Image Processing Approach for Fish Image Analysis – A Review

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***Abstract*— Fish is one of the most socioeconomic concern for food. To avoid the frauds related to fish it is necessary to identify them and Manual classification of fishes into different types is difficult. So the study was done to find the work done so far that can fast and accurately identify and classify the fishes. Image processing technique can be used to develop such system.**

***Keywords*— Fish, Identification, image and image processing.**

I. INTRODUCTION

Vertebrate means the animals with backbone and fish is one among them. A fish is a scaly skinned vertebrate that swims in water and breathes using gills. The skeleton of fish is made up of softer, rubbery substances called cartilage. A haunt flaps its bait to swim on water. Instead of legs, they have fins to help them stay upright and steer. The fins are supported by horny or bony rays and are covered in skin without scales.

To identify the name of a query fish from image is a challenge that can be achieved by analysing some parameters of fish such as fins, gills, scales, tail, color, shape and size. The size and the shape of the fish image can be used as morphological feature for accurately identifying the fish *[8]*. The fins are also one of the parameter through which fish identification can be made and the fins can be categorized as one dorsal and two dorsal. The figure 1 below illustrates the different part of the fish body.

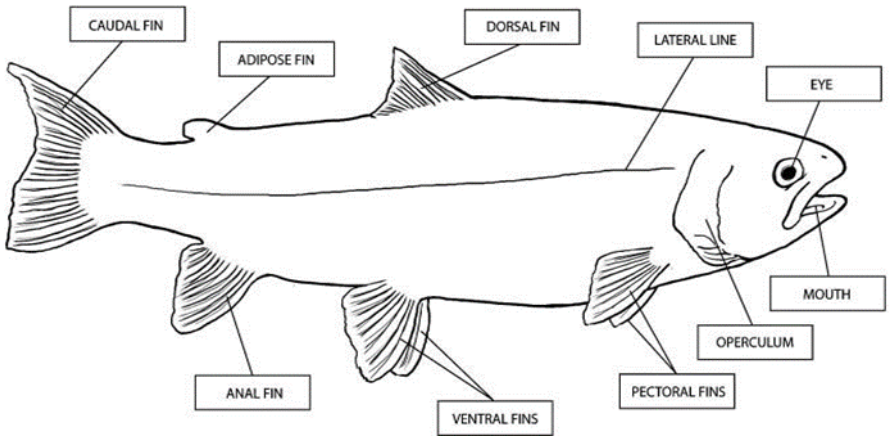


Figure 1: Parameter of Fish

a) Mouth: The mouth helps the fish to ingesting food. The food goes from the mouth into the esophagus before entering the stomach and intestines.

b) Eye: The purpose of the eyes is to provide the fish with vision. For sight, fishes that live in the deep sea or caves have degenerate eyes, or eyes that do not aid them visually.

c) Operculum series: A flap formed of several bones that cover the gills and assists in jaw opening in bony fishes, operculum is the most dorsal.

d) One dorsal fins: The purpose of the fin is to protect fish against rolling and helps them to stop and turn quickly.

e) Two dorsal fins: The determination of the fin is to protect fish against rolling and helps them stop and turn quickly.

f) Caudal fin: The tail part of fin is known as caudal fin and is used for propulsion.

g) Caudal peduncle: It is the narrow part of the fish body where the tail attaches.

h) Anal fins: The task of this fin is to help the fish to stabilize itself during swimming.

i) Lateral line: This line is an organ in fishes that is capable of sensing and detects vibrations in the water.

j) Pectoral fin: It use of this fin is depended on the fish, they can used it for swimming, maneuvering, creating a lifting force, walking, lifting or gliding out of the water.

k) Pelvic fin: This fin helps to move up and down, turn sharply, and stop quickly.

1.1. Taxonomy of Fishes:

The taxonomy of the fishes divides them into three group such as jawless, bony and cartilaginous. The following figure 2 details the basic taxonomy of fishes:

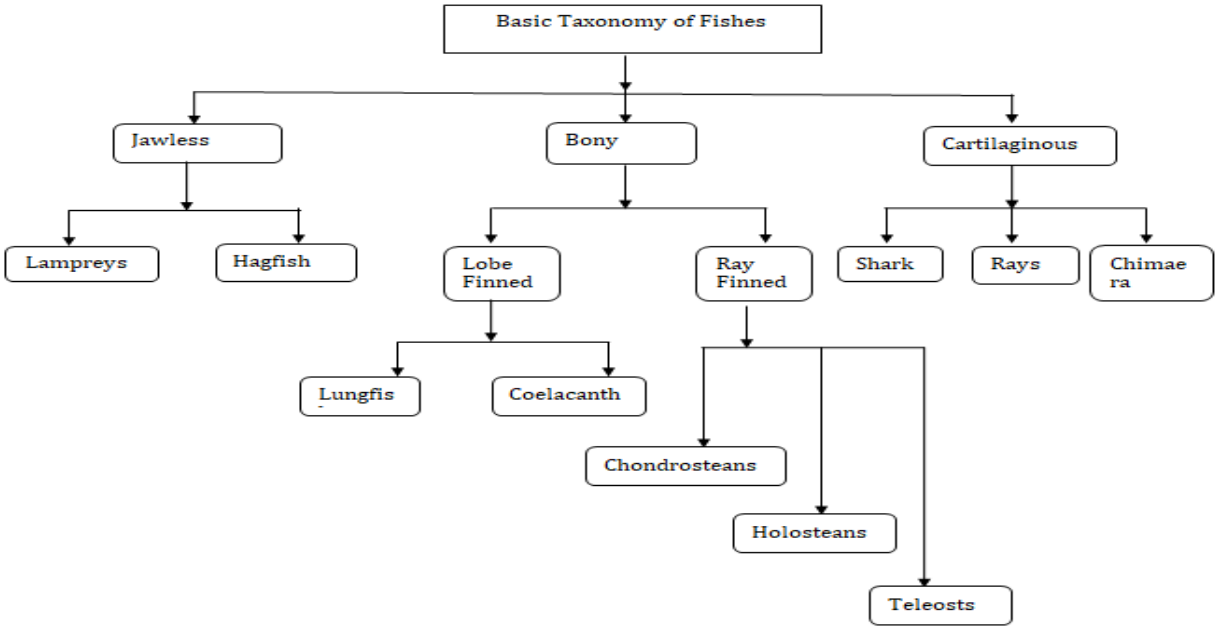


Figure 2: Basic Classification of Fish

A. Jawless:

The Jawless fishes are the fishes without jaws which include cyclostomes and extinct related forms. There are more than 100 species of jawless fish, which can be distributed into two groups such as:

i. The Lampreys
ii. The Hagfish

Along with their lack of jaws, the jawless fish are notably different than other fish because they do not have paired fins. Instead of jaws that close for biting, these eel-like fish have a simple round mouth. The Hagfish use their tongues to rasp at food with a pair of "brushes" covered in hornlike teeth *[21].*

B. Bony:

The Bony fishes demonstrate good variety in body shape, but the "typical" fish body shape is roughly tapering and cylindrical at both ends. This characteristic fusiform shape is quite energy efficient for swimming. As compared to other body shapes, this body shape creates less drag *[22].*

C. Cartilaginous:

The Cartilaginous in addition have gills to their skeletons that open to the ocean through slits, rather than the bony covering that is present in bony fish. These fish may also breathe through spiracles, rather than gills. Spiracles are found on top of the heads of all rays and skates, and some sharks. These openings allow the fish to rest on the ocean bottom and draw oxygenated water in through the top of their head, allowing them to breathe without breathing in sand. A cartilaginous fish's skin is covered in placoid scales, or dermal denticles, tooth-like scales different from the flat scales (called ganoid, ctenoid or cycloid) found on bony fish *[23].*

II. Literature Review

The most important socioeconomic concern is food forgery which has contributed in increasing the awareness of the people on what they should eat. This awareness has led to identify the species of fishes. There is a high risk of commercial frauds if one is not aware of the species. To protect from this commercial frauds, there is a need to identify the fish. This can be achieved by recognizing the fish image through image processing technique. This image processing technique can generally be divided in three steps as:

Step 1: Import an image. (With an optical scanner or directly through digital photography).

Step 2: Manipulate or analyse the image. (This stage can include image enhancement and data compression, or the image may be analysed to find patterns that aren't visible by the human eye. For example, meteorologists use image processing to analyse satellite photographs).

Step 3: Output the result. (The result might be the image altered in some way or it might be a report based on analysis of the image).

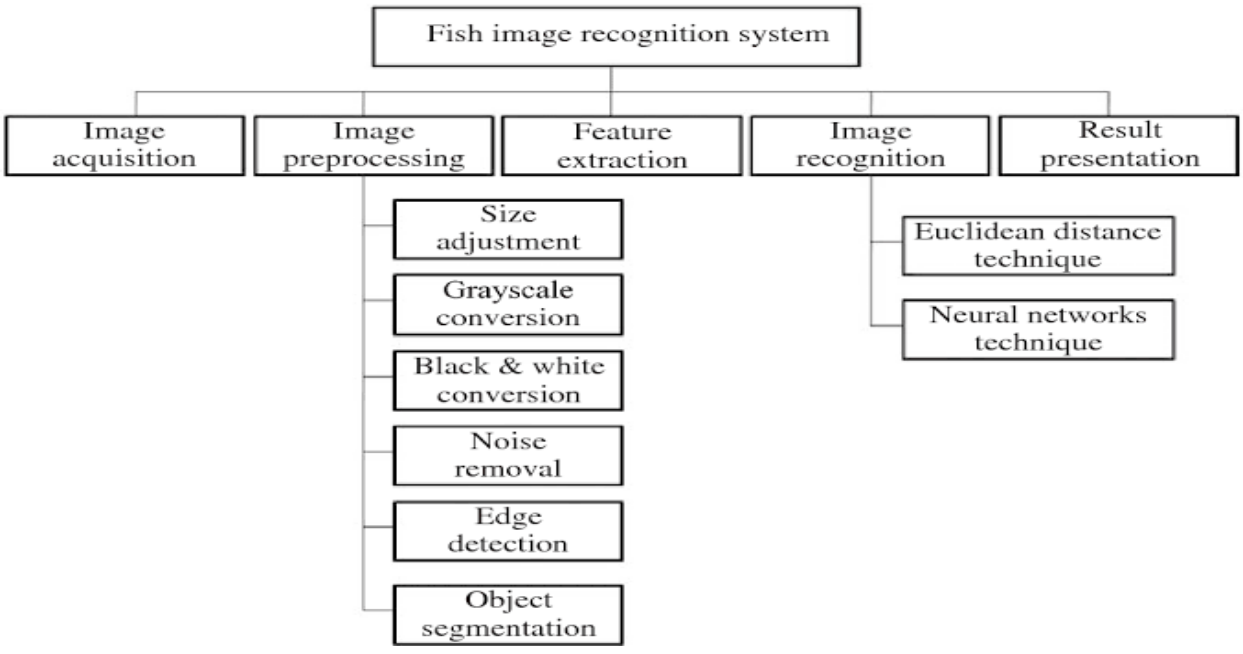


Figure 3: object recognition process with block diagram [1].

The figure 3 illustrates the direction through which image can be recognition using image processing.

a. Image acquisition:

A step for collecting data or acquiring the images is known as image acquisition. Various equipment's are available through which data acquisition can be done. The acquisition of data can be made with an optical scanner or directly through digital photography.

b. Image Pre-processing:

After the acquisition of data pre-processing is an important step. Pre-processing using to reduce the size or to convert an image into a grey scale image, noise removing and edge detection etc. Following operations can be performed in pre-processing *[1].*

i. Size Adjustment: This sub module help to resize the image size.

ii. Grayscale conversion: System convert color image into the grayscale with the range of 0-255 to see the detailed edges of image.

iii. Black and White Conversion: System convert image in black and white after grayscale.

iv. Noise Removal: The unwanted data in an image is nothing but noise and this process helps to remove the noise from an image such as spot, dust, and water droplets.

v. Edge Detection: The edge detection techniques helps to find the objects boundary in an image. It works by detecting the discontinuities form the image. Edge detection is used for the extraction of data and image segmentation.

vi. Object Segmentation: System segment the object from the black and white image to produce two objects: a fish body and another is the reference object. The smaller object are assumed to be as reference object.

c. Feature Extraction:

The feature extraction technique helps to extract the features from an image such as width, length, area, and boundary.

d. Image Recognition:

Image recognition, in the context of machine vision, is the ability of software to identify objects, places, people, writing and actions in images. Computers can use machine vision technologies in combination with a camera and artificial intelligence software to achieve image recognition.

e. Result Presentation:

It is a step that shows the result of the study. The results can be presented using Graphic User Interface (GUI) on a system *[2]*.

2.1. Fish Feature:

There are various categories of fish's and all of them differ from each other in some way. The fish can be analysing or categorized on the bases of the some parameters body shape, mouth, fins

A. Body Shape

Various species of fishes deviate from the fusiform body shape in three ways as: Compression, Depression, and Elongation.

i. A laterally compressed (flattened, side-to-side):

Body shape is common in bony fishes that live in dense cover or within coral reefs. For e.g. Butterfly fishes (family Chaetodontidae) with a laterally compressed.

Figure 4: Bony Fish

Figure 5: Butterfly Fish

ii. A depressed (flattened, top-to-bottom):

The shape of body is common in bottom-dwelling fishes. Goosefishes (family Lophidae) and batfishes (family Ogcocephalidae) depressed body shape.

Figure 6: Goosefishes

Figure 7: Bat Fishes

iii. The body shape of an eel (for example, the morays, family Muraenidae):

The Morays Eel is an extreme example of an elongated shape.

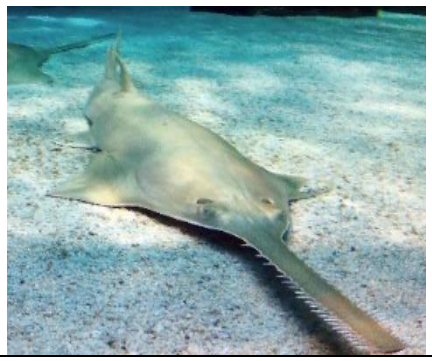
Figure 8: Morays Eel

B. Mouth/ Mouth Opening:

The mouth of the fish is at the front, or at the anterior end. The mouth discloses a lot of information about the fish's and its feeding habits. The table 1 below describes more about the mouth and the type of the fish *[19].*

Table 1: Fish Mouth

Sr. No	Fish Name	Fish Image	Type	Description
1)	Jawless Lamprey Fish		Circular mouth	The sea lamprey has an eel-like body without paired fins. Its mouth is jawless, round and sucker-like, and as wide as or wider than the head; sharp teeth are arranged in many consecutive circular rows.

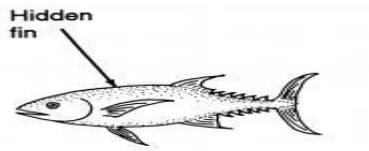
2)	David shale fish		Superior Mouth	The superior mouth is oriented upwards, and the lower jaw is longer than the upper jaw.
3)	White Crocker		Terminal Mouth	Terminal mouths are located in the middle of the head and point forward. Both jaws are the same length. Most barbs, cichlids, gouramis, and tetras have terminal mouths.
4)	Cat Fish		Inferior Mouth	Also called a sub-terminal or ventral mouth, the inferior mouth is turned downward. The lower jaw is shorter than the upper jaw, and the jaw will often be protrusible. Fish with inferior mouths are bottom feeders and often possess barbells that assist in locating food particles.
5)	Ruby Fish		Protrusible Mouth	A protrusible mouth allows a fish to extend its reach when attempting to snatch prey or food particles. This feature can be seen in all mouth types.
6)	White Sucker	 	Sucker Mouth	Sucker mouths are a common feature in fish with inferior mouths. Catfish, such as the popular pleco, use a sucker mouth to rasp algae off driftwood or rocks. Some species use a sucker moth to help those combat currents.
7)	Saw Fish		Elongated Mouth	A greatly elongated snout is another kind of mouth adaptation. This type of mouth allows the fish to poke into small crevices and holes to find food. Freshwater species with elongated mouths include the halfbeaks, gars, and pencilfish. Saltwater species include the needlefish and the wrasse family.
8)	Puffer Fish		Beak	The mouth consists of two very hard pieces that are

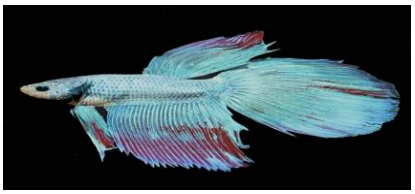
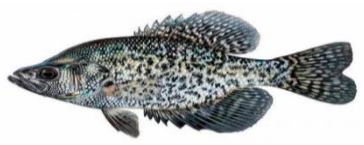
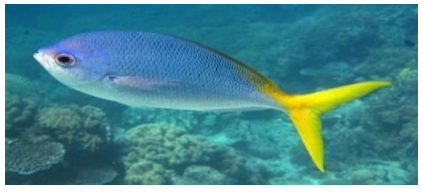
			Mouth	hinged and come together in a scissor-like fashion. This allows them to crush hard shells of invertebrates. Pufferfish, both freshwater and saltwater varieties, possess a beak type mouth. Saltwater parrotfish, octopus, and squid also possess a beak.

C. Fins

The Fins of fishes are located at different places on the body of fish and serve with different purposes as moving forward, turning, keeping an upright position or stopping. Most fish use fins when swimming, flying fish use pectoral fins for gliding, and frogfish use them for crawling. The table 3 below describes the different structure of fish fins and their use.

Table 2: Fish Fins

Sr. No	Fish Type	Fish Image	Finns	Description
1	Blue Gill (Reader Sunfish,)		Spiny and soft-rayed dorsal fin.	Flared to make the fish look bigger
2	Fish Diagram		Tucked dorsal fin	Reduces drag in fast swimming fish
Caudal (tail) Fins (the speed it swims)				
3	Bullheads Drop Off		Squared Finn(moderate)	
4	Cat Fish		Forked (very fast)	
5	Parrot fish		Truncated (sprints)	
6	Tiger Shark		Pointed (fast)	

			
Dorsal Fins on back (for steering and preventing rolling)			
7	Zebra Danio		Tiny fins
8	Bat Fish		One long fin
9	Tropical Fish		Large fins
10	Red-Finn Fish		Small fins
Pectoral Fins on sides (for balance, turning and braking)			
11	Scalloped Hammerhead Shark		Pointy fins (sharp turns and fast stops)
12	Squaretail Bristletooth Tang		Short and square fins (maneuvers quickly)
13	Black Crappie		Irregular fins (balances, hops or sits on fins)
14	Yellow Tail Fusilier		Triangular fins (stabilizer)

Many researchers have worked on the identification of the fish form images. The below table 3 details the work done by the researchers on different type of fishes along with the techniques they have adopted to obtain the results.

Table 3: Methods, Techniques and Dataset used for fish identification

Sr. No	Targeted Fish(Experiment conducted)	Fish Type	Methods/Techniques	Dataset	Result	Ref.
1	30 fish spices,900 fish image,600 for training and 300 for testing	Marine(Thai fish spices [2700])	EDM,ANN	Collected from Thailand in Southeast Asia(Andaman Sea)recorded during 1991-1998	81.67	1
2	18 fish spices	Indigenous fish species	K-NN,SVD	EBUTE River in Epe local govt area of lagos state, Nigeria (cannon power A14000HD digital camera used.)	94%	2
3	76 for training,74 for testing	Different type of fishes	K-NN,K-mean cluster, NN,SVM	Fishery Departments of the Federal University of Technology, Akure (FUTA), Ngeria and Adekunle Ajasin University, Akungba-Akoko(AAUA).	78.59%	3
4	369 fishes of various size of 30 species.	Used large medium and small fishes from 30 species	Used the fish image segmentation algorithm designed for head, abdomen and tail	Yuan Ge, the author of 'QUT Fish data 'collected 3960 image of 468 species	87.5%	4
5	Used 10 fish sample	Sharks	Haar wavelet transformation, edge detection(gradient and laplacian)	---	---	5
6	100 fish image used to trained NN and 75 used for test. Database contains 1513 of fish image. Acquired on 22th August,2008.is used	7 diff. Fish Families	ANN, NN, Back Propagation	Global information system on Fishes (Fish-base) and department of fisheries Malaysia ministry of agricultural and Agro-based industry in putrajaya.	97.4%	6
7	1000 fish image used	Fish having one or two dorsal fins	Multistage classification, Nearest Neighbour algorithm	---	99%	8
8	Total 350 fish image divides into 2 datasets 257 training images and 93 testing images	20 diff fish families	ANN,NN,	Global information system on Fishes (Fish-base) and department of fisheries Malaysia ministry of agricultural and Agro-based industry in putrajaya.	75% min,97 %max	9
9	Totally 27,370 verified fish images of 23 clusters	Under Water Fishes	SVM Classifier, CNN Classifier	Ground-Truth dataset made by the Fish4Knowledge(F4K)Project Capture from the open sea.	98.75%	10
10	Total 10 sharks used	Sharks	Edge detection	Online		11

			used (sobel, Roberts etc.)		---	
11	Total 740 species and 11,198 individuals of fish, plants and butterflies.	Used fish, plants and butterflies	Geometrical, texture, Morphological, Neural Network	Natural history records Online Fish specimen image taken from Canon EOS 6dD with 1280*960 pixel	Fish91.65%,plants 92.87%, 93.25%	12
12	Used 20 fish families, 400 for training, 210 testing image.	610 fishes	Back propagation classifier, edge detection method and some algorithm like Genetic Algo and Great Delux Algo	Global information system on Fishes (Fish-base) and department of fisheries Malaysia ministry of agricultural and Agro-based industry in putrajaya.(aquaria on 22th august 2008)	96%	13
13	320 images used. For each fish they used 14 images acquired from the live streaming and 18 images obtained by affine transformation.	Under water Fishes	1)Fish Affine Transformation 2)Texture Features 3)Boundary Features	Acquired from an ecological source in Taiwan and made accessible to marine biologists via the Ecogrid project coordinate by the national center for high performing computing(NCHC) Taiwan	Fish detection and tracking accuracy 85%	15
14	500 for training and 110 for testing	20 different fish families	ANN, NN, Back Propagation	Global information system on Fishes (Fish-base) and department of fisheries Malaysia ministry of agricultural and Agro-based industry in putrajaya, Malaysia acquired on 22th august 2008.	84%	16

III. METHODS / TECHNIQUES:

From the table1 it can be absorbed that many other countries have used image processing technique for the identification of fishes but in India only a small number of researchers have used the technique. So, it is also found that for the classification of fish image various methods and techniques wear used as shown in table 1 but among these methods and techniques mostly widely used are listed below:

A. Euclidean Distance (ED) Method:

An image can be interpreted as a graph. The ED is the straight-line distance between two pixels. Every pixel is a vertex and the edges. A variable image is that which keep the input as binary image. A binary image is an image with contains only zeros and ones. The ones are the border white pixels whereas the zeros are regular black pixels. A variable distance is that which keeps the current cost assigned at each pixel. The Euclidean distance is used in image processing to calculate the mathematic value *[1].*

B. Artificial Neural Network (ANN) Classification:

An ANN is based on a collection of connected nodes called artificial neurons which loosely model the neurons in a brain. Each connection are like a junction in a brain that can transmit a signal from one artificial neuron to another. An artificial neuron that receives a symbol can process it and the artificial neurons are connected to each other through signal. In common ANN implementations the symbol at a connection between artificial neurons are a real number, and the output of each artificial neuron is computed by some non-linear function of the sum of its inputs. The connections between neurons are called edges. Artificial neurons and edges have a weight that adjusts as learning proceeds. The strength of the signal at a connection (weight increases or decreases). Artificial neurons have a threshold that the

signal is only sent if the aggregate signal crosses that threshold. To solve complex problems it gives the method to characterize the synthetic neurons *[1, 6, and 3].* The ANN is mostly useful:

- To know the impact of variation (increasing or decreasing) of our dataset.
- To understand the cases in which the model correctly fits.
- To show how particular model shows good results that other.

C. Principle Component Analysis:

Principal Components Analysis (PCA) is a mathematical formulation used in the reduction of data dimensions. Thus, the PCA technique allows the identification of standards in data and their expression in such a way that their similarities and differences are emphasized. Patterns are found, they can be compressed, and their dimensions can be reduced without losing of information *[1, 2].*

D. Neural Network Technique:

Neural Networks (NNs) is used for compressing image for good performance. The image compression convergence time is not efficient, due to the fact that the NN is used in image decompression and compression stages in almost all NN methods. The image is decomposed into eight matrices and each of which corresponds to the values in a bit position. The matrices are saved in reduced form to constitute the compressed image. The NNs are constructed to predict the removed values from the reduced matrices to produce the image in the origin size. This method produces an acceptable and comparable image quality *[6, 12].*

E. Feed Forward Neural Network:

A Feed Forward Neural Network (FFNN) also known as multilayer perceptron. The FFNN are mostly used for supervised machine learning tasks. While working with such a technique the targeted function is already known that is the result that our network should achieve is known *[4].*

F. K-Nearest Neighbour:

The k-nearest neighbour's algorithm (k-NN) is a non- parametric method and one among the supervised learning that is used for classification. This technique is used to check the similarity of the data from other data. In this technique the case is deal by having the majority votes by the neighbours. The assessment is made by using the distance function among the k nearest neighbours. For example: If k = 1, then the object is simply assigned to the class of that single nearest neighbour. In k-NN regression, the output is the property value for the object. This value is the average of the values of its k the nearest neighbours *[2, 3].*

G. K-Mean Clustering:

K-means clustering algorithm uses K as a parameter and n objects are distributed into K clusters. The intra-cluster have high similarity and the inter-cluster have low similarity. K-means clustering algorithm attempts to find the minimum square error function value for K divisions. Once the intra-cluster is intensive, and the inter-cluster is obviously different, the result are good. However, the K - means algorithm is not suitable for the clusters of non-globular, different sizes and densities, and it is sensitive to noise or outliers *[3].*

H. Support Vector Machine:

The Support Vector Machine (SVM) classification algorithm has been used for classifying the imagery. SVM is one among the supervised learning classifiers. It is used for classification and regression. This algorithm is good for face recognition in photos, handwriting and object recognition before it was used for other data. It is a non-parametric method classifier that distinguishes and splits the classes by determining the boundaries in feature space and maximizes the distance between the classes. The surface is named as the optimal hyper plane, and the data points are closest to the hyper plane are termed as the support vectors *[2].*

I. Edge detection technique:

The Edge detection techniques is an image processing technique used for finding the border or edge of objects within an images. Edge detection is used for data extraction and image segmentation in the areas such as computer vision, machine vision, and image processing *[11].* There are various edge detection techniques and some of them are as below.

a. Gradient:

The gradient method detects the boundaries by looking for the maximum and minimum values in the first derivation of the image. The gradient can be performed with the following methods.

i. Roberts

Roberts approximate the gradient of an image through discrete differentiation which is achieved by computing the sum of the squares of the differences between diagonally adjacent of pixels.

ii. Prewitt

At each point in the object the result of the Prewitt operator is either the corresponding gradient vector or the norm of this vector. The Prewitt operator is based on convolving the object with a separable, integer, and small valued filter in vertical and horizontal directions.

iii. Sobel

Sobel is a discrete differentiation operator. At each point in the object, the result of the Sobel operator is either the norm of this vector or the corresponding gradient vector. The Sobel operator is based on convolving the object with a separable, integer-valued, and small filter in the vertical and horizontal directions and is therefore relatively cheap in terms of computations.

b. Laplacian Transformation

The laplacian method searches for zero crossings in the second derivation of the image to find edges. The Laplacian transformation can be performed by Marrs-Hildreth *[5].*

i. Marrs – Hildreth

The Marr–Hildreth edge detection method is a simple and is operated by convolving the image with the Laplacian of the Gaussian function, as a fast nearby difference of Gaussians. The zero crossings are distinguished in the filtered result to obtain the boundaries of the image. The Laplacian-of-Gaussian image operator is also referred to as the Mexican hat wavelet due to its visual shape when turned upside-down.

J. Feature Extraction:

Features are defined in terms of local neighborhood operations applied to an image. The action is commonly referred as feature extraction *[9].* Image feature can be categorized into two types as below:

- Natural: Features are defined by the visual appearance of an image.
- Artificial: Features are obtained from some amplitude histogram and filters *[13].*

IV. CHALLENGES

To recognition of digital image there are some unsolved problems that are distortion, noise, segmentation error, overlap and occlusion *[6-7, 13-14, 16]* of image in color. Some problems that are found in the fish images are:

1. Arbitrary fish size and orientation: The size of fish in some cases are totally unpredictable.
2. Feature Variability: Some time a large difference is found in the fish features of different families.
3. Environmental changes: These changes can be outdoor or indoor.
4. Poor image quality: At the time of image acquisition some noise is present from various sources.
5. Segmentation failure: Due to its inherent difficulty, segmentation may become unreliable or fail completely.

V. BENEFITS

There are many benefits of using image processing for the identification of fishes. Image processing techniques can be used for various purposes but while working with the fish images following purposes can be achieved *[1, 12].*

1. More sharpness and better visual appearance can be provided.
2. Image sizes can be increased or decreased.
3. Images can be compressed and decompressed for faster image transfer over the network.
4. Images can be automatically sorted depending on the contents they have.
5. Unrecognizable features can be made prominent.
6. Images can be smoothened.

VI. CONCLUSION

The present study represents the work done for the identification of fishes. Most widely image processing techniques were used to perform the task. The ANN, KNN, K means clustering and SVM are the techniques that were widely used for the classification. As compared to other classification techniques ANN provides better and fast results.

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