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Region Based 3D Face Recognition using a Convolutional Neural Network

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***Abstract:** In this paper we are proposing a compact CNN model for expression insensitive 3D face recognition. 3D face recognition is a trendy interested area in computer vision and is applied in different real time applications. Lots of research work is going on in industry and academia in this area. Traditional machine learning approaches for 3D face recognition is now superimposed by deep neural networks and are trained using large amount of data. We are applying a region based 3D face recognition approach along with a fusion CNN. 15 sub regions are generated from the frontal face region and features are extracted from it. The features extracted from each region are fused using the fusion CNN. These facial features are rich in identification information and they are not represented using single features. Fusions of multiple features extracted from the 15 regions are combined. The set of values extracted from the features after preprocessing are given as input to the CNN. The fusion CNN uses the features from different layers and fuses them together for a prediction as shown in figure1. The lower layer and higher layer features are fused. The computation time of the proposed system is 3.24 s for preprocessing and 0.09 s for matching. The overall computation time is 3.33 s. The running time of our previous region based approaches [13][14] is around 6 .48 seconds and 12 seconds. It is evident that the computation time of our proposed approach stands good and can be applied in time critical security applications.*

The three major steps are preprocessing, deep feature learning and deep feature classification.

***Keywords** : 3D Face recognition, CNN, Deep Learning.*

I. INTRODUCTION

3D data is very important in the field of computer vision because it provides complete geometrical information of the sensed object.

Deep learning techniques applied on 3D data are finding lots of applications in recognition, detection, segmentation and classification. The most important and outstanding characteristics of deep learning architectures is their capability to learn gradually discriminant hierarchical features from the input data. Deep learning is applied enormously in 2D data due to its availability and large size. This emphasizes the requirement of large dataset for training. Limited works are reported on 3D data due to its reduced dataset size and availability.

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Convolutional neural networks are producing improved results in 3D face recognition. The architecture of the CNN plays a vital role and the dimensionality of the learned features can be reduced without affecting the recognition accuracy. We can improve the performance of a deep neural network by increasing the number of levels and also by increasing the unit in each level. The major disadvantage is the increased use of computational resources resulting from the use of increased parameters. A Sparsely connected network can replace a fully connected network and can be used as a solution for the above said disadvantages.

The intra class variability and the inter class similarity of the face data can be easily learned by the CNN. Along with the discriminative features CNN also reduce the dimensionality of data. CNN are end-end learning system that doesn't require combination of any additional methods.

In [1] the authors mentioned that training Discriminant features for 3D face recognition is very difficult due to the lack of large data sets. They suggest that a transfer learning mechanism of a 2D trained CNN can easily work with 3D face recognition with minimal number of 3D facial scans. A detailed survey of deep learning methods and applications is given in [2].

The representations of 3D based methods are classified as Model based and view Based methods. In the model based approach a full 3D model is used for extracting features.

If high voxel resolution is used to describe the 3d facial shapes are structures then the memory requirement is increased enormously.

The major contributions of this work are

- We propose a compact region based 3D face recognition using 15 sub regions extracted from the frontal face.
- CNN model is used for fusion of facial features extracted from the 15 sub regions.
- Experiments are done on the publically available 3D dataset Bosphorus and obtain good results.

The rest of the paper is organized as follows Section II gives a brief and precise review about the related works, Section III explains our proposed methodology in detail with architecture and phase diagrams. Section V concludes with future directions

II. RELATED WORK

[[3] Huan etal., 2012] highlight the fact that most of the face recognition system relies on feature representation given by a descriptor such as Local Binary pattern. Several complementary representations are obtained by using deep learning techniques. The authors suggest a Convolutional deep belief network for extracting features from a high resolution images.

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A comparison between the performance of network trained with unsupervised learning and random filters are given. The paper concludes by highlighting the performance of deep learning in recognition by using the representation generated by the DL network.

[[2] Eman etal., 2019] suggests that Deep learning techniques can be applied on 3D data , as large 3D datasets are available now a days. Based on the 3D representation of data some changes may be applied on the DL architectures. The paper gives a clear distinction between Euclidean and non Euclidean 3D data representations and its applications using DL.

[[4] Guosheng etal., 2015] give emphasize on the fact that CNN is achieving promising results in face recognition. A detailed and extensive evaluation of CNN based face recognition system is given in this paper. The dataset used for training is LFW. Three different architectures are applied on the LFW datasets and a quantitative analysis of the different architectures is also given. This work highlights the good properties of CNN face recognition system. The source code and the models are made publically available for reproducibility.

[[5] Parkhi etal., 2015] proposes a face recognition approach from a single image or a set of images tracked from a video. They point out the promising properties of CNN and the availability of large dataset is paving way for deep learning approaches. Experiments are done on LFW data sets.

[[6] Xudong etal., 2017] proposes a new face detection technique using deep learning. For bench marking FDDB is used and a variant of the fast RCNN framework is used in this work.

[[7] Feng etal., 2018] presents the drawback of 2D face recognition and points out the advantages of 3D. In 3D face system robustness can be improved by using depth information. A deep Convolutional neural network with a softmax classifier is used in the proposed system. By using the recognition rate maximization principle and fusion, good recognition rate is attained.

[[8] Wang etal., 2018] works on facial land marking on the facial data and is providing a base for the semantic facial structures. A coarse to fine approach for facial landmark detection using deep learning is focused in this work. A fused CNN is employed for feature extraction. Experiments are all done on Bosphorus and BU-3DFE datasets and obtain remarkable results.

III . METHODOLOGY

An expression insensitive region based 3d face recognition approach is used here. Two datasets are used one for storing the trained data and next for storing the test data. The image is smoothed by applying a median filter, this constitute the preprocessing steps.

By using an automatic nose tip detection algorithm[12] nose tip is identified and considering nose tip as origin crop 15 sub regions from the face image. Extract the features from each region and is fed into the CNN. The CNN fused the sub features from each region .

The training is based on the mapping functio0 from the fused CNN features from all the 15 sub regions

When a new image is taken from the test database, it again passed through the above mentioned steps and comparison of fused features occurs between the gallery and the test database .Training and testing algorithm phase diagram is shown in figure 2. The computation time comparison is given in table 1.

Training Algorithm:

1. Input 3D face image
2. Preprocessing using a Median filter
3. Automatic detection of nose tip
4. Region splitting
5. Feature extraction & Feature fusion using CNN
6. Store the features in Gallery

Testing Algorithm:

1. Input 3D face image
2. Preprocessing using a Median filter
3. Automatic detection of nose tip
4. Region splitting
5. Feature extraction & Feature fusion using CNN
6. Compare the extracted feature with gallery
7 Results: Match/ No Match

Table 1: Computation Time (s)

Approach	Pre processing	Matching	Total
Alyuz et al[9].	36	0.02	36.02
Kakadiaris et al[10].	15	0.5	15.5
Reji et al.[13]	4.54	1.94	6.48
Our current work	3.24	0.09	3.33

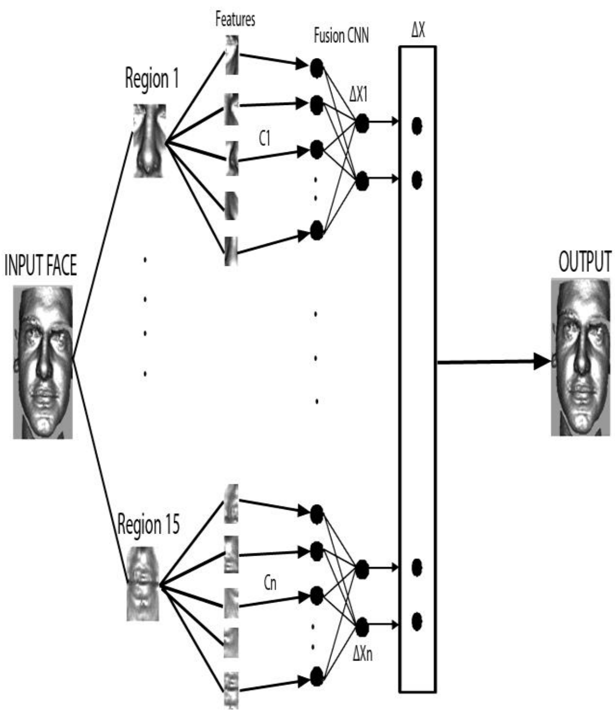

Figure 1: Architecture diagram of FRS

Experiments are all done on Bosphorus dataset [11][12]. This dataset is having 105 subjects with 4666 faces. The major characteristics of this datasets are it is a good repository of expressions. More systematic head poses and occlusions are also present.

IV.CONCLUSION

In this paper we propose a region based 3D face recognition system incorporating a deep learning approach. We implement a CNN model for feature extraction and fusion. Our method is making use of a simple preprocessing step with an automatic nose tip detection algorithm developed by us in our previous work. Dividing the frontal face area into 15 regions and extracting features from each region. Our method is time efficient and is tested on a public 3D dataset. The systems reports a computation time of 333 seconds. The system can be used in different real time applications.

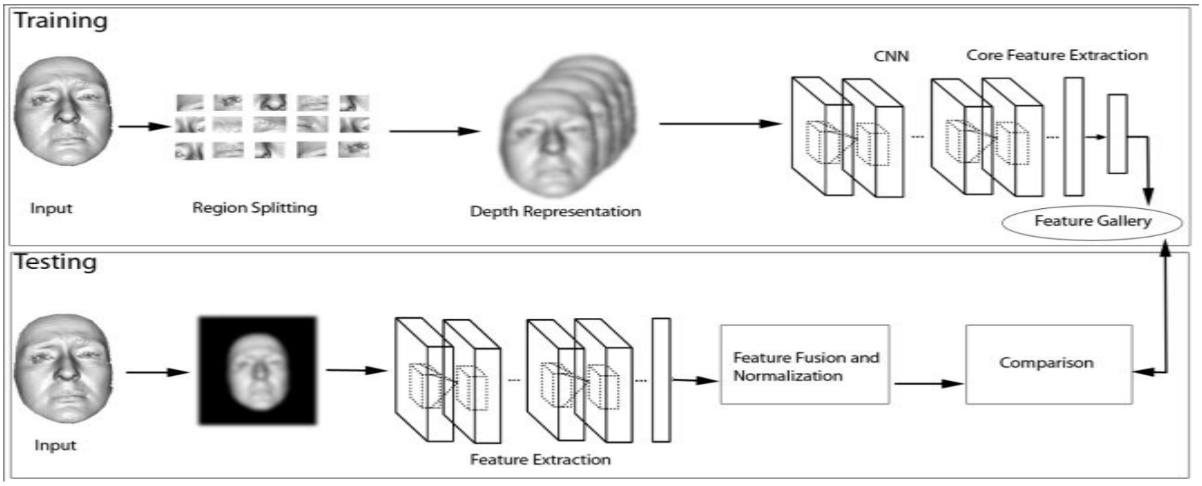

Figure 2: Training and Testing phase diagram

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