Fish Species Classification, Disease Prediction and Predictive Health Analytics

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Abstract*— One of the leading income sources around the world in the Fishing Industry. However, as the change in climatic condition, water quality, oil leakages through the ships leads to spread disease in marine life. Some of the fish are currently endangered species and some are dangerous to humans. Sometimes it is difficult to recognize fish species who don't have knowledge about it. Fish infections are seen as a severe concern among fish eaters and fishermen, and they have a tendency to spread swiftly through the water. Fish illnesses were once detected manually by expert fish growers using just their eyes. Despite the fact that it takes time since some lab work is necessary to identify the relevant bacteria that cause the illnesses, this traditional technique frequently produces erroneous and misleading results. Also the health records not useful in any context. Given the nature of the problem, the need for a quick and low-cost solution is critical and desirable. The performance of Convolutional Neural Networks (CNNs) has recently been shown in a number of computer vision and machine learning challenges. As a result, a research employing CNN to recognize fish species and forecast disease is proposed. The predictive health analytics is incorporated into the proposed system using Decision tree, by examining past health records it is easy to some extent to give early treatment to fish. The custom EHR database created for various fish diseases. The proposed system uses CNN and Hybrid CNN model trained on two datasets: fish species dataset and Diseases fish dataset. The CNN model for Fish Detection gives 98% accuracy and The Hybrid CNN model using ResNet50 as a base model for Disease prediction gives 93% accuracy. CUDA platform used while training the model.

***Keywords*— EHR, Fish Species Detection, Disease Prediction, Convolutional Neural Network, CUDA, fish predictive health analytics.**

I. Introduction

In today's world, everyone has seen that climate change is unpredictably occurring. Which has an impact on marine life, such as the extinction of fish species and the spread of fish illnesses. Global warming also has an impact on fish species. Scientists have discovered 25,000 fish species that can be identified, with another 15,000 species that may be recognized in the future. Fish demand continuously rising as the world's population rising day by day and advantages of fish as an animal protein food-source become more generally recognized.

In recent years, both developed and developing countries have seen a major increase in fish consumption. The aquaculture business is gaining traction as a more sustainable manner of assuring a stable fish supply in response to increased worldwide demand. As a result, ensuring the aquaculture industry's economic and ecological viability is crucial.

One of the issues facing the fishing sector is that fishes are susceptible to infections in varied conditions, which limits their capacity to sustain production. In any case, because fish, like other live animals, contain viruses and parasites, they are susceptible to a variety of diseases. The spread of fish illnesses is aided by changes in water temperature from season to season, as well as polluted water. Fishermen consider the fish sickness to be a serious problem since it spreads quickly through water. Image processing, which is based on images, can be a useful tool for automating the procedures of evaluating and identifying fish infections. DL has been discovered to be capable of extracting features automatically without sacrificing output accuracy. DL is also predicted to aid in the identification of fish diseases.

In most industries, data grows at an exponential rate. The massive data volume [1] that overburdens a healthcare institution on a daily basis is referred to as healthcare big scale data. Existing logical approaches may be used to the massive amount of patient-related well-being and clinical data, allowing for a deeper understanding and better healthcare [2].

A. Health-Care Analytics:

Data analytics is beneficial to healthcare practitioners, particularly in terms of forecasting, diagnosing, and treating illnesses, as well as enhancing service quality and lowering healthcare expenses [3]. Data mining is predicted to save the US healthcare system more than $450 billion each year [4]. Many comprehensive studies have been conducted on the use of big data in mental health and other fields, such as the methodological problems of data mining viewpoints [5]. This vast number of data is created by fast-growing companies, drawing the attention of doctors and scientists [6], necessitating the use of modern data analytics. These strategies might help healthcare workers save time, effort, and money by minimizing effort, resources, and time spent on administrative tasks. Professionals may be satisfied by these strategies since they provide them with more useful knowledge and information [7].

B. Predictive Health Analytics:

Data analytics is the science of analyzing raw data in order to derive conclusions about it. Machin learning procedures and algorithms that deal with raw data and are meant for human consumption have automated many data analytics approaches and processes [1,6,8,9].

When information can be turned into action, prediction becomes more valuable. To improve the efficiency of the system, prediction and intervention must be linked into the same system. This is a method of predicting the future based on previous data [8]. Research helps to enhance healthcare by making better judgments and tailoring care to the needs of each individual. Predictive analysis is used by healthcare companies based on fresh data streams directly from patients [9].

Predictive analytics is the process of extracting information from raw data to forecast future patterns [10]. In the medical area, data mining and prediction are becoming more common. Support systems based on various prediction frameworks have emerged as important instruments in illness diagnosis, ensuring disease prevention and the accuracy of disease prediction [11]. The extraction of hidden information and predicting of the course of a disease's development from medical data is known as illness prediction. Many studies have been performed to construct machine learning-based frameworks for illness prediction [11]. Predictive health analytics is the act of gathering this data in the health sector and processing it so that it may be used to make future predictions. Predictive analytics has been used in a variety of fields, including health [10]. Predictive Analytics uses known factors to create a model that can forecast outcomes for a new batch of data. The result of modelling is a prediction that represents the likelihood of the variable being forecasted based on estimations from input variables. Predictive analytics were employed by more than 50% of healthcare executives, and 42% of them thought they were valuable to their firms [12].

II. LITERATURE REVIEW

Various papers were studied to know about research done in the area. Some of the important surveys and techniques are explained below.

In [13], According to the authors, cascading convolution from the first to the last block delivers high-level, low-level and middle and from the first till the last block. CNN is intended to generates high-level features due to cascading convolution. In the last block, CNN has yet to implement low-level functions. As a consequence, the authors created MLR (Multi-Level Residual), unique residual network approach that uses Depthwise Separable Convolution to blend low-level data from the first block, also high-level features from the final block. On the Fish4-Knowledge and Fish-gres datasets, the proposed model MLR-VGGNet beat base VGGNet by up to 10.33 percent and other models by up to 5.24 percent, with an accuracy of 99.69 percent.

In [14], The authors brought up a point of concern. Due to significant background interference and unclear fish traits, typical computer vision algorithms perform poorly in underwater circumstances. The authors introduced a strategy based on cross-convolutional layer pooling on pre-trained CNN Network to decrease quantity of training data required (CNN). A validation accuracy of 98.03 percent was established after a thorough investigation of a dataset of 27,370 fish photos. The suggested approach will be a feasible substitute for marine experts' time-consuming and difficult manual recognition method, making it ideal for monitoring fish biodiversity in natural settings.

In [15] authors proposed method for recognizing fish from photographs is presented in this study. The approach described here combines the gist and GLCM features. Concatenating two characteristics results in a combination. The XgBoost classifier is used to classify the data. Despite the fact that fish photographs come in a variety of textures, shapes and colors the suggested technique performs well on used datasets. This research reveals that the gist and GLCM features play a lead influence in picture recognition. When compared to other classifiers, the XgBoost classifier performs better (KNN, random forest, SVM). This study might be beneficial to the fishing industry. Different feature extraction methods will be tested in the future to see what works best.

In [16] authors study examines several algorithms in order to recommend the best model for overcoming the drawbacks of existing approaches. The gray scale mapping was then submitted to the identical statistical analysis procedure using the horizontal and vertical gradient sobel operators. They have proposed a novel alternative solution to the aforementioned issue that is extremely accurate, taking into account all of the RGB elements and the picture's Stochastic Gradient in both the vertical and horizontal directions. Because it is size agnostic, unlike many image processing models that need a uniform size, the proposed model is flexible enough to account for all photographs of varying sizes. Currently, the authors have suggested study for up to nine fish species, but we will be able to categorize additional species in the future.

In [17], According to the authors, conventional methods such as underwater human monitoring or casting nets are commonly used to determine the existence and quantity of certain fish species. Support vector machines (SVMs) and extraction of feature methods based on the SIFT and SURF algorithms are used to automatically identify the Nile Tilapia fish in this article. The proposed technique then sorts the fish images into different fish species using a number of SVM classifiers. According to the findings, the SVM method outperformed some machine learning approaches such as ANN and k-NN algorithms for overall accuracy in classification.

In [18], According to the researchers, this effort is the first step in creating a system that will be able to parametrize fish schools in underwater images. A Deep CNN called Optical Fish Detection Network (OFDNet) is used to do this. Using visual input from underwater cameras, this system performs fish recognition, localization, and species categorization. cutting-edge object recognition deep learning frameworks is the base. The goal of this investigation was to find herring and mackerel in the North and Baltic Seas, which are both in bad shape. In a dataset taken at sea, OFDNet was demonstrated to accurately recognize 66.7 percent of the fish and categories 89.7 percent of them.

This research [19] is the largest ever study of automated every fish identification utilizing fish skin patterns parameter. Remote individual identification technology, can be utilized in marine cages or tanks without requiring the fish to be handled, might open up new avenues for fish development and health monitoring. With the HOG-based long-term identification approach failed to achieve 100% accuracy, a new dot localization method was created, which has shown to be more accurate for most identification tasks. As a consequence, the technique has a fair likelihood of working in real-world circumstances where fish change in lighting conditions, there movement and fish overlaps diminish the quality of the fish photographs. For 30 fish over a 6-month period and nearly 328 fish for short-term identification, the new approach and tagging had same accuracy.

Some of the foundational results from [20], Predictive analytics, a type of data analytics that uses personal information and patient disease symptoms for disease prediction, is primarily responsible for disease prediction.

The authors [21] conduct a survey of the literature on machine models and, based on their findings, propose an intelligent framework for diabetes prediction. The authors critically explore machine learning models and develop and assess intelligent machine learning based architecture for diabetes prediction and treatment.

The paper [22] briefly discusses domain and core knowledge about chronic diseases, the biological correlations between these diseases, and, most crucially, the application of ML algorithms based predictive analytics for the early detection of chronic diseases in healthcare.

An enhanced hybrid model with classifier and feature selection is investigated in paper [23]. The feature selection method is used on heart disease dataset to choose more appropriate characteristics, with the results being fed into the classifier for disease prediction in heart early on. The feature selection strategy improves the classifier's accuracy, according to the findings of the experiments.

III. PROPOSED METHODOLOGY

A. System Architecture

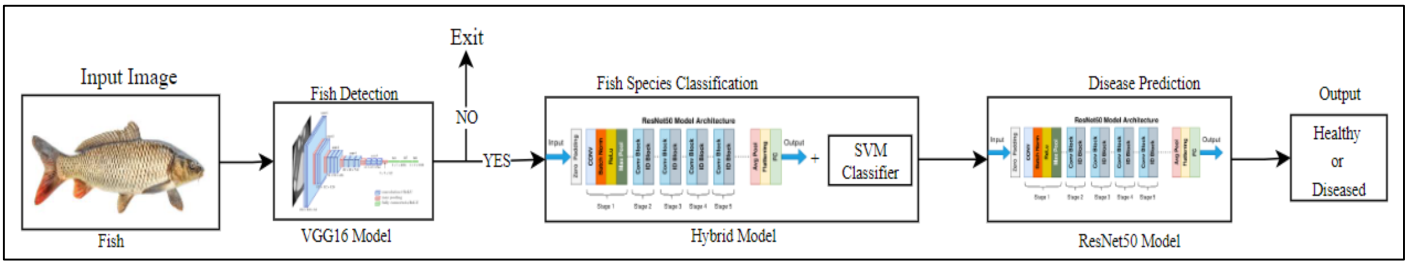

Figure 1. Fish Detection, Classification and Disease Prediction

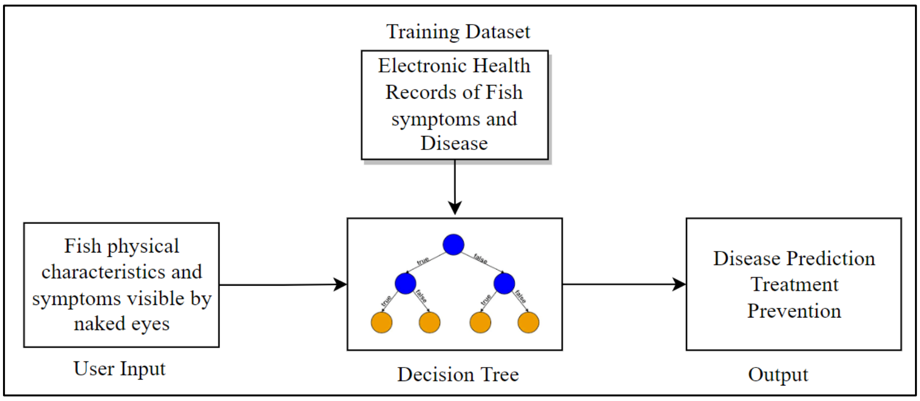

Figure 2. Fish Predictive Health Analytics

In figure 1. explains the entire flow of the detection, classification and disease prediction system. The input image given to the system, In the first part the input image passed through the fish detection model developed using VGG16 model, If the fish is present or detected in the image then it is fed to species detection model developed using ResNet50 and SVM classifier which is nothing but hybrid model. Accordingly, the fish is classified into a respected category. Then the image is passed to the disease detection and prediction model developed using the ResNet50 model. Finally, the predicted disease will be the output of system.

In figure 2. The new approach for Fish predictive health analytics approach is predicted. There are multiple tools for human disease prediction but there is not enough tools do the predictive analysis in fish based on their electronic health records. User have to input the symptoms and abnormal activities of fish manually in the system. The Decision Tree is trained for Predicting possible diseases and finally the Disease, Treatment and Prevention provided as output.

B. Data Preprocessing

Initially VGG16 model is applied on input images to detect fish in the image. There are two main factors considered in preprocessing of images such as increasing contrast and brightness. The Data Augmentation with rotation range of 10 degrees, width shift range and height shift range as 0.1 are used for training the dataset. The zoom factor is 0.1 and rescale as 1/255 are used for training data. The input image preprocessing enhances the accuracy of detection of fish more accurately in low light conditions and blur images also.

C. Dataset

There are four different dataset used in training. For the task of Fish detection part, the dataset available on kaggle is used named as fish dataset sample images shown in fig 3. For the task of fish species classification custom dataset of five fish images is created and image augmentation is applied as there is no any standard dataset is available sample image shown in fig 4. For the task of Fish disease prediction custom dataset is created which includes red spot, white spot, cancer and EHU disease categories and on that dataset image augmentation is applied sample images shown in fig 5. For the task of Predictive health analytics custom dataset is created like the Electronic Health record of Fish. Contains Various Fish Disease and early Symptoms in the fish sample image of dataset is shown in fig 6.

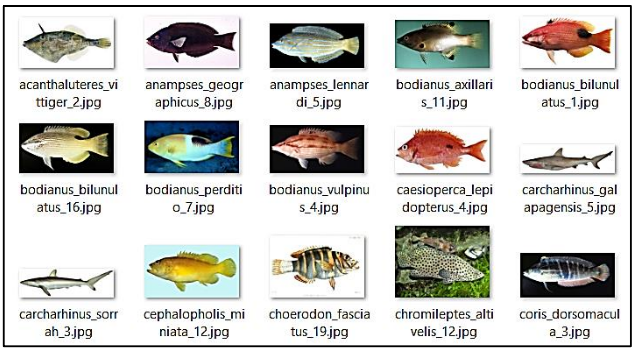

Figure 3. Sample images Fish Dataset

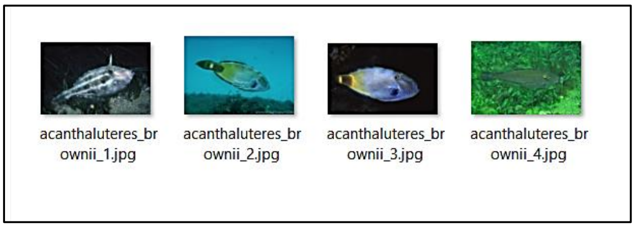

Figure 4. Sample images Fish Species Dataset

Figure 5. Sample images Fish Disease Dataset- Cancer

Disease	Tattered fins	Tattered tail	Skin sores	Swollen abdomen	Bulging eyes
Bacterial infection (Aeromonas, Pseudomonas)	TRUE	TRUE	TRUE	TRUE	TRUE
Bacterial infection (Flavobacterium)	FALSE	FALSE	FALSE	FALSE	FALSE
Carp Pox	FALSE	FALSE	FALSE	FALSE	FALSE
Viral infection (Lymphocystis)	FALSE	FALSE	FALSE	FALSE	FALSE
Water Mold	FALSE	FALSE	FALSE	FALSE	FALSE
Parasites (Costia, Chilodonella, Trichodina, Epistylus)	FALSE	FALSE	FALSE	FALSE	FALSE
Ich (known as freshwater white spot disease)	FALSE	FALSE	FALSE	FALSE	FALSE
Velvet Disease	FALSE	FALSE	FALSE	FALSE	FALSE

Figure 6. EHR Fish Dataset

D. Algorithm

The VGG16 model is used for the task of fish detection, and the Hybrid model is used for fish species prediction using ResNet50 and SVM classifier. The ResNet50 model is trained on Custom dataset. The SVM is trained on the prediction of features generated by ResNet50 on Custom training data. At the last Fish disease prediction done using ResNet50. If the fish is detected in an earlier step the it is passed to the next model otherwise the system exits.
further processing The steps given below explain how the system works.

I. Algorithm for Fish Detection, Classification and Disease Prediction

1. Give input Image to system.
2. Basic Preprocessing Is applied on the image.
3. Image passed to VGG16 model for fish detection.
4. If fish detected, image passed to fish species classification task to ResNet50 model. and feature map generated.
5. SVM classifier is applied to find out the fish Species based on a features map provided by ResNet50.
6. The image is passed for disease prediction to ResNet50.

II. Algorithm for Predictive Health Analytics

1. Input symptoms and abnormal activities of fish input to the system.
2. The input pass to decision tree.
3. Possible Disease Predicted.
4. Prevention and Treatment displayed as output.

IV. Result and Discussion

For analyzing and comparing proposed system goodness the simulated on the Fish Image dataset with the help of Google Colab GPU and local machine GPU (Nvidia 1050 TI).
Used three models training performance is given as follows:

A. Model's Performance Evaluation

Model 1: VGG16 Model (Fish Detection)

The VGG16 model is provided from Tensorflow also the entire model layers freezed and at the bottom flatten layer, 1 Dense layers with 128 dense neurons, 2 Dense layer with 128 dense neurons, and softmax layers with 2 outputs are added and fine-tuned. The Custom dataset is created which consist different fish images near about 484 different fishes having image size 224*224. The model is trained on the dataset with 0.98% training accuracy and 0.03% loss. The model is trained with 1 epoch with batch size of 16. The learning rate is managed by ADAM optimiser and RELU activation function is used. The generated feature map passed to SVM classifier which perform classification.

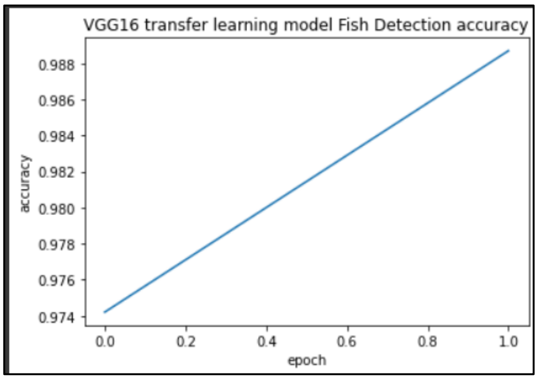

Figure 7. VGG16 training graph

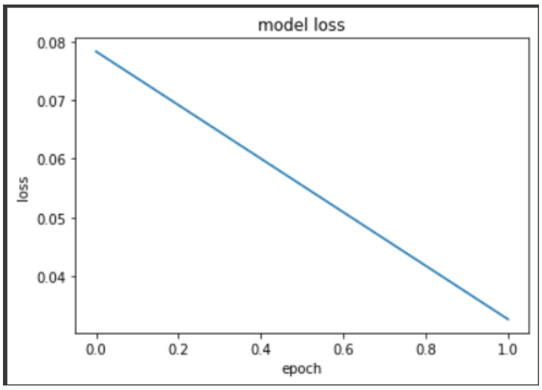

Figure 8. VGG16 loss graph

Figure 7 and 8 shows the training graph and loss graph for the VGG16 model. Here training is increased and loss is decreased.

Model 2: Hybrid Model (Fish Species Classification)

The ResNet50 model is provided from Tensorflow also the entire model layers freezed and at the bottom flatten layer, 1 Dense layers with 128 dense neurons, 2 Dense layer with 128 dense neurons, and softmax layers with 95 outputs are added and fine-tuned. The Custom dataset is created which consist 95 different fish categories. The model is trained on the dataset with 0.93% training accuracy and 0.8% loss. The model is trained with 250 epochs and batch size of 16. The learning rate is managed by ADAM optimiser and RELU activation function is used. The generated feature map passed to SVM classifier which perform classification.

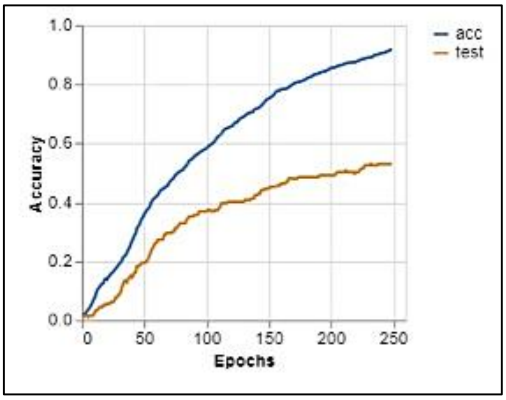

Figure 9. Hybrid model training graph

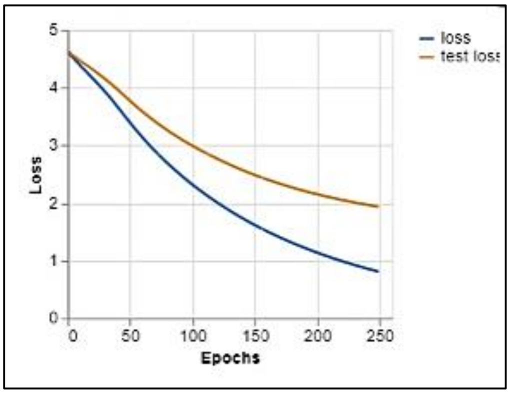

Figure 10. Hybrid Model loss graph

Figure 9 and 10 shows the training graph and loss graph for the Hybrid model. Here training is increased and loss is decreased.

Model 3: ResNet50 Model (Fish Disease Prediction)

The ResNet50 model is provided from Tensorflow also the entire model layers freezed and at the bottom flatten layer, 1 Dense layers with 128 dense neurons, 2 Dense layer with 128 dense neurons, and softmax layers with 5 outputs are added and fine-tuned. The Custom dataset is created which consist 4 different fish diseases and healthy. The model is trained on the dataset with 0.80% training accuracy and 0.7% loss. The model is trained with batch size of 16 and 20 epochs. The learning rate is managed by ADAM optimiser and RELU activation function is used.

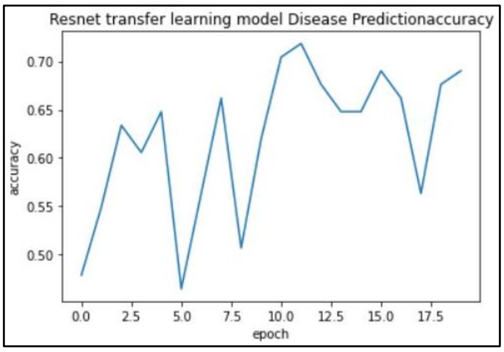

Figure 11. ResNet50 training graph

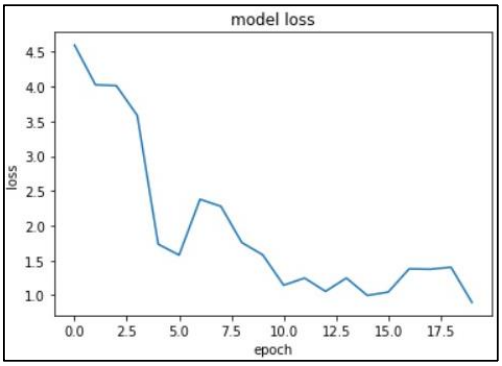

Figure 12. ResNet50 loss graph

Figure 11 and 12 shows the training graph and loss graph for the ResNet50 model. Here training is increased and loss is decreased.

Model 3: Decision Tree (Predictive Health Analytics)

The decision tree model is used using sklearn library. There are total 37 observed symptoms in the fish based on that in the training dataset true and false mentioned for 15 different diseases. The test train split is done and the model is trained which gives 98% accuracy.

B. Sample Output from System:

I. Fish Detection

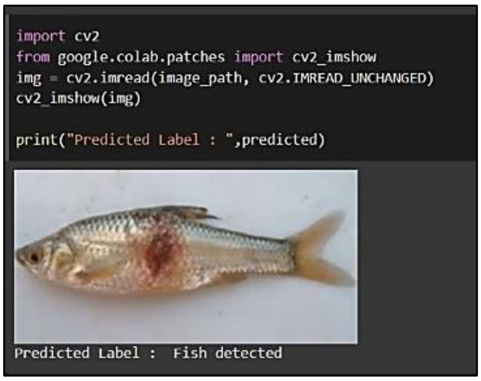

Figure 13. Fish Detected

Figure 11 shows that when the input image passed to the model for fish detection if the fish is in the frame the output is fish detected.

II. Fish Species Classification

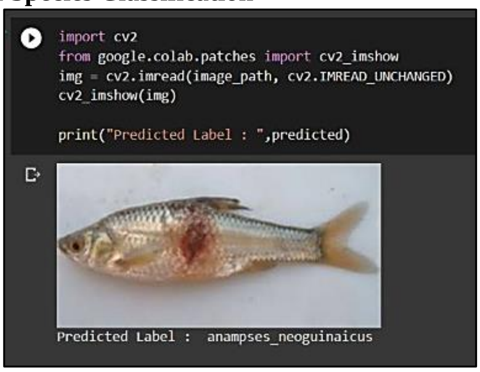

Figure 14. Fish Species Classified

Figure 12 shows that when the input image passed to the model for fish species classification it successfully predicts the species class.

III. Fish Disease Prediction

Figure 15. Fish Disease Predicted

Figure 13 shows that when the input image passed to the model for fish disease prediction it successfully predicts the disease of fish.

IV. Predictive Health Analytics

```
 Please enter index values of symptoms for breaking press -1
Enter Index: 32
Enter Index: -1
[12]
*****************************************************************
According to Entered Symptoms the possible disease is:  Fish Lice
Prevention: When adding new fish, do not add the water they came in.
Treatment: Add Dimilin or Trichlorfon to water
*****************************************************************
```

```
Enter Index: 16
Enter Index: 17
Enter Index: 18
Enter Index: 19
Enter Index: -1
[5]
*****************************************************************
According to Entered Symptoms the possible disease is:  Parasites (Costia, Chilodonella,
Prevention:  When adding new fish, do not add the water they came in. Quarantine new fish
Treatment:  Treat water with copper sulfate
*****************************************************************
```

```
Enter Index: 26
Enter Index: 27
Enter Index: 28
Enter Index: -1
[9]
*****************************************************************
According to Entered Symptoms the possible disease is:  Camallanus Worms. Capillaria Worms
Prevention:  When adding new fish, do not add the water they came in. Quarantine new fish
Treatment:  Remove visible parasites with tweezers. Add Dimilin or Trichlorfon to water.
*****************************************************************
```

```
Enter Index: 29
Enter Index: -1
[10]
*****************************************************************
According to Entered Symptoms the possible disease is:  Gill Flukes. Skin Flukes
Prevention:  When adding new fish, do not add the water they came in. Quarantine new fish
Treatment:  Add Dimilin or Trichlorfon to water
*****************************************************************
```

Figure 16. Predictive Health Analytics

Figure 16 shows that firstly user enters the index positions what symptoms visible in fish, based on that symptoms using Decision tree the predictive disease will be output from the system. Also primary prevention and treatment is suggested.

C. Model Summary:

No	Model Name	Pretrain ed on Dataset	Adde d Layer s	Trainin g Accurac y	Train ing Loss	Epo chs
1	VGG16 model	Fish Image Dataset	2 Dense Layers	0.98%	0.03%	1
2	Hybrid model	Custom Fish Species Dataset	2 dense Layers	0.93%	0.8%	250
3	ResNet50	Custom Fish Disease Dataset	2 Dense Layers	0.80%	0.7%	20
4	Decision Tree	Custom EHR records of fish	-	98%	-	-

Table 1. Summary of Experimental Results

D. Decision Tree evaluation:

- Mapping of disease and corresponding integer value represents that disease. Table 2. Represents the mapping.

Disease	Representing Integer
Bacterial infection (Aeromonas, Pseudomonas)	0
Bacterial infection (Flavobacterium)	1
Carp Pox	2
Viral infection (Lymphocystis)	3
Water Mold	4
Parasites (Costia, Chilodonella, Trichodina, Epistylus)	5
Ich (known as freshwater white spot disease)	6
Velvet Disease	7
Hole-In-the-Head Disease	8
Camallanus Worms, Capillaria Worms	9
Gill Flukes, Skin Flukes	10
Anchor Worms	11
Fish Lice	12
Lack of oxygen	13
Poor water quality	14

Table 2. Disease Mapping

a. Confusion Matrix

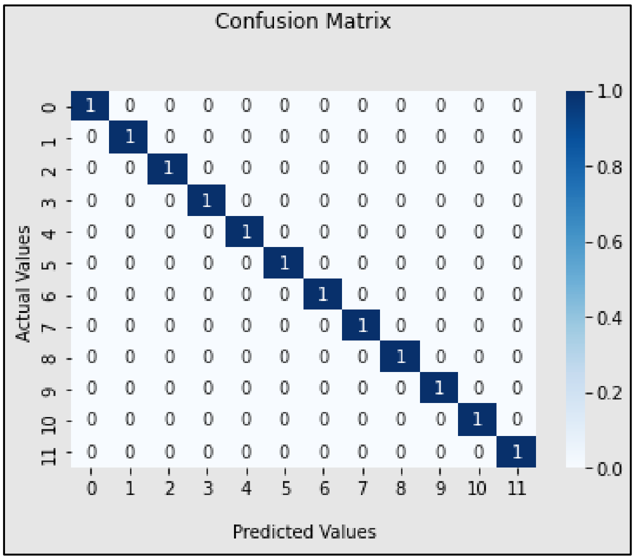

Figure 17. Confusion Matrix for Decision tree

After test train split of dataset. Testing set contains 12 values to test models performance. As a result, predicted output and actual output perfectly matches shown in figure 17.

V. Conclusion

The proposed system using three machine learning for three tasks such as fish detection, fish species classification and fish disease detection and prediction. For fish detection VGG16 model is used which gives 0.98% accuracy. For fish species classification the hybrid model using ResNet50 and SVM model is used which gives 0.93% accuracy. Finally, for disease detection and prediction ResNet50 model is used which gives 0.80% accuracy. Also the models perform efficiently work on augmented training data to predict result. Predictive health analytics is an emerging area in medical sector. Decision tree works efficiently in this area when it is trained on EHR of fish records. It can also be beneficial to other task in predictive health analytics where decision making is there.

VI. Future Scope

In a proposed system there is limit of scope for species prediction and disease prediction of fish due to availability of any standard dataset on fish species and fish disease. If there is any standard dataset for both task, there will be much more accurate and precise output. There is no any proper system to create Electronic health records of every animal if the EHR records of every species is available the same technique will be used for more such task.

VII. Acknowledgement

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