

- **Data available on bankruptcy outcomes**

- **Supervised network**

- **Training time not to be a problem**

Application Design

- **Five Input Nodes**
  - **X1: Working capital/total assets**
  - **X2: Retained earnings/total assets**
  - **X3: Earnings before interest and taxes/total assets**
  - **X4: Market value of equity/total debt**
  - **X5: Sales/total assets**

- **Single Output Node: Final classification for each firm**
  - **Bankruptcy or**
  - **Nonbankruptcy**

- **Development Tool: NeuroShell**

- **Development**
  - Three-layer network with backpropagation (Figure 18.5)
  - Continuous valued input
  - Single output node: 0 = bankrupt, 1 = not bankrupt

- **Training**
  - Data Set: 129 firms
  - Training Set: 74 firms; 38 bankrupt, 36 not
  - Ratios computed and stored in input files for
    - The neural network
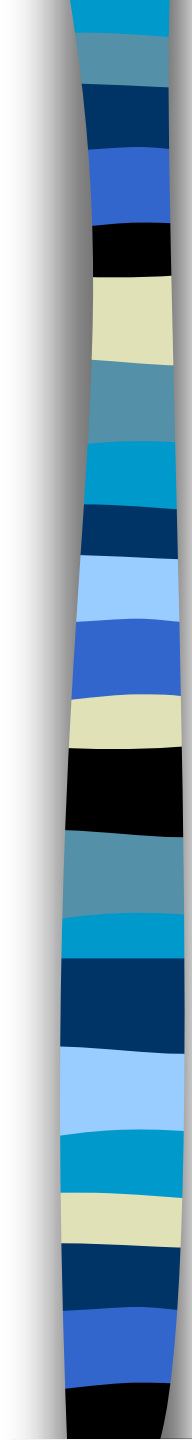   - A conventional discriminant analysis program

- **Parameters**
  - **Learning threshold**
  - **Learning rate**
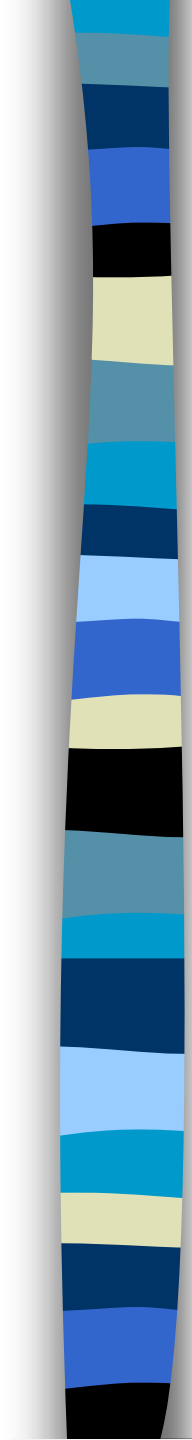 - **Momentum**

- **Testing**
  - **Two Ways**
    - **Test data set: 27 bankrupt firms, 28 nonbankrupt firms**
    - **Comparison with discriminant analysis**
  - **The neural network correctly predicted**
    - **81.5 percent bankrupt cases**
    - **82.1 percent nonbankrupt cases**

- **ANN did better predicting 22 out of the 27 actual cases**

- **Discriminant analysis predicted only 16 correctly**

- **Error Analysis**
  - **Five bankrupt firms misclassified by both methods**
  - **Similar for nonbankrupt firms**

- **Neural network at least as good as conventional**

- ***Accuracy* of about 80 percent is usually acceptable for neural network applications**

18.5 Stock Market Prediction System with Modular Neural Networks

- **Accurate Stock Market Prediction - Complex Problem**

- **Several Mathematical Models - Disappointing Results**

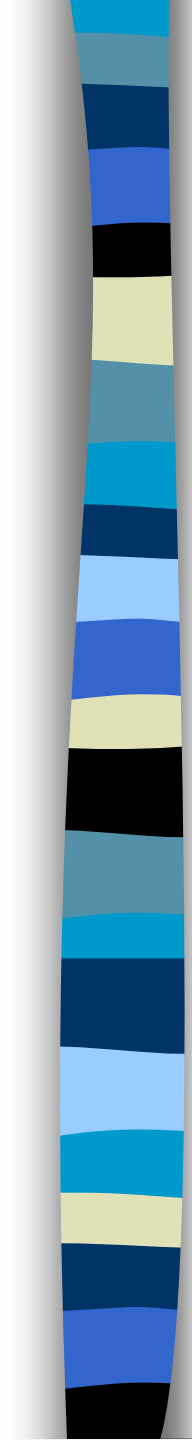- **Fujitsu and Nikko Securities: TOPIX Buying and Selling Prediction System**

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- **Input: Several technical and economic indexes**

- **Several modular neural networks relate past indexes, and buy / sell timing**

- **Prediction system**
  - **Modular neural networks**
  - **Very accurate**

Architecture (Figure 18.6)

Network Architecture

- **Network Model (Figure 18.5): 3 layers, standard sigmoid function, continuous output [0, 1]**

- **High-speed Supplementary Learning Algorithm**

- **Training Data**
  - **Data Selection**
  - **Training Data**

- **Preprocessing: Input Indexes - Converted into spatial patterns, preprocessed to *regularize* them**

- **Moving Simulation Prediction Method (Figure 18.7)**

- **Result of Simulations**
  - **Simulation for Buying and Selling Stocks**
  - **Example (Figure 18.8)**
  - **Excellent Profit**

18.6 Examples of Integrated ANNs and Expert Systems

1. Resource Requirements Advisor

- – Advises users on database systems' resource requirements

- – Predict the time and effort to finish a database project

- – ES shell AUBREY and neural network tool NeuroShell

- – ES supported data collection

- – ANN used for data evaluation

- – ES final analysis

2. Personnel Resource Requirements Advisor

- **Project personnel resource requirements for maintaining networks or workstations at NASA**

- **Rule-based ES determines the final resource projections**

- **ANN provides project completion times for services requested**

  (Figure 18.9)

3. Diagnostic System for an Airline

- Singapore Airlines

- Assist technicians in diagnosing avionics equipment

- INSIDE (Inertial Navigation System Interactive Diagnostic Expert)

- Designed to reduce the diagnostic time
    (Figure 18.10)

18.7 Genetic Algorithms

- **Goal (evolutionary algorithms): Demonstrate Self-organization and A*daptation* by Exposure to the Environment**

- **System *learns* to *adapt* to *changes*.**

- **Example 1: Vector Game**
  - **Random Trial and Error**
  - **Genetic Algorithm Solution**

- **Process (Figure 18.11)**

- **Example: The Game of MasterMind**

Definition and Process

Genetic algorithm: "an iterative procedure maintaining a population of structures that are candidate solutions to specific domain challenges (Grefenstette [1982])

- **Each candidate solution is called a *chromosome***

- **Chromosomes can copy themselves, mate, mutate**

- **Use specific *genetic operators* - reproduction, crossover and mutation.**

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Primary Operators of Most Genetic Algorithms

- **Reproduction**

- **Crossover**

- **Mutation**

Genetic Algorithms Applications and Software

- **Type of machine learning**

- **Set of efficient, domain-independent search heuristics for a broad spectrum of applications**

General Areas of Genetic Algorithm Applications

- **Dynamic process control**
- **Induction of rule optimization**
- **Discovering new connectivity topologies**
- **Simulating biological models of behavior and evolution**
- **Complex design of engineering structures**
- **Pattern recognition**
- **Scheduling**
- **Transportation**
- **Layout and circuit design**
- **Telecommunication**
- **Graphs**

Documented Business Applications

- **Channel 4 Television (England) to schedule commercials**
- **Driver scheduling in a public transportation system**
- **Jobshop scheduling**
- **Assignment of destinations to sources**
- **Trading stocks**
- **Productivity in whisky making is increased**

- **Often Genetic Algorithm hybrids with other AI methods**

Representative Commercial Packages

■ **Evolver (Excel spreadsheet addin)**

■ **OOGA (object-oriented GA for industrial use)**

■ **XperRule Genasys (ES shell with an embedded genetic algorithm)**

18.8 Optimization Algorithms

- **Via Neural Computing sometimes**

- **Genetic algorithms and their derivatives can optimize (or nearly optimize) complex problems**

18.9 Fuzzy Logic:
Theory and Applications

- **Fuzzy logic deals with *uncertainty***

- **Uses the mathematical theory of fuzzy sets**

- **Simulates the process of normal human reasoning**

- **Allows the computer to behave less precisely and logically**
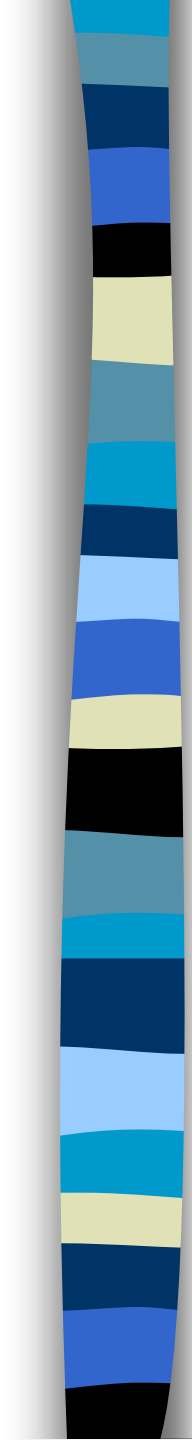
Decision making involves gray areas and the term *maybe*

Fuzzy Logic Advantages

- **Provides flexibility**
- **Provides options**
- **Frees the imagination**
- **More forgiving**
- **Allows for observation**
- **Shortens system development time**
- **Increases the system's maintainability**
- **Uses less expensive hardware**
- **Handles control or decision-making problems not easily defined by mathematical models**

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Fuzzy Logic Example: What is Tall?

■ **In-Class Exercise**

Height	Proportion Voted for
5'10"	0.05
5'11"	0.10
6'	0.60
6'1"	0.15
6'2"	0.10

- – Jack is 6 feet tall
- – Probability theory - cumulative probability
- – There is a 75 percent chance that Jack is tall

- **Fuzzy logic - Jack's degree of membership within the set of tall people is 0.75**

- **We are not completely sure whether he is tall or not**

- *Fuzzy logic* **- We agree that Jack is more or less tall**

- **Membership Function**

$$< \text{Jack, 0.75} \equiv \text{Tall} >$$

- **Knowledge-based system approach: Jack is tall (CF = .75)**

- **Belief functions**

- **Can Use Fuzzy Logic in Rule-based Systems**

Fuzzy Logic Applications and Software

■ **Difficult to Apply When People Provide Evidence**

■ **Used in Consumer Products that have Sensors**
  – **Air Conditioners**
  – **Cameras**
  – **Dishwashers**
  – **Microwaves**
  – **Toasters**

■ **Special Software Packages like FuziCalc Spreadsheet**

■ **Controls Applications**

Examples of Fuzzy Logic

Example 1: Strategic Planning

- STRATASSIST - fuzzy expert system that helps small-to medium-sized firms plan strategically for a single product

Example 2: Fuzziness in Real Estate
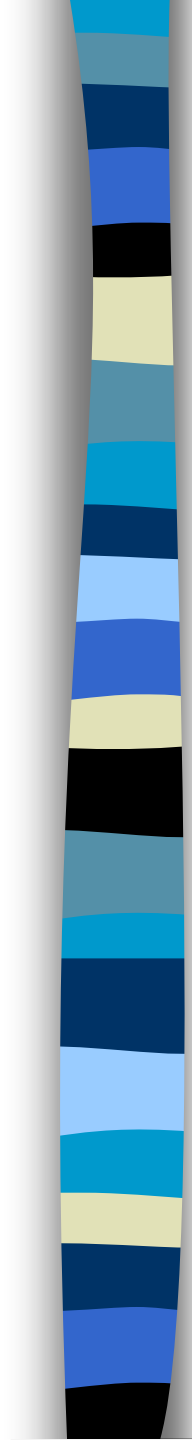
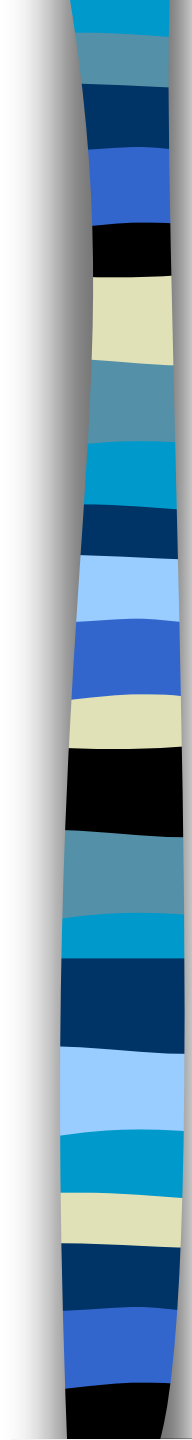## Example 3: A Fuzzy System for Bond Evaluation

AIS In Focus 18.3:
Fuzzy Logic Applications

- **Selecting stocks (on Japanese Nikkei Stock Exchange)**
- **Retrieving data (fuzzy logic can find data quickly)**
- **Regulating auto antilock braking systems**
- **Camera Autofocusing**
- **Automating laundry machine operation**
- **Building environmental controls**
- **Controlling video camcorders image position**

- **Controlling train motion**
- **Identifying killer whale dialects**
- **Inspecting beverage cans for printing defects**
- **Keeping space shuttle vehicles in steady orbit**
- **Matching golf clubs to customer's swings**
- **Regulating shower head water temperature**
- **Controlling cement kiln oxygen levels**

- **Increasing industrial quality control application accuracy and speed**
- **Sorting multidimensional space problems**
- **Enhancing queuing (waiting lines) models**
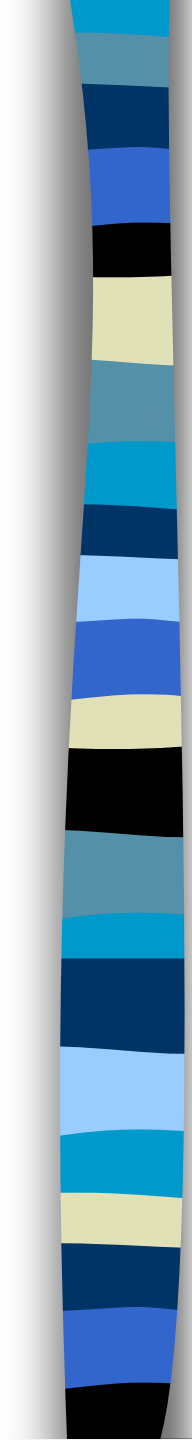- **Decision making (see Glenn [1994])**

18.10 Cross Fertilization Hybrids of Cutting Edge Technologies

- **Combine**
  - **Neural Computing**
  - **Expert Systems**
  - **Genetic Algorithms**
  - **Fuzzy Logic**
- **Example: International Investment Management--Stock Selection**
- **Fuzzy Logic and ANN (FuzzyNet) to Forecast the Expected Returns from Stocks, Cash, Bonds and Other Assets to Determine the Optimal Allocation of Assets**

- **Global markets**
- **Integrated network architecture of the system (Figure 18.12)**

Technologies

- **Expert system (rule-based) for country and stock selection**
- **Neural network for forecasting**
- **Fuzzy logic for assessing factors without reliable data**

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FuzzyNet Modules (Figure 18.13)

- **Membership Function Generator (MFG)**

- **Fuzzy Information Processor (FIP)**

- **Backpropagation Neural Network (BPN)**

18.11 Data Mining and Knowledge Discovery in Databases (KDD)

- **Hidden Value in Data**
- **Knowledge Discovery in Databases (KDD)**

The KDD Process
Start with Raw Data and Do

1. *Selection* to produce target the appropriate data which undergoes

2. *Preprocessing* to filter the data in preparation for

3. *Transformation* so that

4. *Data Mining* can identify patterns that go through

5. *Interpretation and Evaluation* resulting in knowledge.

Data Mining

- **Find _Kernels_ of Value in Raw Data Ore**

- **Theoretical Advances**

  - **Knowledge discovery in textual databases**

  - **Methods based on statistics, cluster analysis, discriminant analysis, fuzzy logic, genetic algorithms, and neural networks**

  - **Ideal for data mining**

Data Mining Applications Areas

- **Marketing**

- **Investment**

- **Fraud Detection**

- **Manufacturing**
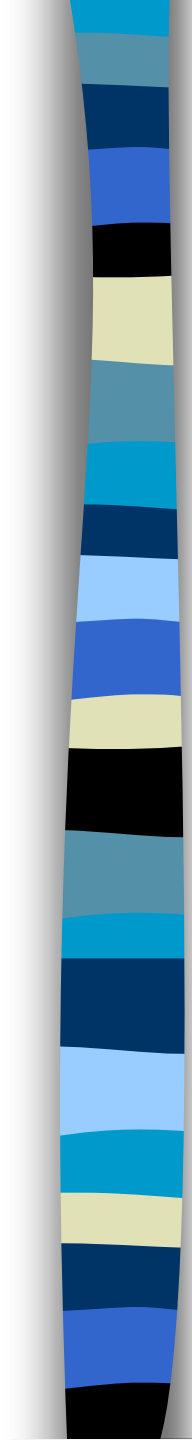
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Information Overload

- **Data mining methods can sift through soft information to identify relationships automatically**

- **Intelligent agents**

Important KDD and Data Mining Challenges

- **Dealing with larger databases**

- **Working with higher dimensionalities of data**

- **Overfitting--modeling noise rather than data patterns**

- **Assessing statistical significance of results**

- **Working with constantly changing data and knowledge**

- **Working through missing and noisy data**

- **Determining complex relationships between fields**

- **Making patterns more understandable to humans**

- **Providing better user interaction and prior knowledge about the data**

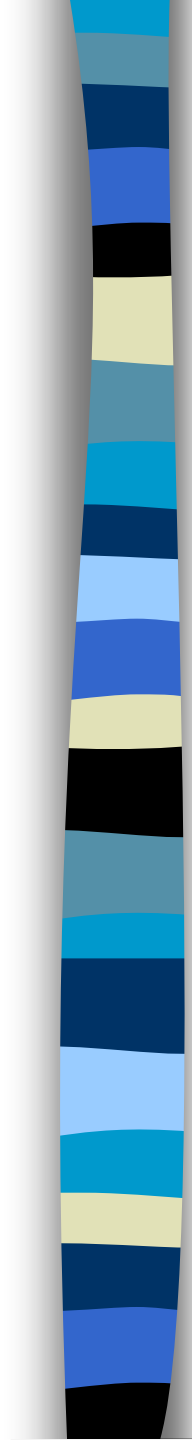- **Providing integration with other systems**
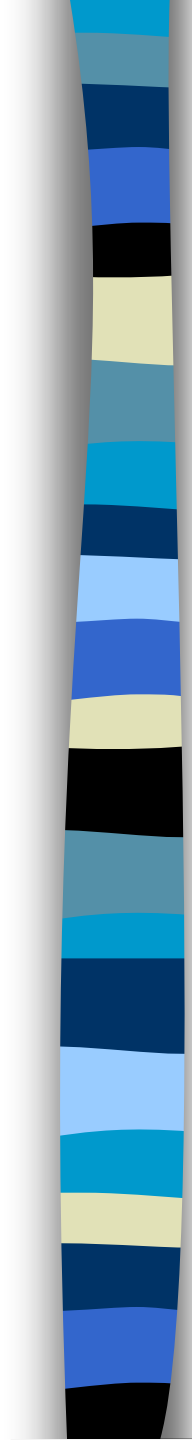
Summary

- **ANN can be applied to several difficult problems in finance (credit authorization, stock market predictions)**

- **ANN can help interpret information in large databases**

- **Integrations seem to have many benefits:**
  - **Expert systems and ANN**
  - **Fuzzy logic and genetic algorithms**
  - **Fuzzy logic and ANN**

- **Genetic algorithms can be used to solve complex optimization problems**

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- **Genetic algorithms use a three-step iterative process: Test a solution to see how good it is, Select the best "parents" and Generate offspring. Results improve as knowledge accumulates**

- **Fuzzy logic represents uncertainty by using fuzzy sets**

- **Fuzzy logic is based on: 1) People reason using vague terms. Classes boundaries are vague and subject to interpretation; 2) Human quantification is often fuzzy**

- **Fuzzy sets have well defined boundaries. Items have membership values to define the imprecise nature of belonging to a set**

- **Data mining methods identify hidden relationships in databases**

- **Data mining can boost an organization's performance by targeting appropriate customers, etc.**

- **Intelligent systems and neural computing can overcome information overload by data mining**
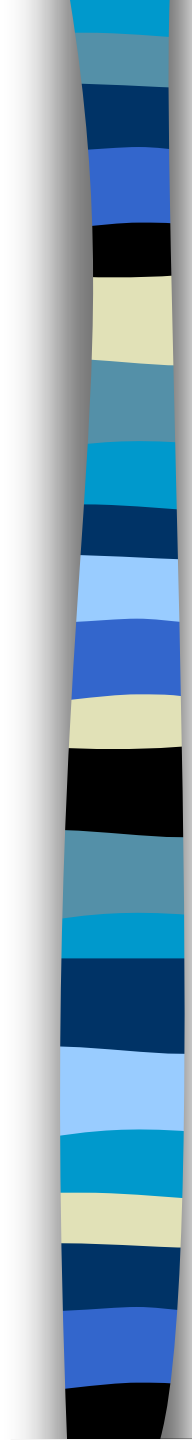
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Questions for the Opening Vignette

1. Describe Veratex's problem.

2. How can ANN identify the best potential customers?

3. How can ANN foster market analysis for Veratex?

4. Why is data collection such an important task in building this marketing ANN?

Exercises

2. Express the following statements in terms of fuzzy sets:

   a) The chance for rain is 80 percent today (Rain? No rain?)

   b) Mr. Smith is 60 years old (Young?)

   c) The salary of the President of the United States is $250,000 per year (Low? High? Very high?)

   d) The latest survey of economists indicates that they believe that the recession will bottom out in April (20 percent), in May (30 percent) or in June (22 percent)

3. You are trying to identify a specific number in the set of 1 to 16. You can ask questions such as, "Is this number in the set 1-8?" The answer can only be yes or no. In either case, you continue to ask more questions until you can identify the number.

    a) How many questions are needed, in the worst and the best possible cases, to identify such a number?

    b) Is the problem suitable for parallel processing? Why or why not?

    c) Can you relate this problem to a genetic algorithm?

Group Exercises

1. *Fuzzy logic.* **Perform a written survey of the class and have everyone write down a height representing "tall" for men, and "tall" for women. Tally up the results and determine what is meant by tall in a fuzzy way. Treat the results like a probability density function.**

3. **Have the members of your group play (the manual version of) MasterMind for about 30 minutes to one hour. How do the better players in your group win? Write down the game concepts in terms of genetic algorithms and express winning strategies. Do you ever have to try random solutions to converge on a solution? Explain.**