Automatic Recognition of Fish Diseases in Fish Farms

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Abstract

Fish diseases are the major cause for increasing mortality in fish farms. Automatic identification of diseased fish is necessary to prevent their spreading. Fish disease diagnosis suffers from some limitations that need high level of expertise to be solved. Recognition of fish abnormal behaviors helps in early prediction of fish diseases. Fish behavior is evaluated by analyzing fish trajectories in videos. Abnormalities may be due to environmental changes. This document introduces a survey on what computer vision techniques propose in that field. A comprehensive comparison between different automatic recognition systems is included. Finally, a suggested approach to automatically recognize and identify abnormal fish behaviors and five different fish diseases is proposed. These diseases are Epizootic ulcerative syndrome (EUS), Ichthyophthirius (Ich) and Columnaris. Based on literature, diseased area segmentation of fish image was applied by various edge detection, and color segmentation techniques. The most effective extracted features was features from Accelerated Segment Test (FAST). Principal component analysis (PCA) was applied to reduce features dimensions. Classification of infected fish image was achieved effectively by convolutional neural network(CNN) and support vector machine (SVM).

1 Introduction

Fish is a major component in global food supply. It makes a big impact in economy. It is considered to be one of the main resources for countries income. As a living organism, fish suffer from various diseases. Diseases are the most major cause for fish death. Infection is extremely dangerous, since it can be spread quickly through water to neighboring in the same fish farms. Therefore, identification and diagnosis of fish diseases is an important step to prevent and control spreading of diseases.

Fish diseases domain is affected by varying expertise of different experts, that may differ in their diagnoses of diseases or abnormal behavior based on their skills. Some problems may face experts due to fast fish movement, which

cause tracking infected fish to be impossible by human vision and Poor quality of unclear water in earthen ponds. Image processing and computer vision techniques support this field of research. Vision can be improved and tracking fish becomes easier by slowing down motion in videos, also automatic fish diagnosis is necessary and needed. Different types of Fish diseases are shown in Fig. 1.

Prediction and detection of fish disease is always related to fish behaviors, that's why it is important to analyze these behaviors. There is a lack of research that concerns abnormal fish behavior. Automatic analysis of fish behavior using computer vision is a fundamental research area as it helps to detect environmental changes by knowing abnormal or new fish behaviors. The normal behavior of fish is observed by human vision. This consumes a lot of time and limits the accuracy of detection. Therefore, an automatic approach is needed by using computer vision to study the behaviors of fish.

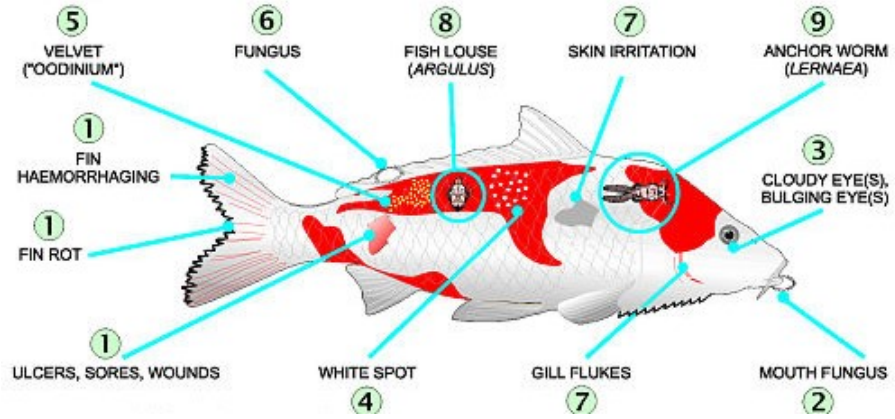


Figure 1: Different type of fish diseases

1.1 Background

There are different types of ponds of fish farms. These types are earthen ponds, concrete ponds and floating cages. These ponds are categorized to either extensive or intensive. Extensive ponds are much like natural ecosystems with respect to nutrient inputs, nutrient cycling, species diversity, oxygen dynamics, and level of human intervention. examples are shown in Fig.2, while Intensive pond relies on technology to raise fish in artificial tanks at very high densities as shown in Fig. 3. Some intensive ponds are completely closed system, this type of ponds is called integrated recycling system. Another type is cage ponds.

1)Earthen ponds **2)Tank – indoor systems**

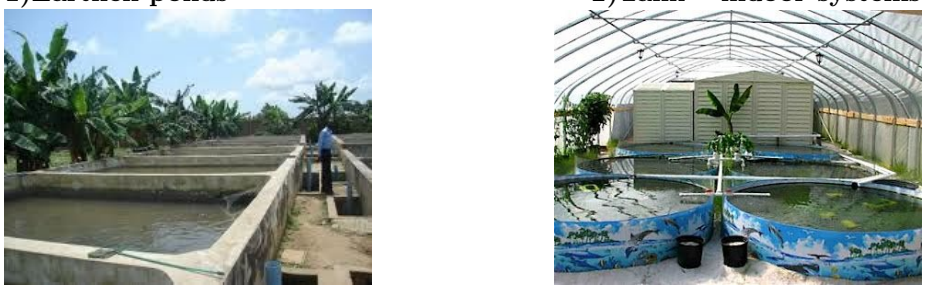


Figure 2: Extensive Ponds

1)Integrated recycling system **2)Cage ponds**

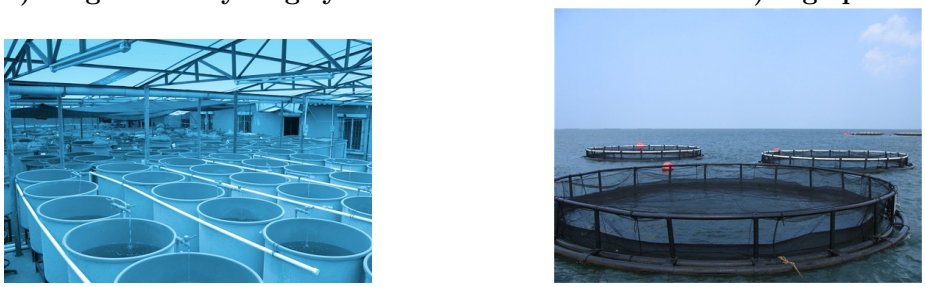


Figure 3: Intensive Ponds

The environment in fish farm is based on the measured amount of oxygen, ammonia-nitrogen, alkalinity and PH. If any disruption happened in these measured values, it will lead to fish diseases and consequent death. There are two causes of fish diseases, infectious or non-infectious illnesses. Fish infections may also cause exceeding mortality. Mortality may reach to 90 percentage of stocks. Non-infectious diseases may occur due to pollution of water. Other environmental diseases may occur due to low dissolved oxygen, high alkali, high nitrite. Infectious diseases can be classified as viral, bacterial, fungal, parasitic, as shown in Table. 1 and 2.

Table 1: Pathogens which can cause fish diseases [6]

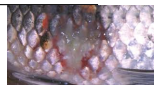
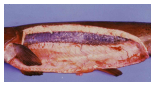
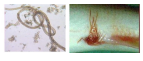
Pathogens	Examples	Figure
Viral infection	Carp pox	
	koi herpesvirus (KHV)	
	Viral hemorrhagic septicemia (VHS)	
Fungal infection	Saprolegniasis	
	Ichthyophonus (ICH)	
	Epizootic ulcerative syndrome (EUS)	
Bacterial infection	Motile aeromonas septicemia (MAS)	
	Columnaris disease	
	Vibriosis	
	Streptococcus	
Parasitic infection	Trichodiniasis	
	Metazoan parasites	

Table 2: Fish Diseases.

Fish Diseases			
Disease	Description	Symptoms	Causes
Ichthyophthirius (Ich)	1)It affects fish that are stressed. 2)Its fungal infection. 3)It's morbidity rate may reach 100 Percentage	1)It appears on the body, fins and gills of fish as white nodules of up to 1 mm. 2)Starting on the head and spreading over the whole body. 2)Rapid breathing or gasping at the surface of the water. 3)Darkness of the body color. 4)Resting on the bottom.	1)Change in the level of PH. 2)Low in the rate of the oxygen. 3)High temperature.
Motile Aeromonas septicemia (MAS)	MAS is almost appears in freshwater	1)Hemorrhage at fins and on the skin . 2)Shallow to deep skin ulcers.	1)Change in water temperature. 2)Infection occurred by water. Most outbreak in summer and spring.
Columnaris	Its a fungal infection.Results from an infection caused by the "Gram-negative".	1)Causing frayed and ragged fins. 2)Fish will breathe rapidly. 3)Gills will change colour. 4)The appearance of ulcerations on the skin. 5)White or cloudy,fungus-like patches.	Low dissolved oxygen levels in the water column.
Epizootic ulcerative syndrome	1) It is a disease caused by a fungal pathogen called Aphanomyces invadans. 2)It influences hundreds of different fish types.	Red spots appear and are hardly identified.	1)Low temperature. 2)Heavy rainfall in tropical and sub-tropical waters.

1.2 Problem Definitions

Fish diseases domain is affected by varying expertise of different experts, that may differ in their diagnoses of diseases or abnormal behavior based on their skills. Some problems may face experts due to:
1) Fast fish movement, which cause tracking infected fish to be impossible by human vision.
2) Poor quality of unclear water in Earthen ponds.
Image processing and computer vision technique overcome this limitation by classifying fish diseases from images, improve human vision in Earthen ponds and track fish by slowing down videos.

1.3 Motivation

The world market control fish farms manually. The market is in bad need to automatic system to solve the problems mentioned in previously. There is a lack of research that concerns handling fish infections. Fish have great importance in the annual revenues of the country. Global fish production reached about 171 million tons in 2016 as shown in Fig 4.

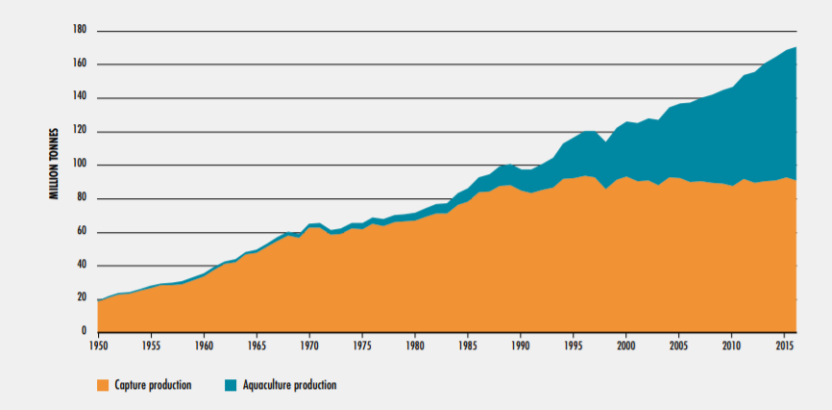


Figure 4: Between 1961 and 2016, the average annual increase in global food fish consumption (3.2 percent) and population growth (1.6 percent) [5].

Huge loss of production in aquaculture is occurring, because of many reasons. Diseases are the most serious constraint that causes damage. For instance, in Egypt. The annual loss of revenues because of fish disease reaches up to 6 billion dollars. Preventing and managing fish disease is critical to minimize the production loss and increasing aquaculture productivity. With the help of computer vision, early prediction can be applied to prevent diseases from spreading among fish and ponds. Image processing enhance vision in forms and facilitate controlling fish disease for analyzing and detecting.

This work is separated into two stages:
1. Tracking the fish in the ponds
2. Detect the fish by applying segmentation, feature extraction and disease Classification.

In Egypt,the intensive aquaculture farming has grown increasingly, especially in the deserts of northern Sinai. Fish farms are distributed through the Nile Delta region and concentrated mainly in the Northern lakes as shown in Fig. 5

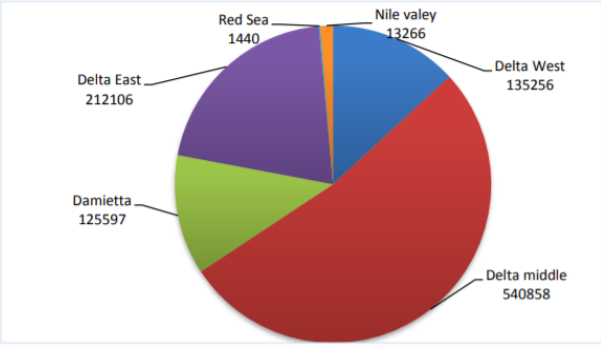


Figure 5: Geographical distribution of Egyptian aquaculture production (million ton) [11]

2 Project Description

2.1 Objective

Diseases spread quickly among fish. Pollution of water, environmental diseases as low dissolved oxygen, high alkali are all reasons that cause fish to be diseased. It affects the annual revenues of the country. Our system offers a solution to analyze fish behavior to prevent fish diseases before spreading by applying deep learning technique.

2.2 Scope

This document targets owners of fish farms and experts in the fish farm domain. Our project will help them in saving much more time rather than manual detection. Fish disease is a substantial source of loss to the owner of fish farm. Production costs are increased by fish disease outbreaks because of the investment lost in dead fish, cost of treatment. Therefore, Our automatic identification system for diseased fish is necessary to prevent fish diseases before huge loss occur.

2.3 Project Overview

Our system aims to detect and diagnose fish diseases in fish farms automatically. Raspberry Pi kit is used and connected to sensors, camera and a personal computer(PC). The system is presented in three consequent stages. During the first stage, water quality is examined by measuring water temperature and rate of pH, while fish captures are acquired by the camera. The kit gets the sensor's measurements and acquired fish captures. In the second stage, all inputs are passed to the PC for processing. This processing concerns detecting any abnormal behavior in farm environment and fish infections. Infection detection starts by pre-processing, then segmentation of infected areas and finally classification. Abnormal behavior of fish will pass by HAAR cascade , then behavior classification. Finally in the third Stage, the kit is responsible for sending notification to farm owner's mobile phones through an application, In case that mobile is not connected to the internet, GSM800 component, sends message to mobile to notify them of any improper changes in farm environment or detected infections. The overview of our system is shown in Fig. 6.

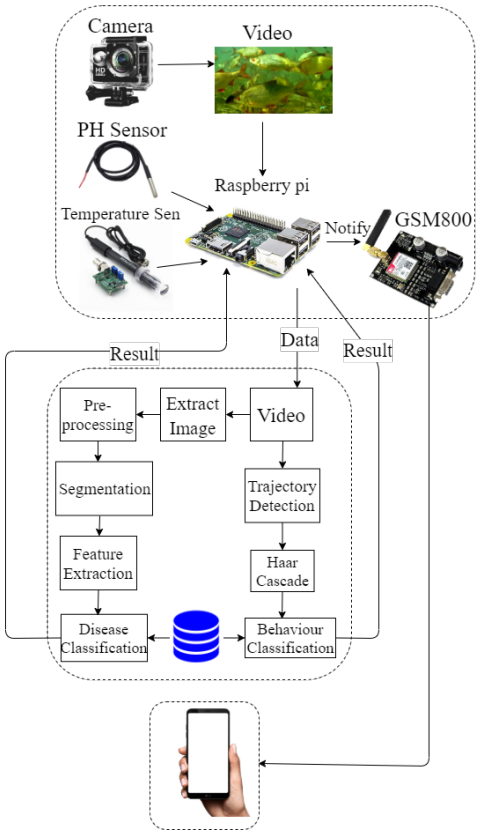


Figure 6: Project Overview

2.4 Hardware Components

2.4.1 Raspberry pi 3 kit

Raspberry Pi kit is used to get the sensor's measurements and acquired fish captures. It is one full function UART port, and can be configured to two independent serial ports. One SIM card interface. Support Bluetooth function. Raspberry Pi 3 has built in (on board) WiFi and Bluetooth. It is shown in figure 7

Figure 7: Raspberry pi 3

Some Features of Raspberry pi 3:

- CPU: 4× ARM Cortex-A53, 1.2GHz
- GPU: Broadcom VideoCore IV
- Bluetooth: Bluetooth 4.1 Classic, Bluetooth Low Energy
- Ports: HDMI, 3.5mm analogue audio-video jack
- RAM: 1GB LPDDR2 (900 MHz)

2.4.2 Raspberry pi camera

Raspberry pi camera is used to capture fish movements under water. It is a professional camera with high resolution day/ night vision, with fish eye lens for wider field of view and adjustable focal lens. It produced high definition (HD) videos. The camera module is good for both professional and beginner users. It can be used for security applications, slow motion, image recognition and many other. It is shown in figure 8
Some Features of Raspberry pi camera:

- Omnivision OV5647 sensor
- 5MPixel sensor
- Still picture resolution : 2592 x 1944
- Max video resolution : 1080p
- Max frame rate: 30fps

Figure 8: Raspberry pi camera

2.4.3 PH Sensor kit

PH sensor is used to examine water quality in fish farms. PH is a measure of acidity or alkalinity of a solution. The pH scale ranges from 0 to 14. The Ph sensor kit include sensor probe and signal conditioning module. They are connected to each other with BNC connector. PH sensor is shown in figure 9
Some Features of PH sensor:

- Measuring Range: 0 -14
- Measuring Temperature :0-60 ℃
- Accuracy : 0.1 pH (25 ℃)
- Response Time : 5 sec

Figure 9: PH Sensor

2.4.4 Waterproof Temperature Sensor

Temperate sensors is used to examine water in fish farms. All weather temperature probe, specifically designed to be used in the field. This sealed digital temperature probe lets you precisely measure temperatures in wet environments

with an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. It is shown in figure 10

Some Features of Temperature sensor:

- Usable temperature range: -55 to 125°C (-67°F to +257°F)
- ±0.5°C Accuracy from -10°C to +85°C
- Temperature-limit alarm system

Figure 10: Temperature Sensor

2.4.5 GSM-GPRS Module

GSM-GPRS is used to notify owner of fish farm of any improper changes in farm environment or detected infections. Frequency GPRS/GSM Module-is an ultra compact and reliable wireless module. It is a breakout board and minimum system of SIM900 Quad-band GSM/GPRS module. It can communicate with controllers via AT commands (GSM 07.07 ,07.05 and SIMCOM enhanced AT Commands). This module support software power on and reset. The GPRS is configured and controlled via its UART using simple AT commands. Just connect on the Arduino/PIC/AVR/ARM/FPGA/CPLD board, you could easy to use AT command control it. The module can be connect to PC via FTDI. It is shown in figure 11

Some Features of GSM-GPRS Module:

- Fully compatible with AVR/PIC/Arduino/ARM/FPGA
- Super capacitor power supply for the RTC
- Not only can use the button for power on , but also can use the digital pin of Arduino to power on and reset the SIM900 module
- Control via AT commands

- Supply voltage range : 3.1 ... 4.8V

Figure 11: GSM-GPRS

2.5 Data-set

The data-set is divided into two parts. The first part is underwater videos that identify normal and abnormal behavior based on fish paths. The second part is fish images containing three types of fish diseases as shown in Fig. 12. The problem we have faced while collecting the data-set was that it was extremely difficult to find a data-set on fish diseases and fish paths. In case of fish images, our data were collected from different internet resources. Our collected data-set include 15 images per disease. However, it is still very few data samples to work on. Therefore, we decided to use Image data augmentation, a technique used to expand the data set. This helps when we have a data set with very small samples. After applying data augmentation, samples are increased to 800 images per disease. 550 images were used as training samples per disease, and the remaining samples were used for testing. The parameters commonly used to increase the image data to increase the data set are: zoom, shear, rotation, reprocessing function etc. For videos representing fish paths to detect normal and abnormal behaviors. the videos that found is 60 minutes or more, then cut them into small videos of 20 to 35 seconds, separated into normal and abnormal videos.

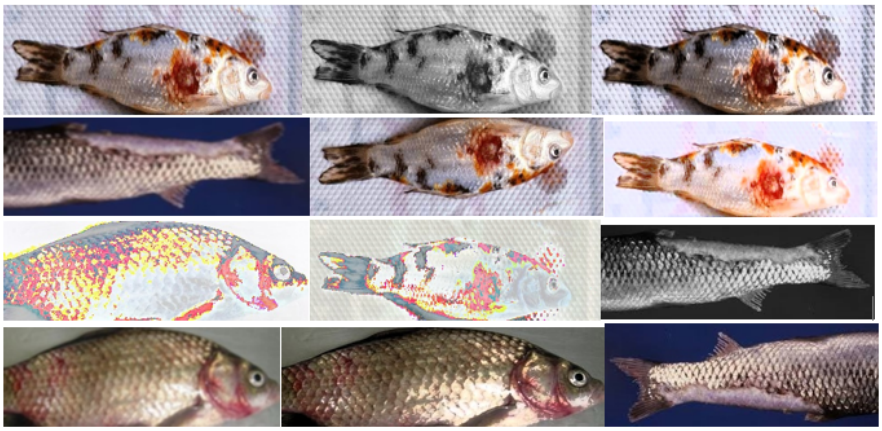


Figure 12: Sample of our data-set by image augmentation

3 Similar Systems

Different approaches [8] [7] [4] [9] [10] applied computer vision techniques to detect and identify fish diseases. Approaches [8][4] were proposed to classify epizootic ulcerative syndrome (EUS) diseased fish. Color segmentation methodology was applied on fish images that have white spot disease and damaged skin [7]. Approach [9] extracted infected regions and send notifications to fish farmers. Notification include diagnosed disease and the suggested treatment method. Approach [10] were proposed to classify fish species.

Another approaches[2] [3] [1] are introduced to analyze fish trajectories in videos. Trajectories are classified to normal and abnormal behaviors. The study of fish behavior is important to analyze the environmental conditions that may cause diseases in the future. Normal fish trajectories are first identified then abnormal ones are detected by applying filtering mechanisms [2][1].

An Approach [8] applied histogram equalization followed by edge detection for segmentation. sobel, canny and perwitt was applied for edge detection and canny's edge achieved the best results. Histogram of gradient (HOG) and feature from accelerated segment test (FAST) have been applied on EUS infected images to extract the features. FAST gave good results compared to others. PCA is applied after FAST as it reduces the features that are useless and save useful one. Neural Network is applied as a classifier as it gets better result than K-NN and better accuracy after train the system.

Approach [4] applied PCA to reduce the dimensionality of the data and remove the useless information. K-Means clustering is applied for segmentation. HSV component is applied to show the diseased area. HSV image is converted to Hue image to indicates the dominant color of fish diseased area. Morphological operations open can also be applied to improved Hue images to get number of pixels of diseased area.

An approach[9] applied noise removal, binarization and edge detection as preprocessing methods. Morphological erosion and dilation operations are applied to delete noise. Then, in order to detect the pathogen parts, it is carried out a labeling process by which small regions are deleted and large ones are separated. Feature Extraction are carried out into two types. The first is based on the polar coordinate and the second set is based on the geometrical feature. PCA is applied for classification.

Approach [10] applied convolutional neural networks (CNN). The classification performed by pre-processing the images using Gaussian Blurring, Morphological Operations, Otsu's Thresholding and Pyramid Mean Shifting, further feeding the enhanced images to a Convolutional Neural Network for classification.

Approach [2] proposed method is filtering mechanism. The mechanism is processing like a cascade classifier. It define rules for normal trajectories. The trajectories which do not satisfy the rule are called the remainders which are the abnormal behaviors. The abnormal could be:
1) Stationary fish for a long time (compared to detection length) inside of coral: this kind of a behavior assumed to be an eating behavior hence differentiated from swimming, ii) Biting at coral (Figure 3c), iii) Fish suddenly (mostly in one frame) diving (Figure 3d), iv) Fish suddenly (mostly in one frame) changing direction, v) Fish turning around in an area like a predator.

An approach [3][1] proposed hierarchical method by applying some features as curvature scale space (CSS), moment descriptors, velocity and Acceleration, Turn, centered Distance Function (CDF), Vicinity Features, Loop Features, Features Based on Normalized Size of Bounding Box. Affinity propagation (AP) is applied for clustering method. AP perform better than K-means, mixture models and mean-shift clustering. Outlier detection method is applied.

3.1 Data-set

Approach [8] collected their database from some sources as NGRF, Lucknow and CIFRI. The experimentations were applied on real images of the EUS diseased fish. Approach [2] tested the proposed method on 271 sample videos from fish4knowledge [2] that include 2486 trajectories.These trajectories are divided into: 46 are abnormal and 2440 are normal. Approach [7] experimentation was tested on various images of infected fish as fish with White Spot and damaged skin infections. Approach [3] applied the method on 3102 trajectories that are divided into: 3043 normal and 59 abnormal from 93 different videos. It is the largest dataset in underwater environment. Approach [1] was tested using 271 sample underwater videos from the Fish4Knowledge. Approach [4] collected images of fish have EUS infection from the different part of the Barak Valley and Assam. Approach [9] applied method on 60 parasites microscopic images that have been collected from National Bureau of Fish Genetic Resources (NBFGR, Lucknow) and ICAR-Central Inland Fisheries Research Institute (CIFRI), Kolkata.

Table 3: Proposed systems comparison

System	Function	Data	Algorithms	Accuracy
[8]	Automatically detects or diagnoses the EUS diseased fish	Images of the EUS infected fish collected from sources as NGRF, Lucknow and CIFRI	Canny's edge detection algorithm–Fast algorithm–PCA–Neural Network	86 %
[9]	Extract pathogen area from the microscopic images of infected fish and sending notification about diagnosed disease and treatment to the fish farmers	Microscopic images of diseased fishes collected from National Bureau of Fish Genetic Resources (NBFGR, Lucknow) and ICAR-Central Inland Fisheries Research Institute (CIFRI), Kolkata	3x3 mean filter and edge sharpening filter–Morphological erosion and dilation operations–Polar and geometric feature–PCA	90 %
[2]	Understanding fish behaviors by extracting normal behavior and then identifying abnormal behaviors	Videos of normal and abnormal behavior from fish4knowledge	Filtering mechanism as cascade classifier	38 percent Normal 13 percent Abnormal
[4]	Detects or diagnoses the EUS diseased fish	Fish effected with (EUS) were collected from the different part of the Barak Valley, Assam	PCA–K-Means Clustering–HSV	90 %
[10]	Classification of fish species	Images from fish4knowledge	1) CNN 2) Gaussian Blurring, Morphological Operations, Otsu's Thresholding and Pyramid Mean Shifting	96.29 percent
Proposed Approach	Detecting fish diseases	Collecting our own data (extract images from videos)	CNN HOG	

4 Proect Management and Deliverables

4.1 Tasks and Time Plan

Task	Date
Proposal Evaluation	1)October 2019.
SRS Evaluation	December 2019
SDD Evaluation	February 2020
Prototype Evaluation	March 2020
Technical Evaluation	May 2020
Final Thesis	June 2020
Ceremony	June 2020

Table 3: Tasks and Time Plan.

4.2 Budget and Resource Costs

Name	Price
Temperature Sensor	50LE.
PH Sensor	660LE
Water proof Ultrasonic	25LE
Raspberry Pi Camera Model V2	600LE

Table 4: Budget and Resource Costs

5 Statistics

As shown in fig 13. World fish production, consumption and exchange are required to increment, yet with a development rate that will slow after some time. Food fish supply will increment in all areas, while per capital fish utilization is relied upon to decrease in Africa, which raises worries as far as food security.

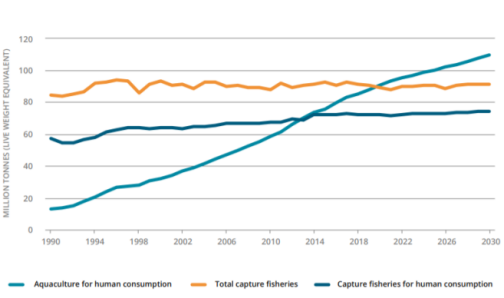


Figure 13: Global capture fisheries and aquaculture production ,1990-2030 [5]

Worldwide all out catch fisheries creation was 90.9 million tons in 2016, a little decrease in comparison with the two earlier years. World all out marine catch was 81.2 million tons in 2015 and 79.3 million tons in 2016 as shown in fig 14.

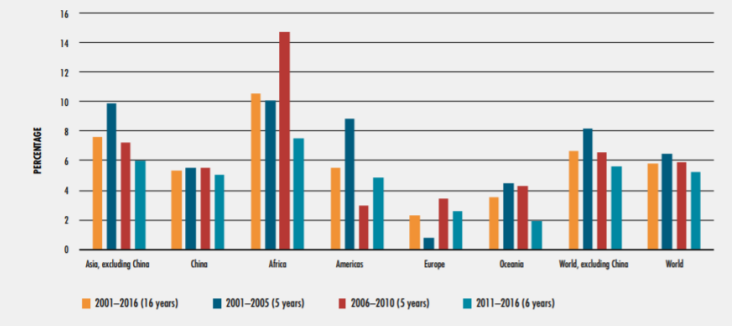


Figure 14: Average annual growth rate of aquaculture production by volume (excluding aquatic plants) [5]

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