Automatic Detection of Acne Lesions by Utilizing Image Segmentation and Blob Detection

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***Abstract*—This document proposes a solution to address the importance of acne detection. Acne, as a common skin disease around the world, affects roughly 9.4% of the world population. Its effects can lead to physical discomfort and scarring if left untreated. As manual acne detection is prone to subjectivity in its process done by humans, an automatic acne lesion detection method is required. The method proposed by this document would follow certain digital image processing methods to identify acne lesions. By utilizing a segmentation method based on global thresholding on image of a person's face, the heat mapping of the green to red (a*) channel in the CIELAB color space was able to extract candidate acne regions in order to be able to use blob detectors to identify the acne on each image. The result of this project which yields 54% accuracy in detecting acne is aimed at giving information about various features of the images such as angle, overlap, size which could be improved in various feature matching schemes alongside being used as a reference of the acne treatment process.**

Keywords—Morphological Operations. Thresholding. Circularity. Color Space Conversion.

I. Introduction

Skin health is a significant aspect of someone's well-being. However, it is susceptible to various conditions and disorders, among which acne stands out as one of the most prevalent and impactful dermatological issues worldwide that affect people of all ages. Acne is a common skin disease affecting approximately 9.4% of the world's population [1]. Acne can cause physical discomfort, lower self-esteem, and lead to long-term scarring if left untreated. Effective and early detection of acne is therefore pivotal for the timely intervention and treatment.

The method of diagnosing acne is significantly influenced by subjectivity because dermatologists or other medical professionals rely on subjective visual evaluations. According to [2], the dermatologist's knowledge and experience are very important and can lead to different diagnoses. This subjectivity poses a challenge to achieving a standardized and objective assessment of the skin condition. Moreover, varying perspectives on the severity of acne and the best course of treatment could arise from individual differences in expertise.

The involvement of human judgment in traditional methods of acne diagnosis introduces a potential source of bias, thereby influencing the accuracy and reliability of acne assessments. Even though dermatologists and other medical professionals are extremely skilled, their assessments may be influenced by personal experiences, prejudices, and viewpoints. Subjective factors can influence how visual cues related to acne symptoms are interpreted, resulting in differences in how severe or what kind of condition people perceive.

By taking into account the past diagnosis of acne, it predominantly depended on subjective visual evaluations performed by dermatologists or medical practitioners. Consequently, this will lead to the dependency on the expertise and experience of the dermatologists [2]. Nevertheless, this approach, which relies on human judgment, is burdened with intrinsic drawbacks, the risk of bias, and the difficulty of accessing healthcare services in underserved areas. These constraints impede the prompt identification and management of acne, permitting its unchecked progression and potentially culminating in more serious complications. Answering to that, this project aims to harness the power of digital image processing by implementing color-based extraction and blob detection to aid the process of acne detection. By developing an acne detection system, it is hoped that the way individuals monitor their skin to make further decisions on treatment would be improved.

II. Previous Studies

Several methods have been explored in previous studies to detect and access acne in digital images. One prevalent approach involves image acquisitions to receive accurate images of acne throughout the face. The research findings represented by [3] showcases the importance of proper equipment and utilization of said equipment, obtaining details of acne lesions from the chin and forehead regions as they are prominently present throughout those areas. Then another strategy as described by [4], incorporates a thresholding system where a color detection method is applied to a facial region on a proposed skin locus in normalized color coordinate (NCC). A region filling method is applied to the largest connected component labeling the region as the facial region.

In the study conducted by [5], a method to discriminate acne and non-acne using several features such as mean. variance, energy, and entropy introduced. Those four features were used to build a vector machine classifier to cluster the skin/acne. However, this method exhibited sensitivity to various lighting conditions within the image. In the same research, [5] introduced an approach that mitigates the effects of the changing of lighting of an image, using pre-processing to evaluate the lighting compensation in order to achieve a normally (balanced) exposed image. This will lead to more accurate and stable identification even in the presence of lighting changes.

Continuing the process of acne detection, the process involves feature extraction and classification. One classification method, following the identification of feature extraction, involves the use of Machine Learning techniques such as Support Vector Machine (SVM) [4]. The process classifies the potential skin defects into patterns, spots, and acnes, which consist of a decision tree structure to identify the defects. Alternatively, another method presented by [5] proposes the idea of identifying a 'blob', and examining the face for a pixel size of lesion blob less than the size of the reference blob, and determining if the lesion is bigger than the reference to label as acnes. All things aside, this report would state the project of detecting acne lesions through digital image processing, specifically with the utilization of sharpening in segmentation with the addition of heat mapping of the a* channel in CIELAB in the segmented image in order to detect acne through a blob detector.

III. METHOD

The overall process of the automatic acne detection would involve three major steps. The flowchart illustrated in Fig. 1 describes the process in a detailed manner. The first step would be to separate skin and non-skin images. This process would be utilizing two different images as one would act as a mask through the process of blurring and thresholding, and the other would be a sharpened image on which the masking would act upon to separate the skin and non-skin pixels, giving output to the sharpened segmented image. Second major step would be involving the process of extracting the candidate acne region. This process would then utilize conversion from RGB color space into a CIELAB color space of the image in order to extract a* color space. The image of the a* color space would then be utilized to construct a heatmap of the image, highlighting details that could be regarded as acne. The highlights shown by the heatmap would then be used for a second round segmentation, to create candidate acne regions. Lastly, the candidate regions would be verified by a blob detector. It would mark the image with a red marker, showing what's supposed to be the acne.

A. Skin Segmentation

Utilizing various images captured through cameras by a total number of 10, with several examples shown by Fig 2 as a means of image acquisition, the process would involve a segmentation of skin and non-skin pixels. To remove noise in the segmentation process, a copy of the image is created, resulting in two images of the same contents. One of the copied images would be subject to a blurring process using a gaussian filter [6] with the size of 3x3 and a sigma value of 5.5. The blurred image would then have its noise removed, making a more thorough segmentation. Result of this process would be a mask of the face, able to separate features such as hairs, eyes, and nostrils. The mask would then utilize a 5x5 ones kernel on morphological operation processes, namely opening and closing [7]. This would then result in a mask, able to properly distinguish between the skin and no-skin pixels.

Discussing the thresholding process used in this method, the project implemented a fixed global thresholding method to separate skins. Utilizing Hue, Saturation, and Value (HSV) color space to set the thresholding method, it would follow a rule as set by (1). It would set the corresponding pixel in a certain location values into either 0 or 1 according to the rule, resulting in a binary image.

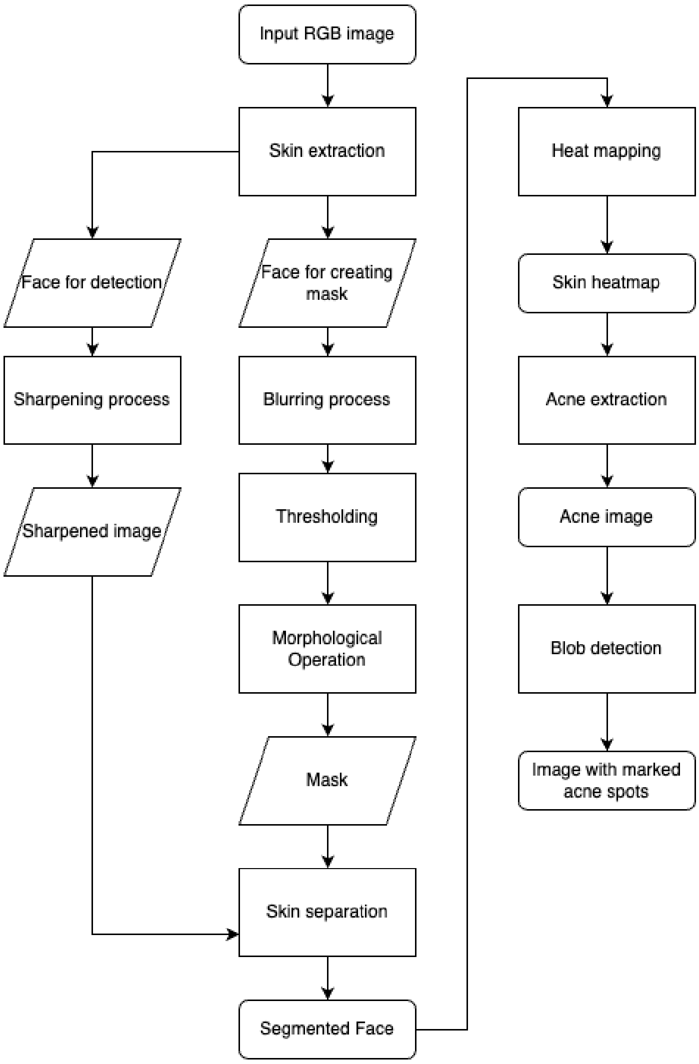

Fig. 1. Proposed method flowchart.

Fig. 2. Example data to be processed

$$S1_{(i,j)} = 1,\ if\ [0 \le H_{(i,j)} \le 40]\ and$$
$$[40 \le S_{(i,j)} \le 255]\ and \quad (1)$$
$$[\,70 \le V_{(i,j)} \le 255]$$

Another image, namely the one subject to the sharpening process would have its pixel separated through the mask generated from the previous process. It would first be subject to a Laplacian of Gaussian (LoG) filter where it would be sharpened and enhanced [8]. The process would then follow with separation of pixels through the aforementioned mask in the previous step. The mask would help in setting non-skin pixels' value to zero and keep the skin pixels to its original value. As stated in Fig. 2, the process would then result in a segmented face, separated from non-skin features.

B. Heat Mapping and Candidate Acne Extraction

Utilizing CIELAB color space conversion from RGB, candidate acne regions can be extracted. CIELAB itself is a color model that was developed by the International Commission on Illumination (CIE). It is a three-dimensional color space that is designed to be perceptually uniform, meaning that the perceptual difference between colors is consistent across the color space. Also known as the L*a*b* color space, it would be able to represent information in a distinctive manner [9].

Lightness (L*) represents the perceptual lightness of the color. The range for L* is from 0 to 100, where 0 represents black and 100 represents white. By which, a value of 50 is considered a neutral gray. The green to red channel (a*) coordinate represents the position of the color on the green to red axis. Positive values of a* represent shades of red, while negative values represent shades of green. The green to blue color space (b*) coordinate represents the position of the color on the blue to yellow axis. Positive values of b* represent shades of yellow, while negative values represent shades of blue [9].

By trying to utilize the a* channel, as it was mentioned to have a representation of green-to-red color, candidate acne regions would be able to be extracted. As the usual color of acnes tend to have a more red color than the surrounding skins. An example of this situation would be the condition where acne of the face would be highlighted more than the surroundings using the a* color channel.

Next step on acquiring the candidate acne region would then be creating another mask through the a* channel image acquired in the previous process. This would involve the usage of otsu adaptive thresholding [10]. As the otsu thresholding would be the best method on this situation, by keeping in mind different images would have different a* values of the highlighted acne, a mask as a result of the thresholding process is produced. This mask would then be used on the first segmented image, giving the result of candidate acne regions.

C. Acne Spots Marking

Through acquiring the candidate acne regions, a specific method to mark and identify the acne was used. Using a blob detection method, acne on the separated image could be marked. Blob itself is a group of connected pixels that share common properties such as grayscale values and shape which utilize a connected components algorithm as one of its steps [11]. The blob itself would implement several properties on deciding if the candidate region would be considered as acne.

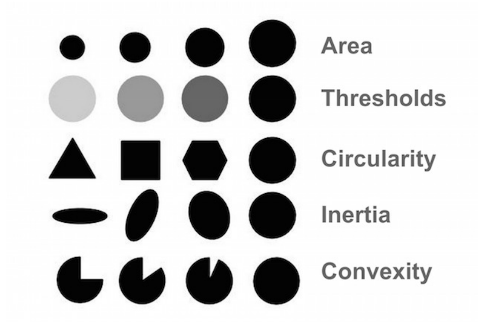

Fig. 3. Blob properties.

Several properties of the blob would be area, threshold, convexity, circularity, and inertia. As illustrated by Fig. xx, the properties would decide how acne and non-acne images would be classified. Starting with the area property, it would set the threshold number of pixels that should belong in the blob object. Sequentially, the threshold would set boundaries of 1 color channel on images. Following up, convexity is a measure of how convex or concave a shape is. For blobs, it is often expressed as the ratio of the area of the blob to the area of its convex hull (the smallest convex shape that encloses the blob). Moving on to the discussion of circularity, it is a measure on how much the blob should represent a circle, with the measurement being a ratio as stated by (2). Lastly, the inertia would describe how elongated or stretched a shape is. For a blob, it is often expressed as the ratio of the minimum inertia to the maximum inertia.

$$4\pi \times \text{Area} \div \text{Perimeter}^2 \quad (2)$$

Due to the different conditions the images would have, the properties would be set manually through experimentation. This would result in a set of properties that would be able to be set interactively by the users. This project would respectively modify some of the pre-existing threshold as stated in Table 1. The process would then follow a marking with a red circle on the acne area.

TABLE I. CHANGED PARAMETERS

Parameters	Modified Parameters	
	Description	***Value***
Color	Minimum Threshold	10
	Maximum Threshold	200
Area	Minimum Area	50
	Maximum Area	1000
Inertia	Minimum Inertia	0.3

IV. RESULTS AND DISCUSSION

The segmentation process managed to acquire a separation of skin and non-skin pixels. As described by Fig. 4, the masking process managed to separate the eyes, eyebrows, nostrils, and hair of the person. Additionally, it can also be seen that the image possesses a more detailed representation of the face as shown by the stronger lines on face features as a result of the sharpening process done by the LoG filter. The segmented as well as sharpened image would then be able to be implemented on heat mapping to acquire the acne regions.

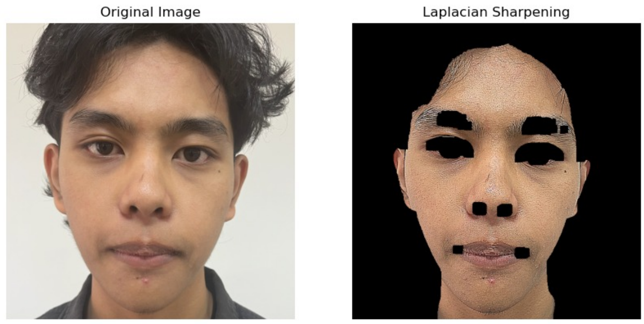

Fig. 4. Original image and segmented image which had been sharpened beforehand.

Acquiring the candidate acne regions, the process involved conversion of the RGB segmented image into the aforementioned CIELAB color space. This process would then follow to result in an image in the a* color channel. The image would then be able to be plotted as a heatmap to show the highlights that were acquired through the conversion into the a* color channel as shown in Fig. 5.

As the image showed that the acne below the lips were able to be highlighted, the process of thresholding the image to create a binary mask in order to extract the candidate acne region. As it would be described by Fig. 6, the process was able to extract the candidate of the acne regions according to a certain threshold set by utilizing the Otsu Adaptive method. This would then follow up to the process of marking the identified acne spots with the blob detection process.

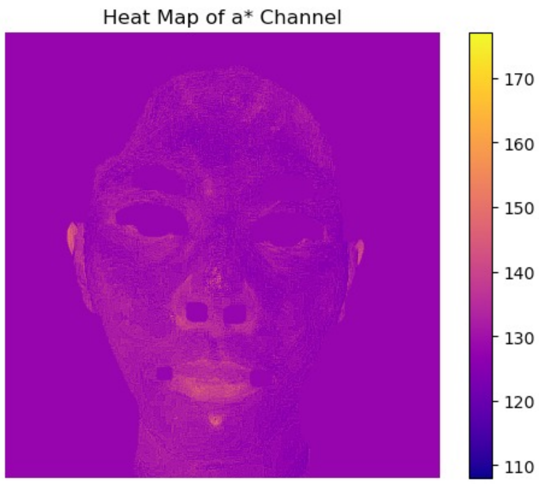

Fig. 5. Heatmap of the a* channel on the segmented image.

Fig. 6. Candidate acne region extraction process through heatmap mask separation.

By acquiring the result of the blob detection process, several parameters would also be able to be acquired. The Blob detector would be able to indicate the location of the marked spots as coordinates and several other features that would be used in the feature matching process were also available. As shown in Fig xx, the red circle shown below the mouth is an indication of the successful blob detection process. The process also reportedly found 1 blob with the matching criteria, meaning there is no misidentification on this image.

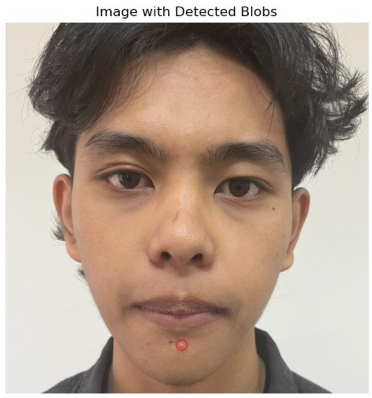

Fig. 7. Image with detected blob to indicate acne.

The process also resulted in several key points of the acne feature able to be extracted from the identification processes. As seen in Table 2, the results available at Fig. 7 are able to identify several key points. These key points would be able to be utilized as reference for further feature matching purposes.

TABLE II. KEY POINTS EXTRACTED

Key Points	***Value***
Point (pt)	(301.1568298339844, 554.5528564453125)
Size	18.75507926940918
Angle	-1.0
Response	0.0

a.

There were also some other images being tested on this project. Namely two low resolution images showing skin colors of a different shade with the previous subject. As a more white skin color subject is being tested on this project, it showed some misidentification in detecting acne. As Fig. 8 suggests, there are some false positives in both images with the addition of a less accurate identification done on the second image.

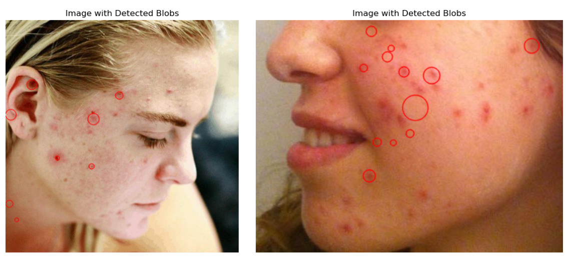

Fig. 8. Additional images of different skin-color being tested.

TABLE III. EXPERIMENTAL RESULTS

Images	Description	Results		
		True Positive	***False Positive***	***False negative***
Image	White Skin	5	7	14
Image2	Indonesian Skin	1	0	0
Image3	White Skin	5	3	6
image4	White Skin	15	1	18
image5	Black skin	0	0	18
image6	Small pimples	39	0	9
image7	Dark skin		191	
image8	White skin	0	53	1
image9	Brown skin	13	138	8
image10	Indonesian Skin	20	2	8
Sum		98	395	82
Accuracy		54.44%		

As Table III stated, there are some images that would produce higher misclassification, especially on detecting false positives images. From the tests that had been run, the segmentation both from the Global Thresholding and the Heatmap Extraction are best for a more white skin rather than a black one. In Fig. 9, it is evident that LoG tends to overemphasize the contrast and inadvertently removes some crucial details on darker skin tones. This makes it challenging to accurately pinpoint and identify acne for individuals with dark skin. This issue can contribute to false negatives, leading to a less effective detection system for diverse skin tones. To overcome this limitation, there is a clear need for a more enhanced feature extractor. This extractor should consider the variety of skin tones and ensure that the system does not affect individuals with a darker complexion disproportionately.

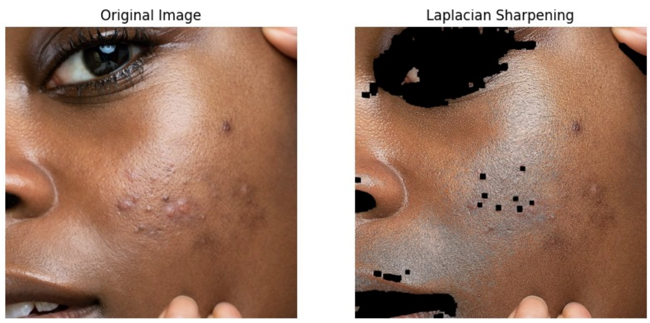

Fig. 9. Over-enhancement done on darker skin images by the LoG filter.

Previously mentioned, misclassification on other images would be highly caused by the heat mapping and candidate acne extraction result of each image. As shown in Fig. 10 and Fig. 11 while bringing back the second image of Fig. 8 showed more misidentification due to bad thresholding of the heatmap, resulting in a bad acne candidate area in Fig. 11. This is also due to the fact that the heatmap in Fig.11 also showed a more homogeneous color distribution, showing similar values in acne and non-acne pixels around the nose and cheeks. Although this was the case, the automated model was able to identify acne correctly on images that exhibit darker skins of those possessed by the people in South East Asia.

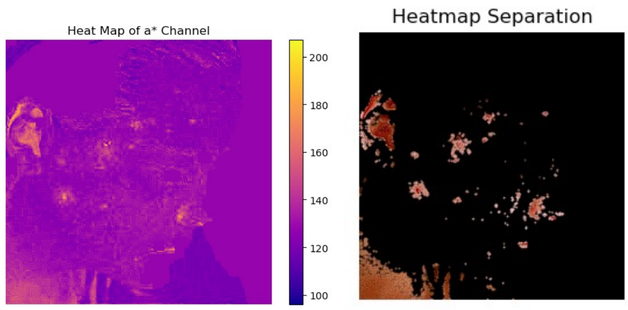

Fig. 10. Heat map and Heatmap extraction of the first woman.

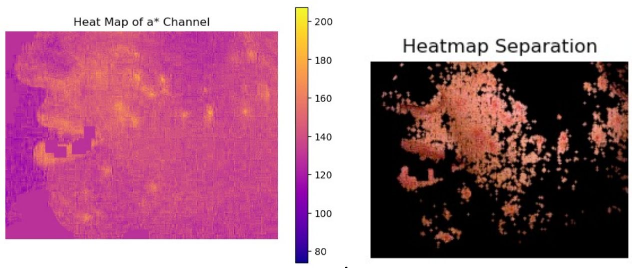

Fig. 11. Heat map and Heatmap extraction of the second woman.

V. CONCLUSION AND RECOMMENDATION

Concluding the project, the proposed method being tested on several images was able to detect acne correctly by giving results of extracted key points and number of detected blobs with some minor improvements being needed. Improvements around the method of separating images through heat maps would be needed in order to acquire a better implementation, especially on handling the false negatives and false positives of the identification process. Additionally, this process could also be implemented as a creation of annotated acne datasets, along with the location of each acne lesion. Increasing the probability of constructing better methods.

Future work is expected to employ a more potent feature extractor. The use of deep learning models would be beneficial and is likely to improve the overall performance of acne detection and could be implemented on the construction of acne classification where types of acne could be classified correctly.

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APPENDIX

The final implementation of this method and the dataset being utilized is accessible through Github: https://github.com/louiswids/Digital-Image-Processing_Automatic-Acne-Detector

References

[1] Vos et al. (2012). Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: A systematic analysis for the Global Burden of Disease Study 2010. The Lancet, 380, 2163–2196. doi:10.1016/S0140-6736(12)61729-2.

[2] Shen et al. (2018). An Automatic Diagnosis Method of Facial Acne Vulgaris Based on Convolutional Neural Network. Scientific Reports, 8, 5839. doi:10.1038/s41598-018-24204-6.

[3] S. K. Madan, K. J. Dana and O. Cula, "Learning-based detection of acne-like regions using time-lapse features," 2011 IEEE Signal Processing in Medicine and Biology Symposium (SPMB), Brooklyn, NY, USA, 2011, pp. 1-6, doi: 10.1109/SPMB.2011.6120114.

[4] C. Chang and H. Liao, "Automatic Facial Spots and Acnes Detection System," Journal of Cosmetics, Dermatological Sciences and Applications, Vol. 3 No. 1A, 2013, pp. 28-35. doi: 10.4236/jcdsa.2013.31A006.

[5] A. S. Malik, R. Ramli, A. F. M. Hani, Y. Salih, F. B. -B. Yap and H. Nisar, "Digital assessment of facial acne vulgaris," 2014 IEEE International Instrumentation and Measurement Technology Conference (I2MTC) Proceedings, Montevideo, Uruguay, 2014, pp. 546-550, doi: 10.1109/I2MTC.2014.6860804.

[6] L. G. Shapiro and G. C. Stockman, Computer vision. Upper Saddle River Prentice Hall, 2001. pp. 137 - 150

[7] R. M. Haralick, S. R. Sternberg and X. Zhuang, "Image Analysis Using Mathematical Morphology," in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. PAMI-9, no. 4, pp. 532-550, July 1987, doi: 10.1109/TPAMI.1987.4767941.

[8] J. W. Woods, 'Chapter 7 - Image Enhancement and Analysis', in Multidimensional Signal, Image, and Video Processing and Coding (Second Edition), Second Edition., J. W. Woods, Ed. Boston: Academic Press, 2012, pp. 223–256.

[9] M. R. Luo, 'CIELAB', in Encyclopedia of Color Science and Technology, R. Luo, Ed. Berlin, Heidelberg: Springer Berlin Heidelberg, 2014, pp. 1–7.

[10] N. Otsu, "A Threshold Selection Method from Gray-Level Histograms," in IEEE Transactions on Systems, Man, and Cybernetics, vol. 9, no. 1, pp. 62-66, Jan. 1979, doi: 10.1109/TSMC.1979.4310076.

[11] H. Samet and M. Tamminen, "Efficient component labeling of images of arbitrary dimension represented by linear bintrees," in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 10, no. 4, pp. 579-586, July 1988, doi: 10.1109/34.3918.