# SHRIMPAI: A Mobile Application for the Early Detection of White Spot Syndrome Virus in Shrimp Using Convolutional Neural Network

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## Abstract

*The white spot syndrome virus (WSSV) is a highly infectious and potentially fatal disease that has a significant worldwide impact on the shrimp farming industry. This study aims to develop a mobile application that assists in the early detection of WSSV in shrimp using convolutional neural network. This early detection enables timely interventions, such as quarantining infected shrimp; hence, preventing crop losses. The application also incorporates predictive analytics and historical health data, enhancing farm management and allowing farmers to make informed decisions about feeding, breeding, and harvesting. This data-driven approach improves productivity and promotes sustainable practices by reducing reliance on chemicals. The CNN model was trained and tested using 5-fold cross-validation on original and augmented datasets. Performance evaluation involved shrimp farmers, SEAFDEC/AQD staff, BFAR experts, and vendors from Cogon Market, Cagayan de Oro City. Results showed the system achieved real-time WSSV detection with 100% accuracy and 99.9% specificity, maintaining a low false positive rate of 0.1%. This ensures reliable disease management for infected and healthy shrimp. The proposed system offers a cost-effective alternative to traditional detection methods, with the potential to transform aquaculture through early and accurate WSSV detection. This study underscores the importance of leveraging mobile technology and deep learning techniques, like CNNs, to develop accessible solutions for disease detection.*

***Keywords:*** artificial intelligence, CNN, mobile application, shrimp, White Spot Syndrome Virus (WSSV)

## 1. Introduction

White Spot Syndrome Virus (WSSV) is one of the most devastating pathogens affecting shrimp aquaculture worldwide, particularly targeting whiteleg shrimp (*Penaeus vannamei*) and tiger shrimp (*Penaeus monodon*). WSSV infections result in mortality rates of up to 100% in infected populations, causing catastrophic losses to shrimp farms and significant economic instability (Dungca *et al*., 2021; Leaño *et al*., 2018). The Philippines, as a leading shrimp producer, is especially vulnerable to WSSV outbreaks, which threaten the sustainability of its aquaculture sector (Cabrera *et al*., 2019; Jumawan *et al*., 2019; Philippine Statistics Authority, 2021). Beyond the financial losses, outbreaks reduce consumer confidence and disrupt the market for shrimp products (Ladia *et al*., 2020).

Early detection is crucial for mitigating the spread of WSSV and minimizing its impact. Traditional diagnostic techniques, such as polymerase chain reaction (PCR) and real-time PCR (RT-PCR), remain the gold standard but are constrained by the need for advanced equipment and skilled personnel, limiting their accessibility for small-scale farmers (Han *et al*., 2019; Magbanua *et al*., 2019; Phuoc *et al*., 2019). Alternative methods like enzyme-linked immunosorbent assay (ELISA) and loop-mediated isothermal amplification (LAMP) have been explored but face similar limitations in practical applications (Mohapatra *et al*., 2020; Sirimanapong *et al*., 2019). Advanced molecular techniques, such as the use of immune response markers, have provided insights into WSSV infection pathways but have yet to translate into field-ready solutions (Ladia *et al*., 2020).

Recent advancements in machine learning (ML) and deep learning (DL) offer promising opportunities for improving disease detection in aquaculture. Techniques leveraging convolutional neural networks (CNNs) have demonstrated significant potential in automating and expediting the diagnostic process (Chen *et al*., 2020; Duong-Trung *et al*., 2020; Minaei *et al*., 2021). For example, the application of hybrid neural networks with fuzzy logic, as explored by Fabregas *et al*. (2018), and the use of transfer learning models, as studied by Ashraf and Atia (2021), have enhanced accuracy in detecting shrimp diseases. More recently, models such as LeNet have been improved for rapid and precise disease identification, further demonstrating the potential of CNNs for real-world applications (Wang *et al*., 2023).

Studies on intelligent aquaculture systems have also highlighted the importance of integrating ML techniques with user-friendly interfaces to facilitate field applications. For instance, Faster R-CNN-based systems have been developed for disease and species detection in aquaculture, showcasing the potential of ML algorithms in creating practical solutions (Rosales *et al.*, 2021). Sapin *et al*. (2022) further emphasized the need for intelligent systems tailored to aquaculture's specific requirements, including disease diagnosis and farm management. While these advancements have contributed to the field, there remains a gap in accessible tools designed specifically for small-scale shrimp farmers.

The proposed study wants to address these gaps by developing a mobile application leveraging CNNs for the early detection of WSSV in shrimp. The application will integrate advanced image analysis techniques to accurately classify shrimp as infected or healthy, enabling rapid and accessible diagnostics for farmers in diverse conditions. Through rigorous testing and evaluation, the study aims to ensure the application's reliability and practicality in real-world settings (Fabregas *et al.*, 2018; Chen *et al.*, 2020). By integrating these technologies, the research aspires to provide a transformative tool for early disease detection, reducing economic losses and promoting sustainable shrimp farming practices.

## 2. Methodology

### *2.1 Data Gathering*

The main data of the study is gathered from Southeast Asian Fisheries Development Center Aquaculture Department (*SEAFDEC/AQD*), Fish Health Section, Tigbauan, Iloilo, Philippines. An interview was conducted with a technical assistant and a resource person specializing in fish species diseases, specifically on White Spot Syndrome Virus (WSSV). The interview focused on understanding the prevalence and impact of WSSV on shrimp populations, obtaining expert knowledge on disease management practices, and deriving valuable information on the symptoms, diagnosis, and treatment of WSSV. In addition, datasets of shrimp infected with the virus were requested from SEAFDEC. This datasets will be used for training, validation, and testing of the planned development of mobile application for identification and detection of WSSV in shrimp.

According to SEAFDEA/AQD, WSSV is detected using two types of shrimp species: whiteleg shrimp (*P. vannamei*) and tiger shrimp (*P. monodon*). Figure 1 and 2 shows one of the thousands of datasets provided by SEAFDEC/AQD, consisting of three datasets each of tiger shrimp (*P. monodon*) and whiteleg shrimp (*P. vannamei*).

Figure 1. Sample photos of tiger shrimp (*P. monodon*)

Figure 2. Sample photos of whiteleg shrimp (*P. vannamei*)

This study conducted a series of tests using various thresholds to evaluate the accuracy of the mobile application designed for detecting WSSV in shrimp. By adjusting these thresholds, the optimal settings that would maximize the application's performance in distinguishing between healthy and infected shrimp specimens will be identified. The results of these tests provided insights into the sensitivity and specificity of the detection system, allowing to fine-tune the algorithm for improved accuracy. Ultimately, this process contributed to the development of a reliable tool for early disease diagnosis, which is crucial for minimizing economic losses in the shrimp aquaculture industry. The usage of a large number of datasets was an essential component in improving the effectiveness and robustness of the model in determining whether or not the shrimp had WSSV.

To provide this study with numerous datasets and to boost the diversity of a dataset, image augmentation, a method that creates modified replicas of the original photos, was utilized. Images are, in computer words, a collection of two-dimensionally ordered numbers that represent the pixel values. To produce new and improved photographs, these variables can be altered in a variety of ways.

In addition, this study collected data from "Roboflow," an online tool developed using the company's end-to-end platform for picture and video collecting, organization, annotation, preprocessing, and model training and deployment.

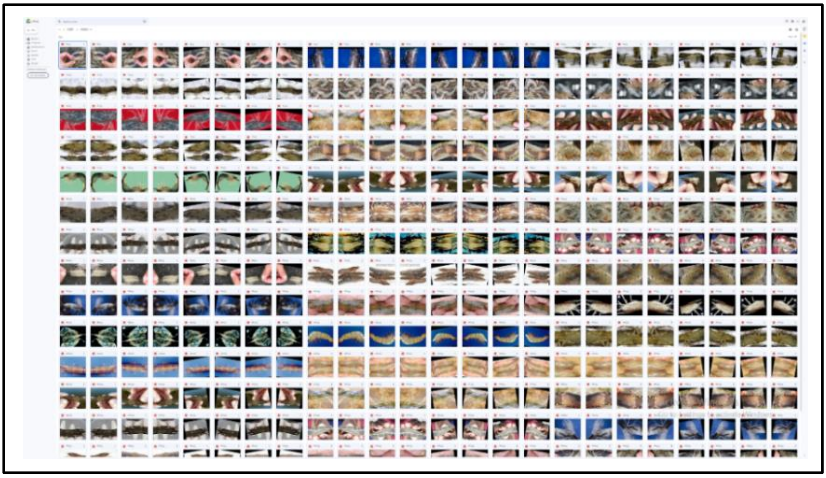


Figure 3. Shrimp WSSV Dataset

Figure 3 showed a total of 2,400 datasets from Roboflow and augmented photos from SEAFDEC/AQD. The constrained dataset size increases the risk of overfitting, wherein the model learns specific details and noise present in the training data rather than general patterns. As a result, the model may exhibit high accuracy on the training set but struggle when exposed to new, unseen data or conditions that were not represented in the training set. Specifically, this limitation could affect the model’s ability to generalize across different environmental conditions, such as variations in water quality, lighting, or background elements, as well as across different shrimp species, which may exhibit unique morphological characteristics.

### *2.2 Application Design for Detecting Whiteleg Shrimp (P. vannamei) and Tiger Shrimp (P. monodon) Potentially Infected with White Spot Syndrome Virus (WSSV).*

This study designed an application that can take a picture, analyze it, and determine presence or not of WSSV.

#### 2.2.1 System Architecture

The system architecture of the SHRIMPAI mobile application is designed to facilitate the early detection of WSSV in shrimp through image classification. A critical component of this architecture is the dataset utilized for training the convolutional neural network (CNN) model, which consists of images of two primary shrimp species: whiteleg shrimp (*P. vannamei*) and tiger shrimp (*P. monodon*). The dataset comprises a diverse collection of shrimp images categorized into two main classes: healthy shrimp and shrimp infected with WSSV. Images in the healthy shrimp category depict shrimp exhibiting normal coloration and physical characteristics, such as a smooth exoskeleton without any visible lesions or discoloration. In contrast, the WSSV-infected shrimp category includes images showing clear symptoms of infection, such as the presence of white spots on the exoskeleton, discoloration of the hepatopancreas, and other internal symptoms like lethargy and loose shells.

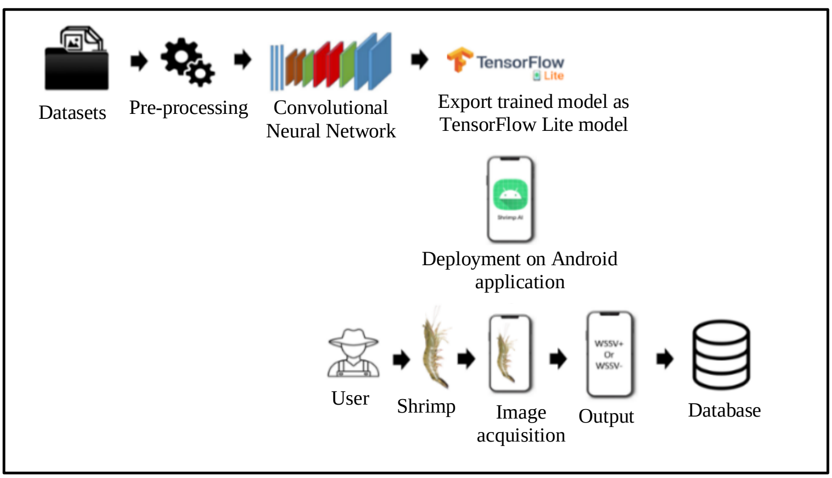



Figure 4. System Architecture

Figure 4 shows the System Architecture on the classification involving training the CNN model to distinguish between the two categories effectively.

The model learns to identify key visual features associated with each class, enabling it to classify new images accurately. By incorporating a well-structured dataset with clear examples of both healthy and infected shrimp, the SHRIMPAI application aims to provide users with a reliable tool for early detection of WSSV.

### 2.2.2 Convolutional Neural Network (CNN)

A Convolutional Neural Network (CNN) is a specialized deep learning model designed for image analysis, consisting of layers that automatically learn and extract features from visual data. In the SHRIMPAI application as shown in Figure 5, CNNs are specifically used to train datasets of shrimp images to differentiate between healthy shrimp and those infected with WSSV. The training process involves a curated dataset that includes images of both healthy and infected shrimp. The CNN learns to identify key visual features, such as the normal coloration of healthy shrimp and the characteristic white spots of WSSV infection. Techniques like data augmentation are employed to enhance the model's robustness by exposing it to a variety of image variations, improving its accuracy in classifying new images. Once trained, the CNN model is integrated into the SHRIMPAI application, allowing users to capture images and receive real-time feedback on shrimp health, thereby effectively aiding in the early detection of WSSV.

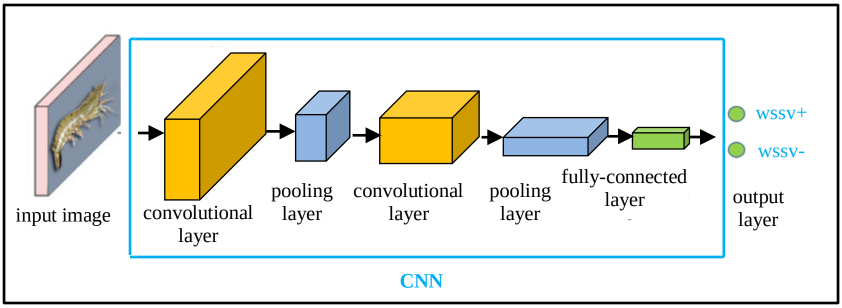



Figure 5. CNN Layer

### 2.2.3 Database Design

SQLite was utilized as the database management system to construct, design, and modify the database files that support the mobile application for detecting WSSV in shrimp. SQLite is a self-contained, serverless, and configuration-free transactional SQL database engine, making it an ideal choice for mobile applications due to its lightweight nature and ease of integration.

SQLite was employed to store and manage the data collected from the application, including images of shrimp, detection results, and historical records of WSSV tests. This database allowed for efficient data retrieval and storage, enabling the application to quickly access previous test results and provide users with a comprehensive history of their shrimp health assessments. By using SQLite, the application could maintain a local database on the user's device, ensuring that data was readily available even without an internet connection.

| test_records | |
|---|---|
| **id** | INTEGER |
| result | TEXT |
| accuracy | TEXT |
| created_at | TIMESTAMP |

Figure 6. Database Design of the Proposed System

Additionally, the use of SQLite, as shown in Figure 6, depicted the organization of the dataset used for training the CNN model. This study could easily update and modify the database as new images and detection results were generated, allowing for continuous improvement of the application's accuracy and performance. Overall, SQLite played a critical role in the functionality of the mobile application, supporting data management and enhancing the user experience by providing timely and relevant information regarding the presence of WSSV in shrimp.

2.2.4 Use Case Diagram

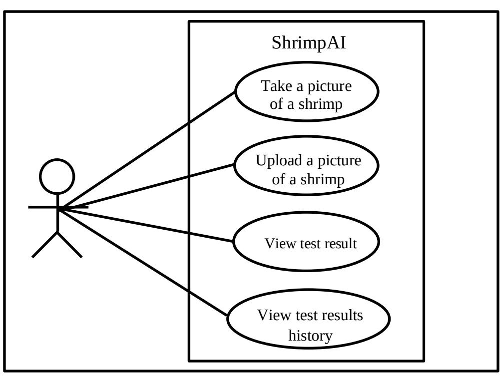



Figure 7. A Diagram Illustrating the Potential Scenarios and Interactions of the Proposed System

Figure 7 shows the various choices accessible to the user. The user can take a picture of a shrimp and view the result indicating whether the shrimp was positive or negative for WSSV. Furthermore, the user can access the result history of the detected tiger shrimps.

2.2.5 Context Diagram

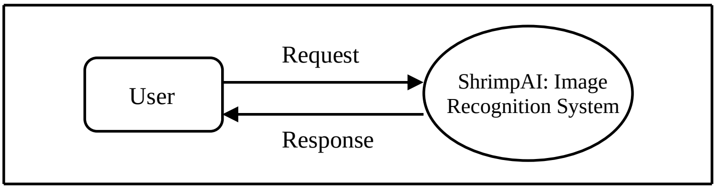



Figure 8. A Diagram Illustrating the Context of the Proposed System

Figure 8 illustrates the abstract view of the mobile application system (ShrimpAI) and its intended users: shrimp farmers, aquaculture personnel, and SEAFDEC/AQD staff. The image captured by the users (shrimp farmers or aquaculture personnel) is processed and diagnosed by the application; afterwhich, the results, including the health condition of the shrimp are displayed back to the users. The SEAFDEC/AQD personnel may also use the application for monitoring and validation purposes, ensuring the accuracy of diagnoses and recommendations.

2.2.6 Data Flow Diagram

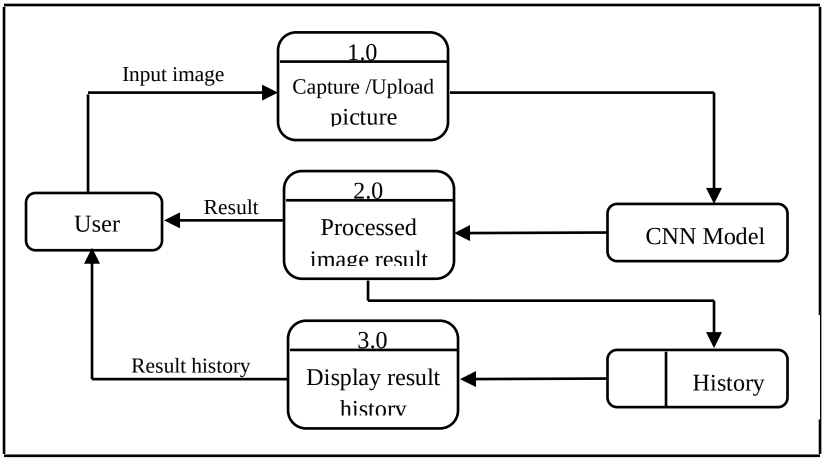



Figure 9. Data Flow Diagram of the Proposed System

Figure 9 demonstrates the Data Flow Diagram that was used to demonstrate the flow of data in the mobile application. The user could take a picture of the shrimps and after that, the image taken was processed. The results, together with the time taken and health condition of the shrimps whether positive or negative of WSSV were stored in the database and were displayed on the screen after the process. The user could also view the history of the results with the data taken from the database that contained the history information.

### *2.3 Classification of White Spot Syndrome Virus Presence in a Developed Mobile Application*

To develop the system, this study utilized image processing to detect and classify the white spot syndrome virus in shrimp, with the goal of preventing its spread.

#### 2.3.1 Software Specification

The software specifications utilized in the research played a crucial role in the successful development and implementation of a mobile application designed to detect WSSV in shrimp. Each software component contributed uniquely to the overall functionality and effectiveness of the application. Android Studio served as the primary integrated development environment (IDE), providing this study with a comprehensive platform for building the application. Its features, such as a smart code editor, versatile build system, and real-time profilers, facilitated efficient coding and debugging, ensuring that the application was user-friendly and capable of delivering accurate results.

TensorFlow Lite 2.18.0 was instrumental in deploying machine learning models on mobile devices, allowing to convert trained models into a format that is both space-efficient and optimized for speed. This capability ensured that the application could perform real-time image processing and analysis, which is critical for timely intervention in aquaculture practices. Additionally, Google Colab provided the necessary computational resources to process and train the machine learning models in a cloud-based environment. This tool enabled collaborative work and easy access to powerful hardware, streamlining the development process and enhancing the overall efficiency.

While not explicitly mentioned, the use of image processing libraries would have been integral to the application’s functionality, allowing it to analyze images of shrimp, identify features indicative of WSSV, and classify the health status of the specimens. This capability is vital for the application's primary goal of early detection and prevention of disease spread. Overall, the combination of these software tools and frameworks significantly contributed to the research by enabling the development of a sophisticated mobile application that leverages advanced technologies for disease detection in aquaculture.

2.3.2 Hardware Specification

The hardware specifications for the study included the use of an advanced smartphone running Google's Android operating system, specifically with Android 9 (Android Pie). The smartphone was equipped with at least an 8-megapixel camera, 50MB of free storage, and 2GB of RAM for optimal performance. Additionally, this study utilized an Acer A315-55 series laptop for the development and implementation of the mobile application. This laptop featured an Intel Core i5-1135G7 processor, a 15.6-inch FHD display, 8GB of DDR4 RAM (upgradable to 24GB), and 512GB NVMe SSD storage, ensuring sufficient processing power and storage capacity for the application development and testing processes.

*2.4 Evaluation of the functionality of the developed mobile application.*

System functionality testing was conducted to determine whether the developed mobile application satisfied the basic standards and requirements of the study. To gather feedback and recommendations, testing was carried out with experts, farmers, and vendors. The ISO/IEC 25010 guided questionnaire was utilized to test the functionality of the proposed mobile application. ISO/IEC 25010 is an international standard that defines a quality model for software product evaluation.

## 3. Results and Discussion

*3.1 Summary of Collected Data*

The data gathered from SEAFDEC/AQD provided the foundational datasets necessary for the study. The collected datasets comprised images and information pertaining to two specific shrimp species: tiger shrimp (*P. monodon*) and whiteleg shrimp (*P. vannamei*).

The acquired sample photos and pertinent information from SEAFDEC/AQD, were subsequently integrated into the application's training dataset. These datasets were instrumental in developing and testing the mobile application's functionality, ensuring its capability to accurately identify WSSV infections at an early stage. This thorough approach to data gathering was crucial for improving the accuracy and reliability of the mobile application's WSSV detection capabilities, thereby enhancing its effectiveness in practical aquaculture scenarios. The outcomes of this data gathering phase established a solid foundation for the subsequent evaluations of the application's functionality, ensuring that it was developed using a robust and relevant dataset that accurately represented the conditions and challenges encountered by shrimp farmers and vendors.

### *3.2 Development of the Mobile Application for Detecting Whiteleg Shrimp (P. vannamei) and Tiger Shrimp (P. monodon) Potentially Infected with White Spot Syndrome Virus (WSSV).*

The mobile app features a user-friendly interface that allows farmers to easily input data, access diagnostic tools, and receive real-time feedback on shrimp health. This accessibility ensures that even those with limited technical expertise can utilize the app effectively.


Figure 10. A screenshot of the application ShrimpAI

The main page of the mobile application is showed in Figure 10, and it features four buttons situated below the application's logo. The "Capture" button provides the ability to capture images directly from the user's phone camera, allowing for quick and easy access to diagnostic functions. The "Upload" button allows users to add previously taken pictures to the application, giving them a more comprehensive view of their diagnostic history. The "Records" button gives users access to their previous diagnostic history, which can be useful in monitoring progress and identifying potential issues. Finally, the "App Manual" button offers detailed instructions on how to use the mobile app effectively, ensuring a seamless user experience.

Overall, the mobile application's main page design and functionality were optimized to provide a straightforward and effective user experience. By offering quick and easy access to the diagnostic functions and previous diagnostic history, users can monitor shrimp health status with ease.


Figure 11. A screenshot of the mobile application interface indicating the test button.

Figure 11 shows the "Test" button, which provides users with the ability to take a picture using their phone's camera. This feature is designed to be intuitive and straightforward, allowing users to take pictures quickly and easily.

Figure 12 displays the outcome after selecting the "Upload" button in the mobile application. Upon selecting this button, the application searches through all of the images in the user's gallery and online drive to find images that are suitable for diagnostic purposes. This feature is designed to be both comprehensive and convenient, allowing users to quickly and easily access their image library and select relevant images for analysis.

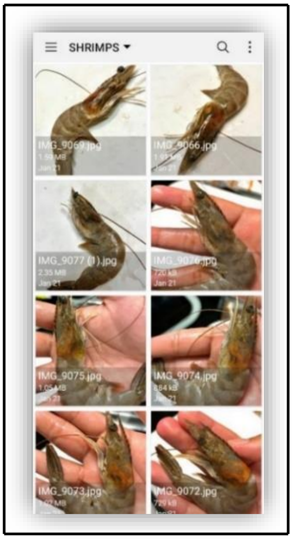



Figure 12. A screenshot of an uploaded image from the gallery

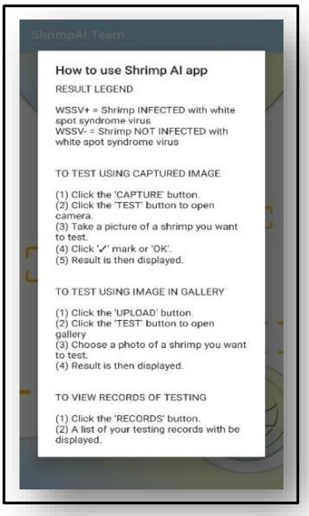



Figure 13. The screenshot of the “App Manual” for the Mobile Application

Figure 13 shows the user manual or instruction manual that served as a critical tool for users to operate the mobile application efficiently and effectively. The manual provided detailed instructions and guidance on how to use each button and feature within the application. It was an essential component of the application, contributing to the overall user experience and promoting its ease of use. The manual was created with the goal of being simple and easy to use. It was organized in a way that was clear and easy to follow, ensuring that users could easily comprehend the various functions and features of the application. Additionally, the manual provided context and purpose behind each button, helping users to understand the rationale behind the application's design.

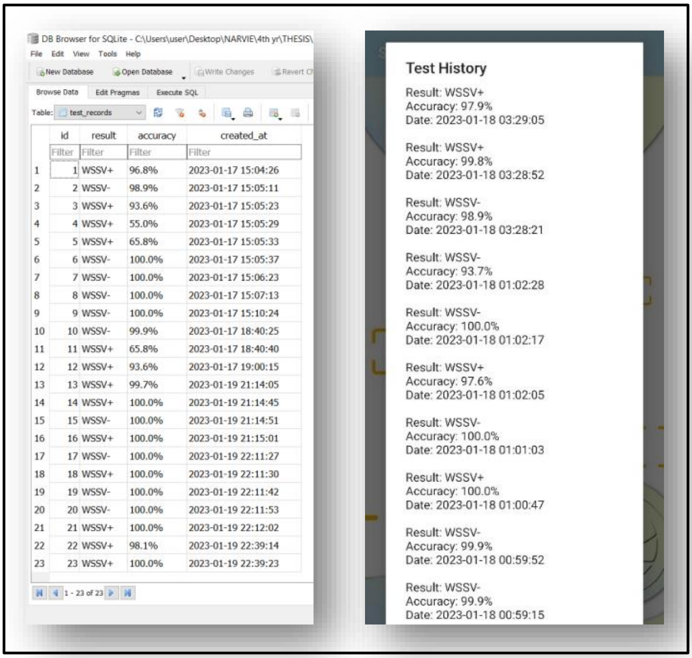



Figure 14. A screenshot of the button labeled "Records"

In Figure 14, the view of the test history log is presented. The list of previous White Spot Syndrome Virus (WSSV) detections that the user had recorded is displayed, along with the result, accuracy, and date of each test. This feature was an essential component of the mobile application as it allowed users to keep track of their health status over time and monitor any changes in the results of the tests.

The test history log served as a valuable reference tool for users who were using the proposed mobile application's detecting method. It provided users with an easy-to-read record of previous test results, enabling them to stay on course with the shrimp health management plan.

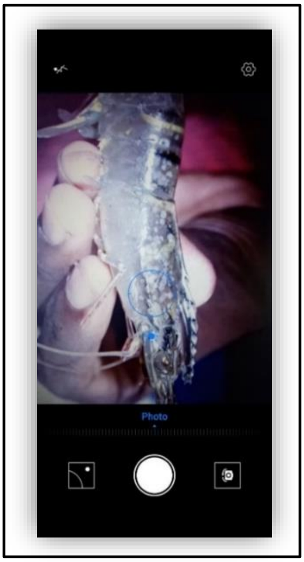



Figure 15. A screenshot displays the ShrimpAI Camera button

Figure 15 shows the camera view which appears after the user clicked the "Camera" button on the mobile app. In the lower center of the screen, there is a capture button that the user could click to take a picture of the image they wanted to use for diagnosis. This feature was an essential component of the mobile application as it enabled users to capture high-quality images of the target organism for accurate diagnosis.

After the user pressed the camera app's capture button, the outcome was shown in Figure 16. On the screen's lower side, two buttons—the “×” and “✓” buttons—could be located. The "✓" button responsible for initiating the diagnosis process. Once the user clicked the button, the application's algorithm processed the image, and identified whether there were white spots on the body of the shrimp or not. The algorithm used in the application was designed to provide accurate and reliable results, ensuring that users could make informed decisions based on the diagnosis. On the other hand, the "×" button in Figure 16 allowed users to cancel the image capture process if the image quality was not up to standard or if the user changed their mind about capturing the image. This feature was especially useful in situations where the lighting or camera settings were not optimal, resulting in a low-quality image that would not provide reliable results.

Figure 16. A sample tiger shrimp photo that has been captured


Figure 17. Screenshot of the Positive result classification

Figure 17 displays the outcome of pressing the "✓" button, which leads to the display of the application's detection result. The test's output shows the existence of WSSV as well as the accuracy of the result. This information can be particularly useful for shrimp farmers who need to quickly identify whether their shrimp are infected with the virus.

Figure 18 displays the outcome after selecting an image on a mobile device. The result shows that the application has detected a negative for the presence of the WSSV. The regular monitoring of their stock's health is imperative for shrimp farmers to ensure their well-being. By having access to this test and result through a mobile application, it becomes easier for farmers to diagnose and take necessary actions to prevent the spread of the virus.


Figure 18. Screenshot of the Negative result classification

*3.3 Accuracy Testing for Detecting Whiteleg Shrimp (P. vannamei) and Tiger Shrimp (P. monodon) Potentially Infected with WSSV.*

Figure 19 shows the graph of accuracy as well as loss for each epoch of the Convolutional Neural Network (CNN) model training. The graph in the figure provides an insight into how well the CNN model is learning to detect WSSV in shrimp. This study used these results to fine-tune the CNN model to increase its accuracy in detecting the virus. The graph's trend indicates that the CNN model is performing well, with accuracy improving as the number of epochs increases.

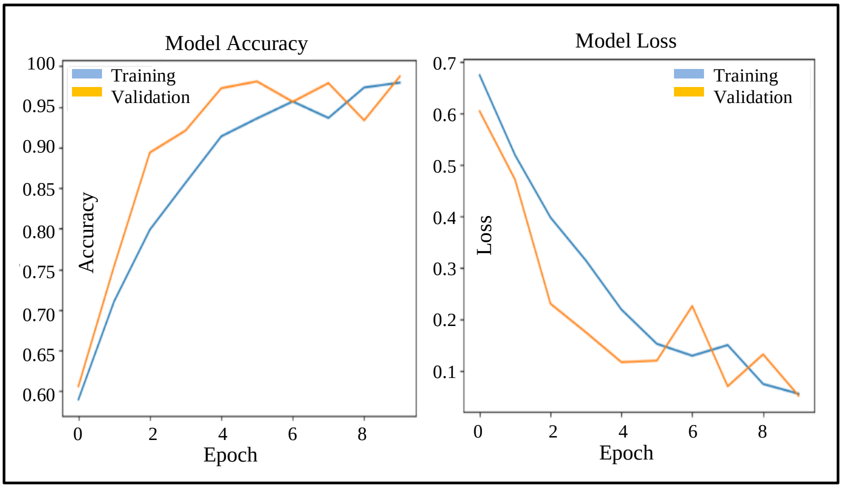
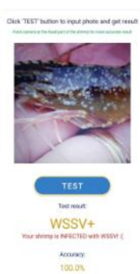



Figure 19. Captured image of the accuracy and loss graph for 10 epoch is presented

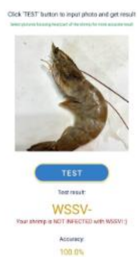
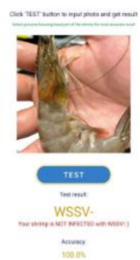
This study captured five shrimps without WSSV. To achieve uniformity in lighting and aspect, these images were most likely taken under carefully controlled circumstances. This study used the app to classify each shrimp as having WSSV or not after taking the images. Based on the test's results, which are presented in Table 1, the app proved to be 100% accurate in classifying shrimps without WSSV. This indicates that the app accurately recognized each of the five shrimps that were negative of WSSV.

Table 1. Shrimps without WSSV

| POSITIVE WSSV RESULTS OF A SAMPLE SHRIMPS | | | | |
|---|---|---|---|---|
| Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 |
|  |  |  |  |  |
| Accuracy: 100% | Accuracy: 100% | Accuracy: 99.9% | Accuracy: 99.9% | Accuracy: 99.9% |

Five pictures of WSSV-infected shrimp were taken by this study to use as a sample. Based on the test's results, which are presented in Table 2, the app showed an average accuracy of 99.9%. This shows that the app may be useful for identifying and preventing the virus's spread throughout shrimp populations. However, additional research and testing may be necessary to validate the app's accuracy in different settings and with larger sample sizes. Overall, the study highlights the potential of the mobile application to enhance the health and productivity of shrimp farming.

Table 2. Shrimps without WSSV

| NEGATIVE WSSV RESULTS OF A SAMPLE SHRIMPS | | | | |
|---|---|---|---|---|
| Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 |
|  |  |  |  |  |
| Accuracy: 100% | Accuracy: 100% | Accuracy: 100% | Accuracy: 100% | Accuracy: 100% |

The study demonstrated that ShrimpAI was effective in detecting WSSV in shrimps, as the mobile application provided results when tested with two types of shrimps: whiteleg shrimp (*P. vannamei*) and tiger shrimp (*P. monodon*). The images taken under optimal lighting settings, with uniform lighting and angle, derived accurate results.

Additionally, the app compiles historical health data and provides predictive analytics, helping farmers make informed decisions about feeding, breeding, and harvesting practices. This data-driven approach enhances overall farm management and productivity. The integration of the study into daily farming practices can drastically reduce losses from disease outbreaks. For instance, early detection of WSSV allows for immediate interventions, such as quarantining infected stock or adjusting environmental conditions, potentially saving entire crops from devastation. As the app expands to detect other diseases, farmers can adopt a more proactive approach to aquaculture management, reducing the industry's reliance on chemical treatments or antibiotics.

*3.4 Evaluation of the functionality of the mobile application.*

In the study, the functionality of the developed mobile application was assessed by the group of specialists from the field of aquaculture, vendors, and farmers who were selected as respondents. The evaluation was conducted after testing the system, where errors were found and fixed, and enhancements were made to ensure better performance of the mobile application for the business. The evaluation process aimed to determine whether the developed mobile application satisfied the basic standards and requirements of the study.

The overall result of the evaluation of the functionality of the mobile application revealed a significant level of effectiveness and user satisfaction. The assessment involved a diverse group of respondents, including shrimp farmers, vendors, and experts from aquaculture organizations, who provided valuable insights into the application's performance.

The survey results indicated that the application received a high mean average rating of 4.4775 out of 5, reflecting a strong consensus among users regarding its functionality. Specifically, respondents expressed strong agreement on several key aspects of the application, such as its capability to detect the White Spot Syndrome Virus (WSSV) in shrimp, the reliability of the detection results, and the overall user experience. For instance, the application was rated 4.55 for its ability to detect WSSV, indicating that users found it highly effective in identifying infected shrimp.

Moreover, the evaluation process utilized a structured questionnaire based on the ISO/IEC 25010 guidelines, which provided a comprehensive framework for assessing software quality. This approach ensured that various dimensions of functionality, including accuracy, usability, and performance, were thoroughly examined. The feedback gathered from the respondents highlighted that the application not only fulfilled its intended purpose but also offered a user-friendly interface that facilitated ease of use in practical settings.

The positive evaluation results suggest that the mobile application is not only functional but also a significant advancement in the early detection of WSSV in both whiteleg shrimp (*P. vannamei*) and tiger shrimp (*P.monodon*). By enabling timely diagnosis, the application has the potential to enhance disease management practices in aquaculture, ultimately contributing to improved shrimp health and reduced economic losses for farmers and vendors.

## 4. Conclusion and Recommendation

The research demonstrated that the mobile application was functional and effective in detecting WSSV in both samples of tiger shrimp and white leg shrimp. Results of functionality testing administered to 20 respondents, including shrimp farmers, vendors, and experts from SEAFDEC/AQD and BFAR, indicated that ShrimpAI received a high mean average rating of 4.4775 out of 5, which demonstrated that respondents appreciated a better quality of service.

Additionally, expanding the dataset by collecting more samples across various environmental conditions and shrimp species would directly address the issue of generalization. Incorporating data from different geographical locations, seasons, and water conditions, as well as various species and sizes of shrimp, would improve the model’s ability to adapt to diverse real-world scenarios. This would significantly enhance its robustness and ensure that the model is not overly reliant on specific conditions observed in the current dataset. The scalability of the study could revolutionize global aquaculture practices, particularly in developing regions where access to advanced diagnostic tools is limited. By providing a cost-effective and scalable solution for disease detection, the app can support small- and medium-scale farmers in improving their productivity and contributing to global food supplies. Additionally, its ability to be applied across different species increases its potential for widespread adoption.

Overall, the study's findings suggest that the integration of image processing using CNN into ShrimpAI was a success, and the mobile application has the potential to aid farmers and experts in preventing massive production losses by detecting WSSV early. The study's contribution to the field of shrimp farming is significant, as it provides a practical and cost-effective solution for early detection of WSSV.

To enhance the study and address future research efforts, several recommendations have been proposed. First, it is essential to gather additional datasets related to White Spot Syndrome Virus (WSSV) in shrimp to expand the available data for analysis. This would improve the robustness of the detection application. Second, incorporating more trained images of shrimp exhibiting various diseases and species would further enhance the model's accuracy and versatility. Additionally, utilizing underwater cameras for video processing could facilitate real-time results, allowing for more immediate detection of WSSV. It is also recommended that molecular biology techniques, such as polymerase chain reaction (PCR), be employed as a concluding step, as these methods currently represent the most accurate means of detecting and diagnosing WSSV infections. Finally, exploring the use of other models may provide valuable insights and improvements for future researchers in the field.

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## 6. References

Ashraf, A. & Atia, A. (2021). Comparative Study Between Transfer Learning Models to Detect Shrimp Diseases. International Journal of Advanced Science and Technology, 30(04), 3671-3684.

Cabrera, J. A., Sornillos, J. B., & Gopez, R. L. (2019). Detection of white spot syndrome virus in shrimp using nested PCR and RT-PCR. Philippine Journal of Veterinary Medicine, 56(1), 48-56.

Chen, J., Huang, H., Guan, Y., Liu, J., & Ye, Y. (2020). Convolutional neural network-based image analysis for white spot syndrome virus detection in shrimp. Aquaculture, 520, 734993.

Dungca, J. Z., Tangonan, N. G., & Peralta, J. P. (2021) In vitro antiviral activity of selected compounds against white spot syndrome virus (WSSV) in whiteleg shrimp (Litopenaeus vannamei). Aquaculture Reports, 20, 100702.

Duong-Trung, N., Quach, L., & Nguyen, C. (2020). Towards Classification of Shrimp Diseases Using Transferred Convolutional Neural Networks. International Journal of Advanced Computer Science and Applications, 11(12), 512-518.

Fabregas, A.C., Cruz, D., & Marmeto, M. D. (2018). SUGPO: A White Spot Disease Detection in Shrimps Using Hybrid Neural Networks with Fuzzy Logic Algorithm. In 2018 6th International Conference on Information and Education Technology (ICIET) (pp. 9-12). IEEE.

Han, J. E., Kim, S. K., Kim, K. I., Kim, J. H., Kim, K. H., & Lee, K. W. (2019). Detection of white spot syndrome virus in shrimp using real-time polymerase chain reaction. Aquaculture and Fisheries, 4(4), 135-140.

Jumawan, J. C., Tuble, S. C., Abao, E. B., Aralar, E. V., & Fernandez, A. B. (2019). Outbreak of white spot syndrome virus in tiger shrimp (Penaeus monodon) farms in Davao region, Philippines. Aquaculture Asia Pacific, 15(3), 6-8.

Ladia, V. L., Casal, C. M. B., & Fornshell, E. P. (2020). Effect of white spot syndrome virus (WSSV) infection on the immune response and gene expression of whiteleg shrimp (Litopenaeus vannamei). Aquaculture, 523, 735174.

Leaño, E. M., Bautista, N. B., & Lavilla-Pitogo, C. R. (2018). Detection of viral pathogens in shrimp farms in Western Visayas, Philippines. Philippine Journal of Science, 147(2), 271-277.

Magbanua, F. O., Lluisma, A. O., & Chua, J. V. (2019). Molecular characterization of white spot syndrome virus (WSSV) infecting farmed shrimp in the Philippines. Aquaculture International, 27(5), 1277-1292.

Minaei, S., Rabbani, H., & Talebi, A. F. (2021). A review of machine learning and deep learning applications in the field of aquaculture. Aquaculture, 530, 735879.

Mohapatra, A., Sahu, P., & Sridhar, S. (2020). Current advances in molecular diagnosis of white spot syndrome virus in aquaculture. Reviews in Aquaculture, 12(1), 287-301.

Philippine Statistics Authority. (2021). Fisheries Situation Report: January-March 2021. Retrieved from:
https://psa.gov.ph/sites/default/files/Fisheries%20Situation%20Report/Fisheries%20Situation%20Report%20-%20January-March%202021.pdf

Phuoc, L. H., Trung, D. D., & Van Dung, D. (2019). Early detection of white spot syndrome virus in shrimp by loop-mediated isothermal amplification (LAMP) method. Aquaculture, 500, 411-417.

Rosales, M.A, Palconit, M. G. B., Almero, V.J.D, Conception, R.S., Magsumbol, J.V., Sybingco, E., Bandala, A.A & Dadios, E. (2021). Faster R-CNN based Fish Detector for Smart Aquaculture System. Journal of Physics: Conference Series, 1778(1), 012011.

Sapin, S.B., Alibudbud, B.A., Molleno, P.B., Veluz, M.B., & Asor, J.R. (2022). Intelligent aquaculture system for pisciculture simulation using deep learning algorithm. International Journal of Advanced Science and Technology, 31(3), 1319-1330.

Sirimanapong, W., Pongsamart, S., Taengphu, S., Taengphu, W., Klanchui, A., Thitamadee, S., Khunrae, P., & Chanpreechasakul, S. (2019). The effectiveness of probiotic mixture in preventing and controlling White Spot Syndrome Virus (WSSV) in whiteleg shrimp (Litopenaeus vannamei) culture. Aquaculture Reports, 15, 100217.

Wang,Q., Qian, C., Nie, P. & Ye, M (2023) Rapid detection of *Penaeus vannamei* diseases via an improved LeNet DOI: 10.1016/j.aquaculture.2023.109938