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Fuzzy Logic for Smart Lake

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ABSTRACT

The study focuses on major lakes in the Philippines such as Laguna Lake, Taal Lake and Lanao Lake. It use Fuzzy Logic (FL) for faster decision making to update real time status of lake in terms of pH level, Nitrogen, dissolved oxygen, Temperature and Water Level for flossing control purposes of the lakes. The data from three major lakes will send to command center through wireless network every hour and give graphical presentation for easy analysis. These will show Low level, Alarming level and Highly Contaminated level of the three lakes. It also give auto alarm for flooding area. The design propose to use underwater robot for the analysis of lake basin where in more contaminant can be seen.

KEYWORDS: *Fuzzy Logic, Wireless Network, Smart Lake, Fresh Water, Laguna Lake, Taal Lake, Lanao Lake.*

1 INTRODUCTION

Fresh water is naturally occurring water on the Earth's surface in ice sheets, ice caps, glaciers, icebergs, bogs, ponds, lakes, rivers and streams, and underground as groundwater in aquifers and underground streams. It is an important natural resource necessary for the survival of all ecosystems. The use of water by humans for activities such as irrigation and industrial applications can have adverse impacts on down-stream ecosystems. Chemical contamination, improper disposal of garbage on fresh water can also seriously damage eco-systems and polluting the environment, drinkable water, plants and animals.

LAKE STRUCTURE

Laguna Lake

Laguna de Bay is a large shallow freshwater body in the heart of Luzon Island with an aggregate area of about 911 square kilometres (352 sq mi) and a shoreline of 220 kilometres (140 mi). It is considered to be the third largest inland body of water in Southeast Asia. Laguna de Bay is bordered by the province of Laguna in the east, west and southwest, the province of Rizal in the north to northeast, and Metropolitan Manila in the northwest. The southern and eastern portions of Metro Manila occupy a huge portion of its watershed. The lake has an average depth of 2.8 metres (9 ft 2 in) and its excess water is discharged through the Pasig River.

The lake is fed by 45,000 square kilometres (17,000 sq mi) of catchment areas and its 21 major tributaries. Among these are the Pagsanjan River which is the source of 35% of the Lake's water, the Sta. Cruz River which is the source of 15% of the Lake's water, the Balanak River, the Marikina River, the Mangangate River, the Tunasan River, the San Pedro River, the Cabuyao River, the San Cristobal River, the San Juan River, the Bay, Calo and Maitem rivers in Bay, the Molawin, Dampalit river, Dampalit, and Pele river, Pele rivers in Los Baños, the Pangil River, the Tanay River, the Morong River, the Siniloan River, and the Sapang Baho River. Taal Volcano is a complex volcano located on the island of Luzon in the Philippines. It is the second most active volcano in the Philippines with 33 historical eruptions. All of these eruptions are concentrated on Volcano Island, an island near the middle of Taal Lake. The lake partially fills Taal Caldera, which was formed by prehistoric eruptions between 140,000 and 5,380 BP. Viewed from Tagaytay Ridge, Taal Volcano and Lake presents one of the most picturesque and attractive views in the Philippines.

Lake Lanao (Maranao: Ranao or Ranaw) is a large lake in the Philippines, located in Lanao del Sur province in the country's southern island of Mindanao. With a surface area of 340 km^2 (130 sq mi), it is the largest lake in Mindanao, and the second largest lake in the Philippines and counted as one of the 15 ancient lakes in the world.
The lake was formed by the tectonic-volcanic damming of a basin between two mountain ranges and the collapse of a large volcano. It has a maximum depth of 122 m (400 ft), and a mean depth of 60.3 m (198 ft). The basin is shallowest towards the north and gets progressively deeper towards the south.[1]
The lake is fed by four rivers. Its only outlet is the Agus River, which flows northwest into Iligan Bay via two channels, one over the Maria Cristina Falls and the other over the Linamon Falls. A hydroelectric plant installed on the Lanao Lake and Agus River system generates 70% of the electricity used by the people of Mindanao.

Three lakes produce thousands of metric tons of fish every year that contribute for food sustainability in the Philippines. Indeed, developing of technology called SMART LAKE that would analyze and improve the quality of water as well as to protect livelihood and lives of human in times of flood. Also, determine earlier the contaminant from the lake basin. Real time monitoring of quality of water is very expensive here in the Philippines. This research proposed to use Fuzzy Logic for monitoring of quality of water, flood control and basin contaminant of three lake.

II. METHODOLOGY

The SMART LAKE technology use sensors to monitor the Quality of Water, Flood Level Control sensor and Basin Quality sensor. Figure 1 shows that the system are interconnected and can simultaneously monitor three lakes which can

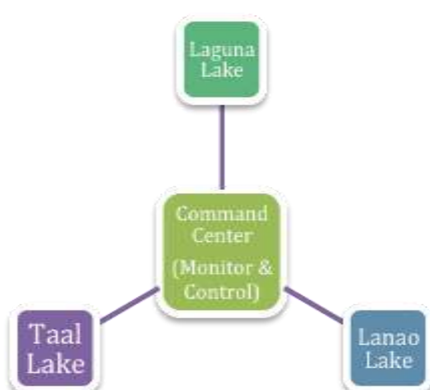

Figure 1, SMART LAKE Connection

control the flooding system and give signal to every concern municipality and barangay. All these connection can be done trough wireless connectivity using SMS signal.

This study is in pursuant to Presidential Decree No. 1152 [Philippine Environment Code], Chapter II Protection and Improvement of Water Quality Section 21 Water Quality Monitoring and Surveillance, which states that *"The various government agencies concerned with environmental protection shall establish to the greatest extent practicable a water quality surveillance and monitoring network with sufficient stations and sampling schedules to meet the needs of the country. Said water quality surveillance network shall put to maximum use the capabilities of such government agencies. Each agency involved in such network shall report to the National Environment Protection Council the results of these monitoring activities as the need arises."*

The proposed system will use Fuzzy Logic for entire project. It includes three main aspect for fuzzy logic to control such as: (1)Water quality monitoring; (2)flood control system and (3)lake basin quality monitoring. These application will give a low cost and practical application for SMART LAKE.(3] http://www.chanrobles.com/pd1152.htm)

The basic process of designing a fuzzy logic for the water quality monitoring and surveillance system involves five (5) steps:

a) Formulating the problem and selecting the input and output variables state. For this water quality system, the inputs to the fuzzy controller are the physical status and chemical status of water. The manipulated variable is produced (scored) and sent to the water quality assessment (output).

b) Selecting the fuzzy inference rules. This generally depends on human experience and trial-and-error. The interference rule is selected based on the degree of match and the results of interview conducted to water experts. The values are averaged and rounded off to fit linguistic terms.

c) Designing fuzzy membership functions for each variable. This involves determining the position, shape as well as overlap between the adjacent membership function, as these are major factors in determining the performance of the fuzzy logic. In defining membership function, geometric shapes such as triangular, trapezoidal, etc are used. The selection is dependent on the expert's knowledge and understanding of the process (Aprea et al., 2004; Ross, 2004).

d) Performing fuzzy inference based on the inference method. Smoothness of the final control surface is determined by the inference and defuzzification methods.

e) Selecting a defuzzification method to assess the water quality. The choice of the defuzzification method determines to a large extent the "quality" of assessment. Hence, it must be chosen carefully. In this case defuzzification is done by calculating the center of gravity and the output is produced through averaging techniques.

Figure 2 show the Water Quality Assessment using fuzzy logic, it describe the fuzziness in water quality of Lake, develop a fuzzy-based water quality monitoring system in Lake, and test and evaluate the performance of the fuzzy system. It is a tool that provides a single grade of several water

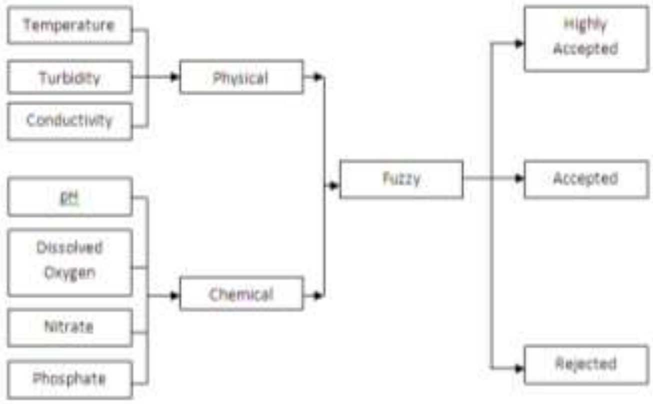

Figure 2, Water Quality Assessment

quality parameters at a predefined time and location to express the overall water quality. The index aims to convert water quality data into an output that is understandable by the user to further simplify the interpretation and analysis of qualified data.

[http://bcn.boulder.co.us/basin/watershed/wqi_info.html]

Input / Output Membership Function

The system use four basic steps of building and simulating fuzzy logic such as: a) Define Inputs and Outputs; b) Create member functions; c) Create Rules and d) Simulate the result in fuzzy logic system.

The system use two inputs into the water quality fuzzy controller the Physical and Chemical status of water. Physical parameter contains Temperature, Turbidity and Conductivity. Chemical parameter contains pH, Dissolve Oxygen, Nitrate and Phosphate. To describe each status of water quality, Figure 3 gives three membership functions can be use, such as: Rejected, Accepted and Highly Accepted.

Physical Parameters contains six Fuzzy rules to be evaluated by fuzzy system;

1. *(Temperature==approaching _hot)|(Turbidity==Bad)|(Conductivity==Bad)=>(Physical=Rejected)*
2. *(Temperature==approaching _cold)|(Turbidity==Bad)|(Conductivity==Bad)=>(Physical=Rejected)*
3. *(Temperature==Accepted)|(Turbidity==Good)|(Conductivity==Good)=>(Physical=Accepted)*
4. *(Temperature==Accepted)|(Turbidity==Good)|(Conductivity==Excellent)=>(Physical=Accepted)*
5. *(Temperature==Accepted)|(Turbidity==Excellent)|(Conductivity==Good)=>(Physical=Accepted)*
6. *(Temperature==Accepted)|(Turbidity==Excellent)|(Conductivity==Excellent)=>(Physical=Highl y Accepted)*

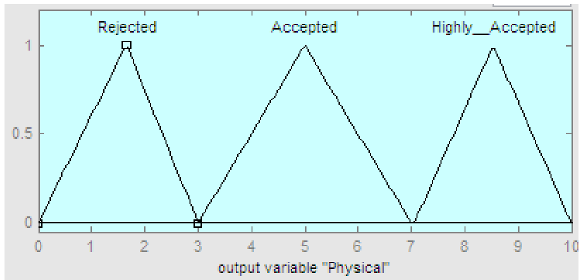

Figure 3, Output Membership Function

Using six rules from fuzzy logic above, as been discrive from figure 4, fuzzy logic easily determined the status of Physical Quality of Water in terms of Temperature, Turbidity and Conductivity even they are Highly Acceptable, Acceptable or Rejected.

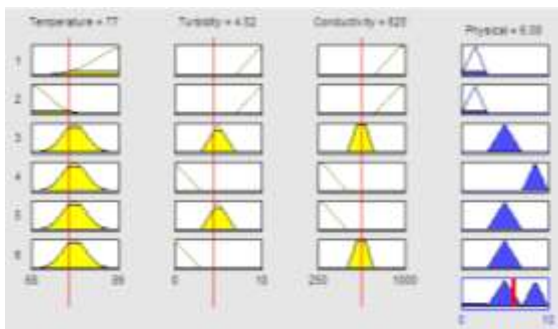
Figure 4, Rules Viewer

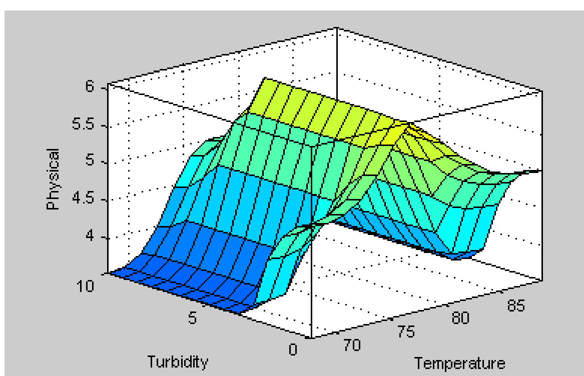

Figure 5, Surface Viewer

Graphical presentation of Physical Quality of water corresponding to Temperature, Turbidity and Conductivity, easily recognize from figure 5. It shows the corresponding value of Temperature, Turbidity and Conductivity for Physical status of quality of water.

Flood Control Assessment

Number two of the topic from the conference of LLDA under the program of The Laguna Lake Flood Management Imperative is “Discuss effective and workable solutions, both short and long term, to the problems and challenges facing the Laguna Lake Basin including the identification of sustainable and feasible measures, innovations, policies, programs and projects, particularly in terms of water and flood management, for implementation in the short, medium and long terms.” [http://www.llda.gov.ph/dox/llwimf/lldaimf.pdf]. Fuzzy Logic can give practical and easy way to manage Laguna Lake Flood Control using proposed

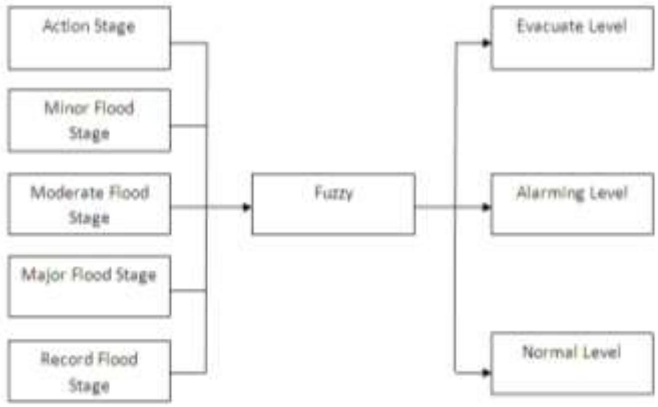

Figure 6, Water Flood Assessment

system of SMART LAKE with block diagram on Figure 6. It will give precise signal to command center that automatic responds to open or close flood control gate from Pasig river, Marikina River and Taguig Flood Control.

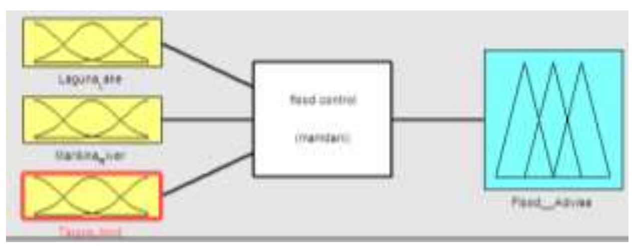

Figure 7, Fuzzy Inference Flood Control

Figure 7 and Figure 8 identifies the input for fuzzy inference for flood control, such input are latest water level of Laguna Lake, Marikina River and Taguig Flood Control. The result will be the output evaluation of Fuzzy control base on the given input and fuzzy rules. The numerical and graphical presentation of output for flood control can be seen on figure 9.

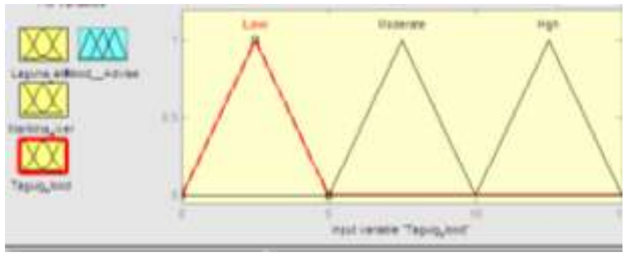

Figure 8, Fuzzy Membership Function

To evaluate the input parameters from the fuzzy system for flood control assessment, eleven fuzzy rules were develop.

Fuzzy Rule for Flood Control Assessment:

1. *If (Laguna_Lake==Low) & (Marikina_River==Low) & (Taguig_Flood==Low) => (Flood_Advise = Action_Stg)*
2. *If (Laguna_Lake == Low) & (Marikina_River == Moderate) & (Taguig_Flood == Low) => (Flood_Advise = Action_Stg)*
3. *If (Laguna_Lake == Low) & (Marikina_River == Low) & (Taguig_Flood == Moderate) => (Flood_Advise = Action_Stg)*
4. *If (Laguna_Lake == Low) & (Marikina_River == High) & (Taguig_Flood == High) => (Flood_Advise = Min_Fld_Stg)*
5. *If (Laguna_Lake == Moderate) & (Marikina_River == Moderate) & (Taguig_Flood == Moderate) => (Flood_Advise = Min_Fld_Stg)*
6. *If (Laguna_Lake == Moderate) & (Marikina_River == Low) & (Taguig_Flood == Moderate) => (Flood_Advise = Min_Fld_Stg)*
7. *If (Laguna_Lake == Low) & (Marikina_River == Moderate) & (Taguig_Flood == Low) => (Flood_Advise = Min_Fld_Stg)*
8. *If (Laguna_Lake == Moderate) & (Marikina_River == Moderate) & (Taguig_Flood == Moderate) => (Flood_Advise = Mod_Fld_Stg)*
9. *If (Laguna_Lake == Moderate) & (Marikina_River == Moderate) & (Taguig_Flood == High) => (Flood_Advise = Mod_Fld_Stg)*
10. *If (Laguna_Lake == Moderate) & (Marikina_River == High) & (Taguig_Flood == High) => (Flood_Advise = Mod_Fld_Stg)*
11. *If (Laguna_Lake == High) & (Marikina_River == High)& (Taguig_Flood == High) => (Flood_Advise = Rcd_Fld_Stg)*

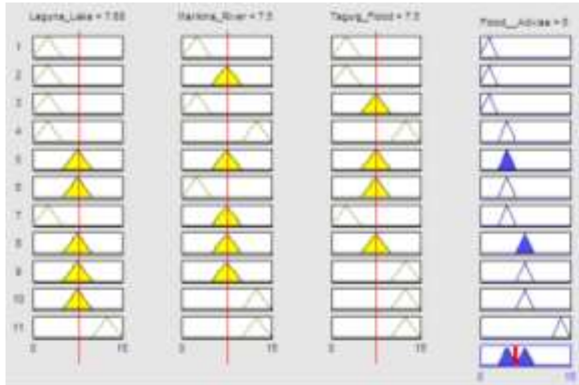

Figure 9, Fuzzy Rule Viewer Flood Control

Flood control assessment simulation for the input given can be seen on Figure 10. After the evaluation of result, it is found that the fuzzy logic give a precise output with respect to the actual scenario of three input parameters.

Figure 10 shows the surface viewer of flood simulation.

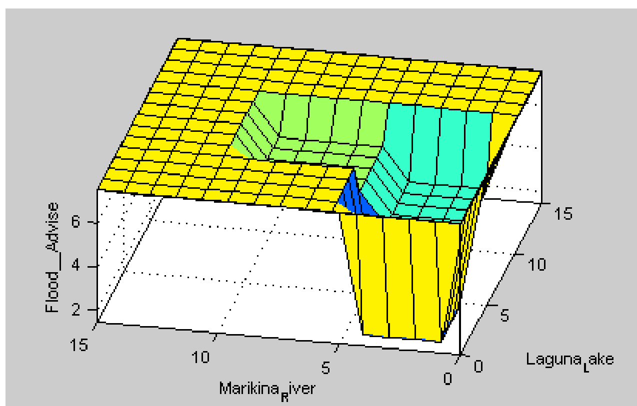

Figure 10, Surface Viewer Flood Control

III. EXPERIMENT EVALUATION

With the result of simulation, Graphical presentation of Physical Quality of water corresponding to Temperature, Turbidity and Conductivity Quality of water in terms can easily be noticed. The flood control assessment logically seen from the surface viewer,.,., some data and information to be follow…

IV. CONCLUSION

The conclusion will be given after the complete result of simulation.

V. ACKNOWLEDGMENT

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