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Image Based Machine Learning Technique for Aquatic Animal Health Management

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Abstract

Aquaculture contributes immensely to global food security and economic development but remains under threat in terms of its sustainability due to disease outbreaks resulting in enormous losses. Management of aquatic animal health is very critical in managing such challenges. In this article, the integration of new technologies like machine learning (ML) and image processing is discussed for the diagnosis of diseases and health monitoring. These novel methods facilitate the early detection of pathogens, real-time monitoring, and automatic fish disease classification, which minimize losses and enhance productivity. Through ML-based diagnostics, biosecurity tools, and computerized monitoring platforms, aquaculture can optimize disease surveillance. Implementing new technologies will be fundamental in overcoming today's constraints and providing long-term sustainability to the industry.

Keyword: Aquaculture, Machine Learning, Image Processing, Aquatic Animal Health Management, Disease Surveillance

Introduction

Aquaculture refers to the cultivation of aquatic animals, such as fish, crustaceans, molluscs, and aquatic plants, under controlled conditions (Huntingford et al., 2012). Aquaculture is an important contributor to world food security, economic development, and rural poverty mitigation. Aquaculture contributes enormously to different aspects of society, providing many advantages. For example, aquaculture offers huge employment opportunities, especially in rural communities, hence improving livelihoods and economic stability. Also, being a rich source of good-quality protein, it contributes to the fight against protein malnutrition and ensures nutritional security (Pradeepkiran et al., 2019).

Current Challenges in Aquaculture

Disease outbreaks are still one of the most prominent challenges facing the sustainable development of aquaculture. Disease agents and diseases themselves are big concerns for the industry, and their effects on it are greatly restraining its maximum potential (FAO, 2024). Fish diseases are having a high economic effect with a global estimated loss of $6 billion each year (World Bank, 2014). A study on white spot syndrome virus (WSSV) and

Enterocytozoon hepatopenaei (EHP) estimated a loss of about 1.02 billion USD (~₹8,300 crore) per year. The study was conducted on the basis of a survey of 7,259 hectares in 23 coastal districts in 2018–2019 (Patil et al., 2021).

ML for Aquatic Animal Health Management

Machine learning (ML) contributes significantly to the management of aquatic animal health by facilitating the diagnosis of fish disease accurately. Two major components are involved in the process: image processing technology and ML-based analysis. Image processing improves the quality of images by eliminating noise and achieving clearer views, which assist in identifying and diagnosing the disease in fish accurately, this is a necessary step to maintain high-quality data prior to analysis (Torres & Arroyo, 2018). After processing the images, ML algorithms scan sub-images of infected fish body parts to identify key features like color and texture through statistical and wavelet methods. The features enable discrimination between healthy and diseased fish, enabling early detection and intervention (Morimoto et al., 2018).

Image Processing Technology

Image processing technology adopts a systematic methodology in the analysis of digital images. It begins with image acquisition, then pre-processing to improve quality and eliminate noise. Segmentation then splits the image into meaningful regions, while feature extraction isolates significant features. Target recognition then identifies and localizes objects for proper interpretation.

Image Acquisition

Image acquisition is a core element of aquaculture health monitoring since it allows for the acquisition of high-resolution images necessary for accurate analysis sophisticated imaging methods, including cameras and drones, are commonly employed to obtain underwater images of fish in their natural environment. It includes taking good quality pictures in order to determine the aquatic habitat, observing fish surface irregularities or swimming habits. (Bohara et al., 2024).

Image Pre-Processing

Pre-processing of an image eliminates noise or removes unnecessary information from the image and enhances the quality of the image. Image pre-processing improves the visual data collected from images. In this median filter is utilized, showing its efficiency in processing pixels with impulse noise contamination, thus enhancing the quality of the fish images. Furthermore, sharpening and smoothing methods are applied to improve the images. Sharpening accentuates the contours and edges so that distinguishable features that are important in disease identification become simpler to analyze. Smoothing assists in achieving a smoother and more gradual brightness throughout the image, further enhancing overall image quality. Lastly, contrast enhancement is used to

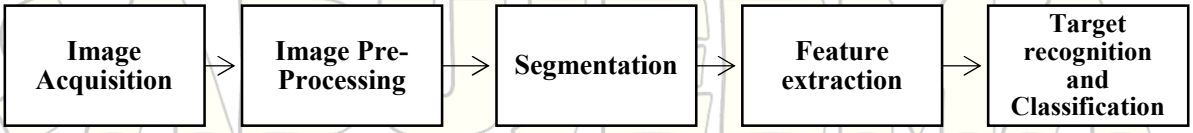
manipulate the contrast of the image to make the features clearer and enable identification of color and textural alterations associated with disease. All these preprocessing procedures guarantee that the images are in their best form for precise analysis and diagnosis of fish disease (Pauzi et al., 2021).

Image Segmentation

Segmentation is the act of dividing an image into meaningful, separate regions. Segmentation makes it easy to analyze individual components and measure the area of a diseased surface in fish. Dividing the image into meaningful segments allows ML model to isolate and analyze individual features or anomalies, which is necessary for effective diagnosis and planning treatment (Malik, Kumar, & Sahoo, 2017).

Target recognition and Classification

This is a process that depends on feature extraction and feature classification according to color, shape, and texture. For example, Chakravorty created a system for the diagnosis of Epizootic Ulcerative Syndrome (EUS) in freshwater fish by applying image processing methods. They extracted features from images of affected fish and utilized Principal Component Analysis (PCA) for feature processing. Then they applied Euclidean distance for classification with an accuracy of more than 90%. Despite its success, more research could investigate any shortcomings or limitations that were not well described in the provided research (Chakravorty et al., 2015).



Feature extraction

This is a method of applying computer algorithms to read images and pick out certain measurable features or characteristics within them. There are multiple features that may be used to make accurate automatic detection of fish diseases. Color, texture, shape, and spatial features are generally included in feature extraction. Some of the more popular techniques include Haar, LBP, HOG, and SIFT features (Li et al., 2022).

Conclusion

Aquatic animal health management is crucial to maintaining aquaculture's sustainability and productivity. Disease outbreaks are still the key challenge, which has the potential to create major economic losses and jeopardize food security. Improved technology, specifically machine learning (ML) and image processing, presents innovative opportunities for the early detection of diseases and successful health monitoring. Through the integration of real-time monitoring systems, automated diagnostic

platforms, and ML-based analysis, aquaculture can improve disease surveillance, reduce losses, and enhance overall efficiency.

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