

Abstract

India's fisheries sector has emerged as a global leader, driven by initiatives like the Pradhan Mantri Matsya Sampada Yojana (PMMSY) and the integration of Industry 4.0 technologies into aquaculture. These advancements, termed "Aquaculture 4.0," employ Artificial Intelligence (AI) and Machine Learning (ML) for real-time monitoring, disease detection, feed optimization, and fish species identification. Among these, fish species recognition is a critical yet challenging task, especially in cluttered fish market environments, where the disorganized placement of fish, occlusions, background noise, and varying illumination hinder accurate manual identification. This thesis aims to develop automated methods for fish species recognition using advanced ML and deep learning (DL) techniques, addressing the complexities of both non-cluttered and cluttered environments.

Fish is a vital part of the Indian diet, particularly in coastal and inland regions, due to its high protein content and rich nutritional profile. However, consumers often lack awareness of the nutritional benefits of different fish species, making it difficult to select fish that meet specific dietary needs. The manual identification process is labour-intensive, time-consuming, and susceptible to errors. Automated fish recognition not only assists consumers in markets but also benefits the fisheries and aquaculture industries by improving efficiency, accuracy, and productivity. This thesis presents a comprehensive approach to fish species recognition, leveraging machine learning frameworks and novel dataset development tailored to the Indian context.

The study begins by addressing fish recognition in non-cluttered environments. A dataset of three Indian major carps (IMCs) and three exotic carps was created to train and test the proposed models. Using deep convolutional autoencoders, latent features were extracted and integrated with traditional machine learning algorithms for classification. Transfer learning approaches were applied to fine-tune pre-trained DL models like VGG16, InceptionV3, and ResNet, achieving state-of-the-art performance in classifying fish in controlled settings.

The research progresses to tackle the more complex scenario of fish recognition in cluttered environments, such as live fish markets. Here, object detection models like YOLOv3 and YOLOv5 were employed for fish localization and identification, overcoming occlusion and background noise. Additionally, semantic segmentation techniques using U-Net and PSPNet architectures were implemented for pixel-level fish identification, further enhancing recognition accuracy. A novel dataset, annotated with bounding boxes and segmentation masks, was developed for these tasks, making a significant contribution to the field. Advanced techniques such as Weighted Box

Fusion and Testing Time Augmentation were integrated to optimize detection performance.

Recognizing the practical implications of this work, a consumer-centric mobile application was developed to identify fish species in real-time and provide tailored nutritional information. This application empowers consumers to make informed dietary choices, linking AI technology with everyday usability. By bridging the gap between technical innovation and societal needs, the application showcases the versatility and impact of AI in daily life.

The contributions of this thesis are manifold: the creation of four comprehensive datasets for fish species recognition, the application of cutting-edge DL models in cluttered environments, and the development of an end-to-end system for industrial and consumer applications. These advancements hold immense potential for automating fish identification in fisheries management, aquaculture operations, and consumer markets.

In conclusion, this research addresses a pressing need in fisheries and aquaculture by developing robust solutions for fish species recognition. Beyond enhancing operational efficiency, it provides consumers with tools for better nutritional decision-making, contributing to public health and sustainable fisheries. Future directions include expanding the datasets to include more fish species and exploring underwater recognition systems for ecological and biodiversity applications.