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DEEP LEARNING-BASED AGE AND GENDER DETECTION USING CNN AND HYBRID MACHINE LEARNING APPROACHES

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Abstract

Age and gender detection using facial images is a critical task in computer vision with applications in personalized marketing, healthcare, surveillance, and human-computer interaction. This paper presents a deep learning-based system utilizing Convolutional Neural Networks (CNN) combined with hybrid machine learning models for accurate age and gender classification from facial images. The proposed framework employs OpenCV-based face detection with HAAR-cascades, followed by feature extraction and classification using CNN and Support Vector Machines (SVM). The UTKFace and FG-NET datasets were used for training and evaluation, ensuring robust testing across diverse age groups and gender categories. Image pre-processing techniques, including mean filtering and alignment, were applied to improve system accuracy and noise reduction. Experimental results demonstrate the model's effectiveness across different age brackets (children, teenagers, adults, and elderly), achieving consistent gender and age group detection with high accuracy while retaining computational efficiency. The study highlights the potential of combining deep learning with traditional feature extractors and hybrid optimization strategies for scalable, real-time, and ethically responsible age and gender detection systems.

Keywords: Age and Gender Detection; Convolutional Neural Networks; Deep Learning; Facial Recognition; Hybrid Machine Learning; Computer Vision.

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INTRODUCTION

Recently age and gender prediction systems have been growing rapidly due to its important modules and beneficial uses for many computer vision applications such as human-computer interaction (HCI), security systems, and visual surveillance. [1] There are many indications that demonstrated the importance of a gender and age prediction. For instance, such models are currently being used by hotels, airports, bus stations, casinos, government buildings, universities, hospitals, cinemas, etc. to increase the level of security and facing any possible threats or deficiencies. [2] Besides the security applications, age and gender prediction techniques are used also in health care systems, information retrieval, academic studies and researches, and Electronic Customer Relationship Management (ECRM) systems, where customers are distributed to different gender and age groups like children, teenagers, adults and senior adults in addition to determine whether they are male or female. [3] Face identification has a severe challenges with skin color segmentation, the accuracy of facial segmentation are usually affected.

Although several studies have been conducted in this field such as study from [4] that conduct a research on AGE AND GENDER ANALYSIS USING OPENCV, their work was developed based on Python & Machine Learning Algorithms. Another study by [5] who carried out a research on AGE AND GENDER DETECTION USING DEEP LEARNING where there work focuses on giving dietary recommendations to people according to their age and gender.

Therefore, this work is to develop a model that can accurately predict the Age and Gender of a person by analyzing their facial features in an image using deep learning techniques, To find out if the age of an individual can be detected from their facial images using computer vision techniques, and also to increase the performance and accuracy of predicting age of people from their facial images which can perform and obtain high accuracy by using and combining several feature extractors.

REVIEW OF RELATED LITERATURE

Developed age and gender dictations using Python and CNN (Convolutional Neural Network) which is an application of deep learning that uses machine learning algorithms to automatically determine the age and gender of a person from a given image. Their work is based on computer vision techniques, which involves analysing images and extracting useful features from them. The work involves several steps, starting with the collection of a large dataset of labelled images, the dataset is used to train the model to recognize and differentiate between different age and gender categories. The model is deployed as

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an application, where the user can upload an image, and the model will predict the age and gender of the person in the image.

Study conducted by [7] on Machine Learning Approach to Users' Age Prediction. Using Artificial Neural Network (ANN), Random Forest (RF), Gradient Boosting (GB), and Decision Tree (DT). These models were compared and evaluated based on their predictive performance. The ANN emerged as the optimal classifier, achieving an accuracy of 60%, comparable to similar studies conducted within the telecommunications industry.

The study conducted by [8] on Age and Gender Detection Using Open CV (Open Source Computer Vision Library) in their work they have propose a deep learning that estimate age and gender recognition. They have simply classify age and gender with additional accuracy although they've less refined values. They used Kaggle dataset that contains all the Meta information. Keras was used for age and gender classification. The result demonstrate that the proposed method have shown better performance on age and gender estimation as compared to other methods.

According to a study conducted by [9] on Age and gender dictation using OPENCV. In their work they show how easy it is to detect faces and identify gender along with age with the help of CNN (Convolutional Neural Networks) and OpenCV. They used Adience dataset so that the output is achieved with accurate values in training and validation. For the output to be determined even with multiple parameters they used pre-trained model that is caffee model along with OpenCV. The proposed model can be used in surveillance purposes or in medical purposes.

A study by [10] on Age and Gender Identification through Advanced Deep Learning Techniques. The goal of their work is to create a model that are very accurate at identifying a person's gender and age. The study's objectives include incorporating ethical issues into the creation and use of the- models as well as enhancing the models' effectiveness on members of underrepresented groups. The model also was optimized for real-time uses in their work, including security and marketing.

Similarly a study conducted by [11] On Gender and Age Detection Using Deep Learning Techniques. Where face discovery, acknowledgment and gender assessment are one of the most huge exploration territories in PC vision. The fundamental commitments of their work are isolated into three sections, specifically face location, acknowledgment and sexual orientation assessment for individual recognizable proof. In their research work, they utilize Local Binary example Histogram (LBPH) strategy and Convolution Neural Network (CNN) to extricate the facial highlights of face pictures whose computational unpredictability is low. CNN speed up of testing constant video and furthermore improve

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the acknowledgment rate. By utilizing LPBH, they get 63% exactness on normal where CNN gives 89.88% preparing exactness for face

Lastly a study by [12] on age and gender recognition using deep learning. Their research paper outlined convolutional neural network (CNN) using deep learning, methodologies, and algorithms that can be used, and how everything fits together for gender classification and age detection. The paper's prime objective is to use deep learning to develop a gender and age detector that can roughly predict the gender and age of a human face in an image. Furthermore, the map shows how this technology might be applied to our benefit and look at the broad array of applications where it could be used: from intelligence agencies, CCTV cameras, and policing to matrimony sites.

PROPOSED FRAMEWORK

The proposed framework for age detection incorporates hybrid machine learning models, specifically OpenCV-based system, which uses a combination of HAAR-cascades and SVMs.

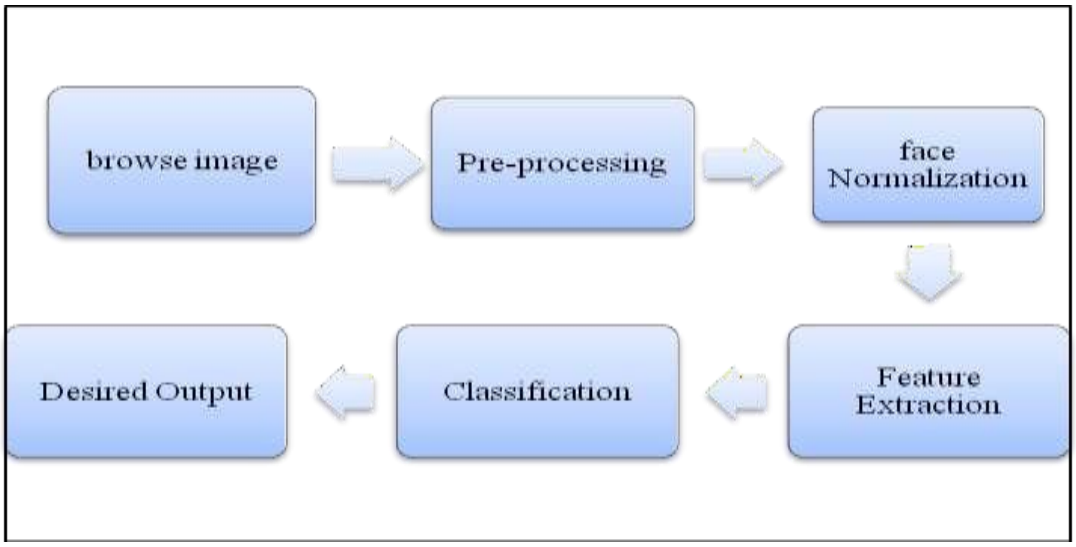


Figure 1: Proposed Methodology

Datasets

In this work UTKFace and FG-NET dataset has been utilized to train the model of age and gender detection. UTKFace: This is a large-scale dataset with over 20,000+ facial images of persons between 0 and 100 years old. In addition to age, the dataset is also labelled by gender, making it more suitable to train the system. The dataset is divided into two portions. The first portion is training and testing, which is used to train and validate

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models A and B. This portion consists of 22,508 images. The second portion is only used to test both models and the whole system, and it contains 1164 images. 80% of the images is use for training and 20% for validation for the first portion. The FG-NET dataset has been widely used in age estimation tasks, and it is relatively smaller in size. The dataset contains 1009 facial images, and it is used to further validate the performance of our implementation. Out of these images, we use 200 random images for testing. Table. 1 and 2 present the breakdown of our age classes and the number of male and female images in each dataset.

Table 1: Classes and Number of Samples per Class (Males)

Age Classes	No. of images
0–12	1363
13–19	413
20–59	8358
60+	1512

Table 2: Classes and Number of Samples per Class (Females)

Age Classes	No. of images
0–12	1588
13–19	614
20–59	7571
60+	1089

Image Pre-processing.

The image pre-processing in the proposed system enhances the input image and prepares it for the next step in Model development. The pre-processing step achieves improved accuracy, sensitivity, and specificity. Thus, using efficient pre-processing algorithms for image filtering, face detection, and face alignment makes the proposed system robust. Mean Filter is a technique for modifying and enriching an image. The main objective of such effects is to reduce noise, but they could be used to accentuate specific characteristics. 2D filtering techniques are used in this work to minimize picture noise, and to replace individual pixels value in a picture with the mean value of its neighbors, including itself. A 3 × 3 square kernel is often employed, although a 5 × 5 square kernel could be utilized for extreme flattening.

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Feature Extraction

This is an essential step for automated methods which helps in extracting unique features from the given image. It helps in dimensionality reduction by mapping from a multidimensional space into a space of lesser dimensions. The proposed DCNN-based feature extraction technique is evaluated with other existing techniques such as SIFT, histogram of oriented

Feature Selection

Feature selection is also a dimensionality reduction method that helps in discarding irrelevant features by retaining only the discriminatory features. Several feature selection approaches such as GA, PSO, and ACO are evaluated with the proposed hybrid PSO-based feature selection strategy.

Classification

Age and Gender Classifications Identity refers to the factors which differentiate one face from another. It can be age, gender, facial expression, and facial landmarks. The proposed system considers identity as the age and gender classifications. The proposed method uses classification to determine the age and gender of a human based on the input image. To categorize the age and gender, the classification procedure uses SVM, which assists to understand the attributes present in image and carry out the classification. SVM constructs an ideal hyper plane in multidimensional space, which aids in the categorization of images into two classes in gender. The results of HPSO is mapped into the multidimensional space. The maximum marginal hyper plane (MMH) helps in distinguishing the classes.

Result.

This section specifies the results obtained by conducting the experiment. We depict the testing results on various conditions.

Test case 1: Picture of a child



Figure 2 Child Picture

From the above figures when given a picture, the child's face is detected and the age and gender are shown. The child in the image is of the age group 4-6 who is a male. The output

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satisfies the age and gender. The output is shown with a green square box that shows the face of the child and above the box are the gender and age.

Test case 2: Picture of a teen

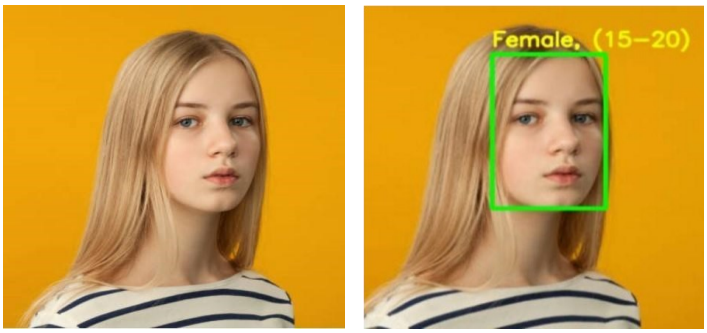


Figure 3 Teen Picture

In the above figure when given an image of a teen the face is detected and age, gender the person are given. The person in this image is of the age group 15-20 who is a female. The output satisfies the age and gender. The output is shown with a green square box that shows the face of the teen and above the box are the gender and age.

Test case 3: Picture of an adult.



Figure 4 an Adult Picture

In the above figure when given an image of an adult the face is detected and age, gender of the person are shown. The person in this image is of the age group 38-43 who is a female. The output satisfies the age and gender. The output is shown with a green square box that shows the face of the woman and above the box are the gender and age.

Test case 4: Picture of an elderly person



Figure 5 Elderly Person Picture

Just like the other cases in this case also the face is detected and gender along with age of the person in the image are depicted. The person in this image is of the age group 60-100 who is a male. The output satisfies the age and gender. The output is shown

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with a green square box that shows the face of the person and above the box are the gender and age.

Discussion of Result.

The results from the four test cases demonstrate that the face detection and age-gender prediction models work well across a wide variety of age groups, from young children to elderly people.

The system effectively detected faces in all cases and provided reasonable and accurate predictions of the person's age and gender. This shows that the models are well-trained and robust enough to handle different age groups and diverse facial features.

The output with a green bounding box and the age/gender text above the face makes the predictions easy to understand visually. The consistent success in predicting both gender and age proves that the system's underlying deep learning architecture is functioning as expected.

While the results are accurate, the age ranges are predefined in broad categories (e.g., 0-2, 15-20, 60-100), which may limit the precision in predicting exact ages, but this is typical for models like this that work in ranges. The result is been summarize in table 3 below.

Table 3: summary of the result

s/n	Test case	Test activity	Test Result
1	Test case 1	Given a picture, the child's face is detected and the age and gender are shown. The output satisfies the age and gender	The child in the image is of the age group 4-6 who is a male
2	Test case 2	An image of a teen, the face is detected and age, gender the person are given. The output satisfies the age and gender.	The person in this image is of the age group 15-20 who is a female.
3	Test case 3	Given an image of an adult the face is detected and age, gender of the person are shown.. The output satisfies the age and gender	The person in this image is of the age group 38-43 who is a female
4	Test case 3	Just like the other cases in this case also the face is detected and gender along with age of the person in the image are depicted. The output satisfies the age and gender.	The person in this image is of the age group 60-100 who is a male

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Summary

Age and gender detection is a computer vision task that uses deep learning models to predict a person's age group and gender based on facial images. It is widely applied in areas like personalized marketing, surveillance, healthcare, and user analytics. The system typically consists of face detection followed by age and gender classification using pre-trained deep learning models.

Key Steps are: Face Detection: The first step is identifying and extracting the face from an image often using tools like OpenCV's deep learning-based face detectors (e.g., SSD or Haar cascades). Image Pre-processing: The face image is resized, normalized, and pre-processed to match the input format of the deep learning models. Gender Prediction: A Convolutional Neural Network (CNN) model is used to classify gender, typically as male or female. Age Prediction: Another CNN model predicts the age group of the person, outputting predefined ranges (0-2, 4-6, 8-12, etc.).

Conclusion:

In conclusion, age and gender detection using Python CNN has proven to be a promising approach to accurately predict the age and gender of an individual based on facial images. Deep learning techniques, specifically CNNs, have shown high accuracy in predicting age and gender from facial images. These techniques have significantly improved upon traditional handcrafted feature-based approaches, which were limited in their ability to generalize to new datasets. Studies have also shown that combining handcrafted features with deep learning techniques can further improve the accuracy of age and gender detection. Multiple classifier systems have also shown high accuracy in predicting age and gender from facial images. However, there are still some limitations to current age and gender detection systems. One limitation is that the accuracy of these systems can be affected by variations in lighting, facial expression, and pose. Additionally, age and gender detection systems may be influenced by factors such as ethnicity, culture, and geographic location, which can affect facial features and expression.

Recommendations

The following are recommended to ensure successful implementation of an age and gender detection system using deep learning, consider the following recommendations:

- Optimize for Real-Time Performance: If implementing for real-time systems, ensure the model is optimized for speed by using lightweight architectures such as MobileNet or quantized versions of CNNs. This will ensure fast processing without sacrificing too much accuracy.

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- Consider Privacy and Ethics: Age and gender detection systems should be implemented responsibly. Ensure compliance with privacy laws and obtain explicit consent when collecting facial data, especially for commercial applications. Additionally, guard against biases in the model by testing it on diverse demographic groups to prevent skewed results.
- Leverage Cloud Services: For scalability, consider cloud-based solutions for running deep learning models. This approach allows for handling larger datasets and multiple concurrent users, especially in applications like retail analytics or surveillance.

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