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Artificial Intelligence in Power Station

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ABSTRACT

With increased competitiveness in power generation industries, more resources are directed in optimizing plant operation, including fault detection and diagnosis. One of the most powerful tools in faults detection and diagnosis is artificial intelligence (AI). Faults should be detected early so correct mitigation measures can be taken, whilst false alarms should be eschewed to avoid unnecessary interruption and downtime. For the last few decades there has been major interest towards intelligent condition monitoring system (ICMS) application in power plant especially with AI development particularly in artificial neural network (ANN). ANN is based on quite simple principles, but takes advantage of their mathematical nature, non-linear iteration to demonstrate powerful problem solving ability. With massive possibility and room for improvement in AI, the inspiration for researching them are apparent, and literally, hundreds of papers have been published, discussing the findings of hybrid AI for condition monitoring purposes. In this paper, the studies of ANN and fuzzy logic application will be presented.

KEYWORDS: *Artificial intelligence; ANN; Fuzzy logic*

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I. INRODUCTION

POWER STATION:

A power station, also referred to as a power plant or powerhouse and sometimes generating station or generating plant, is an industrial facility for the generation of electric power. Most power stations contain one or more generators, a rotating machine that converts mechanical power into three-phase electric power. The relative motion between a magnetic field and a conductor creates an electric current. The energy source harnessed to turn the generator varies widely. Most power stations in the world burn fossil fuels such as coal, oil, and natural gas to generate electricity. Cleaner sources include nuclear power, biogas and an increasing use of renewable such as solar, wind, wave and hydroelectric.

ARTIFICIAL INTELLIGENCE:

Artificial intelligence (**AI**), sometimes called **machine intelligence**, is intelligence demonstrated by machines, in contrast to the **natural intelligence** displayed by humans. any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals Colloquially, the term "artificial intelligence" is often used to describe machines (or computers) that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving.

NECESSITY FOR AI IN POWER SYSTEMS:

power system analysis by standard techniques becomes more complex because of:

Complex, versatile and large amount of information used in calculation, diagnosis and maintenance of systems.

Increase in data handling and processing time due to to the vast data generated during such process been accepted, prepare it in two-coloumn format ,including figures and tables.

II. LITERATURE SURVEY

There are three types of major power plants known for the huge electricity generation

1. Thermal power plants
2. Hydro electric power plant
3. Nuclear power plants

Thermal power generation plant thermal power station is the most conventional source of electric power. Thermal power plant is also referred as coal thermal power plant and steam turbine power plant. Before going into detail of this topic, we will try to understand the line diagram of electric power generation plant.

The theory of thermal power station or working of thermal power station is very simple. A power generation plant mainly consists of alternator runs with help of steam turbine. The steam is obtained from high pressure boilers. Generally in India, bituminous coal, brown coal and peat are used as fuel of boiler. The bituminous coal is used. It works on the

principle of Rankine cycle.here dangerous and highly specialized operationsare required such as live maintenance of boiler.

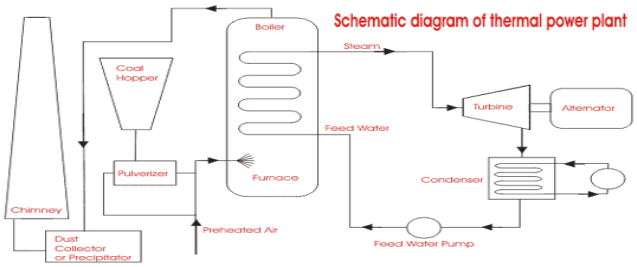


Fig-a schematic diagram of thermal powerplant

III. Nuclear power plant:

A nuclear power plant is a facility for obtaining electrical energy using nuclear energy. of energy is solar radiation.

As in a Its operation is similar to that of a thermal power plant or that of a solar thermal plant: from a source of energy thermodynamic is used to obtain heat, with the heat to get steam and with the steam to drive a turbine that will generate electricity.

The difference between the different types of electrical installations is in the energy source: a nuclear power plant uses the heat released in the nuclear fission reactions of certain atoms, in a thermal power station the heat source (thermal energy) comes from the combustion of one or more fossil fuels (coal, natural gas, fuel ..). Finally in thermoelectric solar plants, the source conventional thermal power plant the heat is used to generate steam that drives a steam turbine connected to a genaratot that produces electricity.

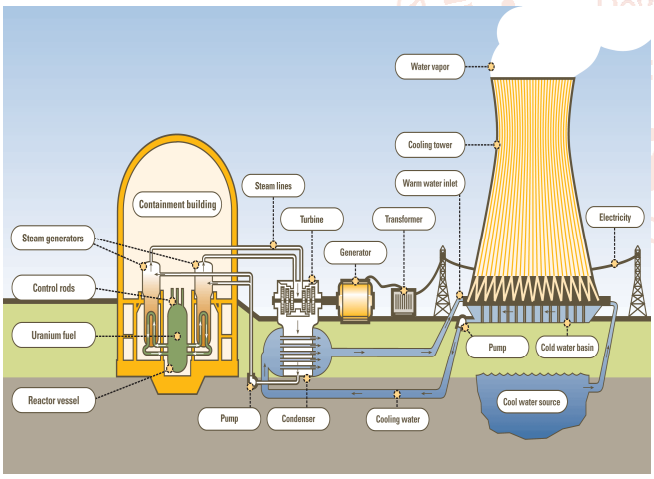


Fig-b nuclear power plant

The thermal energy used by the nuclear power plant to generate electrical energy is generated by a nuclear reactor. Within the reactor, chain fission reactions

Fig-b schematic diagram of nuclear power plant

IV. HYDRO POWER PLANT:

hydroelectric power station the kinetic energy developed due to gravity in a falling water from higher to lower head is utilised to rotate a turbine to produce electricity. The potential energy stored in the water at upper water level will release as kinetic energy when it falls to the lower water level. This turbine rotates when the following water strikes the turbine blades. To achieve a head difference of water **hydroelectric electric power station** are generally constructed in hilly areas. In the way of the river in hilly areas, an artificial dam is constructed to create required water head. From this dam water is allowed to fall toward downstream in a controlled way to turbine blades. As a result, the turbine rotates due to the water force applied to its blades and hence the alternator rotates since the turbine shaft is coupled with alternator shaft.

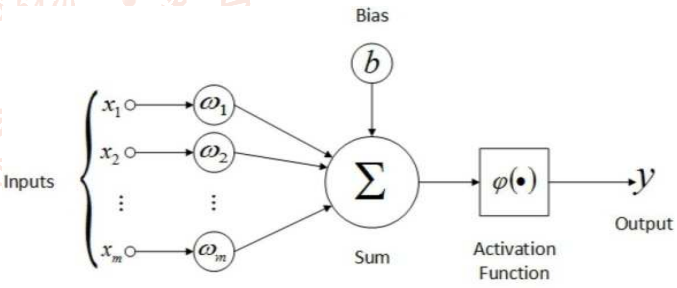
Fig-c Hydro power plant

V. ARTIFICIAL INTELLIGENCE TECHNIQUES

A. ARTIFICIAL NEURAL NETWORKS

Neural networks are simplified models of the biological nervous system and therefore have drawn motivation from the kind of computing performed by brain An Artificial neural network is generally a highly interconnected network of a large number of processing elements called 'Neurons' in an architecture inspired by the brain. the brain is highly complex, Non linear and parallel computer (Information processing system).It has the capability to perform certain computations (e.g: pattern recognition, perception and motor control) many times faster than the digital computer.

Neural networks derive their computing power in two ways. First massively parallel distributed structure and second its ability to learn. These two information processing capabilities make it possible for neural networks to solve complex problems.



(A.1)-NEURAL NETWORK ARCHITECTURE

An artificial neural networks is defined as a data processing system consisting of a data processing system consisting of a large number of simple but highly connected processing elements (artificial neurons) in an architecture inspired by the structure of brain. Generally an artificial neural network can be represented using a directed graph G (digraph).

Artificial Neural Networks are systems designed based on organic thought processes which convert a set of inputs into a set of outputs by a network of neurons. Each neuron produces one output as a function of inputs. These system are used in real world applications wherein the need for classification of patterns and pattern recognition arises. They are classified by their architecture: number of layers and topology: connectivity pattern, feed forward or recurrent.

They are classified by their architecture: number of layers and topology: connectivity pattern, feed forward or recurrent. Input Layer: The nodes are input units which do not process the data and information but distribute this data and information to other units. Hidden Layers: The nodes are hidden units that are not directly evident and visible. They provide the networks the ability to map or classify the nonlinear problems. Output Layer: The nodes are output units, which encode possible values to be allocated to the case under consideration.

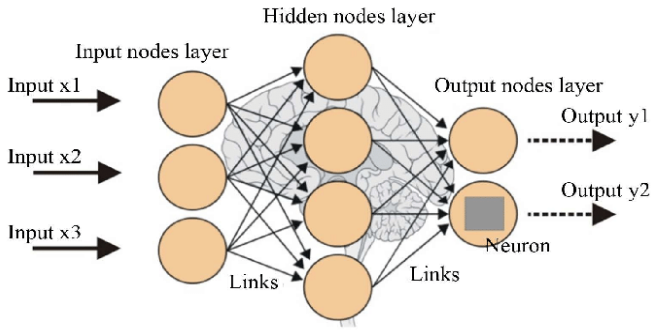


Fig-D Structure of ANN

Application in Power Systems:
As they are designed to perform biological based evaluation of problems due to their inherent design, They are suitable for obtaining solutions to problems arising in power generation, distribution and transmission. Based on the constraints of a practical transmission system , taking into account factors such as environmental factors and other unbalancing features, ANN's can arrive at a solution.

ADVANTAGES OF ANN:-

1. ANNs have the ability to learn and model non-linear and complex relationships, which is really important because in real-life, many of the relationships between inputs and outputs are non-linear as well as complex.
2. ANNs can generalize — After learning from the initial inputs and their relationships, it can infer unseen relationships on unseen data as well, thus making the model generalize and predict on unseen data.
3. Unlike many other prediction techniques, ANN does not impose any restrictions on the input variables (like how they should be distributed). Additionally, many studies have shown that ANNs can better model heteroskedasticity i.e. data with high volatility and non-constant variance, given its ability to learn hidden relationships in the data without imposing any fixed relationships in the data. This is something very useful in financial time series forecasting (e.g. stock prices) where data volatility is very high

DISADVANTAGES:-

I. Large dimensionality.
II. Results are always generated even if the input data are unreasonable
III. They are not scalable i.e. once an ANN is trained to do certain task, it is difficult to extend for other tasks without retraining the neural network.

B. FUZZY LOGIC:

What is Fuzzy Logic?

Fuzzy Logic (FL) is a method of reasoning that resembles human reasoning. The approach of FL imitates the way of decision making in humans that involves all intermediate possibilities between digital values YES and NO.

The conventional logic block that a computer can understand takes precise input and produces a definite output as TRUE or FALSE, which is equivalent to human's YES or NO.

The inventor of fuzzy logic, Lotfi Zadeh, observed that unlike computers, the human decision making includes a range of possibilities between YES and NO, such as

CERTAINLY YES
POSSIBLY YES
CANNOT SAY
POSSIBLY NO
CERTAINLY NO

The fuzzy logic works on the levels of possibilities of input to achieve the definite output.

Implementation

- It can be implemented in systems with various sizes and capabilities ranging from small micro-controllers to large, networked, workstation-based control systems.
- It can be implemented in hardware, software, or a combination of both.

Why Fuzzy Logic?

Fuzzy logic is useful for commercial and practical purposes.

- It can control machines and consumer products.
- It may not give accurate reasoning, but acceptable reasoning.
- Fuzzy logic helps to deal with the uncertainty in engineering.

Fuzzy Logic Systems Architecture
It has four main parts as shown –

- **Fuzzification Module** – It transforms the system inputs, which are crisp numbers, into fuzzy sets. It splits the input signal into five steps such as –

LP	x is Large Positive
MP	x is Medium Positive
S	x is Small
MN	x is Medium Negative
LN	x is Large Negative

- **Knowledge Base** – It stores IF-THEN rules provided by experts.
- **Inference Engine** – It simulates the human reasoning process by making fuzzy inference on the inputs and IF-THEN rules.
- **Defuzzification Module** – It transforms the fuzzy set obtained by the inference engine into a crisp value.

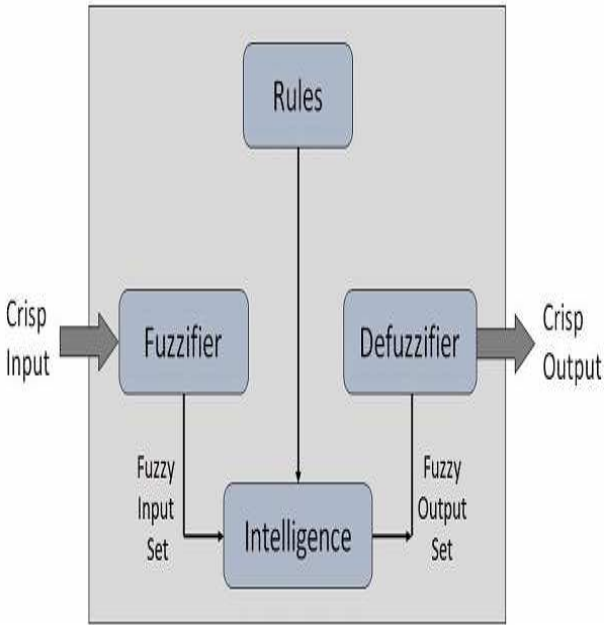


Fig-E Defuzzification module

The **membership functions work on** fuzzy sets of variables.

Membership Function

Membership functions allow you to quantify linguistic term and represent a fuzzy set graphically. A **membership function** for a fuzzy *set A* on the universe of discourse X is defined as μ_A:X → [0,1].

Here, each element of *X* is mapped to a value between 0 and 1. It is called **membership value** or **degree of membership**. It quantifies the degree of membership of the element in *X* to the fuzzy set *A*.

- x axis represents the universe of discourse.
- y axis represents the degrees of membership in the [0, 1] interval.

There can be multiple membership functions applicable to fuzzify a numerical value. Simple membership functions are used as use of complex functions does not add more precision in the output.

All membership functions for **LP, MP, S, MN,** and **LN** are shown as below –

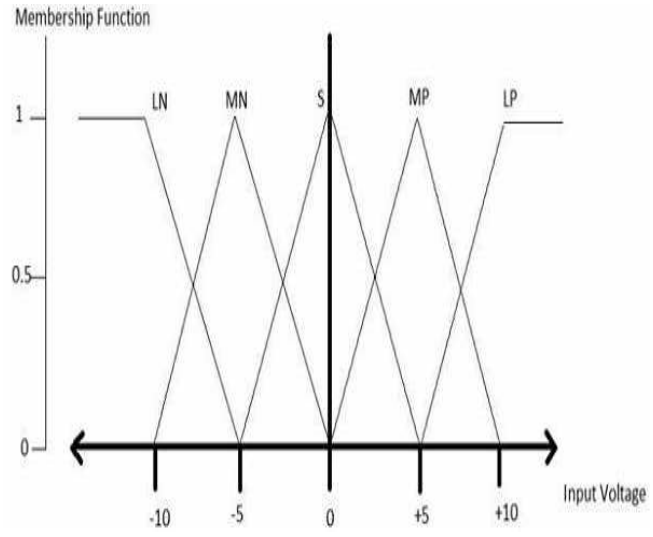


Fig-F all membership functions

The triangular membership function shapes are most common among various other membership function shapes such as trapezoidal, singleton, and Gaussian.

Here, the input to 5-level fuzzifier varies from -10 volts to +10 volts. Hence the corresponding output also changes.

Example of a Fuzzy Logic System

Let us consider an air conditioning system with 5-level fuzzy logic system. This system adjusts the temperature of air conditioner by comparing the room temperature and the target temperature value.

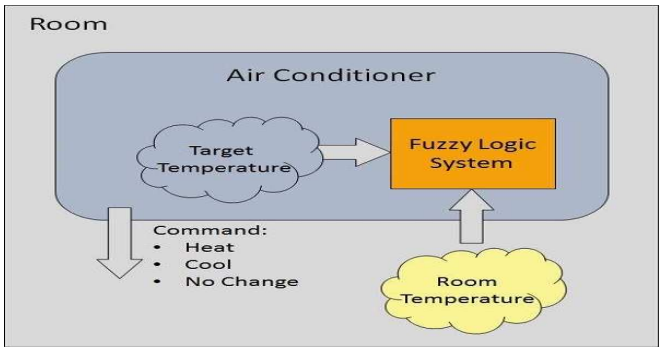


Fig-G conditioning system

Algorithm

- Define linguistic Variables and terms (start)
- Construct membership functions for them. (start)
- Construct knowledge base of rules (start)
- Convert crisp data into fuzzy data sets using membership functions. (fuzzification)
- Evaluate rules in the rule base. (Inference Engine)
- Combine results from each rule. (Inference Engine)
- Convert output data into non-fuzzy values. (defuzzification)

Development

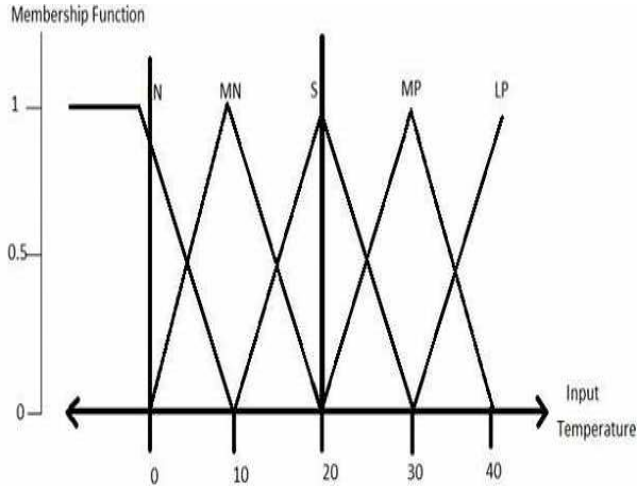
Step1 – Define linguistic variables and terms

Linguistic variables are input and output variables in the form of simple words or sentences. For room temperature, cold, warm, hot, etc., are linguistic terms.

Temperature (t) = {very-cold, cold, warm, very-warm, hot}
Every member of this set is a linguistic term and it can cover some portion of overall temperature values.

Step2 – Construct membership functions for them

The membership functions of temperature variable are as shown –



Step3 – Construct knowledge base rules

Create a matrix of room temperature values versus target temperature values that an air conditioning system is expected to provide.

Room Temp. /Target	Very_Cold	Cold	Warm	Hot	Very_Hot
Very_Cold	No_Change	Heat	Heat	Heat	Heat
Cold	Cool	No_Change	Heat	Heat	Heat
Warm	Cool	Cool	No_Change	Heat	Heat
Hot	Cool	Cool	Cool	No_Change	Heat
Very_Hot	Cool	Cool	Cool	Cool	No_Change

S. No.	Condition	Action
1	IF temperature=(Cold OR Very_Cold) AND target=Warm THEN	Heat
2	IF temperature=(Hot OR Very_Hot) AND target=Warm THEN	Cool
3	IF (temperature=Warm) AND (target=Warm) THEN	No_Change

Build a set of rules into the knowledge base in the form of IF-THEN-ELSE structures.

Step4 – Obtain fuzzy value

Fuzzy set operations perform evaluation of rules. The operations used for OR and AND are Max and Min respectively. Combine all results of evaluation to form a final result. This result is a fuzzy value.

Step5 – Perform defuzzification

Defuzzification is then performed according to membership function for output variable.

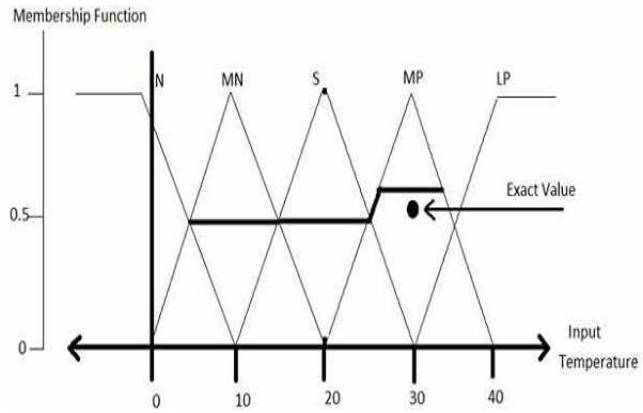


Fig-H Defuzzification output

Application Areas of Fuzzy Logic

The key application areas of fuzzy logic are as given –

Automotive Systems

- Automatic Gearboxes
- Four-Wheel Steering
- Vehicle environment control

Consumer Electronic Goods

- Hi-Fi Systems
- Photocopiers
- Still and Video Cameras
- Television

Domestic Goods

- Microwave Ovens
- Refrigerators
- Toasters
- Vacuum Cleaners
- Washing Machines

Environment Control

- Air Conditioners/Dryers/Heaters
- Humidifiers
- Advantages of FLSs
- Mathematical concepts within fuzzy reasoning are very simple.
- You can modify a FLS by just adding or deleting rules due to flexibility of fuzzy logic.
- Fuzzy logic Systems can take imprecise, distorted, noisy input information.
- FLSs are easy to construct and understand.
- Fuzzy logic is a solution to complex problems in all fields of life, including medicine, as it resembles human reasoning and decision making.

Disadvantages of FLSs

- There is no systematic approach to fuzzy system designing.
- They are understandable only when simple.
- They are suitable for the problems which do not need high accuracy.

VI. CURRENT APPLICATION OF AI IN POWER SYSTEMS

Several problems in power systems cannot be solved by conventional techniques are based on several requirements which may not feasible all the time. In these situations, artificial intelligence techniques are the obvious and the only option. Areas of application of AI in power systems are:

A. Replacing human workers for dangerous and highly specialized operations, such as live maintenance of high voltage transmission lines, has been a long standing effect in the power community

B. Operation in hazardous environments, such as radioactive locations in nuclear plants, access to tight spaces, such as cable viaducts and cooling

C. Expert systems use the interface mechanism and knowledge to solve problems which cannot be or difficult to be solved by human skill and intellect. Results are permanent and consistent can be easily documented. Results can be easily transferred and reproduced.

D. The understanding of the working of neurons and the pattern of their interconnection can be used to construct computers for solving real world problems of classification of patterns and pattern recognition.

E. Fuzzification provides superior expressive power, higher generality and an improved capability to model complex problems at low or moderate solution cost
F. Stability analysis and enhancement

VII. CONCLUSION

The main feature of power system design and planning is reliability, which was conventionally evaluated using deterministic methods. Moreover, conventional techniques do not fulfill the probabilistic essence of power systems. This leads to increase in operating and maintenance costs. Plenty of research is performed to utilize the current interest AI for power system applications. A lot of research is yet to be performed to perceive full advantages of this upcoming technology for improving the efficiency of electricity market investment, distributed control and monitoring, efficient system analysis, particularly power systems which use renewable energy resources for operation.

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