Project Synopsis
on

NEMO: Intelligent Fish Species Identification & Insights

Submitted as a part of course curriculum for

Bachelor of Technology
in
Computer Science

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ABSTRACT

The marine ecosystem plays a vital role in sustaining life, providing livelihoods for millions of fishermen worldwide. However, accurate species-level catch reporting remains a challenge, hindering effective management and conservation efforts. In this study, we propose the development of an innovative mobile application aimed at revolutionizing the process of fish species identification and catch reporting in the Indian seas. The proposed application will leverage cutting-edge technology, integrating an AI-ML-based model for real-time fish species identification. Built using Kotlin programming language for Android platforms, the app will empower fishermen to capture images of their catch using their smartphones and instantly identify the species with the help of our ML model. This approach minimizes manual intervention and significantly improves the accuracy and efficiency of species-level catch reporting. Furthermore, the application will incorporate a comprehensive history feature, allowing fishermen to maintain a record of their past catches. Additionally, real-time weather tracking functionality will be integrated to provide valuable environmental context at the moment of image capture, enhancing the quality and relevance of catch data. By providing fishermen with a user-friendly and intuitive tool for accurate species identification and catch reporting, our application aims to enhance the effectiveness of Marine Fishery Advisory Services provided by organizations like INCOIS. This innovative solution has the potential to foster sustainable fisheries management practices and contribute to the conservation of marine biodiversity in the Indian seas.

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LIST OF ABBREVIATIONS

- **INCOIS -** Indian National Centre for Ocean Information Services
- **ML –** Machine Learning
- **GPS -** Global Positioning System
- **AI –** Artificial Intelligence
- **CNNs -** Convolutional Neural Networks
- **DNN -** Deep Neural Network
- **STFT -** Short-Time Fourier Transform
- **Fig. -** Figure
- **e.g. -** exempli gratia (meaning "for example")
- **RGB –** Red Green Blue
- **APIs -** Application Programming Interfaces
- **SDK -** Software Development Kit
- **et al. -** Et alia (meaning "and others")

CHAPTER 1: INTRODUCTION

Sustainable fisheries are crucial for food security and the livelihoods of millions in India. To achieve this, accurate data on fish catch, particularly at the species level, is essential. However, current methods of fishermen reporting fish types are often manual and prone to errors. This limits the effectiveness of advisory services provided by organizations like the Indian National Centre for Ocean Information Services (INCOIS).

This project proposes an innovative solution: a mobile application for Android devices that leverages the power of machine learning (ML) for real-time fish species identification. The app aims to streamline the data collection process for fishermen and INCOIS, ultimately leading to more accurate and species-specific fishery advisories.

The app will be built using Kotlin, a programming language well-suited for Android development. Fishermen can simply take a picture of their catch using their smartphone. The app will then utilize a pre-trained ML model to analyse the image and identify the fish species within seconds. This eliminates the need for manual reporting and reduces the risk of errors.

Furthermore, the app will leverage the smartphone's GPS functionality to capture the location where the image is captured. This additional data point, along with the identified fish species and weather conditions, can provide valuable insights into fishing patterns and environmental factors that influence fish populations in specific areas. Additionally, the app will maintain a history of each user's catches, including the location of capture, acting as a comprehensive logbook for fishermen to track their success and analyse their fishing strategies.

By integrating this app with INCOIS's existing fishermen feedback system, we can create a powerful tool for data collection and analysis. Location data will provide a crucial layer of detail, enabling INCOIS to provide highly targeted and effective advisories based on specific fishing grounds. This will ultimately promote sustainable fishing practices and the health of our oceans.

1.2 PROBLEM STATEMENT

Problem/Current Situation: INCOIS is providing Marine Fishery Advisory Services to the fishermen. To evaluate its accuracy and in order to develop species-specific advisories it is necessary to collect the fish-catch information at the species level. While fisherfolk are supportive to these efforts, often species level catch reporting is having hinderances due to several reasons pertaining to manual efforts which results to low or erroneous reporting.

Solution Needed: One may develop AI-ML based tool for image-based identification of fish-species found in the Indian seas. The images of fishes may be taken from online image searches. INCOIS will be able to use this for its fishermen feedback app, where fishermen need to take a photo of fishes caught and fish-identification will be done through code, minimizing the manual intervention.

1.3 OBJECTIVES

The objectives of this project can be summarized by these key goals:

- **Improve Data Collection for INCOIS:** Develop a user-friendly and efficient tool for fishermen to report fish catches with accurate species identification. This will provide INCOIS with higher quality data for better analysis of fish populations.
- **Empower Fishermen with Real-time Identification:** Equip fishermen with a mobile app that instantly identifies fish species through pictures, eliminating the need for manual reporting and reducing errors.
- **Enhance Fishery Advisories:** By providing INCOIS with more accurate and species-specific data, the project aims to enable them to deliver more targeted and effective fishery advisories to fishermen. This can contribute to sustainable fishing practices and improved ocean health.
- **Streamline Data Collection Process:** By simplifying fish catch reporting with the app, the project aims to reduce reliance on manual methods and associated time constraints for both fishermen and INCOIS.
- **Gain Valuable Insights:** The project aims to collect additional data points like location and weather conditions alongside fish identification. This comprehensive data can provide valuable insights into fish distribution patterns and environmental influences.

Overall, this project focuses on leveraging technology to bridge the gap between fishermen and INCOIS, leading to improved data collection, better decision-making, and ultimately, promoting sustainable fishing practices.

1.4 SCOPE

This project focuses on developing a mobile application for Android devices to streamline fish species identification for fishermen and improve data collection for INCOIS. The scope encompasses the following key functionalities:

- **Real-time Fish Species Identification:** The app will utilize a pre-trained machine learning model to analyse pictures of fish captured by users. This model will be trained on a comprehensive dataset of fish species commonly found in Indian waters. The app will aim to identify the fish species within seconds, eliminating the need for manual reporting and reducing errors.
- **User-friendly Interface:** The app will be designed with a user-friendly interface, ensuring easy navigation for fishermen with varying levels of technical expertise. The app will primarily focus on functionalities relevant to fishermen, such as the camera function for capturing fish pictures and a clear display of the identified species.
- **Offline Functionality (Limited):** While a primary internet connection will be required for real-time fish identification using the ML model, we will explore the possibility of allowing users to capture fish pictures offline. These pictures could then be uploaded and analysed when an internet connection becomes available.
- **Location Tracking:** The app will leverage the GPS capabilities of smartphones to capture the location where the fish picture is taken. This data will be crucial for INCOIS to understand fish distribution patterns across different regions.
- **Weather Data Integration:** The app will explore integrating weather data from external sources based on the captured location. This data, along with the identified fish species and location, can provide valuable insights into potential correlations between weather patterns and fish populations.
- **Catch History:** The app will maintain a history of each user's catches, including the identified species, location, and date. This digital logbook will be beneficial for fishermen to track their catches, analyse trends, and potentially inform their fishing strategies.

Exclusions:

- This project will focus on fish species commonly found in Indian waters. Expanding the app's scope to include a global fish database is beyond the current project's timeframe.
- Developing a dedicated server-side infrastructure for data storage and analysis is outside the scope of this project. We will explore integrating the app with INCOIS's existing data management systems.
- Advanced features like real-time fish size or weight estimation are not included in this project's initial scope but can be considered for future enhancements.

CHAPTER 2: LITERATURE REVIEW

Identifying fish species accurately is crucial for various fields, from marine biology and fisheries management to environmental conservation efforts. Traditionally, this task has relied on the expertise of researchers and fishermen, a process that can be time-consuming, labour-intensive, and prone to human error. However, the exciting world of artificial intelligence (AI) and machine learning (ML) is revolutionizing this field by offering automated fish identification systems. This review dives into recent research, exploring the potential and challenges of these automated approaches.

One promising avenue for fish identification involves smartphone applications [2][3]. These user-friendly apps capture images of fish and leverage image recognition techniques to identify the species. A study by [2] achieved a remarkable 98% accuracy using a deep learning network, showcasing the immense potential of this approach. Imagine fishermen or researchers in the field being able to quickly and accurately identify a fish species simply by capturing an image with their smartphones! This not only saves time and resources but also ensures consistent and objective identification.

Another exciting area of research tackles the complexities of underwater fish classification [1][4]. Underwater environments pose unique challenges for automated identification due to factors like background noise, variations in lighting, and image distortion caused by water movement. One approach by [1] utilizes convolutional neural networks (CNNs) – a powerful deep learning technique – alongside image processing methods to achieve an accuracy of 96.29%. Another study by [4] explores the effectiveness of short-time Fourier transform (STFT) in extracting features from the unique shapes of fish ear bones (otoliths) for species identification. Their findings demonstrate promising results, paving the way for more robust identification methods in challenging underwater environments.

The quest for accurate fish identification extends beyond static images. Researchers are actively investigating methods for analysing unconstrained video data from tropical waters [5]. This data presents a particularly complex challenge due to factors like multiple backgrounds, weather variations, and the rapid growth of algae. One study by [5] proposes a transfer learning approach using a RestNet50 deep convolutional neural network. Transfer learning involves leveraging a pre-trained model for a similar task and fine-tuning it for the specific problem of fish identification in tropical waters. Their study yielded promising results, suggesting that this approach can be effective in these challenging environments.

Despite the significant advancements, there are still hurdles to overcome. One common challenge is the vast diversity of fish species, with new species being discovered regularly. Building robust identification systems requires extensive training datasets encompassing a wide range of fish species from various geographic locations. Additionally, underwater environments continue to pose challenges due to limited visibility, variations in water quality, and the presence of other marine life that can obscure the target fish.

Future research directions include:

- Expanding Training Datasets: Continuously collecting and incorporating data on a broader range of fish species will enhance the accuracy and generalizability of these systems.

- Addressing Environmental Challenges: Developing algorithms that can effectively handle variations in lighting, water quality, and background noise will be crucial for real-world applications in diverse underwater environments.
- Real-Time Identification: While some studies achieve high accuracy, processing times can be a limiting factor. Optimizing algorithms for real-time identification in the field would be a significant advancement.
- Integration with Existing Technologies: Integrating these automated identification systems with existing underwater exploration tools and mobile applications would create a powerful suite of tools for researchers, fishermen, and conservation efforts.

In conclusion, automated fish identification systems are a rapidly evolving field with immense potential to revolutionize various industries. The reviewed studies showcase the effectiveness of deep learning, image processing, and other AI techniques in achieving high accuracy rates. As research continues to address the existing challenges and explore new avenues, these systems are poised to become even more robust, versatile, and user-friendly, ultimately contributing to a deeper understanding of our underwater world and its inhabitants.

CHAPTER 3: PROPOSED METHODOLOGY

This project will follow a systematic approach to develop the mobile application for fish species identification. Here's a breakdown of the key steps involved:

1. **Data Collection and Preprocessing:**
    - Gather a comprehensive dataset of fish images representing various species commonly found in Indian waters. Sources can include collaborations with research institutions, fisheries departments, and online repositories.
    - Preprocess the image data to ensure consistency and quality. This may involve tasks like resizing images, removing background noise, and potentially segmenting the fish from the background for clearer identification.

2. **Machine Learning Model Development:**
    - Select a suitable machine learning model architecture, such as Convolutional Neural Networks (CNNs) which excel at image recognition tasks.
    - Train the chosen model on the pre-processed fish image dataset. This training process involves feeding the model labelled images, allowing it to learn the distinctive features of each fish species.
    - Evaluate the model's performance using metrics like accuracy and precision. This helps assess the model's effectiveness in correctly identifying fish species.

3. **Mobile App Development:**
    - Develop the Android application using Kotlin, focusing on a user-friendly interface for fishermen.
    - Integrate the trained machine learning model into the app. This may involve optimizing the model for mobile device deployment to ensure efficient performance.
    - Implement functionalities like camera access for capturing fish pictures, real-time species identification using the model, and location tracking via GPS.
    - Develop a system to display the identified fish species along with potentially relevant details about the species.
    - Explore options for limited offline functionality, allowing fishermen to capture pictures without an internet connection and upload them for identification later.

4. **Testing and Deployment:**
    - Conduct thorough testing of the app to ensure functionality, accuracy of fish identification, and user-friendliness.
    - Prepare the app for deployment on the Google Play Store, ensuring adherence to their guidelines.

5. **Integration with INCOIS System (Optional):**
    - Explore the possibility of integrating the app with INCOIS's existing data management system. This would allow fishermen's catch data to seamlessly flow into INCOIS's platform for further analysis and informing fishery advisories.

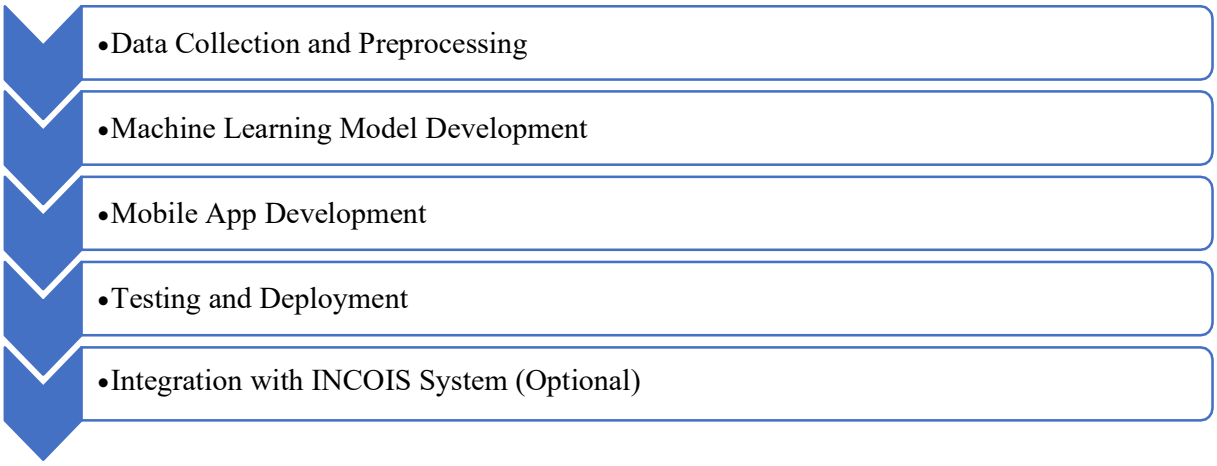

Fig.1. Proposed Approach

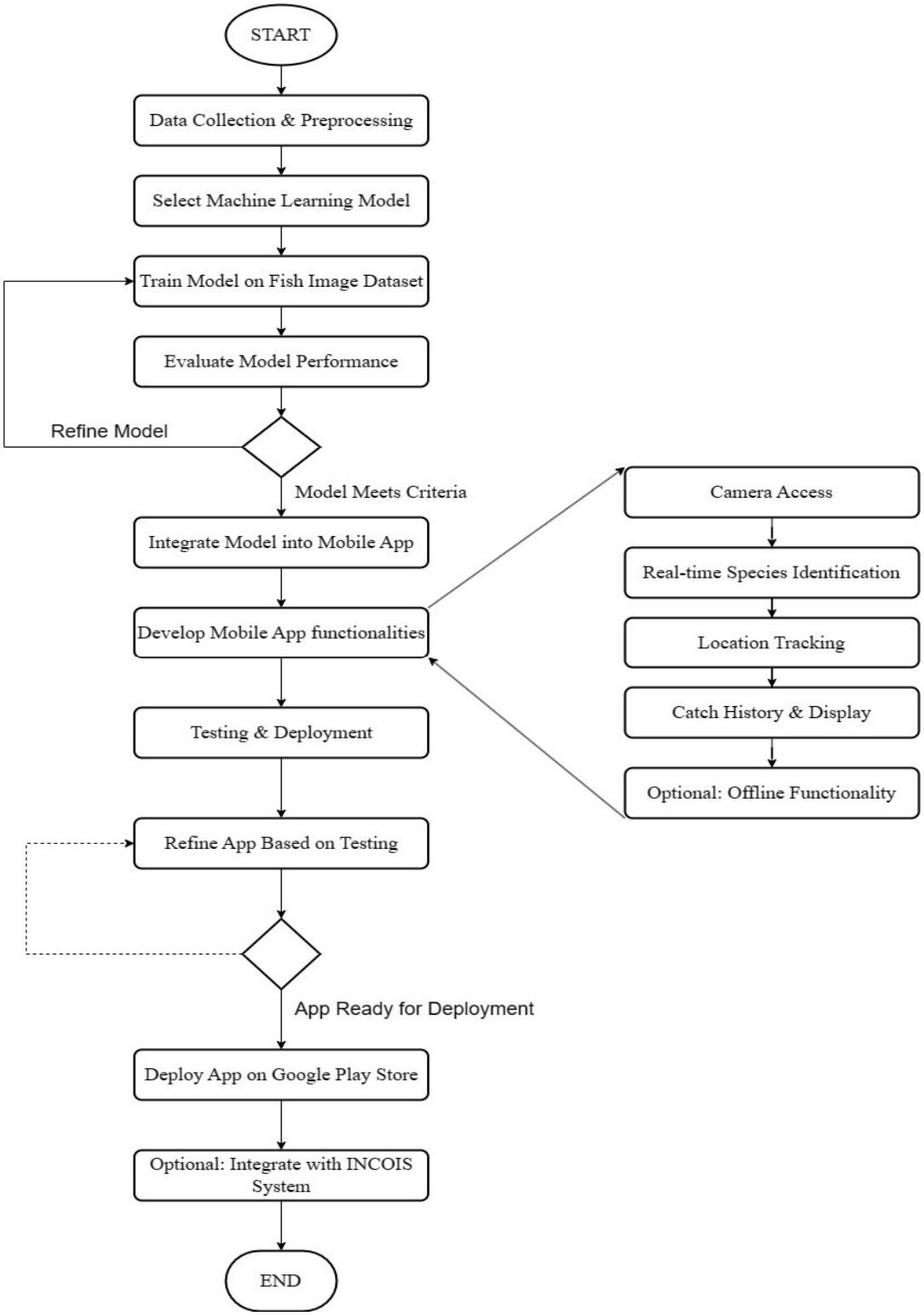

Fig.2. Flowchart

3.2 ALGORITHM PROPOSED

1. **Data Preprocessing:**
   - Input: Raw fish image dataset.
   - Steps:
     - Resize images to a consistent size.
     - Convert images to a common colour format (e.g., RGB).
     - Apply techniques like normalization or standardization to ensure data uniformity.
     - Optionally, implement image segmentation to isolate the fish from the background for clearer identification.

2. **Machine Learning Model Training:**
   - Model Selection: Choose a Convolutional Neural Network (CNN) architecture known for its effectiveness in image recognition tasks. Popular options include VGG16, ResNet, or MobileNet (considering mobile device deployment).
   - Training Process:
     - Divide the pre-processed fish image dataset into training, validation, and testing sets.
     - Train the CNN model on the training set. The model learns to identify distinctive features in the images that correspond to specific fish species based on labelled data.
     - Use the validation set to monitor the model's performance during training and prevent overfitting.
     - Evaluate the model's accuracy and precision on the testing set to assess its generalization capabilities on unseen data.

3. **Mobile App Functionality:**
   - **Image Capture:** The app utilizes the phone's camera to capture an image of the fish.
   - **Preprocessing (Optional):** Depending on the chosen implementation, basic preprocessing steps like resizing or colour conversion might be applied on the captured image within the app.
   - **Model Inference:** The captured image is fed into the pre-trained CNN model.
   - **Species Identification:** The model analyses the image and outputs the most likely fish species based on the learned features.
   - **Additional Information (Optional):** The app can display relevant information about the identified species, retrieved from a database (if available).
   - **Location and Weather Data (Optional):** If enabled, the app can access the device's GPS to record the location of the fish capture. Additionally, it can integrate with external weather data APIs to retrieve weather information at the capture location.
   - **Catch History:** The app can store information about each identified fish, including species, location (if enabled), date, and potentially weather data (if enabled). This serves as a digital logbook for fishermen to track their catches.

CHAPTER 4: TECHNOLOGY USED

1. Machine Learning and Image Recognition:

- **Machine Learning Model:** We'll be utilizing a pre-trained Convolutional Neural Network (CNN) for image recognition. Popular choices for mobile deployment could be VGG16, ResNet, or MobileNet. These models excel at identifying patterns and features within images, allowing them to learn the distinct characteristics of various fish species.

- **Training Data:** A comprehensive dataset of fish images representing the species we want the app to identify is crucial. This data will be used to train the CNN model. Sources for this data can include collaborations with research institutions, fisheries departments, or online repositories.

2. Mobile App Development:

- **Programming Language:** Kotlin is a modern and well-suited language for developing Android applications. It offers features like type safety and null-safety, making it efficient and reliable for app development.

- **Software Development Kit (SDK):** The Android SDK provides the tools and libraries needed to build Android apps. It includes essential functionalities like camera access, GPS integration, and user interface development tools.

- **Optional: Offline Functionality:** If we want to explore allowing image capture without an internet connection, we might need to consider additional libraries or frameworks for handling temporary image storage on the device.

- **Optional: Integration with External APIs:** For features like retrieving weather data based on location, the app might leverage APIs (Application Programming Interfaces) provided by weather service providers.

Additional Technologies (Optional):

- **Cloud Storage:** Depending on the chosen implementation, cloud storage services might be considered for storing large datasets of fish images or user catch information (if INCOIS integration isn't feasible).

- **Data Management System:** If integrating with INCOIS's existing data management system is pursued, additional technologies related to data transmission protocols and API interactions might be involved.

CHAPTER 5: ER DIAGRAM

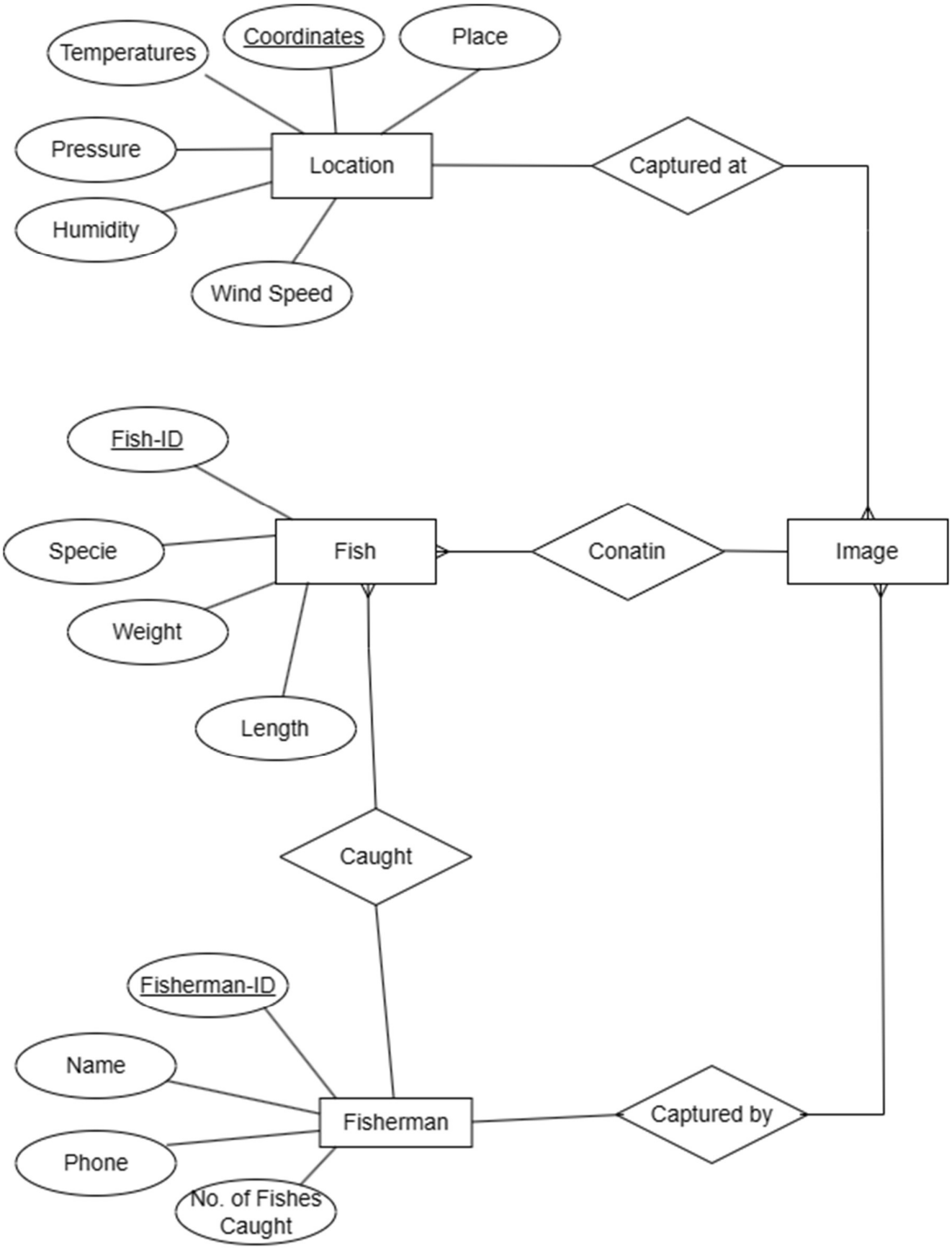

Fig.3. ER Diagram

CHAPTER 6: CONCLUSION

This project proposes a novel mobile application designed to revolutionize fish species identification for fishermen and data collection for INCOIS. By leveraging the power of machine learning, the app has the potential to significantly improve the efficiency and accuracy of reporting fish catches.

The core functionality revolves around a pre-trained Convolutional Neural Network (CNN) model integrated within the Android app. This model, trained on a comprehensive dataset of fish images commonly found in Indian waters, will enable real-time fish species identification based on pictures captured by fishermen. This eliminates the need for manual reporting, reduces errors, and streamlines the data collection process. Furthermore, the app can capture the location of fish capture using the device's GPS. This, along with the identified fish species, provides valuable data points for INCOIS. Additionally, the app can explore integrating weather data from external sources based on the location. This comprehensive data set can offer valuable insights into fish distribution patterns, environmental factors impacting fish populations, and potential correlations between weather and fish catches.

The app also offers benefits to fishermen. They gain access to a user-friendly tool that instantly identifies fish species, eliminating the need for reference guides or relying on memory. The app maintains a history of each user's catches, acting as a digital logbook. This allows fishermen to track their success, analyse trends, and potentially inform their fishing strategies.

Ultimately, this project aims to bridge the gap between fishermen and INCOIS through technology. By providing accurate and species-specific data, the app empowers INCOIS to deliver more targeted and effective fishery advisories. This, in turn, can contribute to promoting sustainable fishing practices, healthier fish populations, and a more robust fishing industry in India. The success of this project hinges on a well-trained CNN model, a user-friendly and efficient mobile application, and potential integration with INCOIS's existing systems. By addressing these aspects, this project offers a promising solution for improving fish species identification, data collection, and ultimately, promoting sustainable fisheries in India.

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