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Biometric Face Recognition System using Deep Dream and CNN

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Abstract—This paper explores the use of Deep Dream, which is a computer vision algorithm that uses deep learning neural networks to find and enhance different patterns in images and to increase the security of face recognition used for biometric validation systems. The motive of the system is to identify and verify individuals based on their facial features. This paper also cares about the security aspects along with the accurateness and efficacy of the system. In this research, we are using CNN model for the recognition of the face along with the DeepDream concept. By applying DeepDream to existing face images in the training dataset, new images with altered visual features can be produced. This system has many applications in areas such as law enforcement, access control, border security, and identity management. We have seen many biometric face recognition systems all over but using deep dream concepts in it will increase security and accuracy. This paper will go through various deep dream algorithms that we can use with CNN. The paper presents experimental results and conclusions on the effectiveness of using Deep Dream in enhancing the security of biometric systems.

Keywords- *DeepDream, Deep Learning, Biometric System, CNN, ResNet512, VGG16 and Security.*

1. Introduction

A. Need/Concern/Background

Biometric systems make a substantial contribution to the field of information security and are crucial for authentication, recognition, and access control. The biometric system of today relies on photos supplied by users. From such photos, the system extracts feature, which it then compares to features in a database. The biggest drawback is that in order to extract features, users must submit their biometric photos. The difficulty with the biometric system is that biometric characteristics are tied to their target person and cannot be separated from them. However, if a biometric particularity is stolen, it cannot be changed, unlike passwords and credit cards. The data must therefore be ciphered and confidentiality must be guaranteed by the biometric authentication mechanism. The only way to improve the security, precision, and threat reduction of biometric systems is to use CNN and Deep Dream together.

Deep Dream is an algorithm that uses deep learning neural networks to find and intensify patterns in images. Deep dream is typically used for artistic purposes, but for improving security it is not having variety of applications. Deep Dream is usedto produceartificial biometric data or notice and highlight probable security threats in biometric data, the accuracy, robustness, and safety of biometric systems can be enhanced. Biometric systems have comprehensive applications in areas like law enforcement, access controller, border security, and identity management. By incorporating the deep dream algorithm, this paper iscontributing to the evolvement of practical and proficient solutions for real-world challenges.

B. Research objectives

The objective of this research is to cultivate a biometric System that incorporates the Deep Dream algorithm to surge the accurateness and robustness of biometric recognition structure. The aim is to explore the potential of Deep Dream, a deep learning technique that generates visually intriguing and artistic images, in the field of biometrics.

C. Organization of the paper

This paper aims to explore the use of Deep Dream in Biometric systems and its potential to increase security. The paper will first provide an overview of biometric authentication systems and their vulnerabilities. It will then discuss the use of biometric systems and their advantages. Next, the paper will introduce Deep Dream and its application to biometric systems. Finally, the paper will present experimental results and conclusions on the effectiveness of using Deep Dream in enhancing the security of biometric systems.

2. Literature Survey

A. How much work has been done in this problem area

Due to the many applications and difficulties associated with human face recognition, it is a common research topic in biometric applications. Because of this, researchers from all over the world are constantly experimenting with different combinations of various methods to increase the

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face recognition technology's precision and predictive models.

In paper [1], Basma Abd El-Rahiem and et alpresent a multi-biometric cancellable scheme (MBCS) which demonstrates the verified use of deep learning models to combine multiple exposed iris, finger vein, also fingerprint biometrics using an Inspection V3 pre-trained version to produce a combination tamper-evidence cancellable template that is grander to state-of-the-art methods that are reported in the literature. Arthi Rengaraj and et al [2], suggest a brand-new method of identifying an individual that combines vein and iris biometrics. The CNN and Deep Dream algorithms are used to initially process the incoming images. The network will then utilize that image to help minimize category errors. This method was also resistant to spoofing and replay attacks, among other types of assaults.

The authorE. A. Elshazly and et al [3] suggest a cancelable biometric system based on deep dreams, hashing techniques, and photo composition. This system is put to the test using inputs from multiple biometric sources, including the palm, iris, fingerprint, and face. Additionally, it is assessed in written and visual reports. The simulation findings show that the system looks to perform better than other systems that deal with the same issue. As per the A. Sedik and et al [4] authors advise a system which is implemented on 4 biometric pics, particularly palm, iris, fingerprint, face snapshots. Moreover, it's miles proven via contrast with different works in the literature. A comparative study exhibits that this system suggests advanced overall performance for privacy and encryption of created cancelable templates.

Ding Lu and Li Yan [5] propose a system for face recognition and detection in digital images. The system uses a combination of face recognition and detection to identify people in digital images. The system first locates faces in the image using face detection. Once a face has been located, the system identifies the people in the image using face recognition. The system was able to recognize and detect faces with a high degree of accuracy. facial identification is reinvented by combining facial recognition with detection.

A multi-modal biometric system using visible light communication (VLC) is suggested by the authors in the study [6]. Users are identified by this system using a combination of fingerprint, face, and iris biometrics. Additionally, the system transmits biometric data securely and effectively via VLC. Balzarotti, Davide and et al [7], the authors provide a comparison of the performance across corporations for two distinct deep learning architectures designed for facial and vocal recognition. These architectures are governed by seven integrated rules that cover various pipeline steps (such as model, feature, selection, and score). The author does an experiment, and the findings demonstrate that, in comparison to unimodal systems and other integrated policies, the multimodal system is acquired by integration of steps, leading to the best typical accuracy and the least unfair treatment among enterprises.

Vijay Kumar and Mathivanan M.[8] have worked on a system that uses particular features, Laplace of Gaussian filter out-based totally Discrete Wavelet Transform (LGDWT), and Discrete Cosine rework compressed based totally Log Gabor Filter (DCTLGF), using mixed LGDWT and DCTLGF functions. This work, using gadget (MSVM) classification, converted 200 facial images into a 5-megapixel face dataset of 25 people using a low-target internet camera and provided accurate results within the limits of the usual comparison of existing methods. Riseul Ryuand et al[9] provides an in-depth analysis of a biometric authentication device that is based on a scientific examination of the prior literature. The analysis reveals that more research is required to target wearable and/or mobile devices and to remember a continuous authentication method. Shivalila Hangaragiand et al[10] suggests a system that uses Face mesh to identify and recognise faces. The proposed model works in a variety of circumstances and with variations in varied lighting and heritage thanks to Face mesh. Additionally, the model can handle non-frontal pictures of women and men of any age and race. The deep neural network of the model is trained using photos from the LWF (stands for Labeled Wild Face) dataset and images that were taken in real time.

B. Typical methods which are being employed to investigate this class of problem

Author uses a variety of methodologies, including Deep fusion which is a technique that is used to combine multiple biometric features into a single feature vector. Deep dream is an algorithm that is used to generate images that are visually appealing to humans and Cancellable biometrics are biometric features that are resistant to attacks such as spoofing and replay[1]. The CNN algorithm, which is used to extract features that can be used to identify users, the Deep Dream image algorithm, which aids the CNN in reducing categorical errors, and the GSM-based alert system, which alerts the supervisory authority if the system is being accessed without proper authentication, are some of the methodologies the author uses from [2].

Compression, cancellable biometrics, DWT, and LDA are the techniques employs to maintain security[3],[23]. The discrete wavelet transform (DWT) is a method for breaking down a signal into its component wavelet coefficients. This can be used to shrink a biometric template while maintaining its ability to discriminate. A biometric template can be Papered onto a lower-dimensional space using the linear discriminant analysis (LDA) method while maintaining its discriminative power. By doing this, it is possible to increase the accuracy of biometric templates while reducing their size.

Some of the author uses Crypto-mapping techniques which are used to generate a secure template from the extracted features [4]. CNN algorithm as a main methodology which is well-suited for image processing tasks, such as face detection and face recognition[5]. Visible Light Communication (VLC) which is used to transmit biometric data securely and efficiently is used for security [6]. Author uses general methodologies including Speaker recognition, Audio-visual speaker recognition and Demographic fairness. Hybrid biometrics which is a technique that combines multiple biometric features to work in uncontrollable environmental conditions, such as varying lighting, pose, and occlusion [7,8].

In the paper [9] the author uses a PICOC criteria as a main methodology. PICOC stands for Population, Intervention, Comparison, Outcomes, and Context. It is a framework or valuable tool for ensuring that research questions are well-defined and that the research is conducted in a rigorous and systematic way. From [10] the author mainly uses two algorithms, The Viola-Jones algorithm, used to detect faces, is the first algorithm. The Blaze face mesh algorithm, used to depict the 3D structure of a face, is the second.

C. Research Gap

We have identified several gaps in the literature survey done. There is still opportunity for improvement in making face recognition algorithms more resilient to real-world circumstances, despite major advancements in handling position variations, occlusions, and lighting shifts. Factors such as variations in facial expressions, aging effects, and low-resolution or noisy images pose challenges that require further investigation. So Ensuring fair and accurate performance across diverse demographic groups, including different ethnicities, age groups, and genders, remains a research challenge. In addition to this, the proposed systems could have used optimizers such as Adagrad or Adadelta to potentially improve accuracy or learning speed. Furthermore, no comparison has been made with other biometric security systems using different modalities or technologies. The compression-based approach used in the system was noted to introduce a trade-off between security and recognition accuracy, as the compression process could lead to loss of information affecting accuracy.

3. Research Methodology

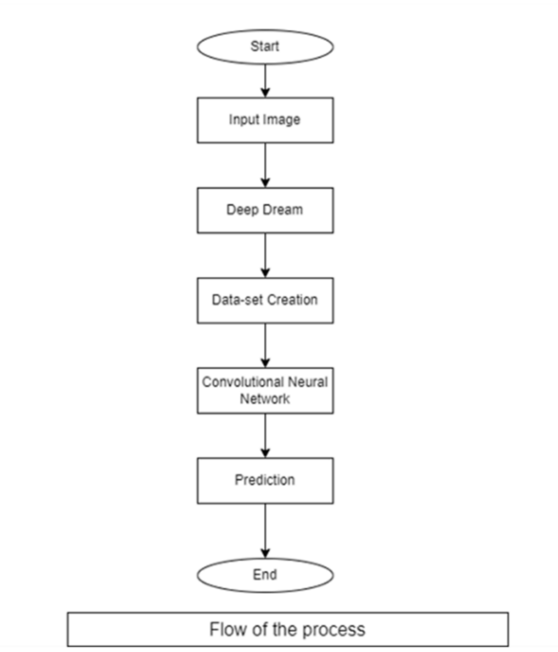

Fig 1. System Flow Chart

The Basic Methodology of System or Model is given step by step in the Fig 1 the System Flow Chart. This flowchart starts with taking input pictures and converting these pictures into Deep Dream Image by passing through the Deep Dream algorithm. And after completing this process we will start creating a dataset for this Deep Dream Image. After creating a proper dataset, we will use it to train the CNN model and then in the prediction step will test this model to analyze the result so that we can understand, is there any need of improvement or not.

Convolutional Neural Networks (CNNs)

Convolutional Neural Networks (CNNs) work by using different filters or kernels, which are like specialized lenses, to look at different parts of an image. These filters are adjustable and learn to recognize specific features like edges or shapes as they are trained on a large dataset. It's like training the network to see the world through different lenses. As the image passes through the network, the filters in each layer build upon each other, gradually detecting more complex and abstract patterns. It's similar to how our brain processes information, starting with simple shapes and gradually recognizing more intricate objects or structures.

By the time the image reaches the later layers of the CNN, it has been transformed into a highly abstract representation. It's like the network has distilled the image down to its most essential and distinctive features, making it easier to understand and predict. Based on the patterns it has learned, the network can produce precise predictions thanks to its abstraction. In essence, CNNs simulate the way our brains perceive and interpret visual information. They learn to see the world in a more sophisticated and nuanced way, ultimately enabling them to make sense of complex images and make predictions with a high level of accuracy.

To create a productive CNN model, we utilize different layers that work together to extract meaningful features from the given input image. These layers include:

A. Convolutional Layer:

The Convolutional Layer extracts detailed information from the input image, such as edges. By applying filters, it detects patterns and gradients. Initially, the first Convolutional Layer detects low-level features like edges, while subsequent layers adapt to more complex features, allowing the network to understand images more comprehensively.

B. Batch Normalization Layer:

Deep neural network training with numerous layers can be difficult due to the sensitivity of initial weights and learning algorithm configuration. Batch Normalization solves this problem by standardizing inputs for each mini-batch, stabilizing the learning process, and lowering the number of training epochs required for deep networks.

C. Max Pooling Layer:

The Max Pooling Layer minimizes the spatial size of the features, which aids computational performance by reducing dimensionality. It aids in the extraction of dominating characteristics that are rotationally and positional invariant, allowing for more successful model training. Max Pooling also functions as a noise suppressor, rejecting noisy activations and helping to reduce dimensionality.

D. Dropout Layer:

Dropout is a regularization technique used in neural networks to assist prevent overfitting. Dropout promotes the network to learn more resilient properties that are effective with varied combinations of other neurons by randomly deactivating neurons during training. It promotes better generalization and reduces interdependent learning among neurons.

E. Fully Connected Layer:

High-level features gathered by earlier layers are combined in non-linear ways by the Fully Connected Layer. It performs a non-linear transformation on the flattened input image, allowing the network to classify the image using techniques like SoftMax. This layer enables the model to distinguish dominant features and make accurate predictions.

4. Problem Description

A. Problem Statement

Biometric facial recognition systems suffer from limitations in accuracy, robustness, and usability, especially in challenging scenarios where traditional algorithms do not work effectively. To overcome these shortcomings, this Paper aims to use Deep Dream Algorithm and Convolutional Neural Networks (CNN). By using the Deep Dream Algorithm, which generates visually appealing images using neural networks, in the context of Biometric Face Recognition Systems and incorporating CNNs for image analysis, the Paper aims to improve the overall performance of these systems. By proposing this innovative approach, the Paper aims to address identified limitations and advance the field of facial recognition technology.

5. Modeling and its Details

A. Modeling approach & justification

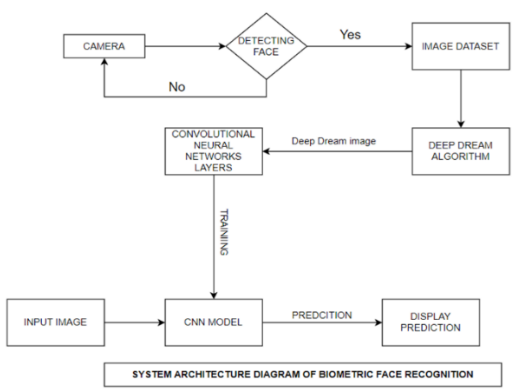

Fig 2. System Architecture diagram

The Architecture diagram for the proposed system is as shown in Figure 2. Initially the user will stand in front of the camera; the system will detect the face and will click the face images as per the requirement. In the next step those images will go through the Deep Dream Algorithm before providing them to CNN, because CNN is trained to detect deep dream images which will enhance the security feature. CNN uses two different optimizers and adjustments are made in each simulation to use the most efficient optimizer. Accordingly, some hyper parameters have been adjusted to account for profit loss. In the last stage of the system an input image is provided for face detection purposes. Provided image will go through a trained CNN model and will predict the corresponding image of whom. If the prediction is correct, then the user will be provided access or access will be denied for the unauthorized person.

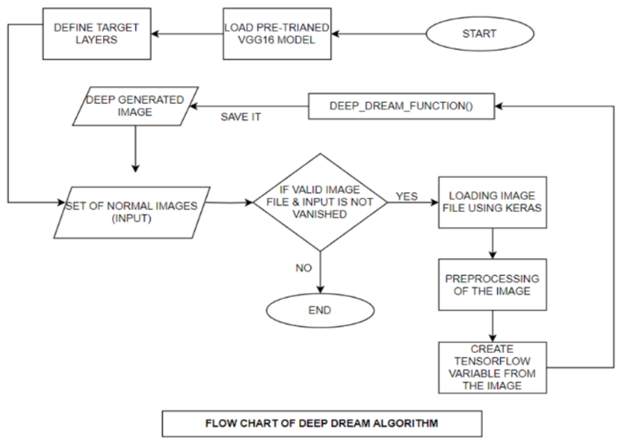

Fig 3. Working of Deep Dream Algorithm

The above flow chart shown in figure 3 is working on Deep Dream Algorithm. The Deep Dream algorithm using the VGG16 model, which is pre-trained on the ImageNet dataset. The algorithm enhances and transforms input images by maximizing the activations of specific layers in the neural network. Firstly, it loads the VGG16 model and defines the target layers for activation maximization. The deep dream () function is implemented to compute the Deep Dream effect on an image by iteratively applying gradient ascent to maximize activations in the specified layers. Then it iterates over each image file from the given input of the set of images, loads the image, applies Deep Dream, and saves the transformed image. By leveraging the VGG16 model and gradient information, the code produces visually stunning and abstract images that highlight patterns and features in the original images.

B. Notations & Assumptions used for modeling

Notations:

a_old: Old or current parameter values of the model.

a_new: Updated parameter values after one iteration of Gradient Descent.

x : Learning rate, which determines the step size or the amount by which the parameters are updated at each iteration.

y : A decay factor that controls the influence of past gradients. It is usually set to a value close to 1, such as 0.9.

L(a_old): Loss function, which calculates the variance between the forecast and actual values.

∇(L(a_old)): Denotes the gradient of the loss function with veneration to the parameters. It represents the direction and magnitude of the steepest descent in the parameter space to minimize the loss.

E: weightedExponentially for moving average of the squared gradients.

α (epsilon): A constant for numerical stability to avoid division by zero.

L_r : Learning rates

X: It's The first moment estimate.

B: The exponential decay rate for the first moment (typically set to 0.9).

G: Gradient for the parameters bythe loss function.

Y is the second moment estimate.

þ is the exponential decay rate for the second moment (typically set to 0.999).

X_hat : bias correction for the first moment

Y_hat : bias correction for the second moment

t: iteration counter

Assumptions:

1. It is assumed that the input face images are already accurately detected and aligned. This implies that any pre-processing steps such as face detection, landmark detection, or facial alignment have been performed prior to feeding the images into the CNN model.

2. It is assumed that a labeled training dataset is available, containing enough face images for each individual or class to train the CNN model. The training data should be diverse and representative of the target population, covering variations in pose, illumination, expression, and other relevant factors.
3. A fixed input size for face images is assumed, which means that all input images are resized or cropped to a consistent width and height (W, H). This allows for efficient training and processing within the CNN architecture.
4. A specific CNN architecture or variant is chosen for face recognition, such as VGGNet, ResNet, or InceptionNet.
5. The face recognition system is trained using supervised learning, where the training data includes both face images (m) and their corresponding identity labels (n). The CNN model learns to map the input face images to their respective identity representations during the training process.

C. Mathematical Modeling in mathematical form

1. Gradient Descent:

The great Gradient Descent optimization algorithm commonly add in machine learning and deep learning for updating the parameters of a learning model in order to minimize the loss function. The general equation for gradient descent is as follows:

$$a\_new = a\_old - x * \nabla(L(a\_old))$$

1. RMSprop Optimization:

RMSprop is also an optimization algorithm its objectivesis to adapt and adjust the learning rate throughout training by considering the magnitude of past gradients. It helps overcome the restrictions of a fixed learning rate in Gradient Descent. The equation for the RMSprop update step is as follows:

$$E = y * E + (1 - y) * (\nabla(L(a\_old)))^2$$

$$a\_new = a\_old - a / \sqrt{(E + \alpha)} * \nabla(L(a\_old))$$

VGG (Visual Geometry Group) refers to deep convolutional neural network architecture commonly used for image classification. The choice of optimizer in training a VGG network is not tied to the architecture itself.

parameter = parameter - L_r * G

Adam:

The Adam optimizer is an extension of stochastic gradient descent (SGD) that combines adaptive learning rates with momentum.

Calculate the gradient of the parameters g for the loss function.

Increment the iteration counter t.

$X = \beta * X + (1 - \beta) * G$

The second moment estimate (v) represents the average of the squared gradients. It is calculated using the following formula:

Y = þ * Y + (1 - þ) * (G ** 2)

Bias correction for the first and second moments estimates:

$X\_hat = X / (1 - \beta^{**} t)$

Y_hat = Y/ (1 - þ** t)

These bias-corrected estimates help compensate for the initialization bias at the start of training.

Update the parameters:

parameter = parameter - L_r * X_hat / (sqrt(Y_hat) + ε)

L_r is the step size or learning rate

ε is a small constant added to the denominator for numerical stability (usually a small value like 1e-8).

These optimization algorithms, Gradient Descent and RMSprop, are widely used in training machine learning and deep learning models, including those used in biometric face recognition systems, to iteratively update the model's parameters and optimize the loss function.

6. Analysis & Discussion

A. Findings (What extra you are providing):

The currently used Facial Biometric Systems fail to maintain the accuracy when the light source gets dim & we can overcome this problem by using Deep Dream Algorithm in our process. Using Deep Dream, the system is able to identify the images in less light regions which will help in maintaining the accuracy of the system in brighter light sources(areas) as well as in dim light sources(areas). Techniques like liveness detection, which verifies the "liveness" of the presented biometric, can enhance security and protect against spoofing attacks. Combining face recognition with other modalities like fingerprint, iris, voice, or gait recognition can improve overall performance, especially in scenarios where unimodal systems may face limitations or challenges.

The Convolutional Neural Network (CNN) is skilled on the basis of data containing 4 classes, which is further divided into a ratio of 80:20 into a train with 9600 samples and with 2400 samples.

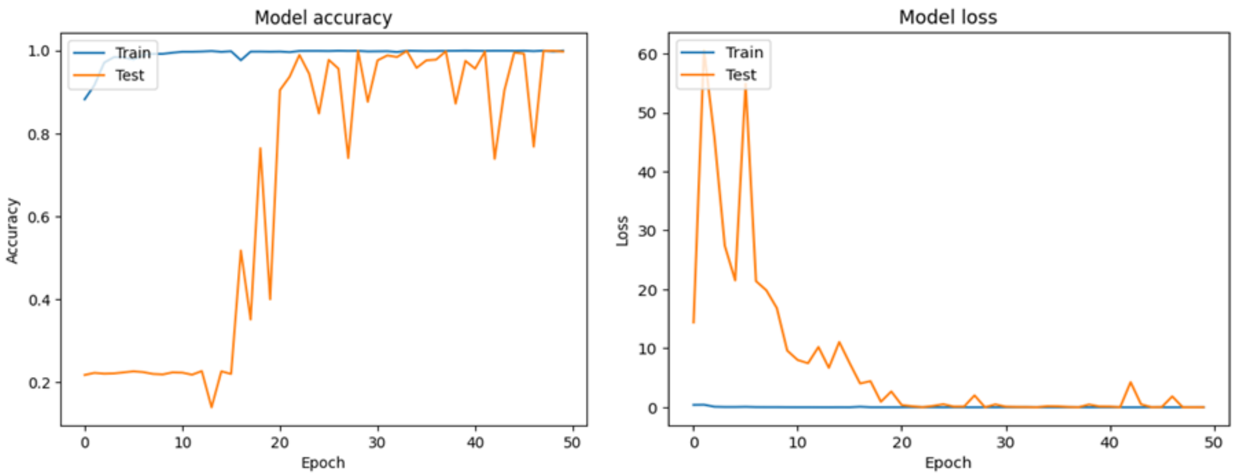

Fig 4. Graph of Model accuracy and loss

We have used two optimizers Adam and RMSProp for the training of the dataset. We are going to compare both the optimizers on their accuracy performance. For RMSProp learning Rate considered is 0.001 and Loss Metric is Categorical Cross Entropy Batch size we have taken is 256 with 50 Epochs are used for the model training.

Figure 4 illustrates the changes in accuracy and loss of the CNN model as the number of epochs increases during training on both the train and test data. It is clear from the graph that as the number of epochs increases, the accuracy of the model improves, while the loss decreases. Eventually, there reaches a point where further increasing the number of epochs does not significantly impact the accuracy or loss.

B. CNN Model Results

The class-wise accuracy of the CNN model represents the classification accuracy with respect to each class based on the predictions of the test data and it is represented in Table 1.

Class Label	**Accuracy**
1	100%
2	99.49%
3	100%
4	100%

Table 1: Accuracy Table

The different classification metrics such as Classification Accuracy, Precision, Recall, F1 Score and Kappa Score are used to evaluate the CNN model performance on the test or unseen data and the results are illustrated in the Table 1.

Metric	**Value**
Classification Accuracy	99.8671%
Precision	99.861%
Recall	99.874%
F1 Score	99.867%
Kappa Score	99.822%

Table 2. Metric Value Table

The Accuracy and the loss of the CNN model is 99.86% and 0.0019 and predictions samples of the images from the test data are shown in Figure 2

7. Contribution & Implications of the Research

Deep dream-based face recognition systems enhance security measures by accurately identifying individuals in real-time. They can be used in surveillance systems, access control, and law enforcement to identify potential threats or track individuals of interest. Deep dream helps to prevent criminal events, increase public safety, and helps in investigations.

In various situations deep dream offers handiness and efficiency. As an example, it can be used in automated check-in processes at airports, access control systems in workplaces or residential areas, and in unlocking personal devices. This abolishes the necessity for bodily identification or physical authentication procedures, saving time and refining user experience. Improves observation and investigation competences. Society benefits from improved safety, betterefficacy, and the inhibition of criminal activities.

8. Conclusion

This research work is the review of deep dream and it explored the use of Deep Dream in the area of security. By using the concepts of deep learning neural networks we tried improve the safetyof biometric authentication systems. In this paper we have underlined the vulnerabilities of biometric systems and also discussed the prospective benefits of deep dream technology to increasethe accuracy, robustness, and security of biometric system. The experimental outcomes presented in this paperillustratesdeep dream can be used to identify and highlight possible security threats in biometric data. These findings aresignificant implications for the biometric authentication systems. The outcome of proposed deep dream algorithm exhibits the increase in the security of biometric systems.

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