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Sustainable IoT Solution for Freshwater Aquaculture Using FPGA

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A B S T R A C T

In recent years, we have seen the impact of global warming on changing weather patterns. The changing weather patterns have shown a significant effect on the annual rainfall. Due to the lack of annual rainfall, developing countries like India have seen a substantial loss in annual crop pro- duction. Indian economy largely depends on agricultural products. To compensate for the economic loss, the Indian government encouraged the farmers to do integrated aquaculture-based farming. Despite government subsidies and training pro- grams, most farmers find it difficult to succeed in aquaculture- based farming. Aquaculture farming needs skills to maintain and monitor underwater environments. The lack of skills for monitoring and maintenance makes the aquaculture base- ness more difficult for farmers. To simplify the pearl farming aquaculture, we have proposed an Internet of Things (IoT)- based intelligent monitoring and maintenance system. The proposed system monitors the water quality and maintains an adequate underwater environment for better production. To maintain an aquaculture environment, we have forecasted the change in water parameters using an ensemble learning method based on random forests (RF). The performance of the RF model compared with the linear regression (LR), sup- port vector regression (SVR), and gradient boosting machine (GBM). The obtained results show that the RF

model outport-formed the forecast of the DO with 1.428 mean absolute error (MAE) and pH with 0.141 MAE.

Keywords: IoT, Aquaculture, Data analytics, Random Forecast.

Introduction

In INDIA, 70 % population directly or indirectly depends on agriculture. Indian agriculture has a major contribution to the Indian economy. Over the past few years, the changing weather patterns and global warming have impacted annual crop production. The lack of rainwater harvesting and canalling system further adds to the difficulties to get better crop production .Due to the inadequate supply of irrigation facilities, India has seen a substantial rise in crop failure cases every year. To compensate for the crop failure losses, the Indian government encouraged the farmers to do integrated aquaculture-based farming. Freshwater pearl farming has the potential to generate an alternative source of income for small farmers. Indian freshwater river bodies have 51 types of species that can produce pearls; still, India imports 2.4 billion dollars' worth of pearls from china and japan. To reduce the import burden on the Indian economy, the government encouraged the farmers to do integrated freshwater pearl farming.Aquaculture-based farming needs a small investment for initial setup. Although, the Indian government promotes aquaculture-based farming through subsidies and free training programs. However, farmers still find it difficult to get success in aquaculture-based farming. The lack of technological intervention and skill-oriented manual operation makes it difficult to get success in this business. Aquaculture is the controlled cultivation or farming of fish, shellfish, and aquatic plants. The purpose is to create a source of aquatic-sourced food and commercial products in a way that will increase availability while reducing environmental harm and protecting various aquatic species. There are several different kinds of aquaculture that each has varying degrees of sustainability. Rising global populations and income will continue to increase the demand for fish. And with wild catch levels essentially flat, all increases in fish and seafood production have come from aquaculture. While aquaculture does face challenges such as sea lice and pollution many players in the industry are actively working to address its challenges**.**

1.1 Internet of Things

The Internet of Things (IoT) is a network of physical objects or people called "things" that are embedded with software, electronics, network, and sensors that allow these objects to collect and exchange data. The goal of IoT is to extend internet connectivity from standard devices like computers, mobile, and tablets to relatively dumb devices like a toaster. IoT makes virtually everything "smart," by improving aspects of our life with the power of data collection, AI algorithms, and networks. The thing in IoT can also be a person with a diabetes monitor implant, an animal with tracking devices, etc. This IoT tutorial for beginners covers all the Basics of IoT.

1.2 Very Large- Scale Integration (VLSI)

The earliest digital circuits were designed with vacuum tubes and transistors. Integrated circuits were then invented where logic gates were placed on a single chip.These chips were called MSI chips with the advent of LSI; designers could put thousands of gates on a single chip. At this point, the design process is getting complicated and designers felt the need to automate these processes. With the advent of VLSI technology, designers could design a single chip with more than a hundred thousand gates. Because of the complexity of these circuits, computer-aided techniques became critical for verification and for designing these digital circuits. Traditional paper and pencil and capture and simulate methods have largely given way to the described UN synthesized approach.

1.3 Verilog

Verilog was started in the year 1984 by Gateway Design Automation Inc as a proprietary hardware modeling language. It is rumored that the original language was designed by taking features from the most popular HDL language of the time, called HiLo, as well as from traditional computer languages such as C. The Verilog simulator was first used in 1985 and extended substantially through 1987.The implementation of the Verilog simulator sold by Gateway. The first major extension of Verilog is Verilog-XL, which added a few features and implemented the infamous "XL algorithm" which is a very efficient method for doing gate-level simulation. This was a powerful combination.

1.4. VLSI Design Flow

Logic synthesis tools convert the RTL description to a gate-level netlist. A gate-level netlist is a description of the circuit in terms of gates and connections between them. The gate level netlist is input to an automatic place and route tool, which creates a layout. The layout is verified and then fabricated on a chip. Thus most digital design activity is concentrated on manually optimizing the RTL description of the circuit. After the RTL description is frozen, CAD tools are available to assist the designer in further process Designing at the RTL level has shrunk design cycle times from years to a few months

1.5. Basic Concepts

Hardware Description Language

Two things distinguish an HDL from a linear language like “C”: Concurrency:

• The ability to do several things simultaneously i.e. different code-blocks can run concurrently.

Timing:

• Ability to represent the passing of time and sequence events accordingly

2. Proposed System

The proposed model predominantly centers on continuously observing the water quality factors at all times in order to take preventive steps early to harm water animals. The proposed architecture has The work is concerned with three major issues Effective measurement of water quality for aquaculture. They connect the PH sensor, conductivity sensor, and turbidity sensor which is collected in Nodemcu and uploaded over the Cloud for analysis.

Proposed system we are using Feeders that can turn the water and oxygen pumps on and off by clicking on and off in the web application using IoT and machine learning. The result was that when feeders accessed the web application in terms of the turning on and off module, when they clicked “turn on”, the pumps worked. The electronic devices test is in the form of a sensor instruction system to measure the water turbidity level, sensor system to measure the food volume and system response toward any condition based on the data taken through the sensor system as well as to observe the entire monitoring system using IoT and VLSI.

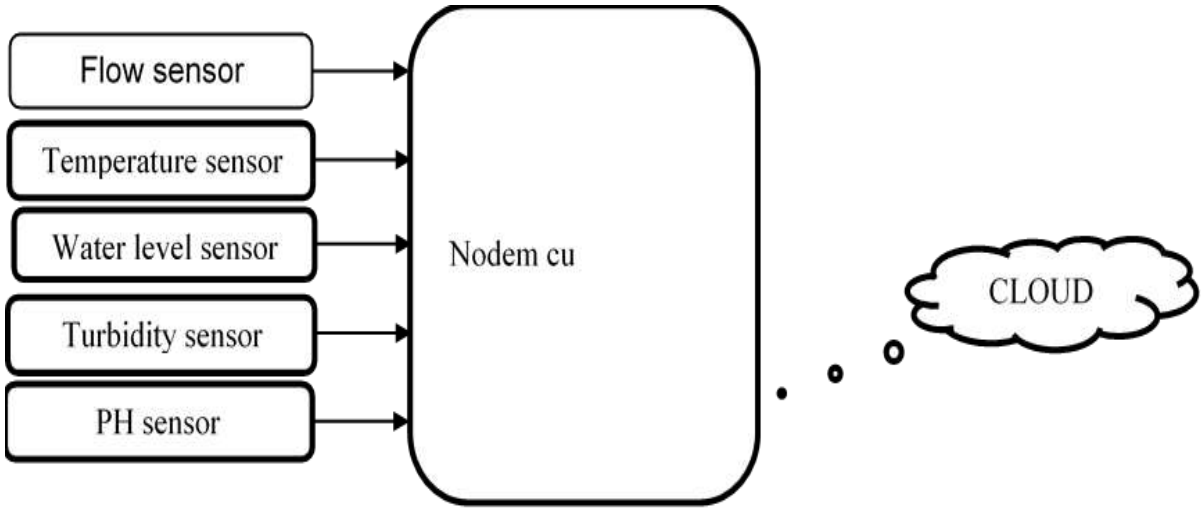

Fig. 1 – block diagram of IoT

In this paper, we have proposed a comprehensive IoT system for aquaculture management. The system design is partitioned into three frameworks; physical design, network design, and logical design. The physical design has various sub-systems for individual requirements. The system intergated sensor and actuators are used for developing the separate sub-system. Similarly, the network design deals with the topological con- figuration between the edge node, fog node, and gateway. The network design deals with data security and integrity via the OpenVPN server. The local data analytics is performed at the fog node. In comparison, the logical design framework assists in data visualization and analytics over the public cloud server. Intelligent data analytics forecast the DO and pH using machine learning models. To identify the effective machine learning model for data analytics, we have analyzed the performance of RF, LR, SVR, and GBM. The experimental evaluation found that RF has the highest prediction accuracy with a correlation of 0.7612 with an MAE of 1.428. In future research, we will consider more relative water parameters for robust forecast and analyze the M5 model tree for predictive analysis and controls

3. Equations

Later, the sensor data is preprocessed for anomalies detec- tion. The local outliers factor (LOF) is used to remove the anomalies from the dataset. The LOF technique finds the anomalous data point using the local deviation from its neighbours. The LOF score determines weather the data point is outliers or not.

LO F(k) 1 data point in a same cluster

LO F(k)< 1 data point i s Inlier

LO F(k) > 1 data point i s outlinear

In the above equation, k represent the locality with respect to its kth neighbours. To know the effectiveness of LOF, we have augmented the outlier data point in the dataset. The experimental result shows that LOF effectively detects the outlier from the data, as shown in Fig. 8.

4. Verilog Stimulation

Verifying Functionality using Behavioural Simulation as shown in fig 2 Create a test bench waveform containing input stimulus you can use to verify the functionality of the counter module. The test bench waveform is a graphical view of a test bench. Create the test bench waveform

Fig 2- Stimulation output

5. Conclusion

The system design is partitioned into three frameworks; physical design, network design, and logical design. The system intergated sensor and actuators are used for developing the separate sub-system. Similarly, the network design deals with the topological con- figuration between the edge node, fog node, and gateway. The network design deals with data security and integrity via the OpenVPN server. The local data analytics is performed at the fog node. In comparison, the logical design framework assists in data visualization and analytics over the public cloud server. To identify the effective machine learning model for data analytics, we have analyzed the performance of RF, LR, SVR, and GBM. The experimental evaluation found that RF has the highest prediction accuracy with a correlation of 0.7612 with an MAE of 1.428.

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