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Fish Feeder Automation for Home Aquariums with Holistic Water Quality Monitoring and Control Using IoT

[1]Jacob S. Midenga, [2]Dr. Caroline Koome

[1]School of Pure and Applied Sciences, Department of Computing & Information Science, Kenyatta University, Kenya
[2]School of Engineering and Architecture, Department of Electrical & Electronic Engineering, Kenyatta University, Kenya

Abstract: This study seeks to explore various dimensions of fish tank management, aiming to improve the welfare of aquatic organisms through the integration of technological innovations. Key focus areas encompass the monitoring, the identification of fish diseases, the inhibition of algae proliferation, and the creation of an automated fish feeder equipped with remote control functionalities. The proposed methodologies utilize contemporary technologies, including online monitoring systems, image processing techniques, and mobile applications, to develop efficient and accessible tools for aquarists. The system continuously evaluates water quality and delivers real-time information to users. This capability facilitates timely interventions to sustain an optimal environment for fish, thereby mitigating potential health risks associated with substandard water conditions. Additionally, a significant component of this research involves the creation of a mobile application that employs image processing to detect fish diseases. By analyzing images taken through the application, sophisticated algorithms will recognize prevalent fish ailments, enabling early diagnosis and swift treatment. This method reduces the reliance on manual inspections and minimizes the likelihood of misdiagnosis, ultimately enhancing the health management of fish populations. A mobile application will be developed to forecast and inhibit algae proliferation in home aquariums. By evaluating a range of parameters, including illumination, nutrient concentrations, and water circulation, the application will offer tailored suggestions and protocols to curtail algae development. This anticipatory strategy minimizes the labor and resources necessary for algae management, thereby fostering a cleaner and more healthful habitat for the aquatic inhabitants. Additionally, an automated fish feeder will be created, which can be operated remotely via the mobile application, dispensing food in accordance with the fish's behavioral patterns. This device will enable fish keepers to plan and modify feeding schedules and portion sizes, even in their absence. The mobile app's user interface enhances convenience and adaptability, ensuring that the fish receive adequate nutrition and consistent feeding.

Keywords: Water quality monitoring, fish disease detection, proactive interventions, domestic fish tanks, automatic fish feeder, real-time data, algae growth prediction and image processing.

I. INTRODUCTION

In recent years, the popularity of keeping fish as pets has increased significantly, which has led to more attention being paid to aquarium management and the welfare of aquatic life. The aim of this research project is to address various aspects of aquarium management by developing and implementing cutting-edge solutions. These innovations aim to improve the overall well-being of aquatic life and provide fish farmers with effective and user-friendly tools. The mesmerizing beauty of fish and the tranquil underwater world have led to a boom in recreational fish farming. With this growing popularity, there is a growing need for innovative approaches to simplify and improve aquarium management. Water quality plays an essential role in the health and vitality of fish. Factors such as temperature, pH, turbidity, dissolved oxygen and ammonia concentration significantly affect the well-being of aquatic organisms. Continuous evaluation of these parameters to make predictions and provide real-time data to fish owners enables them to proactively intervene and make necessary adjustments to maintain a favorable environment for their fish. This proactive approach prevents potential health problems caused by poor water conditions and mitigates financial losses due to the destruction of aquatic organisms. Early detection and prompt treatment of fish diseases is essential for effective health management. Traditional disease detection methods are often based on manual examinations, which can be time-consuming, subjective and prone to diagnostic errors. To overcome these limitations, this research project proposes the development of a mobile application based on image processing. When fish images are captured via the app, advanced algorithms

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analyze these images and identify common fish diseases. Early detection of diseases enables rapid treatment, increases the chance of recovery, and minimizes the spread of disease within the fish population. This technology solution not only improves the accuracy and efficiency of disease detection, but also reduces the burden on fish owners and makes fish health management more accessible and efficient. Algae growth is a common problem in aquariums and can affect water quality and the overall well-being of aquatic life.

By studying factors such as light levels, nutrient levels and water flow patterns, the project aims to identify optimal strategies to minimize algae growth while maintaining a healthy environment for fish. These findings will contribute to the development of practical guidelines and technologies for algae control in aquariums. Feeding is a fundamental aspect of fish care and maintaining a consistent feeding schedule is essential for the health and growth of aquatic organisms. This research project focuses feeder is programmable to dispense the right portions of fish food at specific intervals, providing convenience and flexibility to fish owners. The remote control and automatic feed dispensing system allows fish owners to control feeding according to the behavior of fish in the aquarium, even when they are not at home. This technology ensures that fish receive sufficient nutrition and minimizes the risk of over- or underfeeding.

Aquarium management and the welfare of aquatic life have attracted a lot of attention due to the growing popularity of keeping fish as pets. This research project aims to address various aspects of aquarium management through innovative technological solutions. The project focuses on improve the overall welfare of aquatic life and provide fish owners with effective tools that require less effort and are easy to use. These advances have the potential to revolutionize aquarium management by making it more accessible, less demanding in maintenance, efficient and enjoyable for fish lovers around the world.

II. RELATED WORK AND REVIEW

The study aims to generate real-time predictions about the condition of the aquatic environment, which will enable pet owners to take necessary actions to maintain the use of evidence-based recommendations supported by data can aquatic pets while easing the burden of care for pet owners. By automating certain aspects of aquatic pet care and providing real-time notifications, pet owners will have an easier care of their aquatic pets.

The findings of this study can lead to better care for aquatic pets and enhance their well-being and quality of life[1] By automating certain aspects of aquatic pet care and providing real-time notifications, pet owners will have an easier time managing the care of their aquatic pets. The findings of this study can lead to better care for aquatic pets and enhance their well-being and quality of life.[2] The study aims to enhance the care of aquatic pets by utilizing real-time predictions about the condition of the aquatic environment. The use of automated systems will enable pet owners to maintain water quality without constant monitoring, which will ease the burden of care and the findings of the study will be evidence-based, supported by data, and effective in providing recommendations for better care of aquatic pets.

The study addresses the challenges faced by pet owners in managing their aquatic pets' care by utilizing technology to monitor the environment and provide real-time notifications, allowing for timely actions to maintain a favorable environment for aquatic life. The care of aquatic pets and enhances their well-being and quality of life, which will benefit both pet owners and their pets. By automating certain aspects of aquatic pet care and utilizing technology to monitor water quality, pet owners will have an easier time managing their aquatic pets' care, which will lead to better outcomes for both pet owners and their pets.[3]

The use of low-cost sensors and machine learning algorithms in managing the care of aquatic pets is a promising approach towards improving their well-being and reducing the burden of care for pet owners. Aquatic pets aquatic environment, including temperature, pH levels, and oxygen levels. This information can help pet owners take necessary actions to maintain a favorable environment for aquatic life. The use of automated systems triggered by the predictions generated by the machine learning algorithms can enable pet owners to maintain the water quality without constant monitoring remotely through a mobile app. The findings of this study will be evidence-based, which means that the recommendations made will be supported by data and are more likely to be effective. By automating certain aspects of aquatic pet care and providing real-time notifications, pet owners will have an easier time managing the care of their aquatic pets, which will ultimately enhance their well-being and quality of life. [4]

[5]This article offers a thorough analysis of image processing methods that have been applied to fish illness identification. The authors point out that while visual examination is still a common approach for identifying fish

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infections, it can be time-consuming and inaccurate. Techniques for automate diagnosis, cutting down on the amount of time needed for diagnosis.

[6] This paper uses a CNN to identify fish diseases. The authors note that CNNs have shown promise in detecting diseases in medical images and hypothesize that they can also be used for fish disease detection. The study uses images of fish infected with various diseases, which are preprocessed and then fed into the CNN for training. The authors report that the CNN achieved an accuracy of over 90% in detecting the diseases, showing the potential of fish disease detection.

[7] Additionally, this paper outlines a study that employs to identify fish diseases. The Bag of Visual Words (BoVW) model, an image-based specifically used in the study. The authors point out that this method has been effectively applied in other contexts, such as face and object recognition. Images of fish with various pathologies are used in the study, which are preprocessed before being put into the BoVW model for training. The accuracy of the BoVW model in identifying the illnesses was above 95%, according to the scientists, highlighting the promise of machine learning methods for fish disease identification.

[8]This study describes a method for identifying fish infections using image processing. The method, according to the scientists, entails taking photographs of fish, processing those images, and then examining them to look for sickness. The phases of the image processing pipeline, such as picture capture, image enhancement, segmentation, feature extraction, and classification, are described in detail in the study. According to the scientists, the method had a detection rate of more than 80% for fish infections, proving the utility of image processing methods for this purpose.

[9]This study suggests a novel method for diagnosing fish infections that makes use of augmented reality and image processing methods. The author describes a method that uses a smartphone camera and computer vision to identify and categorize fish ailments in real-time. The method uses augmented reality to photographs that were taken to find any abnormalities or illnesses.

[10] In this research paper, In Bangladesh, a fish illness detection system was created for freshwater fish. To identify the illnesses that were present in the fish samples, the scientists used image processing techniques, and they assessed the system's performance using several performance measures. The findings demonstrated that the devised method had a 90% overall accuracy rate for diagnosing different illnesses in freshwater fish. The ability of this method to aid in managing and controlling fish infections in aquaculture was also noted by the authors. This study adds to the expanding corpus of work on computer vision and image processing-based fish illness detection systems.

[11] The burgeoning field of research employing image processing techniques for the recognition and differentiation of algae in domestic fish tanks has recently seen significant advancements. A notable study by introduced a groundbreaking classification technique tailored for the identification of various types of algae. The researchers harnessed the capabilities of hyperspectral imaging in conjunction with machine learning algorithms and image processing software to meticulously scrutinize hyperspectral images of algae culture media. Remarkably, the findings of this research underscored the exceptional accuracy achieved in distinguishing between different algae species through the innovative classification methodology. The implications of this pioneering study are far-reaching. It opens doors to the potential development of detection and recognition of diverse types of algae within domestic fish breakthrough has the potential to revolutionize the monitoring of algae growth and its impact on the water quality of fish tanks, thereby facilitating the implementation of timely and effective interventions to safeguard the well-being of aquatic ecosystems.[11].

[12] The presence of dairy industry wastewater, contributes to our understanding of this multifaceted relationship between temperature and microalgal growth in aquaculture settings. While research on the impact of temperature on microalgal growth in domestic fish tanks is limited, insights from aquaculture studies are relevant. Some research suggests that higher temperatures can accelerate the growth of specific microalgal species used in aquaculture feed, though the optimal temperature range varies with the microalgae species and environmental conditions. Temperature also influences the nutritional quality of microalgae, with elevated temperatures reducing essential fatty acid levels. Thus, maintaining an appropriate temperature range for the specific microalgae species and monitoring their nutrient content is crucial to meet the dietary needs of the fish. The use of temperature sensors can serve as a valuable tool in achieving these objectives.

A pertinent study, titled "Study of the Influence of Nutrients on the Microalgae Growth" by El Kaihal, A., Kifani-Sahban, F., Mohcine, A., and Moad, M. in 2019, conducted on the nutrient concentrations commonly harnessed for bioenergy

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production and wastewater treatment—offers valuable insights into the role of nutrients in algae growth dynamics. The research underscored the significance of nutrients like nitrogen and phosphorus in positively influencing microalgae growth, while also highlighting the potential negative consequences of excessive nutrient levels. Employing techniques like spectrophotometry and microscopy, the researchers meticulously measured microalgae growth across various nutrient conditions. These findings hold the potential to inform the formulation of strategies for optimizing microalgal production in diverse applications, encompassing aquaculture and wastewater treatment, through the judicious combination of multiple sensors for monitoring and regulating growth conditions.[13]

One of the earliest works in this field was proposed by Cao et al. (2008), who developed an automated fish feeding system that utilized a camera and an algorithm to the fish in a tank. The system used a feed distribution mechanism that adjusted the dispensed position of the fish. The results showed that the system was able to reduce feeding time by 50 percent and improve feed conversion ratio by 10 percent[14].

Another area of research has been the integration of additional sensors and data sources into automated fish feeding systems. For example, Zhang et al. (2019) proposed a system that utilized an ultrasonic sensor to detect the food level in the feeder and adjust the feeding schedule accordingly [15].

In addition to improving the efficiency of feeding operations, automated fish feeding systems can also help a system that utilized a camera to detect the behavior of the fish and adjust the feeding schedule accordingly. The system was able to reduce the occurrence of aggressive behavior among the fish and improve their growth rate.[16]

Another potential application of automated fish feeding systems is in the management of water quality in aquaculture systems. For example, the system was able to detect oxygen and ammonia, and adjust the feeding schedule accordingly to maintain water quality and reduce the risk of fish mortality.[17]

III. PROPOSED SYSTEM DESIGN

IoT and image processing techniques were primarily utilised, which is fairly important. The fact that new fish owners and somewhat less experienced owners as well as well-experienced ones generally aren't 100 present accurate at spotting diseases in their fish suggests that our system for spotting fish diseases and preventing their spread relies heavily on image processing techniques and IoT. Consequently, our image processing and Internet of Things (IoT)-based fish disease detection and prevention system has four basic parts. As mentioned in Fig 1.

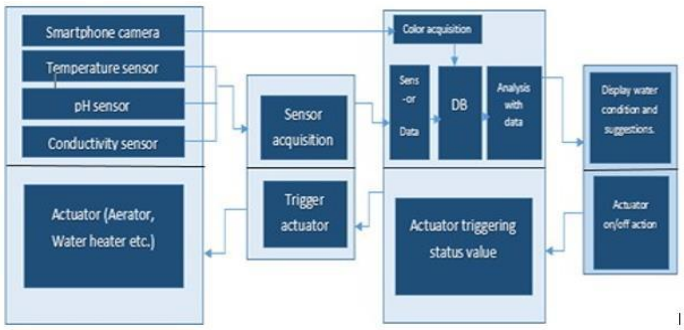

Figure 1: System diagram

- Water Quality Measuring System
- Detecting Fish Disease and Spread Area
- Identifying, Predicting, and preventing Algae Growth
- Automatic Fish Feeding System

The management and monitoring of this system can be effectively conducted through a mobile application. The ESP32 Micro-Controller, capable of playing high-definition media and showcasing images, is ideally suited for adaptive technology and the prototyping of embedded systems. This technology facilitates the development of complex and functional structures in a more cost-effective and efficient manner. Ultimately, a singular mobile application featuring an intuitive interface will integrate all four components seamlessly.

1) Water Quality Monitoring System

The life cycle of fish necessitates careful attention when managing aquariums. It is crucial to recognize and address potentially lethal infections, particularly those linked to water quality. Consequently, the system is designed to a turbidity sensor is employed to identify particulate matter in the water by measuring light transmittance and scattering, which varies with the concentration of total suspended solids (TSS). Additionally, a pH sensor probe assesses the acidity levels of the water, while an underwater temperature sensor monitors the water temperature, and an oxygen sensor evaluates the dissolved oxygen content.

An ultrasonic sensor positioned above the tank measures fluctuations in water levels. All sensor data is updated every five seconds in a database and a mobile application, utilizing an ESP32 Wi-Fi-enabled Arduino microcontroller. Based on the

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sensor readings, a heater is activated to raise the temperature, and a water pump is engaged to enhance oxygen levels, thereby maintaining water quality within optimal parameters. Historical data is visualized through bar charts for end users, and this information is analyzed by an algorithm to predict how variations in water quality may impact fish health. The mobile application offers real-time insights into water conditions and sends alerts for specific environmental states. This aspect of aquarium management software is vital, as it allows users to easily interpret data and take proactive measures based on the information provided. pH value – 6.5-8.0, Water Temperature - 25-30 Degrees Celsius.

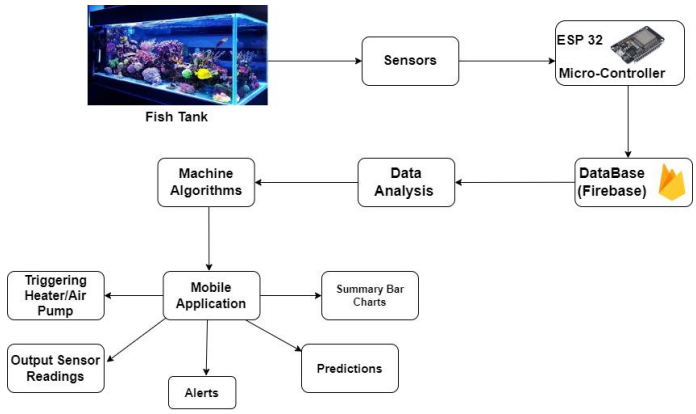

Figure 2: Overall System design

2) Fish Diseases Identification System

The prompt identification of fish diseases is crucial for mitigating their rapid dissemination among aquatic populations. The manual detection of these diseases presents considerable difficulties, a situation exacerbated by the potential for swift transmission in water. Fish owners frequently encounter challenges in accurately diagnosing these conditions, and their assumptions about the specific disease may often be misguided. To overcome these obstacles, it is imperative to utilize image processing methodologies to develop an effective fish disease detection system, as illustrated in Figure 3.

The prompt and precise identification of fish diseases is crucial for preventing their spread. Nevertheless, traditional methods of detecting these diseases manually present significant challenges. The rapid transmission of illnesses among fish in aquatic environments raises serious concerns, highlighting the necessity for prompt diagnosis by the fish owner. Furthermore, the owner's perceptions regarding the nature of the disease may not always align with reality. To overcome these obstacles, the integration of image processing techniques is proposed to create an effective system for detecting fish diseases.

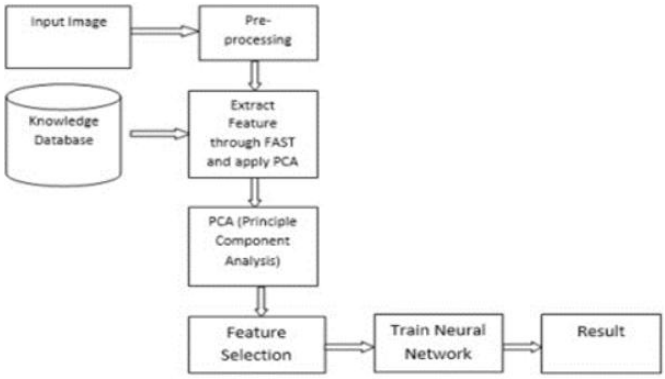

Figure 3: Methodology for the detection of diseases

This approach entails the development of a system that identifies fish diseases and their areas of spread using YOLO v5 through image processing methodologies. The system capitalizes on established datasets of fish diseases following detection. Its primary aim is to furnish detailed information about the identified diseases and recommend appropriate treatments for affected fish, thereby challenging prevalent misconceptions. The first phase involves categorizing the dataset into four specific groups: Fin Rot, Red Spot, Clamped Fin, and a category for healthy fish images.

Following this categorization, pre-processing methods are employed to improve the dataset's accuracy, which includes resizing images to a uniform dimension of 256x256 pixels and applying denoising filters. The YOLO v5 model is then utilized to train the dataset, with the goal of achieving accurate detection of fish diseases. Additionally, pixel analysis is conducted to determine the affected areas of the red spot disease on the fish's skin.

In the training process, a batch size of 32 is employed, and a variety of training and validation datasets are utilized. The effectiveness of the model is assessed by tracking validation accuracy and loss reduction, incorporating a strategy for adjusting the learning rate. Over the course of 50 epochs, manual adjustments to both validation accuracy and the learning rate are made to optimize training results.

YOLO (You Only Look Once) is a cutting-edge algorithm for object detection, recognized for its rapid processing and high accuracy. YOLO v5, an advancement of the original YOLO framework, marks a notable improvement in real-time object

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detection capabilities. This deep learning algorithm is proficient in identifying and localizing multiple objects within a single image or video frame concurrently. The term "You Only Look Once" reflects its capacity to analyze the entire image in a single forward pass through the neural network, setting it apart from conventional detection methods that rely on region-based techniques. This characteristic renders YOLO v5 exceptionally swift and efficient. The architecture of the YOLO v5 model is based on a deep neural network, typically a convolutional neural network (CNN), which employs various layers to predict bounding boxes and class probabilities for the objects detected in the image. YOLO v5 utilizes anchor boxes to ascertain the location and dimensions of objects, enhancing its localization accuracy. Furthermore, it implements a softmax activation function to classify each bounding box, facilitating precise object categorization. A notable advantage of YOLO v5 is its flexibility across different hardware configurations, allowing for deployment on a range of platforms, including GPUs, TPUs, and edge devices. This versatility ensures that the model can be applied in various practical scenarios, spanning from security and surveillance to robotics and autonomous vehicles.

3) Predicting and Preventing Algae Growth in Home Aquariums

Keeping an aquarium is a popular way to enjoy the calming presence of pets and relieve stress. However, maintaining the aquarium and keeping the fish healthy requires effort and attention. One of the biggest challenges in maintaining an aquarium is controlling algae growth.

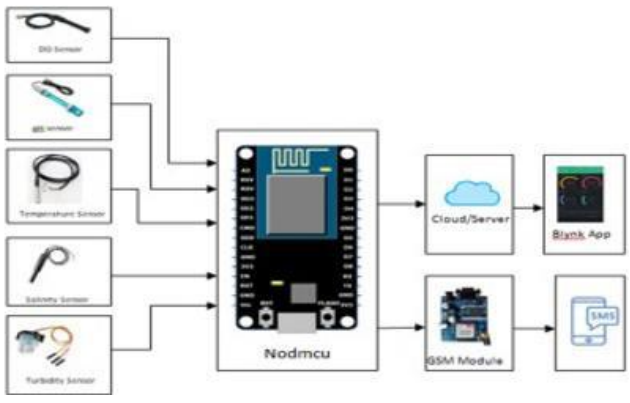

Figure 4: Algae identification system

Algae can grow due to several factors including overfeeding, water temperature, excessive sunlight and poor water quality. With their busy lifestyles, it is obvious that they forget to clean the aquarium regularly. Changes in growth of algae in an aquarium. Excessive algae growth in an aquarium can cause disease or even death in fish.

The implementation of an algae identification system utilizing image processing through a Convolutional Neural Network (CNN) architecture is proposed. This system aims to enhance understanding of the factors contributing to algae proliferation and to recommend strategies for their prevention. In instances where conditions are conducive to algae growth, the application will issue notifications to users, along with suggestions for mitigation, such as minimizing sunlight exposure or modifying nutrient concentrations. Initially, the dataset is categorized into two distinct groups: one comprising images of algae-infested fish tanks and the other consisting of images from clean fish tanks devoid of algae. Subsequently, the dataset undergoes preprocessing to maximize accuracy, with images standardized to a resolution of 256x256 pixels. TensorFlow Lite is employed for training the datasets. The dataset is partitioned into three segments for training, testing, and validation, adhering to proportions of 80%, 10%, and 10%, respectively. The utilizing multiple datasets for training and validation. Validation accuracy and learning rate adjustments are monitored manually throughout the training process. After completing 50 epochs, modifications are made based on the validation accuracy. A combination of backend and frontend functionalities facilitates this process. The backend manages the image upload and algae identification tasks, while the FastAPI framework is utilized to create an interface that captures images and initiates the algae prediction workflow. The trained model analyzes the uploaded images to predict the type of algal growth that corresponds most closely to the user's input.

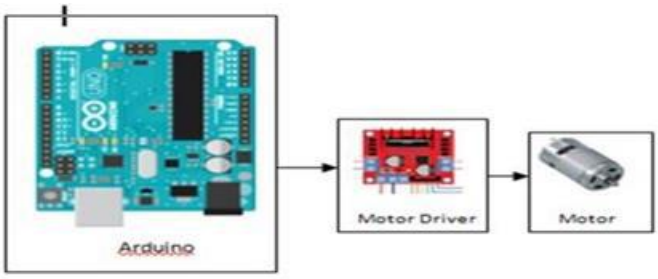

Figure 5: Food feeding system architecture

Additionally, the integration of Firebase enables the storage and retrieval of information related to algal growth, including images and supplementary data. Users can upload images and utilize the camera feature within the front-end interface to

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capture photos of their tanks, allowing the technology to generate predictions based on the images taken.

4) Factors Contributing to Algae Proliferation

An array of sensors, such as Light Dependent Resistors (LDRs), Total Dissolved Solids (TDS) sensors, and temperature sensors, is employed to gather real-time data for predicting algae growth in aquatic settings. The LDRs track sunlight exposure, evaluating both the intensity and duration of light within the fish tank. Simultaneously, temperature sensors monitor variations in water temperature, while TDS sensors assess nutrient concentrations. By examining this extensive dataset, machine learning algorithms create predictive models that forecast algae growth based on changes in water temperature, sunlight exposure, and nutrient levels. Users receive notifications regarding potential algae problems, enabling them to implement preventive actions and maintain the health of their aquatic pets.

5) Automated Fish Feeding Systems

Feeding is crucial for the health of fish. They tend to eat whenever they feel hungry and food is available. When sufficient food sources are present, fish may feed multiple times throughout the day. Conversely, if food is limited, they might go without meals for several days. Fish are inherently opportunistic feeders, taking advantage of any available food.

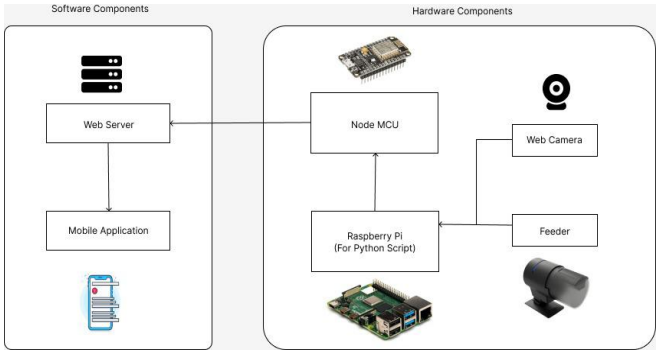

Figure 6: Testing image processing algorithm in tank

Our advanced fish tank management system employs the latest technology to promote the health and wellbeing of your aquatic pets. Extensive research has shown that feeding fish every five hours meets their nutritional requirements. To facilitate this, a webcam is installed to monitor the tank continuously. When the fish are hungry, they tend to gather at the bottom of the tank in search of food. The fish feeder is activated only when two conditions are satisfied: a five-hour interval since the last feeding and a majority of the fish positioned at the bottom level. The system utilizes YOLO (You Only Look Once) technology to determine the fish's location by dividing the tank into upper and lower sections.

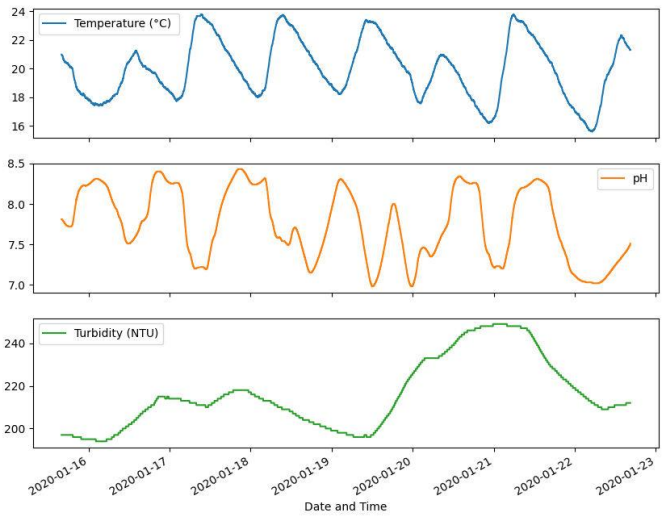

Figure 7: Calculate and collect real-time data from various intervals

Once both conditions are met, users receive a notification via a mobile app, prompting them to activate the fish feeder and dispense food. This allows users to feed their pets remotely, provided they have an internet connection. The system is powered by an ESP32 microcontroller linked to the feeder, which updates the database every five seconds over Wi-Fi. Additionally, it monitors the food level in the feeder using an ultrasonic sensor, reporting the percentage of food remaining to the Firebase database. This feature helps users know when to replenish the feeder. When the food level drops to 50%, the system sends a notification to the user, urging them to refill the feeder promptly. All notifications are stored in a history log, allowing users to review past alerts as needed.

IV. RESULTS ANALYSIS AND DISCUSSION

1) Water Quality Monitoring System

This component is designed to collect real-time data from various sensors and provide output to end users while maintaining water quality within acceptable parameters. Figure 10 illustrates the turbidity readings displayed in the mobile application as a percentage. Figure 7 presents test readings of pH levels over several days, reflecting different water qualities. The pH sensors collect data and relay it to a microcontroller, which subsequently transmits the information to a database via Wi-Fi at

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five-second intervals. Utilizing the bar chart data (with the x-axis representing Days and the y-axis indicating pH as a percentage), the backend system generates forecasts regarding future conditions and their potential impact on aquatic ecosystems.

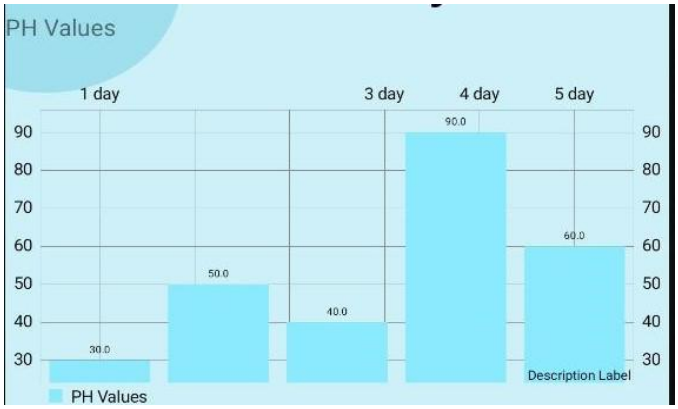

Figure 8: Variation of pH readings with 5 days of testing period

Figure 8 depicts a chart that tracks the temperature variations of water over a five-day period, with manually controlled samples represented in Celsius on the y-axis as a percentage and Days on the x-axis. The samples included boiling water, cold water, and normal water. This methodology is similarly applied to other parameters, such as oxygen levels and water levels, to calibrate sensors and conduct testing. Relevant alerts are generated for the end user through the mobile application, prompting necessary actions. Additionally, the heater and air pump are programmed to activate automatically if the water quality reaches predefined thresholds set by the backend system; however, users also have the option to manually operate these mechanisms.

Figure 9: Variation of Temperature readings with 5 days of testing period

2) Fish Diseases Identification System

The initial step involves the fish or aquarium owner identifying signs of illness or disease in their fish by observing symptoms. Subsequently, they capture high-quality and clear photos of these disease symptoms using the camera on their mobile phone. These captured images are then processed using image processing techniques. Leveraging the power of the YOLO v5 (You Only Look Once) algorithm and data analysis techniques, the processed images are then channelled into a user-friendly mobile application, providing a seamless and efficient disease identification system for the user. As illustrated in the diagram provided in Figure 9, the system will present the final output.

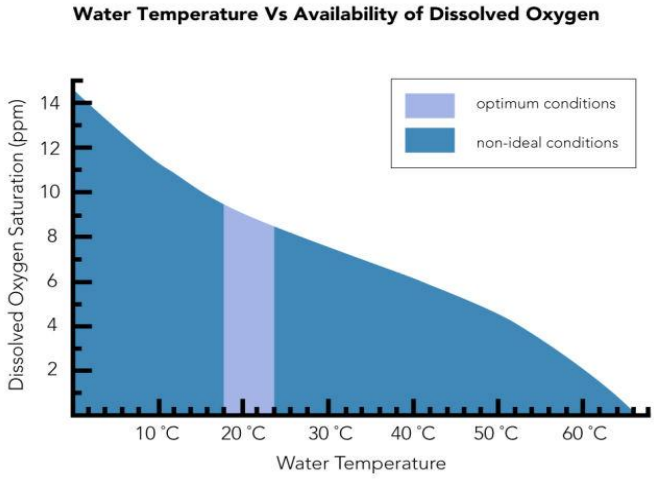

Figure 10: Image processing phase extensive collection of water temperature

In the image processing phase, an extensive collection of disease datasets is crucial to ensure optimal accuracy for the system. To gather these datasets, we utilized sources such as kaggle.com, along with manual collection and insights from trusted experts in the field. During the research, our model exhibited an initial training accuracy of 78.99 percent per epoch. With each training run, the model's accuracy progressively improved. After ten runs, the training accuracy elevated to 97.03 percent per epoch. Post training, the prediction code efficiently identifies the disease, recommends suitable medication, and provides additional information about the identified disease.

3) Predict and Prevent Algae Growth in Domestic Fish Tanks

The first action for an aquarium or fish owner involves the detection of algae, which is primarily achieved through the

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analysis of water samples. To verify the presence of algae, the owner captures high-resolution photographs of the algae blooms using a smartphone camera. These photographs are subsequently uploaded to an image processing system. Utilizing the TensorFlow Lite algorithm alongside sophisticated data analysis methods, the system processes the images to accurately identify and categorize the algae.

```
Temperature: 27.56Celsius
voltage: 2.68
NTU: 2989.30
pH:9.67
Turbidity is high
Temperature is optimal
Ph is not in normal range
```

Figure 11: The output in the Arduino

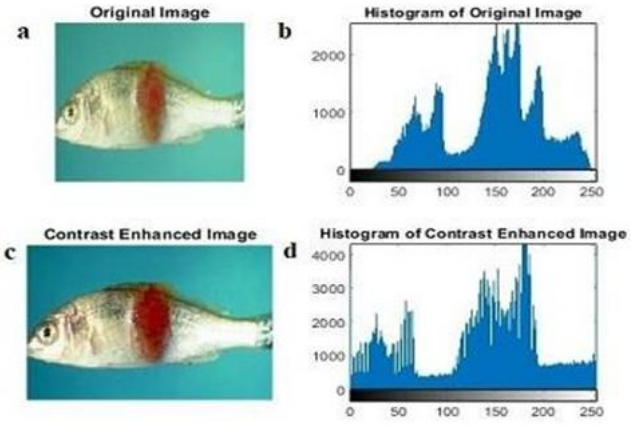

Figure 12: (a) Input of the Affected Original Fish Image (b) Histogram Result (c) Enhanced Result and (d) Histogram of Enhanced Image

The resulting information is then transmitted to an intuitive mobile application, equipping the owner with essential insights and recommendations for the effective management and upkeep of their aquarium, thereby promoting a vibrant and healthy aquatic ecosystem.

- Show the Algae Growth in the Tank High Or Low
- Show the reasons for algae
- Show The Algae Prevention Methods

In the image processing segment, achieving optimal accuracy necessitates an extensive dataset of algae fish tank images. To acquire this vital resource, we meticulously gathered data through manual efforts and consulted trusted experts in the field. In this study, the model had a 66.99% training accuracy. The model was trained after each run, and over time, the results became more accurate. The training and validation accuracy climbed to 81.12% after ten runs. The prediction algorithm will output the recognized algae in the fish tank following model training. To understand the drivers of algae growth, temperature, TDS, and light sensors were employed.

The collected data displayed a notable contrast, with the algaeladen fish tank yielding higher sensor readings, signifying conditions conducive to algae proliferation. In contrast, the clean fish tank exhibited lower readings, indicating a less favorable environment for algae growth. This data-driven approach underpins our pursuit of precision in fish tank management, facilitating healthier aquatic ecosystems.

V. FISH FEEDING AUTOMATION SYSTEMS

Cultivating a seamless blend of technology and aquaculture, our innovative fish tank management system has redefined the way we care for our aquatic companions. The tank is ingeniously divided into two distinct levels, a design born from meticulous research and observation. Extensive studies have affirmed that feeding fish every 5 hours is not only optimal but also essential for their well-being. Recognizing the natural behavior of fish, particularly their tendency to congregate at the tank's bottom when hungry, led to the implementation of our intelligent monitoring system. Through the lens of a sophisticated webcam, our system discerns the fish at the tank's bottom. When a substantial gathering is detected, an instantaneous notification is dispatched to the user via our intuitive mobile app.

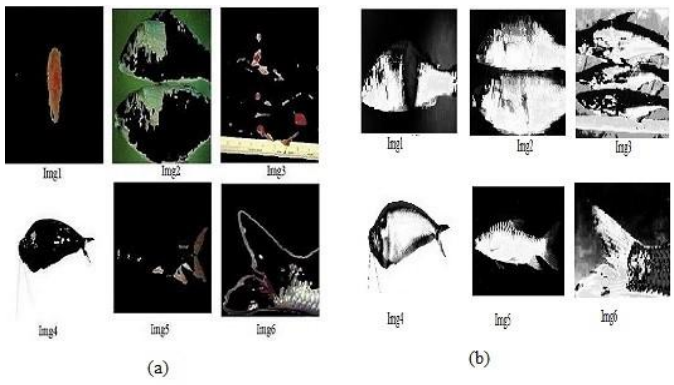

Figure 13: Segmented Outputs

This alert empowers users to remotely activate the fish feeder from any corner of the globe, a revolutionary convenience tailored for today's fast-paced lifestyles. In addition to this, our system incorporates cutting-edge ultrasound sensors to precisely

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gauge food quantities. Should the food levels drop below 50 present, an automatic notification is dispatched to the user's mobile app, providing invaluable insights into their fish's dietary needs.

Figure 14: User Interface of the application

This feature grants users a comprehensive understanding of their stock, enabling effortless management of their aquatic pets' nutrition. This amalgamation of advanced technology and user-centric design not only simplifies the user's life but also offers peace of mind. With the ability to remotely manage fish feeders and monitor food supplies, our system embodies unparalleled convenience, ensuring that the well-being of your fish is never compromised. Experience a new era of aquaculture management, where precision meets simplicity, and caring for your fish is as effortless as it is intelligent.

VI. CONCLUSION

The increasing trend of keeping fish as pets has highlighted the necessity for sophisticated and accessible solutions in the management of fish tanks, particularly for individuals with demanding lifestyles. This research initiative adopts a holistic perspective, leveraging technological advancements to tackle the diverse challenges associated with maintaining ideal conditions for aquatic life.

This initiative introduces a proactive system for monitoring water quality. By equipping busy fish owners with predictive analytics and real-time data feedback, it aims to reduce the likelihood of health complications arising from suboptimal water conditions, thereby protecting aquatic species and minimizing financial losses. Furthermore, the field of disease management is poised to gain substantial advantages from a mobile application that utilizes image processing. By providing fish owners with a tool for the early detection of diseases through automated image analysis, this project enhances both the precision and efficiency of disease identification.

This technology not only enables aquarists to respond promptly to the needs of their fish but algae growth, which poses a frequent challenge, is addressed innovatively within this research initiative. By investigating the various factors that contribute to algae expansion, the project aims to offer practical recommendations and strategies for effective algae management, thereby fostering a balanced ecosystem for aquatic organisms and maintaining water quality. Additionally, the creation of an automatic fish feeder equipped with remote control features marks a significant advancement in the management of fish tanks. This technology allows for the programming of feeding schedules and the adjustment of portion sizes based on the behavior of the fish, effectively merging convenience with responsible husbandry. The capability to manage feeding remotely guarantees consistent nutrition while mitigating the risks associated with both overfeeding and underfeeding. In conclusion, our research project embodies a progressive vision for fish tank management through portable technology, leveraging advancements to create a thriving and harmonious environment for aquatic life. These innovations have the potential to transform the experience of fish enthusiasts worldwide, making the practice of fish keeping more accessible, efficient, portable, and enjoyable. Future endeavors will focus on scaling the system for large-scale aquaculture operations, incorporating a wider array of sensors.

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