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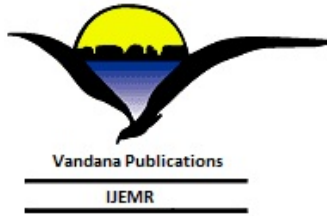
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## Intelligent System's Design Approaches: A Review

Kunjal Bharatkumar Mankad

### ABSTRACT

Intelligent systems are capable to provide efficient and powerful decision making in real applications. Moreover, automatic decision support, artificial evolution, intelligent search and optimization are unique capabilities of intelligent systems which are not available in traditional information system. The paper presents an extensive review of design approaches of intelligent systems. These approaches are classified as artificial intelligence and soft computing methods. These include methods of expert systems, natural language processing, intelligent agents, evolutionary computing, fuzzy systems, neural network, hybrid systems, swarm intelligent systems and many more. The paper briefly narrates applications of intelligent methods such as natural language processing, evolutionary systems, imprecision and uncertainty handling, automation and various conversion systems. The paper provides an extensive review on the widely popular methods of designing intelligent system. The second section of the paper briefly discusses characteristics of intelligent systems. Differences between intelligent systems and conventional computer based systems are also narrated. The third section of paper presents discussion on major approaches of designing intelligent system. The fourth section of the paper describes the highly popular approaches of intelligent systems. The fifth section of the paper highlights popular applications of each designing methods. The final section concludes with significance of review of the intelligent methods.

**Keywords:** Artificial Intelligence (AI), Intelligent Systems, Soft Computing.

### I. INTRODUCTION

Intelligent computing systems learn and interact naturally with people to encompass what either humans or machine could do on their own. In today's world, intelligent system has gained high popularity in successful implementation of real time tasks. Conventional computer based system suffers with several limitations such as non-parallel execution, lack of optimization, lack of decision

making, lack of automation and many more. Intelligent system is designed to solve above stated problems. There are two major approaches such artificial intelligence and soft computing. Artificial Intelligence is the branch of computer science that deals with ways of representing knowledge, using symbols rather than numbers, and heuristics, or rules of thumb, rather than algorithms for processing information whereas soft computing techniques are highly advanced techniques which are biologically inspired methods. The paper has presented an extensive discussion on various methods of intelligent system designing. These include expert system, multi-agent system, machine learning, evolutionary algorithms, neural networks and many more. The paper has systematically highlighted different applications which are outcome of these above stated techniques.

The second section of the paper briefly discusses characteristics of intelligent systems. Differences between intelligent systems and conventional computer based systems are narrated. The third section of paper presents discussion on major approaches of designing intelligent system. These approaches include artificial intelligence and soft computing. The fourth section of the paper presents the widely popular approaches of intelligent systems. An extensive review of these methods is presented which shows significance of various methods in designing intelligent systems.

### II. INTELLIGENT SYSTEMS

Intelligent computing systems learn and interact naturally with people to encompass what either humans or machine could do on their own. Any intelligent system is designed to engage in certain activities that, taken together, constitute its functional capabilities. A truly intelligent system adapts itself to deal with changes in problems (automatic learning).

- Machine intelligence has a computer follow problem solving processes something like that in humans.

- Intelligent systems display machine-level intelligence, reasoning, often learning, not necessarily self-adapting.

An Intelligent Decision Support System (IDSS) can be defined as an intelligent information system for decreasing the decision-making time and improving consistency and quality of decisions as stated by Haagsma & Johans in 1994 [1]. An IEDSS is an ideal decision-oriented tool for suggesting recommendations in an environmental domain. The main outstanding feature of IEDSS is the knowledge embodied, which provides the system with enhanced abilities to reason about the environmental system in a more reliable way [2].

### III. DIFFERENCE BETWEEN INTELLIGENT SYSTEM AND INFORMATION SYSTEM

Distinguished characteristics of intelligent systems and traditional computer systems are narrated as under [3]:

- The behaviour and attributes of intelligent systems distinguish it from conventional system.
- Traditional computer systems do not exhibit any intelligence in providing solutions. They are based on algorithms or steps of designed procedure written by programmer.
- Intelligent systems are more flexible and adaptive. They provide inference mechanism for knowledge processing. This processing is possible after complex interaction among elements of system rather than a step.
- Intelligent system can reach to useful result even if there is limited information while it is not possible to achieve result with traditional system in such cases.

### IV. CHARACTERISTICS OF INTELLIGENT SYSTEMS

Characteristics of intelligent systems are narrated as under [3,4]:

- They are capable to use knowledge to perform certain tasks to solve problems
- The ability to handle any type of fuzziness in program
- The ability to provide explanation in case of expert system
- The capability to solve complex optimization problems using search technique
- The capability to possess human like reasoning process
- The capability to learn from experience or training

- The capability to deal with imprecise expressions of facts
- The capability to find solutions through processes similar to natural evolution
- The capability to provide more sophisticated interaction with the user through natural language understanding, speech recognition and synthesis, and image analysis

## V. APPROACHES OF DESIGNING INTELLIGENT SYSTEMS

The primary goals of designing intelligent systems are as under:

- Development of software aimed at enabling machines to solve problems through human-like reasoning;
- Attempts to build systems based on a model of knowledge representation and processing in the human mind;
- Encompasses study of the brain to understand its structure and functions.

Most current intelligent systems are developed by utilizing approaches of following fields:

#### A. Artificial Intelligence

The branch of computer science that deals with ways of representing knowledge, using symbols rather than numbers, and heuristics, or rules of thumb, rather than algorithms for processing information. It involves studying the thought processes of humans. It deals with representing those processes via machines. The objectives of Artificial Intelligence are as under:

- to make machines smarter
- to understand what intelligence is
- to make machines more useful
- to learn from experience
- to interpret ambiguities
- to apply reasoning to problem solving
- to apply knowledge to manipulate environment
- to apply thinking and reasoning

Eg. Knowledge-based Systems, Rule based expert systems, Case Based Reasoning Systems, Natural Language Processing are examples of AI based systems.

#### B. Soft Computing

Soft computing is a branch that deals with real life applications. Soft computing is a consortium of methodology which has provided smart techniques for knowledge engineering, learning, searching, optimization and classification. The principal constituent methodologies in soft computing are complementary rather than competitive. Due to such quality, designing intelligent system becomes possible by hybridizing different methods. One or more of the methodologies belonging to soft computing are as under:

Multi Agent systems, Evolutionary Systems, Neural Network, Fuzzy Logic Based System, Machine Learning systems especially hybrid systems such as Evolutionary-fuzzy, Evolutionary-Neural, Neural-Fuzzy, Fuzzy-neural-genetic are highly popular in today's era.

## VI. POPULAR APPROACHES OF INTELLIGENT SYSTEMS

### A. Expert systems (ESs)

An expert system is an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution [5]. Expert system provides decision with human expertise in problem solving. Human knowledge stored on machine for use in problem-solving [6].

✚ Types of Expert systems: Expert systems can be constituted using any of the following forms:

- Rule-based Systems: Knowledge represented by series of rules
- Frame-based Systems: Knowledge represented by frames
- Hybrid Systems: Several approaches are combined, usually rules and frames
- Model-based Systems: Models simulate structure and functions of systems
- Off-the-shelf Systems: Ready -made packages for general use
- Custom-made Systems: Meet specific need
- Real-time Systems: Strict limits set on system response times

### B. Natural Language Processing

This type of processing allows user to use native language instead of English. Natural Language Processing is capable to process information contained in natural language text. It is also known as Computational Linguistics (CL), Human Language Technology (HLT), and Natural Language Engineering (NLE). It applies computational techniques to language domain. Examples of NLP are as follows [7]:

- Question answering
- Text Categorization/Routing
- Text Mining
- Machine (Assisted) Translation
- Language Teaching/Learning
- Spelling correction

### C. Machine Learning

Machine learning is best described as learning from example. Machine learning mode can potentially employ any learning method that can generate descriptions discriminating between classes of individuals in a population for example, a rule learning method, a decision tree learner, or a neural net. If individuals are described by structural descriptions, a structural (relational) learning

method is needed: e.g. a system that learns descriptions in annotated predicate calculus [8]. Machine Learning employ two major learning methods which are briefly discussed as follows [9]:

#### ✚ Supervised Learning

A computer system learns from data, which represent some "past experiences" of an application domain. In other words, a target function can be used to predict the values of a discrete class attribute, e.g., approve or not-approved, and high-risk or low risk. The task is commonly called: supervised learning, classification, or inductive learning.

#### ✚ Unsupervised Learning

Learning is performed without the help of a teacher. Here, learning process is independent and not supervised. Unsupervised learning is the learning scheme used by systems that do not require a 'trainer'.

### D. Intelligent Agents

Intelligent agents are basically, computer programs that automatically conduct tasks. They are applications that include the concept of "agency." This means that those applications represent a user and satisfy the goals of the task autonomously without further direction from the user. Agents are applications that exhibit characteristics of intelligent behavior (such as learning or classification), but are not in themselves AI techniques. There also exist other agent-based methods such as agent-oriented computing and multi-agent systems [10].

### E. Soft Computing Systems

In order to design an intelligent system, Soft computing techniques are developed because designing automatic system is a crucial task and cannot be fulfilled with traditional computing methods. Soft Computing techniques are widely popular as they are integrated techniques and highly suitable to find solutions for the problems which are highly complex, ill-defined and difficult to model. Soft computing is enriched with set of different techniques which are complementary in nature of each other. These techniques include Genetic Algorithms, Genetic Programming, Evolutionary Programming and Evolutionary Strategies, Fuzzy Logic, Probabilistic Reasoning and Neural network. Soft computing paradigms are highly suitable to implement design of intelligent systems as they can satisfy various demands of real life applications very efficiently. These includes implementing intelligent search and optimization, incorporating machine learning, handling imprecision and uncertainty as well as automatic decision making. Hybridization of soft computing methods has gaining popularity in recent years [11]. The prominent characteristics of soft computing are narrated as follows:

- Real life applications require modeling of problems. But it is not always possible to design model using traditional computing.

- Real time applications have to deal with different tasks. Soft computing family is highly suitable order to provide solution of different tasks.
- The type of algorithm supported by soft computing is dynamic. Hence, to accommodate changes in the algorithm is become possible.
- Soft computing provides economical and feasible solutions with reduced complexity. This feature helps to design and deploy intelligent system.
- Soft computing provides intelligent search method which is capable to find best solution.
- Soft computing provides parallel computing environment which provides fastest solutions for real time applications.

#### **F. Fuzzy Systems**

Fuzzy system can focus on modeling problems characterized by imprecise or ambiguous information. The systems which are developed based on theory of fuzzy logic are known as fuzzy systems. The fuzzy logic is basically, a multi-valued logic and that is used to describe fuzziness. It uses the continuum of logical values between 0 (completely false) and 1 (completely true). Fuzzy logic is the theory of fuzzy sets, which calibrate vagueness. It incorporates the idea that all things admit of degrees. Knowledge representation is made possible with fuzzy logic using membership functions [12].

#### **G. Biologically Inspired and Hybrid Models**

##### **A. Neural Networks**

Neural network being a simplified model of biological neuron system is a massively parallel distributed processing system made up of highly interconnected neural computing elements that have an ability to learn and thereby acquire knowledge and make it available for use [13]. Neural networks (NN) are generally considered as learning machines that work on the basis of observed data. Connectionist system is able to acquire knowledge about the world from observational instances. There are no a priori conceptual patterns that could lead to a learning process [14]. NN is a network of many simple processors ("units"), each possibly having a small amount of local memory. The units are connected by communication channels ("connections") which usually carry numeric (as opposed to symbolic) data, encoded by any of various means. NN is basically a nonlinear classification system of interconnected nodes that can learn the underlying behavior patterns in a collection of data using a set of examples. Neural networks can be taught to recognize specific patterns or they can be allowed to discover and arbitrarily learn patterns in large databases [15].

##### **B. Evolutionary Algorithms**

Evolutionary Computation (EC) refers to the computer-based problem solving systems that use computational models of evolutionary process. In recent years, cognitive systems have gained prominence by implementing evolutionary approach to the computational problems. Usually, evolutionary computation is constituted

with four evolutionary methods namely: genetic algorithms, evolution strategies, evolutionary programming and genetic programming [16,17,18,19,20].

##### **Evolutionary Fuzzy Hybrid Systems**

Recent years have contributed to large number of new hybrid evolutionary systems. There are several ways to hybridize a conventional evolutionary algorithm for solving optimization problems. In order to have learning and dealing with imprecise knowledge handling, Evolutionary algorithms are hybridized with FL. This is popularly known as evolutionary - fuzzy Hybridization. Evolutionary method is capable to encode and to evolve rule antecedent aggregation operators, different rule semantics, rule- based aggregation operators and de-fuzzification methods [21].

##### **Neural Fuzzy Hybrid Systems**

Neural network can model complex nonlinear relationships and are appropriately suitable for classification into predetermined classes. But at the same time, the precision of outputs is often limited and does not admit zero error but only minimizes least square errors. Fuzzy systems are capable to handle imprecision hence hybridization of NN with FL becomes powerful designers for intelligent systems. Neural network learning techniques could be used to learn the fuzzy inference system in a cooperative and an integrated environment. In an integrated neuro-fuzzy model, neural network learning algorithms are used to determine the parameters of fuzzy inference systems.

##### **Neural-Genetic-Fuzzy Hybrid Systems**

In an integrated neuro-fuzzy model, there is no guarantee that the neural network-learning algorithm will converge and the tuning of fuzzy inference system is successful. Optimization of fuzzy inference systems could be further improved using a meta-heuristic approach combining neural network learning algorithm and evolutionary algorithms. This type of evolutionary Neural Fuzzy framework could adapt to Mamdani, Takagi-Sugeno or other fuzzy inference systems. The architecture and the evolving mechanism could be considered as a general framework for adaptive fuzzy systems that is a fuzzy model that can change membership functions (quantity and shape), rule base (architecture), fuzzy operators and learning parameters according to different environment [22].

##### **C. Swarm Intelligent systems**

Swarm intelligence models are referred to as computational models inspired by natural swarm systems. It can be defined as follows: "any attempt to design algorithms or distributed problem-solving devices inspired by the collective behavior of social insect colonies and other animal societies" [23].



## VII. EXAMPLES OF INTELLIGENT SYSTEMS

Table 1 represents popular applications of intelligent methods.

Table 1  
Pioneer Applications of Intelligent Methods

Expert Systems	Medical Diagnostic, Office Advisory, Financial Management, Task Specific Systems and many more
Natural Language Processing	Question Answering, Text Mining, Machine Translation, Language Learning, and many more.
Fuzzy Systems	Appliance control systems, Medical Diagnostic Systems and many more
Intelligent Agents	Customer Help Desk, Web Browser, Intelligent, Personal Shopping Assistant and many more
Neural Networks	Pattern Recognition, Optimization, Forecasting, Control System, and many more
Evolutionary Systems	Applications in cellular automata, Scheduling, Applications in mechatronics, Aeronautics, etc.
Swarm Intelligent Systems	Ant colonies, Bird flocking, Animal herding, Bacterial growth, and Fish schooling, etc.
Hybrid Systems	Artificial bee colony (ABC) algorithm for feature selection and support vector machines for classification, etc.
Robotics and Sensory Systems	Medical robots, military robots, social robots, industrial robots, household robotics and many more
Speech (voice) Recognition	Speech to text conversion ,speech translation, Speech synthesis, Intelligent word processing, Dialogue systems, Conversation machines
Computer Vision and Scene Recognition	Digital Library, Surveillance, Segmentation, etc.

## VIII. CONCLUSION

The paper has presented an extensive review on intelligent system design approaches. The introductory

section explains intelligent system and differences with traditional information system. Characteristics of intelligent system are explained. Intelligent system is capable to provide numerous advantages over conventional information system. The paper has significantly explained characteristics of intelligent systems. The paper has explained two major approaches of designing intelligent systems. A brief introduction of artificial intelligence and soft computing is presented. There are various approaches of designing intelligent systems. The paper has provided extensive review of such approaches. These approaches include expert systems, machine learning, and biological inspired methods. The paper has highlighted various applications of different methods. The paper has briefly discussed contribution of intelligent methods in achieving various tasks such as intelligent search, imprecision and uncertainty, optimization, machine learning, decision making, robotics, engineering design, linguistic and fuzzy modeling, etc. The paper has provided significant review of intelligent techniques and their utilities.

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