Mehran University of Engineering & Technology, Pakistan

Agent Based Intelligent Systems

INTRODUCTION

Department of Software Engineering

Course Content

Title of Subject	:	**Agent Based Intelligent Systems (SW-318)**
Discipline	:	Software Engineering (5th Semester)
Effective	:	17 Batch & onwards
Pre-requisite	:	None
Assessment	:	Theory: 20% Sessional, 80% Written Semester Examination (20% Mid, 60% Final)
Credit Hours	:	03 + 0 **Marks:** 100
Minimum Contact Hours:		45

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

CLOs	Description	Taxonomy level	PLO
1	Explain basic principles of Agent based Intelligent Systems, related theory and terminology.	C3	1
2	To understand and analyze NLP and NLP based techniques	C4	2
3	Create agent-based systems for different computing problems.	C5	3

PROGRAM LEARNING OUTCOMES (PLOs):

The course is designed so that students will achieve the following PLOs:

1	Engineering Knowledge:	☑	7	Environment and Sustainability:	☐
2	Problem Analysis:	☑	8	Ethics:	☐
3	Design/Development of Solutions:	☑	9	Individual and Team Work:	☐
4	Investigation:	☐	10	Communication:	☐
5	Modern Tool Usage:	☐	11	Project Management:	☐
6	The Engineer and Society:	☐	12	Lifelong Learning:	☐

Course Content

Course outline:

INTRODUCTION

Agent based modelling Definitions, Agents, concept of Rationality, Structure and Types of Agents, intelligent Agents, Environment types & properties.

INTELLIGENT AGENT SYSTEMS

Problem Solving, Searching - Heuristics -Constraint Satisfaction Problems - Game playing.

NATURAL LANGUAGE PROCESSING

NLP basic, NLP applications and research areas, NLG, NLU, NLP problems and possible solutions, Analysis levels in NLP, NLP system and algorithms.

AGENTS AND UNCERTAINITY

Acting under uncertainty – Probability Notation-Bayes Rule and use - Bayesian Networks-Other Approaches-Time and Uncertainty-Temporal Models- Utility Theory - Decision Network – Complex Decisions.

INTELLIGENT AGENTS & NEURAL NETWORKS

Artificial Neural Networks, Characteristics of ANN, Topologies of ANN, Basic Learning Laws of

Recommended Books:

1. Russell S.; Norvig P.; "Artificial intelligence – A Modern Approach", Latest Edition, Prentice Hall.
2. Michael Wooldridge, "An Introduction to Multi Agent System", John Wiley Latest Edition.
3. Coppin B.; "Artificial Intelligence Illuminated", Latest Edition, Jones and Bartlett Publishers USA.

Artificial Intelligence

- It is the science and engineering of making:
  - Intelligent machines
  - Intelligent computer programs.

- It is related to the task of:
  - Using computers to understand human intelligence,
  - Not restricting itself to methods that are biologically observable.

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Artificial Intelligence (Cont.)

- INTELLIGENCE can be defined as:
  - Learn or understand from experiences
  - Make sense out of ambiguous and contradictory messages
  - Respond quickly and effectively to a new situation
  - Deal with complex situations
  - Applying knowledge to manipulate the environment
  - Does not mean how fast the information is processed
  - Ability to demonstrate the intelligence by communicating effectively (by any mean)
  - Learning new concepts (by any mean).

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Other Artificial Intelligence definitions:

- AI is a collection of hard problems which can be solved by humans and other living things, but for which we don't have good algorithms for solving.
  - e. g., understanding spoken natural language, medical diagnosis, circuit design, learning, self-adaptation, reasoning, chess playing, proving math theories, etc.
- A computer program that
  - Acts like human (Turing test)
  - Thinks like human (human-like patterns of thinking steps)
  - Acts or thinks rationally (logically, correctly)
- The art of creating machines that perform functions that require intelligence when performed by humans.

What's easy and what's hard for AI?

- It's been easier to mechanize many of the high level cognitive tasks we usually associate with "intelligence" in people
  - e. g., symbolic integration, proving theorems, playing chess, some aspect of medical diagnosis, etc.
- It's been very hard to mechanize tasks that animals can do easily
  - catching prey (animal to animal hunt)
  - interpreting complex sensory information (visual, aural, …)
  - modeling the internal states of other animals from their behavior
  - working as a team (ants, bees)
- Some complex problems (e.g., solving differential equations, database operations) are not subjects of AI

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Artificial VS Natural Intelligence

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Advantages of Artificial Intelligence:

- ***AI is more permanent.***
  - Natural intelligence is perishable from a commercial standpoint in that human can change their information.
  - AI is permanent as long as the computer systems or programs remain unchanged.
- ***AI offers ease of duplication and distribution.***
  - Transferring a body of knowledge from one person to another usually requires a lengthy process, yet fully expertise can never be transfer.
  - However, knowledge embodied in computer systems can be copied or duplicated to another and so on.
- ***AI can be less expensive that natural intelligence.***
  - Some times buying computer software costs less than having corresponding human power to carry out same task.
- ***AI can be documented.***
  - Decisions made by a computer can be easily documented by tracing the activities of a system, while natural intelligence is difficult to trace out.

Advantages of Natural Intelligence:

- ***Natural Intelligence is creative, while AI is uninspired.***
  - The ability to acquire knowledge is inherent in human mind, but with AI customized knowledge must be built into a carefully constructed system.
- ***Natural intelligence enables people to benefit from and use sensory experience directly,***
  - while AI mostly works on symbolic inputs.
- ***Natural intelligence is able to make reasons at all times by wide context of experience and bring it to bear on individual problems.***
  - While AI systems typically gain their power of knowledge by having a narrow focus of problem domain.
- ***Natural Intelligence is powerful but has limitations.***
  - Humans are intellectual but have limited knowledge bases, and information processing is comparably slow in brain when done with computers.

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How AI Works:

- **Think well**
- **Act well**
- **Think like humans**
- **Act like humans**

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Think well

- Develop:
  - Formal models of knowledge representation
  - Reasoning
  - Learning
  - Memory
  - Problem solving that can be rendered in algorithms.

- There is often an special importnace on systems that are provably correct, and guarantee finding an optimal solution.

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Act well

- For a given **set of inputs**:
  - Generate an appropriate output that is not necessarily correct but gets the job done.

- A **heuristic** (**heuristic rule**, **learning/discover for yourself method**) is:
- Rule of thumb
- Strategy
- Trick
- Simplification
- Any kind of device which drastically limits search for solutions in large problem spaces.

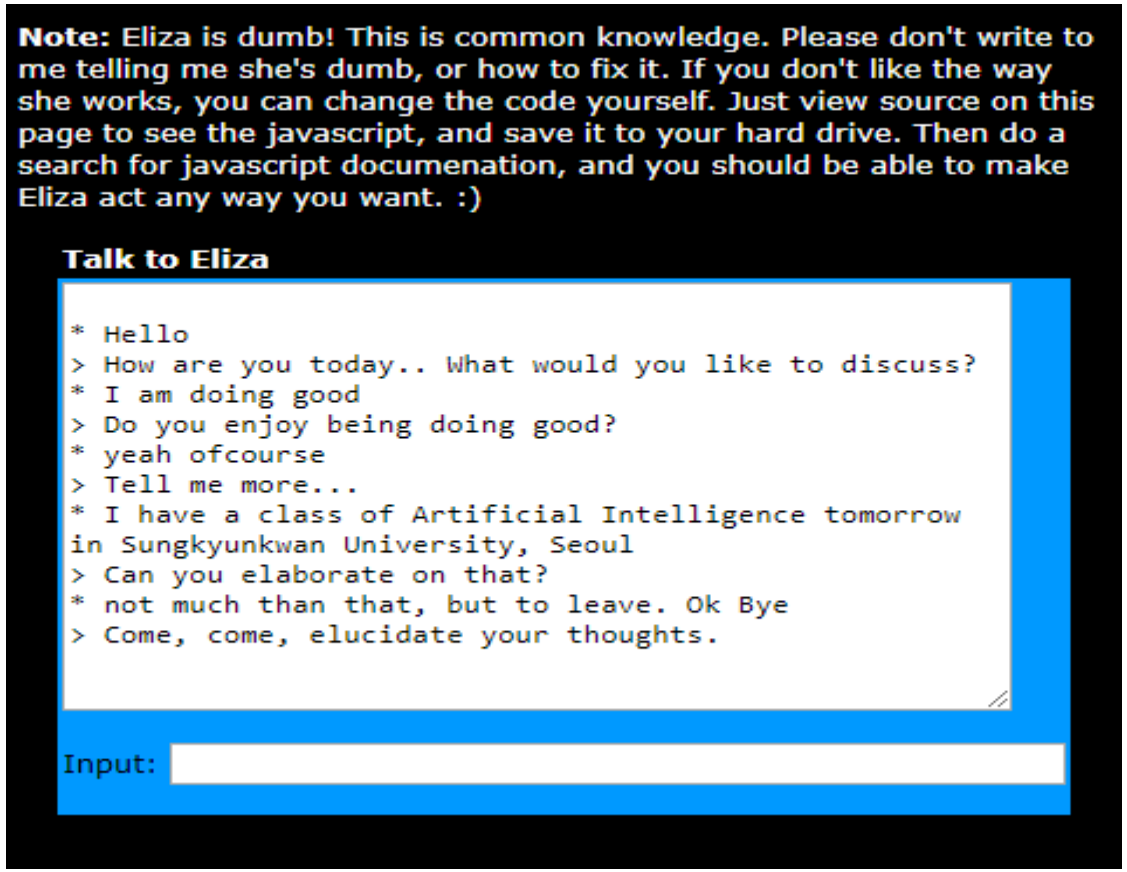
- Heuristics do not guarantee optimal solutions:
  - In fact, they do not guarantee any solution at all.
  - **Offers a solutions which is good enough most of the time.**

Think like humans

- Cognitive (A process of getting knowledge) science approach
- Focus not just on behavior and I/O but also look at reasoning process.
- Computational model should reflect "**how**" results were obtained.
- Provide a **new language** for expressing cognitive theories and new mechanisms for evaluating them
- **GPS (General Problem Solver):**
  - Goal not just to produce humanlike behavior, but to produce a sequence of steps of the reasoning process that was similar to the steps followed by a person in solving the same task.
- **ELIZA:** A program that simulated a psychotherapist interacting with a patient and successfully passed the Turing Test.

Think like humans

- **ELIZA:** A program that simulated a psychotherapist interacting with a patient and successfully passed the Turing Test.



Act like humans

- Behaviorist approach.
- Not interested in how you get results, just the similarity to what human results are.
- Exemplified by the Turing Test (Alan Turing, 1950).

Turing Test

- Three rooms contain a person, a robot, and an interrogator.
  - The interrogator can communicate with the other two.
  - The interrogator tries to determine which the person is and which the machine is.
  - The machine tries to fool the interrogator into believing that it is the person.
  - If the machine succeeds, then we conclude that the machine can think.

Some Example Applications

- **Computer vision:** face recognition from a large set (Interpreting Images)
- **Robotics:** autonomous (mostly) automobile
- **Natural language processing:** simple machine translation
- **Expert systems:** medical diagnosis in a narrow domain
- **Spoken language systems:** ~1000 word continuous speech
- **Planning and scheduling:** Hubble Telescope experiments
- **Learning:** text categorization into ~1000 topics
- **Games:** Grand Master level in chess (world champion), checkers, etc.

State of Art (of AI)

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State of the Art

- Deep Blue beats Kasparov.
- Sojourner, Spirit, and Opportunity explore Mars.
- NASA Remote Agent in Deep Space I probe explores solar system.
- DARPA grand challenge: Autonomous vehicle navigates across desert and then urban environment.
- iRobot Roomba automated vacuum cleaner, and PackBot used in Afghanistan and Iraq wars.
- Automated speech/language systems for airline travel.
- Spam filters using machine learning.
- Question answering systems automatically answer factoid questions.
- Usable machine translation thru Google.

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AI Application Areas

Game Playing:

- Involves mostly the research on **board games** as:
  - Have certain properties that made them ideal subjects for early work on AI.

- These properties include:
  - Well defined set of rules
  - Easy board configuration representation in computers
  - Easy implementation of state space search and many others.

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Game Playing:

- Games Playing:
  - Generate extremely large search spaces.
  - These spaces are large and complex enough to require powerful ***techniques*** for determining what alternatives to explore in the problem space.
  - These techniques are called ***heuristics*** and constitute a major area of AI research.

- A ***heuristic*** is a useful but potentially fallible problem-solving strategy:
  - Like checking to make sure that an unresponsive appliance is plugged in before assuming that it is broken
  - to castle in order to try and protect your queen from capture in a chess game.

- Much of what we commonly call intelligence seems to reside in the heuristics used by humans to solve problems.

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Automated reasoning and Theorem proving:

- When the system is required to do something that it has not been explicitly told how to do:
  - it must reason - it must figure out what it needs to know from what it already knows.
- The study in automated reasoning helps:
  - Producing software which allows computers to reason completely or nearly completely, automatically.
- Automated theorem proving:
  - Attempts to find proofs to theorems which are usually assumed to be true.
  - Early efforts to create theorem provers were not much successful because of:
    - Generation of infinite non-relevant provable theorems.
    - With the time grew, the results got better and better.

Expert Systems:

- These are the programs that serve:
  - Either in place or for assistance of human experts.
- They rely on:
  - Domain knowledge
  - Problem solving strategies of human experts incorporated in them.
- One of the earliest expert system was DENDRAL:
  - that used to conclude the structure of organic molecules from their chemical formulas
  - The mass spectrographic information about the chemical bonds present in the molecules.
- Another important system was MYCIN:
  - Diagnose bacterial diseases.
  - It served as **Base** for establishment of methodology of development of many other systems.

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Natural Language Processing

- Natural language is human language.
- Natural-language-processing
  - Programs use artificial intelligence to allow a user to communicate with a computer in the user's natural language.
  - The computer can both understand and respond to commands given in a natural language.
- It involves much more than:
  - Analyzing sentences into individual parts of speech
  - Looking those words up in a dictionary.
- It also requires extensive knowledge about the domain in concern.

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Robotics & Planning:

- It is a difficult problem for a number of reasons, not the least of which is the size of space of possible sequences of moves.

- For example:
  - A simple robot that can move forward, backward, right or left can have indefinite ways of moving around a room with obstacles.
  - While humans plan effortlessly, creating a computer program that can do the same is a difficult challenge.
  - So this has been an important topic of research for AI researchers.

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Languages & Environments:

- Major AI languages are Python, R, Prolog and LISP.
- PROLOG is a:
  - Logic-based language.
  - Presents with a set of facts, rules, and goals, and it attempts to prove that the goals are true by applying the rules to the facts.
    - If it succeeds it proving the goal, it has established the truth of that goal
    - if it does not, it has established that the goal is false or at least that there is not enough information to determine whether it is true or false.
- The main distinguishing point of Lisp is:
  - In Lisp, *everything* is a list (the name "Lisp" means "List Processing").
  - It was found that artificial intelligence applications often required the use of many lists of items; hence in Lisp essentially everything is a list.

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Languages & Environments:

- Major AI languages are Python, R, Prolog and LISP.
- PYTHON is:
  - Considered to be in the first place in the list of all AI development languages due to the simplicity.
  - The syntaxes belonging to python are very simple and can be easily learnt.
  - It takes short development time in comparison to other languages like Java, C++ or Ruby.
- R is:
  - The most effective language and environment for analyzing and manipulating the data for statistical purposes.
  - Using R, we can easily produce well-designed publication-quality plot, including mathematical symbols and formulae where needed.
  - It has numerous of packages like RODBC, Gmodels, Class and Tm which are used in the field of machine learning.

Machine Learning:

- It is concerned with:
  - The design and development of algorithms, that allow computers to evolve behaviors based on empirical data, such as from sensor data or databases.

- A learner can take advantage of examples (data) to capture characteristics of interest of their unknown underlying probability distribution.

  - It is a difficult problem for AI programs, in spite of their success as problem solvers.

  - This is severe and most expert systems creates difficulties by the inflexibility of their problem solving strategies.

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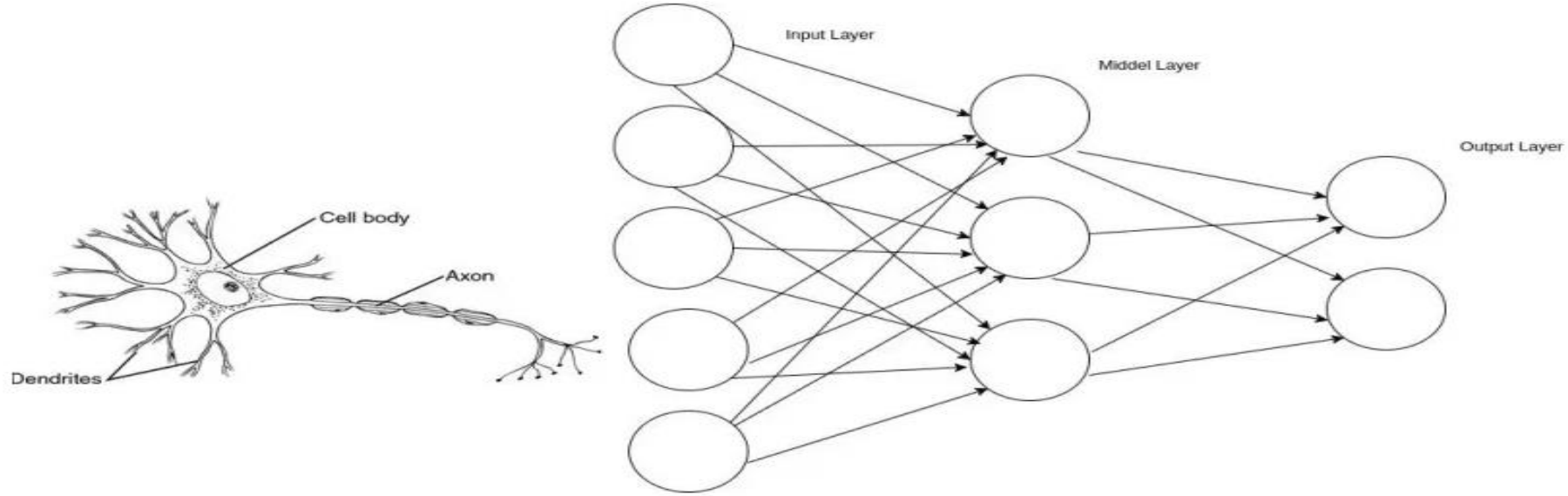
Artificial Neural Networks:

- An **artificial neural network (ANN):**
  - Usually called "neural network" (NN),
  - Is a mathematical model or computational model
  - Tries to simulate the structure and/or functional aspects of biological neural networks.
  - It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation.



Computer Vision

- **Computer vision** is the science and technology of machines:
  - **See**, where ***see*** in this case means that the machine is able to extract information from an image that is necessary to solve some task.
- It is concerned with the theory behind artificial systems that extract information from images.
- The image data can take many forms:
  - Video sequences
  - Views from multiple cameras
  - Multi-dimensional data from a medical scanner.
- The goal of computer vision research is to give computers the same powerful facility for understanding of their surroundings.