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Face Recognition Systems: Comparation Point of View between CNN and LBPH Methods

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Abstract

Face recognition systems have become increasingly prevalent in various applications, including security, biometric authentication, and digital identity verification. This article presents a comparative study on the implementation and performance of two face recognition methods: Convolutional Neural Network (CNN) and Local Binary Pattern Histogram (LBPH). The research utilized the Labeled Faces in the Wild (LFW) dataset, which comprises 19 classes of faces, with 760 images for training and 475 images for testing. The system was developed using the Python programming language, incorporating TensorFlow/Keras, OpenCV, and Visual Studio Code, along with a Graphical User Interface (GUI). The primary focus of this study was to implement both face recognition methods and analyze the selectivity of the system in distinguishing between known and unknown faces. Experimental results demonstrated that the CNN method offered superior classification stability and consistent face recognition, whereas the LBPH method provided faster training times and reduced computational complexity. Additionally, the results indicated that threshold settings significantly influenced the system's ability to classify recognized and unknown faces. In conclusion, the study found that CNN is more suitable for applications requiring robust classification capabilities, while LBPH is better suited for lightweight face recognition systems that prioritize processing speed and efficiency.

Keywords: Face Recognition; CNN; LBPH; LFW; GUI.

1. Introduction

Advances in digital image processing technology in the era of globalization have opened up opportunities for the development of systems capable of automatically identifying individuals through digital image analysis [1]. This technology enables computers to perform facial recognition as a form of biometric authentication across a wide range of applications [2]. Face recognition systems are one of the most widely used applications of computer vision and artificial intelligence in security systems, biometrics, digital attendance tracking, and identity verification [3]. Advances in facial recognition technology require systems capable of operating accurately and efficiently under various image conditions, such as changes in lighting, pose, and facial expressions [4]. Therefore, selecting the right method is a key factor in developing a reliable facial recognition system [5].

One of the most widely used methods in facial recognition systems is the Convolutional Neural Network (CNN). CNN is a deep learning-based method capable of automatically extracting features from facial images, enabling it to achieve high classification and generalization performance [6]. Several studies have shown that CNNs achieve good accuracy in facial recognition under complex image conditions [7]. However, the CNN method requires greater computational resources and a relatively longer training time compared to conventional methods [8]. In addition to CNN, the Local Binary Pattern Histogram (LBPH) method is also widely used in facial recognition systems. LBPH works by extracting local facial texture patterns using histogram representations [9]. This method offers advantages in terms of computational efficiency, lower complexity, and faster training [10]. However, the performance of LBPH tends to decline in image conditions with variations in lighting, poses, and inconsistent facial quality [11].

Several previous studies have compared deep learning methods and texture-based methods in facial recognition systems. A study conducted by Said, Atri, and Ayachi [4] shows that the CNN method is capable of delivering good facial recognition performance because it can automatically extract features through deep learning. In addition, Yin and Liu [7] also state that CNN demonstrate high classification and generalization capabilities in facial recognition across a variety of poses and image conditions. On the other hand, research conducted by Chen, Lin, and Chen [9] shows that the LBPH method remains effective for use in facial recognition systems with low computational requirements, as it offers faster computation and lower complexity compared to deep learning methods. Putra's research [11] It also notes that the LBPH method has a shorter training time, but its classification performance tends to decline under inconsistent lighting conditions and image quality.

Although numerous studies have evaluated CNN and LBPH for face recognition, most of them primarily focus on recognition accuracy or computational performance separately. In addition, only a limited number of studies have implemented and compared both methods within a single GUI-based face recognition system while simultaneously analyzing threshold selectivity for distinguishing recognized and unknown faces. This limitation indicates a research gap regarding the practical implementation and comparative behavior of CNN and LBPH under the same testing environment.

Therefore, this study aims to implement and compare CNN and LBPH methods in a GUI-based face recognition system using the Labeled Faces in the Wild (LFW) dataset. The comparison focuses on recognition performance, classification consistency, computational efficiency, and threshold selectivity in distinguishing recognized and unknown faces. The proposed system was developed and implemented using Python, TensorFlow/Keras, OpenCV, and Visual Studio Code to provide a fair and consistent evaluation of CNN and LBPH performance under identical experimental conditions [12].

The contributions of this research are threefold. First, this study provides a direct comparison between CNN and LBPH methods using the same dataset and testing environment. Second, it presents a GUI-based implementation that enables practical evaluation of both methods in face recognition applications. Third, it analyzes the effect of threshold selectivity on recognized and unknown face classification, providing insights into the strengths and limitations of each method. The findings are expected to serve as a reference for researchers and developers in selecting appropriate face recognition techniques according to application requirements, computational resources, and desired system performance. In addition, the proposed system can be utilized as a practical framework for implementing face recognition applications in security, attendance monitoring, and identity verification systems.

2. Material and Methods

This study employs Convolutional Neural Network (CNN) and Local Binary Pattern Histogram (LBPH) methods in a face recognition system. The system was developed using the Python programming language, and the dataset used in this study is Labeled Faces in the Wild (LFW). Furthermore, both methods were implemented in a GUI system to perform real-time face recognition. The GUI system is capable of displaying the input face image, as well as the face classification status as "recognized" or "unknown."

The overall workflow of the system is shown in Figure 1, which includes the stages of dataset acquisition, image preprocessing, model training, GUI system implementation, face recognition, and testing of the "recognized" and "unknown" face classification results on the developed system.

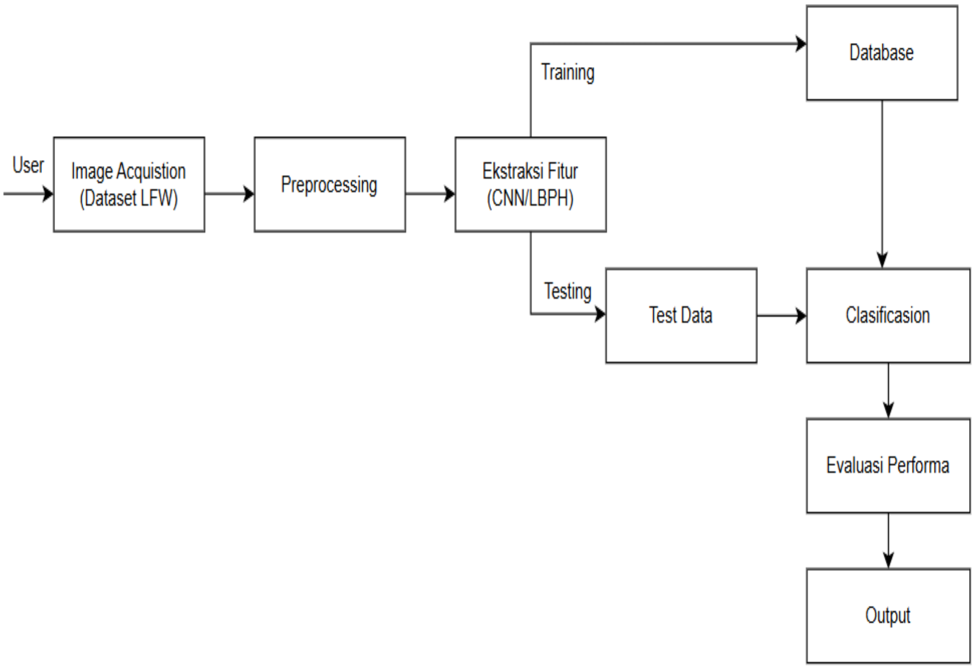

Figure 1. Diagram Block

The workflow of the developed facial recognition system, as illustrated in Figure 2. The flowchart provides a more structured overview of the research process, thereby facilitating the analysis and implementation of the facial recognition system.

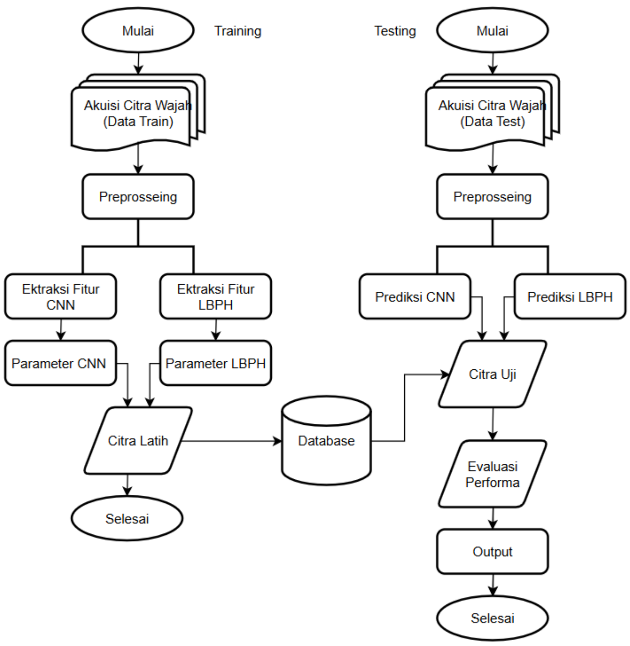

Figure 2. Flowchart

Dataset

This study uses the Labeled Faces in the Wild (LFW) dataset, which consists of 19 face classes. Each class has 40 training images and 25 testing images, resulting in a total of 760 training images and 475 testing images. The dataset is used for training and testing the CNN and LBPH methods in a face recognition system.

Preprocessing

The preprocessing stage is performed to improve image quality prior to the training and testing processes. In the CNN method, preprocessing involves resizing the images to 64×64 pixels and normalizing pixel values using a rescaling factor of 1/255. In the LBPH method, preprocessing involves grayscaling, Gaussian blur, histogram equalization, and resizing the images to 64×64 pixels.

Feature Extraction of CNN and LBPH

In the Convolutional Neural Network (CNN) method, feature extraction is performed automatically through several convolution layers that detect important patterns in facial images, such as edges, textures, and facial shapes. Each convolution output is then processed using the ReLU (Rectified Linear Unit) activation function to enhance the model's ability to learn non-linear features. Next, a max pooling process is performed to reduce the feature dimensions and retain important features from the facial images. At the end of the CNN architecture, a dense layer and the softmax activation function are used to perform facial classification based on the probability of each class [13]. Meanwhile, the Local Binary Pattern Histogram (LBPH) method performs feature extraction based on local facial texture patterns. This method works by comparing the value of a central pixel to its neighboring pixels in a grayscale image. The results of these comparisons are converted into binary values that form a Local Binary Pattern (LBP) [14]. Next, local texture patterns are represented as histograms, which are used as facial features in the classification process. The LBPH method has lower computational complexity, allowing the training and testing processes to be completed more quickly than with the CNN method.

Evaluation Method

This study compares the performance of Convolutional Neural Network (CNN) and Local Binary Pattern Histogram (LBPH) methods in a GUI-based face recognition system. The experiments utilized the Labeled Faces in the Wild (LFW) dataset consisting of 19 face classes, with 40 images per class used for training and 25 images per class used for testing, resulting in 760 training images and 475 testing images. All images were resized to 64 × 64 pixels during the preprocessing stage.

The CNN model was trained using a supervised multiclass classification approach with the Adam optimizer, a learning rate of 0.001, and a batch size of 16. The LBPH model employed radius = 1, neighbors = 8, grid_x = 6, and grid_y = 6. The system was implemented using Python, TensorFlow/Keras, OpenCV, and Visual Studio Code. Performance evaluation focused on recognition accuracy, computational efficiency, classification consistency, and threshold selectivity. For the recognition process, a confidence threshold of 80% was applied to the CNN method, while a distance threshold of 40 was applied to the LBPH method. The results were analyzed through GUI implementation outputs and comparative performance analysis between CNN and LBPH methods [15].

3. Result and Disscussion

Performance testing of the CNN and LBPH methods was conducted using the Python programming language with the Visual Studio Code editor to analyze the system's ability to recognize faces based on the GUI implementation. The test results for both methods are shown in Table 1. However, to simplify the presentation and improve the readability of the article, the table displays face samples that represent the overall test results. These samples were selected to illustrate the results of the CNN and LBPH method implementations in recognizing faces as "recognized" or "unknown" in the developed system.

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Table 1. Testing Results for both Methods

No	Image Sample for Each Class	Result for CNN Method	Result for LBPH Method
1		Recognized Confidence: 93.22%	Recognized Confidence: 18.02
2		Recognized Confidence: 89.34%	Recognized Confidence: 22.19
3		Recognized Confidence: 96.79%	Unknown Confidence: 48.00
4		Recognized Confidence: 85.95%	Recognized Confidence: 20.67
5		Recognized Confidence: 97.86%	Recognized Confidence: 34.58
6		Recognized Confidence: 88.84%	Recognized Confidence: 19.69
7		Recognized Confidence: 99.49%	Recognized Confidence: 18.20

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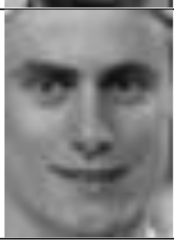
8		Recognized Confidence: 97.78%	Unknown Confidence: 45.24
9		Unknown Confidence: 54.76%	Recognized Confidence: 21.14
10		Recognized Confidence: 99.90%	Recognized Confidence: 20.40
11		Recognized Confidence: 95.79%	Recognized Confidence: 19.73
12		Recognized Confidence: 98.42%	Recognized Confidence: 23.02
13		Recognized Confidence: 99.99%	Recognized Confidence: 34.37
14		Recognized Confidence: 99.97%	Recognized Confidence: 18.09
15		Recognized Confidence: 99.47%	Recognized Confidence: 22.08

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16		Recognized Confidence: 98.91%	Recognized Confidence: 20.11
17		Recognized Confidence: 99.99%	Unknown Confidence: 41.85
18		Unknown Confidence: 62.23%	Recognized Confidence: 18.71
19		Recognized Confidence: 97.23%	Recognized Confidence: 24.78

Based on the results of the GUI implementation shown in the table, the CNN and LBPH methods were able to recognize most face samples well. The CNN method generally produced higher confidence scores with more stable recognition consistency during the testing process.

Table 2. Comparative Performance Results of CNN and LBPH

Performance Metric	**CNN**	**LBPH**
Threshold	80%	40
Recognized Samples	17	16
Unknown Samples	2	3
Recognition Rate (%)	89.47%	84.21%

Based on the testing results presented in Table 1, both CNN and LBPH methods were able to recognize most facial samples successfully. The CNN method recognized 17 out of 19 representative samples, resulting in a recognition rate of 89.47%, while the LBPH method recognized 16 samples with a recognition rate of 84.21%. The results indicate that CNN achieved slightly better recognition performance than LBPH. Several CNN predictions produced confidence values above 95%, demonstrating stable classification performance. In contrast, several facial samples processed by LBPH were classified as unknown because their distance values exceeded the predefined threshold of 40. This result indicates that LBPH is more sensitive to variations in facial texture, illumination, and image quality.

These findings are consistent with previous studies conducted by Said et al [4] and Yin and Liu [7], which reported that CNN-based face recognition methods generally achieve higher recognition performance due to their ability to automatically learn discriminative facial features through deep learning architectures. The threshold values applied in the system also influenced the recognition results. CNN used a confidence threshold of 80%, while LBPH used a distance threshold of 40 [16]. These threshold values helped reduce false recognition and improve system reliability in distinguishing recognized and unknown faces. Overall, CNN provided better recognition performance, whereas LBPH offered advantages in computational simplicity and faster processing.

4. Conclussion

This study successfully implemented and compared the Convolutional Neural Network (CNN) and Local Binary Pattern Histogram (LBPH) methods in a GUI-based face recognition system using the Labeled Faces in the Wild (LFW) dataset, which consists of 19 face classes, 760 training images, and 475 test images. The implementation results show that both methods are capable of recognizing most face samples well in the developed system. The CNN method demonstrates more stable recognition consistency with high confidence scores, while the LBPH method offers faster processing performance due to its lower computational complexity.

The results of the implementation testing also show that the threshold selectivity affects the classification of recognized and unknown faces in both methods. Some face samples yielded different classifications between CNN and LBPH based on the confidence scores obtained during the face recognition process. Overall, the CNN method is more suitable for applications requiring strong classification capabilities and recognition stability, while the LBPH method is more efficient for lightweight face recognition systems with faster computational performance. The developed GUI implementation demonstrates that both methods can be effectively applied to face recognition systems with different computational characteristics and recognition performance. Further research can be conducted using larger datasets, real-time camera implementations, and the development of hybrid methods to improve the performance of face recognition systems.

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