Introduction to Artificial Intelligence

MODULE 04
Expert Systems

Department of Computer Science, YIASCM

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Module 4: Expert System **(8 Hours)**

Expert System: Need and justification for expert systems, knowledge acquisition, Case studies: MYCIN, R1 Learning: Concept of learning, learning automation, genetic algorithm, learning by inductions, neural nets

Introduction to Expert Systems

An **expert system** is a computer program designed to mimic the decision-making ability of a human expert in a specific field.

Expert systems are made up of two parts:

- A knowledge base that stores facts and rules,
- And an inference engine that uses those rules to draw new conclusions

- It uses knowledge and inference rules to solve complex problems, often requiring specialized expertise.
- Expert systems are a key application of artificial intelligence (AI), and they are used in domains such as medical diagnosis, engineering, finance, and more.

Applications of Expert Systems

- **Medical Diagnosis**: Systems like MYCIN assist doctors in diagnosing infections by suggesting treatments based on symptoms.
- **Financial Services**: They are used for credit risk evaluation, investment analysis, and fraud detection.
- **Manufacturing**: They help optimize processes, troubleshoot machinery, and ensure quality control.
- **Customer Support**: Expert systems power automated customer service systems, providing solutions based on common issues and queries.

Components of an Expert System

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1. Knowledge Base:

Core component that stores all the domain-specific knowledge needed for the expert system to function. It consists of: Facts, Rules.

2. Inference Engine

- This component is the "brain" of the expert system.
- It applies logical reasoning to the knowledge base to draw conclusions or make decisions.

3. User Interface

- This is the component through which users interact with the expert system.
- It can be a graphical user interface (GUI), CUI (Character User Interface), or web-based interface.
- That allows users to input data and receive outputs.

- Example for CUI, MS-DOS allows the user to navigate, open, and otherwise manipulate files on their computer from a command line instead of a GUI like Windows.

4. Explanation Facility

- This component provides users with explanations of how the expert system arrived at its conclusions or recommendations.
- It helps users understand the reasoning process and increases trust in the system.

5. Knowledge Acquisition Module

- This component is responsible for gathering, updating, and maintaining the knowledge base.
- It can involve interactions with domain experts to capture their knowledge and ensure the system stays current with new information

Advantages of Expert System

- **Consistency in Decision-Making:** Provides reliable and uniform outputs based on the same inputs, reducing variability due to human factors.
- **Availability:** Operate continuously, providing access to expertise at any time, which is crucial for critical applications.
- **Efficiency and Speed:** Process large amounts of data rapidly, enabling quicker decision-making than human experts.
- **Cost-Effective:** Can reduce labor costs over time by automating routine tasks and minimizing human error.
- **Knowledge Preservation:** Captures and retains the expertise of human specialists, making it accessible to future users.
- **Training and Education:** Can be used as training tools for less experienced individuals, improving their knowledge and skills.

Disadvantages of Expert System

- **Limited to Knowledge:** Expert systems are only as good as the knowledge encoded in them: rosy may struggle with situations not covered in the knowledge base.
- **High Initial Development Costs:** Developing an expert system can be expensive and time-consuming due to the complexity of capturing and encoding knowledge.
- **Maintenance Challenges:** Keeping the knowledge base updated requires ongoing effort and outdated information can lead to poor decisions.

Expert systems differ from regular software

Expert Systems	Regular Software
Relies on a rich knowledge base specific to a domain.	Typically follows fixed procedures without extensive knowledge.
Uses reasoning and inference to simulate human decision-making.	Executes predefined algorithms without reasoning.
Can be updated with new knowledge and rules easily.	Requires extensive rewriting for changes.
Features advanced interfaces for interactive problem-solving.	Usually has simpler interfaces focused on task execution.

Provides explanations for conclusions and recommendations.	Generally lacks insight into processes.
Tailored for specific domains, leveraging specialized knowledge.	Often general-purpose and may lack depth of expertise.
May incorporate machine learning to improve over time.	Generally lacks adaptive learning capabilities.
Solves complex problems requiring human-like expertise.	Suited for straightforward, routine tasks.

Knowledge engineers contribute to the knowledge acquisition process

Knowledge acquisition is the process of obtaining, organizing, and structuring knowledge from various sources and then using it to develop something.

- Knowledge engineers play a crucial role in the knowledge acquisition process of expert systems.
- Their expertise lies in extracting, structuring, and formalizing knowledge from human experts and other sources.
- To create a robust knowledge base that the expert system can use effectively.

Contribution

1. Identifying Knowledge Sources

- Knowledge engineers work closely with domain experts to identify and extract relevant knowledge.
- They conduct interviews, surveys, and workshops to gather insights into the expert's thought processes, decision-making criteria, and problem-solving strategies.
- They analyze existing documentation, manuals, and databases related to the domain to identify useful information that can be included in the knowledge base.

2. Knowledge Representation

- Knowledge engineers are responsible for organizing and structuring the acquired knowledge in a way that the expert system can process.
- They convert expert insights into formal rules and heuristics (if-then statements, for example) that can be programmed into the expert system.

3. Creating a Knowledge Base

- Knowledge engineers compile the structured knowledge into a knowledge base.
- This involves not only entering the knowledge but also ensuring its integrity, consistency, and relevance.
- They may need to refine and update the knowledge base based on feedback from testing and real-world use.

4. Knowledge Validation and Testing

- This involves checking whether the system's reasoning aligns with expert judgment and whether the outputs are accurate and reliable.
- They conduct testing to ensure the system works as intended, debugging any issues that arise.

5. User Training and Support

- Knowledge engineers often provide training to end-users and domain experts on how to interact with the expert system effectively.
- They gather user feedback on the system's performance and utility.

Types of Learning

- Supervised Learning
- Unsupervised Learning
- Semi-Supervised Learning
- Reinforcement Learning

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Learning automation

- Using machine learning to enable systems to learn and adapt to perform tasks more efficiently.
- Systems can learn from their rules and automatically discard or assign low certainty factors to rules that don't contribute.

Tools and techniques for automating learning processes

1. **Data Preparation Automation**

- Tools like Scrapy and Beautiful Soup automate the extraction of data from web pages or APIs, gathering large datasets quickly.
- Platforms like Trifacta and OpenRefine can automatically detect and correct data quality issues, such as duplicates, missing values.

2. Model Selection and Tuning Automation

- Tools like Google Cloud AutoML, and Microsoft Azure AutoML evaluate multiple algorithms and select the best-performing models based on specific criteria.
- Techniques like random search, and grid search automate the process of finding the optimal hyperparameters for models.

3. Training Automation

- Tools like Jenkins, GitLab CI (Continuous Integration), and CircleCI automate the process of training and deploying models,
- Ensuring that new data and changes are automatically integrated into the production environment.

4. Monitoring and Maintenance Automation

- Automated systems can analyze incoming data distributions and compare them with training data
- To detect concept drift, indicating that the model may need retraining.

MYCIN and R1

- The form –mycin comes from a combination of two elements. The first is Greek mýkos, meaning "fungus." The second is the suffix -in, a variant of –ine, which is used to name chemical terms. The form –mycin literally refers to **chemicals from fungus (or fungus-like bacteria)**.
- It is a software program
- Primarily designed to diagnose bacterial infections and recommend antibiotics
- R1- Used to configure orders of computer systems

Design of MYCIN

- MYCIN was developed at Stanford University to diagnose bacterial infections and recommend antibiotics.
- It utilized a rule-based system where knowledge about infections and treatment was encoded in the form of production rules (if-then).
- MYCIN employed a backward chaining reasoning approach, starting with the conclusion (diagnosis) and working backward to gather the necessary evidence (symptoms, patient history).

Impact of MYCIN

Influence on Expert Systems:

- MYCIN demonstrated the effectiveness of rule-based systems in complex decision-making domains and paved the way for future medical expert systems.

Understanding of Medical Knowledge:

- It provided insights into the nature of medical reasoning and knowledge representation, influencing the design of subsequent systems in healthcare.

Limitations of Traditional Diagnosis:

- MYCIN highlighted the limitations of traditional medical training and decision-making, showing how expert systems could complement human expertise.

R1

- It is also known as XCON – eXpert CONfigurer.
- It is an Expert System
- Used to configure orders of computer systems.
- When a company wanted to buy a computer system, they would specify what they needed, like the type of processor, amount of memory, storage capacity, and other features.
- The order involves selecting the right combination of parts to build a computer system that meets the customer's needs. This can be complicated.
- XCON takes the details from the customer’s order and automatically figures out which parts to use.
- It checks that everything is compatible and suggests the best configuration.

GENETIC ALGORITHM

- It is optimization techniques inspired by the process of natural selection.

- Used in AI to find approximate solutions to complex problems by mimicking the process of evolution.

Applications of Genetic Algorithms

- **Optimization Problems:** Finding optimal solutions in complex search spaces, such as scheduling, routing, and resource allocation.

- **Machine Learning:** Feature selection, hyperparameter tuning, and training neural networks.

- **Engineering Design:** Optimizing parameters in engineering designs and simulations.

- **Game Development:** Evolving strategies or behaviors for game AI. Financial Modeling: Portfolio optimization and algorithmic trading strategies.

Learning by Induction

- Learning by induction is a way of figuring things out by looking at specific examples and then making general rules from them.

- It is all about making guesses and rules based on what you see.

- Ex: you can see different fruits: an apple, a banana, and a kiwi.

Notice Patterns:

- The apple is red and round.
- The banana is yellow and long.
- The kiwi is green and round.

From these examples, you create a general idea.

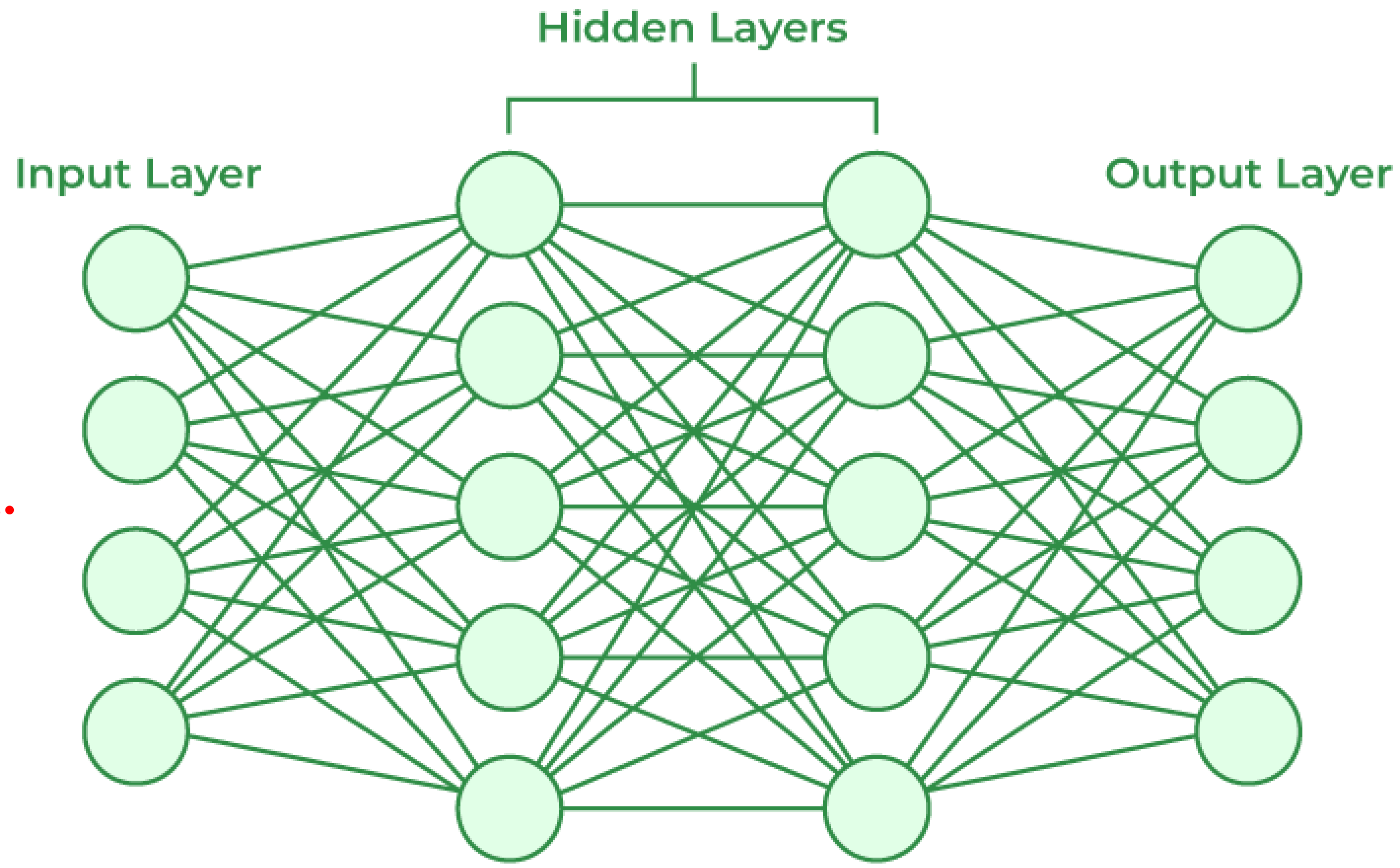
- For example, you might think,
- "All round fruits are apples," or
- "Bananas are always yellow and long.“

- **Test Your Rule**:
- Later, if you see a new fruit that’s round and red, you might say, "That must be an apple!“
- But if you see a round green fruit (like a kiwi), you’ll realize your rule needs adjusting.

What Are Neural Networks?

- Neural networks are computer systems designed to recognize patterns and make decisions, similar to how our brains work.

- They are made up of layers of "neurons" that process information.



How Neural Networks Work in Pattern Recognition

1. Input Data:

- Neural networks take raw data as input, which can include images, audio, text, or numerical data.
- Each piece of data is represented in a way that the network can process.

2. Layers of Neurons:

Input Layer:

- The first layer receives the raw data.
- Each neuron corresponds to a feature in the data (e.g., pixels in an image).

Hidden Layers:

- One or more layers of neurons process the data.
- Each neuron in these layers transforms the input using weights and activation functions, allowing the network to learn complex patterns.

Output Layer:

- The final layer produces the output, which might be a classification label (like “cat” or “dog”)

3. Learning Through Training:

- Neural networks learn patterns through a process called training, where they are exposed to labeled data (inputs with known outputs).

- They adjust their internal parameters (weights) based on how well they perform during training, using techniques like backpropagation.

Real-World Applications of Neural Networks in Pattern Recognition

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1. Face Recognition:

- Neural networks can identify and verify individuals in photos or videos.
- Applications include security systems, social media tagging, and smartphone unlocking.

2. Speech Recognition:

- Voice-activated assistants (like Siri, Alexa, and Google Assistant) use neural networks to convert spoken language into text.
- They learn to recognize different accents.

3. Natural Language Processing (NLP):

- Neural networks are used in sentiment analysis to determine the emotional tone of text (positive, negative, or neutral) in applications like customer feedback and social media monitoring.

4. Healthcare:

- Neural networks analyze medical images (such as X-rays, MRIs, or CT scans)to detect anomalies or diseases, such as tumors or fractures.
- This aids radiologists in making accurate diagnoses.

5. Financial Services:

- In fraud detection, neural networks analyze transaction patterns to identify suspicious activity, helping banks and financial institutions prevent fraud.

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