商業智慧
Business Intelligence

智慧系統
(Intelligent Systems)

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課程大綱 (Syllabus)

週次	日期	內容（Subject/Topics）	備註
1	101/02/17	商業智慧導論 (Introduction to Business Intelligence)	
2	101/02/24	管理決策支援系統與商業智慧 (Management Decision Support System and Business Intelligence)	
3	101/03/02	企業績效管理 (Business Performance Management)	
4	101/03/09	資料倉儲 (Data Warehousing)	
5	101/03/16	商業智慧的資料探勘 (Data Mining for Business Intelligence)	
6	101/03/24	商業智慧的資料探勘 (Data Mining for Business Intelligence)	
7	101/03/30	個案分析一 (分群分析)： Banking Segmentation (Cluster Analysis – KMeans)	
8	101/04/06	教學行政觀摩日 (--No Class--)	
9	101/04/13	個案分析二 (關連分析)： Web Site Usage Associations (Association Analysis)	

課程大綱 (Syllabus)

週次	日期	內容（Subject/Topics） 備註
10	101/04/20	期中報告 (Midterm Presentation)
11	101/04/27	個案分析三 (決策樹、模型評估)： Enrollment Management Case Study (Decision Tree, Model Evaluation)
12	101/05/04	個案分析四 (迴歸分析、類神經網路)：Credit Risk Case Study (Regression Analysis, Artificial Neural Network)
13	101/05/11	文字探勘與網頁探勘 (Text and Web Mining)
14	101/05/18	智慧系統 (Intelligent Systems)
15	101/05/25	社會網路分析 (Social Network Analysis)
16	101/06/01	意見分析 (Opinion Mining)
17	101/06/08	期末報告1 (Project Presentation 2)
18	101/06/15	期末報告2 (Project Presentation 2)

Outline

- Intelligence
- Artificial Intelligence (AI)
- Expert System (ES)
- Machine Learning (ML)
- Case-Based Reasoning (CBR)
- Genetic Algorithms (GA)
- Fuzzy Logic and Fuzzy Inference System (FIS)
- Support Vector Machines (SVM)
- Intelligent Agents (IA)

Signs of Intelligence

- Learn or understand from experience
- Make sense out of ambiguous situations
- Respond quickly to new situations
- Use reasoning to solve problems
- Apply knowledge to manipulate the environment

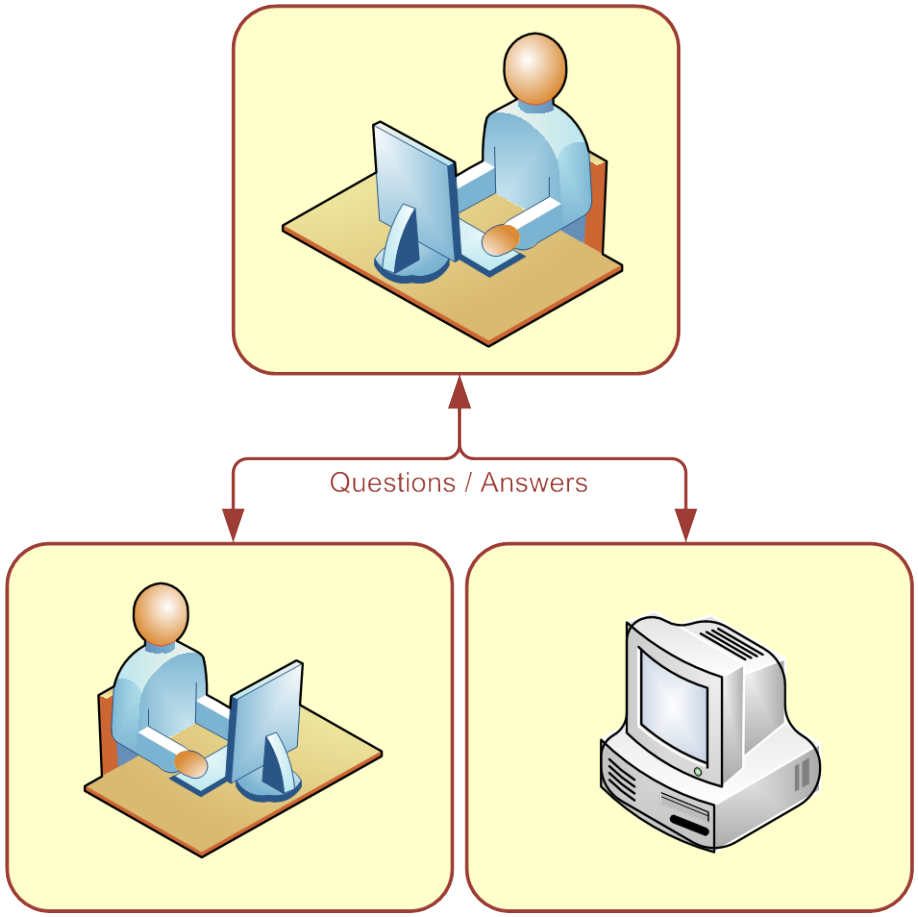
Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Test for Intelligence

Turing Test for Intelligence

- A computer can be considered to be smart only when a human interviewer, "conversing" with both an unseen human being and an unseen computer, can not determine which is which.

- Alan Turing



Artificial Intelligence (AI)

- **Artificial intelligence (AI)**
  - A subfield of computer science, concerned with symbolic reasoning and problem solving

- AI has many definitions…
  - Behavior by a machine that, if performed by a human being, would be considered intelligent
  - "…study of how to make computers do things at which, at the moment, people are better
  - Theory of how the human mind works

AI Objectives

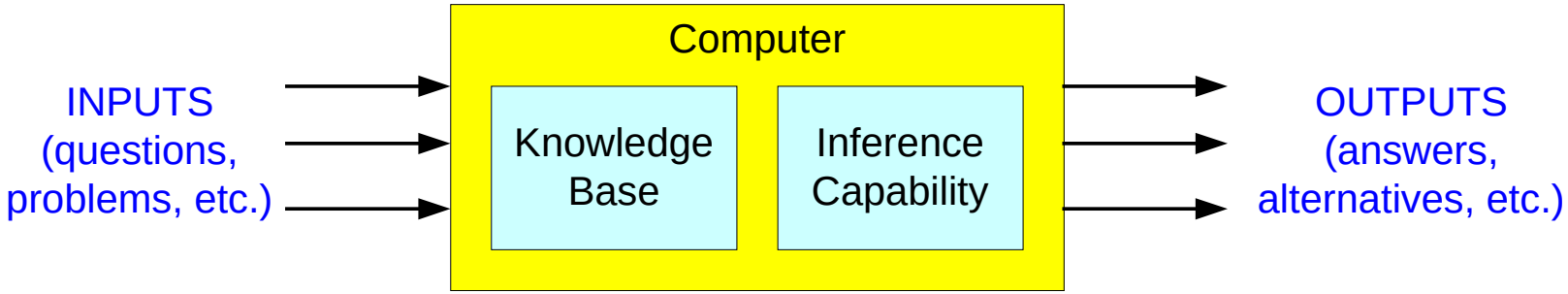
- Make machines smarter (primary goal)
- Understand what intelligence is
- Make machines more intelligent and useful

Symbolic Processing

- AI …
  - represents knowledge as a set of symbols, and
  - uses these symbols to represent problems, and
  - apply various strategies and rules to manipulate symbols to solve problems
- A symbol is a string of characters that stands for some real-world concept (e.g., Product, consumer,…)
- Examples:
  - (DEFECTIVE product)
  - (LEASED-BY product customer) - LISP
  - Tastes_Good (chocolate)

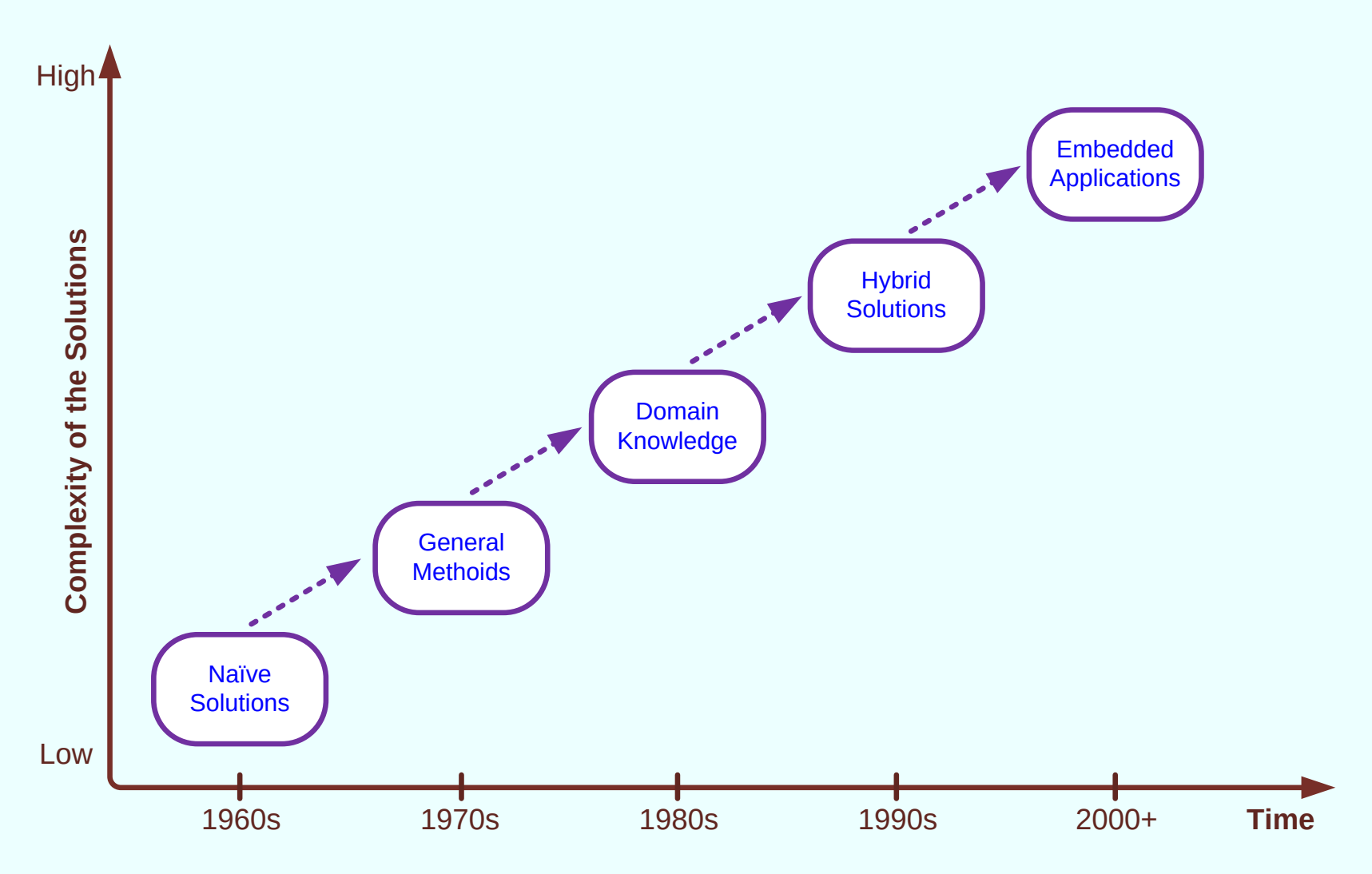
AI Concepts

- Reasoning
  - Inferencing from facts and rules using heuristics or other search approaches
- Pattern Matching
  - Attempt to describe and match objects, events, or processes in terms of their qualitative features and logical and computational relationships
- Knowledge Base



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Evolution of artificial intelligence



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

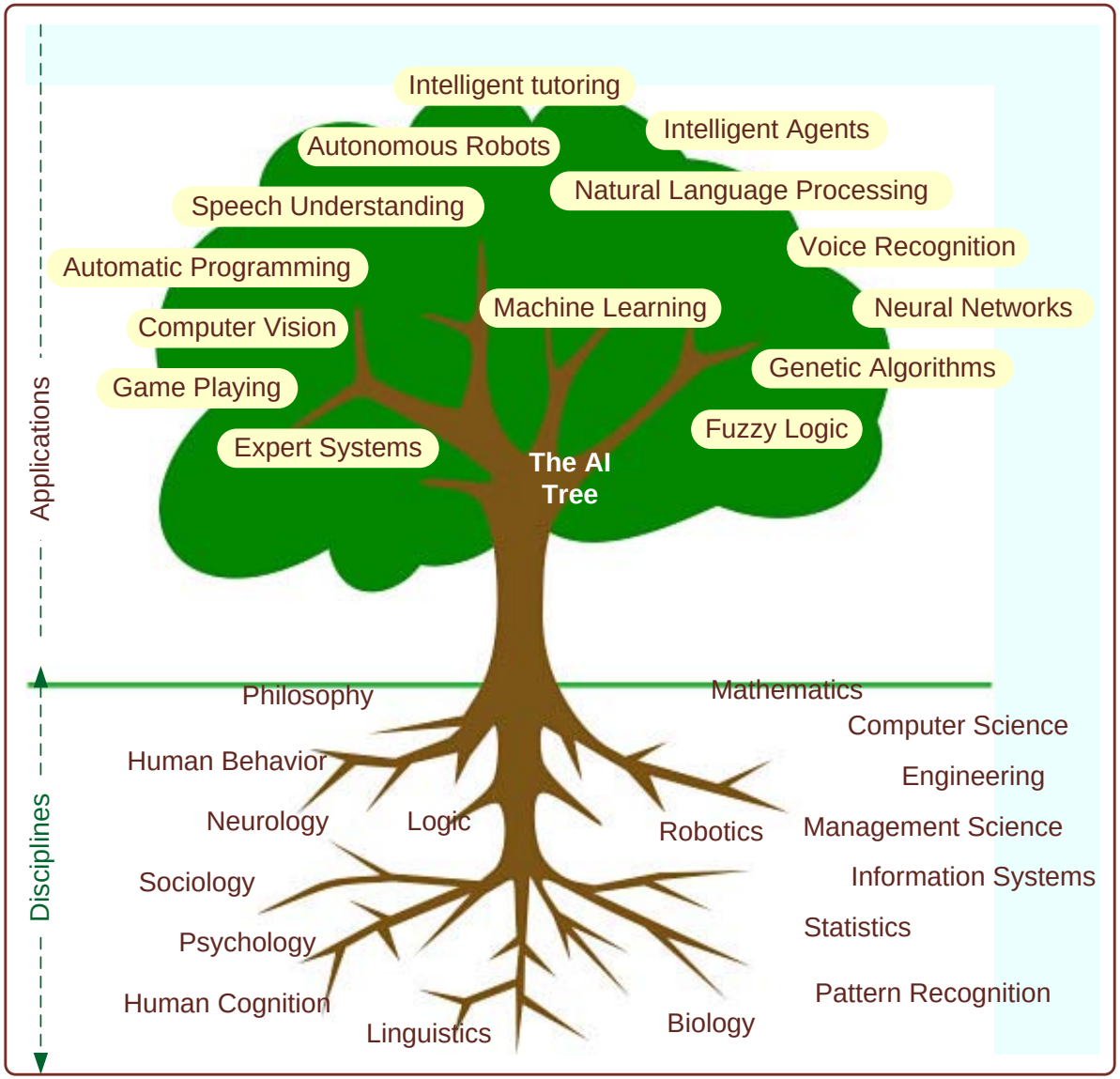
Artificial vs. Natural Intelligence

- Advantages of AI
  - More permanent
  - Ease of duplication and dissemination
  - Less expensive
  - Consistent and thorough
  - Can be documented
  - Can execute certain tasks much faster
  - Can perform certain tasks better than many people
- Advantages of Biological Natural Intelligence
  - Is truly creative
  - Can use sensory input directly and creatively
  - Can apply experience in different situations

Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

The AI Field…

- AI provides the scientific foundation for many commercial technologies



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

AI Areas

- Major…
  - Expert Systems
  - Natural Language Processing
  - Speech Understanding
  - Robotics and Sensory Systems
  - Computer Vision and Scene Recognition
  - Intelligent Computer-Aided Instruction
  - Automated Programming
  - Neural Computing Game Playing
- Additional…
  - Game Playing, Language Translation
  - Fuzzy Logic, Genetic Algorithms
  - Intelligent Software Agents

AI is often transparent in many commercial products

- Anti-lock Braking Systems (ABS)
- Automatic Transmissions
- Video Camcorders
- Appliances
  - Washers, Toasters, Stoves
- Help Desk Software
- Subway Control…

Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Expert Systems (ES)

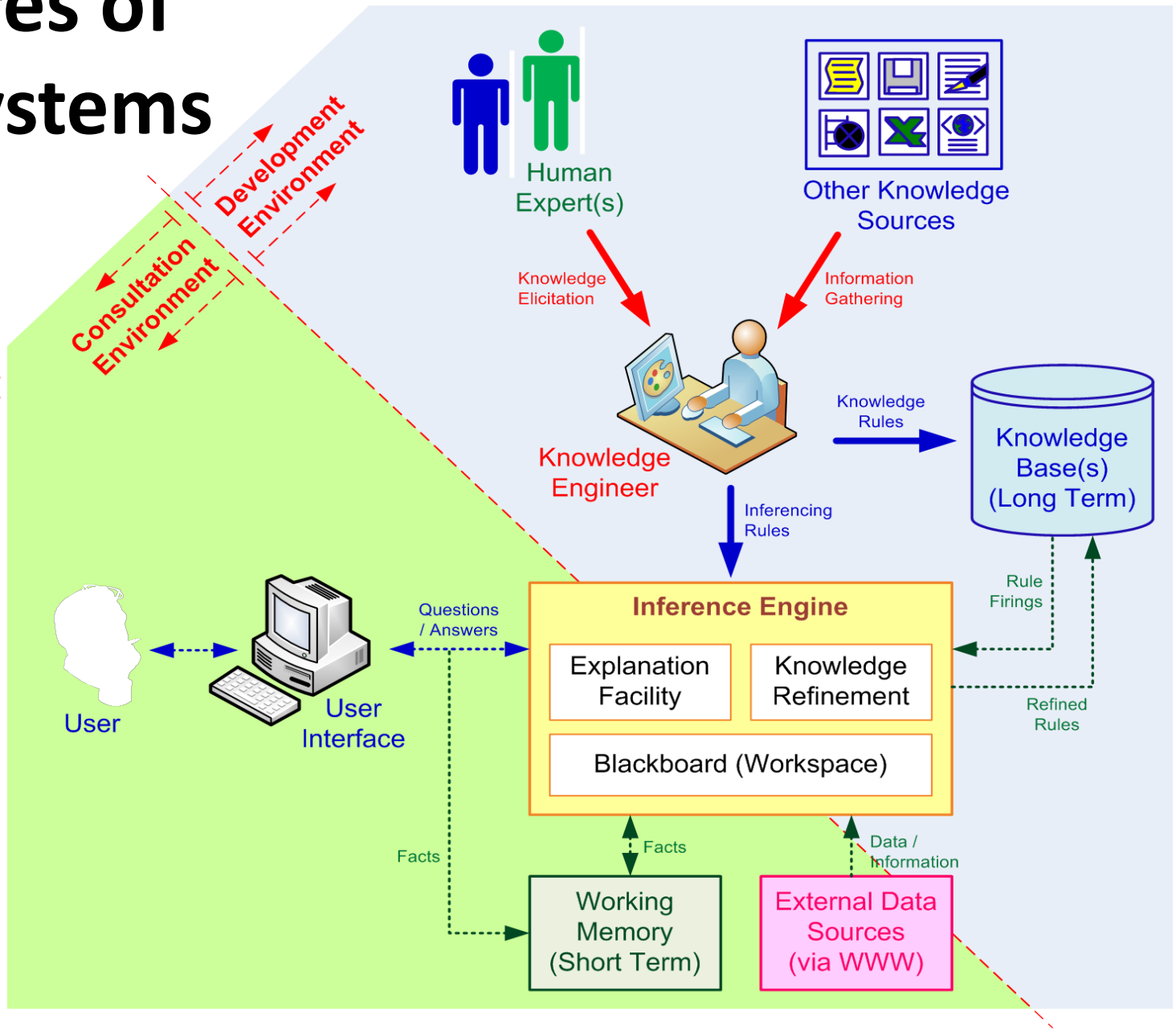
- Expert System (ES) is a computer program that attempts to imitate expert's reasoning processes and knowledge in solving specific problems
- Most Popular Applied AI Technology
  - Enhance Productivity
  - Augment Work Forces
- Works best with narrow problem areas/tasks
- Expert systems do not replace experts, but
  - Make their knowledge and experience more widely available, and thus
  - Permit non-experts to work better

Applications of Expert Systems

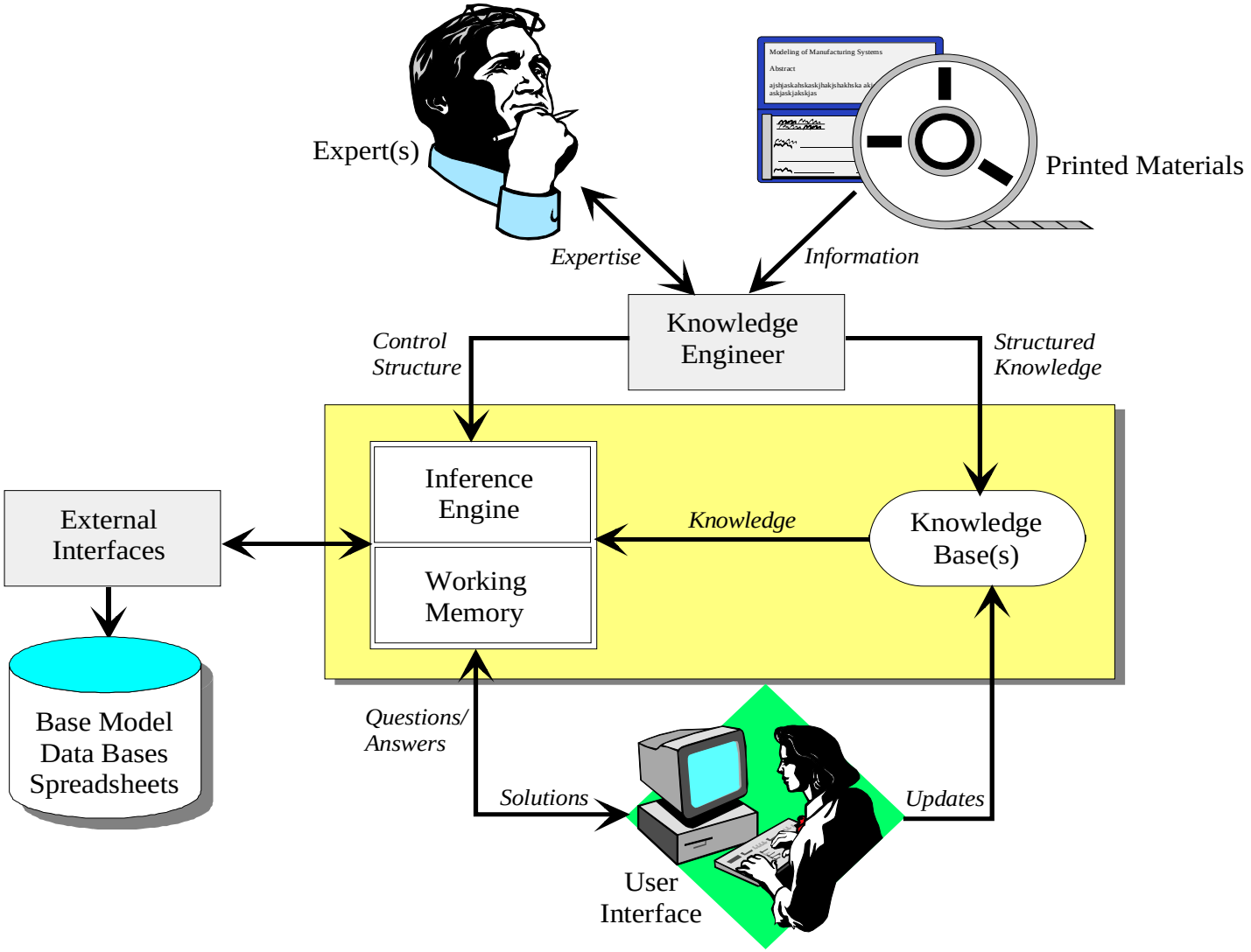
- DENDRAL
  - Applied knowledge (i.e., rule-based reasoning)
  - Deduced likely molecular structure of compounds
- MYCIN
  - A rule-based expert system
  - Used for diagnosing and treating bacterial infections
- XCON
  - A rule-based expert system
  - Used to determine the optimal information systems configuration
- New applications: Credit analysis, Marketing, Finance, Manufacturing, Human resources, Science and Engineering, Education, …

Structures of Expert Systems

1. Development Environment
2. Consultation (Runtime) Environment



Conceptual Architecture of a Typical Expert Systems

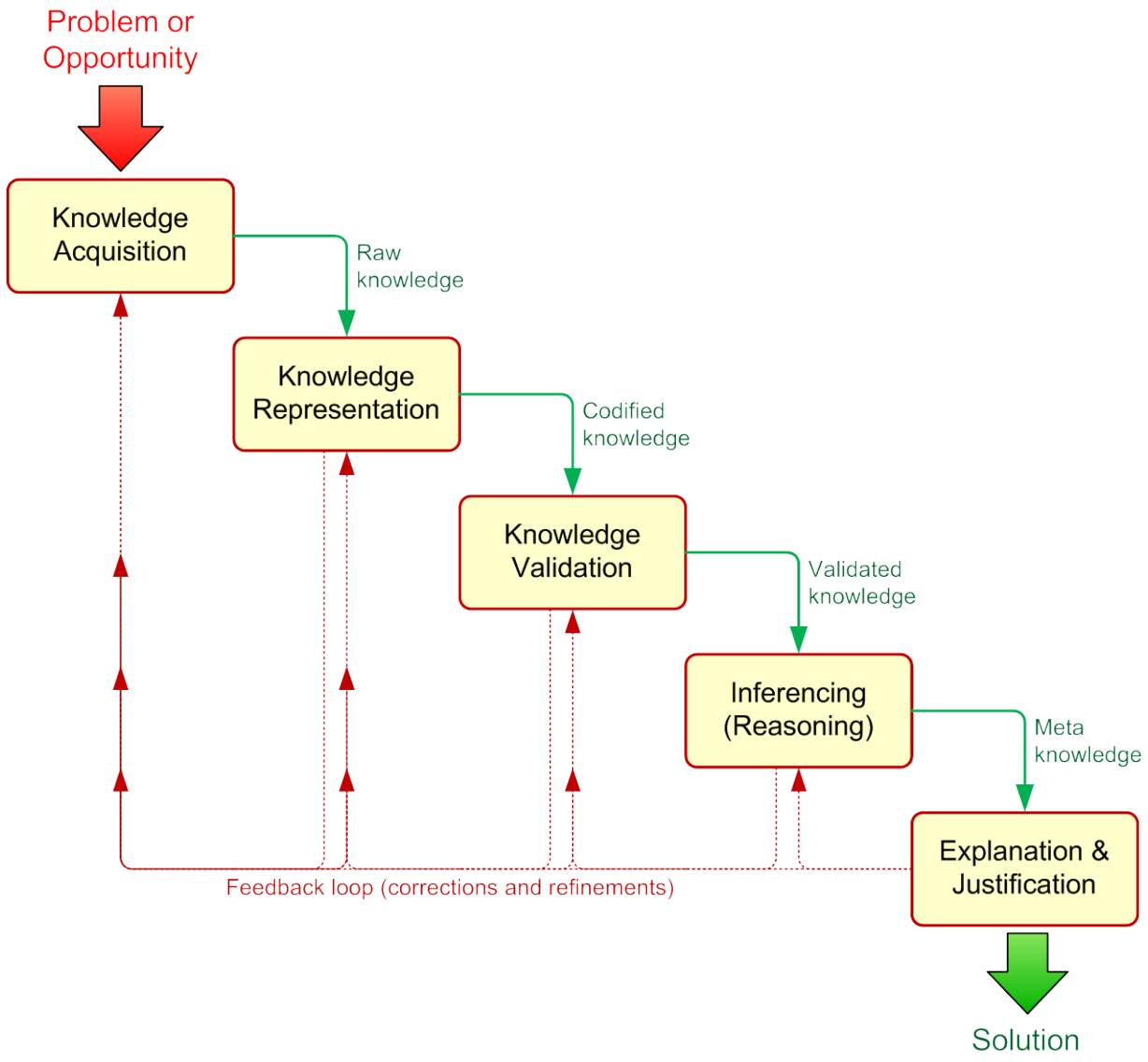


Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Knowledge Engineering (KE)

- A set of intensive activities encompassing the acquisition of knowledge from human experts (and other information sources) and converting this knowledge into a repository (commonly called a knowledge base)
- The primary goal of KE is
  - to help experts articulate *how they do what they do*, and
  - to document this knowledge in a reusable form

The Knowledge Engineering Process



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Machine Learning (ML) 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

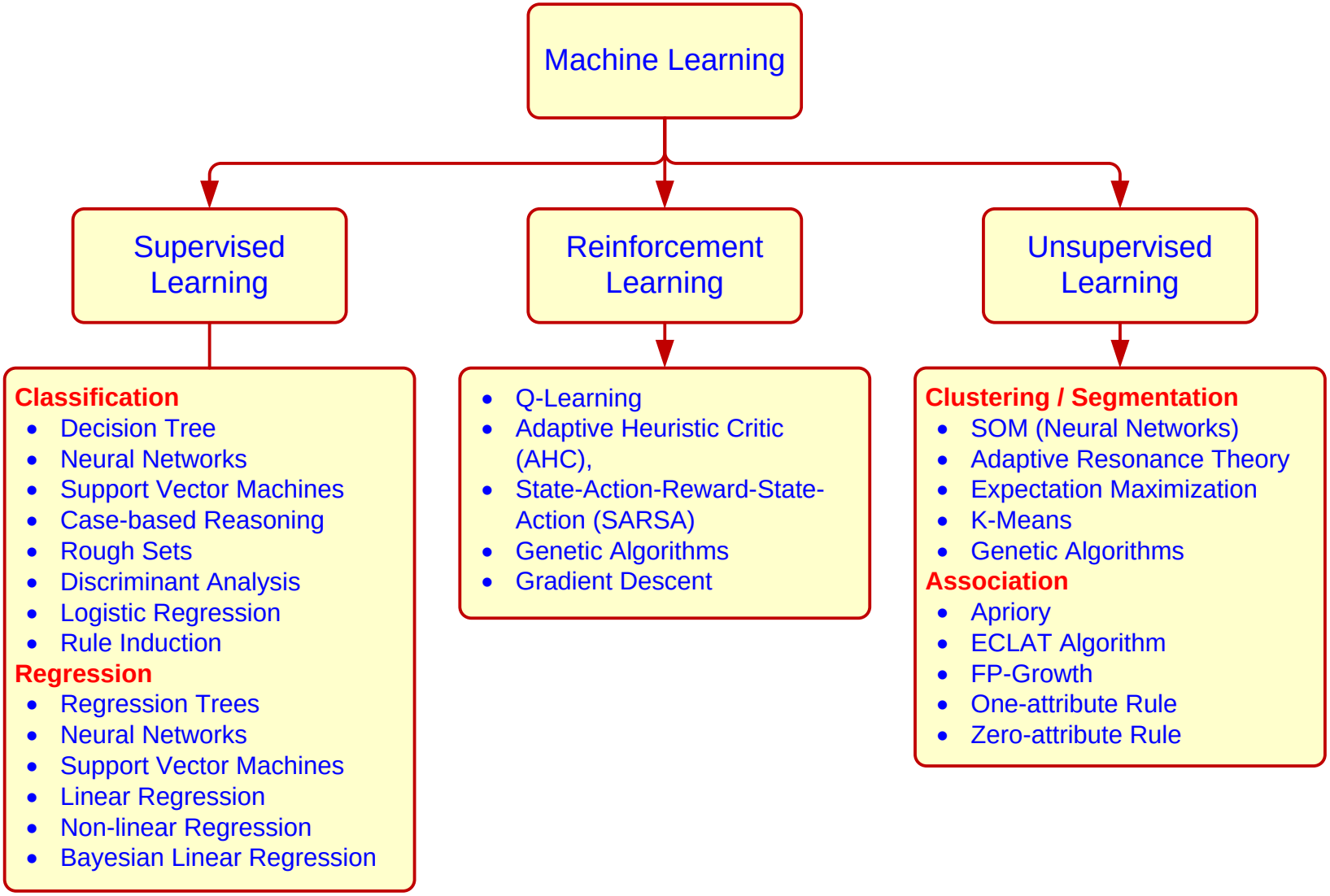
Machine Learning (ML) Concepts and Definitions

- 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 (ML) 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



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

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

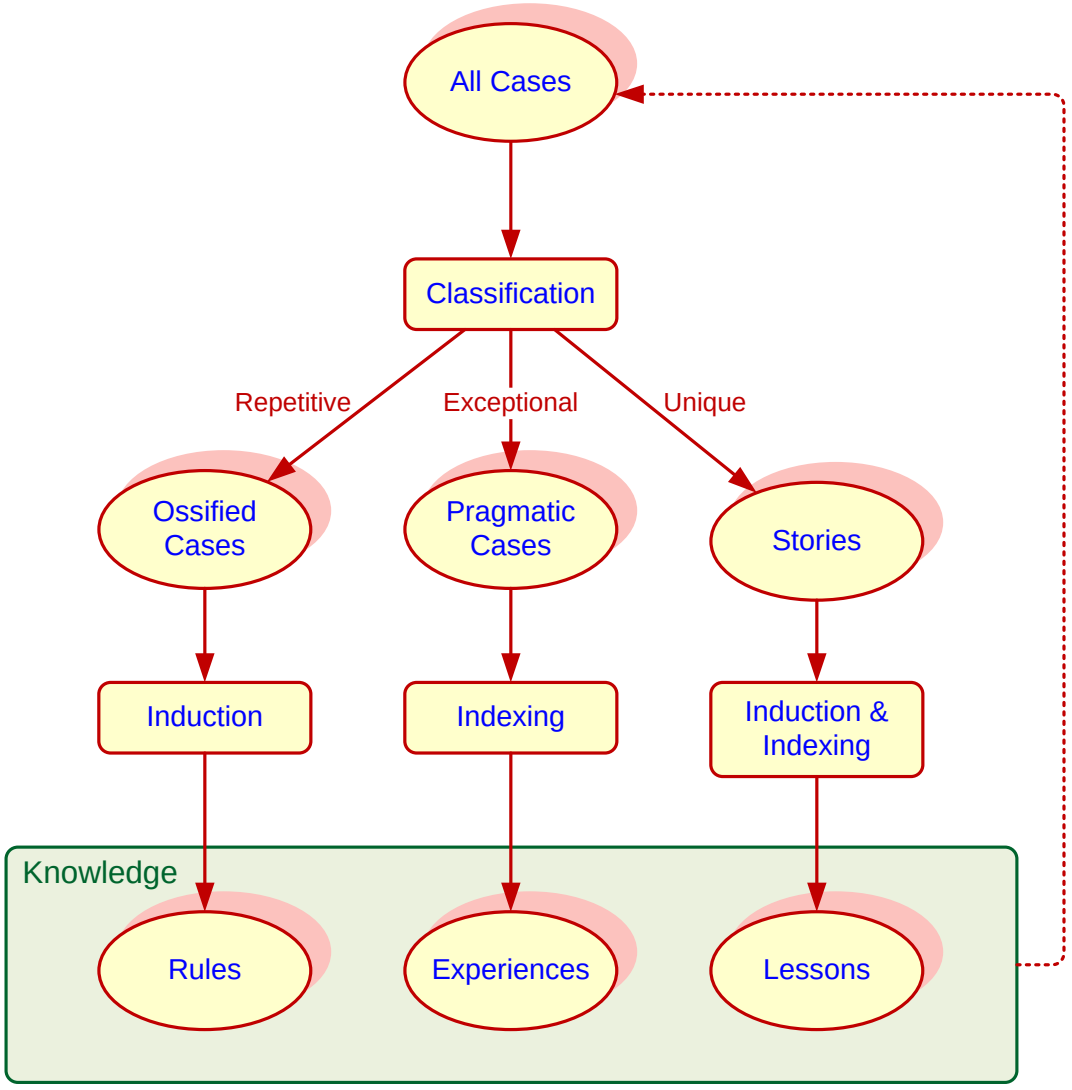
CBR vs. Rule-Based Reasoning

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

Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Case-Based Reasoning (CBR)

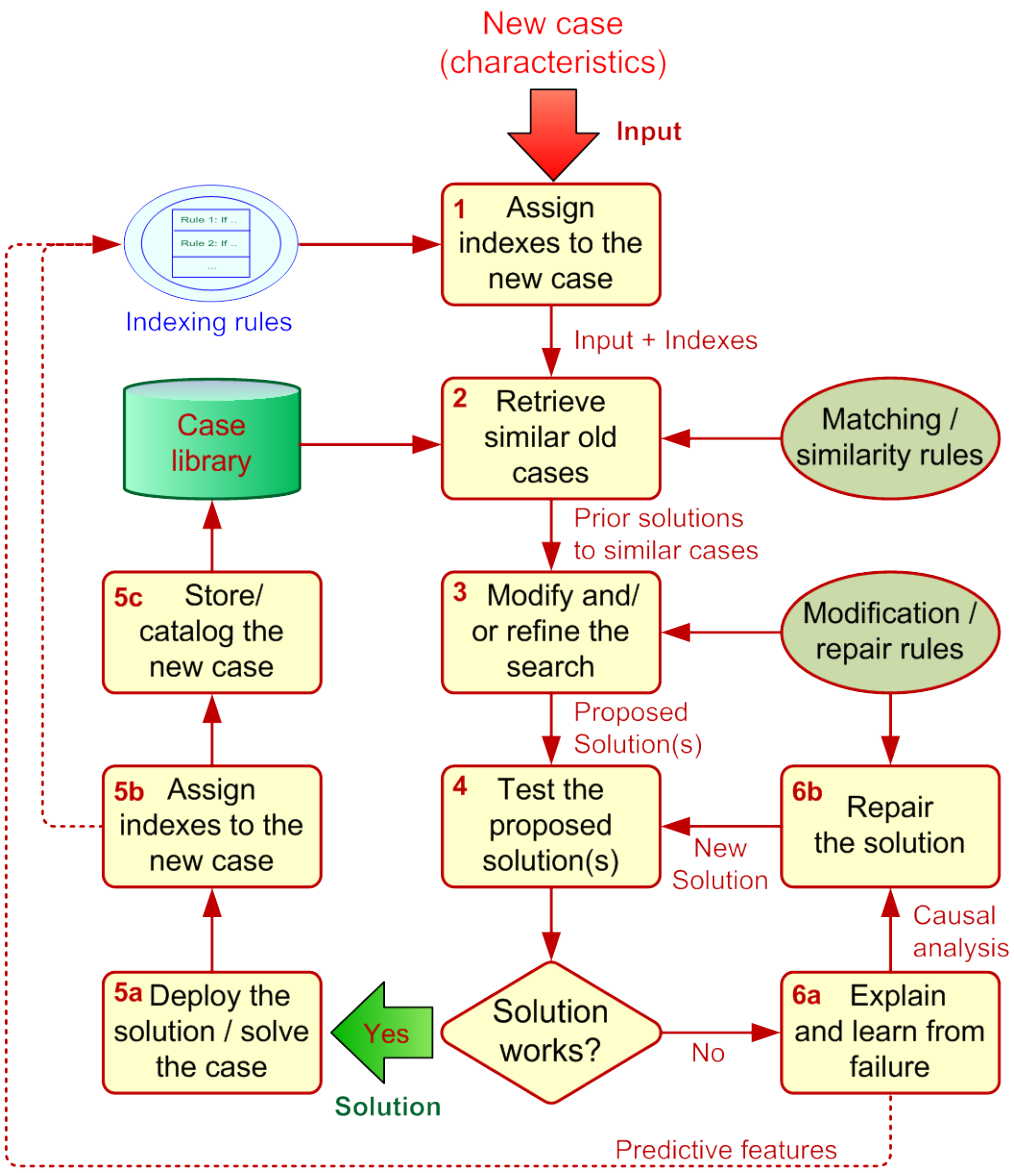
- CBR is based on the premise that new problems are often similar to previously encountered problems, and, therefore, past successful solutions may be of use in solving the current situation



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

The CBR Process

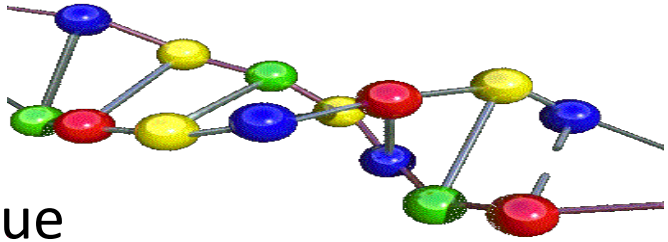
- The CBR Process (4R)
  - Retrieve
  - Reuse
  - Revise
  - Retain (case library)



Case-Based Reasoning (CBR)

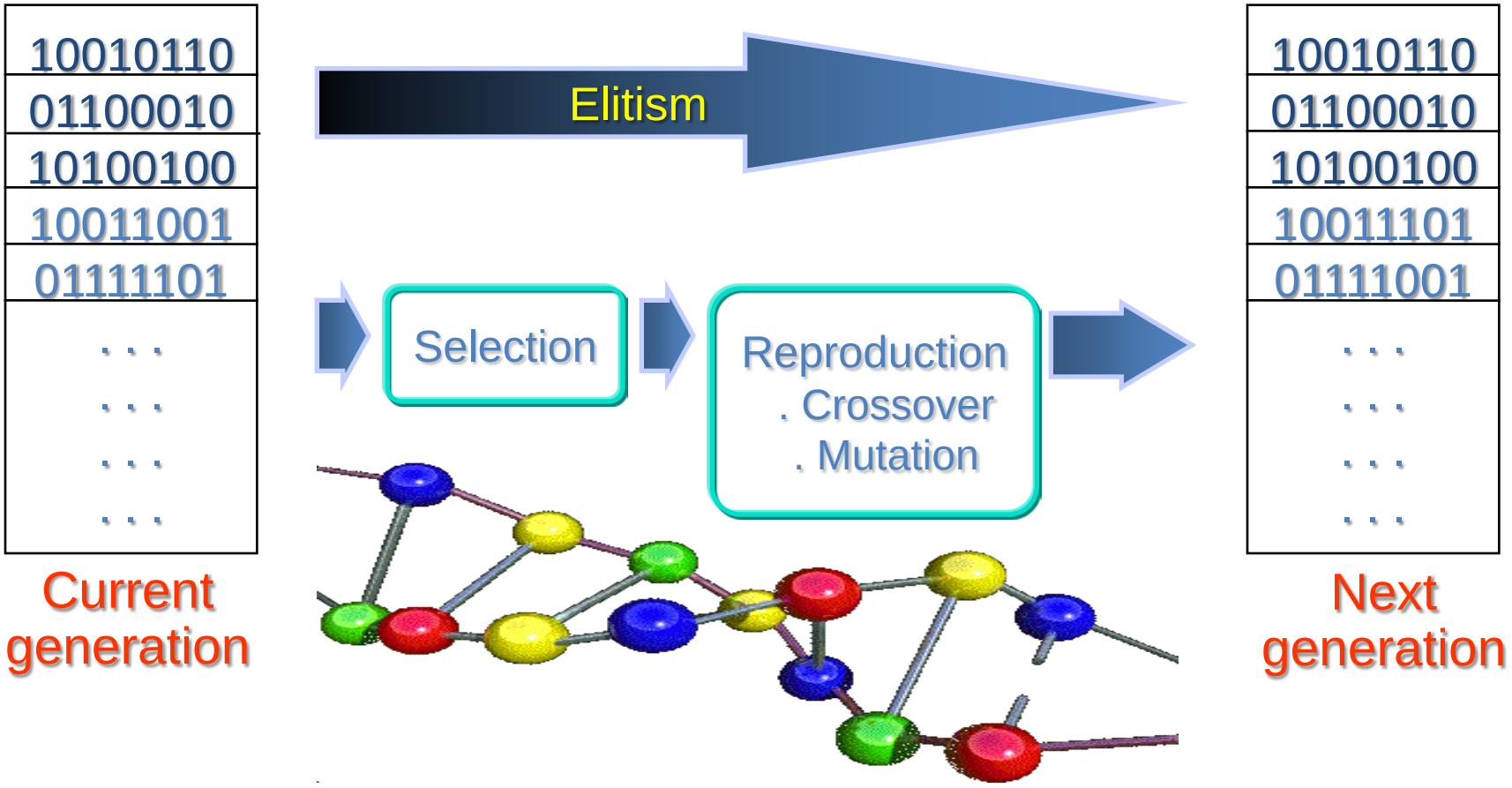
- Success factors for CBR systems
  - Determine specific business objectives
  - Understand your end users (the customers)
  - Obtain top management support
  - Develop an understanding of the problem domain
  - Design the system carefully and appropriately
  - Plan an ongoing knowledge-management process
  - 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 (GA)



- 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

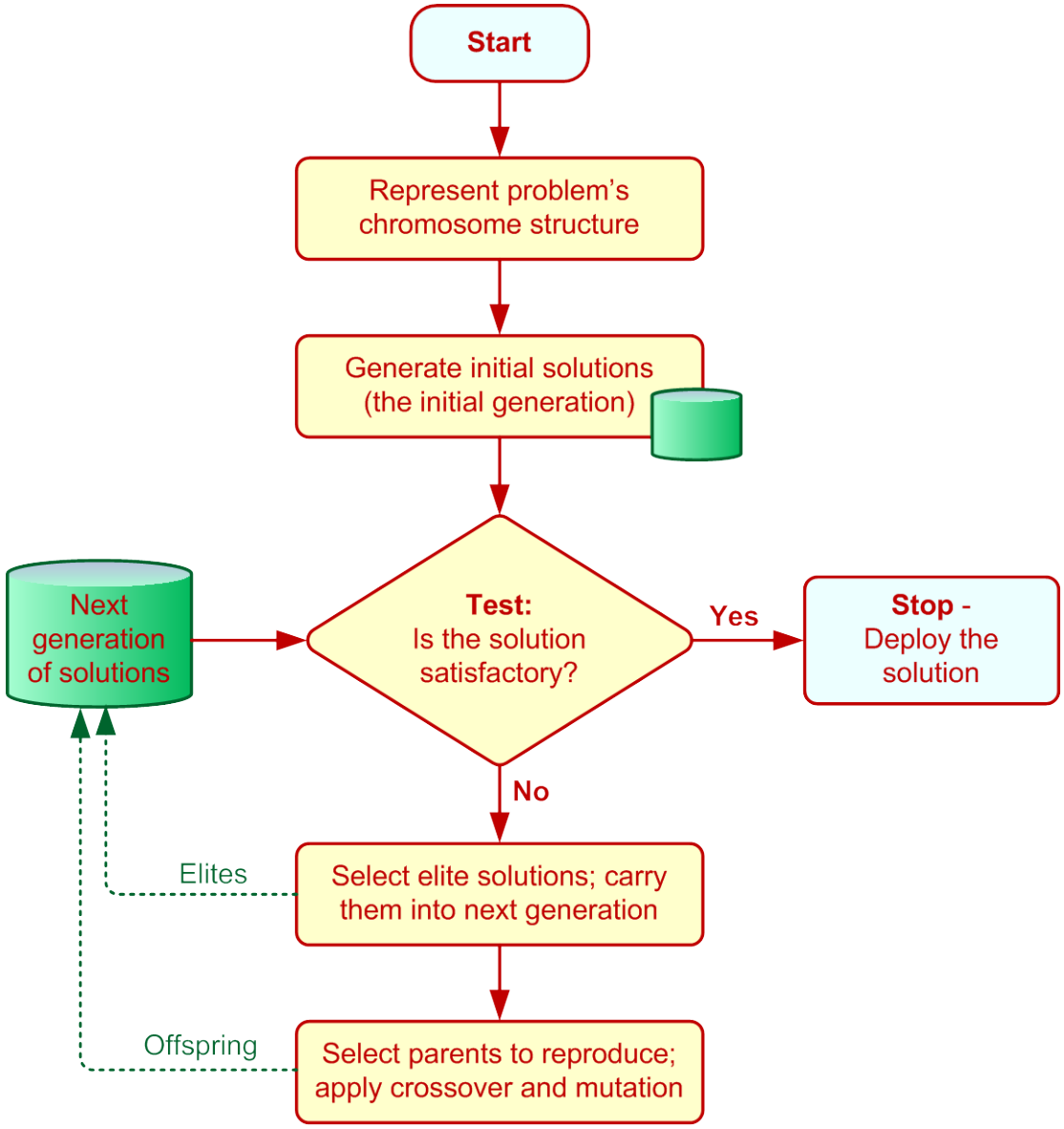
Evolutionary Algorithm



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

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



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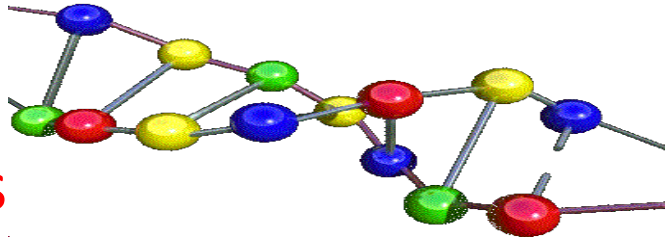
Genetic Algorithms (GA)



- 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

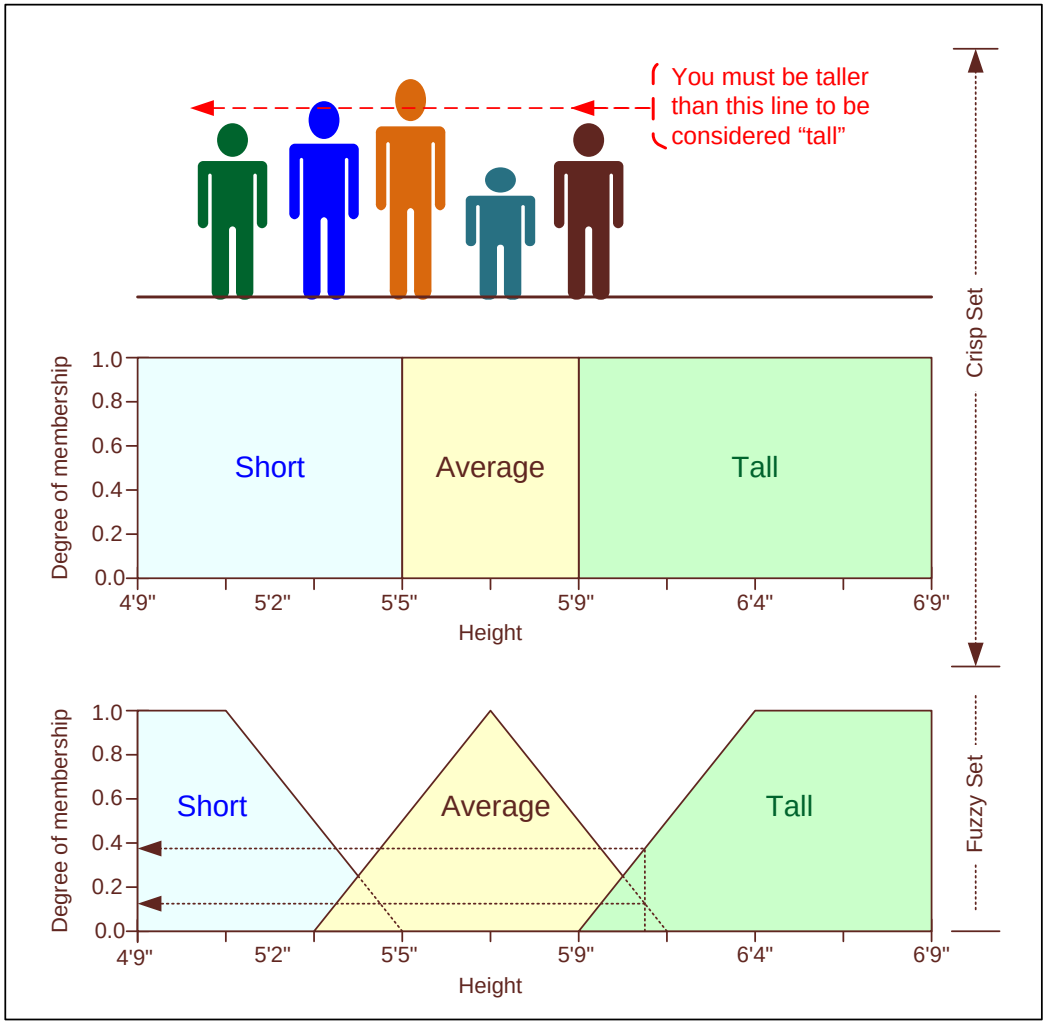
Fuzzy Logic and Fuzzy Inference System

- 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…

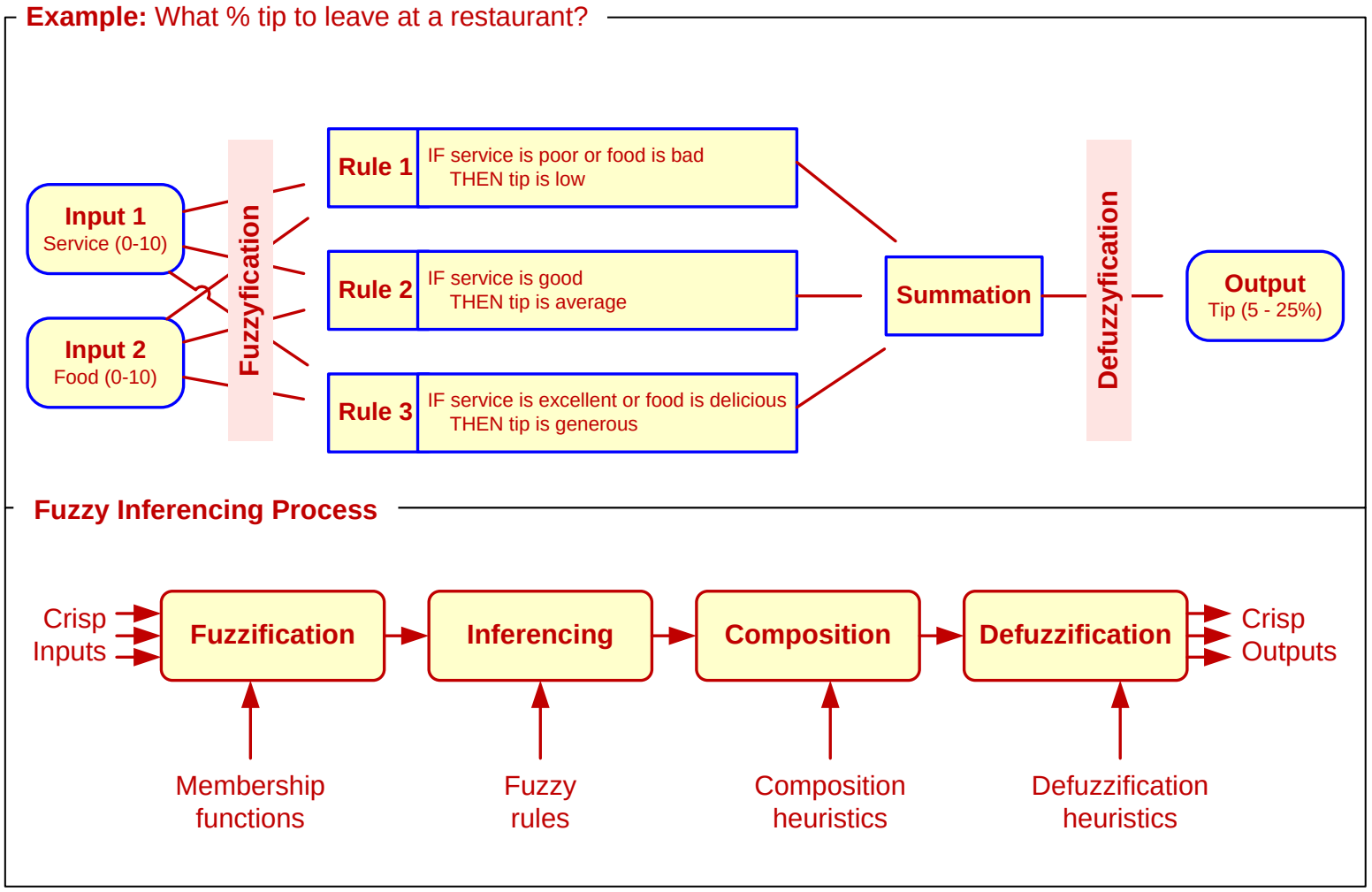
Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

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, …

Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Support Vector Machines (SVM)

- SVM are among the most popular machine-learning techniques
- SVM belong to the family of generalized linear models… (capable of representing non-linear relationships in a linear fashion)
- SVM achieve a classification or regression decision based on the value of the linear combination of input features
- Because of their architectural similarities, SVM are also closely associated with ANN

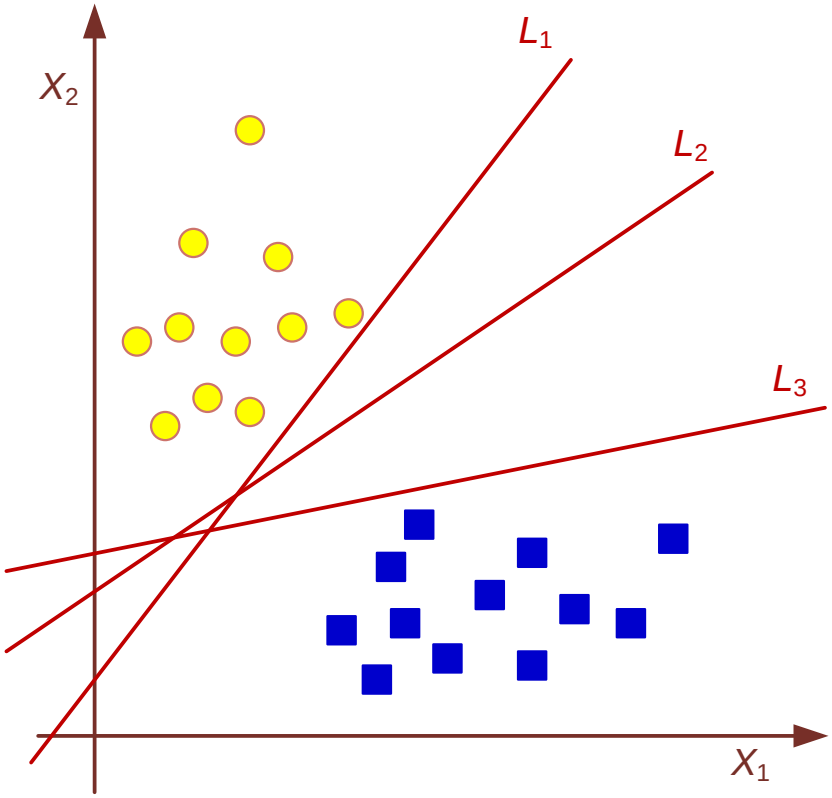
Support Vector Machines (SVM)

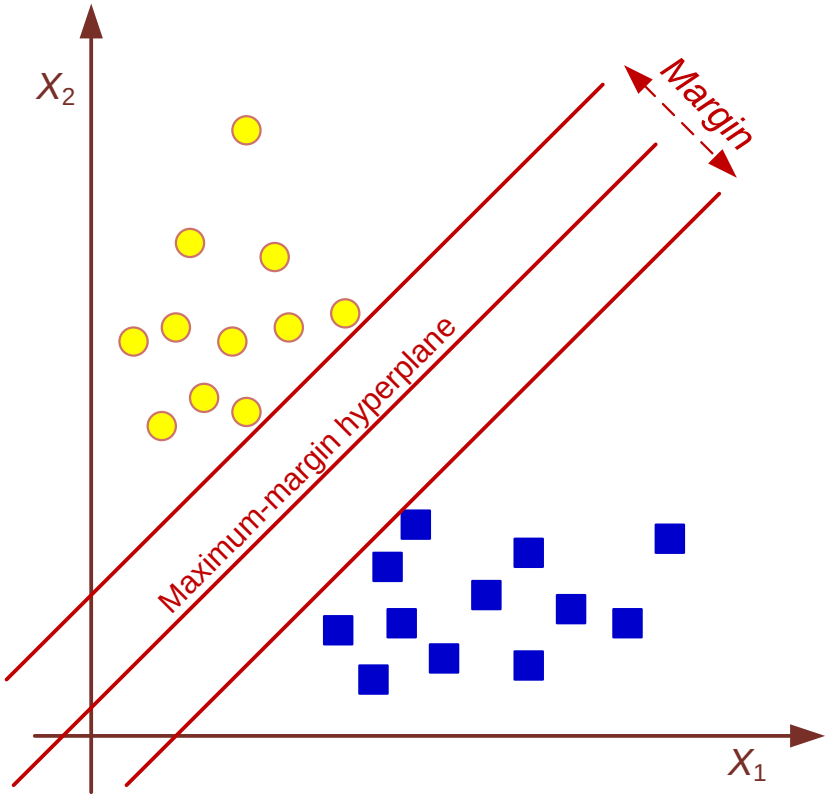
- Goal of SVM: to generate mathematical functions that map input variables to desired outputs for classification or regression type prediction problems
  - First, SVM uses nonlinear kernel functions to transform non-linear relationships among the variables into linearly separable feature spaces
  - Then, the maximum-margin hyperplanes are constructed to optimally separate different classes from each other based on the training dataset
- SVM has solid mathematical foundation!

Support Vector Machines (SVM)

- A hyperplane is a geometric concept used to describe the separation surface between different classes of things
  - In SVM, two parallel hyperplanes are constructed on each side of the separation space with the aim of maximizing the distance between them
- A kernel function in SVM uses the kernel trick (a method for using a linear classifier algorithm to solve a nonlinear problem)
  - The most commonly used kernel function is the radial basis function (RBF)

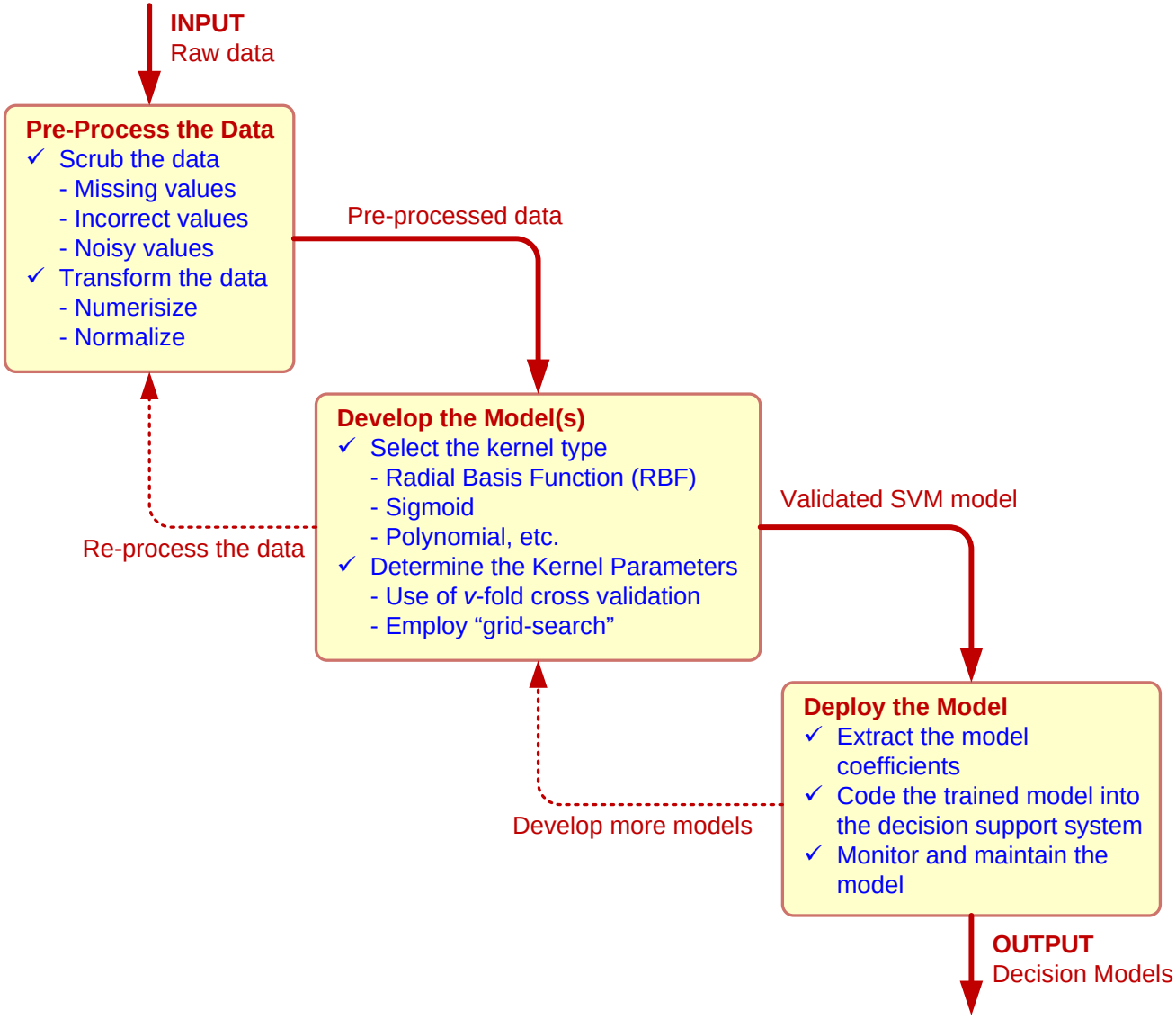
Support Vector Machines (SVM)





- Many linear classifiers (hyperplanes) may separate the data

The Process of Building a SVM



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

SVM Applications

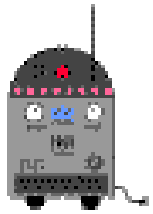
- SVM are the most widely used kernel-learning algorithms for wide range of classification and regression problems
- SVM represent the state-of-the-art by virtue of their excellent generalization performance, superior prediction power, ease of use, and rigorous theoretical foundation
- Most comparative studies show its superiority in both regression and classification type prediction problems

- SVM versus ANN?

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

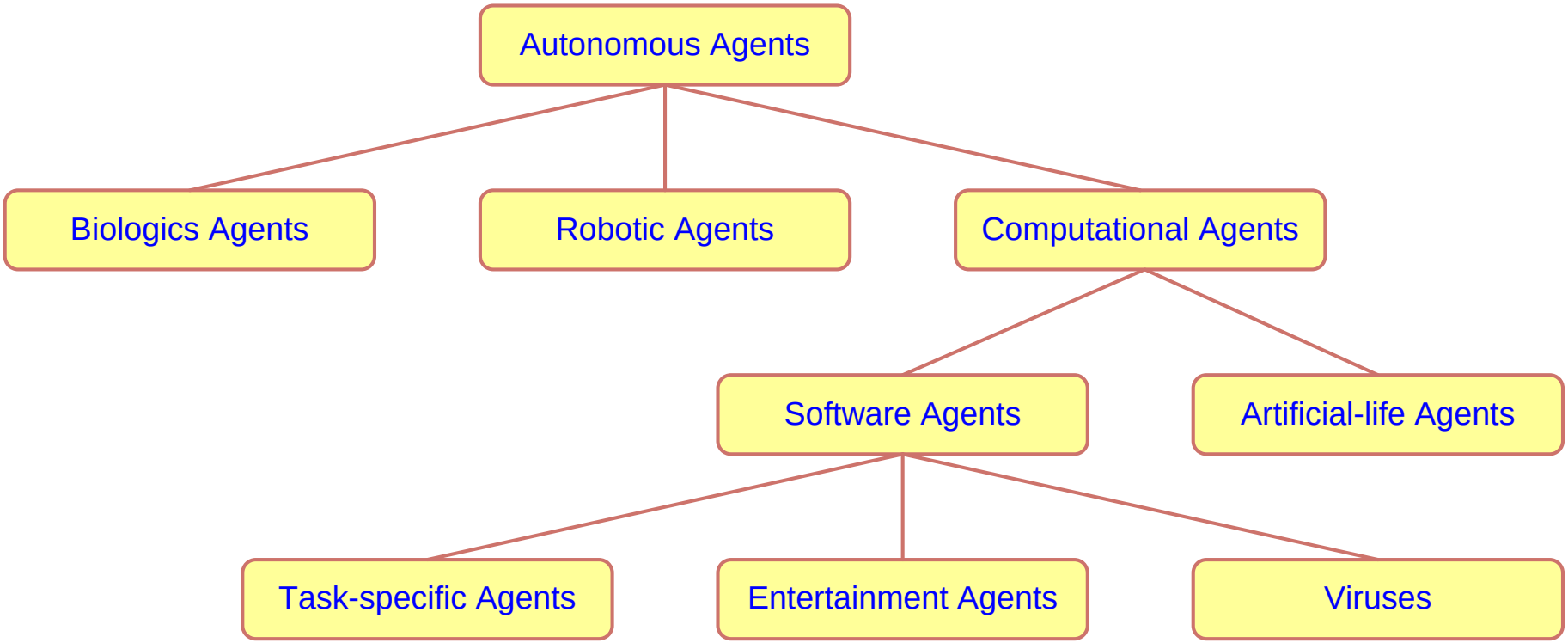
(Maes, 1995, p. 108)

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

Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

A Taxonomy for Autonomous Agents



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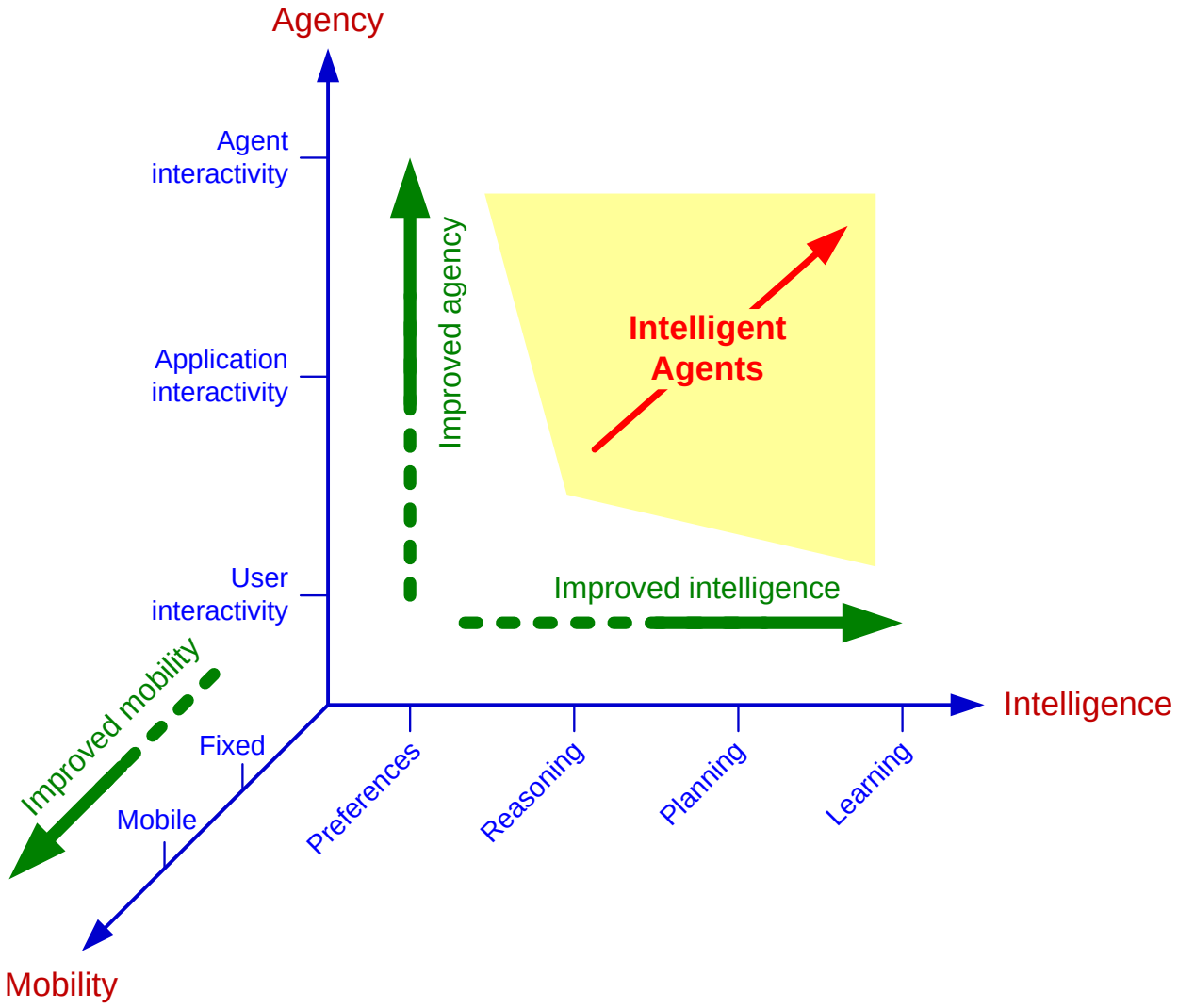
Intelligent Agents' Scope in Three Dimensions



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

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)

Leading Intelligent Agents Programs

- IBM [research.ibm.com/iagents]
- Carnegie Mellon [cs.cmu.edu/~softagents]
- MIT [agents.media.mit.edu]
- University of Maryland, Baltimore County [agents.umbc.edu]
- University of Massachusetts [dis.cs.umass.edu]
- University of Liverpool [csc.liv.ac.uk/research/agents]
- University of Melbourne (<URL>agentlab.unimelb.edu.au</URL>)
- Multi-agent Systems [multiagent.com]
- Commercial Agents/Bots [botspot.com]

Summary

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References

- Efraim Turban, Ramesh Sharda, Dursun Delen, Decision Support and Business Intelligence Systems, Ninth Edition, 2011, Pearson.