Comparison of Beef Marbling Segmentation by Experts towards Computational Techniques by Using Jaccard, Dice and Cosine

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Article History: Received: 11 January 2021; Revised: 12 February 2021; Accepted: 27 March 2021; Published online: 4 June 2021

Abstract: In Indonesia, the physical quality assessment of beef is determined based on the color of the fat and meat, texture, tenderness and marbling (Badan Standar Nasional, 2018). This research is aimed to compare the beef marbling segmentation conducted by experts towards computational techniques by using Jaccard, Dice and Cosine. The Jaccard similarity index focuses on the proportion of the cardinalities of the images assessed together with the cardinalities of all the images calculated in both segments. Then Cosine similarity calculation is done to calculate marbling similarity by using vector. The Dice Similarity Coefficient is used as a statistical validation metric to evaluate the performance of both manual segmentation reproducibility and the spatial overlapping accuracy of automatic probabilistic fractional segmentation in images. The research began with acquiring beef images using a digital camera. Beef image data used by experts to determine the marbling point is also used in the segmentation process of this study. In the meat image segmentation process, 50 marbling points are determined to get the RGB value of each selected marbling point. Furthermore, the results of the meat image were determined by the ground truth by experts as a knowledge base and computational image segmentation was also carried out. The results of determining ground truth marbling are then tested for similarity with the results of image segmentation. If the results match, the next step was image processing and image segmentation. Furthermore, in the marbling segmentation test, the range of RGB values is then entered as the Beef marbling Tresholding Value by taking the difference in the values of Red and Green as well as Red and Blue. Jaccard, Dice, and Cosine values ranged from 0.3 to 0.6, the results show: Jaccard: 0,397, the Dice: 0,561, Cosine: 0,572. These indicate the similarity of marbling markings performed by experts and computing is small. This is because the expert's sense of sight has limitations in seeing marbling with a small size, while computational techniques are able to calculate marbling to the smallest size. Based on the results described, it can be concluded that assessing marbling with expert vision is not enough. Thus, it needs to be added and validated with computational techniques. In this study, the marbling marking results appear more detailed and accurate. Finally, it can be concluded that computational techniques are able to calculate marbling better than experts

Keywords: Beef marblings segmentation, experts, Jaccard, Dice, Cosine

1. Introduction

In 2019 the Ministry of Health of the Republic of Indonesia announced that the nutritional status of children in Indonesia experienced a change from 19.6% in 2013. On the other hand, on the beginning of 2019, the number of children's nutritional status has gradually dropped to 17.7% as of the beginning of 2019. This is because the intake of animal protein that was previously not met in children and toddlers has begun to be fulfilled. This was in accordance with the market demand related to beef for consumption which is increasing every year in an effort to meet the nutrition of children and toddlers (National Socio-Economic Survey). Based on this statement, it was concluded that currently the needs of the community related to beef consumption need to be considered. Thus, people need to understand the quality of beef that is fit for consumption to avoid consuming poor quality beef. Then, we need a guideline to assess the quality of beef.

In Indonesia, the physical quality assessment of beef is determined based on the color of the fat and meat, texture, tenderness and marbling (Badan Standar Nasional, 2018). Currently, assessing the quality of meat still uses a fairly lengthy and manual procedure. The first step is to look at the color of the meat, the color of the fat, the texture and the marbling using a flashlight which has a minimum intensity of 700 lux and is matched with a quality stamp. Then, sampling is carried out on meats that have been through the chilling process for about 24-48 hours. Furthermore, the assessment was carried out with careful visual observation on the surface of the cross-section of the 12th rib-eye muscle. Then the assessment method is done by using the sense of sight of the physical appearance of muscle and fat in the meat. The physical appearance grade of meat and fat is then determined by using quality standard aids. The physical appearance of the meat evaluated includes the color of the meat and fat, and the marbling intensity and muscle texture. This study aims to compare the results of the visual segmentation of fat by experts with computational techniques.

Research on segmentation of retinal vessels has been carried out by GeethaRamani and Balasubramanian (2016). The process in order to obtained segmentation of the retinal vessels begins with image trimming, color transformation and color channel extraction, contrast enhancement, Gabor filtering, and half-wave repairs applied sequentially during the pre-processing stage. Segmented images are produced and formed by combining the results of the classification and classification process. The proposed technique was validated based on images from publicly available DRIVE databases. The proposed methodology achieves 95.36% accuracy, which was comparable to existing blood vessel segmentation techniques. Then, Hamuda *et al.* (2016) conducted a review of image processing techniques for the extraction and segmentation of plants on plantations. Based on that review that has been done, the segmentation phase involves crop segmentation by identifying plants from the background of the soil and other residues. Generally, researchers used three plant extraction algorithms namely, color index-based segmentation, threshold-based segmentation, and learning-based segmentation.

The next study was carried out by Singh and Misra (2017) who also conducted research related to segmentation with the object of leaf disease in plants. The research aimed to detect leaf disease by segmentation techniques. Detection of plant diseases with computational techniques was useful because it reduces monitoring work in agriculture. The research which has been done presented an algorithm for image segmentation techniques used for automatic detection and classification of plant leaf diseases. The research included a survey of various disease classification techniques that was able to be used to detect leaf disease in plants. Furthermore, image segmentation was done using genetic algorithms with an accuracy reaching 97.6%. Moreover, Stegmann, *et al.* (2020) conducted a study related to segmentation of tomographic measurements for knee joint tears. The study compared optical coherence tomography systems created specifically to study knee joint tears with computational techniques for segmenting image data with thresholding-based segmentation algorithms (TBSA). A total of 6658 images were labeled TBSA and used as training data by the convolutional neural network method. Then the algorithm was evaluated with k-fold cross validation and produced a sensitivity of 96.36%, specificity of 99.98% and Jaccard index of 93.24%.

Research that has been done (GeethaRamani & Balasubramanian, 2016; GeethaRamani & Balasubramanian, 2016; Hamuda, et al., 2016; Singh & Misra, 2017; Stegmann, et al., 2020) proved that segmentation techniques capable to help in many fields. Thus, this study utilizes segmentation techniques in beef marbling. This is done aiming to help experts determine marbling in beef. The next section will discuss the segmentation techniques used. Then proceed with a discussion of the results of the proposed method and the results of marbling segmentation in beef. Finally closed with a conclusion.

2. Data and Methods

The research began with acquiring beef images using a digital camera. The part of cattle selected in this study is the body part of a cow that has different work tasks (Du, et al., 2008; Jackman, et al., 2010; Widiyanto, et al., 2017). So, these parts have a variety of fat marbling. Table 1 section of meat used as training data and test data in this study.

Table 1 Beef Section

No	Part	Trade Code	Amount
1	Tender Loin	D-Tender Loin Roast	3
2	Top Side	G-Top Side Roast	3
3	Blade	I-Blade Roast	1
4	Chuck	K-Chuck Roast	2
TOTAL			9

Furthermore, the results of the meat image were determined by the ground truth by experts as a knowledge base and computational image segmentation was also carried out. The results of determining ground truth marbling are then tested for similarity with the results of image segmentation. If the results match, the next step was image processing and image segmentation.

The image acquisition process begins by taking a meat image using a digital camera with JPG format size 5184 × 3456 pixels, then converted to PNG with a size of 1900 × 1200 pixels. This is done to avoid areas outside beef that do not contain marbling and sharpen the image of beef. After image processing, image processing results through the segmentation stage. In this study there are two segmentation processes carried out namely marbling segmentation by experts to obtain ground truth and segmentation using computational techniques.

Image processing results are then tagged the marbling area by experts. Furthermore, the expert determines marbling standards in each beef image by referring to the USA marbling standard which has six quality standards. Detailed USA standards and expert ground determination methods for marbling standards (Slight-0, Small-1, Modest-2, Moderate-3, Slightly Abundant-4 and moderately Abundant-5). Beef image data used by experts to determine the marbling point is also used in the segmentation process of this study. In the meat image segmentation process, 50 marbling points are determined to get the RGB value of each selected marbling point. The process of determining 50 marbling points can be shown in algorithm 1.

Algorithm 1: Marbling Point Determination

Input: Meat Image
Algorithm
1. Read the image of the meat
2. Determine the point to be calculated the RGB value
3. THEN GET RGB value

Result: Marbling RGB value

Furthermore, in the marbling segmentation test, the range of RGB values is then entered as the Beef marbling Tresholding Value by taking the difference in the values of Red and Green as well as Red and Blue. Image segmentation process to determine marbling points refers to the research of Stien et al. (2007) which separates the color of fat from meat using equation 3.1.

$$\alpha(x,y) = \{1\ 0 \frac{R(x,y) - G(x,y)\ \leq 25}{others} \tag{3.1}$$

If α (x, y) is equal to 1, then pixels (x, y) are the marbling area and if vice versa (0) then the area is not marbling which is simply shown in Algorithm 2. The way the equation works is to delete the background on meat used for research. This equation technique focuses on the intensity of sharp blue and green colors. In plain view, the marbling area is a whiter of fat colored whiter compared to the meat around it. Thus, in this study, areas other than white in meat are considered background.

Algorithm 2: Marbling Segmentation

Input: Meat Image
Algorithm
1. Read the image of the Meat
2. IF α (x, y) = 1, THEN pixels (x, y) is the marbling area ELSE α (x, y) = (0), THEN is not marbling
3. For each IF image in Rows, Columns and Layers with a difference ≤ threshold THEN Fat Image, ELSE Meat Image

Result: Image Segmentation

Testing similarity in this study using the Jaccard Index, Cossine and Dice Coefficient Similarity. The Jaccard similarity index focuses on the proportion of the cardinalities of the images assessed together with the cardinalities of all the images calculated in both segments (Thada & Vivek, 2013). In this study the proportion of cardinalities used is marbling in each picture. So the process of finding similarities with jaccard is shown in Equation 1.

$$Sim(u,v)^{Jaccard} = \frac{(I_u \cap I_v)}{(I_u \cup I_v)} \tag{1}$$

Where I_u and I_v are itemset which are valued by users (u) in sequence (v). Then Cosine similarity calculation is done to calculate marbling similarity by using vector (Jimenez, et al., 2016). In this study the vector used was obtained from Ground Truth Segmentation Image and Computation Segmentation. The use of Cosine Similarity is shown in Equation 2.

$$Sim(u,v)^{Cossine} = 2\frac{(I_u \cap I_v)}{|I_u|^{\frac{1}{2}} \times |I_v|^{\frac{1}{2}}} \quad (2)$$

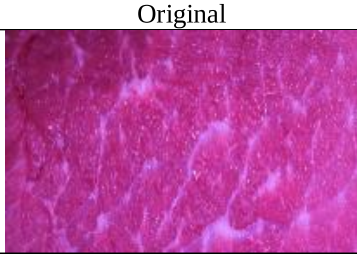
Furthermore, similarity using Dice serves to assess the degree of similarity of marbling by weighting (Can & Ozguven, 2016). The image of processed beef will be calculated as a vector that has distance and direction. Equation 3 is a process to get the similarity value using Dice. The Dice Similarity Coefficient is used as a statistical validation metric to evaluate the performance of both manual segmentation reproducibility and the spatial overlapping accuracy of automatic probabilistic fractional segmentation in images.

$$Sim(u,v)^{Dice} = 2\frac{(I_u \cap I_v)}{|I_u| + |I_v|} \quad (3)$$

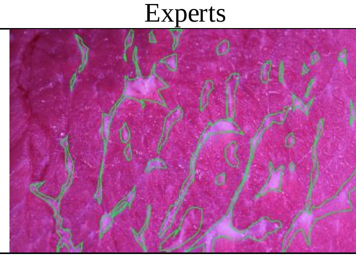
3. Results and Discussion

The results of segmentation by experts and computational techniques are shown in Figure 1.

Original



Experts



Computational Techniques

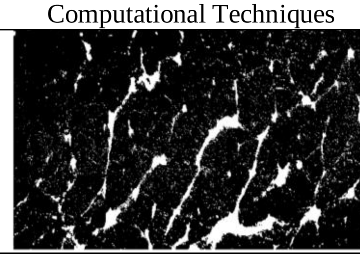


Figure 1

In plain view can be seen differences in detail marking marbling done by experts with computational techniques. In Figure 1, marbling computational techniques mark each marbling in an image in detail. But on the other hand, the results of segmentation by experts only mark the obvious marbling. This is supported by testing similarity with Jaccard, Dice and Cossine in Table 1.

No	Id. Image	Dice	Jaccard	Cosine
1	IMG_2262_2_2.png	0.528	0.359	0.574
2	IMG_2264_1_1.png	0.620	0.450	0.623
3	IMG_2264_2_1.png	0.597	0.425	0.598
4	IMG_2264_3_0.png	0.545	0.375	0.549
5	IMG_2264_3_1.png	0.561	0.389	0.569
6	IMG_2266_1_2.png	0.231	0.130	0.319
7	IMG_2266_2_2.png	0.249	0.142	0.338
8	IMG_2266_3_2.png	0.198	0.110	0.285
9	IMG_2268_1_4.png	0.523	0.354	0.530
10	IMG_2268_3_4.png	0.723	0.567	0.724
…	…	…	…	…
70	IMG_2245_3_4.png	0.558	0.387	0.569

Table 1. Similarity Table

Based on Table 1, Dice Jaccard and Cosine values ranged from 0.3 to 0.6, the results show average value : Jaccard: 0,397, the Dice: 0,561, Cosine: 0,572. this indicates that the similarity of marbling markings performed by experts and computing is small. This is because the expert's sense of sight has limitations in seeing marbling with a small size, while computational techniques are able to calculate marbling to the smallest size.

4. Conclusion

Based on the results described, it can be concluded that assessing marbling with expert vision alone is not enough. Then, it needs to be added and validated with computational techniques. In this study, the marbling marking results appear more detailed and accurate. So, it can be concluded that computational techniques are able to calculate marbling better than experts. Furthermore, further research is recommended to use data streaming so that the marbling assessment process does not take too long.

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