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Colors and Texture Feature Extraction Using Learning Vector Quantization 3 Algorithm in Optimization of Beef Identification

Suendri [1]*, Eka Susanti [2], Agung Hartono [3]
* Universitas Islam Negeri Sumatera Utara, Medan, Indonesia
suendri@uinsu.ac.id [1]

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ABSTRACT

The Assessment Institute for Foods, Drugs, and Cosmetics of the Indonesian Ulama Council (LPPOM MUI) is responsible for conducting research, evaluations, and determining the halal status of products in accordance with Islamic teachings. In Indonesia, where religious diversity is prevalent, the halal certification process is crucial, particularly due to differences in the halal status of certain foods, such as beef and pork, across religions. One of the challenges in this process lies in ensuring a rapid and accurate determination of various types of meat, including beef, pork, goat, and buffalo, which currently tends to be time-consuming within the LPPOM MUI Halal Center. To address this issue, there is a need for a technological solution that can quickly and accurately identify different types of meat, thereby reducing consumer uncertainty when selecting halal products. This study aims to develop an Android-based application utilizing the Learning Vector Quantization 3 (LVQ3) method to facilitate the classification of meat types by analyzing patterns specific to beef, pork, goat, and buffalo. This system is expected to expedite the halal verification process, thereby supporting more efficient and accurate decision-making in the halal certification sector.

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I. Introduction

The rapid development of Information Technology (IT) has significantly enhanced the quality of human life. This progress has resulted in numerous changes in various activities and work processes, enabling more effective and efficient solutions [1]. The application of IT has become indispensable in numerous fields, aiding in problem-solving and task execution, to the point where it is now considered essential in some aspects of daily life. Efficient and accurate meat classification is a critical challenge in halal certification, particularly in distinguishing visually similar types such as beef and pork.

Currently, halal certification processes are carried out for various products, including beef, pork, goat, and buffalo. However, these procedures often require a considerable amount of time, especially in accurately identifying meat types. This delay not only affects certification bodies but also presents challenges for consumers who seek to purchase halal meat in the market. In response to these challenges, this study aims to leverage advances in Artificial Intelligence (AI) to identify different types of meat—specifically beef, pork, goat, and buffalo—more accurately and efficiently. AI, particularly in the form of Artificial Neural Networks (ANNs), offers promising solutions. This research focuses on utilizing the Learning Vector Quantization 3 (LVQ3) method, a subset of Supervised Neural Networks, recognized for its capabilities in pattern recognition [2], [3].

The LVQ3 method is particularly useful for distinguishing meat types based on differences in color and texture. The system developed in this study will be Android-based, allowing for ease of use and accessibility. By utilizing the device’s camera, the system captures images of meat, which are then analyzed to classify the type of meat in question. This approach is expected to significantly streamline the identification process at LPPOM MUI Halal Centers, reducing both time and costs, while enhancing consumer confidence in ensuring the halal status of meat products [4].

Although beef and pork share some similar visual characteristics, this study utilizes the Learning Vector

Quantization (LVQ3) algorithm, which has been proven effective in recognizing subtle patterns. Prior research [5]. has demonstrated that differences in color and texture can sufficiently classify meat types with high accuracy.

Digital image processing, which involves the analysis of images captured through digital devices, is essential for this classification process [6]. Digital images are represented numerically, typically as 8-bit binary values stored in pixels. The study will utilize various types of digital images, including binary, grayscale, and RGB (Red, Green, Blue) images, commonly used in image processing [7].

Learning Vector Quantization (LVQ) is a pattern classification method where each output unit represents a specific category [2], [8]. The weight vector of each output unit serves as a reference for its corresponding class. In this research, RGB normalization, HSV (Hue, Saturation, Value) conversion, and texture feature extraction using GLCM (Grey Level Co-occurrence Matrix) will be applied to optimize classification accuracy [9], [10]. Additionally, UML (Unified Modeling Language) will be employed to model the system architecture, providing a clear visual representation of the software development process [11].

II. METHOD

This study utilizes the Research and Development (R&D) method, which is designed to produce a tangible product as its final output [12]. Such products may include systems, models, or other practical tools that can be evaluated for their effectiveness. The data collection process in this study involves two main approaches:

- Observation: Direct observation was conducted at LPPOM MUI in North Sumatra to identify existing issues and gather primary data.
- Literature Study: This approach is employed to gather references and source materials pertinent to color feature extraction, image processing, artificial neural networks, and the LVQ3 algorithm [13], [14].

A. *System Development Method*

The Rapid Application Development (RAD) methodology is employed for system development in this study. RAD is a software development process that emphasizes a short and iterative development cycle [15].

Figure 1. Rapid Application Development

The stages involved in RAD include requirements analysis, design workshops, and implementation [16], [17]. This methodology is chosen to accelerate the development process while ensuring system quality. Figure 1 illustrates the RAD system development scheme.

B. *Framework*

Creating a framework is crucial in structuring and organizing the research process.

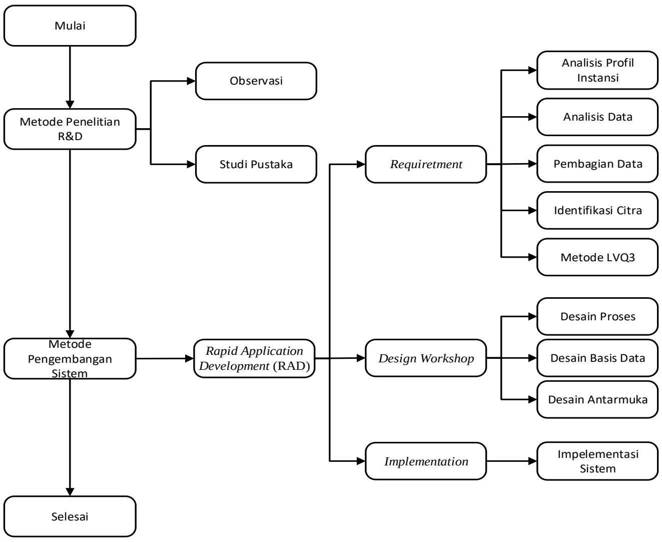

Figure 2. Research Framework

The framework designed for this study ensures that the research flow is methodical and coherent, facilitating a clear progression from data collection to system implementation.

III. RESULTS AND DISCUSSIONS

A. *Requirement*

At this stage is the stage of analysis to identify problems and identify solutions to solving these problems. The process of collecting data on meat consisting of beef, buffalo goat, and pork obtained from the results of direct collection from traditional markets. In this case, the image capture process is carried out using a smart phone camera with a resolution of 13 MP in .jpg/.jpeg format. The following is a sample image of beef that will be identified.

Figure 3. Real Beef Image

In order to obtain the desired and required image data to be used as image objects, the cropping stage is carried out. For the results as in the figure 4.

Figure. 4 Image Cropping Results

The data should be divided into training data and test data. Training data are all data from all types of meat, namely beef, beef, pork, mutton, and buffalo meat. The value stored as training data is the result of color image extraction using the HSV (Hue, Saturation, Value) method and texture feature extraction using the GreyScale Co-ocurrence Matrix (GLCM) method. Test data is data that will be predicted using training data that has been previously stored in the database. The distribution of test data is done by dividing all image data of beef, pork, mutton, and buffalo meat from all image data as test data using the LVQ3 method.

Before carrying out the color and texture extraction process, you must first carry out the process to form a training image by making a set of pixels from each image which contains RGB values. The following is a table of RGB identification results from the resulting meat image based on the image above.

TABLE 1.
RED BEEF IMAGE RESULTS

Red	**0**	**1**	**2**	**3**	**4**	**5**	**…**	**299**
0	136	135	130	130	133	126	…	125
1	133	134	142	140	132	122	…	158
2	156	139	142	137	137	128	…	126
3	177	138	142	133	134	134	…	130
4	143	138	138	134	131	135	…	136
5	130	162	158	141	137	139	…	130
6	142	162	158	163	147	143	…	126
7	157	159	173	167	154	150	…	140
8	166	188	156	153	159	149	…	143
9	141	152	161	158	169	155	…	151
10	136	154	156	158	157	176	…	141
…	…	…	…	…	…	…	…	…
299	157	143	136	133	142	169	…	161

The following is a table of RGB identification results from meat images that produce a green color based on the image above.

TABLE 2.
GREEN BEEF IMAGE RESULTS

Green	**0**	**1**	**2**	**3**	**4**	**5**	**…**	**299**
0	57	56	53	53	56	51	…	53
1	57	58	65	63	55	47	…	85
2	80	63	65	60	60	53	…	53
3	41	62	65	56	57	59	…	57
4	62	62	61	58	55	59	…	60
5	49	86	86	65	61	63	…	54
6	61	86	86	87	71	67	…	49
7	76	83	97	97	78	74	…	63
8	91	118	80	77	83	71	…	66
9	62	78	85	88	93	77	…	74
10	56	84	80	82	81	98	…	64
…	…	…	…	…	…	…	…	…
299	74	60	53	50	61	90	…	85

The following is a table of RGB identification results from meat images that produce a blue color based on the image above.

TABLE 3.
BLUE BEEF IMAGE RESULTS

Blue	**0**	**1**	**2**	**3**	**4**	**5**	**…**	**299**
0	62	61	59	59	62	56	…	64
1	61	62	71	69	61	51	…	96
2	84	67	71	66	66	57	…	64
3	45	66	71	62	63	63	…	68
4	68	66	67	62	59	63	…	70
5	55	90	82	69	65	67	…	64
6	67	90	82	89	73	61	…	57
7	82	87	99	93	90	76	…	71
8	95	120	82	77	83	71	…	74
9	65	79	85	88	93	77	…	82
10	59	85	80	82	81	98	…	72
…	…	…	…	…	…	…	…	…
299	82	68	61	58	68	96	…	89

To obtain a simpler value, the RGB value normalization process is carried out through the equation (1):

Red Normalization:

$$r(0,0) = \frac{R(0,0)}{(R(0,0) + G(0,0) + B(0,0))} = \frac{136}{136 + 57 + 62} = 0.53333$$

$$r(1,0) = \frac{R(1,0)}{(R(1,0) + G(1,0) + B(1,0))} = \frac{133}{133 + 57 + 61} = 0.52988$$

$$r(2,0) = \frac{R(2,0)}{(R(2,0) + G(2,0) + B(2,0))} = \frac{156}{156 + 80 + 84} = 0.4875$$

The overall results can be seen in the following table 4.

TABLE 4.
NORMALIZATION VALUE RED

Red	**0**	**1**	**2**	**…**	**299**
0	0.53333	0.53571	0.53719	…	0.51652
1	0.52988	0.52755	0.51079	…	0.46607
2	0.4875	0.51672	0.51079	…	0.51851
3	0.67300	0.51879	0.51079	…	0.50980
4	0.52380	0.51879	0.51879	…	0.51127
5	0.55555	0.47928	0.48466	…	0.52419
…	…	…	…	…	…
299	0.50159	0.52767	0.544	…	0.48059

Green Normalization:

$$g(0,0) = \frac{G(0,0)}{(R(0,0) + G(0,0) + B(0,0))} = \frac{57}{136 + 57 + 62} = 0.22352$$

$$g(0,1) = \frac{G(0,1)}{(R(0,1) + G(0,1) + B(0,1))} = \frac{56}{135 + 56 + 61} = 0.22222$$

$$g(0,2) = \frac{G(0,2)}{(R(0,2) + G(0,3) + B(0,2))} = \frac{53}{130 + 53 + 59} = 0.21900$$

The overall results can be seen in the following table:

TABLE 5.
NORMALIZATION VALUE GREEN

Green	0	1	2	…	299
0	0.22352	0.22222	0.21900	…	0.21900
1	0.22709	0.22834	0.23381	…	0.25073
2	0.25	0.23420	0.23381	…	0.21810
3	0.15589	0.23308	0.23381	…	0.22352
4	0.22710	0.23308	0.22932	…	0.22556
5	0.20940	0.25443	0.26380	…	0.21774
…	…	…	…	…	…
299	0.23642	0.22140	0.212	…	0.25373

Blue Normalization:

$$b(0,0) = \frac{B(0,0)}{(R(0,0) + G(0,0) + B(0,0))} = \frac{62}{136 + 57 + 62} = 0.24313$$

$$b(0,1) = \frac{B(0,1)}{(R(0,1) + G(0,1) + B(0,1))} = \frac{61}{135 + 56 + 61} = 0.24206$$

$$b(0,2) = \frac{B(0,2)}{(R(0,2) + G(0,3) + B(0,2))} = \frac{59}{130 + 53 + 59} = 0.24380$$

The overall results can be seen in the following table 6.

TABLE 6.
NORMALIZATION VALUE BLUE

Blue	0	1	2	…	299
0	0.24313	0.24206	0.24380	…	0.26446
1	0.24302	0.24409	0.25539	…	0.28318
2	0.2625	0.24907	0.25539	…	0.26337
3	0.17110	0.24812	0.25539	…	0.26666
4	0.24908	0.24812	0.25187	…	0.26315
5	0.23504	0.26627	0.25153	…	0.25806
…	…	…	…	…	…
299	0.26198	0.25092	0.244	…	0.26567

Calculation of the value using equation (2):

$$v(0,0) = \max(r_{(0,0)}, g_{(0,0)}, b_{(0,0)}) = \max(0.53333, 0.22352, 0.24313) = 0.53333$$

$$v(0,1) = \max(r_{(0,1)}, g_{(0,1)}, b_{(0,1)}) = \max(0.53571, 0.22222, 0.24206) = 0.53571$$

$$v(0,2) = \max(r_{(0,2)}, g_{(0,2)}, b_{(0,2)}) = \max(0.53719, 0.21900, 0.24380) = 0.53719$$

The overall results can be seen in the following table:

TABLE 7.
VALUE IMAGE RESULTS

Value	0	1	2	…	299
0	0.53333	0.53571	0.53719	…	0.51652
1	0.52988	0.52755	0.51079	…	0.46607
2	0.4875	0.51672	0.51079	…	0.51851
3	0.67300	0.51879	0.51079	…	0.50980
4	0.52380	0.51879	0.51879	…	0.51127
5	0.55555	0.47928	0.48466	…	0.52419
…	…	…	…	…	…
299	0.50159	0.52767	0.544	…	0.48059

Calculation of the saturation using equation (3):

$$s_{(0,0)} = 1 - \frac{\min(r,g,b)}{v} = 1 - \frac{(0.53333, 0.22352, 0.24313)}{(0.53333)} = 1 - \frac{0.22352}{0.53333} = 0.58087$$

$$s_{(0,1)} = 1 - \frac{\min(r,g,b)}{v} = 1 - \frac{(0.53571, 0.22222, 0.24206)}{(0.22222)} = 1 - \frac{0.22222}{0.53571} = 0.58518$$

$$s_{(0,2)} = 1 - \frac{\min(r,g,b)}{v} = 1 - \frac{(0.53719, 0.21900, 0.24380)}{(0.53719)} = 1 - \frac{0.21900}{0.53719} = 0.59232$$

The overall results can be seen in the following table 8.

TABLE 8.
RESULT OF SATURATION VALUE

Sat	0	1	2	…	299
0	0.58087	0.58518	0.59232	…	0.57600
1	0.56953	0.56716	0.54225	…	0.46203
2	0.48717	0.54675	0.54225	…	0.57937
3	0.76836	0.55072	0.54225	…	0.56155
4	0.56643	0.55072	0.55797	…	0.55882
5	0.62307	0.46914	0.48101	…	0.58461
…	…	…	…	…	…
299	0.52865	0.58041	0.61029	…	0.47204

Calculation of the hue using equation (4):

$$H_{(0,0)} = 60 \times \frac{(g-b)}{s \times v} = 60 \times \frac{(0.22352 - 0.24313)}{0.58087 \times 0.53333} = 60 \times \frac{-0.01961}{0.3097953971} = -3.79799058028$$

$$Nilai\ H_{(0,0)} < 0, maka\ H_{(0,0)} = -3.79799058028 + 360 = 356.20200942$$

$$H_{(0,1)} = 60 \times \frac{(g-b)}{s \times v} = 60 \times \frac{(0.22222 - 0.24206)}{0.58518 \times 0.53571} = 60 \times \frac{-0.01984}{0.3134867778} = -3.79728934137$$

$$Nilai\ H_{(0,1)} < 0, maka\ H_{(0,1)} = -3.79728934137 + 360$$
$$= 356.202710659$$
$$H_{(0,2)} = 60 \times \frac{(g-b)}{s \times v} = 60 \times \frac{(0.21900 - 0.24380)}{0.59232 \times 0.53719}$$
$$= 60 \times \frac{-0.0248}{0.3181883808} = -4.6764749745$$
$$Nilai\ H_{(0,2)} < 0, maka\ H_{(0,2)} = -4.6764749745 + 360$$
$$= 355.323525025$$
$$H_{(0,3)} = 60 \times \frac{(g-b)}{s \times v} = 60 \times \frac{(0.21900 - 0.24380)}{0.59232 \times 0.53719}$$
$$= 60 \times \frac{-0.0248}{0.3181883808} = -4.6764749745$$

The overall results can be seen in the following table:

TABLE 9.
HUE VALUE RESULTS

Hue	0	1	2	…	299
0	356.202009	356.20271065	355.3235250	…	350.8320749
1	356.832	356.84163304	355.3252246	…	350.9584138
2	356.842043	356,84195615	355.3252246	…	350.9583309
3	358.235030	356.84153083	355.3225224	…	350.9584450
4	355.555046	356.84153083	355.3259285	…	352.1059236
5	355.555639	356.84055221	356.8420552	…	352.1056422
…	…	…	…	…	…
299	354.216443	354.21677201	354.2168284	…	356.8420732

Converting RGB into Greyscale to perform texture extraction in order to get the value from the meat image data. The RGB value that has been obtained will be converted into a Gryscale value, done by changing the value of each pixel into a gray degree value using equation (9):

$$Gray_{(0,0)} = \frac{R_{(0,0)} + G_{(0,0)} + B_{(0,0)}}{3} = \frac{136 + 57 + 62}{3} = \frac{255}{3}$$
$$= 85$$
$$Gray_{(0,1)} = \frac{R_{(0,1)} + G_{(0,1)} + B_{(0,1)}}{3} = \frac{135 + 56 + 61}{3} = \frac{252}{3}$$
$$= 84$$
$$Gray_{(0,2)} = \frac{R_{(0,2)} + G_{(0,2)} + B_{(0,2)}}{3} = \frac{130 + 53 + 59}{3} = \frac{242}{3}$$
$$= 80{,}67$$
$$Gray_{(0,3)} = \frac{R_{(0,3)} + G_{(0,3)} + B_{(0,3)}}{3} = \frac{130 + 53 + 59}{3} = \frac{242}{3}$$
$$= 80{,}67$$

The overall results can be seen in the following table:

TABLE 10.
RGB TO GRAYSCALE CONVERSION VALUE RESULTS

Gray	0	1	2	3	...	299
0	85	84	80,67	80,67	...	80,67
1	83,67	84,67	92,67	90,67	...	113
2	106,67	89,67	92,67	87,67	...	81
3	87,67	88,67	92,67	83,67	...	85
4	91	88,67	88,67	84,67	...	88,67
5	78	112,67	108,67	91,67	...	82,67
...	...	...	...	...	...	...
299	104,33	90,33	83,33	81,33	...	111,67

After all the required image data is available, then proceed with the image classification process by applying the Learning Vector Quantization (LVQ) algorithm, in which the results of the HSV and GLCM values will be used as the classification input values. The LVQ3 algorithm architecture has two layers, namely the input layer and the output layer. Here is the LVQ3 algorithm architecture.

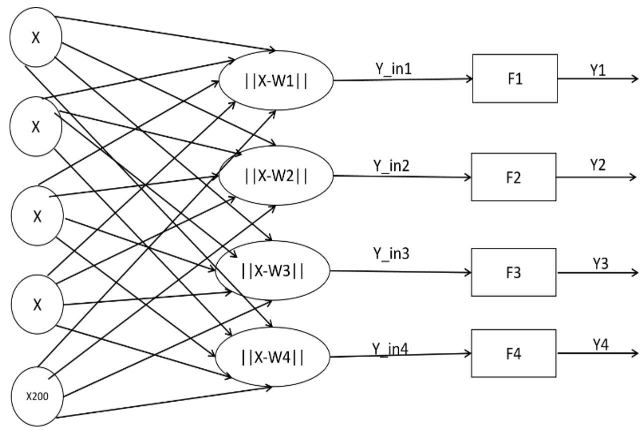

Figure 5. LVQ3 Architecture

The description of the image above is that the input data in this study amounted to 200 data or (x). The w value is a weight value of 4 weights, consisting of w1 for the cattle class, w2 for the pig class, w3 for the goat class, and w4 for the buffalo class. The values of F1 to F4 are the output layers and the values of Y1 to Y4 are the output values used in the testing process.

B. Implementation

At this stage, it is the stage of translating the interface design using program code to become an application that will be a solution to the problem solving in this study, namely for the introduction of beef, pork, goat, and buffalo.

The main display that will appear is the home page. This page is the main page which contains a meat photo menu, history data, reports, and an about menu.

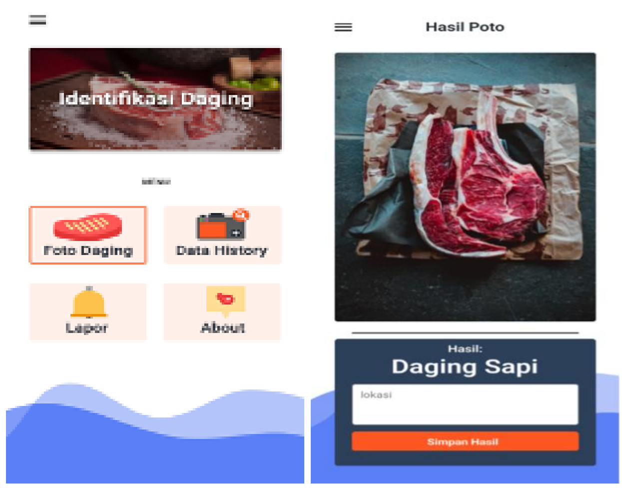

Figure 6. Home Page View & Meat Photo Results Page View

On this page there is a camera page and a meat photo page. When you click on the Photo Meat menu, a camera will appear which is used to take photos of the meat you want to identify. After clicking the photo capture button on the camera, the system will display the results of the identification of the meat photo on the photo results page. This page provides photo identification information whether the meat is beef, pork, goat, or buffalo. In this report menu, there is a reporting page that can only be accessed by guests and a report results page that can only be accessed by the admin.

IV. Conclusions

Based on the analysis and research conducted, it can be concluded that the developed application serves as an effective platform for consumers seeking to purchase meat in the market, providing them with a reliable tool to distinguish between halal and non-halal meat products. This system also supports the LPPOM MUI Halal Center in classifying various types of meat, including beef, pork, goat, and buffalo, thereby enhancing the efficiency and accuracy of the certification process. By leveraging the Learning Vector Quantization 3 (LVQ3) method, the system enables precise meat classification based on unique patterns, such as color and texture, specific to each meat type. The implementation of this Android-based application not only simplifies the user experience but also accelerates the classification process. significantly reducing the time required for halal verification. This study focuses on the classification of meat types as one component of the halal certification process. However, it does not address critical aspects such as slaughtering and handling methods, which are integral to halal certification. Future research could explore complementary solutions to encompass these aspects.

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