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A Review Of Art Of Various Reservoir Operating Techniques And Reservoir Operation Using Modern Technique Of Fuzzy Logic

KEYWORDS: Optimisation, Reservoir operation, Techniques in optimisation and Fuzzy logic.

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ABSTRACT The stored water in reservoir can be used as per the requirement of crop and its demand rather than depending on runoff or rainfall is the main benefit of reservoir storage. Hence, the successful reservoir management and operation lies in the ability in selecting the appropriate operation policy amongst the available set of policies. To achieve optimised reservoir operation, an effective reservoir operation model for various objectives are considered and the decisions at any level have to be taken with optimization technique. Numerous optimization techniques like conventional and non-traditional techniques are used in finding the optimal operating policies. In this paper, review of different optimisation techniques such as linear programming (LP), dynamic programming (DP), stochastic dynamic programming (SDP), non linear programming (NLP), Computational techniques like fuzzy logic is consider at various level related to optimal reservoir operation. Inaccuracies and uncertainties prevails in the parameter then Fuzzy Logic (FL) proves to be best technique to overcome. Data sets of Inflow and Outflow for 10 years (1998-2007) have been used to train and validate the fuzzy logic based models and for two years (i.e. 2008 and 2009) performance characteristics and results for fuzzy logic based techniques have been made. Statistical analysis for the two years (2008,2009) model run have been done.

1. INTRODUCTION:

Reservoir operation depends upon many parameters such as storage level of reservoir, releases for irrigation, releases for water supply, releases for hydropower, releases for downstream water demands in Industries, evaporation and leakages from the reservoir. All of these parameters have combine to form the operating model for the reservoir operation.

Review of Art: Reservoir Operation Techniques: A review of various techniques for reservoir operation has been explained below one by one and later fuzzy logic based model is justified.

Linear programming (LP) may be classified as the most popular optimization technique usedever in any sector. LP deals with the optimization (minimization and maximization) of afunction of variables known as objective function, subject to a set of linear equations and/orinequalities known as constraints.

Dynamic programming, a method formulated by Bellman in 1957 is a procedure foroptimizing a multistage decision process. Dynamic programming is a computational method that allows us tobreak up a complex problem into a sequence of easier sub problems.

Genetic algorithms (GA's) are a stochastic heuristic search method whose mechanisms arebased upon simplification of evolutionary processes observed in nature as proposed inDarwin's Theory of Evolution. GA attempts to emulate the evolutionary mechanism ofnatural biological systems where the best gene is selected for the next generation. The GAs consists of an initial set of random solutions called a population. Each individual inthe population is called a chromosome, representing a solution to the problem. Thechromosomes evolve through successive iterations called generations.

With the advent of computers and their increase in computation power, engineers andscientists are more and more interested in the creation of methods and techniques that willallow computers to reason with uncertainty. Fuzzy logic refers to all of the theories andtechnologies that employ fuzzy sets, which are classes with unsharp boundaries. . A fuzzy setis a set with a smooth boundary. Fuzzy sets and fuzzy logic was introduced in the mid sixtiesby Lofti A. Zadeh, professor of electrical engineering and computer science at University ofCalifornia, Berkley, USA.

Fuzzy Linear Programming: In manypractical situation, it is not reasonable to require that the constraints in linear programming problems be specified in precise, crisp terms. In such situations, it isdesirable to use some type of Fuzzy Linear Programming. To fuzzify the objective functionor constraints, we need to find out the lower and upper bound of the same. After finding thebounds, using proper membership function fuzzification is done and the value of the problemis obtained between 0 to 1, and it gives the results according to required form.

2. LITERATURE REVIEW

This section of paper covers the important part of literature survey carried out for research. The thoroughly read research papers are described briefly with their lucid importance. The techniques which were used or adapted for reservoir operation are described by Louks et al. (1981). Yeh (1985) summarized the various approaches of operating the reservoir.and their remedial measures to make them more acceptable to the operators were discussed by Simonovic (1992). Vedula et al (1990), Wurbs Ralph. A. (1993), Shreshta et al (1996), Panigrahi et al (2000) and Paul S. et al (2000)developed models for evaluating reservoir operations. Folded Dynamic Programming (FDP) technique was handled by Nagesh Kumar D. and Baliarsingh F. (2003) for multireservoir system problem. Regulwar D.G and Anand Raj (2009) proposed the Multi Objective Genetic Algorithm Fuzzy Optimization (MOGAFUOPT) model for multi objective, multireservoir system model.Use of few variables may be best suited to avoid the same problem as pointed out by Kosko and Isaka (1993).In the paper, fuzzy logic based model for reservoir operation has been developed for operation of Ukai reservoir, Tapi basin, India.

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3. STUDY AREA AND DATA COLLECTION

Ukai Dam has been taken as the study area. Ukai dam is situated on Tapiriver at Ukai, Gujarat, India. Figure 1 shows the Ukai dam and reservoir.

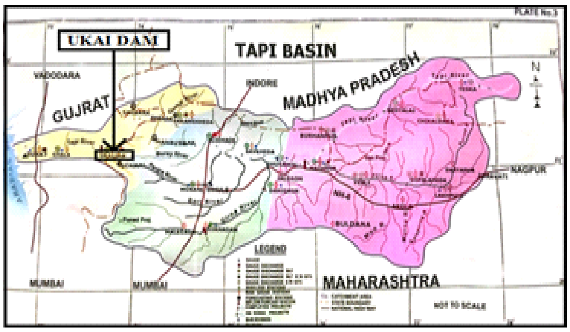

Figure 1: Ukai dam and Tapi basin

4. FUZZY LOFIC BASED MODEL FOR RESEERVOIR OPERATION

Fuzzy logic based model has been developed for optimised reservoir operation. The mass balance equation is given by St+1 = St + It - Rt1.

where, St+1 = Reservoir storage at next time period i.e. t+1.
St = Reservoir storage at same time period t.
It = Inflow occurred at time interval t.

Rt = Release (Total Expected Release) at time interval t.
Mass balance equation in terms of all respective multiple releases

St+1 = St + It – Rirr - Rhp– RHP – Eloss– Rgates2.
Or
St+1 = St + It - Rtsame as 1.
and Rt= Rirr + RHP + Eloss+ Rgates3.
where, St+1 = Reservoir storage at next time period i.e. t+1.

St = Reservoir storage at same time period t.
It = Inflow occurred at time interval t.
Rt = Release (Total Expected Release) at time interval t.
Rirr= Release for irrigation requirements through ULBMC.
RHP = Release for hydropower reuirements.
Eloss= Evaporation losses
Rgates= Release through radial gates in case of flood or high inflow.

Fuzzy logic based reservoir operation intends the use of fuzzy rules and decisions along with utilisation of knowledge and data base. Fuzzy rule based model is developed for the operation of multipurpose reservoir. The model gave the total release as an output of fuzzy model and this total release is distributed in multiple releases as per past records or demands for irrigation, hydropower etc. Table 1 shows rule level and corresponding storage at Ukai reservoir.

Table 1: Reservoir storage corresponds to rule level

Date	Min Rule Level in ft.	Min rule level in m	Storage (in MCM) at Rule Level
1st July	321	97.8408	3825.41
1st Aug.	333	101.498	5420.67
1st Sept.	335	102.108	5714.86
15th Sept.	340	103.632	6524.02
1st October	345	105.156	7414.29

Fuzzy Logic based model employs the steps of Fuzzification, Fuzzy Rules construction, Implication and finally Defuzzification.

1. Input and output variables.

Three input variables are used 10Daily period (T), reservoir storage (S) and inflow (I). The output is the release (R) during the period.

2. Number and type of membership functions for variables

The membership functions used for the fuzzy values of the fuzzy variables are selected based on human/expert experience. All the fuzzy values are represented by triangular/trapezoidal membership functions for simplicity and can be changed for others. Figure 2 shows the types of membership function in MATLAB 7.0.

3. Structure of rules

In Fuzzy system the fuzzy rules are generally formed using "expert knowledge" and users intuition. The fuzzy rules are formed based on actual past operation of reservoir. A fuzzy rule may be of the form: if the period (T) is 25, reservoir storage (S) is medium, and the inflow (I) is low then the release (R) is low.

4. Type of inference mechanism

The output of each rule is determined by Mamdani's max-min inference method.

5.Defuzzification method

For the defuzzification process, the standard center of area method (Centroid method) is employed.

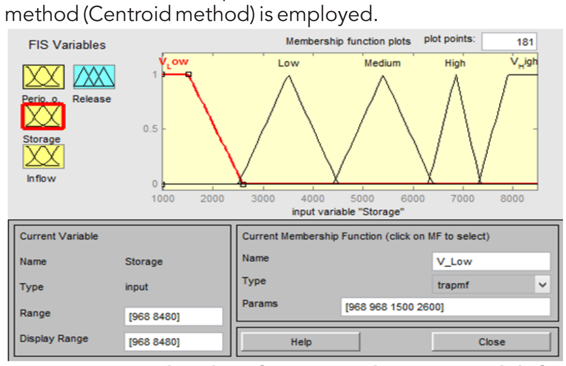

Figure 2: Membership function editor in model for monsoon season

5. RESULTS AND STATISTICAL ANALYSIS OF RESULTS

In the present study reservoir operation is carried out. Also two stepped based Fuzzy Logic based model is proposed. In the first step the amount of expected optimised release using fuzzy logic based model can be estimated. In the second step distribution of the release in to multiple requirements are predicted. This distribution has been done

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based on the past years records.

The inputs for Fuzzy Logic based model for reservoir operation are period number, reservoir storage and inflow while reservoir release is the output. The Fuzzy Logic based model is trained, validated analysed and for this 10 years data sets are developed from 1998 to 2007. The model has been run and compared with observed storage for 2 real data results of years 2008 and 2009. Figure 3 and 4 shows the results that shows Fuzzy Logic based releases offer more storage availability in non-monsoon period. Statistical parameters are used to compare the Fuzzy Logic based model's performance.

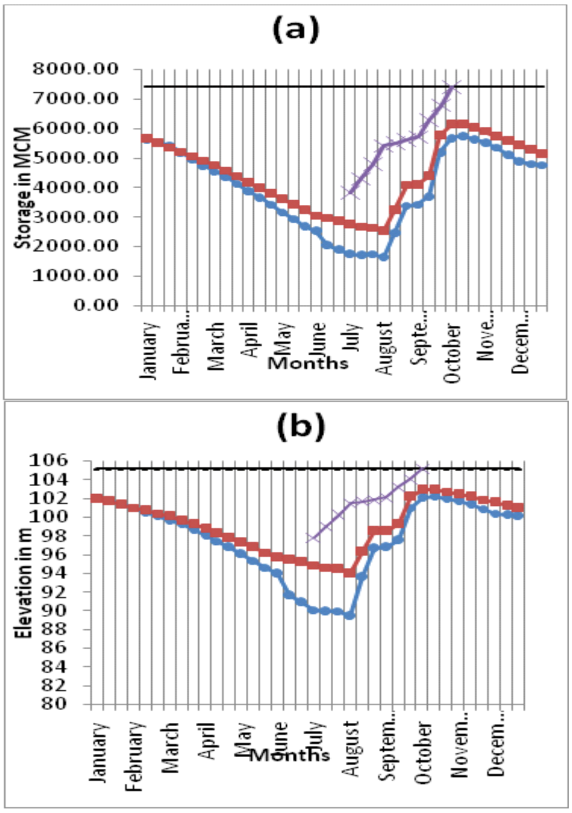
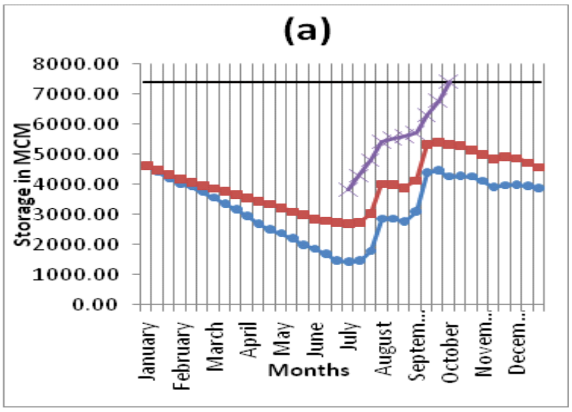


Figure 3: (a) Storage comparison and (b) Elevation comparison of Fuzzy v/s Actual (observed) for year 2008, Fuzzy is upper and Actual one is lower.

The performance of the model can be justified in the sense that the availability of the high storage level for the year 2008 and 2009 predicts more water adequacy in the reservoir. The rule level has been maintained successfully.



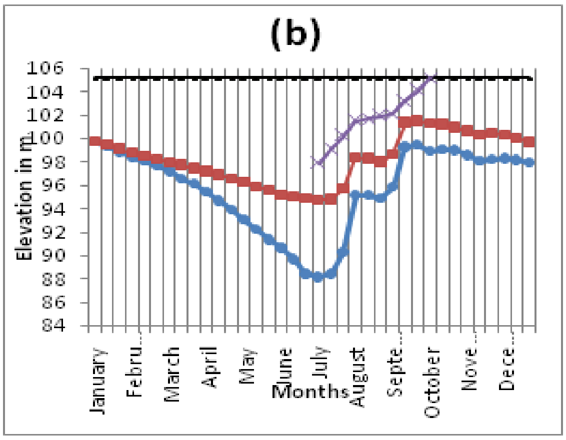


Figure 4: (a) Storage comparison and (b) Elevation comparison of Fuzzy v/s Actual (observed) for year 2009, Fuzzy is upper and Actual one is lower.

Confidence band has been plotted for fuzzy predicted versus observed for storage and elevation as well. For the year 2008 the fuzzy logic based model performs over predict within the confidence limit of 5 percent for elevation level as shown in figure 5 and 7.5 percent for elevation as shown in figure 6. Since the model performs well for elevation though confidence band over predicts by much higher percent for storage but it does not means that model underperform, it means that the storage availability is adequate during the whole year as fuzzy predicted value is higher than observed value.

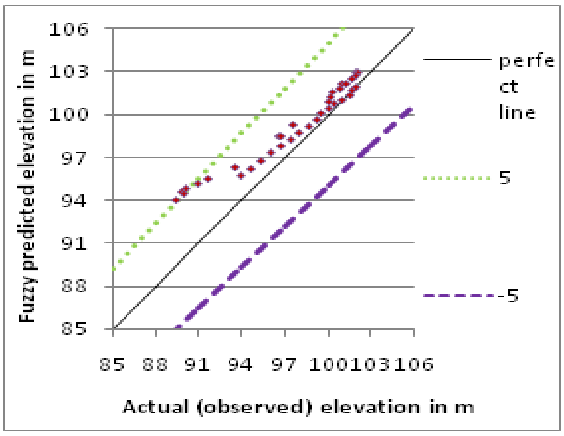


Figure 5: Comparison of Elevation levels of observed and fuzzy predicted (year 2008)

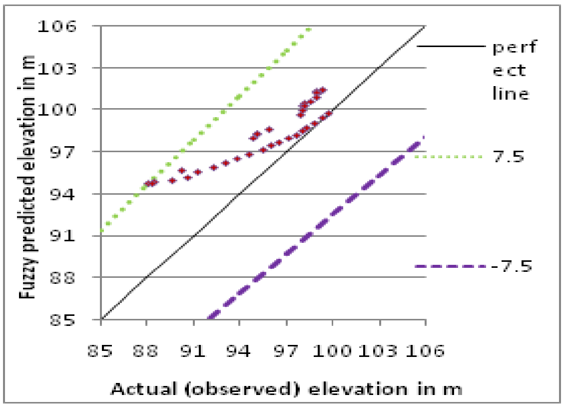


Figure 6: Comparison of Elevation levels of observed and fuzzy predicted (year 2009)6.

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CONCLUSION

In this paper, various optimization techniques are discussed. Numerous investigations of many researchers based on these techniques are explained in detail. An effective operating model for various objectives needs to be considered, so the decision at any level can be taken with optimization technique.

In the present study Fuzzy logic based model for operating reservoir is proposed. The Fuzzy Logic based model is trained, validatedfor this 10 years data sets are developed from 1998 to 2007. The model has been run and compared with observed storage for 2 real data results of years 2008 and 2009. The results exhibits that Fuzzy Logic based releases offer more storage availability in non-monsoon period. Statistical parameters reveals good agreement and better performance of the Fuzzy Logic based model (As shown in Figure 4 and Table 4). Use of many variables may lead to curse of dimensionality; therefore use of few variables may be best suited to avoid the same problem as pointed out by Kosko and Isaka (1993).

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