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# Artificial Neural Network for Determining the Freshness of Nile Tilapia Based on Gill Images Using the LVQ (Learning Vector Quantization) Method

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**Abstract**

Determining the freshness of Nile tilapia is essential in the fisheries industry to ensure quality and safety. This study develops an Artificial Neural Network (ANN) system to classify Nile tilapia freshness based on gill images using the Learning Vector Quantization (LVQ) method, known for its effective data clustering. The process involves collecting fresh and non-fresh gill images, extracting features like color, texture, and shape, and training the ANN with the LVQ algorithm. The system achieved an accuracy of 86.67% and an F1 Score of 88.74%, demonstrating its effectiveness in identifying freshness patterns. This approach provides a reliable solution for assessing fish quality, reducing the risk of consuming non-fresh fish, and contributes to ANN-based advancements in the fisheries sector.

***Keywords***: *Artificial Neural Network, Nile Tilapia Freshness, Gill Images, Learning Vector Quantization (LVQ), Classification*.

## 1. Introduction

Indonesia is one of the largest fish-producing and agricultural countries globally. Nile tilapia (Oreochromis niloticus) is a high-protein freshwater fish commodity, surpassing carp and eel. In 2021, Indonesia produced 1.35 million tons of Nile tilapia. This fish is widely consumed due to its easy cultivation, thick meat, and minimal bones. Tilapia's nutritional content includes 16–24% protein, 0.2–2.2% fat, carbohydrates, minerals, and vitamins. However, its quality, particularly freshness, significantly affects its nutritional value [1].

Fish freshness can be assessed through various organs, including the eyes, gills, color, odor, meat, scales, abdominal wall, or overall body condition [2]. According to fish vendors, gill freshness is a key indicator of overall fish quality. For tilapia, gill color changes indicate freshness: bright red for fresh fish and pale white or black for non-fresh fish. Gills, responsible for gas exchange, ion regulation, and nitrogen excretion, serve as the primary determinant of tilapia freshness.

Currently, not everyone can distinguish between fresh and non-fresh tilapia gills, posing health risks if spoiled fish is consumed. This study aims to develop an Artificial Neural Network (ANN) using Learning Vector Quantization (LVQ) to accurately classify tilapia freshness based on gill images. ANN, widely used in pattern recognition and classification, offers adaptive and accurate classification capabilities. Introduced by Teuvo Kohonen in 1988, LVQ excels in classifying complex data patterns with simplicity and interpretability.

Using LVQ for tilapia freshness classification based on gill images presents an innovative solution. By training ANN with gill image data, this system is expected to automatically and accurately recognize freshness levels. The study's outcomes are anticipated to assist the general public in assessing tilapia freshness, serve as a reference for quality evaluation, and contribute significantly to the fisheries industry and food safety.

## 2. Literature Review

Previous studies served as a comparison and reference to avoid similarities with this research, thus several prior research findings are included in this theoretical framework. Syerli Rahmatul Husna (2019) conducted research on the classification of mango leaves using Learning Vector Quantization (LVQ) and modified direction feature (MDF), achieving 92% accuracy with a learning rate of 0.1 [3]. Irfan Dwi Setyawan (2015) identified the gender of catfish based on body shape using LVQ, achieving 80% accuracy from 160 training data and 40 test data [4]. Usman Sudibyo et al. (2018) classified beef and pork images based on GLCM and HSV features using LVQ, obtaining the highest accuracy of 76.25% [5]. Edwin and Ken Ratri Retno Wardani (2018) diagnosed gastric disorders using iris image data and LVQ, achieving an accuracy of 71.43% [6]. Nurazman (2018) detected fish freshness based on eye color using LVQ, with an accuracy of 96% [7]. These studies demonstrate the effectiveness of the LVQ method in classification tasks using digital images.

### 2.1. Image Processing

Image processing is the manipulation of images using computers to make them easier to interpret by humans or machines. It is typically applied for image enhancement, modification, merging, classification, matching, measurement, and more [8]. The color of an image is defined by the intensity of RGB components required to form it, with each component's intensity ranging from 0–100%. These intensity

levels are displayed in bits, representing the number of colors shown on a monitor [9].

### 2.2. Entry Level Image Processing

Pre-processing is an initial image processing step aimed at simplifying further processing or meeting specific needs. Converting RGB images to HSI simplifies color representation.

### 2.3. Artificial Neural Networks

Artificial Neural Networks (ANN) are mathematical models inspired by biological neural systems, consisting of interconnected artificial neurons that process input, apply activation functions (e.g., sigmoid, ReLU), and produce outputs. Neurons adjust connection weights during learning to map inputs to outputs adaptively. ANN excels in tasks like pattern recognition, prediction, and classification by learning and adapting to complex input data [10]

### 2.4. LVQ (Learning Vector Quantization)

Learning Vector Quantization (LVQ) is a prototype-based algorithm for pattern recognition that classifies input data into specific categories based on proximity to predefined prototype vectors [11], applied in classifying tilapia freshness using gill images through training labeled data ("Fresh" or "Not Fresh"), adjusting prototype weights based on input distances, and testing new images by calculating distances to competitive layer weights, where the closest prototype determines the class, with an LVQ structure consisting of input, competitive, and output layers for processing and classification [12]

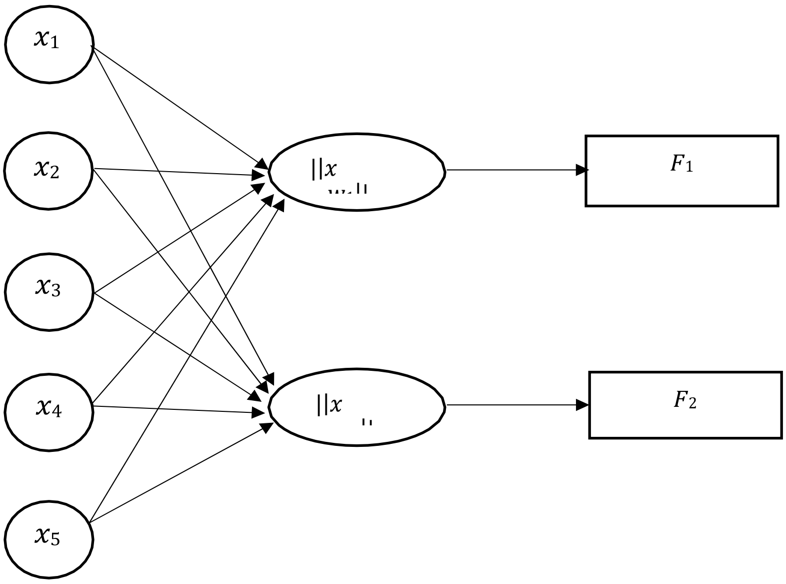



**Fig. 1:** Network Structure Learning Vector Quantization (LVQ) Method

### 2.5. MATLAB (Matrix Laboratory)

MATLAB (Matrix Laboratory) is a computing environment and programming language that supports numerical data analysis, modeling, simulation, visualization, and algorithm development. With its intuitive features, MATLAB simplifies data manipulation, matrix operations, statistical analysis, and graph creation. In this research, MATLAB is used to process image data, train artificial neural network models, analyze results, and evaluate the model's performance in detecting the freshness of tilapia.

### 2.6. Confusion Matrix

Confusion matrix is information about actual classification results that can be predicted by a classification system. The confusion matrix table is shown in table 1

**Table 1:** Confusion Matrix

| | | Prediksi | |
|---|---|---|---|
| | | **Positif** | Negatif |
| Aktual | **Positif** | **TP** | FN |
| | Negatif | FP | TN |

# 3. Research Method

The research flow applied in this research is as follows:

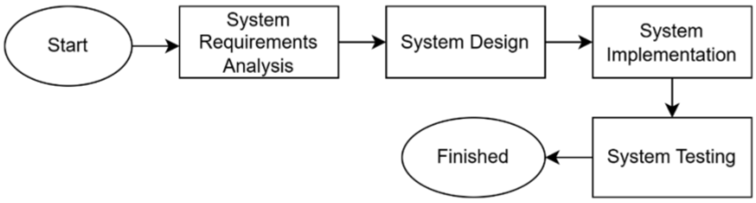



**Fig. 2:** Research Flow

### 3.1. System Requirements Analysis

The process of identifying, documenting, and understanding system requirements to ensure the system meets user goals and expectations effectively and efficiently

### 3.2. System Design

In this system design, analysis is essential before development to ensure the system is appropriate and improves outcomes

### 3.3. System Implementation

The implementation phase involves coding programs based on the analysis and design. It includes applying the Learning Vector Quantization (LVQ) algorithm to predict the freshness of tilapia using gill images and verifying the user interface aligns with the design.

### 3.4. System Testing

This stage ensures that the developed system functions properly. Accuracy testing will be analyzed using the confusion matrix method

### 3.5. System evaluation

This stage evaluates the system's effectiveness in determining the freshness of tilapia. The evaluation is conducted by comparing the system's results with field testing outcomes.

# 4. Results and discussion

This chapter contains a description of the results, analysis and testing of the tilapia freshness detection application using the HSI color space transformation. Testing the level of accuracy will later be analyzed using the confusion matrix method.\

### 4.1. Implementation Process in Matlab

In the data collection stage, 100 training data and 30 test data were processed, where image data was taken directly and then classification of tilapia fish freshness was carried out based on gill images. Then training data is carried out on the system using HSI which is then classified using LVQ. The flow of stages in the designed programming can be seen in the general description of the system stages below.

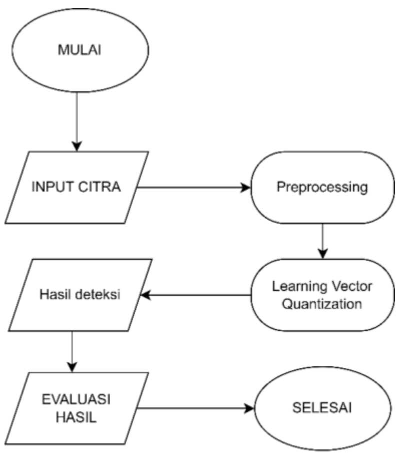



**Fig. 3:** Flow of programming stages

## 4.2. Application display

Data collection involved 100 training images and 30 test images of tilapia gills for freshness classification. The system was trained using HSI and classified with LVQ. The system's process flow is shown in the diagram below.

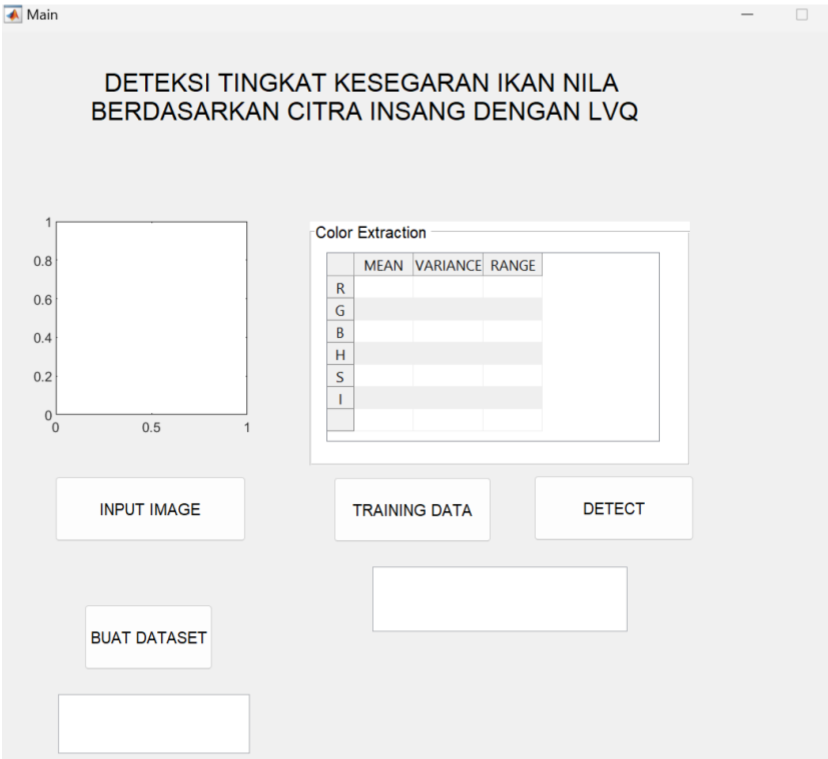
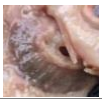
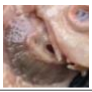



**Fig. 4:** Appearance of Tilapia Freshness Detection Application Based on Gill Image

## 4.3. Evaluation Model

**Table 2:** Test Results

| | | | | |
|---|---|---|---|---|
| 1 |  | SEGAR | SEGAR | TP |
| 2 |  | **SEGAR** | **SEGAR** | TP |
| - | - | - | - | - |
| - | - | - | - | - |
| 28 |  | **TIDAK** | **TIDAK** | TN |
| 29 |  | **TIDAK** | **TIDAK** | TN |
| 30 |  | TIDAK | SEGAR | FP |

Based on the test results, the system was evaluated on 30 images, consisting of 19 fresh fish gill images and 11 non-fresh fish gill images, as shown in Table 5.1. The system correctly identified 16 fresh fish gill images and 10 non-fresh ones, achieving an accuracy of 85%, with 75% recognition for fresh and 95% for non-fresh fish gill images. After testing, we measured the classification success using a Confusion Matrix.

**Table 3:** Test Results

| | Prediksi | |
|---|---|---|
| Kategori | **Segar** | Tidak Segar |
| *True Positives* (TP) | **16** | - |
| *False Positives* (FP) | **1** | - |
| *False Negatives* (FN) | - | 3 |
| *True Negatives* (TN) | - | 12 |

1. Accuracy
   Here's how to calculate accuracy:

$$\boldsymbol{accuracy} = \frac{\mathbf{TP+TN}}{\mathbf{TP+TN+FP+FN}} = \frac{\mathbf{16+10}}{\mathbf{16+10+3+1}} = \frac{\mathbf{26}}{\mathbf{30}} = \mathbf{0.8667}\ \boldsymbol{atau}\ \mathbf{86.67}\%$$

2. Precission
   Here's how to calculate precision:

$$\boldsymbol{Precission} = \frac{\mathbf{TP}}{\mathbf{TP+FP}} = \frac{\mathbf{16}}{\mathbf{16+1}} = \frac{\mathbf{16}}{\mathbf{17}} = \mathbf{0.9286}\ \boldsymbol{atau}\ \mathbf{92.86}\%$$

3. Recall
   Here's how to calculate *recall:*

$$\boldsymbol{Recall} = \frac{\mathbf{TP}}{\mathbf{TP+FN}} = \frac{\mathbf{16}}{\mathbf{16+3}} = \frac{\mathbf{16}}{\mathbf{19}} = \mathbf{0.8667}\ \boldsymbol{atau}\ \mathbf{86.87}\%$$

4. F1 Score
   Here's how to calculate F1 Score, enter the recall and precision values to determine the F1 Score value.

$$\boldsymbol{F1\ Score} = \mathbf{2\ X}\frac{\boldsymbol{Precision \times Recall}}{\mathbf{Precision \times Recall}} = \mathbf{2\ X}\frac{\mathbf{0.9286\ X\ 0.8667}}{\mathbf{0.9286\ X\ 0.8667}} = \mathbf{0.8874}\ \boldsymbol{atau}\ \mathbf{88.74}\%$$

So, the level of accuracy obtained in our program is = 86.67%**.**

## 5. Conclusion

The study concludes that RGB and HSI color parameters effectively classify tilapia freshness based on gill images using an LVQ-based Artificial Neural Network (ANN). A learning rate of 0.2 achieved the highest accuracy of 88.88%, demonstrating LVQ's reliability for gill freshness classification. Testing on 30 images (15 fresh, 15 not fresh) and training on 100 images (50 fresh, 50 not fresh) resulted in 86.67% accuracy and an F1 score of 88.74%, confirming the method's effectiveness.

## 6. Advice

The study suggests that Rencong Tailors refine measurement and pattern application techniques, particularly for short, stout women, to enhance pantalon stitching quality, while researchers should use these findings to improve skills and insights through practice and learning, ensuring better results.

## References


[1] Y. Arifin, "Jurnal Ilmiah Universitas Batanghari Jambi Vol.16 No.1 Tahun 2016 PERTUMBUHAN DAN SURVIVAL RATE IKAN NILA ( Oreochromis. Sp ) STRAIN MERAH DAN STRAIN HITAM YANG DIPELIHARA PADA MEDIA BERSALINITAS M. Yusuf Arifin 1," *J. Ilm.*, vol. 16, no. 1, pp. 159–166, 2016.

[2] "MATA IKAN PADA IDENTIFIKASI LAMA MATI IKAN SKRIPSI Oleh : Nelsy Glorya Joostensz Program Studi Teknik Informatika STMIK Global Informatika MDP Palembang," 2020**.**

[3] U. Klasifikasi, D. Mangga, S. R. Husna, F. Sains, and D. A. N. Teknologi, "UNTUK KLASIFIKASI DAUN MANGGA MENGGUNAKAN MODIFIED DIRECTION FEATURE ( MDF ) TUGAS AKHIR PENERAPAN LEARNING VECTOR QUANTIZATION ( LVQ ) MODIFIED DIRECTION FEATURE ( MDF )," 2019.

[4] I. D. Setyawan, "IDENTIFIKASI JENIS KELAMIN IKAN LELE (CLARIAS SP) BERDASARKAN BENTUK TUBUH DENGAN LEARNING VECTOR QUANTIZATION (LVQ)," 2015, *Universitas Pembangunan Nasional Veteran Jakarta*.

[5] B. Glcm, D. A. N. Hsv, and C. A. Sari, "OPTIMASI ALGORITMA LEARNING VECTOR QUANTIZATION ( LVQ ) DALAM PENGKLASIFIKASIAN CITRA DAGING SAPI DAN DAGING BABI," vol. 9, no. 1, pp. 1–10, 2018.

[6] K. Ratri and R. Wardani, "Penerapan Metode Learning Vector Quantization untuk Mendiagnosa Penyakit Gangguan Lambung," vol. 13, no. 2, pp. 135–140, 1858.

[7] "WARNA MATA MENGGUNAKAN ALGORITMA LEARNING VEKTOR QUANTIZATION ( LVQ ) TUGAS AKHIR," p. 2018, 2018.

[8] P. N. Andono and T. Sutojo, *Pengolahan citra digital*. Penerbit Andi, 2017

[9] M. Niswar and A. Aman, "Sistem Pendeteksi Kesegaran Ikan Bandeng Menggunakan Citra," vol. 8, no. 2, pp. 170–179, 2016.

[10] P. T. Putra and P. Properti, "Implementasi Jaringan Syaraf Tiruan Untuk Memprediksi Jumlah Penjualan Rumah Dengan Menggunakan Metode Backpropagation ( Studi Kasus," vol. 4, no. 2, pp. 1–13, 2021.

[11] E. Setyowati and S. Mariani, "Penerapan Jaringan Syaraf Tiruan dengan Metode Learning Vector Quantization ( LVQ ) untuk Klasifikasi Penyakit Infeksi Saluran Pernapasan Akut ( ISPA )," *Prism. Pros. Semin. Nas. Mat.*, vol. 4, pp. 514–523, 2021.

[12] L. V. Quantization, "Penerapan Learning Vector Quantization ( LVQ ) untuk Klasifikasi Status Gizi Anak 1," vol. 7, no. 2, pp. 155–166, 2013