Face Recognition using Radial Curves and Back Propagation Neural Network for frontal faces under various challenges

Latasha Keshwani
Electronics and Telecommunication Department
Datta Meghe College of Engineering, Airoli, Mumbai University, (MS), India

D.J. Pete
Electronics and Telecommunication Department
Datta Meghe College of Engineering, Airoli, Mumbai University, (MS), India

ABSTRACT
A unique framework is proposed, in which the analysis of 3D faces is carried out on a readily available ORL database. The work is executed on different steps of preprocessing, feature extraction, face restoration, face classification and face recognition. In this novel framework, radial curves are applied for representing the facial surface. This representation shows robustness to various challenges such as occlusions (i.e. wearing glasses, growth of hair), different poses, expressions, and missing parts due to illumination. The face is represented by radial curves on it, starting from nose to the end of the face which helps in further comparison of the face with their corresponding curves. Further Neural Network is employed in this system. The performance analysis is carried out for radial curve based system and neural network based system

Keywords
Occlusion; Pose Variation; Radial curves; Neural Network

1. INTRODUCTION
Face is the natural assurance of someone's identity. Due to this widely accepted representation, a face is shown as approval of who the person is. Biometric recognition systems have gained a tremendous importance everywhere. Other biometric based recognition techniques, like fingerprint detection and iris matching, have attained a high level of success in accuracy, but they are not used widely in noncooperative scenario. Besides, face is the non-intrusive method used in such non-cooperative environment. With every human, the variation in their fiducial parts such as varying size of nose, eyes, lips are noticed which is used as one of the important parameter for face identification and recognition. Automatic face recognition technique has numerous applications in the human computer interface, providing an access to various control systems like ATM machines or office entry, forensic departments, and Crime departments for identification of fraud person, theft, etc. Face recognition system is working at its best level by providing recognition rate of nearly 99% at a False Acceptance Rate (FAR) of 0.01%.

A Face Recognition System analyses individual's features and different characteristics to show assertion of one's identity. The generalised block diagram of face recognition system is as shown in Fig. 1.

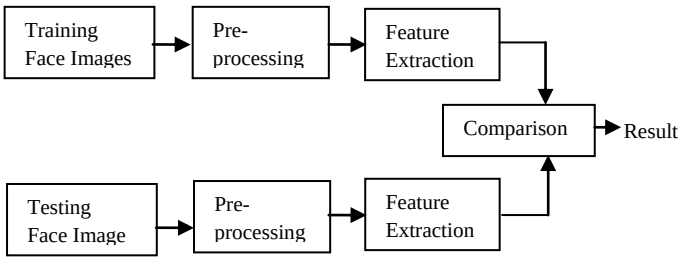

Fig. 1. General Schematic of Face Recognition System

A face recognition system is basically a two step procedure in general; they are Training/Enrollment mode and Testing/Identification mode. They can be defined as follows:

Training/Enrolment mode: In this mode, images of various people are captured and a biometric feature of each person is obtained to be saved in the database. This stage can also be called as database creation stage.

Testing/Identification mode: In this mode a template is created for an individual and then a match is searched for it in the database of pre-enrolled templates.

The face recognition system starts with acquisition of the face images. If the images are blurred or not so clear then the preprocessing stage does the necessary action and makes it suitable for further matching. The features of the face are extracted for the database image as well as the testing image. These features of the test image are compared with the features of all the database images. The result is a probable match at the output.

In real time Face recognition system come across various challenges like pose variation, expression, occlusion, illumination conditions, and clutter. It becomes difficult to identify a person when the face image stored in the database is with a different pose, expression, and illumination conditions; and that for the testing is with a different pose, expression and illumination condition. Face recognition system also faces difficulty when there is some presence of occlusion like wearing of glasses, growth of beard, change in hair style etc. it may also happen that the image captured by the camera is not proper. This paper presents an algorithm which has a provision of identifying the person across various challenges viz. pose variation, expression, occlusion, illumination conditions and clutter.

The content of this paper is organized as follows: Section 2 provides the literature survey related to face recognition system. Section 3 describes the in detail system components and algorithms used in proposed face recognition system. The

experiment results and discussion is elaborated in Section 4. The conclusion and future scope is presented in Section 5.

2. LITERATURE SURVEY

The 3D face recognition has been approached in many ways, leading to different levels of success. Some of the common approaches for face recognition are deformable template based approach, deals with the matching of entire face, estimates the pose and occluded areas. Kakadiaris et al. [2] makes use of annotated face model that is deformed elastically to fit each face thus matching different areas such as nose, eyes, mouth.

Local region / features approach handles expression and is based on matching only parts or regions rather than matching full face. Lee et al. [3] uses the ratio of distances/Euclidean distance and angles between fiducial points followed by SVM (Support Vector Machine) classifier. Surface distance based approach also handles expression variation. It utilizes distance between points on facial surfaces to define features i.e. the geodesic distance. The open mouth problem is discussed[1].

Dirira et al. had given emphasis on the elastic models and radial curve that maximally separates the interclass variability from the intra class variability. Radial curves with the nose tip detection have tremendous potential in detecting expression, occlusion to at a great extent [1], [16]. Queirolo et al. in [4] performs 3D face recognition using Simulated Annealing (SA) for range image registration and the Surface Interpretation Measure (SIM) as the similarity score between two 3D images. The authentication score is obtained by combining SIM values which corresponds to the matching of 4 different face regions: circular and elliptical regions around the nose, forehead, and entire face region [4]. Passalis et al. uses facial symmetry to handle pose variation [14] in real world 3D face recognition where automatic landmark detection is employed which estimates poses and detects occluded parts for each face scan. This method makes use of wavelet based biometric signature as it requires only half of the face to be visible to the sensor [5].

A robust algorithm for 3D face recognition using curvelet transform is proposed in [6]. It detects the fiducial points on specific area of face by examining curvelet coefficient in each subband and builds multi-scale local surface descriptors that can capture highly distinctive rotation/displacement invariant local features around the detected keypoints. The Iterative Closest Normal Point (ICNP) [7] method is introduced to find corresponding points between the reference face and every input face. These points are marked across all faces, enabling effective application of discriminant analysis [7]. A survey of various face recognition approaches along with neural networks implementation is presented in [15].

The face recognition is either feature based using shape and position of facial features such as eyes, nose and lips or holistic using overall analysis of facial image. A comparative study of face recognition under varying expression is given in [8]. N. Erdogmus et al. gives performance comparison based on Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), and Local binary pattern (LBP) [10].

Nese Alyuz et. al [9] introduced a new technique called as masked projection for subspace analysis with incomplete data. Fully Automatic 3D face recognition with Occlusion handling is explained. [9]. Asem M. Ali [11] proposed pose invariant Face Recognition at Distant Framework (FRAD), which introduces an automatic front-end stereo-based system. Once a face is detected by one of the stereo cameras, its 15 facial features are identified using facial feature extraction model. These features are used for steering the second camera to see the same subject. This system performs various steps either in on-line mode or off-line mode and finally face recognition is performed using nearest neighbor classifier.

Face recognition with texture and attribute features [12] proposed an algorithm that computes a descriptor based on entropy of RGB-D faces along with the saliency feature obtained from a 2D face. And the attributes are extracted from the depth of the image. A recent advancement in single modal and multimodal face recognition is given in [12] that use various approaches like visual and 3D, visual and IR, visual and IR and 3D.

3. PROPOSED SYSTEM

This paper presents a framework for analysis of an individual's face, in the process dealing with various challenges of large expressions, pose variation and missing parts. The paper shows comparison between two techniques viz. Radial Curves, BPNN. The concept of matching radial curves for testing a frontal face is employed. BPNN is used as another technique used for comparison of the system in terms of complexity and efficiency. The image acquisition is the first step, after which the database is created. The system then computes the algorithm in various steps.

3.1 Preprocessing

After the database creation, the frontal face images undergo through the face normalization step. In this step the pre processing of an image takes place. Firstly the RGB image is converted to gray scale image. The preprocessing step also uses Weiner filter for the removal of noise and sharpen the edges of the image which avoids deterioration in the output. The system also uses cropping filter which crops and returns a frontal face portion of face. The system also shows a 3D pattern for corresponding face which is then used for testing.

3.2 Feature Extraction and Classifiers

Every human face has distinct features. The system extracts the features of every face image. The classifiers are used for the decision making process. The classifiers are used to distinguish the image in interclass and intraclass variability. The proposed system uses PCA, Radial Curves, BPNN, and Euclidean Distance for the same. The feature extraction step is carried out during both, Indexing phase and Recognition phase. The classifiers (based on similarity) are used only in the recognition phase to classify the output whether match found or not. The Indexing phase and Recognition phase is as shown in Fig. 2 and Fig. 3 respectively.

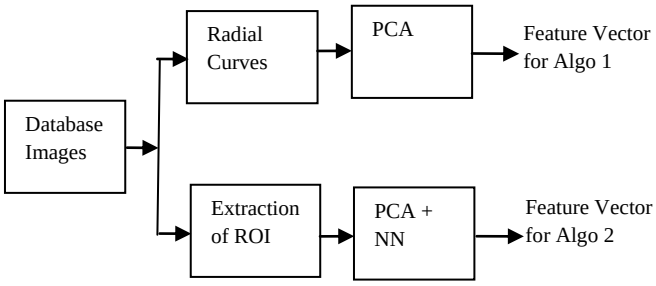

Fig. 2. Indexing Scheme for Feature Vector Creating for Proposed System

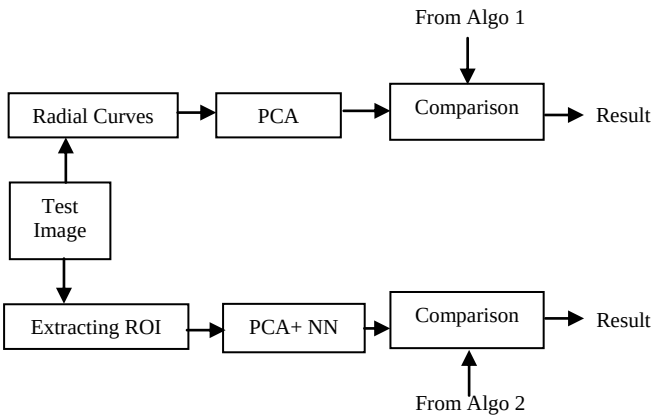

Fig. 3. Recognition Scheme for comparing Feature Vector and obtaining propbable matched result for the Proposed System

3.3 Principal Component Analysis (PCA)

PCA is generally termed as dimensionality reduction technique. PCA also reduces significant redundancies in face images. PCA represents the facial image in the form of vector called feature vector/ Eigen vector. This feature representation of image is comparably better than the original distorted images. PCA is applicable to represent the linear variations.

The goal of PCA algorithm is to capture the direction of maximum variance. The algorithm starts by capturing the variance between all images used for training and then creates a set of information in an orthogonal space which constitute of weights called principal components, i.e. "Eigenfaces". PCA is also called as Eigenface approach. These weights thus obtained become the facial features for classifiers. [17], [18]

3.4 Radial Curves

Radial Curves are the circular curves drawn on the face of every database image. These curves are drawn by taking into consideration the Iterative Closest Point [19]. The radial curves are drawn during both indexing scheme as well as in the recognition scheme. The proposed system extracts, analyses and compares the shape of radial curves. The problem of expression, pose variation, and occlusion is solved using radial curves [1]. Fig. 4 depicts the face with radial curves.

Fig. 4. Facial Image with Radial Curves

Algorithm 1:

a) The images from ORL database are taken to form database of the proposed system.

b) The proposed system draws five radial curves on every face image starting from small circular curve at the centre of the face till the end of the face.

c) The proposed system further uses PCA for feature extraction of each curve.

d) The PCA used for dimension reduction gives feature vectors for all the database images. One feature vector for each subject

e) The total number of feature vectors formed by the system is 40.

f) These vectors constitute as the database for recognition phase.

3.5 Back Propagation Neural Network (BPNN)

Back Propagation Neural Network (BPNN) is used to learn the patterns of PCA features and produce relevant client and imposter scores for verification [18]. BPNN is used to train multi-layer feed-forward Neural Network to learn a complex mapping for classification. The BPNN is designed to adapt the weights based on the corresponding error. The goal is to minimize the output error of the network. The network executes the adaptation of weights throughout the epochs until the error reaches an accepted minimum level. [18]

BPNN has an input layer, an output layer, and one or more hidden layers in between them. The training of a network by back-propagation involves three stages: the feed-forward of the input training pattern, the calculation and back-propagation of the associated error, and the adjustment of the weight and the biases [18]. The architecture of multi-layer Neural Network of the proposed system is as shown in the Fig. 5. Thus with the help of neural networks and sufficient training, the system is provided with Artificial Intelligence for face recognition.

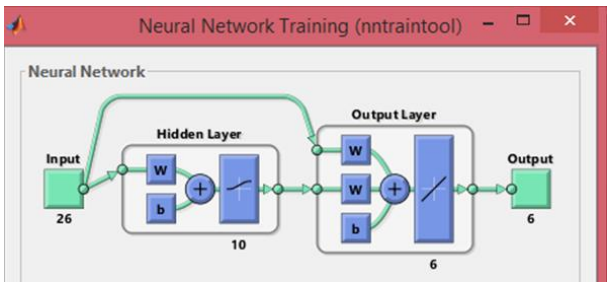

Fig. 5. Architecture of Multilayer Neural Network

Algorithm 2:

a) The images from ORL database are used for training the Neural Network.

b) The proposed system extracts region of interest like nose, eyes and lips from the database image as shown in Fig. 6

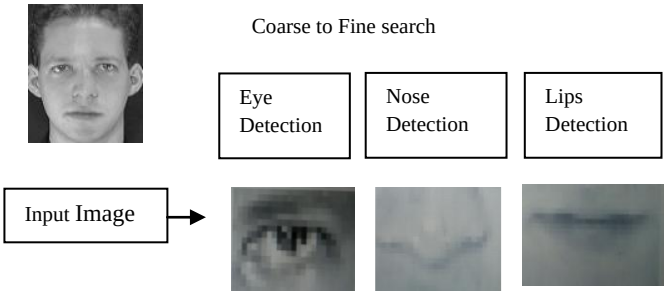

Fig. 6. Block diagram for database creation for back propagation Neural Netwroks

c) The system further uses PCA for feature extraction process.

d) The PCA gives feature Vectors for all the database images. One feature vector for each subject.

e) These images are used for training of the Neural Network.

f) These feature vectors form the database for recognition phase.

3.6 Euclidean Distance

The Euclidean Distance [18] is the most commonly used classifier for the matching of faces. Euclidean Distance between the projection of Y and the projection of the kth training sample, Xk, is commonly used for decision rule, i.e.

$$dE(Y, Xk) = . \sqrt{(Y - Xk)^T(Y - Xk)}$$

The smaller the distance between two vectors, the higher the resemblance in the images. The measure of surface distance is computed by comparing the Euclidean distance of radial curves of the all the database images with the test image. Depending on the value of Euclidean distance it is estimated that if there is any resemblance between any one pair of curves then that shows the similarity between the faces.

Based on the Euclidean Distance score the perfect match of faces will be recognized. The Proposed system shows perfect match is found only when the distance is lower than the threshold. If the distance is greater than the threshold then the proposed system shows no match found.

4. RESULT AND DISCUSSION

The proposed system is evaluated using ORL database. The ORL database contains 400 grey scale images of 40 subjects with 10 images per person. The images are taken at different times, varying illumination conditions and expressions (open/closed eyes, smiling/not smiling), varying poses (frontal view, slight left-right rotation) and facial details (glasses/ no glasses). The image size is 112x92.

All the input images are taken from the ORL database. These images are selected as database. Then one image is taken as the test image and compared with the remaining all images. First of all, the image is converted from RGB to grey. The 3D pattern of face is shown on the screen. In the next step it is passed on to radial curves and extraction of Region of Interest. Radial curves are drawn on each face emanating from the centre of the face to the end of the face in a circular manner. The feature extraction of image is done by using PCA. The output of the system showing 3D face of the input image and the testing phase with the database images using radial curves is as shown in Fig 7.

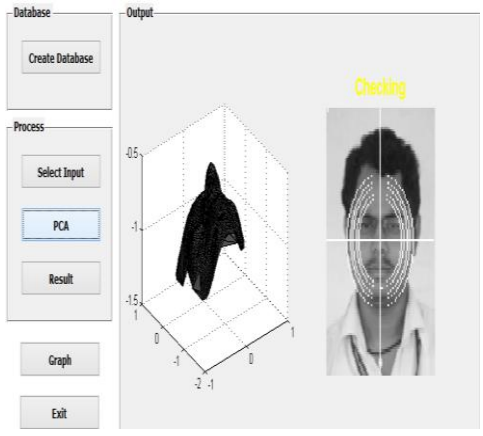

Fig. 7. A snapshot of testing phase by proposed algorithm

These radial curve features of test image are then matched with each database image features (from Algo. 1) using the Euclidean Distance. Based on the score of Euclidean Distance the probably matching faces are recognized as shown in Fig 8. The same experiments are accomplished with Neural Network based system.

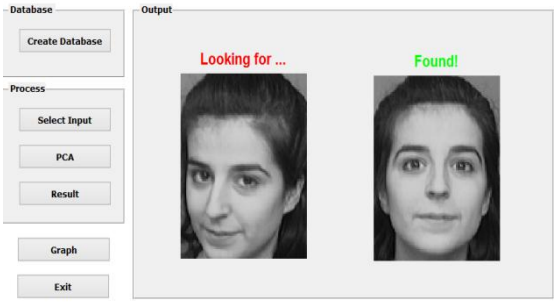

Fig. 8. A snapshot of tested facial image recognition by proposed algorithm

In case of Neural Networks the system extracts the Region of interest i.e. Nose, Eye pair and lips same as that done for the database images. The feature extraction done using PCA and the feature vector of test image is passed to the comparison block. The other input is given from the Algo. 2 as shown in Fig. 3.The perfect matching image is thus found.

The comparative result for RBC and NN is as shown in Fig. 9, which shows a graph of False Acceptance Rate (FAR) versus False Rejection Rate (FRR). The graph shows that, RBC and NN performs best at FAR =0%. The performance of system degrades with increase in FAR

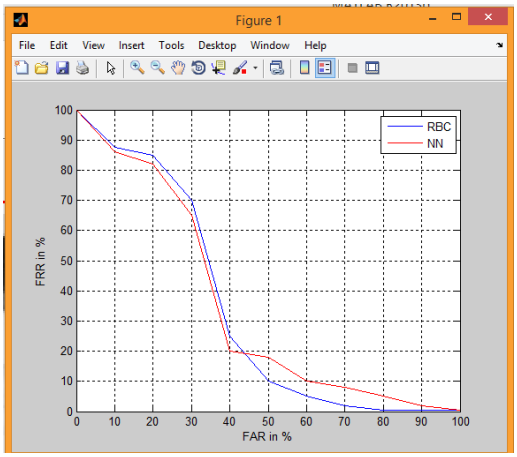

Fig. 9. A comparative graphical result for RBC and NN

The resulting recognition rate using five radial curves and BPNN obtained from the proposed system is as depicted in Table 1. The accuracy is computed by considering the test image once from the database and other time out of the database. When efficiency calculation for image from database is taken into account then 400 images of ORL database are used for training, and one out of them is used as query image. Whereas in efficiency calculation for image out of database, 320 images (8 images for each subject) are used for training and the remaining 80 images (2 images for each subject) which are not a part of database are used for testing.

The results of the work computed on Matlab shows that, by implementing Radial Basis Curves with the help of

thresholding 100% accuracy for ORL database can be acheieved. The results show that Radial Curves prove to be more efficient than the Back Propagation Neural network.

Table 1. Comparison of recognition rate for proposed system

Method	% Efficiency with image from the database	% Efficiency with image out of the database
RBC	100%	99%
BPNN	99%	87%

5. CONCLUSION

This paper presents a Radial Basis Curves Face Recognition system which can recognize the person even with expression, occlusion, pose variation, illumination and clutter. The proposed system uses PCA, and Radial curves to achieve face recognition. The complexity and dimensionality is reduced by robust PCA and radial curve results in better performance useful in real time face recognition systems. The system yields 100% recognition rate accuracy for images from ORL database.

6. REFRENCES

[1] H. Drira, B. Ben Amor, A. Srivastava, M. Daoudi, and R. Slama "3D Face Recognition under Expressions, Occlusions, and Pose Variations," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 35, no. 9, pp. 2270-2283, 2013.

[2] I.A.I. Kakadiaris, G. Passalis, G. Toderici, M.N.M. Murtuza, Y. Lu, N. Karampatziakis, and T. Theoharis, "Three-Dimensional Face Recognition in the Presence of Facial Expressions: An Annotated Deformable Model Approach," IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 29, no. 4, pp. 640-649, 2007.

[3] Y. Lee, H. Song, U. Yang, H. Shin, and K. Sohn, "Local Feature Based 3D Face Recognition," Proc. Audio- and Video-Based Biometric Person Authentication, pp. 909-918, 2005.

[4] C.C.C. Queirolo, L. Silva, O.R.O. Bellon, and M.P.M. Segundo,"3D Face Recognition Using Simulated Annealing and the Surface Interpenetration Measure," IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 32, no. 2, pp. 206-219, 2010.

[5] G. Passalis, P. Perakis, T. Theoharis, and I.A.I. Kakadiaris, "Using Facial Symmetry to Handle Pose Variations in Real-World 3D Face Recognition," IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 33, no. 10, pp. 1938-1951, 2011.

[6] S. Elaiwat, M. Bennamoun, F. Boussaid, and A. El-Sallam, "3-D Face Recognition Using Curvelet Local Features," IEEE Signal Processing Letters, vol. 21, no. 2, pp. 172-175, 2014.

[7] H. Mohammadzade and D. Hatzinakos, "Iterative Closest Normal Point for 3D Face Recognition," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 35, no. 2, pp. 381-397, 2013.

[8] D. Smeets, P. Claes, J. Hermans, D. Vandermeulen, and P. Suetens, "A Comparative Study of 3-D Face Recognition Under Expression Variations," IEEE Transactions on systems, man, and cybernetics—part c: applications and reviews, vol. 42, no. 5, pp. 710-727, 2012.

[9] N. Alyuz, B. Gokberk, and L. Akarun, "3-D Face Recognition Under Occlusion Using Masked Projection," IEEE Transactions on Information Forensics and Security, vol.8, no.5, pp. 789-802, 2013.

[10] N. Erdogmus and J-L. Dugelay, "3D Assisted Face Recognition: Dealing With Expression Variations," IEEE Transactions on Information Forensics and Security, vol. 9, no. 5, pp. 826-838, 2014.

[11] A. M. Ali, "A 3D-Based Pose Invariant Face Recognition at a Distance Framework," IEEE Transactions on Information Forensics and Security, vol. 9, no. 12, pp. 2158-2169, 2014.

[12] G. Goswami, M. Vasta, and R. Singh, "RGB-D Face Recognition with Texture and Attribute Features," IEEE Transactions on Information Forensics and Security, vol. 9., no.10, pp. 1629-1640, 2014.

[13] R.Min, N. Kose, and J.Dugelay, "KinectFaceDB: A Kinect Database for Face Recognition," IEEE Transactions on Systems, Man, and Cybernetics: Systems, vol. 44, no. 11, pp. 1534-1548, 2014.

[14] U. prabhu, J. Heo, and M. Savvides, "Unconstrained Pose-invariant Face Recognition Using 3D Generic Elastic Models," IEEE Transactions on pattern Analysis and Machine Intelligence, vol. 33, no. 10, pp. 1952-1961, 2011.

[15] C.H. Li and I. Gondra, "A Novel Neural Network-Based Approach for Multiple Instance Learning," IEEE International Conference on Computer and Information Technology (CIT 2010), pp. 451-456, 2010.

[16] H. Zhou, A. Mian, L. Wei, D. Creighton, M. Hossny, and S. Nahavandi, "Recent Advances on Singlemodal and Multimodal Face Recognition: A Survey," IEEE Transactions On Human-Machine Systems, vol. 44, no. 6, pp. 701-716, 2014.

[17] Y. Woo, C. Yi, and Y. Yi, "FAST PCA-BASED FACE RECOGNITION ON GPUS," IEEE International Conference on Acoustic, Speech and Signal Processing (ICASSP 2013), pp. 2659-2663, 2013.

[18] L.-H. Chan, S.-H. Salleh, C.-M. Ting, and A.K. Ariff, "PCA and LDA-Based Face Verification Using Back-Propagation Neural Network," IEEE 10th International Conference on Information Science, Signal Processing and their Applications (ISSPA 2010), pp. 728-732, 2010.

[19] J. Yang, H. Li, and Y. Jia, "Go-ICP:Solving 3D Registration Efficiently and Globally Optimally ," IEEE International Conference on Computer - Vision, pp. 1457-1464, 2013.