

Application Of Safe And Efficient Control Methods Using Odd-Numbered Fuzzy Logic Elements For Small Hydropower Plants

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Abstract: Many factors associated with streamflow are vague, subjective, and difficult to quantify. The fuzzy logic method is very useful for such an approach to solving problems as small hydropower. The performance of a fuzzy linguistic variable can easily be characterized in general terms. The paper initially presents a new fuzzy logic controller (FLC) method for the safe control of dam reservoirs through spillway gates.

Key words: fuzzy logic, spillway gate control, turbine valve control.

From a small hydropower project, consumers demand nominal frequency and voltage power. Various controls are required to maintain these parameters within specified limits. Voltage is maintained by controlling the excitation of the generator and frequency is maintained by balancing the mismatch between generation and load demand due to river flow and flow through the turbine. Power can be controlled by controlling the flow through the turbine and dams can be kept safe by controlling the spillway gates [1].

Similarly, the application of the CNL system here consists of two input variables: "Water level" and "Flow rate" and one output variable: "Opening the turbine valve"; The main objective of this control problem is to regulate the flow rate of water supplied to the turbine according to the load disturbances and thus maintain a constant output frequency of the system to a certain extent due to CNL [2]. Indian scientist Mamdani studied uncertainty logic control as an alternative to the PID controller. He developed a controller that followed rules rather than complex numerical formulas. His rules were similar to PID control. As a result, the rules were obtained by evaluating the error and error change. Membership functions were created for errors, error changes and changes in the output to control the uncertainty logic of some variable process. He used the methods of Indian scientist Mamdani to determine odd numbers (3, 5, 7, etc.) of membership functions for each variable. They are triangular in shape (the most popular and widely used), symmetrical, equidistant, and overlapping. Some experiments have been conducted with different numbers and shapes of membership functions, but the increase in complexity has not been sufficiently rewarded with improved performance.

Uncertainty logic is based on the advantage of uncertainty management in controlling processes that are too complex for mathematical modeling. In order to develop an effective QNL to solve the problem, membership functions must be optimally defined. Many factors related to river flow or hydropower are subjective and difficult to quantify in this type of process, such as water level or depth at the level of "under threat - danger - above danger". Similarly, water flow is described as "Slow-Normal-Fast", etc. However, uncertainty logic allows the evaluator or decision maker to incorporate this information into an environmental performance assessment system that is uncertain, uncertain and subjective. Therefore, the CNL method is a very suitable method for solving the problem of energy production in small hydropower plants. The rule base and membership functions have a great impact on the performance of the QNL. The effectiveness of a linguistic variable can be easily described in general terms: "Good - Average - Bad; Strong - Medium - Weak; High-Medium-Low", etc. Each term is called a linguistic modifier. Therefore, when a linguistic variable is combined with a linguistic modifier, an ambiguity set is formed.

Uncertainty arithmetic can be solved manually or in the MATLAB program. Safe and effective uncertainty logic control of a hydropower project in the Marhamat district of Andijan region is considered as an example: In the first stage of this method, the system variables, inputs and outputs are determined according to expert opinion. The second stage is the determination of the linguistic values of the system variables (inputs and outputs). Then the uncertainty intervals of the input and output variables are characterized.

Safe Management of Spilled Water: Based on interviews with experts and measurement data obtained, past experience and on-site calculations, their membership function and other parameters are derived.

Linguistic variables, their linguistic meanings and associated uncertainty intervals are described below. Triangular membership functions (trimf) are defined for all input and output data.

Manual calculation for spillway gate control:

Here we have defined the following uncertain terms:

Definitions of Water Level (M)-Input(1):

Low trimf (0 15 35); Medium trimf (30 45 65); High trimf (60 75 100)

Definitions of Flow rate (Kilo Cumec)-Input(2):

Low trimf (0 15 35); Medium trimf (30 45 65); High trimf (60 75 100)

Now let us consider following condition:

Water Level (63 M): Medium (0.1) & High (0.2)

Flow rate (32 Kilo Cumec): Low (0.15) & Medium (0.133)

Rules fired are 4, 5, 7 and 8

Strength of rule 4: $[0.1 \wedge 0.15] = 0.1$

Strength of rule 5: $[0.1 \wedge 0.133] = 0.1$

Strength of rule 7: $[0.2 \wedge 0.15] = 0.15$ Strength of rule 8: $[0.2 \wedge 0.133] = 0.133$ Now, C.O.G. = $\sum \mu_i * \mu(i) / \sum \mu_i$

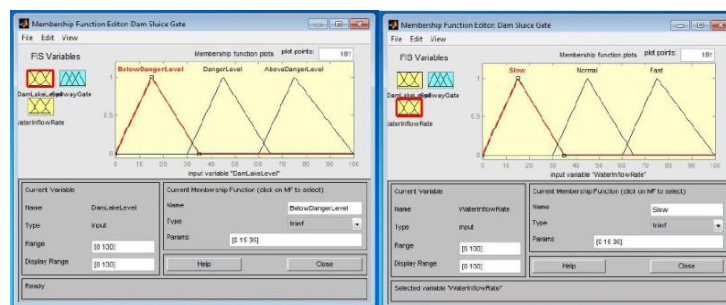
Hence,

C.O.G. = $(65 * 0.1 + 0.1 * 20 + 0.15 * 65 + 0.133 * 65) / (0.1 + 0.1 + 0.15 + 0.133)$ C.O.G. = 55.5% i.e.

“Partially Open” – Output.

Verify the above calculation using the MATLAB FIS editor:

Reference: Dam control methods require the measurement of specific parameters and input variables to evaluate the control performance, as shown in Fig. 1(a) and Fig. 1(b). There are two inputs: dam water level and inflow velocity.



1(a)

1(b)

Figure 1. (a, b): Velocity of water flow through a dam - inlet.

The total number of active rules obtained in this study is 9 rules ($pq=32$; where p = the maximum number of overlapping fuzzy sets and q = the number of input data), as shown in Fig. 2 (c). The rules are based on the “Mamdani inference method”.

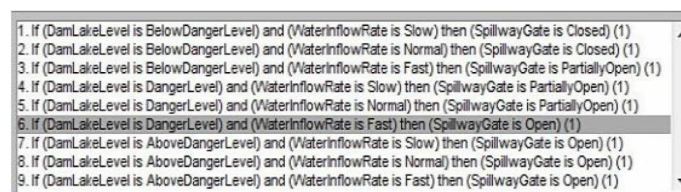


Fig. 1. (c): Mamdani uncertainty rules editor

Output data: Fig. 1(d) shows the relationship of two input parameters, namely “Water level” and “Water flow” to their 1 output parameter, namely “Drain door opening”.

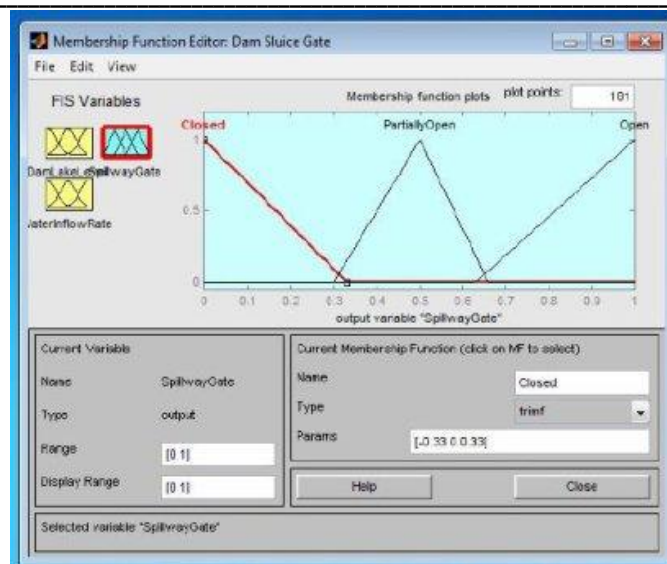


Fig. 1 (d): Opening the drain hatch - exit.

Rule Viewer - Graphic: In Fig. 3(e) the graphic rule viewer shows the correlation of two inputs, namely "water level" and "water flow", to 1 output value, namely "gate opening". The result shows 56%, i.e. "partially open". Therefore, after verification, we find that the uncertainty model's estimated accuracy is quite reasonable, as shown above.

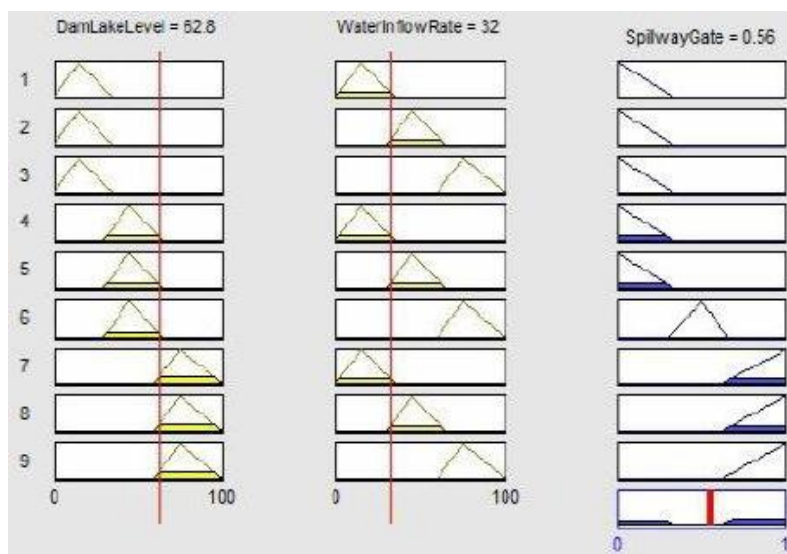


Fig. 1. (e): Fuzzy Rules Viewer - Graphics.

Graphical representation from the surface: in Fig. 1(e) shows a three-dimensional graph of “dam gate opening” as a function of “Lake dam level” and “water flow rate”.

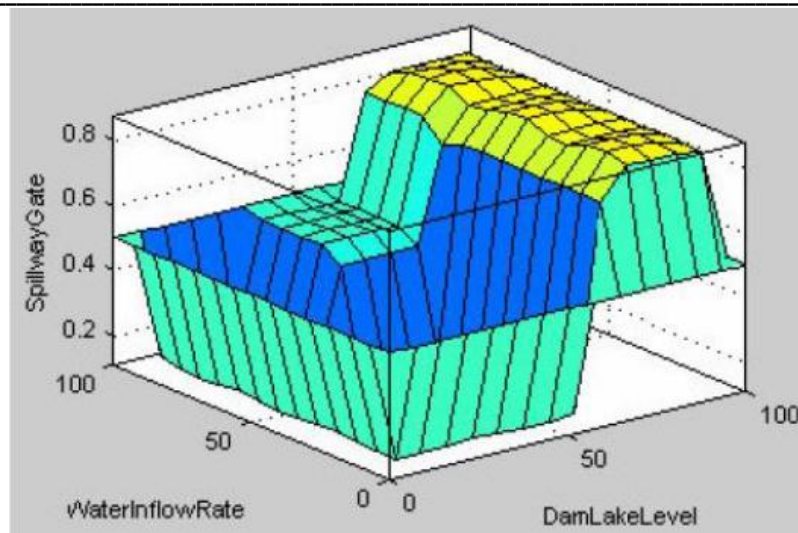


Fig. 1. (f): Fuzzy Rules Viewer - 3D Surface.

The main objective of a hydroelectric power generation and control system for a dam or reservoir is to maintain the system within specified limits by regulating the flow of water through the dam water flow and turbine valves under all conditions to ensure the safe and efficient operation of hydroelectric power. power generation. Due to the uncertain changes in water level during flood or overflow, it is very difficult to control the reservoir quickly and effectively manually. As with uncertain load changes, it is very difficult to control the governor effectively. For all hydroelectric power generation, it is desirable to have a constant frequency value when the load value changes. However, the main problem in hydroelectric power generation is to maintain a constant frequency, because these plants respond quickly to small changes in the river regime. The system frequency changes depending on the difference between the consumed power and the generated power. In addition, people are emotional and forgetful. Thus, people may make wrong decisions under extreme conditions. Therefore, this drawback must be completely solved by automation. Triangular fuzzy membership functions are used because of their simplicity and relative simplicity to PID control. The rule base is built intuitively by initializing the optimal number. Rules for using QNL. The uncertainty is very relevant to the prediction accuracy of the model, as shown by manual calculations or the MATLAB FIS editor. It is well understood that the lack of data in reservoir operation modeling affects the evaluation of appropriate release policies. However, even with very approximate data, the model is able to produce very accurate results. These results show that uncertainty logic is a very useful estimation method and does not require estimation using hard numbers.

CONCLUSION

This study aims to improve the application of uncertainty logic using MATLAB FIS editor or manual calculations for hydropower generation. Hydropower generation is one of the renewable energy sources, and therefore plays an important role in the socio-economic development of countries, and is of particular importance due to its relatively clean and environmentally friendly characteristics. The model here is the basis for understanding the physical system. This paper proposes an effective and accurate uncertainty control-based method for the operation of the hydropower generation system and the dam reservoir for safe and efficient operation. This method has no disadvantages of the human-based control system. In addition, the parameters of the membership functions are optimized using ASP, and the degree of automation of the uncertainty control system can be increased. In addition, we have seen that the KNL rule base is intuitively constructed using the optimal number. Rules using the Delphi method. Initially, the variables, membership functions, and rule base are randomly determined. Then, the most suitable values of the parameters describing the uncertainty membership functions are selected using the Tabu Search Algorithm (TSA). The predictive accuracy of the uncertainty model is quite reasonable. In the future, this work can be extended to develop a method to link uncertainty logical-linguistic variables with various efficient management of other renewable energy sources.

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