The Use of Fuzzy Logic for effective gate opening control in Dams

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Abstract—— ***this paper endeavours to provide a solution to the manual adjustment of gate opening settings due to silting on the dam bed. The sources of silting in the catchment area and the rainfall statistics in the region can give a probabilistic model sufficient to develop a fuzzy logic for the effective control of gate opening without manual intervention and prevent wastage of water.***

Keywords— Fuzzy logic, silting, flood level, gate control
Introduction (Heading 1)

I. Introduction

The phenomenon of silting at the base of rivers or dams is a very common one. De-silting activities are seen at various sites throughout the country. The accumulation of sand and other debris on the bed of a river or dam is known as silting. This results in an effective increase in the floor level of the river or dam. Silting can be a result of many things like reduction in speed of flowing water, obstructions, still water which receives run-off water from streams. All these result in silting which is the base of this paper.

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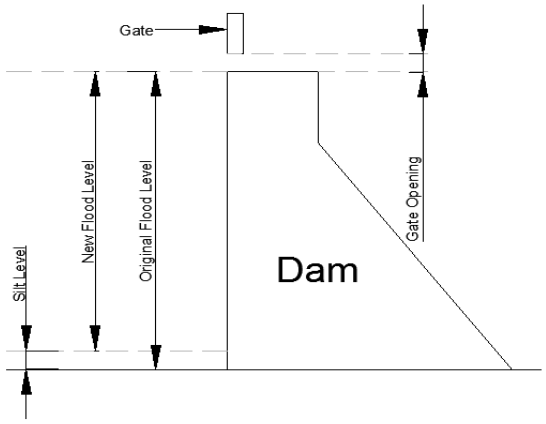

Figure-1: Basic System to be controlled

II. Problem Statement

Silting results in the overall rise of the river or dam bed. This paper, specifically talks about dams. Silting causes the floor level of the dam to rise. Hence, all measurements and calibrations done with respect to the dam floor have to be re-calibrated according to the silt accumulation or de-silting has to be undertaken time and again, which is a very costly affair. This level holds a particular significance with regard to the dams.

The dam is a very dynamic environment and offers a lot of challenges [4]. The flood level of the dams is defined with the reference of the bed. This level governs the gate opening of the dam in case of flooding. The gate opening is directly proportional to the amount of water above the flood level. Hence, all its functionality is based on the accuracy of the flood level and thus indirectly on the bed level. Initial calibration of the flood level is based on a clean bed. But eventually, silting changes the level of the bed and thus the flood level is indicated before that actual amount or level is achieved. This results in faulty opening of the gate and hence leads to wastage of water that we are trying to preserve. Water discharged through the gate cannot be used for drinking. Figure 1 given below explains the system to be controlled. The silt level goes on rising thus causing faulty triggering of the Flood level switch before the actual amount of water is accumulated. The amount of gate opening depends on the level of water above the flood level and this is the parameter that has to be controlled. Thus, to prevent this loss, we need a system which will work with least human interference and maximum accuracy.

III. Fuzzy Logic

Fuzzy logic is a variation of the set theory. Classical Set Theory defines a set as a collection of objects, in which each object has a definite membership to a set. In the Crisp Set Theory [1], an object can have various values of membership between 0 and 1. Classical set theory allows bi-valued output i.e. True or False. Crisp set theory allows multi-valued output [1]. It can be entirely true, partly true, and absolutely false and so on which are valued between 0 and 1. In short, we assign weights to the elements of the set and consider them accordingly. Thus the same input can have a different membership according to the logic implemented. This kind of logic allows us to account for the probabilistic nature of events. It allows us to govern the weight assigned to each parameter that is to be considered. The basic logic for the fuzzy circuit is explained in the figure below (figure 2)
The database will consist of all the statistical data that has been collected. Rule base will govern the processing of that data. A fuzzy logic system contains sets used to categorize input data (fuzzification), decision rules that are applied to each set, and a way of generating an output from the rule results (defuzzification).

IV. Solution

The problem is arising out of silting, thus, there is need to examine the sources of silting in any catchment area. The primary source of silting in any reservoir is the run-off streams that bring water to it. The number of streams in an area can be identified and water samples can be evaluated to get an estimate of the quantity of silt brought in by each stream per litre of water deposited in the reservoir. The amount of flow in that stream is governed by the rainfall in that region. The statistical data for the rainfall in that region will be available with various agencies that track these phenomena. Hence, the silting is a direct result of the amount and flow of water in run-off streams which is in turn dependent on the rainfall in that region for that time. Hence, there are a few assumptions that go into this thought process. These can be eliminated subsequently. They are-

- Water is distributed equally in all streams.
- Slope of the ground for all the streams is the same.
- The velocity of water in all streams is equal.
- There are no other sources of silting.
- There are no obstructions in the path of any of the streams.
- No water percolates in the ground as groundwater.
- All the silt deposited remains at the bottom of the dam, none of it flows out with the water let out.

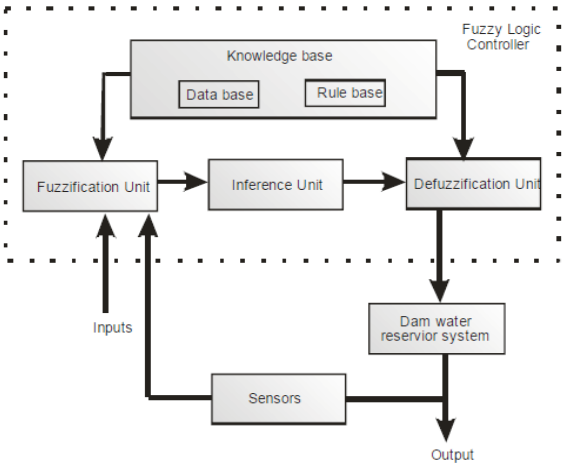

Figure-2: Basic flow diagram for Fuzzy logic [1]

These assumptions leave the probability of the rainfall in that region in any given time period as the sole governing factor for the level rise due to silting and hence deciding the gate opening. The probability element governing the gate opening can be tackled without human intervention using the concept of fuzzy logic. Considering the silting of dam beds, the probability of silting to a certain level is directly proportional to the rainfall. The rainfall can be further categorized into 3 different fuzzy sets namely High, Average and Low. This will give us the flexibility to assign various weights to the rainfall in different regions. The membership will be based on these 3 fuzzy sets depending on the region that we are working in. This makes the system and the logic more generalised. Thus, the probability of the rainfall assigned with proper weights to the silting parameters can offer us a feasible fuzzy logic sufficient to control the gate openings accurately and help to conserve water.

Conclusion

Fuzzy logic thus offers a feasible way to the recalibration of dam flood levels without human intervention. The elimination of the assumptions with more thorough study will increase the accuracy of the system to a large extent. Careful assignment of membership functions will give a very accurate system to tackle this problem.
New systems and developments like the Simulated Evolutionary Algorithm (SEA) [3,5], various mutation strategies [5] can be used to further enhance the accuracy of the systems and make them more suitable for the dynamic environment that they have to work in.

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