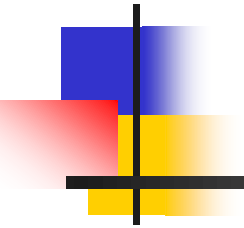
Business Intelligence and Decision Support Systems (9th Ed., Prentice Hall)



Chapter 13:

Advanced Intelligent Systems

Learning Objectives

- Understand the basic concepts and definitions of machine-learning
  - Learn the commonalities and differences between machine learning and human learning
  - Know popular machine-learning methods
- Know the concepts and definitions of case-based reasoning systems (CBR)
- Be aware of the MSS applications of CBR
- Know the concepts behind and applications of genetic algorithms
- Understand fuzzy logic and its application in designing intelligent systems

Learning Objectives

- Understand the concepts behind support vector machines and their applications in developing advanced intelligent systems
- Know the commonalities and differences between artificial neural networks and support vector machines
- Understand the concepts behind intelligent software agents and their use, capabilities, and limitations in developing advanced intelligent systems
- Explore integrated intelligent support systems

Opening Vignette:

"Machine Learning Helps Develop an Automated Reading Tutoring Tool"

- Background on literacy
- Problem description
- Proposed solution
- Results
- Answer and discuss the case questions

Machine Learning Concepts and Definitions

- Machine learning (ML) is a family of artificial intelligence technologies that is primarily concerned with the design and development of algorithms that allow computers to "learn" from historical data
  - ML is the process by which a computer learns from experience
  - It differs from knowledge acquisition in ES: instead of relying on experts (and their willingness) ML relies on historical facts
  - ML helps in discovering patterns in data

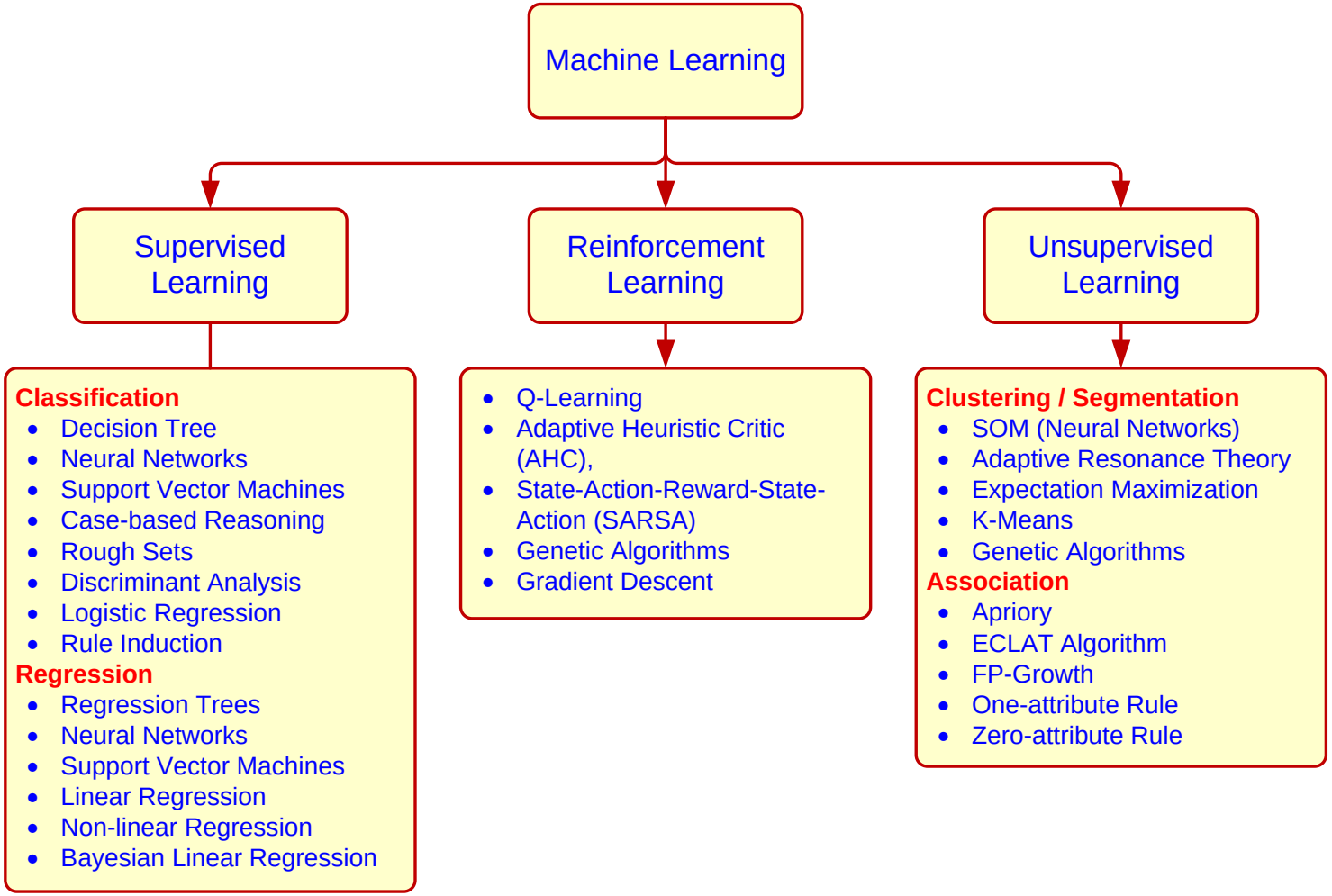
Machine Learning Concepts and Definitions

- Learning is the process of self-improvement, which is an critical feature of intelligent behavior
- Human learning is a combination of many complicated cognitive processes, including:
  - Induction
  - Deduction
  - Analogy
  - Other special procedures related to observing and/or analyzing examples

Machine Learning Concepts and Definitions

- Machine Learning versus Human Learning
  - Some ML behavior can challenge the performance of human experts (e.g., playing chess)
  - Although ML sometimes matches human learning capabilities, it is not able to learn as well as humans or in the same way that humans do
  - There is no claim that machine learning can be applied in a truly creative way
  - ML systems are not anchored in any formal theories (why they succeed or fail is not clear)
  - ML success is often attributed to manipulation of symbols (rather than mere numeric information)

Machine Learning Methods



Case-Based Reasoning (CBR)

- Case-based reasoning (CBR)

  A methodology in which knowledge and/or inferences are derived directly from historical cases/examples

  - Analogical reasoning (= CBR)

    Determining the outcome of a problem with the use of analogies. A procedure for drawing conclusions about a problem by using past experience directly (no intermediate model?)

  - Inductive learning

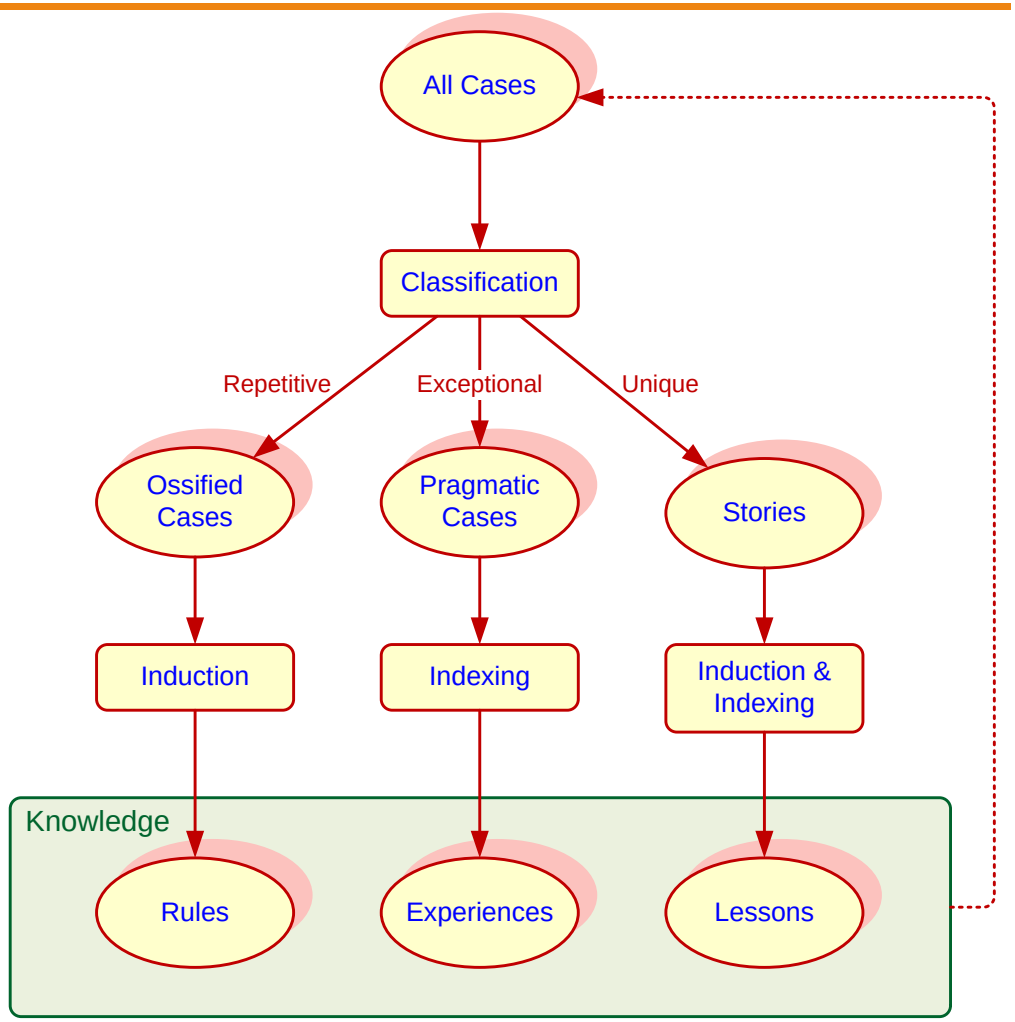
    A machine learning approach in which rules (or models) are inferred from the historic data

CBR vs. Rule-Based Reasoning

Criterion	Rule-Based Reasoning	Case-Based Reasoning
Knowledge unit	Rule	Case
Granularity	Fine	Coarse
Explanation mechanism	Backtrack of rule firings	Precedent cases
Advantages	Flexible use of knowledge Potentially optimal answers	Rapid knowledge acquisition Explanation by examples
Disadvantages	Possible errors due to misfit rules and problem parameters Black-box answers	Suboptimal solutions Redundant knowledge base Computationally expensive

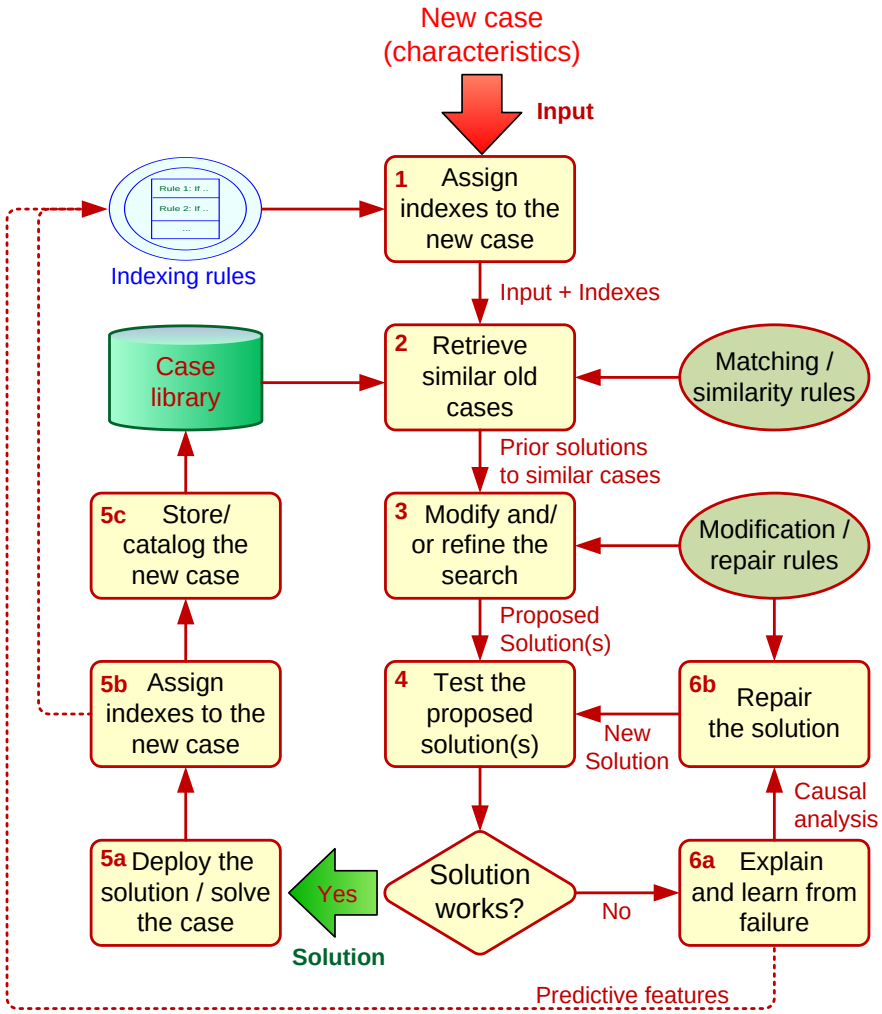
Case-Based Reasoning (CBR)

- CBR is based on the premise that new problems are often similar to previously encountered problems, and, therefore, past successful solutions may be of use in solving the current situation



The CBR Process

- The CBR Process (4R)
  - Retrieve
  - Reuse
  - Revise
  - Retain (case library)



Case-Based Reasoning (CBR)

- Advantages of using CBR
  - Knowledge acquisition is improved
  - System development time is faster
  - Existing data and knowledge are leveraged
  - Formalized domain knowledge is not required
  - Experts feel better discussing concrete cases
  - Explanation becomes easier
  - Acquisition of new cases is easy
  - Learning can occur from both successes and failures
  - …more…

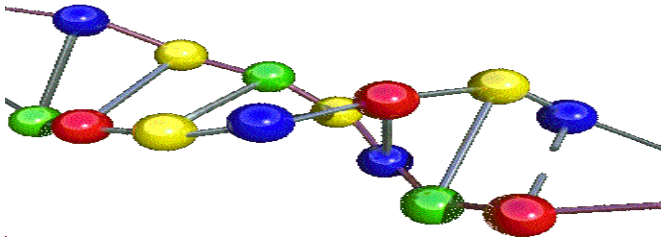
Case-Based Reasoning (CBR)

- Issues and challenges of CBR
  - What makes up a case?
  - How can we represent cases in memory?
  - Automatic case-adaptation can be very complex!
  - How is memory organized (the indexing rules)?
  - How can we perform efficient searching (i.e., knowledge navigation) of the cases?
  - How can we organize the cases?
  - The quality of the results is heavily dependent on the indexes used
  - … more …

Case-Based Reasoning (CBR)

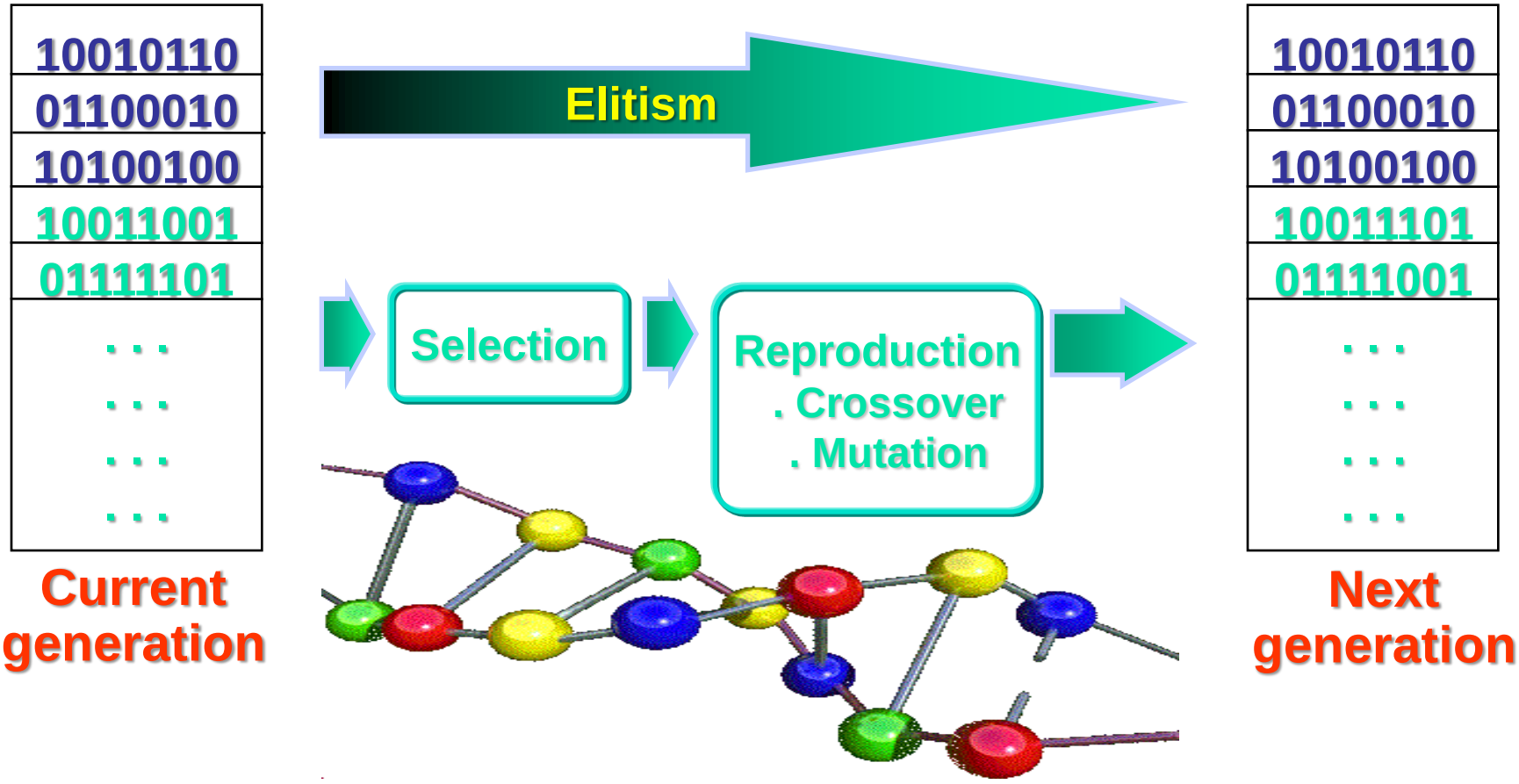
- Success factors for CBR systems
  - Determine specific business objectives
  - Understand your end users (the customers)
  - Obtain top management support
  - Develop an understanding of the problem domain
  - Design the system carefully and appropriately
  - Plan an ongoing knowledge-management process
  - Establish achievable returns on investment (ROI) and measurable metrics
  - Plan and execute a customer-access strategy
  - Expand knowledge generation and access across the enterprise

Genetic Algorithms



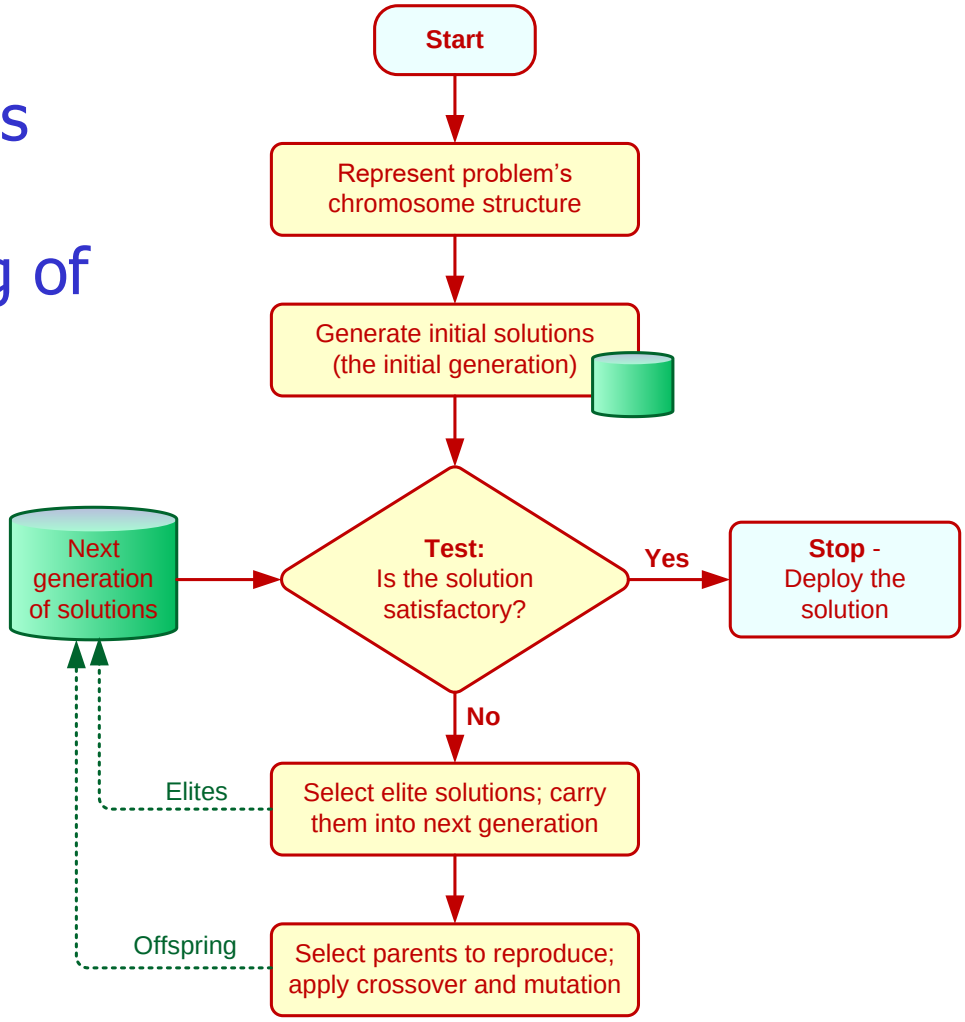
- It is a type of machine learning technique
- Mimics the biological process of evolution
- Genetic algorithms
  - Software programs that learn in an evolutionary manner, similar to the way biological systems evolve
- An efficient, domain-independent search heuristic for a broad spectrum of problem domains
- Main theme: Survival of the fittest
  - Moving towards better and better solutions by letting only the fittest parents to create the future generations

Evolutionary Algorithm

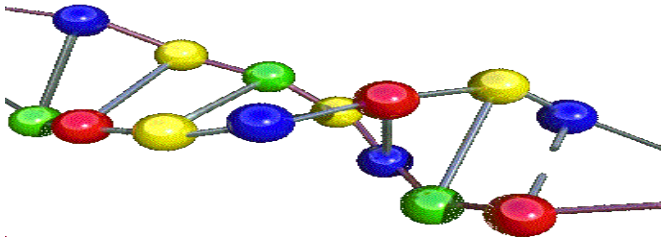


GA Structure and GA Operators

- Each candidate solution is called a chromosome
- A chromosome is a string of genes
- Chromosomes can copy themselves, mate, and mutate via evolution
- In GA we use specific genetic operators
  - Reproduction
    - Crossover
    - Mutation



Genetic Algorithms



- Limitations of Genetic Algorithms
  - Does not guarantee an optimal solution (often settles in a sub optimal solution / local minimum)
  - Not all problems can be put into GA formulation
  - Development and interpretation of GA solutions requires both programming and statistical skills
  - Relies heavily on the random number generators
  - Locating good variables for a particular problem and obtaining the data for the variables is difficult
  - Selecting methods by which to evolve the system requires experimentation and experience

Genetic Algorithm Applications

- Dynamic process control
- Optimization of induction rules
- Discovery of new connectivity topologies (NNs)
- Simulation of biological models of behavior
- Complex design of engineering structures
- Pattern recognition
- Scheduling, transportation and routing
- Layout and circuit design
- Telecommunication, graph-based problems

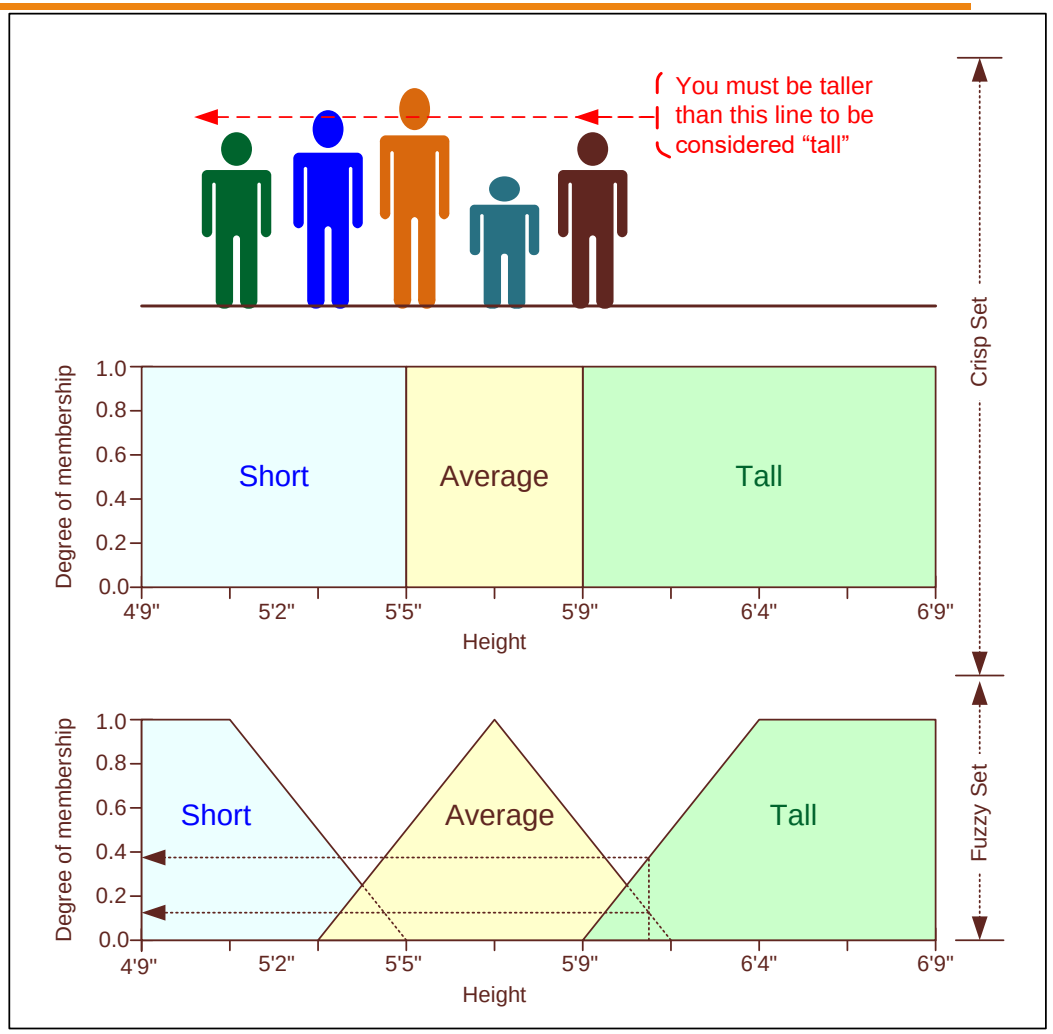
Fuzzy Logic and Fuzzy Inference System

- Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth – truth values between "completely true" and "completely false”
- First introduced by Dr. Lotfi Zadeh of UC Berkeley in the 1960's as a mean to model the uncertainty of natural language.
- Uses the mathematical theory of fuzzy sets
- Simulates the process of normal human reasoning
- Allows the computer to behave less precisely
- Decision making involves gray areas

Fuzzy Logic Example: Tallness

Height	Proportion Voted for
5′10″	0.05
5′11″	0.10
6′00″	0.60
6′01″	0.15
6′02″	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



Advantages of Fuzzy Logic

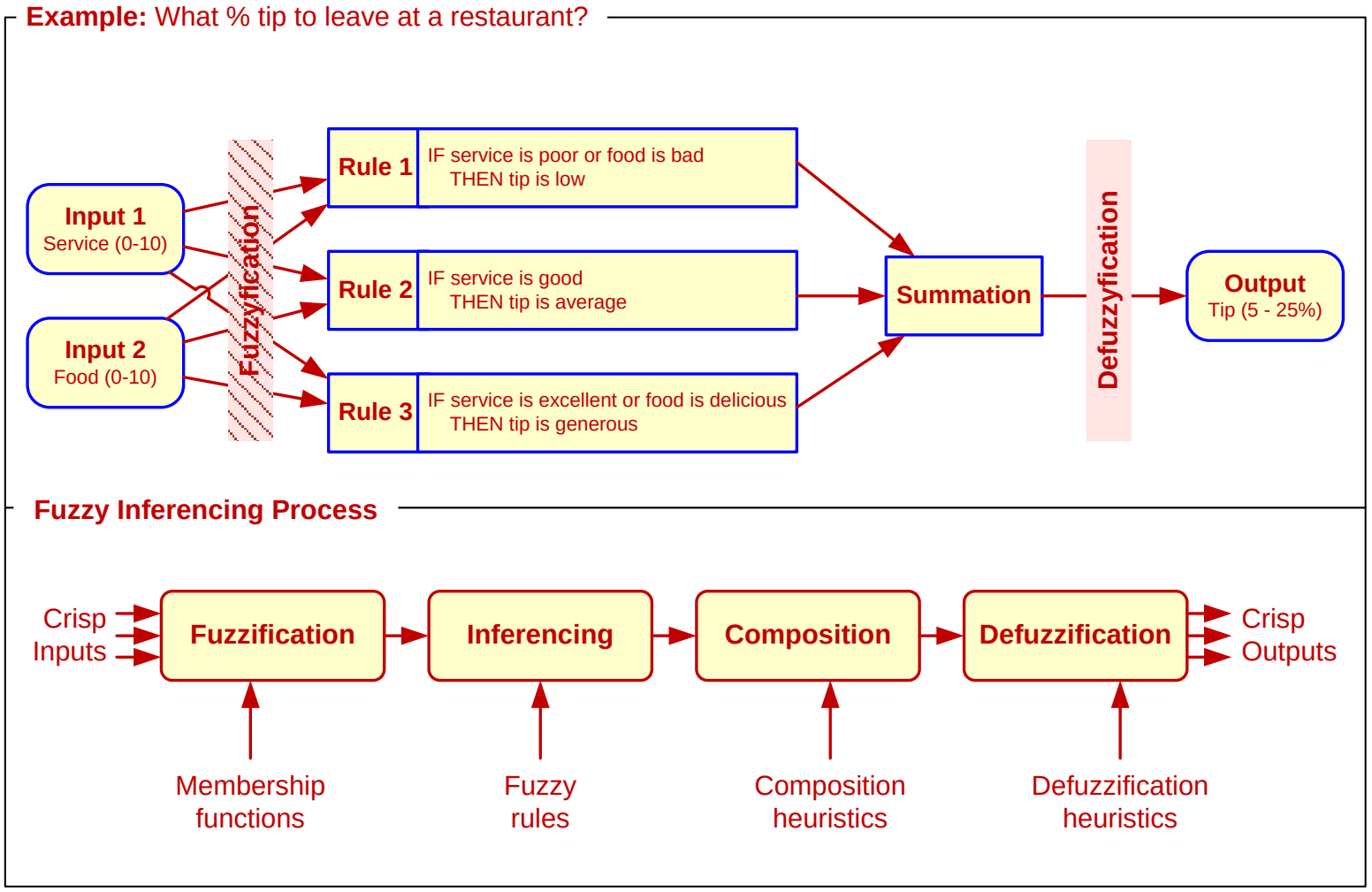
- More natural to construct
- Easy to understand - Frees the imagination
- Provides flexibility
- More forgiving
- Shortens system development time
- Increases the system's maintainability
- Uses less expensive hardware
- Handles control or decision-making problems not easily defined by mathematical models
- …more…

Fuzzy Inference System (FIS) = Expert System + Fuzzy Logic

- An FIS consists of
  - A collection of fuzzy membership functions
  - A set of fuzzy rules called the rule base
  - Fuzzy inference is a method that interprets the values in the input vector and, based on some set of rules, assigns values to the output vector
- In an FIS, the reasoning process consists of
  - Fuzzification
  - Inferencing
  - Composition, and
  - Defuzzification

The Reasoning Process for FIS (the tipping example)

"Given the quality of service and the food, how much should I tip?"

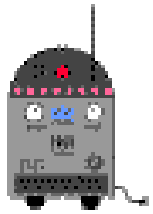


Fuzzy Applications

- In Manufacturing and Management
  - Space shuttle vehicle orbiting
  - Regulation of water temperature in shower heads
  - Selection of stocks to purchase
  - Inspection of beverage cans for printing defects
  - Matching of golf clubs to customers' swings
  - Risk assessment, project selection
  - Consumer products (air conditioners, cameras, dishwashers), ...
- In Business
  - Strategic planning
  - Real estate appraisals and valuation
  - Bond evaluation and portfolio design, ...

Intelligent Software Agents

- Intelligent Agent (IA): is an autonomous computer program that observes and acts upon an environment and directs its activity toward achieving specific goals
- Relatively new technology
- Other names include
  - Software agents
  - Wizards
  - Knowbots
  - Intelligent software robots (Softbots)
  - Bots
- Agent - Someone employed to act on one's behalf



Definitions of Intelligent Agents

- Intelligent agents are software entities that carry out some set of operations on behalf of a user or another program, with some degree of independence or autonomy and in so doing, employ some knowledge or representation of the user's goals or desires."

("The IBM Agent")

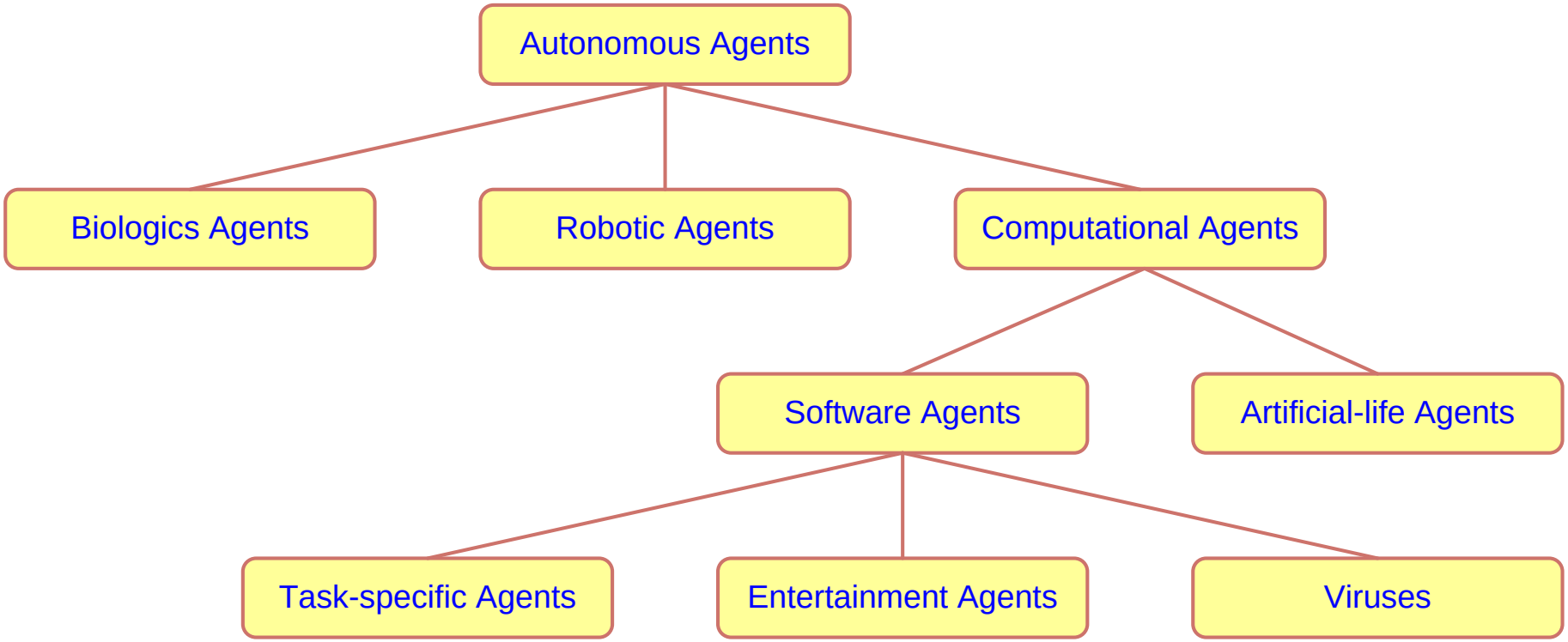
- Autonomous agents are computational systems that inhabit some complex dynamic environment, sense and act autonomously in this environment and by doing so realize a set of goals or tasks for which they are designed

(Maes, 1995, p. 108)

Characteristics of Intelligent Agents

- Autonomy (empowerment)
  - Agent takes initiative, exercises control over its actions. They are Goal-oriented, Collaborative, Flexible, Self-starting
- Operates in the background
- Communication (interactivity)
- Automates repetitive tasks
- Proactive (persistence)
- Temporal continuity
- Personality
- Mobile agents
- Intelligence and learning

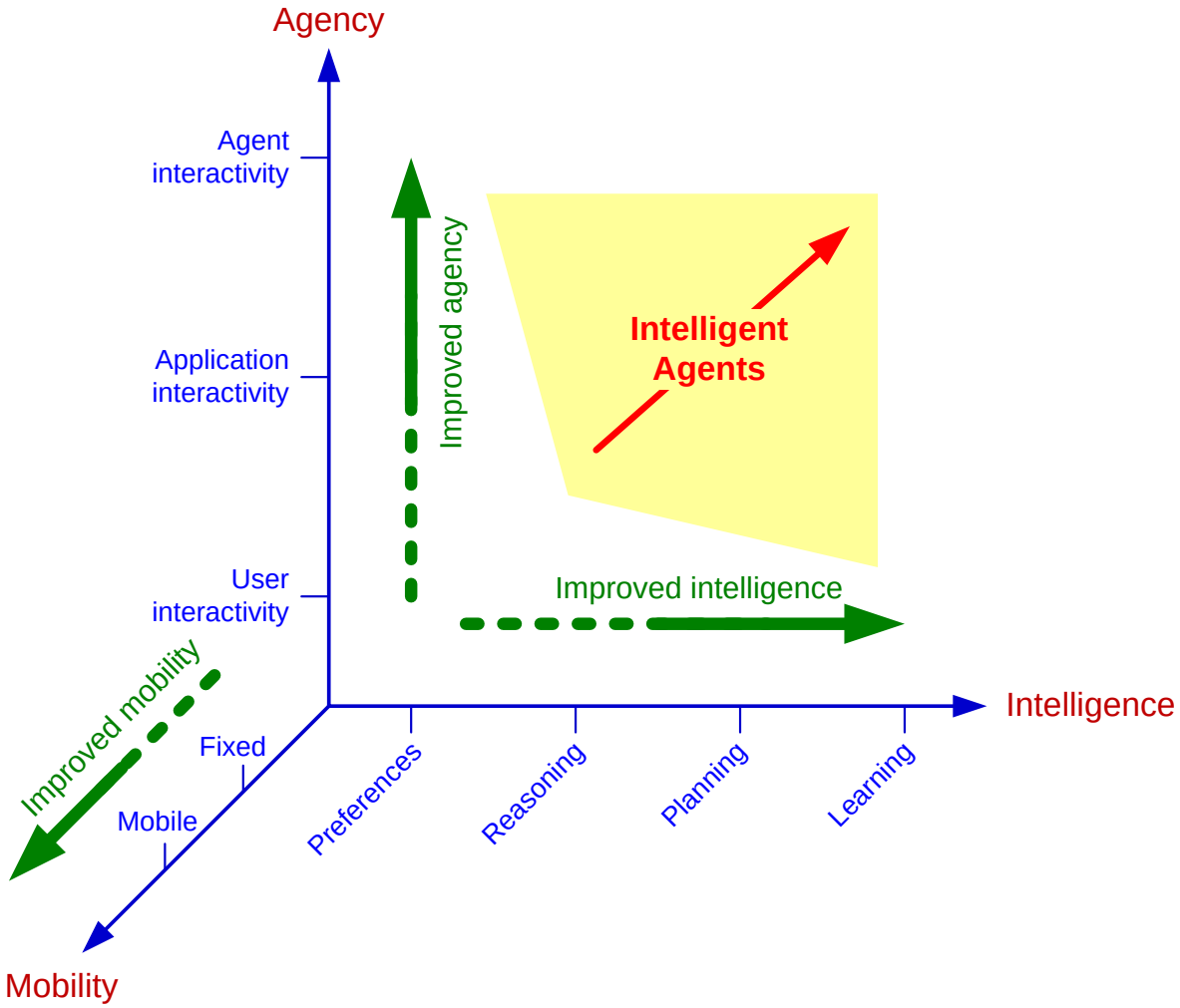
A Taxonomy for Autonomous Agents



Classification for Intelligent Agents by Characteristics

- Agents can be classified in terms of these three important characteristics dimensions
  1. Agency
     - Degree of autonomy and authority vested in the agent
       - More advanced agents can interact with other agents/entities
  2. Intelligence
     - Degree of reasoning and learned behavior
       - Tradeoff between size of an agent and its learning modules
  3. Mobility
     - Degree to which agents travel through the network
       - Mobility requires approval for residence at a foreign locations

Intelligent Agents' Scope in Three Dimensions



Internet-Based Software Agents

- Software Robots or Softbots
- Major Categories
  - E-mail agents (mailbots)
  - Web browsing assisting agents
  - Frequently asked questions (FAQ) agents
  - Intelligent search (or Indexing) agents
  - Internet softbot for finding information
  - Network Management and Monitoring
    - Security agents (virus detectors)
  - Electronic Commerce Agents (negotiators)

End of the Chapter

- Questions / comments…