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Research Article

Face Expression Classification Based On Behavioral Pattern Recognition Using Deep Learning

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Abstract

In this study, a novel personal identification and engagement monitoring approach based on facial recognition in online examinations is proposed. First, the proposed Back Propagation Convolutional Neural Network (BPCNN) model uses deep transfer learning to perform student identity verification and to unravel emotional cues indicating engagement. The system includes a serious of comprehensive authentication modules to block unauthorized access and guarantee integrity of testing. Furthermore, facial expressions like happiness, anger, sadness, surprise are captured to get the insights into the variations in student engagement. Likewise, the system does not utilize separate facial expression analysis refinements, but indirectly uses emotional cues to improve assessment reliability. The model is shown to have achieved a high accuracy rate of 92% overtaking conventional models against key performance metrics including accuracy, recall, and F1 score. This solution integrates robust facial recognition with indirect emotion based insights for improved security and engagement tracking in e learning environments.

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1. Introduction

In our daily lives, security is the most important thing. A biometric system provides a resolution for this issue. Passwords, PIN, Smart Cards, Hard or Soft Tokens, etc. are commonly used to verify an individual's identity [1], [2]. The biometric authentication method is an alternative system to verify individual identity. In biometric systems, the emphasis is on recognizing individuals rather than just authenticating them to grant the system access [3].

Biometric methods use behavioral characteristics to identify a personal identity. These systems are mainly used for identification, access control, and recognizing individuals [4], [5]. Biometric systems use various technologies, which use unique identifiable properties, to authenticate and authorize people [6]. The different authentication techniques consist of face detection, iris, vein pattern recognition, fingerprint recognition, patterns of hand geometry, DNA structure, and speech recognition which can be used to validate an individual's identity.

The function of visual information in all human actions is crucial and ever-changing. Humans may have an advantage when it comes to facial recognition, despite the difficulty of the task for computers. When compared to other forms of biometric identification, facial recognition has gained widespread acceptance as a means of verifying and establishing an individual's identity. An individual's identity can be checked from a digital photograph using their facial traits. It does a mathematical mapping of each facial feature against either live-captured photos or stored digital photographs. There is no need for the user to actively participate, making it non-intrusive. Using a massive library of face datasets, the goal of face recognition is to identify and verify a given facial image. A new optimization technique for detecting face data has been articulated and applied to enhance the system's performance and efficiency in terms of identification. Studies have worked hard for improving the classification and ML techniques' accuracy for improving the recognition rate, reducing the mistake rate, and simplifying the process [7].

Nowadays in the education sector, there is an increase in the usage of facial detection and recognition techniques which can be also used in student learning. According to the survey and observation in the field of virtual or online education, it has proved that students engagement in the learning process can be analyzed as per facial behaviors or actions. A great deal of research has been done in this domain. This domain has been developed at different stages. Through research and development at different stages, it has been shown that the student's educational involvement can be identified through the various facial expressions in online learning environments [8]. In an education system, understanding the learner's engagement with a particular subject has been hard to predict and find the solution as well as the related action for that.

In the automatic face recognition system, the face detection step is the primary step. This system can automatically detect the person at the video source or digital image. The study of faces taken by digital cameras reports a varied range of challenges. These challenges can have adirect effect on face detection and recognition [9], 10]. Though, the finding and recognition process is not that much easier and straight process. There are many hurdles to make this system automated. Different problems and inconsistencies will be raised such as how the image looks, the difference in position forward-facing or non-front, occlusion, the direction of the image, light alignment, and facial appearance of an individual. Nowadays the real challenge experienced in the face recognition system is the ability to handle all these unconstrained environmental issues.

A person's identity can be established and confirmed through the use of a recognition system. Even in such systems, there remains room for improvement in terms of precision. Finding a good feature is critical in

algorithms of traditional face recognition since it allows them for identifying a specific pattern in the data. Traditional algorithms are limited in their efficiency and precision when dealing with any data. We can tackle any pattern-matching problem imaginable by employing various neural network algorithms. Because a neural network can be trained with a vast quantity of data, deep learning can improve recognition and prediction accuracy. Data modeling using deep neural networks is the domain of machine learning (ML) algorithms like deep learning [11].

In this work, the researchers have analyzed different emotions of the students such as anger, sadness, happiness, fear, disgust, and contempt. The facial expressions are identified by using the muscle movements of the eyes, lips, nose, and chin movements. In this work, the main focus is on capturing the student's emotions when students attempt the exam. With the help of the facial expression of the students, the performance of the students gets analyzed. In this module, the facial expressions of the students are interrelated with their emotions, and predicting in which emotions the performance of the students was better. To capture the various moods of the students and to develop the system for emotion analysis various deep learning algorithms and transfer deep learning techniques are used.

The remainder of the research is organized as follows: Section 2 represents different traditional, and modern approaches used in face recognition, ant spoofing, and facial expression analysis systems. The proposed research methodology is presented in Section 3. While the results are discussed in section 4 based on the training and testing of the dataset, section 5 concludes the findings of the proposed research.

2. Research Contributions

The research Contributions of the proposed study are:

- This research makes theoretical assessment of different student emotions in order to understand those emotional cues that may occur during exams, although no practical implementation nor specifics of the environment is described.
- Apply the theoretical application of the proposed (Back Propagation Convolutional Neural Network) BPCNN architecture in the application of facial recognition and emotional analysis.

3. Literature Review

In this Section, different traditional and modern approaches used in face recognition, ant spoofing, and facial expression analysis systems, are studied.

The ways to further improve the accuracy of the facial expression system were demonstrated by Shekhar Singh et al. (2020) performed preprocessing on the data to solve the problems in the unconstrained environment. Feature extraction was used to find the most important features from image data such as jaw, eyes, nose, mouth, etc. [12].

Sagar Deep Deb et al. (2020), proposed the parallel CNN structure for detecting the faces. The author has also reviewed the number of papers. The Viola-Jones algorithm is used to spot faces.

For classification purposes, the CNN model with the SoftMax classifier is used. This proposed model learns about the appearance and shape variances. The new system is trained on CMU Multi-PIE data. For alignment of the face, deep architecture is used [13].

Mohsen Heidari et al. (2020), applied the method to recognize the face with Siamesene work which CNN networks. The two face pictures passed to the network to find likeness among images. This network extracts features from images and feature matching determines whether a person's identity matches or not. The researcher has also used transfer learning with the VGG 16 model. The author has done a different review. The proposed technique

has improved the accuracy of face recognition compared to other models. This model was trained and tested on small LFW data. So, in this study, the author used the technique of transfer learning with pre-trained VGG 16 to exact the features and to recognize the face. The author used Keras to perform the experiments by using the LFW dataset. The LFW dataset has small samples, researcher has used data augmentation to apply various transformations [14].

Suleman Khan et al. (2019), offered a method of face recognition using a transfer learning approach. The researcher has used the pre-trained neural network Alex Net. In this paper, to implement this system the researcher has used CNN with Alex Net. MATLAB is also used for implementation purposes. With the face detector, Haar Cascade detects frontal face images with high accuracy. The new database created and AlexNet is trained on this dataset to recognize the face. In this method, only the frontal faces are considered. The transfer learning concept is used so automatically the time required to train the model will be reduced. As compared to other methods this approach gives high accuracy [15].

Gui Wu1 et al. (2019), recommend a process to recognize obstructed face from the input image using deep learning concepts. Model trained and leaned based on CNN. The method has good results in experimental analysis. In proposed method, the CNN and triplet loss function are used. Model is trained and tested using a huge amount of data. In evaluation, it has been verified that the model even if occlusion also model can recognize the faces correctly.Inception-ResNet-v1 model from transfer learn was used to build the model [16].

Aleksandr Parkin et al. (2019), proposed a new architecture to develop the anti-spoofing method to recognize any type of spoofing attack by unauthorized user. Author has trained models by using different datasets. So, these ensemble models are used to detect any type of spoofing attack. To train customized models the generic features are extracted from transfer learning models. New method is used for identifying spoofing attack. Different evaluation metrics are used such as ROC curve. CASIA dataset is used to detect anti-spoofing [17].

Abhishek Verma et al. (2019), suggested a method that usages the CNN and DNN to design facial emotion recognition model that divides in seven emotions, which are sad, neutral, fear, angry, disgust, happy, and surprised. This article compares two prevailing deep neural designs. The researcher also compared different architectures. Newly proposed architecture offers training precision, loss of training, test precision, and test loss [18].

Kaipeng Zhang et al. (2018), applied a method to recognize the disguised face. The author has used generic face recognition, with the help of DCNN to extract the uniqueness of the feature. In this paper, the two-step approach is used by the author. To extract the distinctiveness features or general features from the face the DCNN gets trained. By using the PCA the transformation matrix gets identified. The author has evaluated the model on the DFW dataset and obtained good outcomes as equated to advanced methods. The model is first checked for generic face recognition and then gets transformed into disguised face recognition. ResNet-like CNN and the SoftMax used as loss functions. The best results of recognition were obtained on the LFW dataset [19].

Mohannad Abuzneid et al. (2018), suggested an approach to enhance the system of face recognition by using the Back-propagation neural network. Generally, data reduction and feature reduction are essential so many researchers are moved toward the neural network. Hence, in this paper researcher used PCA to show that there is enhancement using the conventional method. The two datasets are used as YALE and AT&T datasets. In the proposed network the researcher has used deep transfer learning with pre-trained networks. LFW dataset is used to obtain high accuracy [20].

4. Methodology

Face alignment and segmentation are neglected in the proposed method for reducing the complexity of the model and providing real-time recognition. In a phase of implementation, the researcher employed three cascading steps in which the output of one stage should be transmitted to the next. Face recognition is performed using the BPCNN (Back propagation-CNN) algorithm and embeddings of retrieved features as input to the Siamese neural network.

The suggested solution provides the online examination system with a greater level of authentication. Using face expression recognition technology, the researchers also analyze the behavioral and emotional study of students during the assessment period.

The various emotions are identified and captured. In the same way that emotions play a vital part in human existence, they also play a crucial function in education. They surpass the restrictions of on-campus education. The majority of universities and educational institutions, especially those in higher education, have adopted the e-learning methodology.

The basic goal of this work is to build an authentication system for checking out the physical identity of candidates during online exams. Moreover, the system seeks to evaluate candidate's performance from their facial expressions. Figure 1 is a flowchart describing the proposed methodology.

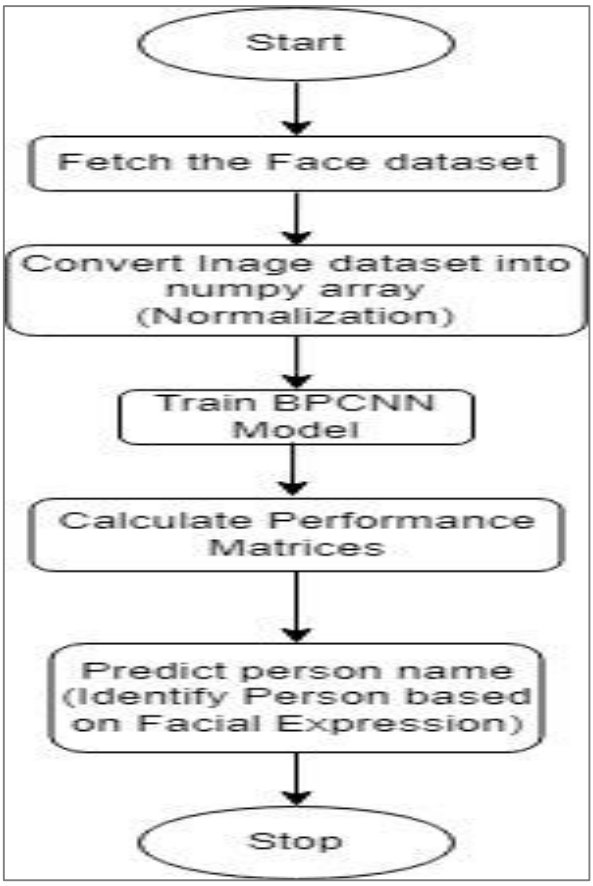

Figure 1: Flow chart of the proposed work

4.1 Back Propagation Neural Network Algorithm

This algorithm has been proposed as a training algorithm as illustrated in Figure 2.

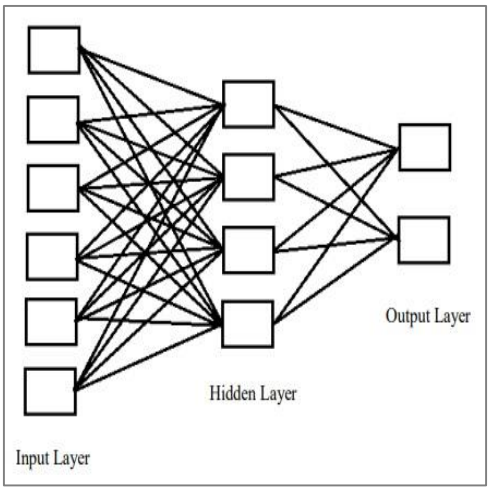

Figure 2: Architecture of backpropagation neural network

Input, hidden, and output layers make up the multi-layer neural network known as backpropagation. Akin to weights, the connections from units whose output is always 1 act as biases for the neurons in the hidden and output layers. The inputs are routed into a backpropagation that returns a binary or bipolar (0, 1) or (-1, 1) value as an output. Any differentiable and increasing function may be used as the activation function. The generalized delta rule is implemented by the backpropagation networks. It is a gradient descent algorithm which seeks to reduce the network's output error by squaring it to achieve the best possible results. To train a backpropagation net, data must go through three phases: feed-forward the training pattern input, error calculation and backpropagation, and weight modifications. Once the network is trained, just the feed-forward phase is required for use.

4.2 Dataset Description

A collection of images of human faces used to train algorithms for facial recognition and detection. To create this dataset, the publicly available labeled faces in the dataset wild as a starting point are used.

1) Every image is stored in RGB color space with, and the focus is on a single person's face. Size-wise, the original pictures are 250 pixels on a side.

2) There are two to fifty pictures of the star in each book.

3) Haar-Cascade Classifier was used to isolate the people in the starting photo (cv2).

Dataset Link of the Used Dataset:

https://www.kaggle.com/datasets/vasukipatel/face-recognition-dataset

5. Results and Discussion

E-learning technologies at educational institutions are gaining popularity among students in the learning environment. The demand for these E-learning systems is soaring due to their adaptability and user-friendliness. Typically, such characteristics are absent from conventional systems. The e-learning platform has increased the demand for an online examination system in the educational industry. Due to its adaptability to the newest technologies and its adaptability to flexibility, online examinations are gaining popularity today. The creation and marketing of contemporary online education approaches have progressed significantly in recent years. In practically all colleges, schools, and other educational institutions, as well as in the specialized education system that provides vocational education, the online education system has grown in popularity over the years.

Emotional aspects are essential in the e-learning environment. Primarily for physical authentication of candidates during the online tests, the system is designed. No continuous or automated facial expression tracking is implemented in the project but emotion analysis is discussed theoretically. Instead of a real time emotion monitoring, the purse stays focused on identity verification.

The proposed approach is predicated on the

physical authentication of candidates during the online examination and the detection of any exam malpractices committed by candidates. A face detect and identity recognition architecture and candidate verification has been proposed to ensure that the faces detected can, in fact, be identified as the person of interest. The automated authentication method used in this system can detect unauthorized users' attempts to fake a photo. The face detection, feature extraction, and identity recognition are used to successfully set up a robust authentication framework. Of course, the dataset is dedicated to detect faces, therefore the face

detection algorithm that is used is the BPCNN algorithm, and the other processes that perform feature extraction and recognition to identify every candidate face with precision. The dedication module used for candidate authentication for the test during the online examination primarily concentrates on candidate authentication. Theoretical considerations of emotion detection are discussed, though there is no implemented module for the capturing or analyzing the facial expressions in real time during the examination.

5.1 Training and Testing of the Dataset

When constructing machine learning models, it is necessary to train the model using a particular dataset, consisting of variables X and y. After the training, it is significant to verify that the trained model can achieve satisfactory performance on new, unseen test data. The train test split is a method used for evaluating the performance of the machine learning model on unseen data. The Image Data Scan (Train +Test Data) consists of 244 images belonging to 16 classes. The Training Dataset consists of an image dataset that comprises digitised images utilised for testing, training, and assessing the efficacy of computer vision algorithms. Image collections facilitate the training of algorithms to identify and extract information from images, enabling them to engage in pertinent cognitive tasks.

This research demonstrates that images depicting various facial expressions are included in the dataset. Fig. 3 represents the Different Expression in a Single Class of Image (Sample).

Figure. 3: Different Expression in Single Class of Image (Sample)

Mapping and Label ID are performed next on the training dataset. In data analysis and machine learning, feature mapping is a technique used to transform input data from a lower dimensional space to a higher dimensional space. This allows for easier analysis or classification of the data. Feature mapping entails the process of choosing or

creating a collection of functions which

multidimensional arrays, commonly known as tensors, and facilitates a broad range of scientific computations. The structure includes a memory pointer and accompanying metadata that is utilised to interpret the stored data. This metadata includes important information like the data the existing data range into a novel, standardised range. Normalisation is crucial when working with datasets that exhibit variations in units or magnitudes across distinct features.

Figure. 4 and Figure.5 give the accuracy and loss ratio over epochs. As the number of transform the initial data into different sets of features that more effectively represent the fundamental patterns within the data. Subsequently, the obtained feature space might be utilized as the input for the suggested machine learning technique.

Next, converting Data into NumPy Array Format takes place. The NumPy array is a fast data structure to store and access type, strides, and shape.
Normalizing Data for BPCNN is done next. Data normalisation is a method employed to rescale data to a particular range, usually between 0 and 1, or to modify features so that they have an average of 0 and a standard deviation of 1. The method entails converting epochs rises, loss lowers, and accuracy rises during the training process. The level of accuracy typically exhibits a positive correlation with the number of epochs, as the model iteratively enhances its comprehension of the training data.

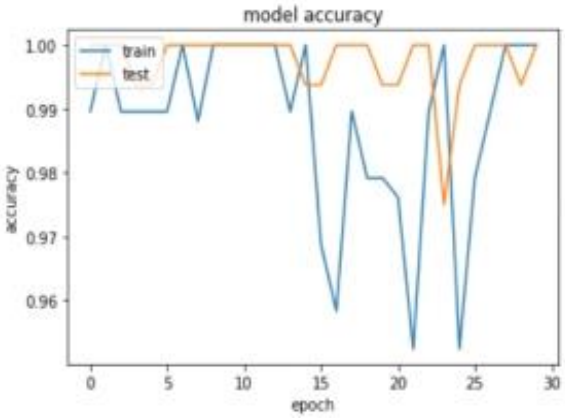

Figure 4: Model accuracy Plot

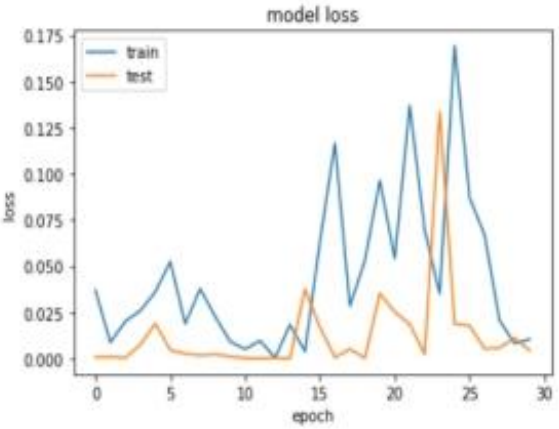

Figure 5: Model loss Plot

Shape and Class of Normalize Testing and Prediction Data are ((244, 16), (244, 16).

5.2 Test and Prediction Data

Future event forecasting uses predictive analytics, a branch of advanced analytics. Statistical, data mining, machine learning, and artificial intelligence techniques are employed to examine the existing situation. A classification report offers various crucial parameters to assess the effectiveness of a classification algorithm. BCNN's Classification Report is shown in Figure 6.

Report:

	precision	recall	f1-score	support
0	0.93	1.00	0.97	14
1	0.95	0.83	0.88	23
2	0.88	0.93	0.90	15
3	0.86	1.00	0.92	12
4	0.92	0.92	0.92	13
5	0.83	1.00	0.91	10
6	1.00	0.88	0.94	17
7	0.94	0.80	0.86	20
8	0.87	1.00	0.93	13
9	1.00	0.88	0.93	16
10	0.94	1.00	0.97	16
11	0.94	1.00	0.97	15
12	0.94	0.94	0.94	16
13	0.93	0.93	0.93	14
14	0.86	0.92	0.89	13
15	0.94	0.88	0.91	17
accuracy			0.92	244
macro avg	0.92	0.93	0.92	244
weighted avg	0.93	0.92	0.92	244

Figure. 6: Classification report of the proposed model

Table 1: Model's Performance scores

Algorithm	Accuracy (%)	Precision (%)	Recall (%)	F1-score (%)	Mean Square Error	Mean Average Error
BPCNN	92.21	92.60	92.21	92.14	0.377	3.147

Figure. 7 explains the confusion matrix of SKCNN, CNN, and RNN algorithms. In the proposed research, the confusion matrix is a tabular representation which provides a concise summary of how well a machine learning algorithm performs on a certain test data set. It is a method of visually representing the quantity of correct and incorrect occurrences based on the predictions of the model. It is commonly employed to evaluate the effectiveness of classification algorithms, that seek to forecast representational labels for every input instance.
The matrix exhibits the number of instances generated by the algorithm when applied to the test data.
When a positive data item is accurately predicted by the model, they are known as true positives (TP).
True negatives (TN) are data points that the model correctly predicts to be negative. False positives (FP) refer to instances where the model is predicting wrongly a positive data item.
False negatives (FN) arise when the model is predicting wrongly a negative data point.

Performance metrics were obtained from the confusion matrix.

Accuracy

The model's accuracy is used to gauge its performance. It is calculated as the proportion of all accurate occurrences to all instances.

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN}$$

Precision

Precision is a metric that quantifies the accuracy of a model's positive predictions. It is the quotient of the number of (true positive predictions) which is divided by the total quantity of positive predictions generated by the model.

$$\text{Precision} = \frac{TP}{TP + FP}$$

Recall

Recall quantifies the efficiency of a classification model in correctly recognising all pertinent instances from the dataset. The precision is calculated by dividing the number of (TP) instances by the sum of true positive and (FN) cases.

$$\text{Recall} = \frac{TP}{TP+FN}$$

F1-Score

A classification model's overall performance is assessed using the F1-score. It is the precision and recall harmonic mean.

$$\text{F1-Score} = \frac{2.\text{Precision .Recall}}{\text{Precision + Recall}}$$

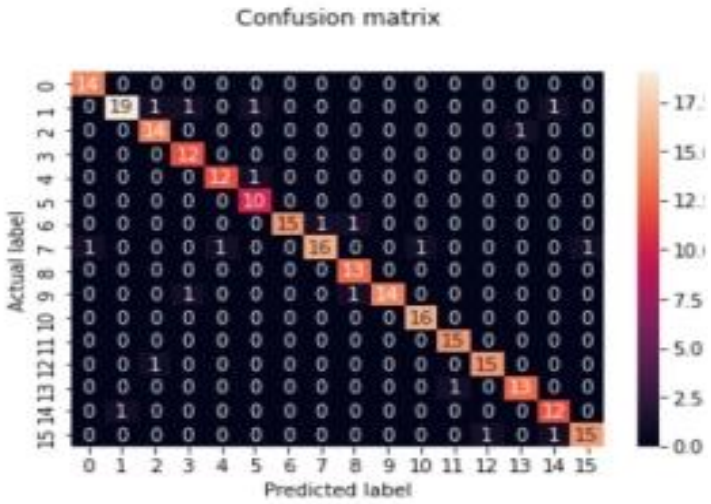

Figure 7: The proposed model's confusion matrix

The Area Under the Receiver Operating Characteristic curve, or AUC-ROC curve, is a visual depiction that illustrates the performance of a binary classification model at various categorization levels. It is frequently employed in machine learning to evaluate the discriminative capacity of a model in distinguishing between two classes, usually referred to as the positive class and the negative class. The calculated AUC/ROC Curve Score is

AUC: [0.7523 1.263]

ROC: [0.8621 1.121]

5.3 Testing Single Image Prediction

After obtaining the required performance metrics of the proposed model, a single image is tested for prediction purposes. An input image is given for test purposes, and a test scan is done using BPCNN. The final image is correctly predicted by BPCNN proving the efficacy of the proposed model. In the below example testing, sample is predicted using BTCNN

Input

Test Scan BCNN

Prediction

Prediction is: face6

Actual Image

{'face1': 0, 'face10': 1, 'face11': 2, 'face12': 3, 'face13': 4, 'face14': 5, 'face15': 6, 'face16': 7, 'face2': 8, 'face3': 9, 'face4': 10, 'face5': 11, 'face6': 12, 'face7': 13, 'face8': 14, 'face9': 15}

##

6. Conclusion

This work aims to automate the system for analyzing and authenticating students' facial expressions during online exams. The models are created using various neural networks and transfer learning architecture. To the highest level of accuracy, the models used to construct the system are trained and evaluated on various datasets. In this study, a unique method employing face detection, identification, and feature extraction was created based on the CNN model in order to establish an authentication model. Face derived from an image using the BPCNN algorithm and the FaceNet model to extract features. The model for facial recognition with anti-spoofing obtains a 92% accuracy rate.

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