International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

The Development of Residual Network (ResNet-18) Convolutional Neural Network (CNN) Architecture Combined with Content-Based Image Retrieval (CBIR) Method to Measure Logo Image Similarity Level

[1]Larissa Navia Rani, [2]Yuhandri, [3]Muhammad Tajuddin

Submitted: 27/04/2023 **Revised**: 29/06/2023 **Accepted**: 09/07/2023

Abstract: In this study, the degree of visual resemblance between two logos—both those that were unique and those that were identical—will be measured. It can be done by compiling a database of logo images from various sources of existing logo image data that have been stored and extracted. In this study, four brand pictures serve as data testing while 210 photo data for the database serve as data training. All of the logo images were provided by the West Sumatera Regional Office of the Ministry of Law and Human Rights of the Republic of Indonesia (Kemenkumham—Kementerian Hukum dan Hak Asasi Manusia—Republik Indonesia). The 320 by 320 color size photos guarantee the most precise dimensional uniformity technique for the images. Instead of using the Residual Network (ResNet-18) Architecture of the Convolutional Neural Network (CNN) type, the Content-Based Image Retrieval (CBIR) approach was employed to generate a suitable similarity score for the research. This approach automatically distributes training images and validation images, using 147 training image data values (70%) and 63 validation images (30%) out of the 210 available photos. As a result of this research, an algorithm that measures logo picture similarity will be created and used in method implementation and tool software. This tool has a 93.65% accuracy rate after 84 iterations.

Keywords*: ResNet 18, CNN, CBIR, Logo Image, Similarity Level.*

1. Introduction

The logo serves as more than just a representation of the firm, institution, or group that utilizes it; it also has hidden icons, symbolism, and meanings [1]–[5]. The distinctions between a corporation, organization, and institution result in distinctive logo variation in light of the goals and objectives to be attained [6]–[10]. The concerned party typically uses the logo to identify themselves to the agency or the public. Law No. 20 of 2016 concerning Trademarks and Geographical Indications states that the role of Marks and Geographical Indications is essential in the age of global trade, particularly in maintaining fair and just business competition, protecting consumers, and protecting the rights of third parties. To prevent sharing brand information with other companies, trademarks (in the form of logos) must be registered as soon as possible [11]–[16].

Depending on where the new business will be located, Kemenkumham is the place to apply for logo registration. A difficulty arose when the trademark application (in the form of a logo) was delivered to the Ministry of Law and Human Rights. Based on the Ministry of Law and Human Rights interviews, they encountered difficulties in verifying the provided logo data due to restrictions on inspecting logos. The logo checking process involves several steps: the Ministry receives the logo registration application, examines it from the applicant's side, accepts the application, and then proceeds with two rounds of logo inspection. During the second inspection, the Ministry announces the logo's pending patent status to the public for a two-month period. The entire logo patenting process typically takes between one and a half to two years, provided there is no evidence of plagiarism.

The World Intellectual Property Organization (WIPO) offers the Ministry of Law and Human Rights an Industrial Property Automation System (IPAS). WIPO collaborated with the Directorate General of Intellectual Property Rights (DJHKI) to customize this system according to the requirements of IPAS users (Director General HKI Decree No. 01.OT.01.01.2012, 2012). One significant drawback of the IPAS system is the extended time it takes to make decisions on logo registration requests, whether to approve or reject them.

Additionally, the system's inability to track logos locally poses a challenge in identifying similarities between two logos, regardless of their appearances. To address this

[1] *Information System, Universitas Putra Indonesia YPTK Padang, Lubuk Begalung Highway, Padang, 25221, Indonesia. Email ID: larissa_navia_rani@upiyptk.ac.id*
[2] *Information Technology, Universitas Putra Indonesia YPTK Padang, Lubuk Begalung Highway, Padang, 25221, Indonesia. Email Id: yuyu@upiyptk.ac.id*
[3] *Information Technology, Universitas Putra Indonesia YPTK Padang, Lubuk Begalung Highway, Padang, 25221, Indonesia. Email Id: tajuddin@universitasbumigora.ac.id*

issue, image processing is employed to evaluate the degree of similarity between logos with distinct or similar visual characteristics.

This research aimed to assess the similarity between two logos, whether they have distinct or identical appearances. To achieve this, a database of logo images was established, comprising data sourced and collected from various existing logo image repositories. Additionally, the logo image database was contrasted with the logo being examined or evaluated to determine how close they were. Character recognition has been done on the logo to determine how close it was to the one used in the previous procedure. The Image Retrieval method was used to compare the test logo with the logo image in the database. The process of categorizing and recognizing images was conducted using image processing within the Image Retrieval approach. The calculations for this comparison's results demonstrated how comparable the logo picture being evaluated was to the logo image that had been around for a while and was kept in the database.

2. Related work

Previous studies have been done by Rezende et al. (2017) [17], who used the ResNet algorithm for image processing and bogus picture detection. This paper suggests combining the ResNet-50 algorithm, the CNN model, and transfer learning. The findings showed that the ResNet-50 algorithm and transfer learning can distinguish between real photographs and fraudulent images with an accuracy rate of 94%.

Arpana Mahajan and her colleagues (2019) [18] conducted further investigations where they utilized the Representational Deep Network (ResNet) to recognize categorical images. They employed a deep learning method for image classification in their study. The suggested approach divides hundreds of high-resolution photos into eight groups using a deeper, more comprehensive Convolution Neural Network. This study pulls image features from previously trained The machine learning Support Vector Machine (SVM) classifier was trained using the ResNet model. The findings showed that the ResNet approach performs better when choosing CNN 18-layer features and SVM classification. Deep learning is a Combine Feature + Classification Approach used by RESNET The suggested technique will be effective for both object and picture categorization.

Graphic logo detection was carried done by Yuanyuan Li et al. in 2019 [19] utilizing Deep Region-based Convolutional Networks. To expand the dataset for this research, 6,400 logo images from the FlickrLogo-32 dataset were consolidated. Subsequently, a Faster R-CNN framework was developed, integrating multiple classification models for logo detection. The experimental results indicated that the proposed framework surpassed other state-of-the-art methods in performance.

The detection and diagnosis of skin illnesses were carried out by Moolchand Sharma et al. (2019) [20] utilizing residual neural networks (ResNet). This study used a 50-layer residual neural network to train data acquired from DERMNET to build the suggested expert system. This work was done in Python. According to the study's findings, the ResNet model training's accuracy level reached 95%, and the prediction outcomes were at an epoch value of 10.

By creating a procedure for selecting values that impact the network training process, this research will subsequently calculate the level of similarity of logo images based on the issues and related research mentioned above. This research has benefited from creating a method for identifying values affecting the network training process because few researchers have conducted this kind of research. This research aims to make a contribution that will make it easier, quicker, and more exact for Indonesia's Ministry of Law and Human Rights (Kemenkumham) to analyze how similar logos are in requests for logo patents. The community, particularly business people, might benefit from this research in another way. When developing a logo that will serve as the company’s brand identity, they will find to reduce logo plagiarism between two companies or agencies.

3. Methodology

3.1 Research Framework

The main objective of this study is to identify the exact parameters in the image feature extraction network training process, allowing for highly accurate calculation of logo similarity. The findings will be utilized to develop a user-friendly computer-based application or tool, offering unrestricted access to assess logo similarity. This application will benefit not only the business community in general but also the Kemenkumham of West Sumatera Regional Office specifically. Figure 1 provides a graphical representation of the study framework, summarizing the various stages involved.

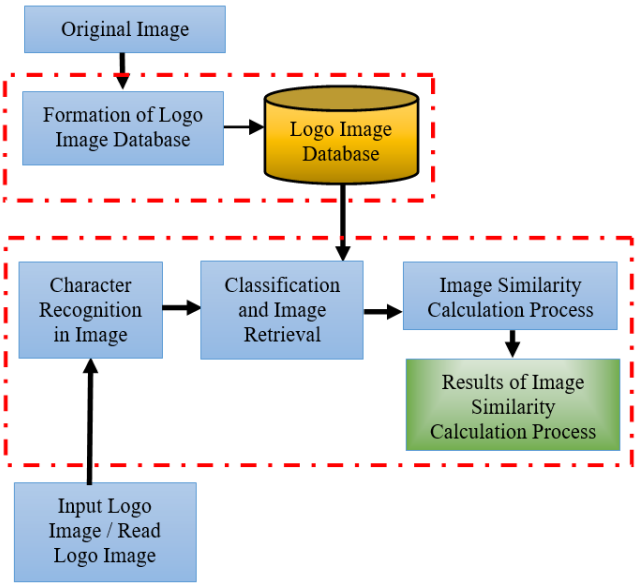


Fig. 1. Research Framework

3.2 Research Framework Details

3.2.1 Input Logo Image

The study's input image is a digital copy of the logo's original design, which will be compared to a database of other logos to determine their similarity. The West Sumatera Regional Office of the Ministry of Law and Human Rights of the Republic of Indonesia (Kemenkumham RI) provided all of the utilized logo images in the form of *.jpg files. In order to study the process of dimensional homogeneity of the images, all of the used logo images are color images with pixel sizes of 320 × 320. There are 12 logos in the collection. As a sample for this research, only six images were shown.

3.2.2 Stages of Creating a Logo Image Database

The stages of making the database aim to get the features or characteristics of the logo image and store it in the database. This stage consists of six processes, namely, image color segmentation, binarization, edge detection, cropping, skeleton, feature extraction or logo image features, and then the process of creating a database and storing logo image features or features. The process of creating a logo database can be seen in Figure 2 below:

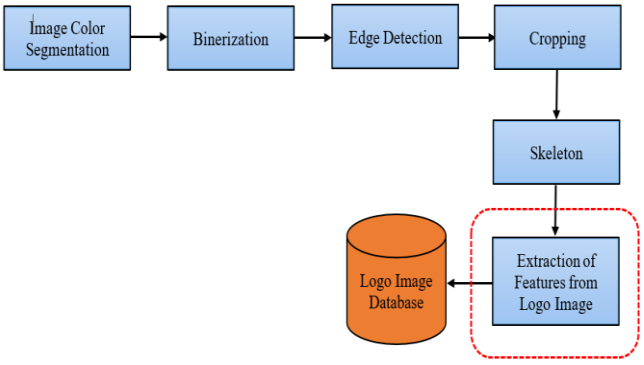


Fig. 2. Database Development Stages

3.2.2.1. Segmentation Process Based on Logo Image Color

The image segmentation is based on the similarity between each pixel's color and the logo image's background color [21]–[23]. The RGB color space and Euclidian distance are used to measure the distance between the two colors. The Euclidian distance formula for RGB colors is given by equation 1 below:

$$D = \sqrt{(R_{ref} - R_p)^2 + (G_{ref} - G_p)^2 + (B_{ref} - B_p)^2} \quad (1)$$

Where: R_{ref}, G_{ref}, and B_{ref}, respectively, are the red, green, and blue reference color components of the background color of the logo image. The R_p, G_p, and B_p are the three color components of each pixel in the image.

The basic principle of logo image color segmentation is to remove all pixels that have the same color or are close to the background color of the logo image (D < Th) and take all pixels with a color range D > Th. The threshold value (Th) can be determined based on experimental results. Based on the basic principles and equation (1) above, a segmentation algorithm is obtained as given in Algorithm 1.

Algorithm 1: Segmentation Process Based on Logo Image Color

1. Read the logo image
2. Display the logo image to be segmented
3. Read pixel color as area color for segmentation
4. Determine RGB space reference color
5. Determine the threshold value = 50
6. Read RGB image size
7. Initialize the RGB resulting image matrix
8. Calculate RGB color distance
9. Separate objects with an image background
10. Display the results of image segmentation
11. Save the results of the segmentation process

3.2.2.2 Binarization

The next step in the database formation process is the binary process. Binarization aims to change the logo image from a color to a gray image and then to a binary image to clarify the area boundaries of each object and facilitate the next analysis process [23]–[26]. The results of the binarization process sometimes still contain noise in the form of small white dots, so a noise removal process is needed. Based on this explanation, a binary algorithm is obtained as given in Algorithm 2 below:

Algorithm 2: Binarization

1. Read the segmented logo image
2. Display the segmented logo image
3. Convert RGB image to grayscale and display grayscale image
4. Convert grayscale image to binary and display binary image
5. Eliminate noise in the binary image and display the resulting image
6. Save the binary image resulting from noise cleaning

3.2.2.3 Edge Detection

This process is the next step in creating a logo image database. Edge detection is a process that detects the edge line that delimits two image regions [27]–[31]. Edge detection aims to mark parts that become detailed images and improve and change images. The stages carried out in this process can be seen in Algorithm 3 below:

Algorithm 3: Object Detection Algorithm

1. Read the binarized logo image
2. Display the binarized logo image
3. Detect edge using canny edge detection
4. Show edge detection results
5. Save the results of the edge detection process

3.2.2.4 Cropping

The next process at the database creation stage is the cropping process. This stage aims to remove/take/cut some of the contents of the image to obtain the desired result. The cropping process in forming this database is done automatically to get the desired part of the logo image. The stages carried out in this process can be seen in Algorithm 4 below:

Algorithm 4: Cropping Process Algorithm

1. Read the edge detection logo image
2. Display the edge-detected logo image
3. Crop automatic image
4. Display the cropped logo image results
5. Save the results of the logo image cropping process

3.2.2.5 Skeleton

The skeleton stage is the last stage before entering [32]–[35] the feature extraction process in database creation. Skeletons represent and recognize handwriting, fingerprint patterns, biological cell structures, circuit diagrams, engineering drawings, path plans of robots, and the like. The skeleton stage uses the arguments "skel" and "inf", which means that the "skel" argument states the expected result is a skeleton, and the "inf" argument states an infinite value or the maximum number of repetitions in forming a skeleton. The stages carried out in this process can be seen in Algorithm 5 below:

Algorithm 5: Skeleton Process Algorithm

1. Read the cropped logo image
2. Display the cropped logo image
3. Use the "skel" operator/argument
4. Display the results of the logo image skeleton
5. Save the results of the logo image skeleton process in a folder with the database name

3.2.3 Feature Extraction

The next process in this research in making the database is the feature extraction process from the logo image. Two types of logo images will be processed at this stage: training images and validation images in the database folder. It is done to get the feature values that exist in the image. The value obtained will be used as a characteristic of the logo image, which will also be used to calculate the level of similarity between the two images. This extraction process is carried out using the ResNet-18 Algorithm. The previous ResNet-18 algorithm has been unable to extract more in-depth images, so if the data is calculated using the cosine similarity algorithm, it gives inaccurate results of similarity calculations. The values obtained will then be stored in the database as the characteristic values of the logo image. Content-Based Image Retrieval Process.

Some of the processes carried out at this stage are as follows:

1. The first stage is the input of the logo image, which will be used as training data and test data
2. The second stage is the logo image process by repeating each step that is carried out in the previous database formation process, including the image color segmentation process, the binary process, the edge detection process, the cropping process, the skeleton process, and feature extraction using the ResNet-18 algorithm, so that feature value of each object in each image to be used in the training and testing process is gotten.
3. The third stage is the image retrieval process. At this stage, a classification of logo image features and

image retrieval is carried out based on the results of the previous process by conducting training and testing.

4. The final stage of the feature extraction process for the logo image stored in the database is tested with the original image of the logo and other test images to measure and compare the level of similarity of the logo image to the training data stored in the database.

The stages carried out in this process can be seen in Algorithm 6 below:

Algorithm 6: Content-Based Image Retrieval Process Algorithm

Training Process:

1. Input logo image
2. Image segmentation process
3. The process of binarization
4. Edge detection process
5. The cropping process
6. Skeleton process
7. Logo image feature extraction process
8. Logo image feature database
9. Training Results

Test Process:

1. Input logo image
2. Image segmentation process
3. The process of binarization
4. Edge detection process
5. The cropping process
6. Skeleton process
7. Logo image feature extraction process
8. The logo image feature database is tested with the training image feature data in the database
9. Results of image character recognition (Optical Character Recognition)
10. The test results are the results of calculating the similarity between the two images as a percentage.

3.2.4 Image Similarity Calculation Process

The logo image, which has undergone classification and image retrieval in the preceding steps, will now be employed for the image similarity calculation process. This process involves applying the cosine similarity algorithm, as depicted in the formula below:

$$Similarity(X,Y) = \frac{x_i * y_i}{||x_i|| * ||y_i||} \quad (2)$$

Where, xi = Input image data, yi = Data centroids, ||xi|| = length of the input image data vector, ||yi|| = length of centroid data vector

In the process of getting good accuracy when testing data, the training set must be able to present test data. The formula used to get the percentage value from the similarity calculation process is as follows:

$$a = b / c \; x \; 100 \quad (3)$$

Where, a = Number of true/similar values, b = Number of incorrect/unsimilar values

Following below is Algorithm 7 that researchers use to perform image similarity calculations.

Algorithm 7: Image Similarity Calculation Algorithm

1. Evaluate the outcomes derived from feature extraction.
2. Inspect the output class of the test results.
3. Perform calculations for the hashing code.
4. Undertake computations for cosine similarity.
5. Implement the class sorting procedure for retrieval purposes.
6. Analyze the obtained output class from the retrieval process.
7. Store the results of the calculations.
8. Present the results of the similarity calculations.

3.2.5 Logo Similarity Measurement Application GUI Design

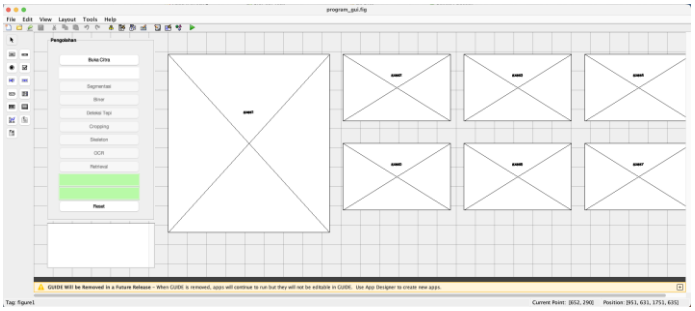


Fig. 3. Similarity Measurement Application GUI Design

4. Result and Discussion

4.1 Input Logo Image

This research was conducted through several stages, including the Data Collection, which collected 12 logo

images in this stage. The results of the 12 logo images are used as reference images whose feature values will be entered into the database. The data that has been collected is then processed to the data preprocessing stage, which includes the process of color segmentation, binarization, edge detection, image cropping, and skeletoning (thinning). The next stage is the logo image feature extraction process using the ResNet-18 algorithm. In this stage, several other stages are added to make the image feature extraction results more accurate. The other steps added are separating training data and validation data, adding data augmentation to get more features, and setting values affecting the feature extraction process.

The next stage after feature extraction is the image character recognition stage and the similarity calculation stage. The stages of image character recognition in this study use simple optical character recognition arguments, so they cannot provide maximum results. Meanwhile, at the stage of calculating the similarity of the two images, several methods are added to provide more accurate similarity calculation results, such as using a locality-sensitive hashing technique that functions to convert feature values into binary code to make the feature dimensions smaller to save computation. The cosine similarity algorithm will use this binary code to calculate the similarity between the two images.

This study uses six logo images for data training and 31 logo images for testing. These data will be used in calculating the level of similarity as shown in Table 1 below:

Table 1. Input Image Result

No	Logo Image	Name
1	AJWA al madina عجوه المدينة	Ajwa Logo
2	KWETIAW SAPI 1985 AKHUN	Kwetiaw Sapi Akhun Logo
3	BT	BT Logo
4	DIAMOND	Diamond Logo
5	JOINWIT	Joinwit Logo
6	NEXGEN	Nexgen Logo

4.2 Stages of Creating a Logo Image Database Result

4.2.1 Image Segmentation Based on Color Result

Image segmentation involves the task of identifying objects within an image or partitioning the image into multiple regions, where each area or object possesses similar attributes. This process has been integrated into the Matlab program, and the outcomes, along with the image results, are presented in Table 2.

4.2.2 Binarization

Some image processing refers to binary images. Using binary images can make comparisons between the length and width of objects. The binarization stage in this study is to change the segmented image into a grayscale form which is then converted to a binary image. Changing this binary image also adds a mathematical morphological operation opening that aims to remove noise in the image. The results of the binary process can be seen in Table 2 below.

4.2.3 Edge Detection Result

In this study, image edge detection is performed using the Canny operator. This particular algorithm offers advantages such as a low error rate, precise localization of edge points (with minimal distance between detected edge pixels and the actual edges), and providing only one response for each edge. By implementing algorithm 3 with the Matlab programming language, the results are obtained and presented in Table 2.

4.2.4 Cropping Image Result

The results of edge detection are then processed using the cropping operator. This process aims to obtain the results of the desired image. The cropping process in this study was made automatically based on image coordinates to avoid inaccurate cropping results. The results of the cropping process are shown in Table 2.

Table 2. Segmentation, Binarization, Edge Detection, And Cropping Image Result

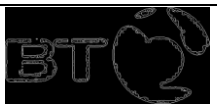
No	Original Logo Image	Segmentation Based on Color Result	Binarization Image Result	Edge Detection Image Result	Cropping Image Result

1					
2					
3					
4					
5					
6					

4.2.5 Skeleton Image Result

The next process is the skeleton process. The process at this stage uses the cropped image. The results of the skeleton process are shown in Table 3 below.

Table 3. Skeleton Image Result

No	Cropping Image Result	Skeleton Image Result
1		
2		
3		
4		
5		
6		

4.3 Logo Image Feature Extraction Result

This stage is an advanced stage of the skeleton process. At this stage, the existing logo image data is multiplied by 10 of each type. Then the augmented data is given a data augmentation process to modify existing data. It was done because of the limited available data, while this research requires much data. The next process is the data that has been reproduced previously divided into two parts, namely training data with a weight of 70% and validation data with a weight of 30%. The result of this

stage is the characteristic value of the logo image. Table 4 is the feature value data resulting from the feature extraction process.

Table 4. Logo Image Feature Extraction Result

No.	Image Name	Logo Image Feature Value											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	'skeleton_ajwa copy 2.bmp'	-5,46	-1,30	0,24	0,83	-0,93	-0,29	0,13	-0,56	-2,23	-0,75	1,18	-0,75
2	'skeleton_ajwa copy 3.bmp'	-5,94	-1,99	0,16	1,35	-1,92	-0,32	-0,45	-0,07	-2,78	-0,12	0,28	-0,78
3	'skeleton_ajwa copy 4.bmp'	-5,37	-0,95	0,20	1,12	-1,24	-0,12	0,23	2,20	-2,54	-1,36	1,44	-0,31
4	'skeleton_ajwa copy 5.bmp'	-6,37	-1,86	1,22	0,51	-1,26	0,02	1,11	0,60	-2,13	-0,48	1,60	-0,36
5	'skeleton_ajwa copy 6.bmp'	-4,65	-1,09	1,53	1,46	-1,70	-0,95	-0,20	1,59	-2,15	-0,97	0,58	-0,26
6	'skeleton_ajwa copy 7.bmp'	-5,40	-1,77	0,45	-0,03	-0,09	-0,22	0,68	0,67	-2,23	-0,87	1,17	-0,05
7	'skeleton_ajwa copy 8.bmp'	-5,47	-2,66	0,98	0,24	-0,06	-1,01	0,22	0,56	-1,60	-0,70	1,33	-0,07
8	'skeleton_ajwa copy 9.bmp'	-4,77	-0,76	0,01	0,49	-0,05	-0,96	-0,41	-0,40	-2,30	-0,68	-0,12	-0,49
9	'skeleton_akhun kwetiaw copy 2.bmp'	-1,59	6,92	0,59	-2,40	-0,34	0,53	-2,70	1,16	1,33	-1,48	-1,42	-1,37
10	'skeleton_akhun kwetiaw copy 4.bmp'	-0,66	6,22	0,19	-2,15	0,00	0,51	-2,62	0,87	1,27	-1,45	-1,25	-0,79

The next process is to carry out the image training process using the ResNet-18 architecture with an updated method in several stages. Figure 4 and 5 compare the training results on the previous ResNet-18 architecture with ResNet-18 with the updated method.

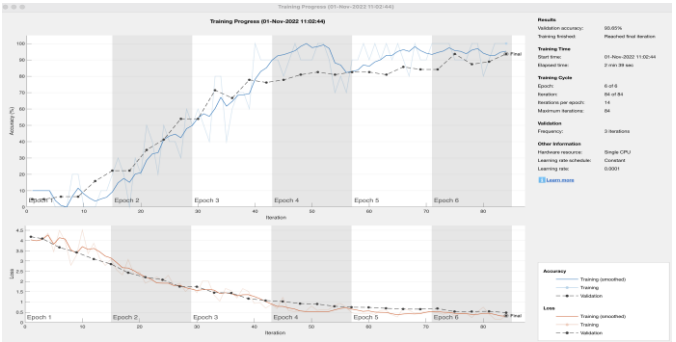


Fig. 4. Results of the Previous Training Process

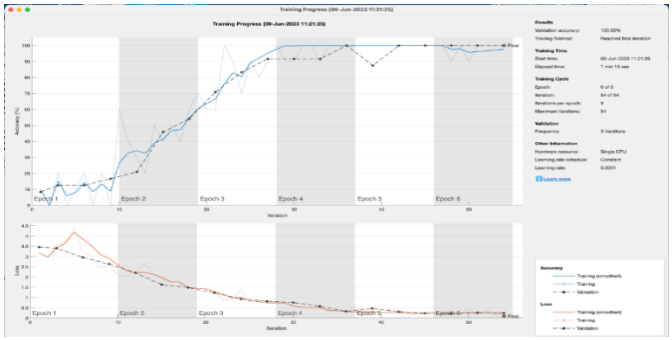


Fig. 5. Results of the current training process

Based on Figure 4 and 5, the feature extraction process using the previous ResNet-18 Algorithm gave an accuracy of 93.65%, while the feature extraction process using the ResNet-18 Algorithm with the updated method yielded 100% accuracy.

4.4 System Testing Results

This testing phase consists of four stages, as explained in Chapter 3 previously. The preprocessing stage comprises segmentation, binarization, edge detection, cropping, and skeleton. The next stage is the image retrieval stage, character recognition of the image, and calculating image similarity as the last. In this study, testing was carried out with two versions, namely the original image and the test image. Based on the test results with the original image data, the results are shown in Table 5.

Table 5. Test Results With Test Image

No	Testing Image	Training Image	Result	Note
1			Same: 82.2846% 	The image used as test data is an image that has been modified
2			Same: 87.6503% 	The image used as test data is an image that has been modified
3			Same: 96.6334% 	The image used as test data is an image that has been modified
4			Same: 68.1246%	The image used as test data is an

				image that has been modified

4.5 Comparison of Results with Previous Feature Extraction Methods with Current Feature Extraction Methods

This stage describes a comparison of the use of the previous feature extraction method with the current feature extraction method. The previous method of the feature extraction process was imperfect, marked by the inaccuracy of the logo image similarity calculation results when tested using the same original image. Based on the results of the similarity calculation, the old method was updated by adding stages during data preprocessing and logo image feature extraction. The current method has better results and has been tested using validator data from the Ministry of Law and Human Rights of the Republic of Indonesia. An example of a comparison of the two methods is shown in Table 6 below.

Table 6. Comparison of Logo Image Similarity Calculations Using The Old Method With The New Method

No	Testing Image	Old Method	New Method	Note
1				The old method is inappropriate for providing image detection results or calculating image similarity. In contrast, the new method has provided better results in detecting logo images and measuring logo image similarity.
2				The old method is inappropriate for providing image detection results or calculating image similarity. In contrast, the new method has provided better results in detecting logo images and measuring logo image similarity.
3				The old method is inappropriate for providing image detection results or calculating image similarity. In contrast, the new method has provided better results in detecting logo

				images and measuring logo image similarity.
4	DIAMOND			Here, the old method is inappropriate in providing image detection results or calculating image similarity. Meanwhile, the new method has provided better results in detecting logo images and measuring logo image similarity.

5. Conclusion

Based on testing of the method developed, it can be concluded that extracting logo image features using the ResNet-18 algorithm with an updated method can produce better image feature extraction. Good extraction results greatly affect the process of calculating the logo image similarity level. The addition of locality-sensitive hashing techniques helps speed up computation in the process of calculating image similarity. The locality-sensitive hashing technique makes it easier for the cosine similarity algorithm to calculate the level of similarity because the feature values stored in the database are converted into binary code by this method. In particular, conclusions can be drawn regarding achieving the objectives of the method built. The color segmentation algorithm is created automatically by taking the x and y pixel points to separate the color between the object and the background. The cropping algorithm is created automatically using the coordinates of the object. It is very helpful in obtaining logo image feature values because for the case of calculating logo image similarity, if the cropping algorithm is made manually, it will give different results every time tested, even with the same image. The proposed method is the addition of steps affecting the logo image feature extraction process, such as the preprocessing stage. This stage has an important role in this case because the results of the preprocessing stage will be used for the feature extraction stage. Apart from that, this case also added a data augmentation stage. Due to the limited available logo data, it is necessary to modify the existing logo image data to become more numerous to obtain more varied image feature values. In the image feature extraction stage using the ResNet-18 algorithm values are also added affecting the process, such as epoch, batch, and other values. In addition, as previously described, this process also uses a locality-sensitive hashing technique which is useful for converting feature values into binary code to save computation. The binary code values obtained using the locality-sensitive hashing technique will be used to calculate similarity using distance with the cosine similarity algorithm.

Acknowledgment

We would like to thank the Yayasan Perguruan Tinggi Komputer (YPTK) Padang, especially the chairman of the Foundation, Mrs. Dr. Hj. Zerni Melmusi, M.M., Ak. CA. and the Advisory Chairman of YPTK Padang, Mr. Dr. Muhammad Ridwan, S.E., M.M., who have supported and funded all of this research, and Universitas Putra Indonesia YPTK Padang, which has facilitated and guided this research.

References

[1] K. Kumar Jakkur Patalappa and S. Maganahalli Chandramouli, “Robust recognition of logo under makeover in the context of content piracy,” *Glob. Transitions Proc.*, vol. 2, no. 2, pp. 421–428, 2021, doi: 10.1016/j.gltp.2021.08.050.

[2] T. Ghosh, S. Sreejesh, and Y. K. Dwivedi, “Brand logos versus brand names: A comparison of the memory effects of textual and pictorial brand elements placed in computer games,” *J. Bus. Res.*, vol. 147, no. March, pp. 222–235, 2022, doi: 10.1016/j.jbusres.2022.04.017.

[3] P. de Lencastre, J. C. Machado, and P. Costa, “The Effect of Brand Names and Logos’ Figurativeness on Memory an Experimental Approach,” *SSRN Electron. J.*, vol. 164, no. February 2022, 2022, doi: 10.2139/ssrn.4052517.

[4] B. R. Estevam and D. M. Riaño-Pachón, “CoCoView - A codon conservation viewer via sequence logos,”

MethodsX, vol. 9, p. 101803, 2022, doi: 10.1016/j.mex.2022.101803.

[5] J. Majeed Sadeq, B. Aziz Qadir, and H. Hassan Abbas, "Cars logo recognition by using of backpropagation neural networks," *Meas. Sensors*, vol. 26, no. January, p. 100702, 2023, doi: 10.1016/j.measen.2023.100702.

[6] X. Gao and W. Chen, "Brand LOGO Image Recognition and Inquiry Creative Teaching Design Based on Deep Learning," *Wirel. Commun. Mob. Comput.*, vol. 2022, 2022, doi: 10.1155/2022/5396468.

[7] X. Jia, Y. Dong, and B. Wang, "Logo Design Process and Method of Intellectual Property Big Data in the Digital Media Era," *Discret. Dyn. Nat. Soc.*, vol. 2022, no. 1, 2022, doi: 10.1155/2022/2556365.

[8] N. Tian, Y. Liu, Z. Sun, and X. Liu, "Clustering-and Transformer-Based Networks for the Style Analysis of Logo Images," *Comput. Intell. Neurosci.*, vol. 2022, 2022, doi: 10.1155/2022/2090712.

[9] H. Zheng, "False Vision Graphics in Logo Design Based on Artificial Intelligence in the Visual Paradox Environment," *J. Environ. Public Health*, vol. 2022, 2022, doi: 10.1155/2022/1832083.

[10] L. Kannappan, S. K. Palaniswamy, M. Kanagasabai, and S. Kumar, "A Car Logo Design-Inspired CPW-Fed Semitransparent Antenna for Vehicular Applications," *Int. J. Antennas Propag.*, vol. 2023, 2023, doi: 10.1155/2023/7101049.

[11] C. P. Leal, J. P. Lis-Gutiérrez, C. Henao-Rodríguez, and M. Lis-Gutiérrez, "Determinants of the trademark in Colombia: A panel data application," *Procedia Comput. Sci.*, vol. 175, pp. 120–126, 2020, doi: 10.1016/j.procs.2020.07.020.

[12] Suslina and P. Mineeva, "Use of Digital Technologies for Optimizing the Handling of Trademark Applications," *Procedia Comput. Sci.*, vol. 169, no. 2019, pp. 435–439, 2020, doi: 10.1016/j.procs.2020.02.242.

[13] F. Mohd Anuar, R. Setchi, and Y. K. Lai, "A conceptual model of trademark retrieval based on conceptual similarity," *Procedia Comput. Sci.*, vol. 22, pp. 450–459, 2013, doi: 10.1016/j.procs.2013.09.123.

[14] P. Szwajdler, "Limitations of the Freedom of Hyperlinking in the Fields of Copyright Law, Trademark Law and Unfair Competition Law: Is Case-by-case Approach Sufficient?," *Comput. Law Secur. Rev.*, vol. 45, no. April 2016, pp. 1–16, 2022, doi: 10.1016/j.clsr.2022.105692.

[15] F. Kaiser, A. Cuntz, and C. Peukert, "Batman forever? The role of trademarks for reuse in the US comics industry," *Res. Policy*, vol. 52, no. 8, p. 104820, 2023, doi: 10.1016/j.respol.2023.104820.

[16] V. I. Nitu, "Comparative Analysis of the Community Trademark Registration Activity of Germany, the United States and China," *Procedia Econ. Financ.*, vol. 15, no. 14, pp. 603–608, 2014, doi: 10.1016/s2212-5671(14)00528-0.

[17] E. R. S. de Rezende, G. C. S. Ruppert, A. Theóphilo, E. K. Tokuda, and T. Carvalho, "Exposing computer generated images by using deep convolutional neural networks," *Signal Process. Image Commun.*, vol. 66, pp. 113–126, 2018, doi: 10.1016/j.image.2018.04.006.

[18] Mahajan and S. Chaudhary, "Categorical Image Classification Based on Representational Deep Network (RESNET)," *Proc. 3rd Int. Conf. Electron. Commun. Aerosp. Technol. ICECA 2019*, pp. 327–330, 2019, doi: 10.1109/ICECA.2019.8822133.

[19] Y. Li, Q. Shi, J. Deng, and F. Su, "Graphic logo detection with deep region-based convolutional networks," *2017 IEEE Vis. Commun. Image Process. VCIP 2017*, vol. 2018-Janua, pp. 1–4, 2018, doi: 10.1109/VCIP.2017.8305065.

[20] M. Sharma, B. Jain, C. Kargeti, V. Gupta, and D. Gupta, "Detection and Diagnosis of Skin Diseases Using Residual Neural Networks (RESNET)," *Int. J. Image Graph.*, vol. 21, no. 5, 2021, doi: 10.1142/S0219467821400027.

[21] Golzari Oskouei and M. Hashemzadeh, "CGFFCM: A color image segmentation method based on cluster-weight and feature-weight learning[Formula presented]," *Softw. Impacts*, vol. 11, no. December 2021, p. 100228, 2022, doi: 10.1016/j.simpa.2022.100228.

[22] S. G. Sodjinou, V. Mohammadi, A. T. Sanda Mahama, and P. Gouton, "A deep semantic segmentation-based algorithm to segment crops and weeds in agronomic color images," *Inf. Process. Agric.*, vol. 9, no. 3, pp. 355–364, 2022, doi: 10.1016/j.inpa.2021.08.003.

[23] S. Bhattacharya, L. Bennet, J. O. Davidson, and C. P. Unsworth, "Ordered iterative colour channel selection enhances segmentation of brain slice image neurons of the sham fetal sheep model," *Intell. Syst. with Appl.*, vol. 15, no. July, p. 200104, 2022, doi: 10.1016/j.iswa.2022.200104.

[24] S. Du, K. Luo, Y. Zhi, H. Situ, and J. Zhang, "Binarization of grayscale quantum image denoted with novel enhanced quantum representations," *Results Phys.*, vol. 39, no. March, p. 105710, 2022, doi: 10.1016/j.rinp.2022.105710.

[25] B. J. Bipin Nair, K. Aadith Raj, M. Kedar, S. P.

Vaishak, and E. Sreejil, "Ancient Epic Manuscript Binarization and Classification Using False Color Spectralization and VGG-16 Model," *Procedia Comput. Sci.*, vol. 218, pp. 631–643, 2023, doi: 10.1016/j.procs.2023.01.045.

[26] R. Gutierrez-Bonet *et al.*, "Analysis of Choroidal Vascularity Index in Keratoconus Patients Using Swept-Source Optical Coherence Tomography-Based Binarization Techniques," *J. Ophthalmol.*, vol. 2020, 2020, doi: 10.1155/2020/1682463.

[27] J. Chen, L. Chen, and M. Shabaz, "Image Fusion Algorithm at Pixel Level Based on Edge Detection," *J. Healthc. Eng.*, vol. 2021, 2021, doi: 10.1155/2021/5760660.

[28] H. Li, "Multilevel Image Edge Detection Algorithm Based on Visual Perception," *Secur. Commun. Networks*, vol. 2022, 2022, doi: 10.1155/2022/3502041.

[29] X. You, G. Yan, and Z. Yang, "Intelligent Edge Computing Detection Vehicle and Detection Method Based on Tunnel Lining Concrete," *Int. Trans. Electr. Energy Syst.*, vol. 2022, 2022, doi: 10.1155/2022/1837800.

[30] D. Hu, H. Yang, and X. Hou, "Distance Field-Based Convolutional Neural Network for Edge Detection," *Comput. Intell. Neurosci.*, vol. 2022, 2022, doi: 10.1155/2022/1712258.

[31] P. Flores-Vidal, J. Castro, and D. Gómez, "Postprocessing of Edge Detection Algorithms with Machine Learning Techniques," *Math. Probl. Eng.*, vol. 2022, 2022, doi: 10.1155/2022/9729343.

[32] T. Leskovar and M. Cre, "Forensic Science International : Genetics Kinship analysis of 5th- to 6th-century skeletons of Romanized indigenous people from the Bled – Pristava archaeological site ˇ ˇ Miriam Ger ˇ," vol. 65, no. March, 2023, doi: 10.1016/j.fsigen.2023.102886.

[33] L. Guan, X. Zhao, Z. Ji, M. Jiang, Y. Cui, and L. Weng, "Preparation of 3D BN-BT / PVDF skeleton structure composites for high thermal conductivity and energy storage," *Polym. Test.*, vol. 125, no. June, p. 108126, 2023, doi: 10.1016/j.polymertesting.2023.108126.

[34] M. Clémot and J. Digne, "Computers & Graphics Neural skeleton : Implicit neural representation away from the surface," *Comput. Graph.*, vol. 114, pp. 368–378, 2023, doi: 10.1016/j.cag.2023.06.012.

[35] S. Sardari *et al.*, "Artificial Intelligence for skeleton-based physical rehabilitation action evaluation: A systematic review," *Comput. Biol. Med.*, vol. 158, no. March, 2023, doi: 10.1016/j.compbiomed.2023.106835.

[36] Prof. Bhushan Thakre, Dr. R.M Thakre. (2017). Analysis of Modified Current Controller and its Implementation in Automotive LED. International Journal of New Practices in Management and Engineering, 6(04), 01 - 06. https://doi.org/10.17762/ijnpme.v6i04.60

[37] Rajendra, K. ., Subramanian, S. ., Karthik, N. ., Naveenkumar, K. ., & Ganesan, S. . (2023). Grey Wolf Optimizer and Cuckoo Search Algorithm for Electric Power System State Estimation with Load Uncertainty and False Data. International Journal on Recent and Innovation Trends in Computing and Communication, 11(2s), 59–67. https://doi.org/10.17762/ijritcc.v11i2s.6029

[38] Raghavendra, S., Dhabliya, D., Mondal, D., Omarov, B., Sankaran, K. S., Dhablia, A., . . . Shabaz, M. (2022). Development of intrusion detection system using machine learning for the analytics of internet of things enabled enterprises. IET Communications, doi:10.1049/cmu2.12530