

Visual Analysis of Facial Features Using a Convolutional Neural Network (CNN) to Provide Styling Recommendations

Irfan Rizki Fadhilah^{1*}, Rafli Adi Septiyan², Syifa Nur Rakhmah³, Findi Ayu Sariasih⁴, Imam Sutoyo⁵,

^{1,2,4} Informatika, Fakultas Teknik dan Informatika, Universitas Bina Sarana Informatika

^{3,5} Teknologi Informasi, Fakultas Teknik dan Informatika, Universitas Bina Sarana Informatika

15230133@bsi.ac.id¹, 15230227@bsi.ac.id², syifa.snk@bsi.ac.id³, findi.fav@bsi.ac.id⁴, imam.ity@bsi.ac.id⁵.

Abstract

This study aims to develop a facial shape analysis system that provides hairstyle recommendations based on face type using the Convolutional Neural Network (CNN) method. The dataset consists of face images categorized into four labels: heart, oblong, round, and square. The preprocessing process includes image resizing and normalization to improve model accuracy. The MobileNetV2 architecture is employed for feature extraction and classification due to its efficiency in handling image-based recognition tasks. The model achieved an accuracy of 77%, indicating that it can effectively classify face shapes and generate hairstyle recommendations. The system is deployed as a web application, allowing users to upload their photos, automatically identify face shapes, and receive hairstyle suggestions that best match their facial characteristics. This research demonstrates the potential of CNN in implementing intelligent styling recommendations based on visual facial features.

Keywords: Face Shape; Convolutional Neural Network; MobileNetV2; Image Classification; Hairstyle Recommendation

1. Introduction

Artificial intelligence (AI) derives from the Latin word "intelligo," meaning "I understand." This concept refers to the capability of machines programmed to mimic human thought patterns in the processes of understanding and problem-solving[1]. Machine learning is an application that is part of artificial intelligence. In Indonesian, machine learning is also referred to as "pembelajaran mesin". [2]. One application lies in the visual analysis of facial images using the Convolutional Neural Network (CNN) method, which is capable of automatically extracting facial features to support data-driven recommendation systems. With advancements in computer vision, opportunities have emerged to develop accurate, consistent, and personalized hairstyle identification systems based on visual data analysis[3]. The continuous advancement of technology in this modern era has significantly facilitated human tasks across various fields[4]. Previous studies have demonstrated the significant potential of Convolutional Neural Network (CNN) technology in image-based recommendation systems by enabling accurate predictions. Techniques utilizing CNN transfer learning specifically the VGG16 model have been applied to detect human face shapes and men's hair types, achieving accuracy rates of 59.62% and 59.61%, respectively; these results validate the effectiveness of CNNs in providing personalized style recommendations[5]

Meanwhile, other studies have demonstrated the effectiveness of Convolutional Neural Networks (CNNs) in detecting face shapes for the purpose of selecting suitable hairstyles. A key system developed is capable of classifying the four primary face shapes with an accuracy of up to 85%, thereby highlighting the CNN's ability to recommend hairstyles that align with the user's characteristics[6].

According to [7] "A Convolutional Neural Network (CNN) is a deep learning algorithm consisting of 3D neurons arranged in layers. The primary process in a CNN is convolution, which utilizes convolutional layers to process image input by extracting information from small areas of the image and calculating the convolution between those areas and a filter or kernel that slides across the image to generate specific features." According to [8], "Hair is a very important part of the body for many people, both women and men. It is common to see the same hairstyles repeated within a crowd due to a lack of references regarding diverse hair styling options." Changing hairstyles is something frequently done among Indonesians[9]. The awareness of the importance of matching one's hairstyle to one's face shape can be understood as part of the effort to boost self-confidence and self-image through appearance[10].

In the realm of fashion specifically regarding hairstyling and personal appearance many individuals struggle to identify styles that complement their facial features. People, particularly men, often select hairstyles based solely on trends without considering how well they suit their face shapes. This can result in unflattering haircuts and diminished self-confidence. Such issues arise because not everyone is familiar with the aesthetic criteria that determine the compatibility between a hairstyle and a face shape. To address this challenge, there is a need for a system that assists users in determining a look that suits their facial characteristics. By utilizing CNN-based visual analysis, the system can recognize a user's facial features and recommend the most suitable styling options. This solution aims to help individuals efficiently and objectively select the right hairstyle or look through the use of modern technology.

2. Research Methods

This study employs the Agile Kanban system development method, as the research is conducted in a phased and flexible manner to accommodate changes during the model and system development process. Agile Kanban enables iterative cyclesspanning design, model training, and result evaluation to ensure optimal system performance. Fig 1 illustrates the flowchart of this study.

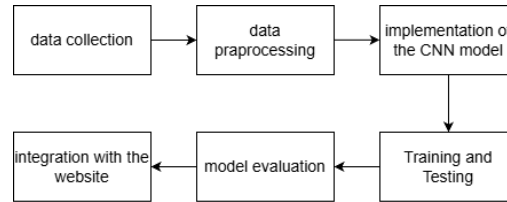


Fig. 1: research flow

2.1. Data collection

This study utilizes a secondary dataset from Kaggle—an open dataset platform widely used in research—comprising four labels: oblong, heart, square, and round. Each label contains 1,000 distinct facial shape images in JPG format. Prior to use, the dataset underwent a selection process to ensure the inclusion of only frontal-facing images with good visual quality. Each image was stored in JPG format and resized to 224×224 pixels to meet the input requirements of the CNN model.

2.2. Praprocessing data

Data preprocessing is performed to prepare facial images before they are used in the CNN model training process. This step aims to ensure that all data is uniform in format and of high quality, enabling the model to recognize visual patterns optimally. The preprocessing stages carried out in this study are as follows:

1. **Resize Image**
All face images are resized to 224×224 pixels to match the input dimensions of the CNN model. This process ensures that every image has the same size, allowing for consistent processing.
2. **Pixel Value Normalization**
Each image is normalized by scaling pixel values from the 0–255 range to a 0–1 range. This normalization helps accelerate the training process of the artificial neural network and stabilizes the model. All paragraphs must be justified alignment. With justified alignment, both sides of the paragraph are straight.
3. **Data Augmentation**
This technique helps improve model performance by reducing overfitting and addressing data imbalance through the modification of original data using transformations such as rotation, flipping, or the addition of noise.
4. **Image Quality Selection**
Only images featuring a frontal face position and adequate lighting were used for training. Blurred or tilted images were discarded to avoid affecting the classification results.
5. **Labeling**
Each image is labeled according to face shape categories namely oval, square, heart, and oblong—which serve as the target outputs (output classes) for the CNN model to learn.

2.3. Training and Testing

A total of 78.87% of the facial shape images were used for training, while the remaining 21.13% were used for testing; since the data was processed by a CNN model, the images had to be resized to uniform dimensions.

Table 1 : number of training and testing samples

data partitioning	amount
Training	78.87%
Testing	21.13%

2.4. Model evaluation

In this study, testing was conducted using test data that was separate from the training data. Model performance was measured using several evaluation metrics: Accuracy, Precision, Recall, F1-Score, and Confusion Matrix.

1. **Accuracy**
Accuracy measures the percentage of correct predictions out of the total test data.
2. **Precision**
Precision is used to measure the accuracy of the model in classifying images as belonging to a specific class, whereas Recall considers the extent to which the model has detected all images that actually belong to that class.
3. **F1 score**
The F1-Score is the harmonic mean of Precision and Recall. It provides a balanced measure of the model's ability to accurately identify classes and avoid misclassification. Only images featuring a frontal face position and adequate lighting were used for training. Blurred or tilted images were discarded to avoid affecting the classification results.

4. confusion matrix

A confusion matrix is a way to visualize the classification results for the four face shape classes. This matrix shows the number of face images correctly and incorrectly classified in each category: round, square, heart, and oblong.

3. Results and Discussion

The model developed in this study can recognize face shapes from two-dimensional (2D) images presented to the application. This research aims to solve the common dilemma of determining which hairstyle suits one's face.

3.1. Classification results

Based on the confusion matrix results shown in Fig 2, the MobileNetV2 model demonstrates good classification capability in recognizing four face shape classes: heart, oblong, round, and square. The heart class had 312 images correctly classified, while some others were misclassified into the oblong, round, and square classes. The model achieved its best results with the oblong class, correctly classifying 375 images, with only a small number misidentified as belonging to other classes. Meanwhile, 306 images in the round class were correctly recognized, and 310 images in the square class were accurately classified. Overall, the MobileNetV2 model achieved an accuracy of 77%, indicating strong performance in classifying face shapes based on visual features extracted from input images.

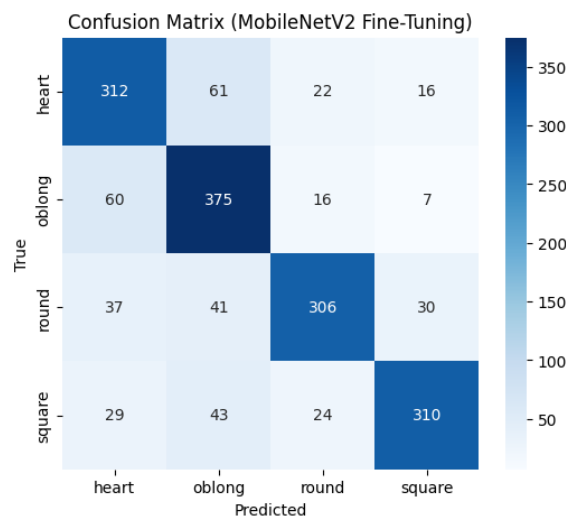


Fig 2 : Confusion matrix

3.2. Classification report

Based on the classification report in Fig 3, the MobileNetV2 model achieved an overall accuracy of 77%, demonstrating a commendable ability to recognize face shapes. The precision, recall, and F1-score values were relatively balanced across all four classes. The "square" class exhibited the best performance, with a precision of 0.85 and an F1-score of 0.81, followed by the "round" class with an F1-score of 0.78. Meanwhile, the "heart" and "oblong" classes showed slightly lower performance—with F1-scores of 0.73 and 0.77, respectively—yet still demonstrated consistency in prediction. The macro-average and weighted-average values, both at 0.77, indicate that the model performs stably and is not biased toward any specific class. Overall, these results demonstrate that the model is capable of classifying face shapes with a good level of accuracy and a reasonably optimal balance of performance across classes.

=== Classification Report ===				
	precision	recall	f1-score	support
heart	0.71	0.76	0.73	411
oblong	0.72	0.82	0.77	458
round	0.83	0.74	0.78	414
square	0.85	0.76	0.81	406
accuracy			0.77	1689
macro avg	0.78	0.77	0.77	1689
weighted avg	0.78	0.77	0.77	1689

Fig 3 : Classification report

3.3. Integration with the website

Our saved model, built using TensorFlow and Keras, is hosted on a server that analyzes images uploaded via a web interface to predict face shapes. Once an image is uploaded, the system performs automated preprocessing steps—such as resizing, pixel value normalization, and format conversion—to meet the CNN model's requirements. Furthermore, the web system is built using the Streamlit framework, which facilitates the integration of the deep learning model with the user interface. Users simply need to upload a facial image through the web interface, after which the system provides the face shape classification results along with hairstyle recommendations.

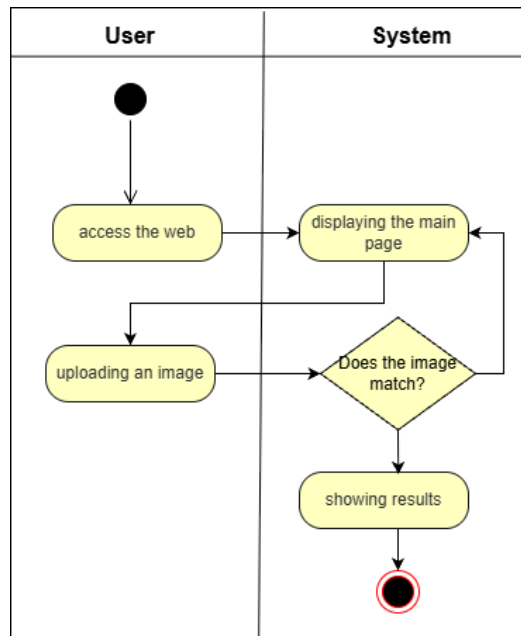


Fig 4 : Activity diagram

The following is an activity diagram illustrating the interaction flow between the user and the web-based hairstyle recommendation system. The diagram features two swimlanes: one for the user and one for the system. The process begins when the user accesses the web application. Upon opening the application, the system's main page appears, and the user uploads a photo of their face for analysis. Next, the system checks the uploaded photo to ensure it meets the specified requirements. If the image does not comply, the system prompts the user to re-upload an image in the correct format. If the image is valid, the system proceeds to display the facial shape classification results—derived from a Convolutional Neural Network (CNN) architecture—to the user. Subsequently, the system provides hairstyle recommendations tailored to the detected face shape. Thus, the diagram depicts a two-way interaction process between the user and the system that unfolds in sequential stages, starting from the initial access to the web application.

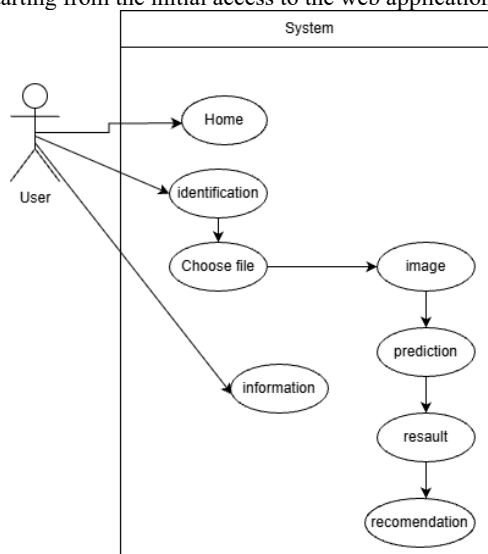


Fig 5 : Use case

The following is an overview of the use case diagram for the web-based hairstyle recommendation system. Each diagram illustrates the relationships between the primary user and the various features or functions required by the system. Based on this design, the system is structured to allow users to access it directly. The process begins by accessing the web application's home page. In the Identification Menu, the user can upload a facial photograph for analysis. Once the image is successfully uploaded, the system processes the file using a Convolutional Neural Network (CNN) model to identify the user's face shape. The results of this predictive analysis are displayed in the Results section, showing the category of the user's face shape. The system then automatically provides hairstyle recommendations tailored

to that face shape. In addition to the core identification and recommendation features, the system includes an Info Menu page. This serves as a supplementary resource for users, explaining how to use the system, providing a brief overview of the underlying model, and outlining the application's purpose and development objectives.

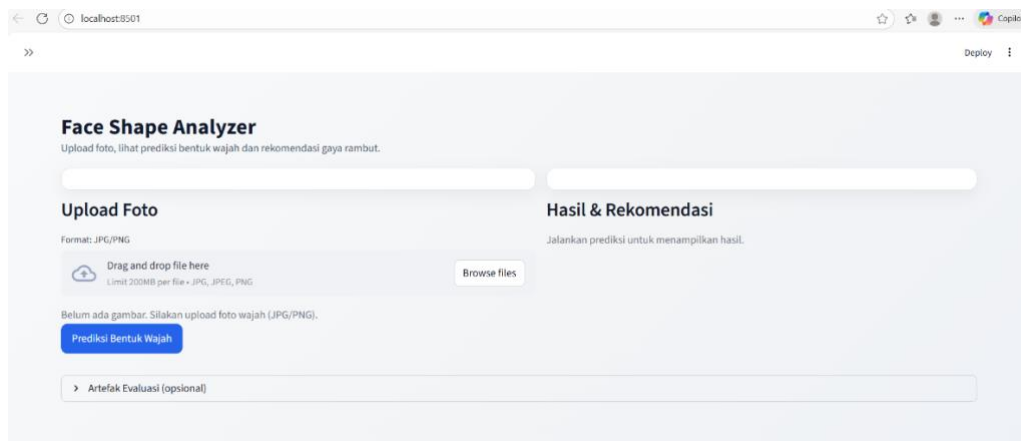


Fig 6 : Home page

In the Photo Upload section, users can input a facial photo in JPG or PNG format via drag-and-drop or by selecting the file directly through the "browse file" tab. Once the photo is successfully uploaded, the user can initiate the analysis by tapping the "Face Shape Prediction" button. At this stage, the system activates Convolutional Neural Network (CNN) technology to extract visual features and classify the face shape based on the characteristic patterns learned during prior training. The analysis results are displayed on the "Results & Recommendations" page, which presents data on the face shape type alongside hairstyle suggestions tailored to the classification outcome. The system also offers an optional "Evaluation Artifacts" feature, designed to provide model evaluation results or related supplementary data. With this interface design, the system is well-positioned to deliver accurate analysis results while demonstrating the effectiveness of CNN technology in facial feature extraction and hairstyle recommendation.

4. Conclusion

Based on the research findings, the author concludes that the application of the Convolutional Neural Network (CNN) model using the MobileNetV2 architecture successfully achieved effective face shape classification. The developed model attained a 77% accuracy rate in classifying face shapes. The results demonstrated a relatively balanced performance across precision, recall, and F1-score metrics for each class, indicating the model's successful generalization of facial data. Notably, the model effectively distinguished between heart, oblong, round, and square face shapes. Furthermore, the web-based application proved successful in enhancing user convenience for face shape identification and hairstyle recommendations.

Future research could be enhanced by incorporating a larger and more varied dataset, particularly regarding lighting conditions and background environments. Regarding model development, more complex architectures—such as EfficientNet or Vision Transformer (ViT) could be employed. In terms of system implementation, the existing web-based system could be further developed into a mobile application. Additionally, the system could be refined by incorporating a broader range of human data to improve recommendations based on public or user preferences.

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