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Simulating Water Quality Prediction for Aquatic Ecosystem (SWQP-AE)

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Abstract: *The versatility and usefulness of aquatic ecosystem cannot be shoved aside due to environmental relevance, commercial benefits and even educational needs. Over the years, the ecosystem has been over bodied with physical, chemical and biological degradation. These degradations have called into question the quality of aquatic ecosystem water. This research paper has applied matrix laboratory (matlab) to aquatic ecosystem dataset in predicting the quality of these water. It has simulated a matlab aquatic ecosystem model with corresponding interfaces. The simulation catered for training, testing, membership and inference interfaces. The histogram graph portrays the progression of each simulation attributein cognizance with histogram values. With an average training error of 5.63 cutting across thirty (30)epochs and an error tolerance of 0.05 the training was indeed optimal in terms of learning eliminating over fitting and under-fitting.*

Keywords: *Aquatic ecosystem, simulation, prediction, water*

1. Study Introduction

Aquatic ecosystem comprises of a body of water and communities of organisms which are mutually dependent (Vaccari, 2005). Aquatic eco systems have always existed from marine or freshwater ecosystem (Alexander, 1999). The presence of dissolved compounds: salts, sodium and chlorine are predominant compounds identifying marine ecosystem (Vaccari, 2005). Usually, marine ecosystem are associated with certain class of organism such as brown algae, dino-flagellates, corals, cephalopods, echinoderms, and all classes of fish. Indeed, the fishes farmed at these marine reserves serves as commercial food and resources to any economy (Alexander, 1999; Vaccari, 2005). Overtime, unsustainable exploitation of marine resources either for commercial or personal purpose has indeed been a fundamental environmental issue affecting and deterred marine ecosystem (Keddy et al., 2007).

Freshwater ecosystems on the other hand are less geographical dispersed compared with marine ecosystem. These ecosystems are highly diminutive and restricted compared with marine ecosystems, with the earth surface, earth productivity and fresh water species describing its forms and formations (Turner and Rabelais, 2003). Freshwater ecosystem can be structured from lentic which accommodate slow running water with pools, ponds and lakes identified under lentic. Lotic addresses fast moving water such as streams and rivers. Wetland areas identify soil saturation over a period of time (Silliman et al., 2009; Keddy, 2010).

Aquatic ecosystem has provided numerous environmental benefits to its environs. This benefit includes recycling nutrient, purifying water, attenuate floods, recharge ground water and providing habitats for wildlife (Loeb, 1994). Aquatic ecosystem has also fueled human recreational needs, it has exposed and expended the boundaries of tourism using costal lines and region as it selling point (Kennedy et al., 2007).This aforementioned point has stressed the versatility and usefulness of the aquatic ecosystem. Although, aquatic ecosystem proffers numerous benefits, the continuous and persistent exploration of the aquatic system by human has degraded and ensured tremendous stress on the system. This degradation could be traced to physical, chemical or biological alterations of the environment (Chapman and Reiss, 1998; Kennedy et al., 2007). Physical proponent could be seen from water temperature, water flow and light availability. The persistent and continue chemical change, nutrient change, oxygen consumption and even toxin are a proponent of chemical alteration. The propagation of exotic species and commercial species has contributed largely to biological degradation *(*Chapman and Reiss, 1998*).*

This degradation propagated by chemical, biological and physical proponents has indeed affected the quality of aquatic ecosystem water existing in different region which has affected the existence of aquatic life (Turner and Rabelais, 2003*;* Vaccari, 2005). It is also pertinent to note that huge resources in term of manpower and material resources are usually explored in identifying viable region for aquatic existences *(*Chapman and Reiss, 1998*;* Turner and Rabelais, 2003).

With the aforementioned in focus, it is relevant and pressing to simulate a model to predicate water quality in aquatic ecosystem. Therefore, it is the intent of this research paper to predicate aquatic water quality for aquatic ecosystem using Matrix Laboratory (MATLAB).

2. Material and Method

Simulation mimics the operations of a real world processes (Bank et al., 2001). The process of simulation is an extension or continuation of a model creation. Simulation identifies the key functionalities of a designed model, usually seen from the model problem or behaviors (Sokolowski, 2009). Simulation has found its contextual use in many fields such as technology, safety engineering, training, education and computer sciences. Simulation can show real event conditions, as well as course of action. It is used as assessors in case where failure may not be tolerated for huge system (Sokolowski, 2009).

Computer simulation, model real hypotheses using computer as a simulator with the help of appropriate parameter: variables/ attributes tied to collected dataset (Zeigler et al., 2000). The continuous change in variables provides vary solutions, behavior or characteristic for the model. Computer simulation has been applied in different field such physic, chemistry, biology and economic (Giambiasi, 2003). Computer simulations are basically used as adjunct in substituting system model for which real world solution could be difficult due to non- tolerant of certain variables. Numerous computer simulation and simulation tools exist, these simulation tools include: Advanced Simulation Library, ASCEND, Celestia, DWSIM, Elmer, Facsimile, feat Flow, free mat, Galatea, GNU Octave, Open Modelica, Mobility Testbed and even MATLAB.

3. MATLAB: Simulating Water Quality Prediction for Aquatic Ecosystem (SWQP-AE)

Matrix Laboratory (MATLAB) simulator built to mimic high level computation and technical abilities. It provides an interactive environment for mathematical functions, intuitional design, algorithm exploration, data visualization, data analysis and numerical computation. The simulation tools and inbuilt mathematical function possessed in matlab provides a platform in solving computing problems possibly faster than with traditional programming tools (C, C++ or JAVA). Matrix Laboratory: MATLAB 7.5 (R2007b) was used in this study for simulating water quality prediction for aquatic ecosystem.

Formulating a Matlab model for predicting water quality for aquatic life was addressed using key variables: temperature, pH Value, nutrients, metals, hydrocarbons, industrial chemicals, dissolved oxygen. These variables encompass key features of the obtained dataset. The dataset was obtained from: (https://catalog.data.gov/dataset?tags=water+quality).It comprises of sixty (60) training cases, forty (40) was use for training or modeling the matlab model while the remaining twenty (20) was used for testing. The Back Propagation Gradient Descent (BPGD) algorithm domiciled in Matlab was used in training the model. An error tolerance of 0.05 was employed along with an appropriate membership function: Gaussian membership function. The model was trained with a training error of 5.6371 and an average testing error of 5.630. Figure 1 – 6 provides various interfaces identifying the components of matalb simulation

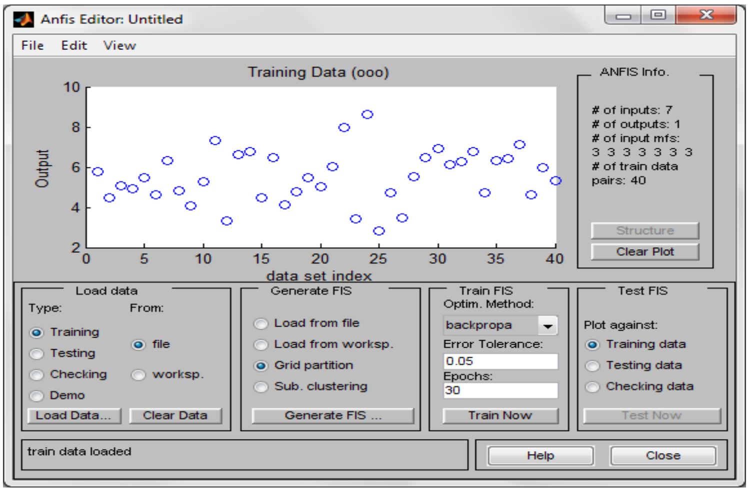

Fig1. *Training Data Interface*

Figure 1 shows the model training data. This training data encompasses of forty cases (40) out of the obtained sixty (60) cases. The chat also shows the training data uniformly dispersed along the training plot, highlighting dataset within different patterns suitable for training.

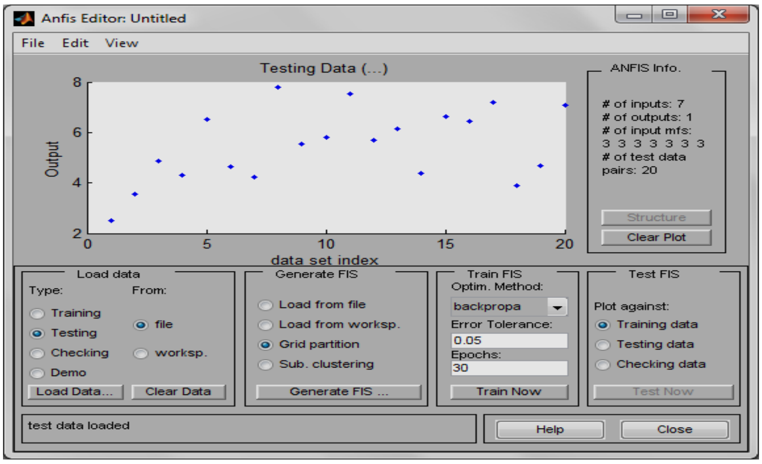

Fig2. *Training Data Interface*

Figure 2 shows the model testing data. This test data encompasses of remaining twenty (20) cases out of the already selected forty (40) for training. The chat also shows the testing data are uniformly dispersed along the training plot, highlighting dataset within different patterns suitable for testing.

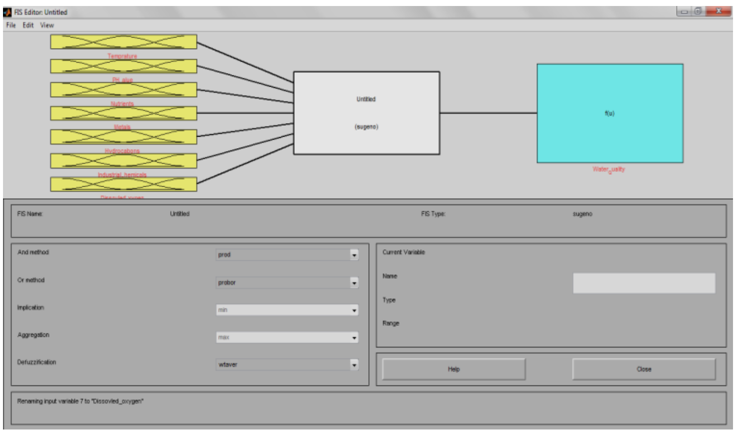

Fig3. *Model Inference Interface*

Figure 3 shows the model inference interface. The chat portrays the interaction between model attributes: temperature, pH Value, nutrients, metals, hydrocarbons, industrial chemicals, dissolved oxygen leading to a simultaneous output. This attributes interact to produce the model prediction values.

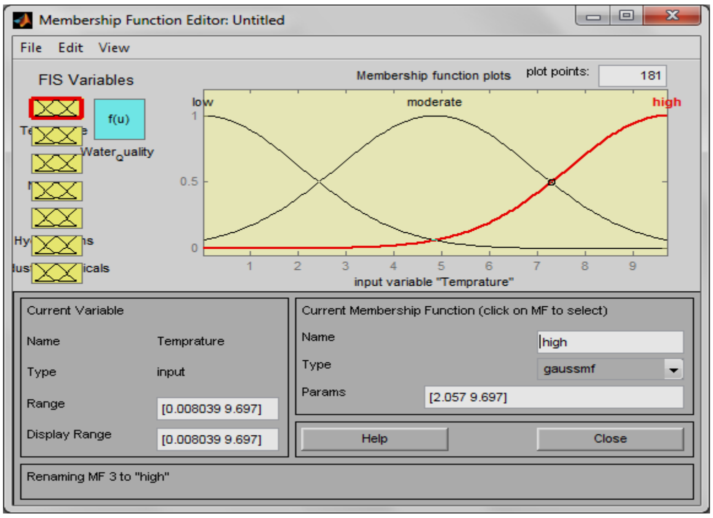

Fig4. *Gaussian Membership Interface*

Figure 4 shows the gaussian membership function assigning membership to certain input parameters. These input memberships are constrained toward; low, moderate and high. The chat exemplify membership assigned for temperature.

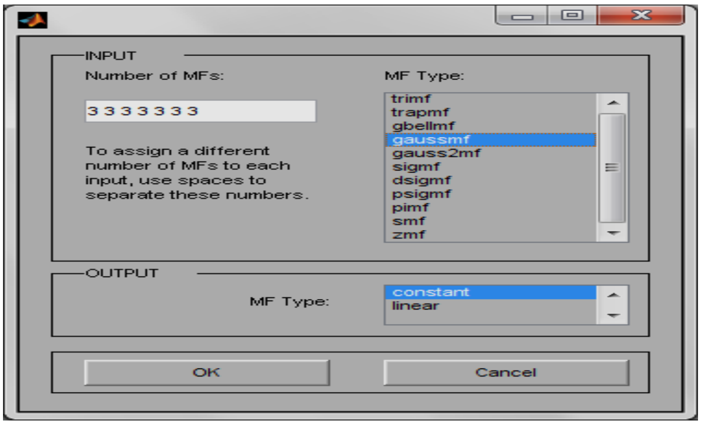

Fig5. *Input Membership Interface*

Figure 5 shows seven (7) inputs variables assigned any of the three (3) classes of membership: high, moderate or low. The chat also showed varied membership with gaussian selected as the most appropriate. It also shows the output identified as constant.

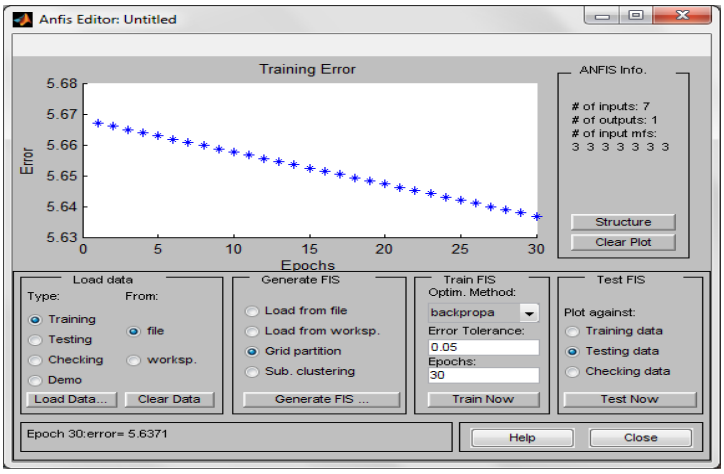

Fig6. *Training Error*

Figure 6 portray the training error obtained in modeling and training the aquatic ecosystem dataset. An average error of 5.63 was obtained after a training epoch of 30. The training error tolerance was initially set at 0.05. The linear training curve highlights the optimality in training.

4. Result Discussion

The simulation result for the predictive model covering water quality in aquatic ecosystem is presented in this section. Table 4.1: identify cumulative training cases, training cases, testing cases, training attributes, training membership, training epoch, training error, average training, and error tolerance.

Table4.1. *Simulation Result Attributes*

SN	Simulation Attributes	Simulation Attributes Values
1.	Cumulative Training Cases	60
2.	Training Cases	40
3.	Testing Cases	20
4.	Training Attributes	7
5.	Training Membership	3
6.	Training Epoch	30
7.	Training Error	5.67
8.	Average Training Error	5.63
9.	Training Error Tolerance	0.05

Figure 7 provide a histogram showing the progression in simulation result attributes. The simulation attributes cut across training case to training error with values ranging from 60 descending toward 0.05.

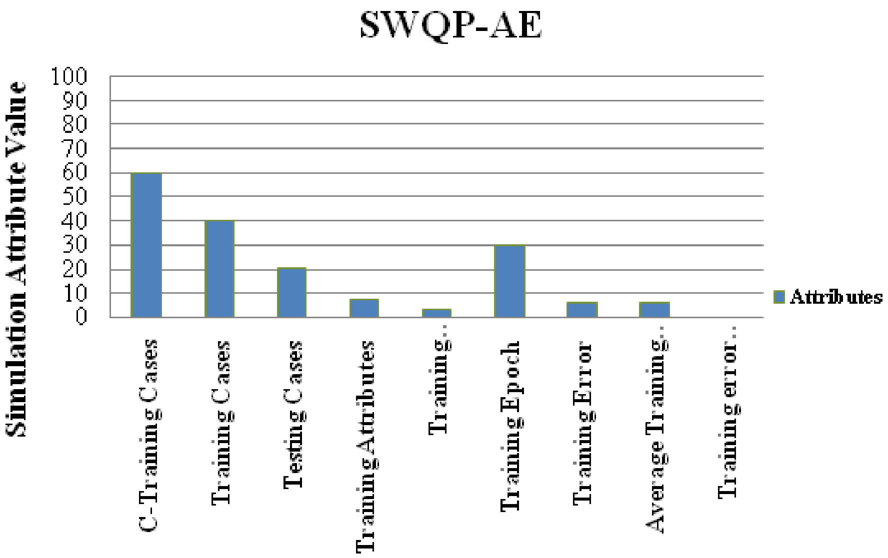

Fig7.*Histogram showing simulation attributes.*

The histogram on Figure 7, shows a cumulative case of sixty (60), which could be used for training due to subdivision which cater for forty (40) training cases and twenty (20) test cases. These cases are tied to an attributes or parameter value of seven (7). The attributes are applied across a three (3) membership running toward a training cycle (epoch) of thirty (30). The training error and average training error are diminutive values: 5.67 and 5.63 respective as compared with the rest simulation attributes these highlighting minima errors. The histogram provides the following finding:

- The training is fairly optimal observing the training and average training errors.
- The membership values are fairly ok, giving the number of attributes.
- The training error tolerance is minima and is acceptable.

5. Conclusion

Simulating a water quality model for predicting aquatic ecosystem has been achieved in this research paper using Matrix Laboratory (MATLAB). The Matlab model was initiated using seven (7) attributes: temperature, pH Value, nutrients, metals, hydrocarbons, industrial chemicals, dissolved oxygen. These parameters were used for simulation. The simulation interfaces identify the simulation, with a training error of 5.67 and an error tolerance of 0.05, these values identifies the optimality in training.

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