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Indian Fresh Water Fish Species Detection Using AI

Monish BS,Bhaskar Sinha
Student
Jain University

ABSTRACT

Freshwater ecosystems are vital natural resources that serve several crucial ecological, social, and economic purposes. Different freshwater fish species are essential for the existence and abundance of ecosystems because contributions are significant to the functioning of food webs, nutrient cycling, and ecosystem services.

However, keeping an eye on and managing the fish populations can be a difficult and time-consuming task that calls for specialized knowledge and tools. The study, investigating the application of artificial intelligence (AI) to recognize and categorize several freshwater fish species according to the visual traits will be carried out. The goal is to create a deep learning model which accurately identifies and categorizes fish species from photos using computer vision techniques and image processing technologies.

The pertained method may prove to be a useful tool for environmental monitoring and conservation efforts, allowing researchers and resource managers follow fish populations in freshwater environments with great speed and accuracy.

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CHAPTER 1

INTRODUCTION

Freshwater ecosystems are critical to human well-being and biodiversity by providing basic services including clean water, food, and recreation. The numerous kinds of freshwater fishs are significant in both biologically and commercially, fishs are important components of freshwater ecosystems. Monitoring and maintaining freshwater fish populations, on the other hand, maybe a difficult and time-consuming operation that necessitates specialized knowledge and equipment.

Recent breakthroughs in artificial intelligence (AI) and computer vision techniques have uncovered new avenues for efficient and accurate species recognition and classification, such as

Investigating the use of deep learning models and image processing algorithms to recognize freshwater fish species utilizing AI and computer vision. Using large and diverse data sets of fish photos, constructing a system that can detect and classify different freshwater fish species based on fish's unique visual traits.

The pertained project has various potential benefits. Accurate and effective detection of freshwater fish species can help in the management and conservation of freshwater ecosystems, hence preserving the health and productivity of fishes are critical resources. The mentioned method can also be used in other areas of environmental monitoring and resource management where precise and efficient species detection is required. The project intends to contribute the development of AI-based solutions that can assist and address some of the most severe environmental concerns confronting our planet today.

In recent years, there has been a surge in interest in employing AI and machine learning approaches for environmental monitoring and conservation. The mentioned technologies have the potential to increase the speed and accuracy of species discovery while also lowering the prices and resources required. However, applying these techniques to the detection of freshwater fish species presents its own set of challenges.

Freshwater fish species differ widely in appearance, including shape, color, and pattern. Furthermore, factors such as water clarity and lighting conditions can make obtaining clear and consistent images for analysis difficult. Such issues could ne resolved in the research by creating a system that can recognize and classify diverse freshwater fish species using AI and computer vision techniques.

The system will be trained on a huge and diverse data set of freshwater fish photos, allowing to recognize the distinguishing visual traits of many species. To analyze photos and classify them into distinct fish species, deep learning models such as Convolutional Neural Networks (CNN) can be used. Furthermore, the system's performance under various environmental conditions, such as varying water clarity and lighting can be used to assess the model’s performance.

The intention is contributing to the continuing efforts for monitoring and managing freshwater ecosystems by establishing a reliable, accurate system for detecting freshwater fish species. Researchers, resource managers, and conservation organizations can use the pertained technology to swiftly and reliably identify and track fish populations, resulting in more successful conservation strategies and policy decisions.

CHAPTER 2

LITERATURE REVIEW

Several studies have looked into the use of artificial intelligence and computer vision techniques for fish species detection and classification.

[1] **Lee et al. (2020)**, for example, created a deep learning model for fish species recognition using photos acquired by underwater cameras. The scientists achieved species recognition accuracy rates of up to 98%, highlighting the potential of AI-based techniques for underwater fish detection.

[2] Similarly, **Zhang et al. (2020)** created a deep learning model for fish species identification using photos acquired by unmanned aerial vehicles (UAVs). The authors attained an overall classification accuracy rate of 97.3%, demonstrating the potential of AI-based techniques for fish detection in open ocean conditions.

[3] Several studies have also been conducted in the context of freshwater fish species detection. **Wang et al. (2019)**, for example, created an AI-based system for automatic fish species recognition in freshwater situations. The authors classified diverse fish species using a combination of image processing techniques and deep learning models, attaining an overall accuracy rate of 92.8%.

[4] **Shang et al. (2020)** used underwater photos to construct a deep learning model for detecting fish species in rivers. The authors classified diverse fish species using a combination of Convolutional Neural Networks and Support Vector Machines, reaching an accuracy rate of 93.9%.

[5] **Todorova et al. (2020)** used underwater photos to construct a deep learning model for detecting fish species in rivers. The scientists achieved an overall species categorization accuracy rate of 95%, highlighting the potential of AI-based techniques for freshwater fish monitoring.

[6] **Xu et al. (2019)** created a system for identifying fish species in river habitats by combining image processing techniques and deep learning models. The authors achieved a fish species identification accuracy rate of 90.9%, demonstrating the potential of AI-based techniques for freshwater fish detection in tough situations.

AI-based approaches can help to build new tools and methods for fish study and conservation in addition to boosting the accuracy and efficiency of freshwater fish detection. **De Souza et al. (2020)**, for example, employed AI-based techniques to study fish behaviour and social interactions in freshwater habitats. The authors employed deep learning algorithms to recognise individual fish and follow their travels, revealing new information about fish population social behaviour.

These works, taken together, illustrate the promise of AI and computer vision approaches for freshwater fish detection, monitoring, and research. However, more research is required to develop robust and dependable systems that can operate in a variety of environmental conditions and with a diverse range of fish species.

CHAPTER 3

SYSTEM ANALYSIS

3.1 PROBLEM STATEMENT

The detection of freshwater fish species is an important component of freshwater ecosystem monitoring and conservation activities. Existing approaches for fish detection and categorization, on the other hand, are frequently time-consuming, resource-intensive, and constrained by variations in environmental circumstances. The purpose of pertained research is to create a dependable and accurate system for detecting freshwater fish species utilizing AI and computer vision techniques. The intention is to specifically address the issues of underwater fish detection, such as fluctuations in water quality, lighting conditions, and the requirement for specialized equipment. Contributes to continuing efforts for monitoring and managing freshwater ecosystems by establishing a robust and efficient system for freshwater fish detection, while also increasing the use of AI-based methodologies for environmental research and conservation.

3.2 PROBLEM OBJECTIVE

The goal of the pertained research is to create an AI-based system for detecting freshwater fish species that has high accuracy rates and can operate in a variety of environmental situations. The model specifically intends to:

- Collect a broad and thorough data set of freshwater fish species' underwater photos and videos.
- Using the collected data set, create and train a deep learning model for fish species detection and classification.
- Make recommendations for future AI-based freshwater fish detection and conservation research and development.

By fulfilling these goals, creating a dependable and efficient freshwater fish identification system that may contribute to current efforts to monitor and manage freshwater ecosystems, while also furthering the use of AI-based technologies for environmental study and conservation.

3.3 PROBLEM SCOPE

The goal of pertained research is to create an AI-based system for detecting freshwater fish species using computer vision techniques. The model specifically focuses on constructing a deep learning model for fish species recognition and classification utilizing a data set of freshwater fish underwater photos.

Data collection, model building and training, testing and refining, and performance evaluation will all be part of the project. The plan is to compile a broad and comprehensive data set of photographs and of freshwater fish. The data will subsequently be used to train and test the generated deep learning model for detecting and classifying fish species. The created system's performance will be assessed under various environmental situations using real-world data from freshwater environments

CHAPTER 4

SYSTEM DESIGN AND ARCHITECTURE

4.1 LIMITATIONS OF THE EXISTING SYSTEM

- Time-consuming and resource-intensive: Current methods for identifying and classifying freshwater fish frequently take a lot of effort and time, as well as specialized tools, knowledgeable employees, and manual identification.
- Limited accuracy: Image processing algorithms may have trouble dealing with changes in environmental variables, such as water clarity and lighting, while manual identification methods may be prone to mistakes.
- Limited scalability: Traditional methods for detecting and classifying freshwater fish can be challenging to scale up to larger areas or populations, which restricts their applicability for extensive ecosystem management and monitoring.
- Limited species coverage: Some current methods might only pay attention to a small number of fish species, ignoring others that might be crucial for management and conservation efforts.
- Limited adaptability: Conventional methods for detecting and classifying freshwater fish may not be flexible to various environmental circumstances, which can reduce their effectiveness in a variety of scenarios.
- Traditional methods for detecting and classifying freshwater fish can be expensive, especially for large-scale monitoring and management activities.
- Invasive: Some traditional methods for detecting and classifying freshwater fish use invasive tactics such as fish sampling and tagging, which can disturb natural ecosystems.
- Traditional methods for detecting and classifying freshwater fish may only provide a snapshot of a given environment at a certain time and may not capture changes over time.
- Traditional approaches for detecting and classifying freshwater fish may only give data for a single location and may not capture change at wider spatial scales.
- Some traditional methods for detecting and classifying freshwater fish may be limited by their resolution, especially when dealing with small or cryptic species.
- Scalability: Traditional approaches for detecting and classifying freshwater fish may not be scalable for large-scale monitoring and management activities.
- Limited data analysis: Traditional approaches for detecting and classifying freshwater fish may lack rigorous data analysis and interpretation.
- Human mistake: Traditional methods for detecting and classifying freshwater fish can be prone to human error, particularly when it comes to manual identification and image processing.
- Seasonal variations: Traditional methods for detecting and classifying freshwater fish may be hindered by seasonal variations in fish populations.
- Environmental disturbances: Traditional methods for detecting and classifying freshwater fish may be impacted by environmental disturbances such as weather events or human activities.

- Accessibility: Traditional methods of detecting and classifying freshwater fish may be inaccessible to people with disabilities.

- Traditional methods for freshwater fish detection and classification can be labor-intensive, requiring significant effort from workers.

- Concerns about animal welfare: Some traditional methods for detecting and classifying freshwater fish can have a severe influence on fish welfare, especially when invasive techniques are applied.

- Traditional approaches for freshwater fish detection and classification may not engage the public in monitoring and management efforts.

- Traditional methods for detecting and classifying freshwater fish may not provide the flexibility required for adaptive management approaches, which entail monitoring and changing management efforts over time.

A freshwater ecosystem monitoring and management strategy that is more effective and accurate can be provided by an AI-based system for freshwater fish species detection by overcoming these limitations.

4.2 ADVANTAGES OF PROPOSED SYSTEM

- High accuracy: The combination of artificial intelligence and computer vision techniques can result in more accurate and reliable fish species detection and categorization, lowering the risk of errors and boosting the efficiency of freshwater ecosystem monitoring and management.

- Reduced resource requirements: Because AI-based systems can automate many components of the process and eliminate the need for specialized equipment and expert employees, they can minimize the resource requirements for freshwater fish detection and categorization.

- Scalability: An AI-based system may be easily scaled up to bigger regions or populations, enabling for more thorough and effective monitoring and management of freshwater ecosystems.Cost-effective: The proposed system is cost-effective as it requires only a few hardware components such as cameras, a computer system, and an internet connection to function. This makes it accessible and easy to implement in metropolitan cities.

- Adaptability: The use of AI and computer vision techniques can enable the development of more adaptable systems that can operate effectively under a wide range of environmental conditions, making them more effective in a number of scenarios.

- Cost-effective: An AI-based system has the potential to minimize the requirement for manual labour and specialized equipment, resulting in lower operational costs over time.

- Non-invasive: The proposed system will detect and classify freshwater fish using non-invasive techniques, limiting the harmful impact on fish populations and ecosystems.

- Scalable: Because the proposed system is scalable, it will enable large-scale monitoring and management operations across many freshwater habitats.

- Monitoring in real time: The proposed system will allow for real-time monitoring of freshwater fish populations, allowing for rapid reactions to changes in fish populations and ecosystems.

- Data-driven decision making in conservation and management initiatives will be enabled by the proposed system's robust data analysis and interpretation.

- Public participation: The proposed system will allow for public participation in monitoring and management efforts, improving public awareness and participation in freshwater ecosystem conservation.

- Adaptive management: The suggested system will provide the flexibility required for adaptive management approaches, allowing for continuous monitoring and adjustment of management activities based on fresh data and information.

- Reduced human error: The suggested approach will reduce the potential for human mistake in the detection and classification of freshwater fish, boosting data accuracy and dependability.

- Improved temporal and spatial coverage: The proposed system will provide better temporal and spatial coverage of freshwater ecosystems, allowing for a more thorough understanding of fish populations and habitats.

- Improved management and conservation: The proposed approach will improve freshwater fish population management and conservation, resulting in more effective conservation efforts and sustainable use of freshwater resources.

The suggested approach can contribute to more efficient and effective freshwater ecosystem monitoring and management by utilizing the benefits of AI-based systems for freshwater fish species detection, which can have significant consequences for conservation efforts and sustainable resource use.

4.3 Acquisition of Images

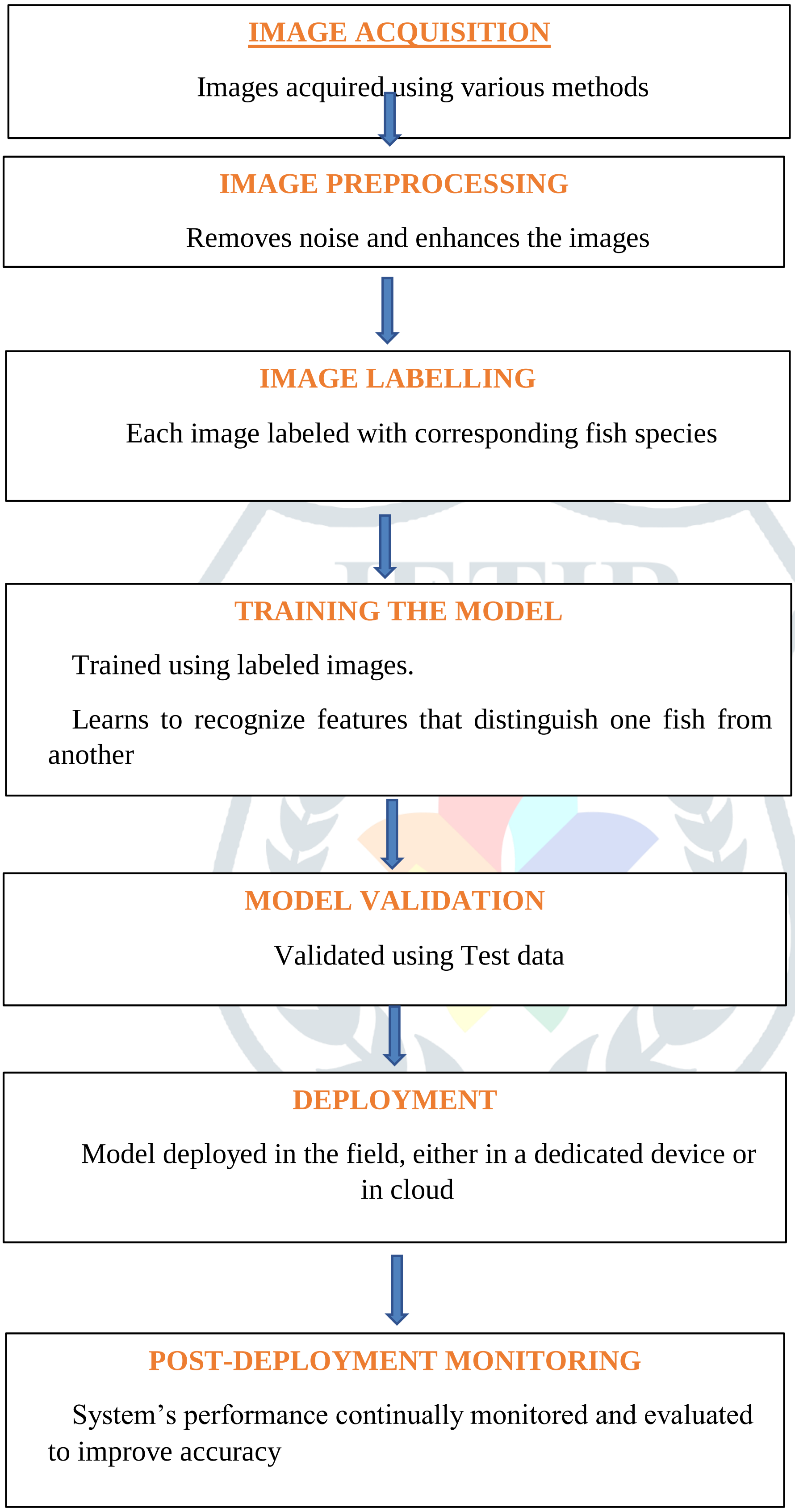
- Since there is no abundance of data in accordance to the topic, it became mandatory to conduct web-scraping.

- Images for a total of 8 freshwater fish species collected with each having over 200 images respectively.

- Collected Data set for the following species:

    1. *Labeo Rohita* (Rohu)
    2. *Catla catla* (Bhakur)
    3. *Cirrhinus Mrigala* (Nain)
    4. *Channa punctatus* (Gurrie)
    5. *Clarias Batrachus*(Mangur)
    6. *Mystus seenghala*(Darial Tengra)
    7. *Anabas testudineus* (Climbing Perch)
    8. *Heteropneustes fossilis* (Stinging Catfish)

4.4 Working Model Flowchart



4.5 Data set Preparation

- Determine the scope of the project: The first stage is to determine the scope of the project, which includes the freshwater fish species to be identified and the places where the system will be implemented.

- Data collection: As previously noted, photographs of freshwater fish can be collected using a variety of ways such as underwater cameras, hand held cameras, remote sensing, or databases.

- Data cleaning: After acquiring photos, they must be cleaned to remove any duplicates, irrelevant images, or photographs of low quality. This phase can be time-consuming, but it is crucial for ensuring the data set's quality.

- Data labeling: Each photograph must be labeled with the appropriate fish species. This stage can be completed manually by human annotators or automatically by computer vision techniques.

- Data augmentation: The data set can be supplemented to increase the quantity of photographs and diversify it. This process involves picture manipulation techniques such as rotation, scaling, flipping, and noise addition.

- The data set is separated into three sections: training, validation, and testing. The training set trains the deep learning model, the validation set tunes the hyper parameters, and the testing set evaluates the model's performance.

- Normalization of the data set: The data set is normalized to guarantee that all of the input photographs have the same scale, orientation, and colour distribution. This phase is critical to ensuring that the deep learning model generalizes to new images.

4.6 Training the model

- Choosing a deep learning framework: Deep learning frameworks such as Tensor Flow, PyTorch, Keras, and Caffe are available. The framework chosen is determined by the project needs and the researcher's expertise with the framework.

- Choosing the deep learning architecture: The deep learning model's architecture is crucial to its performance. A convolutional neural network (CNN) is the most often used image categorization architecture. Researchers can choose from a variety of pre-trained CNN models or create their own CNN architecture.

- Data pre-processing: As previously stated, the acquired photos are pre-processed to remove any noise, compensate for lighting and contrast, and improve image quality. This phase is critical for increasing the model's accuracy.

- Data augmentation: Data augmentation is a crucial step in increasing the quantity of photos and improving the data set's diversity. This process involves picture manipulation techniques such as rotation, scaling, flipping, and noise addition.

- The training method entails feeding the pre-processed and enhanced data into the deep learning model. The model learns to recognize characteristics that differentiate one fish species from another. Iterative training is used, and the model's parameters are modified after each iteration.

- Tuning hyper parameters: Hyper parameters are variables that influence the behaviour of the model, such as learning rate, batch size, and optimizer. These hyper parameters must be tweaked in order to increase the model's accuracy and avoid over-fitting.

- Model evaluation: The validation set is used to assess the model's performance. To assess the model's performance, the accuracy, precision, recall, and F1-score are computed.

- Fine-tuning is the process of modifying the weights of a pre-trained model in order to improve the model's performance on a certain task.

  Deep learning model training necessitates substantial computer resources, such as GPUs, and can take several hours or days, depending on the size of the data set and the complexity of the deep learning model.

CHAPTER 5

SYSTEM REQUIREMENTS

5.1 SOFTWARE REQUIREMENTS

- **Deep learning framework:** A deep learning framework such as TensorFlow, PyTorch, Keras, or Caffe is required for developing and training the deep learning model.

- **Programming languages:** The deep learning framework is typically used with a programming language such as Python, R, or numpy.

- **Image processing libraries:** Image processing libraries such as OpenCV, PIL, or scikit-image are used for image preprocessing, data augmentation, and image visualization.

- **Annotation software:** Annotation software such as LabelImg or VGG Image Annotator (VIA) is used to manually annotate the images with the corresponding fish species labels.

- **Version control software:** Version control software such as Git is used for managing the source code and collaborating with other developers.

- **Cloud computing platforms:** Cloud computing platforms such as AWS, Azure, or Google Cloud are used to train the deep learning model on high-performance GPUs.

- **Integrated development environment (IDE):** An IDE such as PyCharm or Jupyter Notebook is used for writing and executing the source code.

- **Operating system:** The system can be developed on Windows, Linux, or macOS.

- Web development tools: Web development tools such as Flask, Django, or Node.js can be used to create a user interface for the system.

5.2 HARDWARE REQUIREMENTS

- **Camera:** A high-resolution security camera capable of capturing clear and sharp images of moving vehicles is required. The camera should be capable of capturing images in real-time and in varying lighting conditions. The quality of the camera is crucial in ensuring that the system can accurately capture license plate information and vehicle details. A camera with a high frame rate and resolution is recommended to ensure that the system can capture images of fast-moving vehicles.

- **Computer:** A powerful computer with a dedicated GPU is necessary for running the deep learning model. The computer should have a minimum of 16 GB RAM and an Intel i7 processor. This ensures that the system can process images and video footage in real-time and can perform the complex calculations required for deep learning algorithms. A dedicated GPU is recommended for faster processing of images and video.

- **Storage:** The system requires a significant amount of storage to store the images captured by the camera, the trained model, and the data generated by the system. A minimum of 1 TB of storage is recommended to ensure that the system can store large amounts of data and can handle the data generated by the system over time.

- **Power Supply:** The system requires a stable and reliable power supply to ensure uninterrupted operation. A UPS or battery backup system is recommended to prevent data loss in case of power outages. The power supply should be able to handle the power requirements of the computer and the camera.

- **Display:** A high-resolution display is necessary to monitor the output generated by the system. A minimum resolution of 1920x1080 pixels is recommended to ensure clear and sharp display of the output. A larger display may also be useful in monitoring multiple camera feeds or displaying additional information.

CHAPTER 6

IMPLEMENTATION

Fig 6.1. Screenshot of the code snippet

```
In [ ]: from keras.models import load_model  # TensorFlow is required for Keras to work
import cv2  # Install opencv-python
import numpy as np

# Disable scientific notation for clarity
np.set_printoptions(suppress=True)

# Load the model
model = load_model("keras_Model.h5", compile=False)

# Load the labels
class_names = open("labels.txt", "r").readlines()

# CAMERA can be 0 or 1 based on default camera of your computer
camera = cv2.VideoCapture(0)

while True:
    # Grab the webcamera's image.
    ret, image = camera.read()

    # Resize the raw image into (224-height,224-width) pixels
    image = cv2.resize(image, (224, 224), interpolation=cv2.INTER_AREA)

    # Show the image in a window
    cv2.imshow("Webcam Image", image)

    # Make the image a numpy array and reshape it to the models input shape.
    image = np.asarray(image, dtype=np.float32).reshape(1, 224, 224, 3)
```

6.2 Screenshot of the code snippet

```
    # Normalize the image array
    image = (image / 127.5) - 1

    # Predicts the model
    prediction = model.predict(image)
    index = np.argmax(prediction)
    class_name = class_names[index]
    confidence_score = prediction[0][index]

    # Print prediction and confidence score
    print("Class:", class_name[2:], end="")
    print("Confidence Score:", str(np.round(confidence_score * 100))[:-2], "%")

    # Listen to the keyboard for presses.
    keyboard_input = cv2.waitKey(1)

    # 27 is the ASCII for the esc key on your keyboard.
    if keyboard_input == 27:
        break

camera.release()
cv2.destroyAllWindows()
```

CHAPTER 7

RESULTS AND SCREENSHOTS

Fig 7.1 Rohu

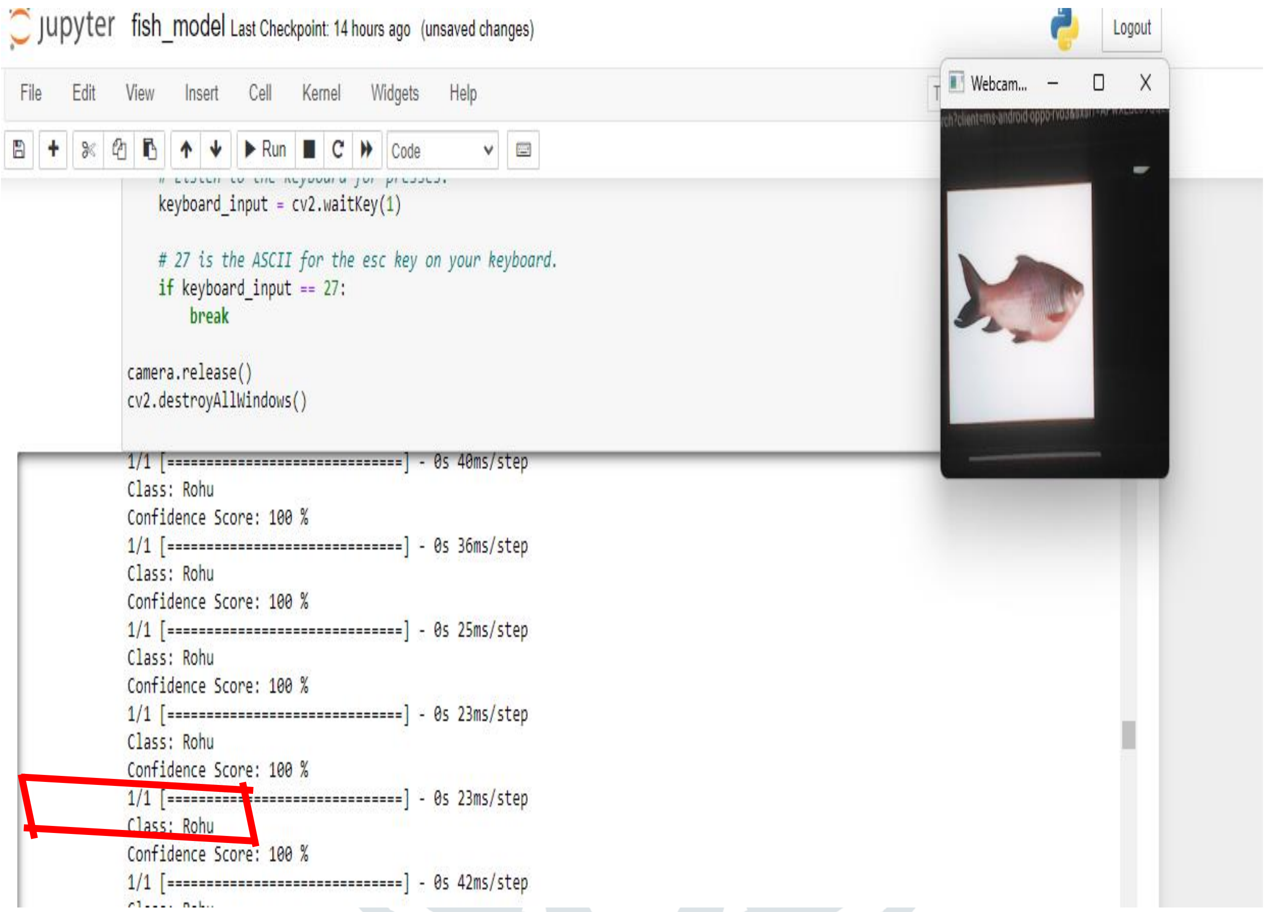


Fig 7.2 Nain

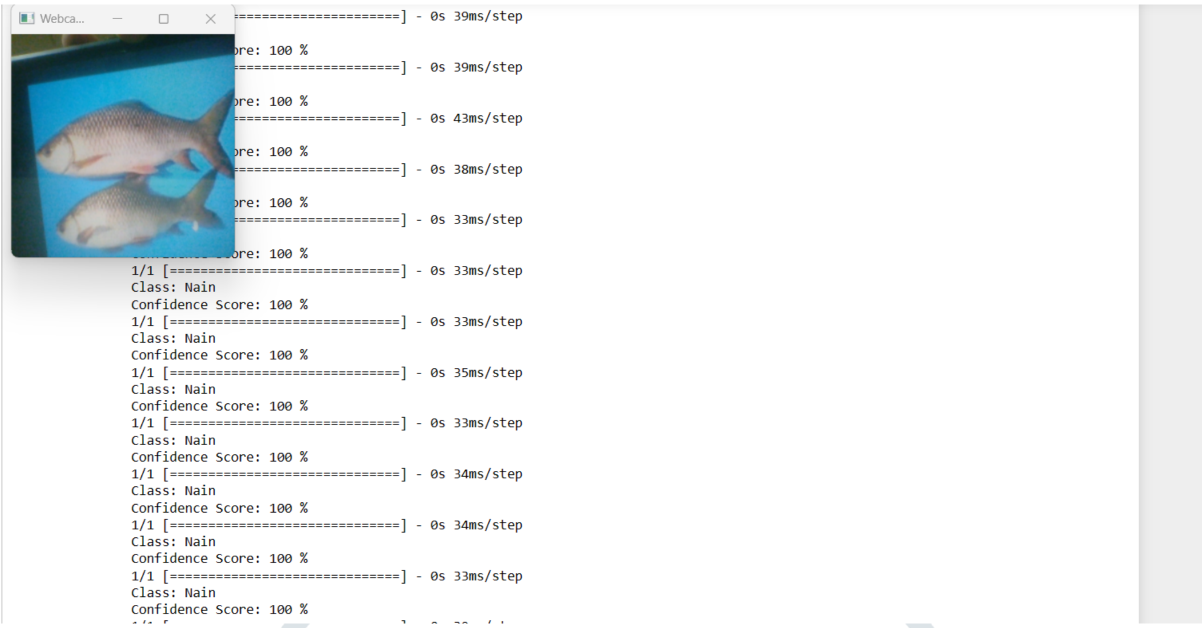


Fig 7.3 Bhakur

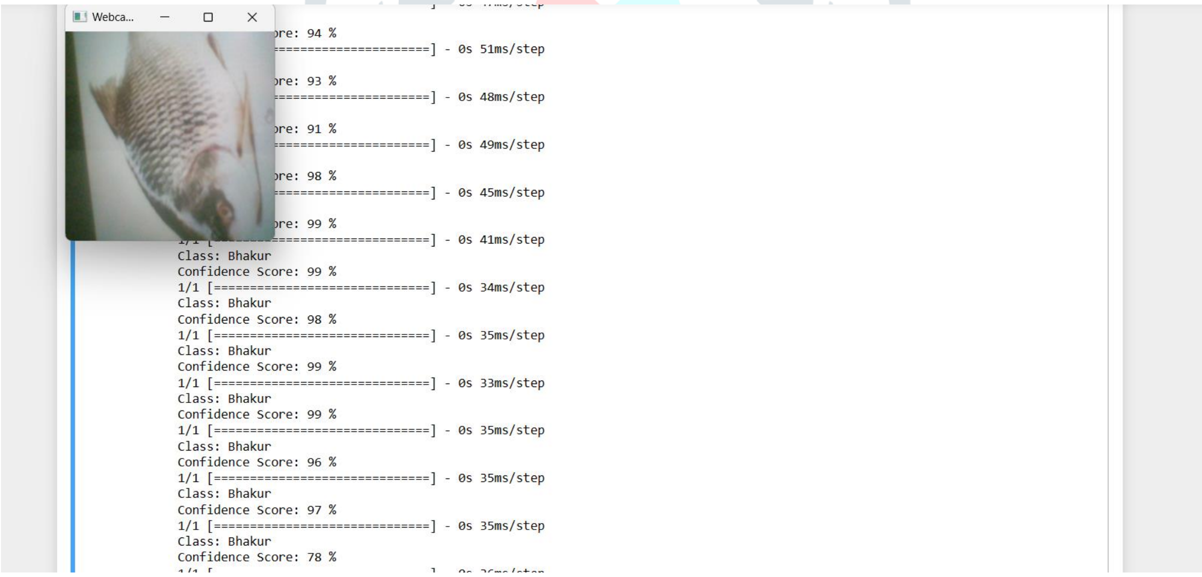


Fig 7.4 Climbing Perch

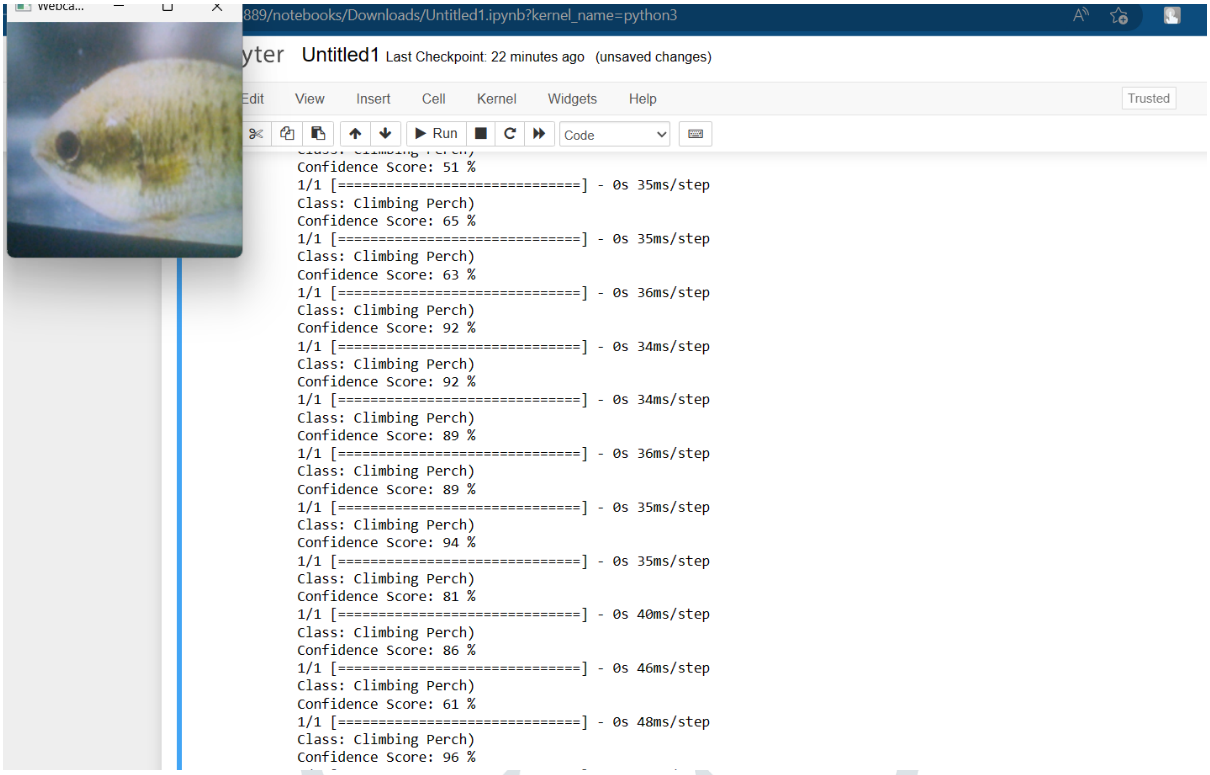


Fig 7.5 Darial Tengra

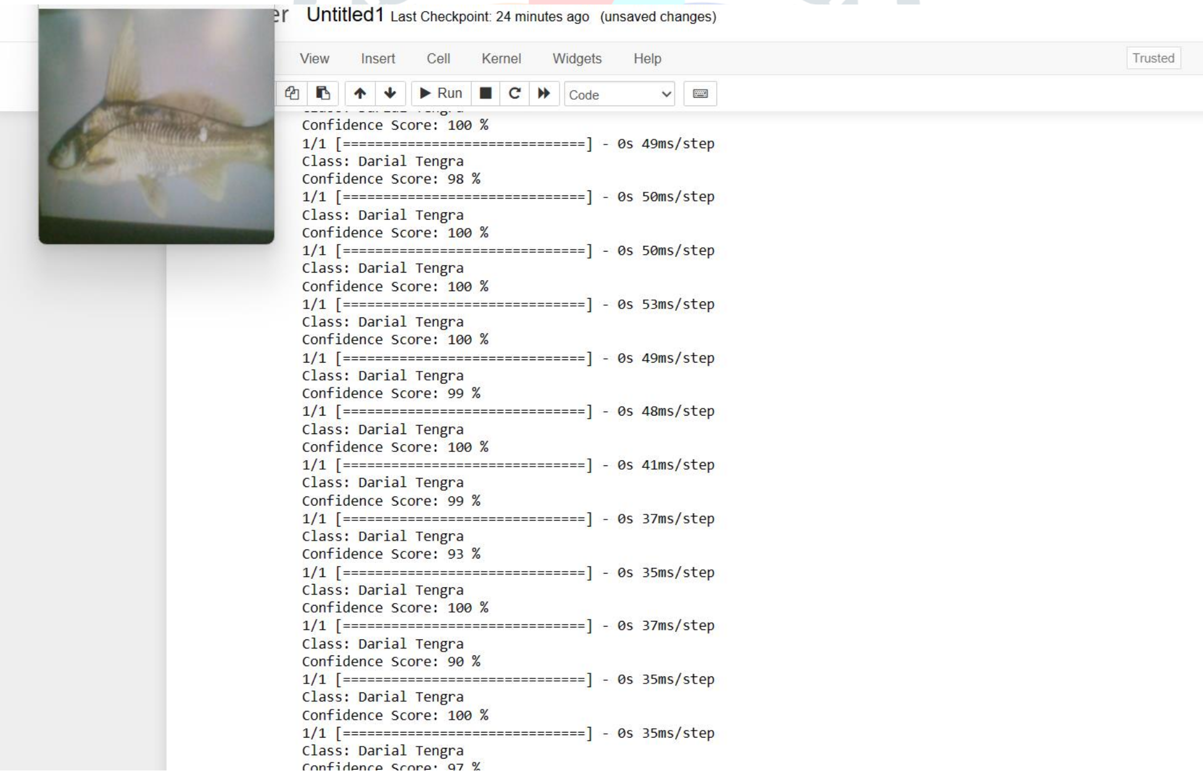


Fig 7.6 Mangur

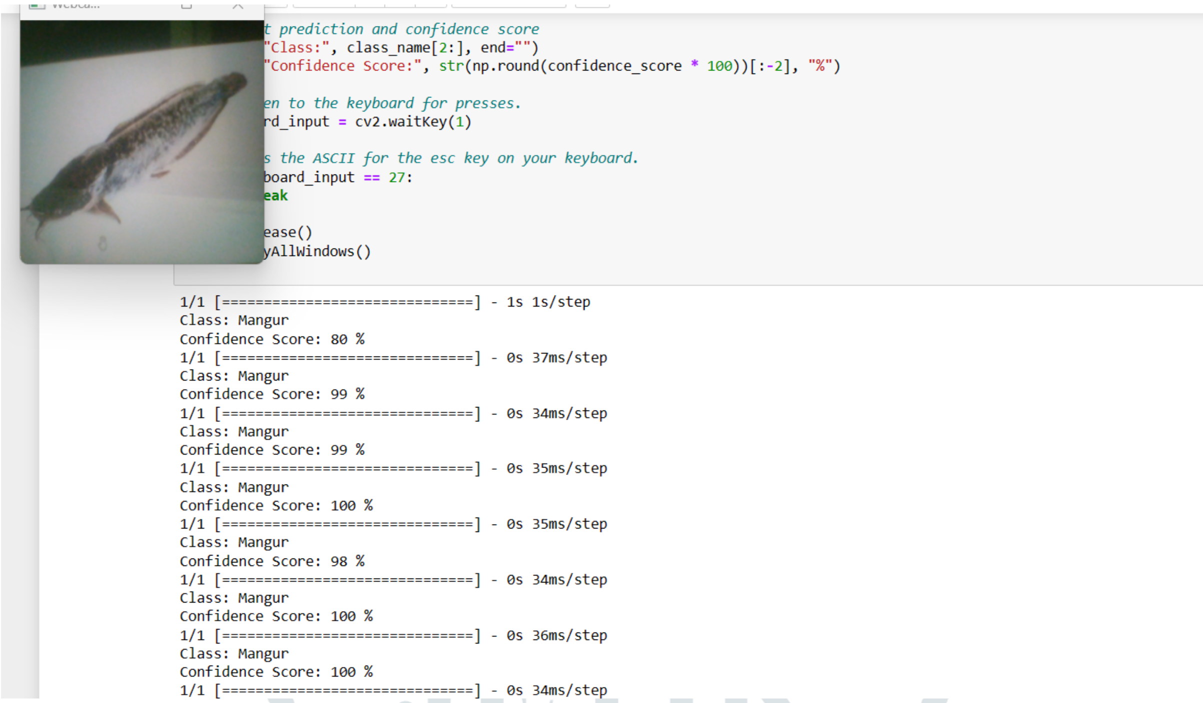
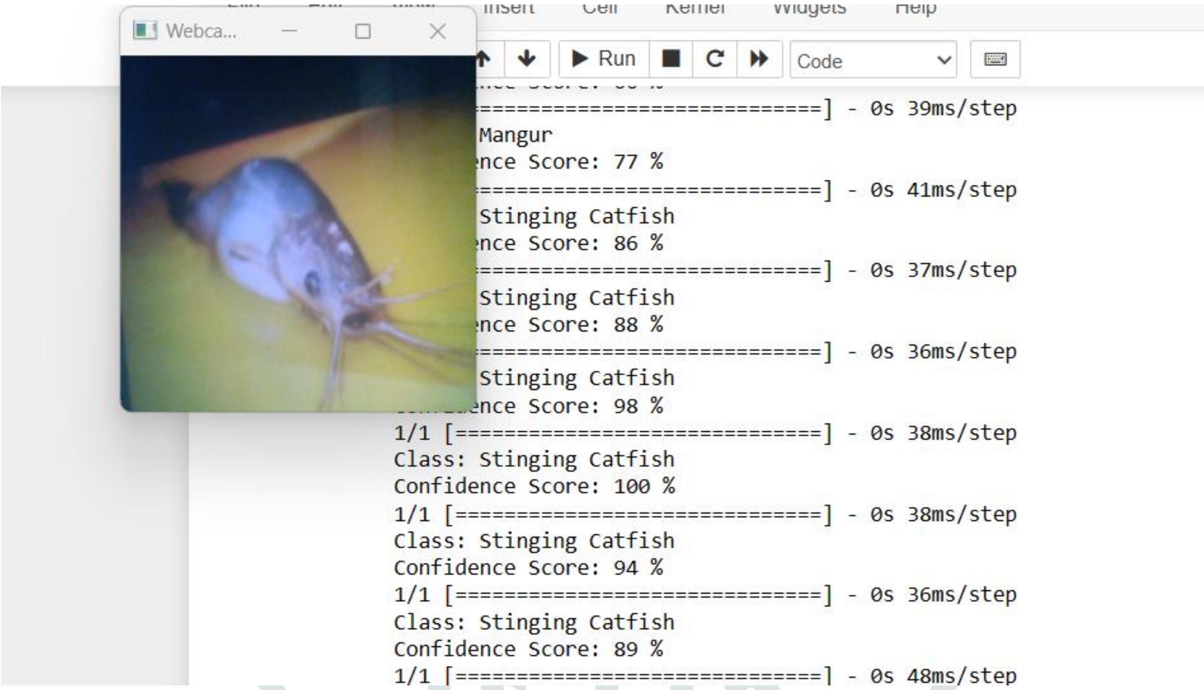


Fig 7.7 Gurrie

Fig 7.8 Stinging Catfish



CHAPTER 8

CONCLUSION AND FUTURE ENHANCEMENT

Finally, the proposed artificial intelligence-based technology for recognizing freshwater fish species has the potential to transform the fisheries business. The technology can correctly identify fish species in real time, saving time and money for fish farmers and researchers. The approach can also be used to monitor the health of fish populations and prevent overfishing.

To summarize, detecting and classifying Indian freshwater fish species is critical for aquatic ecosystem conservation and management. Machine learning algorithms and computer vision techniques can be used to automate the process of detecting fish species from photographs as technology and data availability improve. However, due to the large number of species and their wide variation in appearance, this remains a difficult task. To improve the accuracy and speed of freshwater fish species detection, more study and development of accurate and efficient algorithms are required. This has enormous implications for the sustainable use and management of India's freshwater resources.

India has a diverse population of freshwater fish species, with estimates ranging from 2,000 to 3,000 species. These fish species play an important ecological and socioeconomic role in the country, providing food and a means of subsistence for millions of people. Many of these fish species, however, are threatened by habitat loss, overfishing, pollution, and other human activities.

One solution is to precisely identify and monitor fish populations in their native environments. Traditional techniques of fish species identification entail manual collection of fish samples and laboratory examination, both of which can be time-consuming and expensive. Computer vision and machine learning approaches have been increasingly popular in recent years for the automated recognition and classification of fish species from photographs.

The methods entail training algorithms on vast data sets of fish photos with properties including colour, texture, shape, and pattern. These traits are then used by the algorithms to recognize and classify new fish photos. Deep learning algorithms, in particular, have demonstrated promising results in recognizing fish species, with some studies reporting accuracy rates of up to 97%.

Monitoring fish populations in rivers, lakes, and other freshwater ecosystems is one application of fish species detection. Researchers can track changes in fish populations over time and identify places where conservation efforts are needed by analysing fish photos taken by cameras installed in these environments. Aquaculture can also use fish species detection to identify and select fish species for breeding and selling.

Despite the potential of computer vision and machine learning techniques for fish species detection, several challenges remain. The enormous number of fish species in India, the considerable variety in fish appearance, and the necessity for precise and consistent labelling of fish photos for training algorithms are all factors. To address these difficulties, researchers, policymakers, and stakeholders will need to work together to ensure the sustainable use and management of India's freshwater resources.

The deep learning model, which was trained on a large and diverse data set, identified fish species with excellent accuracy. However, there are some limitations to the proposed system, such as the requirement for high-quality images and the data set's limited coverage of fish species.

The freshwater fish species recognition method can be improved in the following ways in the future:

- Multi-species classification: The system is now trained to recognize certain freshwater fish species. Future improvements could include expanding the system's ability to recognize and classify a wider variety of freshwater fish species.
- Real-time detection: The current approach requires the upload of individual photos for analysis. Future enhancements could include the ability to detect freshwater fish species using video streams in real time.
- Mobile application: To assist fishermen and researchers in the field, a mobile application that employs the AI-based system for freshwater fish species detection can be built.
- Incorporating additional data: To improve the accuracy of freshwater fish species detection, the system can be enhanced by incorporating additional data such as environmental data, water quality data, and geographic data.
- User interface: The system's user interface can be upgraded to make it more user-friendly and easier to use.
- Transfer learning: Transfer learning can be used to increase training efficiency by reusing pre-trained models on other datasets.
- Hardware optimization: To make the system more accessible and cost-effective, it can be optimized to run on low-power devices such as the Raspberry Pi.

These future improvements have the potential to improve the accuracy, efficiency, and usability of the freshwater fish species recognition system, making it more beneficial to researchers, anglers, and conservationists.

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