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Artificial Intelligence in Power Station

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***Abstract*— Recently, due to concerns about the liberalization of electricity supply, deregulation, and global impact on the environment, securing a reliable power supply has become an important social need worldwide. To ensure this need is fulfilled, detailed investigations and developments are in progress on power distribution systems and the monitoring of apparatus. Intelligent system techniques may be of great help in the implementation of area power system controls. Most of these applications require large quantities of system information, which can be provided by modern telecommunications and computing technology, but require new processing techniques able to extract salient information from these large sets of raw data. Importantly, such large data sets are never error free and often contain various types of uncertainty. Finally, control actions may be based on operating strategies specified in qualitative form, which need to be translated into quantitative decisions.**

***Index Terms*— Artificial Intelligence (AI), Expert systems, Interface, Reliable.**

I. INTRODUCTION

POWER SYSTEMS:

An electric power system is a network of electrical components used to supply, transmit and use electric power. Power systems engineering is a subdivision of electrical engineering that deals with the generation, transmission, distribution and utilisation of electric power and the electrical devices connected to such systems like generators, motors and transformers.

ARTIFICIAL INTELLIGENCE:

Commonly, artificial intelligence is known to be the intelligence exhibited by machines and software, for example, robots and computer programs. The term is generally used for developing systems equipped with the intellectual features and characteristics of humans, like the ability to think, reason, generalize, distinguish, learn from past experience or rectify their mistakes. It generally refers to machines or programs with ability to think on an independent level from their operator to make decisions [1].

NEED FOR AI IN POWER SYSTEMS:

Power system analysis by conventional techniques becomes more difficult because of:

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

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

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II. LITERATURE SURVEY

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

1) Thermal power plants
2) Hydal power plants
3) Nuclear power plants

A. *Thermal Power Plant:*

A **thermal power station** is a power plant in which heat energy is converted to electric power. In most of the world the prime movers is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated; this is known as a Rankine cycle. The greatest variation in the design of thermal power stations is due to the different heat sources, fossil fuel dominates here, although nuclear heat energy and solar heat energy are also used[2].

In a thermal power station fuel such as coal, oil or gas is burned in a furnace to produce heat - chemical to heat energy. This heat is used to change water into steam in the boiler. this drives the generator to produce electricity .i.e,kinetic to electrical energy.

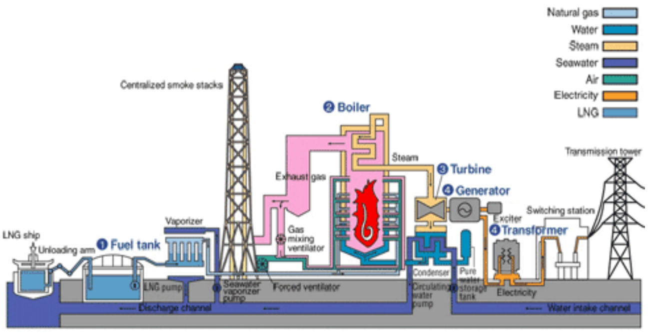

Fig1: Thermal Power plant

B. *Nuclear Power Plant:*

Nuclear plants, like plants that burn coal, oil and natural gas, produce electricity by boiling water into steam. This steam then turns turbines to produce electricity. The difference is that nuclear plants do not burn anything. Instead, they use uranium fuel, consisting of solid ceramic pellets, to produce electricity through a process called fission.

Nuclear power plants obtain the heat needed to produce steam through a physical process. This process, called fission, entails the splitting of atoms of uranium in a nuclear reactor. The uranium fuel consists of small, hard ceramic pellets that are packaged into long, vertical tubes. Bundles of this fuel are inserted into the reactor[3].

Commercial nuclear power plants in the are either boiling water reactors or pressurized water reactors. Approximately two-thirds of the reactors in the are pressurized water reactors, and one-third of them are boiling water reactors.

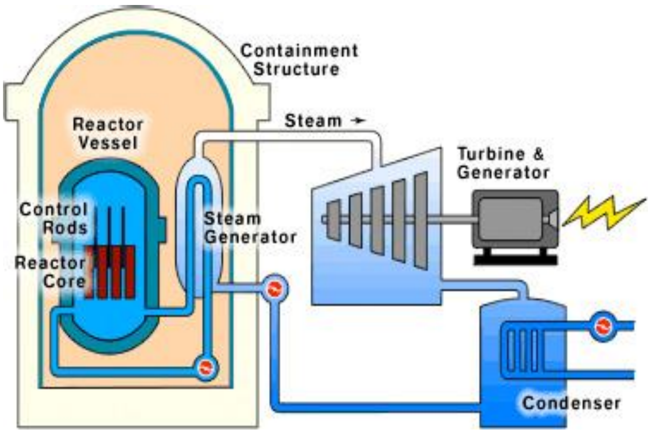

Fig 2: Nuclear Power Plant Structure

C. Hydro Power Plant:

In **Hydro Power Plant** we use gravitational force of fluid water to run the turbine which is coupled with electric generator to produce electricity. This power plant plays an important role in protecting our fossil fuel which is limited, because the electricity generated is due to the use of water which is a renewable source of energy .The force of the water being released from the reservoir through the dam spins the blades of a giant turbine. The turbine is connected to the generator that makes electricity as it spins. After passing through the turbine, the water flows back into the river on the other side of the dam.[4]

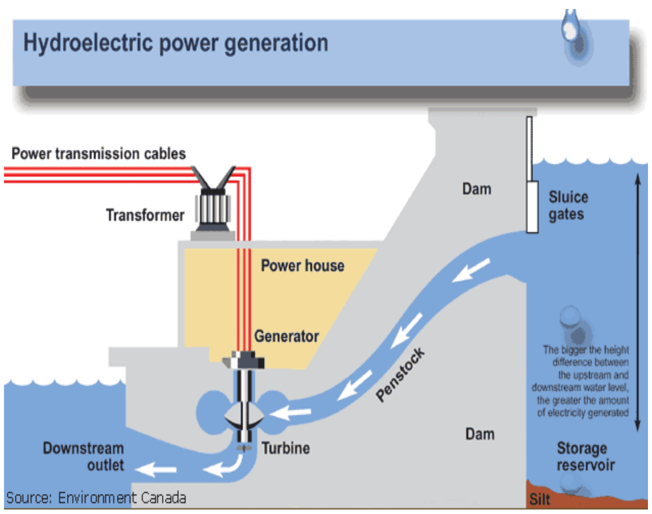

Fig 3: Hydro Power Plant Structure

III. ARTIFICIAL INTELLIGENCE TECHNIQUES

A. Artificial Neural Networks:

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.

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 [5].

Output Layer: The nodes are output units, which encode possible values to be allocated to the case under consideration [6][7].

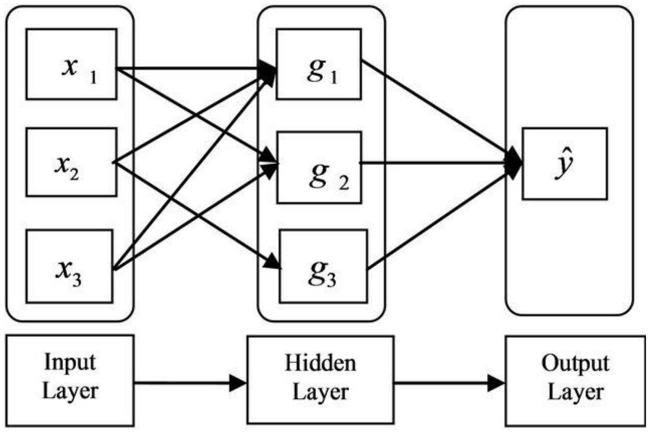

Fig 4 : Structure of an ANN

Application in Power Systems:

As they are designed to perform biological based evaluvation 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[8].

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:

Fuzzy logic or Fuzzy systems are logical systems for standardisation and formalisation of approximate reasoning. It is similar to human decision making with an ability to produce exact and accurate solutions from certain or even approximate information and data. The reasoning in fuzzy logic is similar to human reasoning. Fuzzy logic is the way like which human brain works, and we can use this technology in machines so that they can perform somewhat like humans. Fuzzification provides superior expressive power, higher generality and an improved capability to model complex problems at low or moderate solution cost.

Fuzzy logic allows a particular level of ambiguity throughout an analysis. Because this ambiguity can specify available information and minimise problem complexity, fuzzy logic is useful in many applications. For power systems, fuzzy logic is suitable for applications in many areas where the available information involves uncertainty. For example, a problem might involve logical reasoning, but can be applied to numerical, other than symbolic inputs and outputs. Fuzzy logic provide the conversions from numerical to symbolic inputs, and back again for the outputs [16][17].

Fuzzy Logic Controller:
Simply put, it is a fuzzy code designed to control something, generally mechanical input. They can be in software or hardware mode and can be used in anything from small circuits to large mainframes. Adaptive fuzzy controllers learn to control complex process much similar to as we do.

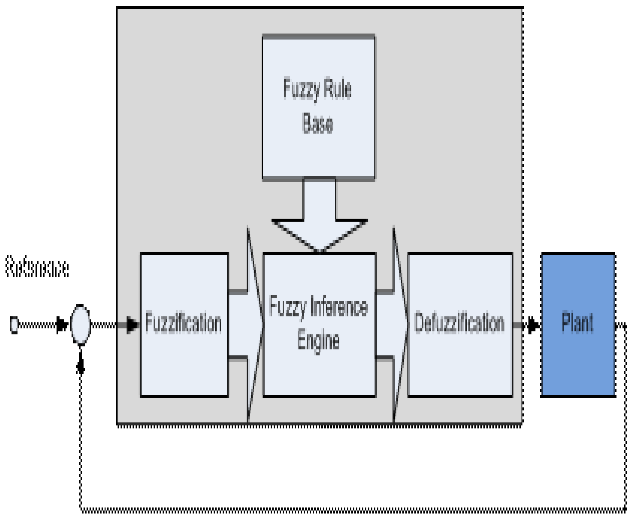

Fig 5: Fuzzy Logic Controller

Applications:
(i) Stability analysis and enhancement
(ii) Power system control
(iii) Fault diagnosis
(iv) Security assessment
(v) Load forecasting
(vi) Reactive power planning and its control
(vii) State estimation

Application in Power Systems:
Fuzzy logic can be used for designing the physical components of power systems. They can be used in anything from small circuits to large mainframes. They can be used to increase the efficiency of the components used in power systems. As most of the data used in power system analysis are approximate values and assumptions, fuzzy logic can be of great use to derive a stable, exact and ambiguity-free output.

C. EXPERT SYSTEMS:

An expert system obtains the knowledge of a human expert in a narrow specified domain into a machine implementable form. Expert systems are computer programs which have proficiency and competence in a particular field. This knowledge is generally stored separately from the program's procedural part and may be stored in one of the many forms, like rules, decision trees, models, and frames. They are also called as knowledge based systems or rule based systems. Expert systems use the interface mechanism and knowledge to solve problems which cannot be or difficult to be solved by human skill and intellect.

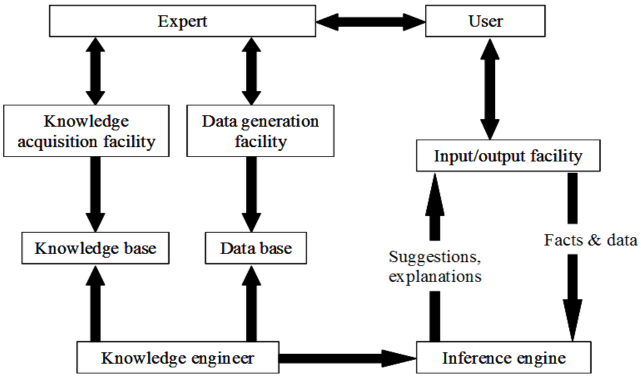

Fig 6: Structure of expert system

Advantages:
(i) It is permanent and consistent.
(ii) It can be easily documented.
(iii) It can be easily transferred or reproduced.

Disadvantage:
Expert Systems are unable to learn or adapt to new problems or situations.

Applications:
Many areas of applications in power systems match the abilities of expert systems like decision making, archiving knowledge, and solving problems by reasoning, heuristics and judgment. Expert systems are especially useful for these problems when a large amount of data and information must be processed in a short period of time.

How expert systems can be used in power systems:
Since expert systems are basically computer programs, the process of writing codes for these programs is simpler than actually calculating and estimating the value of parameters used in generation, transmission and distribution. Any modifications even after design can be easily done because they are computer programs. Virtually, estimation of these values can be done and further research for increasing the efficiency of the process can be also performed density *B* or magnetic field strength symbolized as $\mu_0 H$. Use the center dot to separate compound units, e.g., "A·m^2."

IV. 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:

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

pipes, and precise positioning of measurement equipment.

- 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.
- 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.
- Fuzzification provides superior expressive power, higher generality and an improved capability to model complex problems at low or moderate solution cost.
- Stability analysis and enhancement.
- Power system control.
- Fault diagnosis.
- Load forecasting.
- Reactive power planning and its control.
- Operation of power system like unit commitment, hydro-thermal coordination, economic dispatch, congestion management, maintenance scheduling, state estimation, load and power flow.
- Planning of power system like generation expansion planning, power system reliability, transmission expansion planning, reactive power planning.
- Control of power system like voltage control, stability control, power flow control, load frequency control.
- Control of power plants like fuel cells power plant control, thermal power plant control.
- Automation of power system like restoration, management, fault diagnosis, network security.
- Can be used in anything from small circuits to large mainframes.
- Can be used to increase the efficiency of the components used in power systems.

As most of the data used in power system analysis are approximate values and assumptions, fuzzy logic can be of great use to derive a stable, exact and ambiguity free output.

V. 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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