Neural Models for 3D Face Generation and Recognition

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Abstract

This work introduces a new technique for 3D point clouds generation using a neural modeling system to handle the differences caused by heterogeneous depth cameras, and to generate a new face canonical compact representation. The proposed system reduces the stored 3D dataset size, and if required, provides an accurate dataset regeneration. Furthermore, the system generates neural models for all gallery point clouds and stores these models to represent the faces in the recognition or verification processes. For the probe cloud to be verified, a new model is generated specifically for that particular cloud and is matched against pre-stored gallery model presentations to identify the query cloud. This work also introduces the utilization of Siamese deep neural network in 3D face verification using generated model representations as raw data for the deep network, and shows that the accuracy of the trained network is comparable to all published results on Bosphorus dataset.

Proposed System

Due to lighting conditions and/or makeup or other 2D factors affect face image, the regular 2D image becomes insufficient for face recognition. In order to address these issues, this work presents a 3D faces regeneration and recognition system that can work on the texture free 3D point clouds extracted by depth cameras to identify or verify the person. In this regard, this research introduces a new technique for 3D cloud regeneration using a neural generative model to handle the differences caused by heterogeneous depth cameras, and to generate a new face canonical compact representation. The proposed neural model is shown in Figure 1.

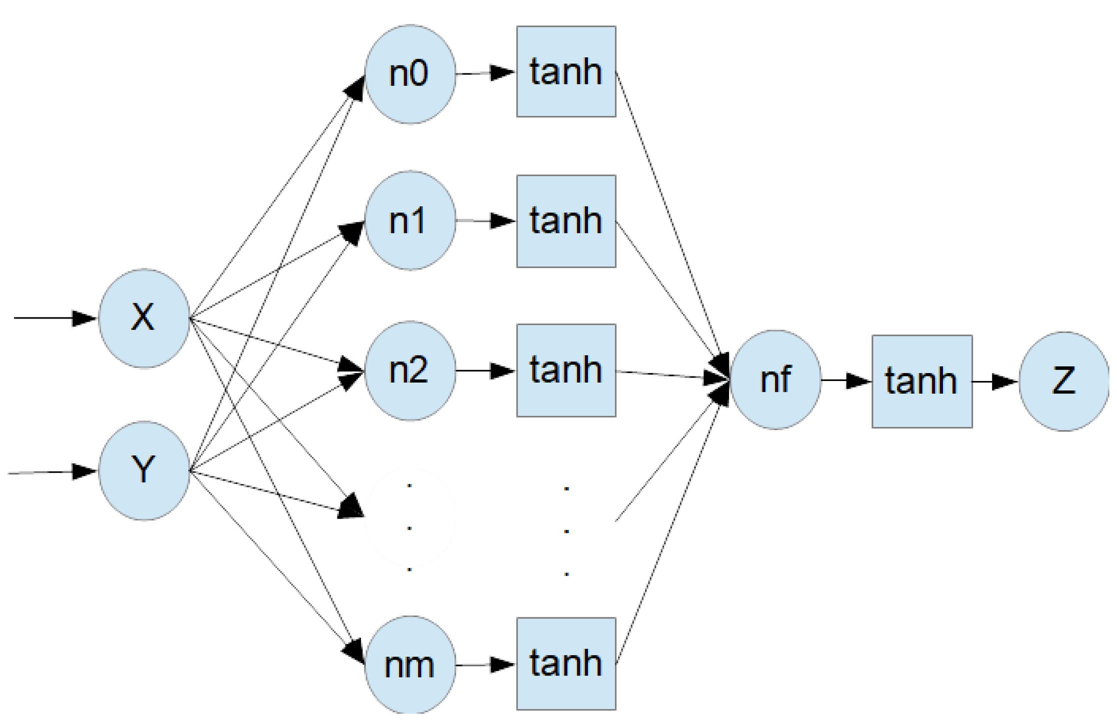

Figure 1, Proposed neural model for 3D face generation

The proposed system reduces the stored 3D dataset size by a factor more than 40, and if required, provides an accurate dataset regeneration. Furthermore, the system generates neural models for every gallery point clouds and stores these models to represent these faces in the recognition or verification process. For the probe cloud to be verified, the system obtains the 3D points cloud as an input with face landmark points. These landmark points are then registered to reference points to be aligned and scaled correctly. After the registration step, a neural model is generated for this prob cloud to provide a compact representation of the 3D face data. The extracted neural model is then applied to a face recognition or verification step to detect the best matched model from the prestored gallery model's presentations. This work also introduces the utilization of Siamese deep neural network (as shown in Figure 2) for 3D face verification using generated model representation as a raw data for the deep network. The complete proposed system is depicted in Figure 3. The following sections will explain each step used in the system.

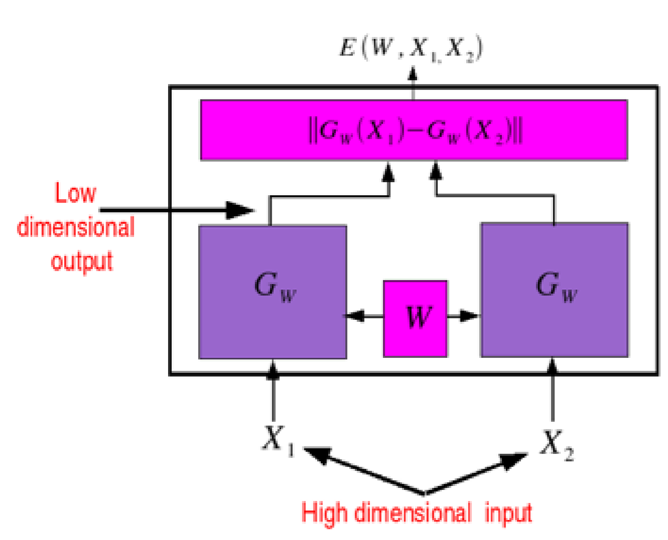

Figure 2, 1D Siamese network utilized in this research

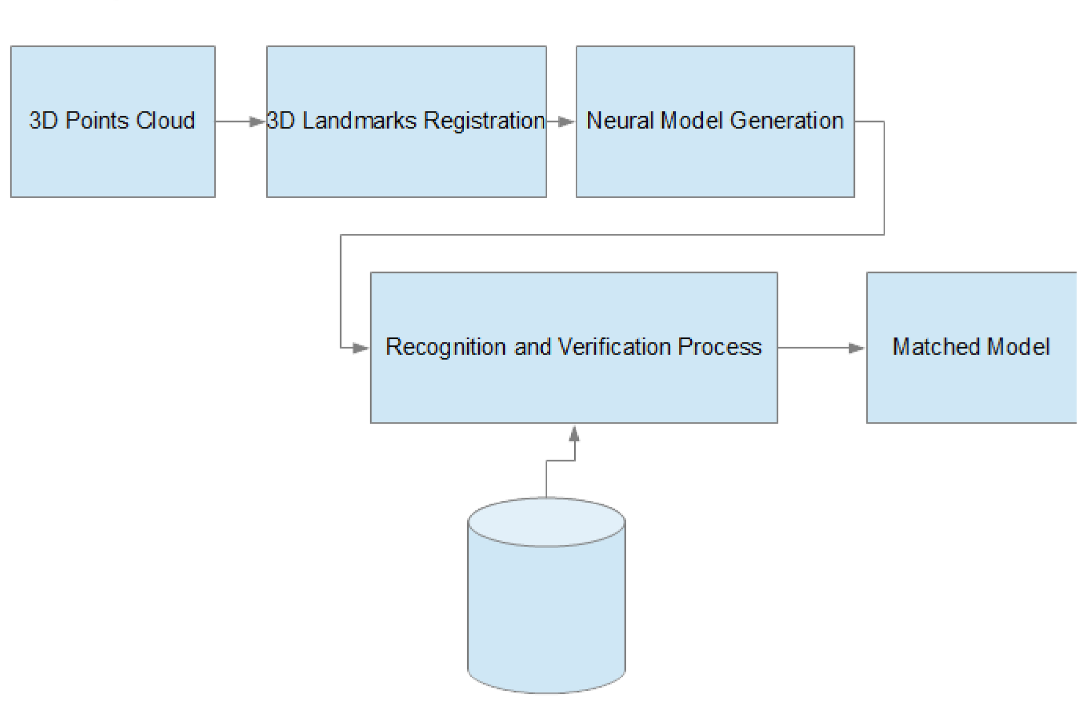

Figure 3, Proposed 3D based face recognition system.

Results

Neural Modeling Results:

Generated models are learned using Levenberg–Marquardt Backpropagation technique to reduce the Root Mean Square error between original and generated points data. The generated models perform better in generating the original face point could as they remove all sensor noises. Figure 4 shows an example of original captured data vs data points generated by the proposed neural model.

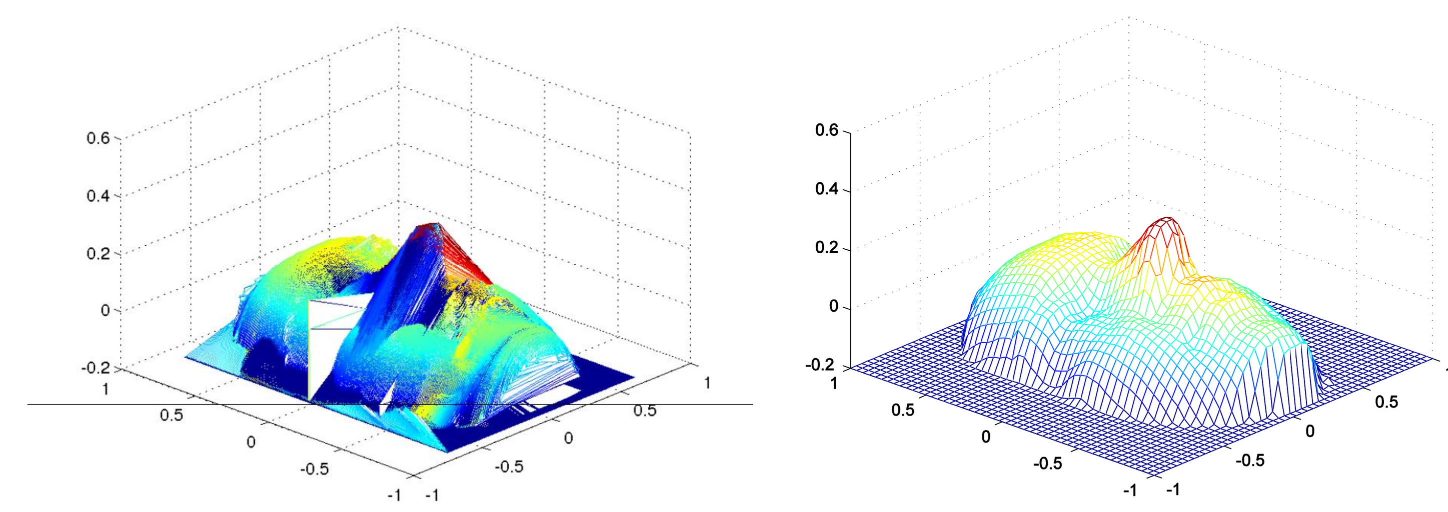

Figure 4, Original point cloud data (to the left), and neural generated point cloud (to the right)

Siamese Network for Face Verification and Recognition:

Siamese Network has been built over the 1D vector features extracted and augmented from the neural face models. The proposed network has been implemented using Python with the Caffe neural framework configured with ADAM optimization algorithm. The proposed network architecture is shown in Figure 5.

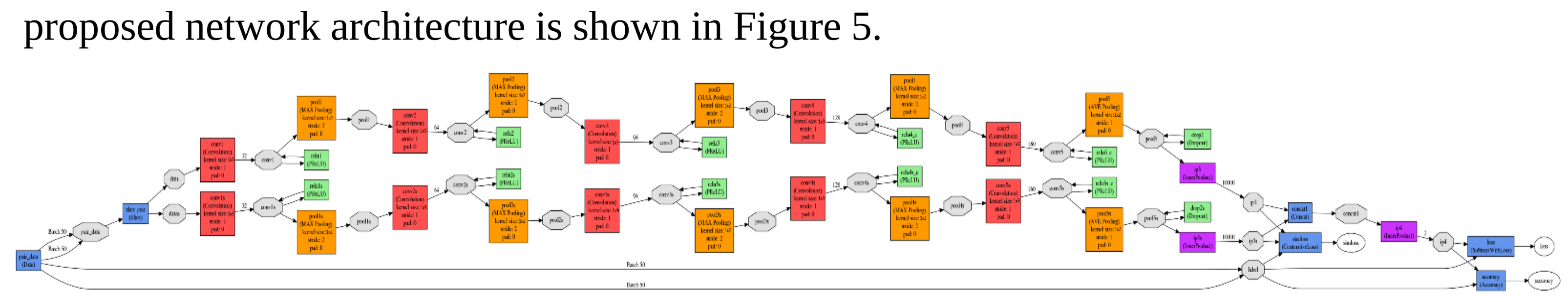

Figure 5, The proposed Siamese Network Architecture

The Receiver Operation Characteristics (ROC) curve and the Precision – Recall curve metrics of the testing dataset for the proposed Siamese Network is shown in Figure 6.

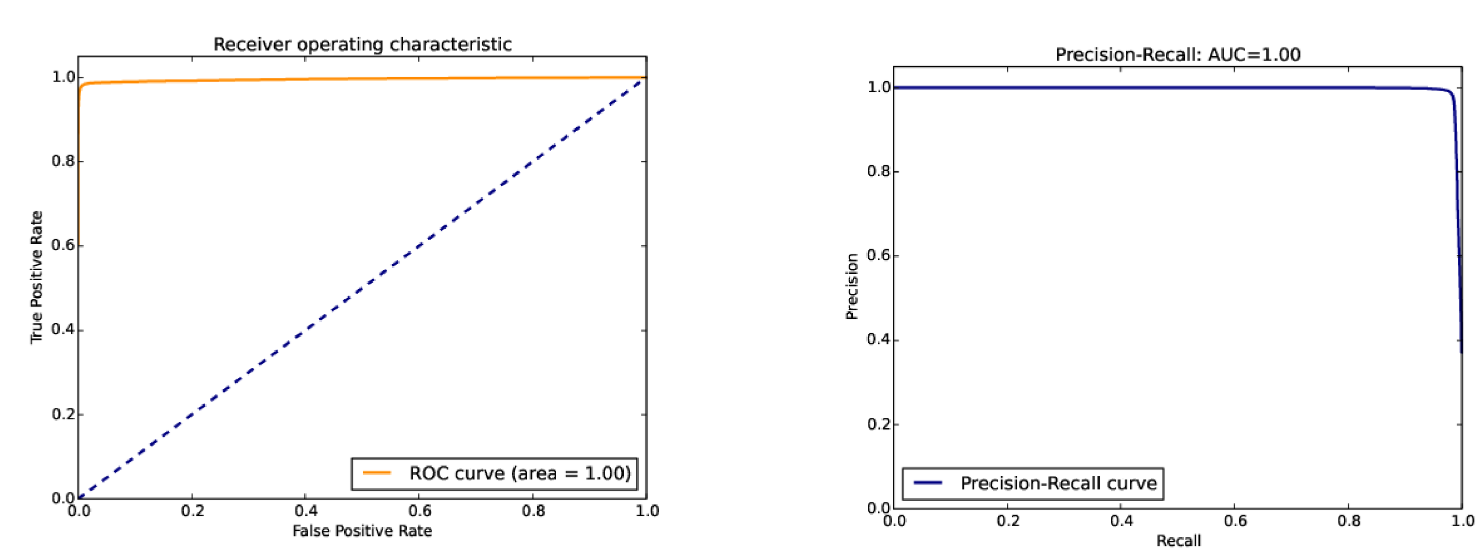

Figure 6, ROC and the Precision – Recall curves of the testing dataset

Recognition rated of the testing group of the Bosphorus dataset is shown in Table 1.

Table 1, Comparison of recognition rate using different techniques over 3D natural expression faces of Bosporus dataset

Method	Rate (%)
ICP-based holistic approach	71.39
Average Regional Models	98.87
HoG+HoS+HoGS	99.98
proposed Siamese Network	100

Conclusions and Future work

The proposed system has introduced a new Neural Computing system that can efficiently represents 3D faces for both regeneration and recognition tasks. The generated models can also be used to generate higher resolution points cloud, which can be considered as a 3D super-resolution system. The generated models can be used as new features representation for the original cloud for recognition and verification purposes. The 3D system has been tested over Bosphorus dataset with high recognition rate. Siamese Network has been trained on the generated models for Bosphorus datasets with high accuracy. All other state-of-the arts techniques for 3D face recognition still can be applied on regenerated points clouds if required

References

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[3] Kim, D., Hernandez, M., Choi, J., and Medioni, G. (2017). Deep 3d face identification. In 2017 IEEE International Joint Conference on Biometrics (IJCB), pages 133–142.]