Techniques to Apply Artificial Intelligence in Power Plants

Anshika Gupta

Department of Mechatronics Engineering,

Mukesh Patel School of Technology Management and Engineering, NMIMS, Mumbai, Maharashtra, India

ABSTRACT

In today's world, we are experiencing tremendous growth in the research and application of Artificial intelligence. Power plants are a vast sector where there is a scope of using AI to rectify the faults and optimize the overall running of the plants. The use of AI will help in reducing human dependence, and during a breakdown, will assist in rectifying the problem by determining the cause quickly. This paper focusses on proposing numerous methods to implement AI in various power plants and how it will help in the same.

KEYWORDS: *Artificial Intelligence, Power Plants, Expert Systems, Artificial Neural Network, Fuzzy Logic*

INTRODUCTION

Power plants have expanded with the increase in the energy demand to serve the growing population. There are many types of power plants, which include; Thermal, Hydroelectricity, Nuclear, Solar, etc. In all these plants, there is a continuous need for monitoring to check the process. Sometimes, minor faults can cause the breakdown of the plant, which is very difficult to restart again. To check on the above is a very time-consuming and tedious job.[1] AI can be employed in managing several problems like these, making it easier for humans. AI is the technology of making the computer systems and machines intelligent for performing tasks like decision making, concluding, data visualization, etc without human reliance.
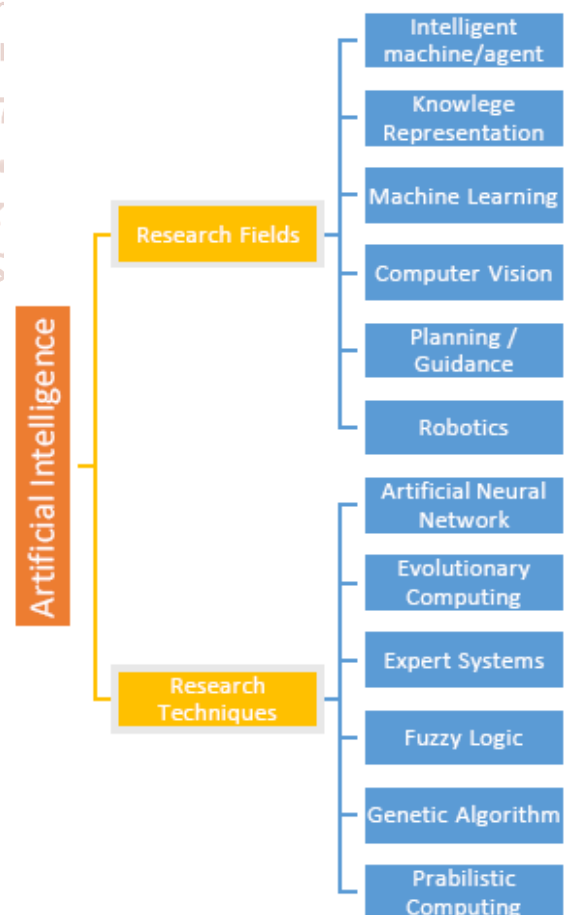

Chart 1: Classification of AI techniques.[3]

Area of Application

The demand for cheap and sustainable energy has led to decentralization in the power generation sector. It has made a large number of participants injecting power into the grid and made it difficult to manage and balance the grid.[2] AI here can help in efficiently evaluate and analyse data in huge volumes.

With the advancement in technology, people are designing and installing Smart Grid which, not only digitizes all the meters and other devices for storing more energy, but supports bi-directional communication for sending and receiving data, useful in real-time. Also, it has to quickly achieve control of load according to the demand, along with taking care of isolating the systems in case of grid failure, eliminating casualties. [4] With the help of AI, the supervision and managing of all this will become much more relaxed.
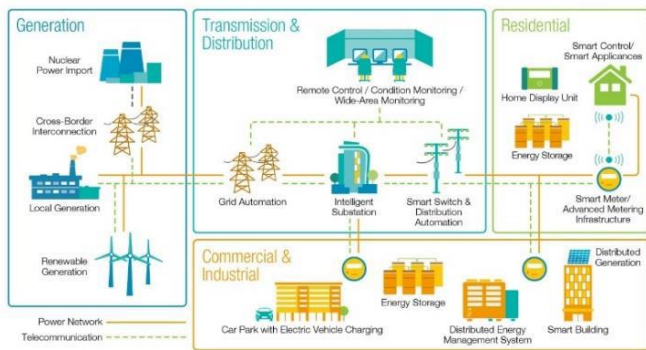

Figure 1: Smart Grid Representation.

Furthermore, AI can assist in the stabilization of the power grid by the detection of irregularities in the generation, transmission, and consumption in real-time. Managing of networks for proper communication and protection against data theft and provide the solutions at a lower cost.[5]

Methods and Implementation

This section consists of various techniques that can be implemented in different areas. Some of them are:

1. Expert System

An Expert System (ES) is a computer program, consisting of a knowledge base and a lot of algorithms or rules based on human expertise, which indicate or predict new facts from the incoming, and past information.[6] It consists of the following components:

➢ User Interface: It is the channel through which the user interacts with the ES.
➢ Explanation Facility: Used to give reasoning behind a conclusion to the user.
➢ Working Memory: Storehouse of a particular database that helps in concluding.
➢ Inference Engine: It helps in prioritizing the rules and uses the rules with the highest priority.
➢ Knowledge Base: Consists of specific information from knowledge and thinking of experts.
➢ Agenda: Rules that serve the condition.
➢ Knowledge acquisition facility: Used to fill the knowledge database. If the component is not stored, it has to be coded separately, which is a cumbersome task.[7]
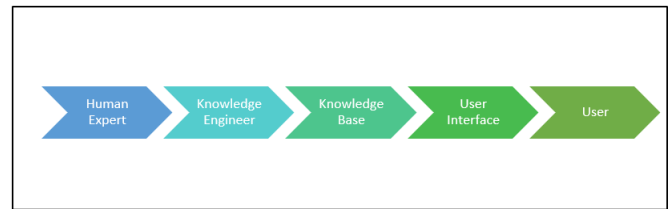

Figure 2: Process of implementing ES

Based on this, they can be used in monitoring and performing calculations about the generation, transmission, and distribution line.

2. Artificial Neural Network

Next is the Artificial Neural Network (ANN), which is a computational model consisting of various processing components that take inputs and give outputs as per the predefined functions.[8] It consists of the following components:

➢ Input layer: This layer consists of artificial input neurons that take the input data for further processing.[9]
➢ Hidden layer: As this is an intermediate layer, located between the input and the output layer, it applies weights to the input using functions, performing non-linear transformation depending on the type of neural network and leading them to an activation function as the output.[10]
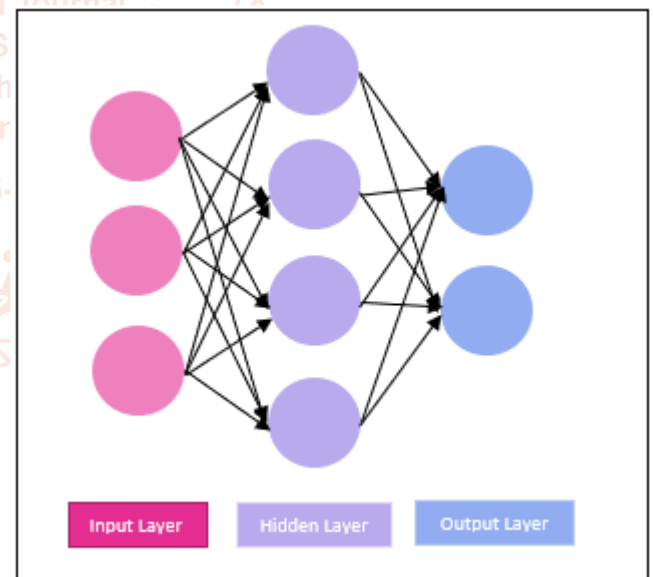➢ Output layer: It is the last layer consisting of neurons that produce the output.

Figure 3: Artificial Neural Network

It can be employed for the fault diagnosis in the transformer by setting up algorithms for parameters like oil leakage, module output, resistivity, etc.[11] Also, it can help determine whether conditions to have an insight about the sun intensity and direction for solar plants, can be used to develop smart solar panels that optimize their position according to the sun's position. Along with that, it can also help in wing power stations to know about the wind trend and speed for efficient power generation. [12]

3. Fuzzy Logic

Fuzzy logic is the process of computation with words. It consists of sets of rules, written in the form of words

according to which the output is determined.[13] It consists of the following steps [14]:

- Input: This step involves getting the crisp input whose output is desired.
- Fuzzification: It is the process of converting the crisp inputs into fuzzy inputs by utilizing Membership Function. A membership function is a curve defining the mapping of each point in the input space to a membership value between 0 and 1.
- Knowledge Base: It is inventory of the rules applied to the fuzzy sets to find the degree of membership.
- Interface Engine: The rules from the knowledge base are applied to the inputs for mapping then into outputs.
- Defuzzification: It is the conversion of fuzzy output into crisp outputs.
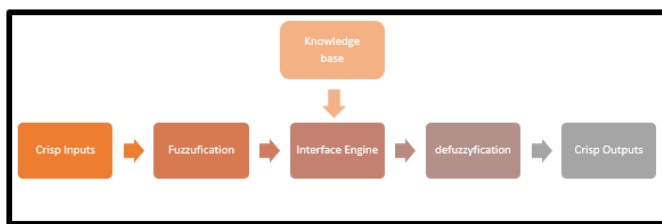- Output: It is the final crisp output obtained at the end of the fuzzy logic process.

Figure 4: Fuzzy Logic Process

This fuzzy logic can help in optimizing the performance of the cooling system by determining the accurate water ratio for regulating the pressure.[15] Also, modelling it in the control system can help in adaptation to differences in the raw material by changing the parameters, especially in coal-based thermal power plants, when the type of coal is not consistent.[16]

So, the description of major techniques for AI implementation are mentioned above and for a clearer concept the comparison between the three, in different aspects is given below in table 1.[18]

Features	Expert System	Artificial Neural Network	Fuzzy Logic
Knowledge Source	Expert knowledge	Human Expert	Sample sets
Knowledge Representation	High	Very low	Very High
Adaptability	Very low	Very High	Low
Fault Tolerance	High	Very high	Very High
Self-learning	Very Low	Very High	Very Low
Computation	Very High	High	Low
Explanation Ability	Very High	Very Low	Very High
Maintainability	Very Low	Very High	High
Uncertainty Tolerance	High	Very High	Very High

Table 1: Comparison between features of the three techniques

From table1, the technique that should be used in the particular area of application can be chosen and implemented accordingly for best results. Apart from these other hybrid techniques can also be used which are a combination of two or more techniques.

Conclusion

This paper presented various techniques of AI that can be used in various parts of a different power plants to increase the efficiency without human dependency and error. It also demonstrates the comparison between the different techniques and what work they perform better. It is also obvious that the more the model is trained with different data, the more it is likely to adapt with the chance in input for providing better efficiency by changing the parameters involved in the process. Hence, it will be a more efficient approach to utilize AI in the power plants.

Reference

[1] Reshmi Banerjee, "Artificial Intelligence in Power Station", INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING Vol. 3, Issue 7, July 2015

[2] https://www.next-kraftwerke.com/knowledge/artificial-intelligence

[3] Sidda, Sakunthala & Kiranmayi, R & Nagaraju, P. (2017). A Review on Artificial Intelligence Techniques in Electrical Drives Neural Networks, Fuzzy logic, and Genetic Algorithm. 10.1109/SmartTechCon.2017.8358335.

[4] Singla and S. Chauhan, "A review paper on impact on the decentralization of the smart grid," 2018 2nd International Conference on Inventive Systems and Control (ICISC), Coimbatore, 2018, pp. 978-983, doi: 10.1109/ICISC.2018.8398948.

[5] Sozontov A, Ivanova M and Gibadullin A 2019 Implementation of artificial intelligence in the electric power industry *E3S Web of Conferences* **114** 01009

[6] F. Jaryani, S. Ibrahim, R. Daruis, S. Sahibudin and N. A. Rahman, "Intelligent reflective e-portfolio framework based on artificial intelligent Expert systems techniques," 2011 3rd International Conference on Computer Research and Development, Shanghai, 2011, pp.214-216, doi:10.1109/ICCRD.2011.5764117.

[7] Umair, Muhammad. (2018). Requirement Engineering Process of Expert Systems. 10.13140/RG.2.2.29305.57447.

[8] A. S. Kumar, T. Cermak and S. Misak, "Short - term wind power plant predicting with Artificial Neural Network," 2015 16th International Scientific Conference on Electric Power Engineering (EPE), Kouty nad Desnou, 2015, pp.584-588, doi:10.1109/EPE.2015.7161192.

[9] https://www.techopedia.com/definition/33262/ input-layer-neural-networks#:~:text=The%20input%20layer%20 of%20a,for%20the%20artificial%20neural%2 0network.

[10] https://deepai.org/machine-learning-glossary-and-terms/hidden-layer-machine-learning#:~:text=In%20neural%20networks% 2C%20a%20hidden,inputs%20entered%20int o%20the%20network.

[11] Q. Yang, M. Li, X. Mu and J. Wang, "Application of Artificial Intelligence (AI) in Power Transformer Fault Diagnosis," 2009 International Conference on Artificial

Intelligence and Computational Intelligence, Shanghai, 2009, pp. 442-445, doi: 10.1109/AICI.2009.497.

[12] A. S. Kumar, T. Cermak and S. Misak, "Short - term wind power plant predicting with Artificial Neural Network," 2015 16th International Scientific Conference on Electric Power Engineering (EPE), Kouty nad Desnou, 2015, pp.584-588, doi:10.1109/EPE.2015.7161192.

[13] P. Subasic and M. Nakatsuyama, "A new representational framework for fuzzy sets," Proceedings of 6th International Fuzzy Systems Conference, Barcelona, 4864, 1997, pp. 1601-1606 vol.3, doi: 10.1109/FUZZY.1997.619780.

[14] Cheulheui Lee and Seonhak Seo, "Analysis of the typical fuzzy logic controller using cell concept," FUZZ-IEEE'99. 1999 IEEE International Fuzzy Systems. Conference Proceedings (Cat. No.99CH36315), Seoul, South Korea, 1999, pp. 90-95 vol.1, doi: 10.1109/FUZZY.1999.793212.

[15] D. Popescu, R. C. Dinu and C. Bratu, "Fuzzy control of cooling water pumps related to a power plant," 2017 International Conference on Electromechanical and Power Systems (SIELMEN), Iasi, 2017, pp. 541-545, doi: 10.1109/SIELMEN.2017.8123382.

[16] D. Pruessmann, B. Krause and C. von Altrock, "Fuzzy logic supervisory control for coal power plant," Proceedings of 6th International Fuzzy Systems Conference, Barcelona, 4864, 1997, pp. 921-925 vol.2, doi:10.1109/FUZZY.1997.622832.

[17] Satish Kumar , Ravali Cherukuri "A Survey on Artificial Intelligence Techniques in Power Station", Vol. 6, Issue 1, January 2017, DOI:10.15680/IJIRSET.2017.0601040

[18] Maxville, Valerie & Lam, Chiou & Armarego, Jocelyn. (2004). Learning to Select Software Components.. 421-426.