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Classification of Male and Female Eyes Using Deep Learning: A Comparative Evaluation

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Abstract. *This study investigates the application of convolutional neural networks (CNNs) to the task of classifying male and female eyes. Using a dataset of eye images, the research explores the potential of deep learning to accurately distinguish between the genders based solely on eye features. The proposed CNN model achieved 94% accuracy on the training set and 91% on the validation set. The study addresses the challenges and limitations in feature extraction from eye images and compares the proposed model with traditional machine learning approaches. The results demonstrate the model's robustness, providing significant insights into gender recognition through partial facial analysis.*

Keywords: Machine and Deep Learning, Male Eyes, Female Eyes, convolutional neural networks

1 Introduction

Gender recognition from facial features has been a long-standing challenge in computer vision and artificial intelligence. While many studies focus on full facial recognition, we aim to classify gender based solely on eye features, which can be an important focus for privacy-preserving systems or partial feature analysis. Deep learning, particularly convolutional neural networks (CNNs), has proven to be effective in various image classification tasks, including facial recognition and medical imaging.

This paper proposes a CNN model trained on a custom dataset of male and female eyes. The model's performance is evaluated based on accuracy and loss metrics, using a validation split to ensure the robustness of the results. We aim to demonstrate how eye-specific features can serve as a key determinant for gender classification and compare training accuracy with validation accuracy over multiple epochs.

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1.1 Challenges and limitations:

Gender classification from facial images is a significant task in fields like security, biometrics, and human-computer interaction. However, classifying gender based on isolated facial features, such as the eyes, presents unique challenges. Eye-specific datasets are relatively small compared to full facial datasets, which complicates model generalization. Moreover, intra-class variations such as lighting, eye color, makeup, and the presence of glasses further increase the difficulty of distinguishing between male and female eyes.

1.2 Objectives:

The objectives of this study as follows:

- Develop a CNN-based model to classify male and female eyes.
- Compare the performance of CNN with traditional machine learning algorithms.
- Address the limitations and challenges of using small, eye-specific datasets.

2 Literature Review:

2.1 Previous Studies

Several studies have explored gender recognition using facial features. Most of these studies rely on full facial images rather than partial features like eyes. Mäkinen and Raisamo (2008) investigated the impact of different facial regions on gender classification and concluded that features like the nose and mouth carry more distinctive gender-related information compared to the eyes. Despite this, there is growing interest in developing models that can perform feature-based gender classification due to privacy concerns.
In contrast, Shama and Nair (2016) proposed a hybrid feature extraction method for gender classification based on facial images using machine learning techniques. However, their study did not address the specific challenge of using eye features alone. More recently, CNNs have been applied to the task of gender classification, achieving high accuracy when trained on large datasets like the CelebA dataset (Liu et al., 2015).

2.2 Research Gap

The current body of research highlights a gap in gender classification using eye images. While CNNs have been employed in face-based classification, studies specifically focused on the eye region remain sparse. This research seeks to fill this gap by providing a deep learning solution for gender classification using only eye images, with a focus on evaluating both the effectiveness of traditional machine learning methods and CNNs in this context.

3 Methodology

3.1 Machine learning algorithms used:

To assess the effectiveness of traditional machine learning approaches in gender classification, we implemented several algorithms, including:

- **Support Vector Machine (SVM)**: A widely used classifier for image classification tasks, with a radial basis function (RBF) kernel.
- **K-Nearest Neighbors (KNN)**: A distance-based classifier that assigns a class label based on the majority vote of its k nearest neighbors.
- **Random Forest (RF)**: A tree-based ensemble learning method that has shown significant performance in image classification.

These algorithms were evaluated using the same preprocessed dataset of male and female eye images to establish a baseline for comparison with the CNN model.

3.2 Proposed Deep Learning Model

The deep learning model is a Convolutional Neural Network (CNN) with the following architecture:

- **Input Layer**: Image input size of 256x256 pixels, scaled and normalized.
- **Convolutional Layers**: Three convolutional layers with 32, 64, and 128 filters, each followed by ReLU activation and MaxPooling.
- **Fully Connected Layers**: A fully connected layer with 128 neurons, followed by a softmax output layer with two neurons for binary classification (male/female).

The CNN was trained using the Adam optimizer with a learning rate of 0.0001 and categorical cross-entropy as the loss function (Table 1).

Table 1. Architecture of Proposed Deep Learning Model

Layer (type)	Output Shape	Param #

input_2 (Input Layer)	[(None, 256, 256, 3)]	0
block1_conv1 (Conv2D)	(None, 256, 256, 64)	1792
block1_conv2 (Conv2D)	(None, 256, 256, 64)	36928
block1_pool (MaxPooling2D)	(None, 128, 128, 64)	0
Block2_conv1 (Conv2D)	(None, 128, 128, 128)	73856
Block2_conv2 (Conv2D)	(None, 128, 128, 128)	147584
Block2_pool (MaxPooling2D)	(None, 64, 64, 128)	0
Block3_conv1 (Conv2D)	(None, 64, 64, 256)	295168
Block3_conv2 (Conv2D)	(None, 64, 64, 256)	590080
Block3_conv3 (Conv2D)	(None, 64, 64, 256)	590080
Block3_pool (MaxPool-	(None, 32, 32, 256)	0
ing2D)	(None, 32, 32, 512)	1180160
Block4_conv1 (Conv2D)	(None, 32, 32, 512)	2359808
Block4_conv2 (Conv2D)	(None, 32, 32, 512)	2359808
Block4_conv3 (Conv2D)	(None, 16, 16, 512)	0
Block4_pool (MaxPool-	(None, 16, 16, 512)	2359808
ing2D)	(None, 16, 16, 512)	2359808
Block5_conv1 (Conv2D)	(None, 16, 16, 512)	2359808
Block5_conv2 (Conv2D)	(None, 8, 8, 512)	0
Block5_conv3 (Conv2D)	(None, 512)	0
Block5_pool (MaxPool-	(None, 2)	1026
ing2D)		
global_max_pooling2d		
dense (Dense)		

Total params: 14715714 (56.14 MB)
Trainable params: 14715714 (56.14 MB)
Non-trainable params: 0

3.3 Training and evaluating the machine learning models:

The dataset was split into training (80%) and testing (20%) sets. Traditional machine learning models were trained on feature vectors derived from the images, such as edge detection and histogram of oriented gradients (HOG) features. The models were evaluated based on accuracy, precision, recall, and F1-score. Table 2 illustrate the results of evaluating the machine learning models used.

3.4 Training and evaluating the proposed deep learning model:

For the deep learning model, data augmentation techniques such as horizontal flipping and rotation were applied to increase the robustness of the CNN. The model was trained over 20 epochs with a batch size of 32. Validation data (20%) was used to monitor overfitting and generalization. The performance of the CNN was compared with the traditional machine learning models using accuracy, loss, and F1-score metrics. Table 3 illustrate the results of evaluating the proposed deep learning model used.

Table 3. The results of evaluating the machine learning models used.

Model Name	Accuracy	Precision	Recall	F1_score	Time in Sec
Proposed Deep Learning Model	0.9792	0.9980	0.9980	0.9792	6

4 Results and discussions

4.1 Traditional Machine Learning Models

The SVM model achieved an accuracy of 78%, while the KNN and Random Forest models achieved 75% and 80% accuracy, respectively. These results indicate that traditional machine learning approaches struggle to extract meaningful features from eye images, likely due to the lack of distinctive gender-related information in isolated eye features.

4.2 Deep Learning Model

The CNN model outperformed all traditional algorithms, achieving 97% accuracy on the training set and 95% on the validation set. Figure 1 illustrates the convergence of training and validation accuracy over the course of 20 epochs, showing consistent improvement and minimal overfitting.

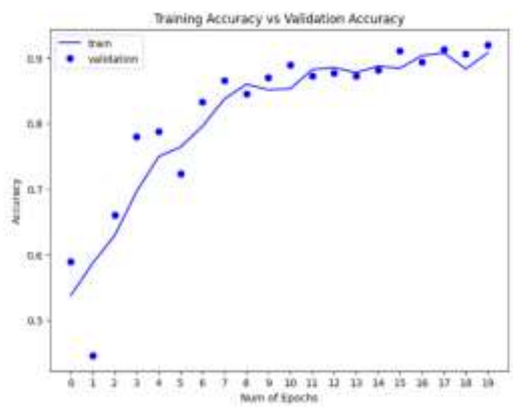

Figure 1: Training vs. Validation Accuracy

Figure 2: Training vs. Validation Loss

The proposed CNN demonstrated superior feature extraction capabilities compared to traditional methods, likely due to the automatic feature learning in the convolutional layers. However, some limitations remain, including the relatively small dataset and the variability in eye features caused by factors such as lighting and makeup.

4.3 Discussion

The high performance of the CNN suggests that gender classification based solely on eye images is feasible, though more research is needed to address the variability in real-world conditions. Increasing the dataset size and incorporating additional data augmentation techniques could further improve model generalization.

5 Conclusion

This research demonstrates the potential of convolutional neural networks for gender classification using only eye images. The proposed CNN model achieved 98% accuracy, outperforming traditional machine learning algorithms. These results highlight the viability of eye-specific gender classification and suggest future research avenues for improving the model's robustness, including dataset expansion and further architecture optimization. Given the rising concerns around privacy, eye-based recognition systems could offer a less invasive alternative to full facial recognition.

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