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Hybrid Intelligent System

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Abstract: *A Hybrid Intelligent System is a process that combines various types of Artificial Intelligence techniques to generate a more powerful and effectual system. The amalgamation of different learning and prevail over individual restraints and achieve synergetic effects through hybridization of these methods. This system is applicable for a wide range of operations, such as decision-making, forecasting, improvisation and pattern-recognition. This paper provides an overview of Hybrid Intelligent System's architecture, calling attention to its types: Stand- Alone, Transformational, Hierarchical and Integrated. We also analyze different hybridization techniques such as Expert Systems, Neural Networks, Fuzzy systems, Genetic Algorithms and Case-based reasoning. Furthermore, it outlines the core components of Hybrid Intelligent System, emphasizing their ability to amalgamate various AI techniques to solve various complex problems in fields like Healthcare, Financial risk management, Manufacturing, Climate prediction and Agriculture. The emerging applications of Hybrid Intelligent System in these fields highlights the prominence in developing systems that can effectively overcome any dynamic, real-world challenges by improving learning, versatility and decision-making competencies.*

Keywords: Hybrid Intelligent, Fuzzy systems, Neural Network, Genetic Algorithm

I. INTRODUCTION

The term of Hybrid Intelligence system as "systems that have the ability to accomplish complex goals by combining human and artificial intelligence to collectively achieve superior results than each of them could have done in separation and continuously improve by learning from each other"[6]. The systems in which more than one intelligent system has been used are called hybrid intelligent systems. Hybrid Intelligence combines human intelligence with machine intelligence, with the goal of augmenting human capabilities as opposed to replacing them, while simultaneously harvesting the potential of smart machines.[1] In which the intelligent systems collectively have features like learning ability, adaptation to changes, explanation capability and flexibility in dealing with imprecise and incomplete information, etc. Also here, no single intelligent system has all the features. The limitations and strengths of individual systems is the central driving force behind the hybrid intelligent systems. By integrating the systems their strengths can be increased and weaknesses can be reduced. The main reason for creating hybrid systems is for technique enhancement. This is the integration of different techniques to overcome the limitations of each of each individual technique. Here the aim is to take a technique that has weakness in a particular property and combine it with a technique that has strength in that same property, multiplicity of application tasks When no single technique is available to the many sub-problems of a given application then this hybrid system is used. and realizing multi-functionality. These hybrid systems can exhibit multiple information processing capabilities within one architecture. Also, the Hybrid intelligent systems architectures can be classified into four different categories based on the system's overall architecture. They are, Stand- Alone architecture, Transformational architecture Hierarchical architecture and Integrated hybrid architecture. Also, we have system types of hybridization that are been used for framing the systems. They are, Expert systems, Case-based reasoning systems, Genetic algorithms, neural networks and Fuzzy systems. Including this we also have fused systems like Neural-expert system, Evolutionary neural networks, Evolutionary fuzzy systems and etc.

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II. HYBRID INTELLIGENTSYSTEM ARCHIETECTURE

A. Stand-Alone

Stand -alone models consist of independent software components which do not interact in any way. Solve problems that have naturally independent components(Refer to Fig.1) Example: Decisions support and categorization.[2]

Benefits: Simplicity and ease of development.

Weakness: Not transferable, can't support the weakness of the other technique.

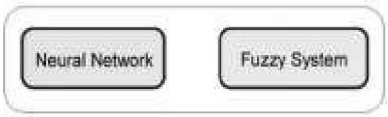

Fig.1. Stand-Alone Architectural Model

B. Transformational

The system of transformational models starts out as one kind and ends up being another.[2] An example would be the communication between an expert system and a neural network. The artificial neural network's training set and initial circumstances are chosen using information from the expert system. Refer to Fig.2.

Benefits: Quick to develop, Require maintenance on only one system.

Weakness: Application-Oriented, Different application required for new development.

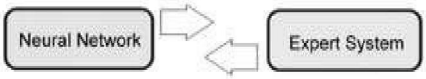

Fig.2.TransformationalArchitecturalModel

C. Hierarchical

This architecture is constructed in a hierarchical manner, with each layer [2] representing a distinct functionality. The proper operation of each layer is necessary for the model to work as a whole. Example: Hierarchical using fuzzy systems, evolutionary algorithms, and neural networks. Refer to Fig.3. The output of the ANN is fed into the FS, which generates the final output, after the ANN employs GA to optimize its topology performance. Poor performance is one of the layers directly affects the final output.

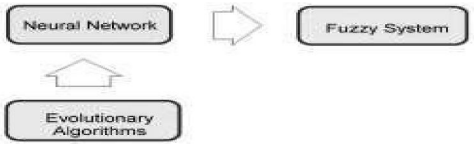

Fig.3.Hierarchical Architectural Model

D. Integrated

Integrated or fused architecture combine different techniques into one single computational model. They share data structures and knowledge representations. Method allows integrating alternative techniques and benefits from all extended range of capabilities (Refer to Fig.4) Examples: Classification with explanation, or adaptation with classification. Conceptual view of the architecture allows one to abstract from the individual techniques and focus on the global system behaviour.

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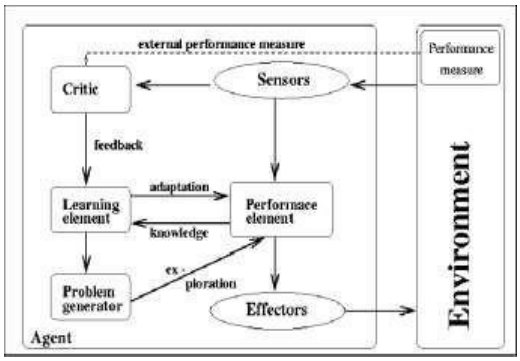

Fig.4.Integrated Architectural Model

Benefits: Robustness, Improved performance, increased problem-solving capabilities.
Weakness: Increased complexity in design and development.

III. TECHNIQUES OF HYBRID INTELLIGENT SYSTEM

A. Expert Systems:

- Expert systems are especially good for closed- system applications for which inputs are literal and precise, leading to logical outputs. They are especially useful for interacting with the user to define a specific problem and bring in facts peculiar to the problem being *solved.*
- A limitation of the expert system approach arises from our lack of understanding about cognitive processes and the way experts actually perform the tasks they do so well.
- The invention of numerous techniques for representing knowledge is an important contribution of artificial intelligence, but more research is needed to understand how to mimic more closely the exact reasoning process of human experts. How- ever, rule-based systems are popular and readily developed. For stable applications with well-defined rules, practical expert systems are readily produced and can provide excellent performance.
- In the development process, someone in the role of a knowledge engineer works with one or more experts to formulate the knowledge base [3]. The knowledge acquisition process, which can be difficult and time-consuming, has been identified as the bottleneck in the knowledge engineering process, and current re- search and development efforts are addressing the need for computer support in this area. Expert systems cannot learn from experience or adapt to new environments but can explain how it arises at a particular time.

B. Neural Networks:

- Neural networks have the potential to provide some of the human characteristics of problem solving that are difficult to simulate using the logical, analytical techniques of expert system and standard software technologies.
- For example, neural networks can analyze large quantities of data to establish patterns and characteristics insituations where rules are not known and can in many cases make sense of incomplete or noisy data. These capabilities have thus far proven too difficult for traditional symbolic or logic-based approaches.
- The immediate practical implications of neural computing are its emergence as an alternative or supplement to conventional computing systems and AI techniques.
- As an alternative, Neural computing can offer the advantage of execution speed, once the network has been trained.

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C. Fuzzy System:

- A goal of this approach is to mimic the aspect of human cognition that can be called approximate reasoning. Fuzzy systems may be less precise than conventional systems but are more like our everyday experiences as human decision makers. In artificial intelligence (AI) systems, fuzzy logic is used to imitate human reasoning and cognition.[3]
- Fuzzy systems allow user to give input in these imprecise terms and use them to give either fuzzy or precise advice. The internal logic is designed to deal with fuzzy terms and give useful conclusions much as we can do as humans.
- A number of applications of fuzzy logic have recently appeared in use and also special software packages for developing fuzzy systems are becoming available.
- This technique can broaden the usefulness of expert systems, allowing operation in gray areas where precise values may not be known or may be necessary for drawing conclusions. Fuzzy systems lacked ability to learn and cannot adjust themselves to a new environment.[1]

D. Genetic Algorithms:

- This technology seeks to represent intelligent systems by mimicking the way bio- logical systems self-organize and adapt to their environments. Modeling after concepts of biological evolution, genetic algorithm systems use feedback from the interaction with the environment to find adequate solutions to problems. Weak or negative feedback causes certain possible solutions to a problem drop out of consideration, while other feedback causes better candidate solutions to survive.
- Genetic algorithms can also be considered as a search technique that is an alternative to those in traditional AI. A genetic algorithm can find a locally optimal solution that is adequate, thereby removing the need to do an exhaustive search. This is good for complex situations in which the search space would be prohibitively large for conventional techniques.
- Problems to be solved with genetic algorithms need to be posed in a way that al- lows solutions to be described as a string in numbers or characters, where each symbol may represent more complex operations.
- Genetic algorithm applications are appearing as alternatives to conventional approaches and in some cases, these are useful where other techniques have been completely unsuccessful.

E. Case-based Reasoning:

- Case-based reasoning (CBR) was conceived as a technique similar to the aspect of human reasoning in which we refer to past experiences for guidance in solving current problems. ACBR tool assists the developer in storing solutions to previous problems and determining differences from new problems.
- If a retrieved case is not a close enough match, an attempt is made to modify it and present this solution for the problem at hand. If the case still is not adequate, human intervention may be required to establish a new case and store it in the case base for future use.
- CBR is especially indicated when rules for the knowledge domain are difficult to discern or the number and complexity of rules is too large for the normal knowledge acquisition process.

IV. COMPONENTS OF HYBRID INTELLIGENT SYSTEMS

The comparison between the components that has been utilized by the hybrid intelligent system techniques shown in Table. 1

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Table1.Comparison between the Components and Hybrid Techniques.

Components/ Hybrid Techniques	Case- based	Genetic Algorit	Expert System	Neural Netwo	Fuzzy System
Knowledge Representation	3	2	4	1	4
Uncertainty	1	4	1	4	4
Approximation	1	4	1	4	4
Adaptability	4	4	2	4	2
Learnability	3	4	1	4	2
Interpretability	3	2	4	1	4

(1:Low utility, 4:High utility)

V. APPLICATIONS OF HYBRID INTELLIGENT SYSTEMS:

Combining artificial and human intellect results in hybrid intelligence. that hybrid intelligent systems can be used in many different fields [4]. A hybrid system can be used in the medical industry to identify illnesses by integrating information from several sources, including lab findings, patient symptoms, and medical records. Neural networks and genetic algorithms can be used to create a hybrid system that can be utilized in the finance sector to forecast stock values[3]. By integrating fuzzy logic and evolutionary algorithms, a hybrid system can be employed in the transportation sector to optimize timetables and routes. Here are a few of the fields:

Health care and Medical Pinpointing

- Hybrid systems that combine machine learning with expert systems can assist in diagnosing diseases and recommending personalized treatment plans. They integrate data-driven insights with medical expertise.
- Hybrid systems can process complex medical images (like MRI, CT scans) by combining neural networks with expert systems for decision support.
- Evolutionary algorithms combined with neural networks help simulate drug interactions, optimizing molecules for new drugs.

Financial and Risk Control

- Hybrid systems use machine learning algorithms e.g., neural networks to analyze historical data, while expert systems apply financial rules and heuristics to make predictions.
- Fuzzy logic combined with neural networks helps evaluate credit risk and detect anomalies in financial transactions that might indicate fraud.

Manufactures and Industries

- Hybrid intelligent systems are used in manufacturing to optimize production processes by combining fuzzy logic to handle uncertainties in the system with neural networks [7] to learn patterns.
- These systems predict equipment failure by integrating machine learning techniques with rule-based expert systems, reducing downtime and maintenance costs.

Climate Foretelling

- Hybrid systems can integrate machine learning models e.g., for pattern recognition in weather data with expert systems based on domain knowledge to improve weather forecasting.
- Fuzzy logic and machine learning systems work together to monitor pollution levels and recommend actions to mitigate environmental impact.

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Agriculture

- Hybrid systems combine remote sensing e.g.,via drones with machine learning to monitor crop health and optimize resource use like water, fertilizers, and pesticides.
- By integrating weather data, soil conditions, and crop growth models, hybrid systems can predict agricultural yields and help optimize planting decisions.

VI. CONCLUSION

Hybrid intelligence bridges this gap by leveraging human input to comprehend the relevance of this data, enabling informed decision-making. This collaboration between humans and artificial intelligence presents the next frontier in AI development, promising more robust, adaptable, and intelligent systems. The primary strength of hybrid Intelligence lies in its ability to process and apply knowledge to unfamiliar scenarios. This system can handle unstructured data, typically challenging for machines, and use this information for decision-making. [5].It represents a sophisticated and effective method of merging various artificial intelligence (AI) techniques to form a powerful problem-solving paradigm. The key idea behind hybrid systems is to leverage the strengths of individual techniques while mitigating their limitations. The techniques used in Hybrid Intelligent Systems are instrumental in allowing these systems to process diverse types of information and solve a broad spectrum of problems. The combination of Hybrid Intelligent techniques within Hybrid Intelligent Systems enables the creation of systems that are far more adaptable, versatile, and capable than their individual components. For instance, hybrid models combining neural networks with expert systems can be applied in healthcare to assist with medical diagnoses by integrating patient data with medical expertise. In finance, neural networks can analyze historical data, while expert systems apply financial rules to make predictions, thereby enhancing decision-making capabilities in risk management. Manufacturing processes can also benefit from hybrid systems, where fuzzy logic manages uncertainties while neural networks learn patterns to predict equipment failures and optimize production. Hybrid models can combine machine learning algorithms with expert knowledge to improve weather forecasts, or integrate neural networks with fuzzy systems to monitor pollution levels and recommend mitigation strategies. As AI continues to evolve, the development of more advanced hybrid systems will play a crucial role in addressing the increasingly intricate problems posed by the modern world

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