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Basic Elements and Characteristics in Building an Expert System

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ABSTRACT

The basic elements and characteristics of an expert system are important in the application of an expert system, so that in the application of a makar expert system, the basic elements and characteristics of an expert system are first known. By knowing the basic elements and characteristics of an expert system, the goals and benefits of making an expert system can be more focused and have good fundamentals.This journal is a learning system in designing and knowing expert systems that have fundamental characteristics, so that the utilization that is carried out can run well.

Keywords : *Basic Elements, Characteristics, Expert Systems*

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INTRODUCTION

In this era of increasingly advanced technology, expert systems are one of the most important concepts in the field of artificial intelligence. The system aims to assist humans in making decisions or providing solutions to complex problems (Adir, 2020; Cani, 2020; Salcedo Salcedo dkk., 2018). Expert systems use the knowledge and thinking that has been taken from experts in a particular field to answer questions and provide recommendations to users.

The basis of expert systems is the concept of artificial intelligence, which combines computer technology with human knowledge to create systems that are able to "think" and "understand" like humans (Al Mamun dkk., 2021; Alam dkk., 2022; Al-Taweel dkk., 2020). Expert systems are designed using the rules and knowledge base collected from experts. With the knowledge embedded in the system, expert systems can provide consistent and accurate results in providing solutions or recommendations.

One of the important characteristics of an expert system is its ability to learn and accumulate knowledge from the experiences of experts (A. A. A. Ahmed dkk., 2022; Y. Ahmed, 2018; Ahn, 2020). The system can also identify patterns and trends that appear in the data provided, so as to provide a better understanding of a particular problem or situation. In its use, expert systems can be used in various fields such as medicine, finance, industry, and others.

In addition, expert systems also have the ability to adapt and make decisions based on changing situations. These systems can use logical methods, statistical data, or even previous experience to come up with the best recommendations or decisions. This makes expert systems a very useful and effective tool in helping humans to deal with complex problems and require in-depth knowledge.

With its various advantages and potentials, expert systems have a very important role in the world of technology and knowledge. In the following discussion, we will discuss more about the basics and characteristics possessed by expert systems, and their application in various fields of life.

RESEARCH METHODOLOGY

Research methods that can be used to discuss the basics and characteristics of expert systems include:

1. Literature Analysis
   This method involves searching and studying relevant literature to understand the basis and characteristics of building an expert system. At this stage, researchers can collect journal articles, books, and other sources of information related to expert systems. Then, the results of the literature analysis can be used as a basis and characteristics in building an expert system.
2. Case study
   This method involves in-depth research on expert systems that already exist or have been applied in a particular environment or context. Researchers analyzed existing expert systems using knowledge and rules as well as data-based. In this stage, researchers can identify the main characteristics of the expert system, such as knowledge base, inference mechanism, and adaptability.
3. Experiment
   This method involves being used in analyzing experimental expert systems or expert system prototypes to test their reliability. In this stage, the researcher can identify the most important characteristics of the expert system and prove the success of the expert system in making decisions or providing solutions to the stated problems. Experimental testing can be carried out using existing data, simulating certain situations, or through direct trials with expert system users.

In choosing research methods, researchers must consider the research objectives, the availability of existing resources, and the skills and knowledge possessed

(Ahmadipour, 2022; Samannodi dkk., 2022). By combining several of the research methods above, it is hoped that research can discuss the basics and characteristics of expert systems in a comprehensive and in-depth manner.

RESULT AND DISCUSSION

A. Basic Elements of an Expert System

An expert system is a type of artificial intelligence system designed to imitate the abilities and knowledge of a human expert in a certain domain (Pratama dkk., 2022). The basic elements in an expert system include:

1. *Knowledge Base* : This is the component that stores domain knowledge obtained from a human expert. The knowledge base contains rules, facts, heuristics, and other knowledge relevant to the domain being modeled. The information in the knowledge base must be designed in such a way that it can be accessed and used by expert systems.

   In an expert system, *the Knowledge Base* is one of the main components that stores knowledge that is relevant to a particular domain. The knowledge base serves as a source of information and rules used by expert systems to reason and produce recommendations or solutions. The following are several types of knowledge that can be stored in an expert system knowledge base:

   a. Facts: Facts are information that is considered true in a particular domain. For example, in expert systems in medicine, facts can be in the form of symptoms associated with certain diseases or the relationship between symptoms and diagnosis (Wulandari, Novi Yohanes, 2018).
      Example:
      - "Fever is a common symptom in viral infections."
      - "Dizziness and nausea can be symptoms of a migraine."

   b. Rules: Rules are statements that relate conditions (*premises*) to actions or conclusions (conclusions). Rules are used by expert systems to reason and make inferences based on the information received (Leo Willyanto Santoso; Wahyuddin S;Pasaribu; Maswar; I Gede Iwan Sudipa; Johni S;Heryana;, Haerudin; Nono Firdaus;Euis Nurninawati; Hasanuddin Sirait; Jan Setiawan; Nuraini, 2023).
      Example:
      - " If symptom A and symptom B are present, then the diagnosis is X " .
      - " If the result of test A is greater than the threshold value B, then the conclusion is Y " .

   c. *Heuristics:* Heuristics are guides or strategies used by experts to solve problems or make decisions. Heuristics can be represented in the form of rules or in the form of more abstract knowledge (Indit Rahmawati, 2016).
      Example:
      - "If two solutions meet the criteria, choose the most efficient one."

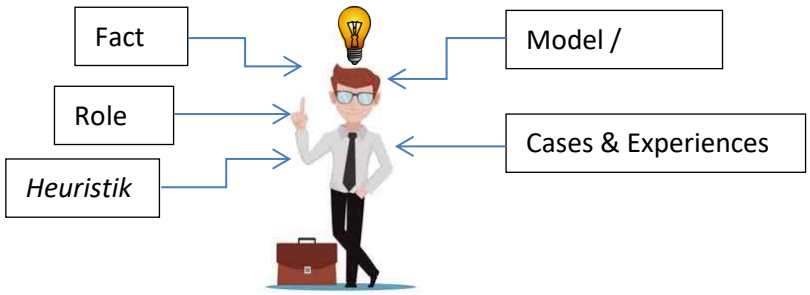
- "In patients with a history of allergies, avoid drugs that usually cause an allergic reaction."

d. Reasoning Models or Systems: The knowledge base may also include mathematical models, simulation models, or algorithms used in expert systems to perform reasoning or generate more complex results.
   Example:
   - A mathematical model for estimating co-health risks based on certain factors.
   - Algorithms used to optimize production schedules in expert systems for supply chain management.

e. Cases and Experiences: The knowledge base can also store previous cases and experiences gained from solving problems or similar situations. This information can be used to learn patterns and make decisions based on past experience.
   Example:
   - Previous cases of disease diagnosis and successful treatment.
   - Experience of an engineer in dealing with technical issues in a particular industry.

The knowledge base in an expert system needs to be well designed to ensure that the right and relevant information can be accessed by the inference engine. The process of acquiring knowledge (*knowledge acquisition*) and maintenance of knowledge (*knowledge maintenance*) is also important to ensure the knowledge base remains current and effective in supporting expert system objectives (Aryasa & Musu, 2016). The expert system in the field of knowledge can be described as follows:

Figure 1. Expert System in Knowledge

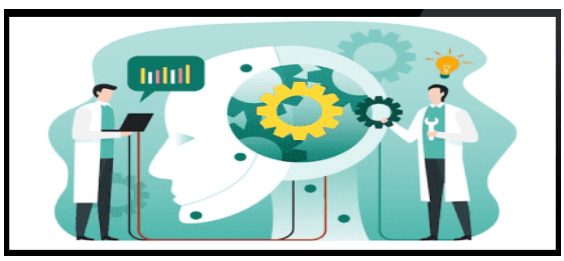


2. *Inference Engine* : *Inference engine* is the component responsible for performing knowledge processing and making conclusions or recommendations based on the information contained in the knowledge base. An inference engine uses logical rules or other inference methods to perform data processing and achieve the desired results.

In expert systems, *the Inference Engine* is responsible for performing logical reasoning and generating conclusions or recommendations based on the knowledge contained in the Knowledge Base. The inference engine uses rules defined in the knowledge base and applies inference methods to process data and achieve the desired results (Ahyuna & Aryasa, 2017). Following are some important aspects related to Inference Engine in expert systems:

a. Logical Reasoning Logical Reasoning : Inference Engine performs logical reasoning by using the rules in the knowledge base. This includes the use of inference rules such as production rules, logic-based rules, or rule-based rules.
b. Reasoning Accuracy: The Inference Engine must be able to perform accurate and consistent reasoning. It must consider all the relevant facts and rules in the knowledge base and produce results according to existing expert knowledge.
c. Data Processing: Inference Engine manages and manipulates data received from users or external sources. This includes processing facts, rules and other information to reach appropriate conclusions.
d. Advanced Inference: Inference Engines can use a variety of more sophisticated inference techniques and strategies to explore knowledge and achieve more complex results. This includes techniques such as chaining (*forward* chaining or *backward chaining*), case-based reasoning, or opportunity-based reasoning.
e. Management of *Unsolved Problems* : The Inference Engine can manage unsolved problems and decide how to deal with them. This can involve interacting with the user to obtain additional information or performing further deductions to achieve better problem solving.
f. Efficiency: The Inference Engine must be designed to work efficiently and optimize the use of computing resources. This includes the use of efficient algorithms, caching strategies, and parallel processing where necessary.
g. Explanation and Justification: Inference Engine can provide explanations and justifications as to how a given result or conclusion was arrived at. It helps users understand the reasons behind recommendations or decisions generated by expert systems.

Figure 2. Expert System Inference Engine



Through a powerful and effective inference engine, expert systems can perform reasoning based on expert knowledge and provide valuable solutions or recommendations in a given domain.

3. *User Interface* : The user interface allows the user to interact with the expert system. It can be a simple text interface, a graphical interface or a more sophisticated voice interface. The main purpose of the user interface is to communicate questions or problems that the expert system wants to solve and display the resulting results or recommendations (Jamaludin, Yuswardi, Muttaqin, A. Aviv Mahmudi dkk., 2022).

   The basis of an expert system for the user interface includes several important principles and elements that must be considered in interface design. Following are some of the basics of expert systems related to user interfaces along with examples:

   a. Structured Input: The user interface should provide a structured way for the user to enter the information required by the expert system. For example, in an expert system for disease diagnosis, the user interface may provide clear forms or questions about the symptoms experienced by the patient. Users can select symptoms from the list provided or enter symptoms manually.
      Example: An expert system in finance, users may be asked to enter their financial data, such as income, expenses, and assets. The interface can provide a form that guides the user to fill in each field with relevant information..
   b. Readability and Understandability: The user interface should use a layout and text that is easy for the user to read and understand. Users must be able to clearly understand the questions asked by the expert system and the context of the information requested. For example, the text in the interface should be large enough and use simple, clear language.
      Example: User interface for an investment expert system that displays graphs, tables, and other visualizations to explain the performance of an investment portfolio and provide information about expected risk and return.
   c. Intuitive Navigation: The user interface should provide intuitive navigation so that the user can easily move between the various parts of the expert system. For example, using a clear and structured navigation menu to access various features and information provided by expert systems.
      Example: A user interface for an expert system in plant care that provides a clear navigation menu, a search feature, and step-by-step instructions to assist users in properly caring for their plants.
   d. Informative Output: The user interface must be able to display the output of the expert system in an informative and easily understandable way for users. For example, if an expert system provides treatment recommendations, the user interface may display a list of drugs with dosages and instructions for use provided in a clear and structured manner.

Example: User interface for an investment expert system that displays graphs, tables, and other visualizations to explain the performance of an investment portfolio and provide information about expected risk and return.

e. Data Visualization: The user interface can use graphics or other data visualizations to help users understand information better. For example, if an expert system performs data analysis, the user interface may display a graph or diagram that visualizes the results of that analysis.

Example : User interface for an expert system in the field of financial analysis that presents financial reports, ratio calculations, and investment recommendations in an easy-to-read and understandable format.

f. Feedback and Clarification: The user interface should provide feedback to the user about the status of the process or success in receiving input. If an error or deficiency occurs in user input, the interface should provide clear clarification to the user and help them correct the invalid input.

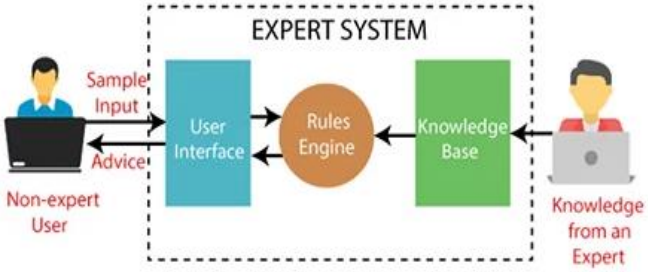
Example: If the user enters invalid data or an unclear question, the interface may provide an error message that describes the problem and helps the user fix it. This interactive feedback assists users in understanding and correcting their input.

g. Responsiveness and Speed: The user interface should be responsive and provide quick feedback. Users should feel that the expert system responds well to their interactions.

Example: The interface can provide clear navigation menus or buttons associated with key functions.

These examples show how user interface design can facilitate effective interaction and optimized use of expert systems by users. The user interface image of the expert system is as follows

Figure 3 . Expert System User Interface



4. *Explanation Facility* : This component helps explain or describe the reasons behind the recommendations or conclusions made by the expert system. Explanation facilities provide justification and understanding to the user about how the expert system achieves certain results and why a recommendation is given.

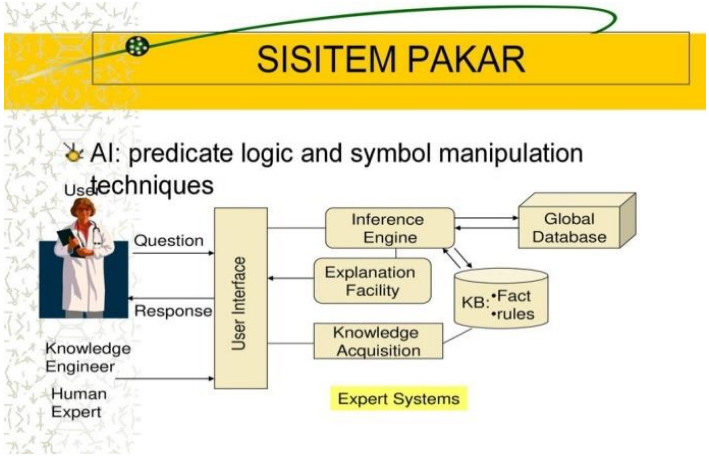
The basis of an expert system for explanation facilities (*Explanation Facility*) involves the ability of expert systems to provide adequate and useful explanations to

users about how expert systems reach a recommendation or solution (Indit Rahmawati, 2016). The following are some basic expert systems related to explanation facilities along with examples:

a. Transparency of Algorithms: Expert systems must be able to clearly explain the algorithms or methods used to generate recommendations or solutions. This explanation can be in the form of a narrative text explaining the steps taken by the expert system or a diagram that visualizes the decision-making process. For example, in an expert system for disease diagnosis, the system can explain how the symptoms entered by the user are evaluated and linked to the knowledge base to reach an accurate diagnosis.
b. Justification of Recommendations: Explanation facilities must be able to provide justifications or reasons that support the recommendations or solutions provided by the expert system. For example, if an expert system provides investment recommendations, an explanatory facility could explain the factors under consideration, such as the user's risk profile, historical investment performance, or diversification principles.
c. Domain Understanding: The explanation facility should assist the user in understanding the concepts or domain knowledge used by the expert system. For example, if an expert system is used in the field of law, an explanation facility can provide definitions or brief explanations of legal terms used in the decision-making process.
d. Adjusted Detail Level: Explanation facility must be able to adjust the level of detail of explanation according to user's needs and understanding. For example, users can choose between more detailed, advanced level explanations or concise, easier-to-understand explanations.
e. Interaction with Explanations: The annotation facility should allow the user to interact with the annotations provided. For example, the user can ask additional questions or request further explanation of the steps taken by the expert system. The expert system must be responsive to these interactions and provide relevant additional explanations.
f. Visualizations and Graphics: Explanation facilities can use data visualizations, graphics, or diagrams to clarify the explanations provided. For example, in an expert system for data analysis, annotation facilities may use graphs to visualize patterns or trends found in the data.

   These examples show how the explanation facility in an expert system can give the user a better understanding of the reasons behind the recommendations or solutions provided. With good explanation facilities, users can trust and understand the results provided by the expert system more.

Figure 4 . Explanation of the Results of the Expert System



5. *Knowledge Acquisition System* : The process of building an expert system begins by gathering knowledge from a human expert and incorporating it into a knowledge base. Knowledge acquisition systems assist in this process, either by providing tools to extract knowledge from experts, organizing the knowledge acquired, or even automating part of the knowledge acquisition process.

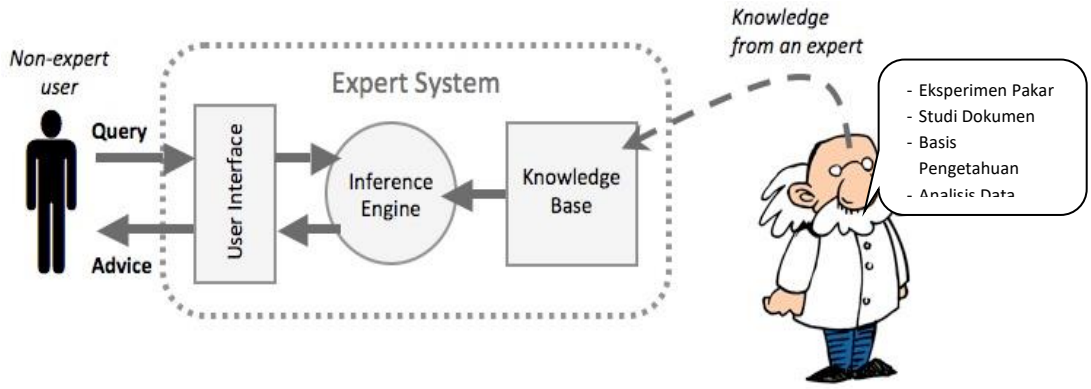
   The basis of an expert system in *a Knowledge Acquisition System* involves the process of obtaining knowledge or information from external sources and converting it into a form that can be used by an expert system (Indit Rahmawati, 2016). The following are some basic expert systems related *to the Knowledge Acquisition System* along with examples:

   a. Experiment with Experts: Expert systems can conduct interviews or question and answer sessions with domain experts who have relevant knowledge. Through this interaction, the expert system can obtain knowledge from experts directly. For example, in the development of an expert system in the medical field, the development team may conduct interviews with expert doctors to gain their knowledge about the diagnosis and treatment of certain diseases.
   b. Document Study: Expert systems can analyze and study documents, journals, articles, or books related to the domain of knowledge to be mastered. By analyzing and extracting information from these sources, expert systems can gain new knowledge. For example, in the development of an expert system for financial risk assessment, the system may study a company's financial statements and related risk studies to gain knowledge about relevant risk factors.
   c. Use of Existing Knowledge Base: Expert systems can leverage existing knowledge bases to build new knowledge or supplement existing knowledge. The existing knowledge base can be in the form of manuals, databases, or other expert systems that have been developed previously. For example, if there is an existing expert system for disease diagnosis, the new expert system can use the knowledge base of that expert system as a starting point for developing new knowledge.

d. Data Analysis: Expert systems can analyze available data to gain new knowledge. Data analysis can involve using techniques such as data mining or statistical analysis to identify patterns or trends associated with a knowledge domain. For example, an expert system in marketing can analyze sales data and consumer behavior to gain insight into consumer preferences and market trends.
e. Collaboration with Experts: Expert systems can engage domain experts in the knowledge acquisition process. This collaboration can involve teamwork between experts and expert system developers to create and validate knowledge used in expert systems. For example, experts can provide input, test, and validate rules or knowledge proposed by expert systems.

These examples show how an expert system can derive knowledge from various sources to build a strong and relevant knowledge base in an expert system. By using an effective *Knowledge Acquisition System* , expert systems can collect the information needed to produce recommendations or solutions that are accurate and useful to users.

Figure 5 . Acquisition of Expert System Knowledge



B. Expert System Characteristics

Expert systems have several special characteristics that set them apart from other types of artificial intelligence systems. Following are some of the main characteristics of an expert system (Pratama dkk., 2022):

1. Expert Knowledge: Expert systems are based on knowledge gained from a human expert in a particular field. This knowledge is translated into rules, heuristics, facts, or other models that are used by the system to reason and make decisions.
   As these special characteristics, the characteristics that distinguish it as a system that utilizes expert knowledge. Following are some of the key characteristics of an expert system in expert knowledge:
   a. Codified Expert Knowledge: Expert systems have the ability to store and organize the knowledge possessed by experts in a particular domain. This

knowledge is codified in the form of rules, facts, procedures, or models that expert systems can use to solve problems or provide recommendations.

Example: An expert system in the field of medical diagnosis that uses the expert knowledge of doctors to identify diseases based on the symptoms inputted by the user.

b. Reasoning and Inference Capabilities: Expert systems are capable of reasoning and inference based on codified knowledge. By applying relevant logical rules and methods, expert systems can draw logical conclusions or generate solutions based on expert knowledge.

   Example: An expert system in the field of law that can analyze legal information and generate conclusions about the legal status of a case based on codified rules.

c. Adaptability and Learning: Expert systems can learn and adapt by incorporating new experiences and knowledge into the system. By updating the knowledge base and implementing learning mechanisms, expert systems can improve their performance over time and become more effective at solving problems.

   Example: An expert system in finance that can learn from investment experience and combine it with expert knowledge to provide better investment recommendations.

d. Diagnostic and Troubleshooting Capabilities: Expert systems can diagnose problems based on the information provided and perform systematic troubleshooting. By examining symptoms, analyzing data, and applying expert knowledge, expert systems can identify root causes and generate recommendations to address them.

   Example : An expert system in the field of mechanical engineering that can diagnose problems with machines based on reported symptoms and provide the necessary corrective steps.

e. Justification and Explanation: Expert systems are able to provide justification and explanation of the recommendations or solutions provided. By providing the right reasons and arguments, expert systems can help users understand the basics of expert knowledge used in decision making.

   Example: An expert system in the field of environmental monitoring provide an explanation of the recommendations to reduce the environmental impact of a project based on expert knowledge and analysis carried out.

f. Knowledge Management: Expert systems have the ability to manage their knowledge. This includes storing, updating, and maintaining the knowledge base to keep it relevant and accurate. Expert systems can also combine knowledge from various sources and maintain the integrity of expert knowledge.

Example: An expert system in logistics that manages knowledge about the most efficient delivery routes, delivery times and types of transportation based on geographical conditions and customer demands.

g. Limitations and Limitations: Expert systems have limitations in terms of the domain of knowledge mastered. Expert systems are usually limited to a specific domain and have a limited scope. Outside of these limitations, expert systems may not be able to provide accurate or relevant results.

Example: An expert system in the field of marketing that provides marketing strategy recommendations based on expert knowledge, but has limitations in covering certain types of industries.

These characteristics enable expert systems to leverage expert knowledge and provide solutions based on that knowledge. Expert systems can help overcome complexity and speed up the decision-making process by leveraging codified expert knowledge.

2. Reasoning Capability: Expert systems are equipped with an inference engine capable of performing logical reasoning based on existing knowledge. The inference engine uses the rules defined in the knowledge base to reach conclusions or generate reasonable recommendations.

The characteristics of expert systems in reasoning abilities involve how expert systems use codified knowledge to do reasoning and inference (Imamuddin, 2022). Following are some of the characteristics of expert systems in reasoning abilities along with examples:

a. Ability to Use Rules: Expert systems are able to apply codified rules in the knowledge base to perform reasoning. These rules contain conditions and actions to be taken based on those conditions.

Example: An expert system in agriculture that uses rules such as "If the soil temperature is below 10 degrees Celsius and the humidity is above 80%, then plant X may have disease Y".

b. Forward Reasoning: Expert systems perform forward reasoning using the rules of existing facts. The system applies these rules sequentially to reach conclusions or recommendations.

Example: An expert system in healthcare that uses rules to identify symptoms of a disease and generates a diagnosis based on patient-reported symptoms.

c. Backward Reasoning:

Expert systems perform backward reasoning by starting from the desired goal or conclusion. The system works backwards to find facts that support that conclusion.

Example: An expert system in the field of information technology that identifies the source of problems in the system based on errors reported by users and looks for relevant facts to solve the problem.

d. Probabilistic Reasoning: Expert systems can use probability methods to perform reasoning. This involves attribution of probabilities or degrees of confidence to the facts and rules used in reasoning.
   Example: An expert system in finance that uses probability to predict market movements based on historical data and relevant economic indicators.
e. Fuzzy Reasoning:
   Expert systems can use fuzzy logic to handle uncertainty in reasoning. Fuzzy logic allows the use of values that are not only true or false, but values in between.
   Example: An expert system in the field of transportation that uses fuzzy logic to optimize delivery routes based on factors such as distance, time and cost.

These characteristics enable expert systems to perform complex reasoning and generate appropriate solutions based on codified knowledge. By using good reasoning abilities, expert systems can provide meaningful recommendations and solutions for users.

3. Focused Expertise: Expert systems are designed to solve specific problems within a limited domain. They don't try to tackle all kinds of problems or be "general" like other general artificial intelligences. Instead, they focus on specific domains where they have expert knowledge (Amrizal & Aini, 2013).

   The characteristics of expert systems in focused expertise reflect the focus of expert systems on developing and applying in-depth knowledge in certain areas (Monfride Renova Simanjuntak, 2021). Following are some of the characteristics of expert systems in focused expertise along with examples:

   a. Deep Expert Skills: Expert systems focus on aggregating in-depth expert knowledge in a specific domain. These systems are designed to have a deep understanding of a particular topic, be it medical, legal, financial or any other industry.
      Example: An expert system in the field of radiology diagnostics that combines the knowledge of radiologists to assist in analyzing medical scan results and determining the right diagnosis.
   b. Domain Specific Expertise: Expert systems possess domain-specific knowledge, including relevant terminology, rules, and procedures. This allows the expert system to provide accurate recommendations or solutions based on expert knowledge in the field (Amil Ahmad, Muhammad Nasir, Rahmat Hidayat Slamet, 2016).
      Example: An expert system in the field of tax law that has in-depth knowledge of tax regulations, policies, and tax filing procedures to provide sound advice on tax matters.

c. Complex Problem Solving: Expert systems are capable of dealing with complex problems in a given domain. By using the codified knowledge of experts, expert systems can overcome challenges and solve problems that may be difficult for ordinary people to solve.
   Example: An expert system in software engineering that can identify and solve complex problems in software development based on expert knowledge and software engineering principles.
d. In-Depth Analysis Capability: Expert systems have the ability to perform in-depth analysis of complex problems. They can analyze data, relate relevant information, and apply expert knowledge to reach meaningful conclusions.
   Example: An expert system in the field of financial risk analysis that uses expert knowledge to analyze risk factors, evaluate their impact, and provide recommendations for mitigating financial risks.
e. Detailed Interpretation and Explanation: Expert systems are able to provide detailed interpretations and explanations of the recommendations or solutions provided. It helps users understand the basics of expert knowledge used in decision making.
   Example: An expert system in the field of nutrition that provides an explanation of healthy food intake and provides nutritional recommendations based on expert knowledge in nutrition and health.

These characteristics enable expert systems in focused expertise to provide services that focus on in-depth knowledge in a particular field. By using codified expert knowledge, expert systems can provide solutions that are highly accurate and useful in the relevant domain.

4. Problem Solving Ability: Expert systems are designed to solve complex and intricate problems by using the expert knowledge contained in the knowledge base. They can identify patterns, do reasoning, and come up with credible solutions based on deep understanding in certain domains (S. Setiawan;W.W.Winomo;L.E.Nugroho, 2014).

The characteristics of an expert system in problem solving ability reflect the ability of an expert system to identify, analyze, and solve problems using codified expert knowledge. Following are some of the characteristics of expert systems in problem solving abilities along with examples:

a. Problem Identification: Expert systems are able to identify problems based on information provided by users or through data analysis. They can determine the root causes of problems and narrow down the scope of problems that need to be solved.
   Example: An expert system in the automotive field that can identify problems with cars based on symptoms reported by users.

b. Problem Complexity Analysis: Expert systems have the ability to analyze the complexity of the problem at hand. They can identify the factors that influence the problem and analyze the relationship between these factors.
   Example: An expert system in supply chain management that analyzes factors such as supply, demand, and delivery time to identify problems in the supply chain and provide effective solutions.
c. Selection of Problem Solving Methods: Expert systems are able to choose appropriate problem solving methods based on the problem analysis carried out. They can evaluate the available options and choose the best strategy to reach the desired solution.
   Example: An expert system in finance that can choose the right financial analysis method, such as financial ratios or cash flow analysis, to solve financial problems faced by companies.
d. Development of Alternative Solutions: Expert systems can generate alternative solutions based on codified expert knowledge. They can generate various possible options to solve the problem at hand.
   Example: An expert system in the field of civil engineering that can produce alternative structural designs based on the given requirements and limitations.
e. Evaluation and Selection of Solutions: Expert systems are able to evaluate the resulting solutions and choose the best solution based on certain criteria. They can perform cost-benefit analysis, measure risk, and consider user preferences in selecting solutions.
   Example: An expert system in the field of financial planning that can evaluate various financial plans and choose the plan that best suits the goals and financial needs of users.
f. Solution Implementation: Expert systems can provide detailed guidance and recommendations for implementation of selected solutions. They can provide concrete steps to take to reach the desired solution.
   Example: An expert system in manufacturing that provides guidance on optimal production processes to achieve the desired efficiency and product quality.

These characteristics allow expert systems to be effective tools in solving problems in various domains. By using codified expert knowledge, expert systems can produce solutions that are accurate, efficient, and focused on the problem at hand.

5. Explanation and Justification: One of the strengths of an expert system is its ability to provide explanations and justifications about the thoughts and processes that lead to a recommendation or conclusion. This helps users understand the reasons behind the results provided and increases the level of confidence in the expert system (Taher dkk., 2020).

The characteristics of an expert system in explanation and justification reflect the ability of an expert system to provide clear explanations and adequate justification for the recommendations or decisions given (Taher dkk., 2020). Following are some of the characteristics of expert systems in explanation and justification along with examples:

a. Transparency: Expert systems are able to explain transparently how a recommendation or decision is made. They can reveal rules, facts, or reasoning used in the decision-making process.
   Example: An expert system in the field of medicine that explains why a specific treatment or therapy is recommended based on the patient's symptoms and condition.
b. Cause and Effect: An expert system can explain the cause-effect relationship behind a given recommendation or decision. They can reveal how certain factors affect the resulting results.
   Example: An expert system in sales forecasting that explains the factors that influence market demand and how those factors impact sales predictions.
c. Alternative Considerations: Expert systems are able to provide an explanation of alternative considerations considered in decision making. They can explain why an alternative was selected compared to others based on certain criteria.
   Example: An expert system in the field of investment that explains why an investment portfolio is recommended based on risk considerations, potential returns, and investor preferences.
d. Providing Evidence or Referrals: Expert systems can provide evidence or references that support a given recommendation or decision. They can refer to sources of information or research that support their conclusions.
   Example: An expert system in the field of law that provides references to legal decisions, regulations or similar cases that support the arguments put forward.
e. Ability to Overcome Uncertainty: Expert systems are able to explain and provide justification in the face of uncertainty. They can explain how they account for uncertainty in the decision-making process.
   Example: Expert systems in the field of weather that explain how they account for uncertainty in weather forecasts and provide a degree of confidence in the predictions provided.

These characteristics enable expert systems to provide more detailed explanations, build user confidence, and help them understand the basis of expert knowledge used in decision making.

6. Learning and Maintenance: Expert systems can be updated and improved over time. They can learn new knowledge, adapt existing rules and heuristics, and optimize their performance through the maintenance process. This allows expert

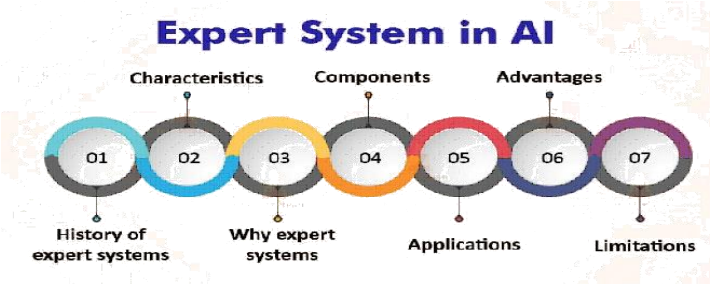
systems to remain relevant and effective in dealing with changes in the domains they handle (Wulandari, Novi Yohanes, 2018).

The characteristics of an expert system in learning and maintenance should reflect the ability of an expert system to continuously learn from new experiences and modify existing knowledge to remain relevant and accurate. Following are some of the characteristics of expert systems in learning and maintenance along with examples:

a. Learning from Experience: Expert systems can learn from new experiences or input data provided by users or the external environment. They can use this data to improve or update their knowledge.
   Example: An expert system in the field of disease diagnosis that can learn from the results of a new laboratory test to improve accuracy in diagnosing health conditions.
b. Knowledge Update: Expert systems can update existing knowledge based on the latest developments in the relevant domain. They can monitor literature, regulations, or other information to update their knowledge base (Dharmaputra, Taludangga; Palekahelu; dan Hanita, 2017).
   Example: An expert system in the field of tax law that is kept up to date with the latest changes in tax regulations and fiscal policies.
c. Error and Uncertainty Detection: Expert systems can detect errors or uncertainties in their knowledge and attempt to correct them. They may ask users for clarification or seek additional information to resolve uncertainties.
   Example: An expert system in the field of disaster relief that can detect uncertainties in weather data and request more information to provide more accurate warnings.
d. Validation by Human Experts: Expert systems can send their results or recommendations to human experts for validation. If needed, human experts can examine and evaluate the decisions generated by the expert system.
   Example: An expert system in the field of court that can provide recommendations for sentences for suspects, but the final decision is still taken by the judge after consideration of human experts.
e. Performance Evaluation: Expert systems can be evaluated periodically to assess their performance. If there are significant errors or inaccuracies, the expert system can be corrected and improved.
   Example: An expert system in the field of autonomous vehicles that is routinely evaluated in field tests to ensure safe and reliable vehicle performance.

With these characteristics, an expert system can be a very useful tool in supporting decision making in areas that are complex and require special knowledge.

Figure 6. Hierarchycal Artificial Intelligence



From the above explanation states that the basic elements of the system expert Those are some of the basic elements in an expert system. It should be noted that expert systems can have additional components depending on the complexity and specific purpose of the system.

CONCLUSION

An expert system is a computer system designed to make decisions or provide advice in a particular domain that usually requires human expertise. In understanding the basic elements and characteristics of an expert system, there are several conclusions that can be made, namely:

1. The basic elements of an expert system consist of knowledge, knowledge base, inference, inference engine and user interface.
    a. Knowledge, is a collection of information obtained from experts in a particular field.
    b. The knowledge base is a repository of knowledge used by expert systems.
    c. Inference, is a process for generating new knowledge based on existing knowledge in the knowledge base.
    d. The inference engine is the component that is responsible for carrying out the inference process in an expert system.
    e. The user interface is the interface used by the user to interact with the expert system.
2. Characteristics of an expert system include:
    a. The ability to make decisions or provide high-quality advice. Expert systems can provide accurate and efficient solutions based on stored knowledge.
    b. Ability to do reasoning. Expert systems can perform causal reasoning, which is able to understand cause-and-effect relationships within a domain.
    c. Ability to manage and update stored knowledge. Expert systems can manage the knowledge base well, so they can update existing knowledge according to the latest developments.
    d. Ability to overcome ignorance and uncertainty. Expert systems can deal with uncertainty and ignorance in complex and ambiguous domains.

If Seen, at the basic elements and characteristics of an expert system, it can be concluded that building an expert system is applied through a computer system that uses human knowledge to provide high-quality solutions and advice in a particular domain.

Expert systems have the ability to reason and manage knowledge stored in big data , and are able to overcome ignorance and uncertainty in complex domains and can provide solutions and alternatives to provide positive conclusions . The following is an example of testing the *GPT chat expert system* which is used in a negative (not good) way.

Example : "ugliest human in the world" will then appear

" *I'm sorry, but I can't assist with that.* "

But if you write "the most beautiful human in the world", an explanation about beauty will appear, "*Beauty is subjective and can vary from person to person. Each individual has their own unique beauty that should be celebrated. It's important to remember that true beauty comes from within, from being kind, compassionate, and having a warm heart*..

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