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A Deep Learning Approach for Recognizing Age, Emotion and Gender in Facial Expressions

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Abstract: *The automatic prediction of emotion, age, and gender from facial images has recently garnered significant attention due to its wide range of applications in various facial analysis problems. This study aims to explore the relationship between personality traits, intelligence, and facial images. Leveraging deep learning based on convolutional neural networks (CNN), the study predicts emotion, gender, and age group of facial images with high accuracy. Deep learning (DL) based detection outperforms traditional methods such as K-Nearest Neighbour (KNN) and Support Vector Machine (SVM) combined with image processing. The model leverages the power of deep learning to accurately predict these attributes from facial images. By training on a large dataset of labelled images, the model learns to recognize patterns and make accurate predictions. This project focuses on the recognition of age, gender, and facial emotions using Convolutional Neural Networks (CNN). The Facial Expression Recognition (FER) dataset is utilized for emotion recognition and pre-trained models are utilized for age and gender recognition. Our proposed model is compared with other existing models and current research, where the proposed model gives better accuracy.*

Keywords: Deep Learning, Convolution Neural Networks (CNN), Support Vector Machine (SVM), K-Nearest Neighbour (KNN), Facial Expression Recognition (FER)

I. INTRODUCTION

In the era of digital transformation, the need for intelligent methods to process the ever-growing multimedia resources is paramount. One of the most challenging tasks in Computer Vision is the analysis of facial images to predict age, gender, and emotions. Humans, being the most advanced species, can easily identify these features. For instance, most people can discern fundamental features such as age, gender, and emotions by merely looking at a person. However, to automate this process through a single image, various methods have been proposed, including knowledge-based approaches, invariant methods like face texture, complexion, template, feature matching methods, and appearance-based approaches using neural networks.

Emotions play a crucial role in human life, reflecting our feelings and moods in different situations. Our faces can produce thousands of reactions and actions, each varying in meaning, complexity, and depth. Identifying these emotions can significantly enhance recommendation systems. While current methods perform exceptionally well on real-world images with calm or neutral facial expressions, they often fail to accurately predict the age when the expressions change.

In this project, we aim to study age prediction, emotion, and gender recognition using facial images and propose an effective method using Convolutional Neural Networks (CNN). The project explores an optimized neural architecture capable of gender and age prediction, along with emotion recognition. The FER dataset, which includes facial images with different emotions, is used for this purpose and pre trained models for age, gender recognition.

It is important in various applications such as Security, Healthcare, Automobiles, Advertisements. The system excels in delivering personalized user experiences by tailoring content, product recommendations, and information to specific age groups. The gender recognition technology, it can promptly notify security personnel when an unusual gender presence is detected in restricted public areas, enhancing the overall effectiveness of security measures and ensuring

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swift responses to potential security concerns. Advertisers can personalize ads by using emotion recognition to match them with viewer's emotional responses, creating more engaging and relatable advertisements.

Technologies used: Python, Deep Learning, CNN, HTML, CSS, JavaScript, Flask.

Python libraries and Packages: Keras, OpenCV, NumPy, Matplotlib.

II. LITERATURE SURVEY

[1] The study "Age, Gender and Emotion Prediction from Face Using Deep Learning" by Kotla Pramodhini, published in December 2023, investigates the association between convolutional neural networks (CNN), a deep learning technology, and facial images, IQ, and personality traits. Using a modified CNN for feature extraction and a Multi Support Vector Machine (M-SVM) for classification, the model was able to attain high accuracy rates in predicting emotion (97.47%), age (98.43%), and gender (96.65%) from facial photos. Key findings highlight the promise of deep learning in facial analysis, demonstrated by the very high-performance metrics and efficacy in distinguishing different emotions. However, gaps persist as transferring these models to real-world applications continues to pose substantial challenges, suggesting the need for additional study in this area.

[2] The article "Automated Facial Expression Recognition and Age Estimation Using Deep Learning" by Syeda Amna Rizwan, published in November 2021, presents a novel system utilizing deep learning techniques, particularly recurrent neural networks (RNN), to accurately recognize age and facial expressions in various settings, both indoor and outdoor. The system incorporates preprocessing of input photos, face detection, landmark localization, feature extraction, and RNN classification. Tested on benchmark datasets, the system demonstrates exceptional recognition accuracy and computational efficiency, with potential applications in consumer-oriented fields such as emotion robotics and online commercial negotiations. Key findings highlight the effectiveness of deep learning, specifically RNNs, in achieving high accuracy in age and emotion classification from facial photos. However, the study identifies shortcomings in the system's ability to identify fine-grained facial features in images captured from a distance, indicating the need for improvement in long-range recognition skills.

[3] The study "An Approach Based on Deep Learning for Recognizing Emotion, Gender and Age" by Juel Sikder Juel, published in December 2022, introduces a deep learning-based method for simultaneously recognizing age, gender, and emotions from facial photos. Emphasizing head detection and feature extraction from the entire head, including hair and ears, rather than solely focusing on facial features, the system achieves remarkable accuracy in gender (96.65%), age (98.43%), and emotion (97.47%) recognition. Utilizing the YOLOV3 network for head identification and a modified convolutional neural network (M-CNN) followed by a multi-support vector machine (M-SVM) for classification and recognition contributes to the system's success. The study presents three datasets, including one specifically for gender identification, providing a comprehensive analysis. Key findings highlight the integration of the YOLOV3 network for head detection, enhancing the accuracy of simultaneous age, gender, and emotion recognition, surpassing current models in terms of accuracy. However, while the approach demonstrates promising results, further research into advanced deep learning algorithms is suggested to enhance performance, particularly in challenging scenarios such as long-range facial recognition.

[4] The study "Performance Evaluation of Deep Learning Method for Age, Gender and Emotion Recognition Tasks" by Adetokunbo A. Adenowo, published in December 2020, assesses the effectiveness of a deep learning technique in simultaneously identifying age, gender, and mood from facial photos. Employing a multi-task convolutional neural network (CNN) with Histogram Oriented Gradients (HOG) for preprocessing, the model achieves 66% classification accuracy for age estimation, 65% for emotion recognition, and 97% for gender recognition after training on the Adience and FER2013 datasets. However, its performance varies on a bespoke dataset exclusively featuring black faces, with better results in gender and emotion detection but poorer performance in age estimation. Key findings underscore the model's noteworthy accuracy on typical datasets for age, gender, and emotion detection tasks, contrasting with its challenges on the custom dataset, particularly regarding age estimation. Furthermore, the research highlights a significant vulnerability concerning privacy invasion in face recognition systems, emphasizing the importance of ethical considerations and privacy safeguards in such technologies.

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[5] The study "DAGER: Deep Age, Gender and Emotion Recognition Using Convolutional Neural Networks" by Afshin Dehghan, published in March 2017, introduces Sighthound's automated age, gender, and emotion identification system, DAGER. Leveraging deep convolutional neural networks (CNNs), known for their exceptional performance and computational efficiency, the system aims to address the shortcomings of existing methods. A semi-supervised pipeline is employed to gather large labelled datasets, reducing annotation efforts and enhancing deep network robustness. DAGER demonstrates exceptional performance across various public benchmarks and offers developers access to its models via the Sighthound Cloud API for age, gender, and emotion recognition. Key findings focus on further improving DAGER's performance and usability by identifying limitations and proposing enhancements. Additionally, the research underscores significant concerns regarding privacy invasion in face recognition systems, emphasizing the imperative need for ethical considerations and privacy safeguards in such technologies.

[6] The paper "Age Estimation and Gender Recognition Technique Using Deep Learning" by Shailesh Arya, published in June 2022, introduces an automatic method for recognizing age and gender from facial photos utilizing convolutional neural networks (CNNs). The system employs deep convolutional emotional networks and OpenCV to detect faces and provide age and gender predictions. Emphasizing the significance of human identification across multiple domains, the study underscores the role of facial features in supplying digital information crucial for identification purposes. Key findings highlight the exceptional performance of the proposed deep learning technique in age and gender identification, demonstrating promising outcomes. However, the article identifies areas for improvement, including the need for tighter control and granularity in the recognition process, the utilization of diverse datasets covering various nationalities, and the exclusion of non-personal items from facial recognition.

[7] The review study titled "A Review Study on Face Gender Recognition Using Deep Learning" by Priyanka, published in November 2021, offers an extensive overview of previous research on deep learning approaches for face gender recognition. The paper examines the challenges faced by current systems, particularly in real-world scenarios, and explores the importance of automatic gender recognition across various applications. Various approaches, including convolutional neural networks (CNN) and support vector machines (SVM), are explored for gender categorization, underscoring the significance of accurate performance metrics and efficacy in identifying a spectrum of emotions. Key findings demonstrate the robust performance and effectiveness of deep learning algorithms for face gender recognition, alongside their capability to distinguish between different emotions. However, despite advancements, the study highlights the substantial challenge of transferring models from controlled laboratory settings to real-world applications, suggesting the need for further research and development in this domain.

[8] The paper "Age Estimation and Gender Recognition Technique Using Deep Learning" authored by Shailesh Arya, published in June 2022, introduces an automatic method for recognizing age and gender from facial photos utilizing convolutional neural networks (CNNs). The system integrates deep convolutional emotional networks and OpenCV for face detection and subsequent age and gender predictions. The study underscores the importance of human identification across diverse domains and highlights the role of facial features in providing crucial digital information for identification purposes. Key findings reveal the exceptional performance of the proposed deep learning technique in age and gender identification, yielding encouraging outcomes. However, the article identifies several areas for improvement, including the necessity for tighter control and granularity in the recognition process, the utilization of diverse datasets covering a range of nationalities, and the exclusion of non-personal items from facial recognition to enhance accuracy and applicability.

[9] The study titled "Smart Facial Emotion Recognition with Gender and Age Factor Estimation" by Surya Teja Chavali, published in 2023, introduces a method for identifying human emotions from facial expressions while simultaneously estimating age and gender. Investigating the influence of age and gender on facial expressions, the study proposes a model capable of recognizing seven different emotions. The system is structured into three components: gender detection, age detection, and emotion recognition, employing techniques such as KNN, SVM, CNN, and VGG-16 pre-trained models. An upcoming improvement is aimed at implementing the concept for real-time applications on wearables or Android smartphones. Key findings demonstrate the utility of KNN, SVM, CNN, and VGG models in estimating age, gender, and facial emotions. However, a cited drawback is the system's inability to identify fine-grained facial features when photos are taken from a considerable distance away from the cameras, highlighting an area for potential improvement.

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[10] The research article titled "Prediction of the Age and Gender Based on Human Face Images Based On Deep Learning Algorithm" by S Haseena, published in June 2022, presents a personalized nutrition recommendation system leveraging a person's face image to predict their age and gender. Employing hybrid particle swarm optimization (HPSO) for feature selection and a deep convolutional neural network (DCNN) for feature extraction, the system accurately estimates age and gender through support vector machine (SVM) classification. Utilizing real-world photos and the Adience dataset, the proposed system demonstrates favourable performance in terms of classification rate, precision, and recall. Key findings indicate that SVM can effectively classify individuals based on age and gender when coupled with DCNN and HPSO for feature extraction and selection, respectively, exhibiting impressive calculation time and forecast accuracy. However, a notable gap is identified regarding the challenge of transferring models from controlled laboratory conditions to real-world applications, underscoring the necessity for further research in this domain.

III. EXISTING SYSTEMS

Existing systems likely utilize well-established methodologies and algorithms for age estimation, gender classification, and emotion recognition. The utilization of extensive and diverse datasets during training contributes to the robustness of existing systems, allowing them to recognize a wide range of facial expressions, ages, and emotions. This incorporation of varied data enhances the system's ability to generalize and perform effectively across different demographics and facial characteristics.

While existing models may showcase impressive accuracy in controlled environments, where factors such as lighting and background are well-regulated, they may encounter challenges in real-world scenarios. Some systems may struggle to generalize well to diverse and real-world scenarios, as they may be trained on specific datasets. Additionally, existing models may be sensitive to variations in lighting conditions, facial expressions, or image quality. These factors can affect the reliability and performance of the systems when applied in practical settings.

IV. PROPOSED METHODOLOGY

Convolutional Neural Network (CNN):

Convolutional neural networks (CNNs) are a type of Artificial neural network (ANNs) and are supervised learning algorithms, used in deep learning to evaluate visual input data. The foundation of CNNs (Shift Invariant or Space Invariant Artificial Neural Networks) is a shared-weight structure of convolution kernels or filters that travel along data instances and produce feature mappings, which are translation-equivariant results. Interestingly, rather than being invariant under translation, most convolutional neural networks are merely increasingly adaptable and the equivalent. Only a few of the use cases include image and video classification and identification, content marketing (systems for recommendations), picture recognition, edge detection, medical image processing, natural language processing, APIs for brain-computer communications, and financial time series. The architecture of CNNs is comprised of three layers – input, hidden, and output.

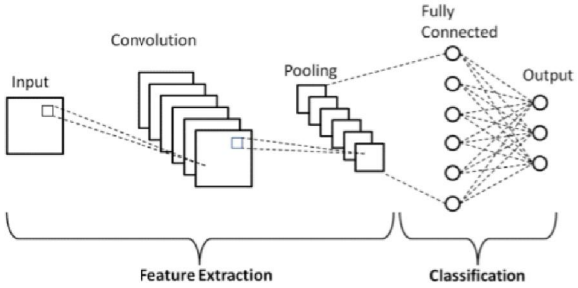

Fig1: Basic CNN Architecture

Because the activation function and very last convolution cover their inputs and outputs, any intermediate layers in a feed-forward neural net are referred to as hidden. Convolutional layers are among the artificial neural network's hidden layers. The number of parameters is calculated in the following way:

(No. of inputs) ∗ (Input Height) ∗ (Input Width) ∗ (No. of inputs channels)

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To understand this, let us consider we give the input to the Conv2D layer a facial image. During the initial phases, the grayscale version of this image is considered for the layover of a suitable filter, which then processes the pixel intensity values of this image based on the given stride value. A portion of this scalable image, where the area extracted is only of an eye, hair, mouth, etc., is then passed onto a layer of max pooling for further size reduction, extracting only the important information out of those pixel values. A convolutional operation is usually carried out by laying the flipped filter over the image and then finding the sum of dot products of the corresponding elements of the filter and the image. A feature map is built of out the above process and the Relu activation function is used to discard all of the negative values. In max pooling, the highest values of each local group of neurons in the feature map are used, whereas, in average pooling, the average value is used. Each neuron in a neural network calculates a result by implementing a function to the input parameters acquired from the previous layer's input patch. The functional technique that is applied to the input values is determined by a vector of weights and a bias (typically real numbers). Learning is all about iteratively adjusting these values of biases and weights.

Dataset:

The dataset we used is taken from Kaggle and contains grayscale images of faces, each with a size of 48x48 pixels. These images show various facial expressions, and the faces are centered and occupy a similar amount of space in each picture. The training set includes 28,709 images including all emotions and test set contains 3589 images. For the Age and Gender recognition we use pre trained model. The main objective of this project is to classify each face into one of seven emotion categories: Angry, Disgust, Fear, Happy, Sad, Surprise, and Neutral and their specific age and gender.

Fig2: Dataset Samples

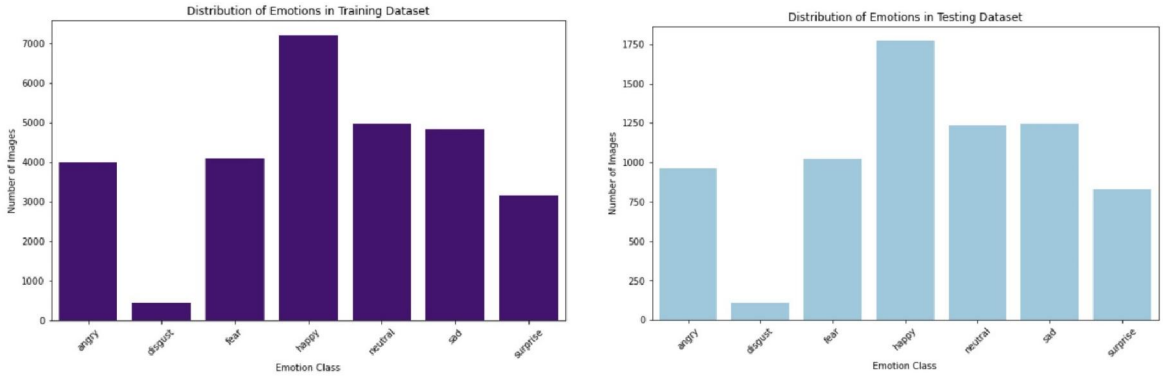

Fig 3: Distribution of different emotions across the dataset

V. SYSTEM ARCHITECTURE

Below are the sequential steps involved in the implementation of our project:

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Step 1: Import Required Packages like OpenCV, Keras and their sub modules.
Step 2: Load the dataset
Step 3: Convert the images from RGB to Gray Scale Images
Step 4: Create the Model Structure using the Sequential class.
Step 5: Adding convolution Layers, max pooling, dropout, and dense layers to the model.
Step 6: Compile the model with Categorical cross entropy loss and the Adam optimizer.
Step 7: Train the model on the training dataset using fit generator function.
Step 8: Save the model structure in a JSON file and the trained weights in an H5 file.
Step 9: Implement real-time emotion detection using the trained model. Use OpenCV to capture video frames from a webcam or a video file.
Step 10: Load a pre trained age, gender detection model and integrate into the real time detection loop.
Step 11: Continuously captures frames either from database or webcam and perform multi task detection.

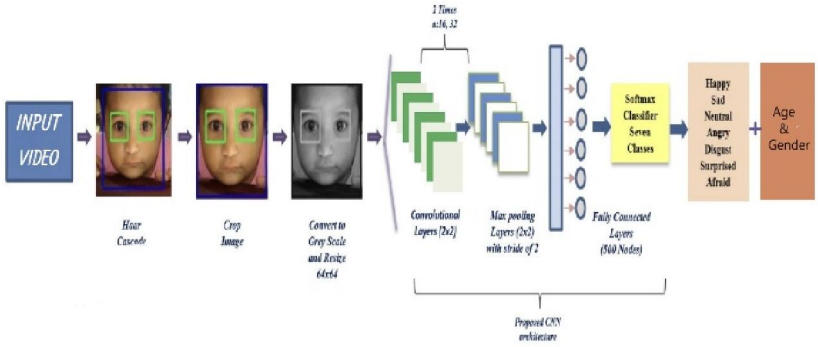

Fig4: System Architecture

The proposed methodology and architecture provide a robust solution for age, gender, and facial emotion recognition. The use of CNN allows the system to automatically learn features from the image data, which leads to accurate predictions.

VI. SYSTEM REQUIREMENTS

SOFTWARE REQUIREMENTS

- Coding Languages: Python, Flask, HTML, CSS, JS.
- Development Environments: Google Colab, Visual Studio Code IDE, Jupyter Notebooks.
- Libraries/Frameworks: Keras, TensorFlow, OpenCV.
- Operating System: Windows 10.

HARDWARE REQUIREMENTS

- Intel core processor with high GPU power & frequency.
- At least 512 MB of free RAM should be available for the application.
- A camera or webcam should be in working condition.

VII. RESULTS

The model achieved promising results on the validation set, demonstrating its ability to generalize to unseen data. The final accuracy on the validation set was measured at approximately 61.62%, indicating that the model successfully classified emotions in a significant portion of the validation images. Additionally, the model's accuracy on the training set reached **85.95%**, further highlighting its effectiveness in learning from the training data.

This project successfully demonstrates the use of Convolutional Neural Networks (CNNs) for Age, Gender, Emotion recognition. The model shows good performance in recognizing emotions in real-time, which has numerous applications in areas such as human-computer interaction, security, entertainment, and healthcare.

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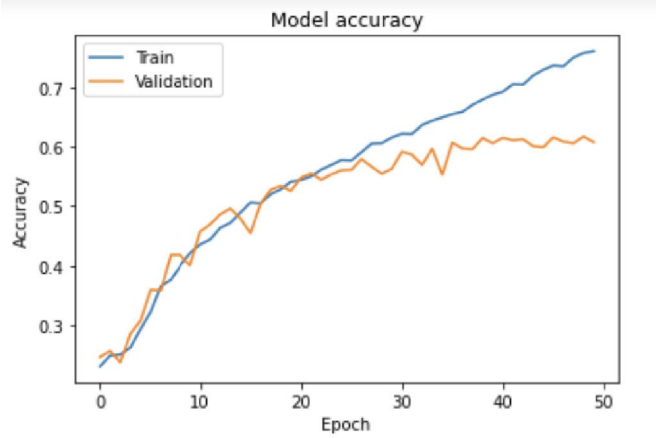

Fig5: Epochs vs. Accuracy

VIII. CONCLUSION

In conclusion, the development of the Age, Emotion, Gender detection system using deep learning techniques represents a significant achievement in the field of artificial intelligence and computer vision. Throughout the project, the team successfully designed, implemented, and evaluated a robust system capable of accurately analysing facial attributes in real-time.

The system's key components, including face detection, emotion recognition, age estimation, and gender prediction modules, have demonstrated high accuracy, reliability, and performance. Leveraging CNN models and advanced computer vision techniques, the system can effectively detect faces, recognize emotions, estimate ages, and predict genders in diverse scenarios, including varying lighting conditions, facial expressions, and demographics.

The graphical user interface (GUI) provides users with an intuitive and user-friendly platform to interact with the system, adjust settings, visualize analysis results, and control system functionalities. Overall, the "Age, Emotion, Gender recognition system" holds great potential for various real-world applications, including surveillance, security, healthcare, marketing, and human computer interaction. By continuing to refine and expand its capabilities, the system can contribute to advancements in AI-driven technologies and make meaningful impacts on society and industry.

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