Fuzzy Logic based control system and Artificial Intelligence in Industrial Automation

R Deepa¹, Sri Rakshitha A K², Gopala Krishnan V³

1 Assistant Professor, Bannari Amman Institute of Technology, Department of Electronics and Instrumentation Engineering, Erode, Tamilnadu, India.
2, 3 UG student, Bannari Amman Institute of Technology, Department of Electronics and Instrumentation Engineering, Erode, Tamil Nadu, India.

rangarajdeepa@gmail.com, srirakshitha.ei19@bitsathy.ac.in, gopalakrishnan.ei19@bitsathy.ac.in

Abstract. Amidst the AI driven world, the Automation plays a major role in every sector. Usually the control systems in industries are manually controlled in unpredictable conditions. We are in need of a human to control a system. In this affair an AI trained machine acts as a human replica to drive it fully automated. The highly labor-intensive industries can be benefited by the use of Artificial Intelligence in the automation part, this reduces the human errors and safeguard them from risky areas. The fuzzy based PID controller is used here because it acts as Human-in-the-loop behind the whole process. This helps in tuning the PID controller to set a desired value which enhances the gains, adding to that it gives a high accuracy and brings up more flexibility in changing the rules. The result which is obtained is simulated in MATLAB with overshoot difference.

Keywords: Fuzzy Logic Control (FLC), Artificial Intelligence (AI), Proportional Integral Derivative (PID), Precision Drilling.

Introduction
Industrial Automation is a major factor to avoid human errors where a small issue leads to big accidents in industries. To make it as an unmanned one, AI takes responsibility in achieving this. Artificial intelligence is a human brain designed machine brain. It is trained by data, tests, predicts it and becomes efficient day by day by emphasizing it and taking decisions on its own. AI technology can be blend in the Oil and Gas sector, improvising the efficiency in operation. The vital accidents takes place in onshore gas station, a high tracking facility infused with AI is a must to ensure the safety of the employees and avoid such happenings. These are often observed by AI-powered cameras, robots, drones, etc. AI models are trained on boundless amount of production data that validates the accuracy of the analysis done and predicts spontaneously. The Fuzzy logic technology is now mainly used in control that includes transfer of technology as a transfer learning method, turbine startup with a high speed is controlled, optimization of turbine cycling is done and finally controls the power supply. Thus use of these technologies in real-time is going to be a biggest game changer in upcoming generation.
1. **Fuzzy Logic Control**

The fuzzy Logic control (FLC) behaves as human interpretation by understanding the tasks of a person which is trained to it in terms of data. The effectiveness of the work done by FLC stands for its accurate results.

![Structure of Fuzzy control](image)

**Figure 1.** Structure of Fuzzy control

### 1.1. Major components of FLC

The following are the major components of Fuzzy Logic Control as shown in the above figure 1.

- **Fuzzifier** – Fuzzification is the method of converting the input values into fuzzy values to set labels.
- **Knowledge Base** – The input and output relationship is stored in this knowledge base.
- **Inference Engine** – Inference engine behave as a support to the knowledge base by deducing the new information based on fuzzy rules.
- **Defuzzifier** – Defuzzifier is known for its work of converting values from inference engine to a crisp output.

### 1.2. Use of Fuzzy logic in PID controller

In these modern days, technology reaches its peak in every sector, in this list Fuzzy logic stands for its broad potential of its application in industrial automation. These are all proven concepts in which engineers rely on. PID controller assumes itself in a linear behaviour where this simplification can be made in stable conditions, the operating point is pushed far away by strong disturbances from the operating point. In this circumstance, the linear approach does not run. The similar one can take place when we change the parameters. In such conditions the PID controller comes into action and it is replaced instead of old methods.

In the PID controller we have this tuning system both manually and automatically. These are not encouraged in certain conditions where we have to control a high pressure using PID.

**Manual PID tuning:** This type of tuning is said to be done by humans manually. They tune it to a value to obtain gains and the adjustments are made prior.

**Auto PID tuning:** It is also called ‘Self-tuning’. Usually PID controllers are designed to simple down matters by selecting their own tuning ranges based on automated analysis. For formulating and auto
tuning it we always want a mathematical procedure which is processed to an extent by input/output predictions.

Taking these two tuners into consideration, some complication occurs in uncertain conditions. To avoid this Fuzzy logic steps into PID for controlling and tuning automatically.

1.3. Implementing Fuzzy logics in PID tuning
The Mathematical application of fuzzy logic is applied here. Mainly the tuning is done with the fuzzy on applying its logics. This is done by Zeigler-Nichols control theory. The fuzzy control decides how the tuner should be tuned to gain appropriate values. For control application the fuzzy logics has always been a trial and error method. The change that occurs in the fuzzy tuned PID controller is far better than normally tuned PID controllers. The optimizations are simulated in the results below.

2. Artificial Intelligence in Control
Artificial intelligence is an upcoming technology in which data can be predicted and analysis is done on historical data. AI is useful to us in recent years, this was first tested by Alan Turing and he came up with the theory of Machine Thinking where the machine decides itself to think and act as a human. This AI is used in control systems in Industries.

2.1. AI in Oil and Gas industry

❖ Production Area
AI gives hands in oil and gas industries for production to find out the area of efficiency to get profits and produce. AI stands for its standard of data analysis that it can train an enormous number of data in the production side as a raw one to refine the data to generate analytics.

❖ Reservoir Management
Maintenance and the degree of optimization is high at many technicalities like seismic interpretation, management of reservoirs, geology and on the production side these come under oil reservoir management in industries. AI models can be trained for such technicalities in the field of surveillance etc. by their information.

❖ Communication:
AI supports in bridging the gap between customers and the industry by designing the Chabot with a recommendation system in it and providing information, queries etc. to the customer to engage with.

❖ Continuous Monitoring:
We have some safety measures always in industry where they continuously monitor the safety of the workers in oil fields, mines, plants etc here the AI cameras and bots come into action and alerts the person or the authority of the risk and take predictive measures to avoid such accidents.

❖ Industrial Automation:
Certain works in industries are sensitive and to be done with utmost care of workers. In this circumstance, AI automates everything and does the task in a perfect way. The only thing is to train it and it will take up the rest. This will avoid many human errors.

These are the advantages of using AI in oil and gas industries. The very concerned part of application is feasibility. Drilling for production fuel and other products have been tough on off-shore has its done by the precision drilling. In this part the historical data of the drills and the mining are collected and trained with the model. This enhances in collecting real time data like the pressure under the ground, temperature till how the driller can withstand and finally seismic reports both in land and ocean.

3. Results
The simulation done in MATLAB software is given here. This is compared with the traditional PID controller and non-linear PID controller.

3.1. Fuzzy in PID
Two different trials are simulated here. The data is collected from the areas where the PID is applicable. In the First trial it gives a normal output by testing the model with turbines. This is trained by calculating
its speed in the run time. The first trial gives an output with limited benefit. So, while heading up to second trial, the data from the pressure steam of reduced one is taken to train the model. This time it causes a reduction of thirty percentages in the gain. The major requirement is to deduce it to get a crisp output. Hence the second trial acts better than first and gives a good benefit in low gains.

The simulation of the Fuzzy PID controllers are done for the trial which is obtained and the difference can be seen in the graph. The table 1 depicts the trial and error method and it is given below:

Table. 1 Trial and Error Method

| Trials | Indexes                  | Relays          | Fuzzy            | Field PI      | Fuzzy            |
|-------|--------------------------|-----------------|------------------|---------------|------------------|
| 1     | Overshoot (%) Settling   | 0.1081          | 0.1556           | 0             | 0                |
|       | time Rise time(s) IAE   | 139.6400        | 139.5350         | 146.1650      | 141.3350         |
|       |                          | 129.9700        | 129.8650         | 136.4100      | 131.3900         |
|       |                          | 2.6147e + 04    | 2.1756e+04       | 4.6981e+05    | 1.6515e+05       |
| 2     | Overshoot (%) Setting    | 0.0361          | 0.1274           | 0             | 0                |
|       | time Rise time(s) IAE   | 139.9150        | 139.7200         | 154.8950      | 143.1050         |
|       |                          | 130.1950        | 129.9800         | 139.2200      | 132.8350         |
|       |                          | 3.4055e+04      | 3.0209e+04       | 6.6299e+05    | 2.2842e+05       |

Figure 2. MATLAB Simulation

3.2. Artificial Intelligence in industry
Hence Artificial Intelligence Technology plays a major role in Oil and gas industries and other sectors by providing safety and monitor measures to the employees and a user friendly support system. AI powered predictive systems analyse huge data from sensors placed in some areas and predict it. AI helps in reducing production costs in order to widen the profit. AI cut production costs from 10% to 20%. This upstream could result in savings of capitals upto $100 billion to $1 trillion by 2025. This prevents cyber threats by its high security. In the areas like using big equipments, the precision drilling uses AI and contributes more on control.

4. Conclusion
Thus the paper forecasts, the future problems and analyses the data on industries using technology, which saves the mankind from certain risks. On a fuzzy approach the physical components like pressure, temperature and humidity can be controlled, monitored and maintained in a smooth way using this approach. The tuning method became easy and it is essential in using Fuzzy logic control. On the other hand, Artificial Intelligence with its algorithms from Machine learning, Deep Learning, Natural Language Processing, Neural networks etc. these entire stand for a big gain in the automation sector.
5. Reference

[1] Li W.-L. "Nonlinear uncertain turbine governor design based on adaptive backstepping method.", 31st IEEE Chinese Control Conf. (CCC), 2012, 744-749.
[2] Morris, A. "Adaptive digital control of a steam turbine.", Proc. Institution of Electrical Engineers. 123 (6) IEE, 1976.
[3] Bolek, et al. "Two-valve control of a large steam turbine.", Control Engineering Practice, 10 (4), 2002, 365-377.
[4] Fang, et al. "Nonlinear inversion-based output tracking control of a boiler-turbine unit.", J. Control Theory and Applications, 2005, 3 (4): 415-421.
[5] Wang, D., Wang, Z., Meng, L., Han, P. "Multi-model based IMC design for steam temperature system of thermal power plant.", Int. Conf. on Test and Meas. ICTM'09, 2009: 5-9.
[6] Kordestani, M., Khoshro, M.S., Mirzaee, A. "Predictive control of large steam turbines.", 9th Asian Control Conference ASCC 2013, 2013.
[7] Ding, H. "Multivariable self-tuning control of a boiler-turbine system.", Int. Conf. Advances in power system control, operation and management, APSCOM-91, 1991: 498-502.
[8] Liu, X.-J., Lara-Rosano, F., Chan, C.W. "Neurofuzzy network modelling and control of steam pressure in 300MW steam-boiler system.", Engineering Applications of Artificial Intelligence, 2003.
[9] Industrial Automation and Process Control Book by Jon Stenerson.
[10] MODERN DATA ANALYTICS: Applied AI and Machine Learning for Oil and Gas by Tatyana Plaksina (Author).
[11] Hung Yuan, Bo Chen, Jin Lin. A PI-type Fuzzy Controller with Self-tuning Scaling Factors [J]. Fuzzy Sets and Systems, 2005, 93 (2):23 - 28.
[12] Caihua Lu, Yuewen Xu, and Weiming Yang. Permanent magnet linear synchronous motor feed system for fuzzy PID control [J]. Journal of Electrotechnics, 2007, 22 (9): 59-63.