I.J. Image, Graphics and Signal Processing, **2021, 6, 23-29**
Published Online December 2021 in MECS (http://www.mecs-press.org/)
DOI: 10.5815/ijigsp.2021.06.03

Face Recognition System based on Convolution Neural Networks

Htwe Pa Pa Win
University of Computer Studies, Hpa-an
Email: hppwucsy@gmail.com

Phyo Thu Thu Khine
University of Computer Studies, Hpa-an
Email: phyothuthukhine@gmail.com

Khin Nwe Ni Tun
University of Information Technology, Yangon
Email: knntun@gmail.com

Received: 05 November 2020; Revised: 26 March 2021; Accepted: 07 May 2021; Published: 08 December 2021

Abstract: Face Recognition plays a major role in the new modern information technology era for security purposes in biometric modalities and has still various challenges in many applications of computer vision systems. Consequently, it is a hot topic research area for both industrial and academic environments and was developed with many innovative ideas to improve accuracy and robustness. Therefore, this paper proposes a recognition system for facial images by using Deep learning strategies to detect a face, extract features, and recognize. The standard facial dataset, FEI is used to prove the effectiveness of the proposed system and compare it with the other previous research works, and the experiments are carried out for different detection methods. The results show that the improved accuracy and reduce time complexity can provide from this system, which is the advantage of the Convolution Neural Network (CNN) than other some of the previous works.

Index Terms: Biometric Modalities, Computer Vision, Convolution Neural Network, Deep Learning, Face Recognition, FEI

1. Introduction

Face recognition is biometric technology, which is used to identify or verify a person to connect their indexed data. This technology is applied for many applications such as law enforcement agencies, access control for secure login processes, border control, social and economic strengthen the application of the citizens, healthcare, and banking [1]. With this ongoing digital society, popular technology corporations and businesses around the world are generating the recognition systems of the face. Due to the increasing market trends and the essential requirements of the commercial applications, the competition of delivering the best performance among these companies emerges. The success technology inventors such as Microsoft, Apple, IBM, and Google are struggling to win at face recognition methods [2].

Therefore, face recognition is an active and hot spot research area in combination with neural networks (NN), human-computer interface (HCI), computer graphics (CG), and psychology methods. The existing recognition systems are the advantages of the previous encouragement to the industry and academia researchers. However, these systems have weaknesses and challenges in some conditions of the real-world unconstrained environments for many reasons such as pose variation, illumination, expression, aging, plastic surgery, low resolution and occlusion. Therefore, many types of research have been done to facilitate any environments and conditions by using different approaches and techniques [3].

In recent years, deep learning has become popular and much research for face recognition has started to move from normal traditional techniques to advanced deep learning methods such as DeepFace, FaceNet, and ResNet. Feature extraction and collection of the face part images can be processed using the deep structures of CNN for solving problems of face recognition [4, 5]. However, deep CNN based methods have much diversity among the implementation settings to get the best performance. Although there is the same method, the effectiveness of the system cannot be confirmed and related ideas in each step [6].

Therefore, this paper proposed a face recognition system using the deep learning-based method to detect and classified to improve the robustness and accuracy of the development. The rest of the paper is planned as follows; section 2 discusses the previous works for the face image recognition systems in different technologies and implementation ideas. Section 3 describes the detail of the proposed system. Section 4 presents the experimental works and results for the proposed system and other systems to compare and analyses. The research work would be concluded in section 5.

2. Related Works

Although there is much previous recognition system for faces, three categories of analyses would be made in this section; some of the systems that used various methods, some of the systems that used CNNs, and some of the systems which have been evaluated on FEI dataset.

The researchers in [7] propose face image recognition methods using discrete complex fuzzy transform (DCFT) and local binary pattern (LBP). They also used maximum pooling technology to create the feature fusion method. They used 5 facial datasets to prove the effectiveness of their proposed method and tested using SVM and KNN classifiers.

The authors in [8] examined extensive works for face recognition development in the recent era. They described the techniques for face recognition in detail including various datasets. They analyzed the datasets including benchmark accuracy results and specific information. The various techniques for face detection are also studied and discussed. The availability of recognition methods is described in precisely and debate for those approaches. Finally, their works are concluded with the list of the previous works are described in the table.

The authors in [9] proposed a new approach for recognition of the faces using Bayesian Neural Networks recognizers. They extract face information for identification using Gray Level Co-occurrence Matrix. They used the ORL database to the MLP of one hidden layer that has 10 hidden neurons. The input is 6 and the output has 40 neurons. They used the SoftMax function for output units. They get the 81.23 % for the classification test.

The researchers in [10] proposed a technique to detect and recognition of the face using image processing methods. They detect faces using MatLab toolbox and PCA features are used. They assumed about 90% as the classification accuracy would get.

The combination features of spatial domain and transformation domain are invented in [11]. They extract the face using popular Viola Jones Algorithm and scaled to 100x100 size. Then spatial feature is extracted using Asymmetric Region Local Binary Pattern (ARLBP) and transformation features are extracted using Fast Discrete Curvelet Transform (FDCT). Then these two features are concatenated to classify the input image against the trained images. They tested for JAFFE, L-Space k, FERET and NIR databases and get a recognition rate between 76.8 % to 95.48 %.

After the recent various face recognition system based on different implementation methods have been analyzed, the different CNNs based methods are started to discuss. The author in [12] worked extensive reviews for deep learning face recognition system.

The deep deep neural network based on CNNs has been proposed in [13]. They used the whole pixel data as the input image and using Yale faces dataset to test the system with a 9:1 ratio and achieved 97.05%. They used 4 layers and the results are produced using 50 epochs.

The systematic evolution for face recognition using deep learning is summarized in [6]. They made a comprehensive evolution rather than a normal survey among the DCNN implementation diversities. They used the combination of CASIA-WebFace and UMD-Faces named UMD-CASIA as the 90% training and 10% validation set. They created YTF, CACD-VS, LFW, and CFP datasets are as the testing set. They used MTCNN as the face detector and analyzed for all criteria of CNN including batch normalization, feature normalization, downsample, and SE block. They tested on ResNet-50, Face-ResNet, Google-Net, and VGG-16 networks for all datasets and evaluate the results. They showed that ResNet-50 provides the best results among the DCNN.

The system for face recognition base on CNN is proposed in [14] where they applied the Dropout idea to scale the activation values. They use 20,000 face images of private university datasets called SWUNs which are taken from 50 peoples. They normalize the face image into 32x32 gray images to input deep CNN and get 98.8% for recognition. They showed that the scaling of the activation values for training and testing can improve the classification results.

The face recognition system using the CNN model is developed by [15] by improving the CNN criteria. They used 600 faces of Chinese actresses dataset with a size of 160x120 and obtain 79.41% and improve about 11% from the basic classification. They selected a 3x3 kernel for the first two layers and used 32 filters for each layer. They experimented with various model layers, dropout value, activation function, and optimization algorithm and described detailed results separately.

The CNN design for real-time recognition for face is designed and evaluated in [16]. They used Keras library and used a combination of CONV with RELU layers. The faces are detected using the Viola-Jones algorithm and normalized into 120x120 and 32 filters for each layer. The output of the RELU is set to the POOL layer and then pass to DROPOUT. Then pass again to the 40x1 DENSE/FC for classification. They used an AT&T dataset of 40 individuals, which has 400 images, and 320 images are used for training, and 80 are used for testing and obtained 98.75% accuracy.

The lightweight CNN face recognition model for student monitoring system have been proposed in [17]. They used MTCNN face detector and enhance the image such as rotation, lightening, and noise addition at the preprocessing stage. Then the CNN model is used to extract features and 2 FC layers are used for classification. The target system is to use in learning management system (LMS) and tested for their student dataset, Yale, AT & T, and Labeled Face in the Wild (LFW) datasets. They achieved recognition rates between 99.63 to 100% with 150 epochs and 20% for testing and 80 % for training.

The rest works in [18] to [22] are the previous works that are evaluated based on the FEI dataset.

The group in [18] proposed a face recognition system using Gabor Filter and PCA for feature extraction. They tested using FEI and MUCT datasets. For the FEI dataset, only the 11th image of each individual from 200 people is used as the training set and the other 13 images are used as the testing set. They obtained 53.76%, 77.83%, and 87.43% for SVM, KNN, and their proposed classification method based on multi-distance respectively.

The face recognition using Deep CNN has been done in [19]. They detect face using histograms of oriented gradient (HOG) detector and improve the system architecture for template protection. They extract 4096 features using pre-trained VGG-Face CNN. The first 15 layers are used as weights to comprise 13 convolution layers and fully connected layers. They tested on various datasets namely FEI, CMU-PIE, and color FERET to evaluate their method. For the FEI dataset, only 9 images of each individual are used and 4 images act as the trainer and the remaining 5 images are as the tester. They obtained 99.1% accuracy for verification of the FEI dataset using CNN.

The face template protection using a hash function is developed in [20]. They use Multi-task CNN to detect and align faces, the simplest color balance and gamma correction are used to reduce illumination. They obtain 98.90± 0.14% for verification of the FEI dataset using their proposed hash function.

The recognition system using a greedy-based method is created in [21] where they designed to reduce the elapsed time and improve accuracy. Their experiments are carried out on FEI and ORL datasets. The images are divided into patches and combine again into patch sequences and then match using the greedy based algorithm by finding the distances. They evaluate two methods DWT and their greedy method where they obtain 94.5% and 96% respectively.

The real-time system to detect and recognize the face was implemented in [22] using local binary patterns histograms (LBPH) and CNN. They used FEI and ORL datasets for experimental results and split 50% for training and 50% for testing. They used the Haar-Cascade classifier to detect face and extracted features and recognize using the LBPH algorithm. They obtained 70.5% for accuracy and continue the testing using CNN architectures and recommend CNN performed than their proposed LBPH algorithms.

Finally, the comprehensive review for face recognition methods has been done in [23] by considering the factors that can affect the recognition accuracy. Therefore, this paper proposed a face recognition system to get a high accuracy result by considering the above factors based on deep learning and CNN.

3. System Design

The design of the proposed Face Recognition, FR system includes pre-processing, feature extraction, and recognition.

3.1. Pre-processing

The pre-processing of face recognition includes face detection and normalization. The face is detected from the input image using the Dlib method. Although, there are many popular face detectors, this system implemented using three detectors to analyze the most effective detection method for the proposed system.

Haar detector is based on the first method of the face detection algorithm, the Viola-Jones algorithm, and the Haar Wavelet method. It uses the Ada-boost machine learning algorithm to train cascade function from a lot of images to identify the face. The kernels haar features are created from the pixels value of the rectangles by integration. These features of the weighted intensity difference are classified using the cascading method to detect face from the input image. The boosting method is used to find the highly accurate hypothesis.

Dlib library is a popular, open-source, face recognition method, which is based on Histogram of Oriented Gradients (HOG) features and linear SVM classifier is used to determine where the face is in a determined region or not.

Multi-Task Cascaded Convolutional Neural Network (MTCNN) is the combination technique to detect face and align in a multi-task function. It consists of three stages; P-Net, R-Net, and O-Net to detect a face.

3.2. Feature Extraction

The size of the normalized input face images is 224x224. These images are put to the CNN model which is made up of 10 layers and the detailed structure is shown in Fig 1. The first convolution layers have 2 sub-layers with shape 224x224x64, the second convolution has also 2 with shape 112x112x128, but remaining convolution has 3 layers with shapes 56x56x256, 28x28x512, and 14x14x512 respectively in serial.

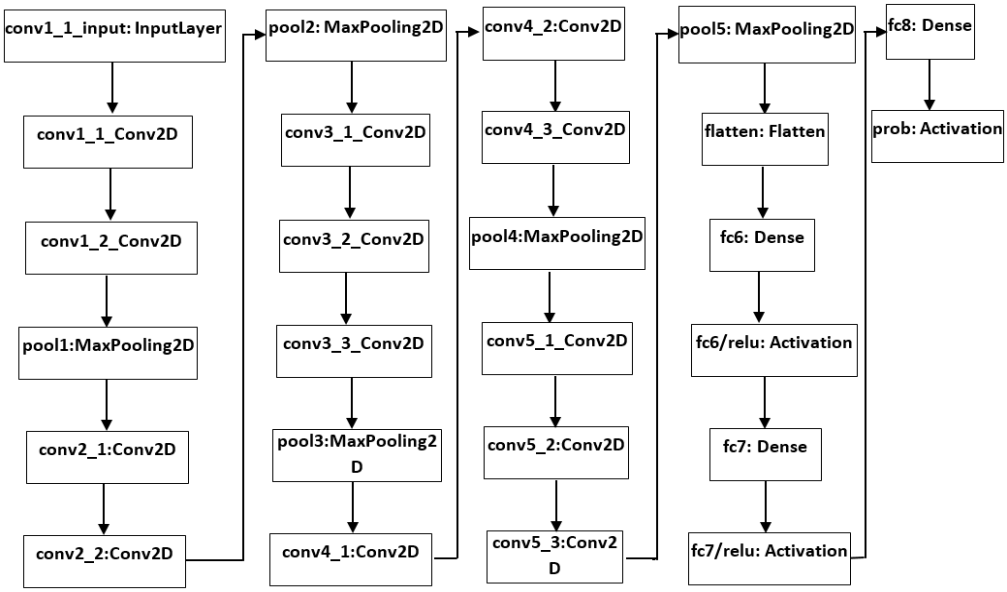

Fig.1. The structure of CNN feature extraction block

3.3. Recognition

The recognizing process to classify CNN features is done using an instance-based K Neighbour classifier. It is simple and predicts faster another classifier, uses Euclidean distance to find the nearest labels.

4. Experimental Results

4.1. Database Description

The FEI face dataset is a database of the Brazilian faces that contains an image set of faces taken in 2005 at the AI Laboratory of FEI in Brazil. The 14 images of each individual are taken for 200 people including staff and students, and so there are 2800 images in total. These images are color and taken on a homogenous background in various pose between 180 degrees with size 640x480 pixels. The people consist of equally 100 for both males and females. The sample images of the FEI dataset are described in Fig 2 with the sample description of the split between train and test for 28.57 % and 71.43% of the original set respectively.

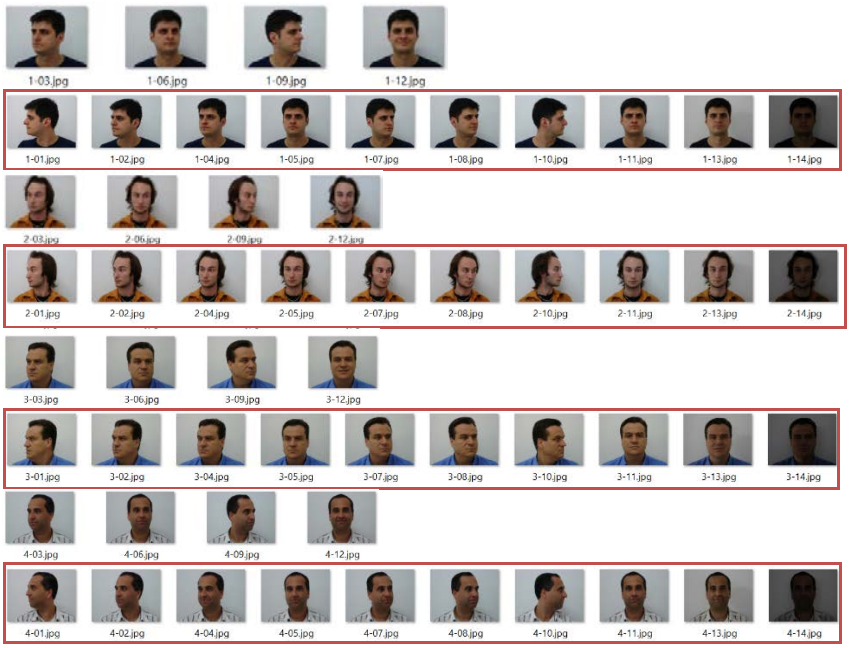

Fig.2. Sample images of the FEI dataset

4.2. Results

Firstly, the original input images are preprocessed to detect face using OpenCV harr cascade detector with the scale factor 1.2 with frontal face default weight. It cannot truly detect some of the faces and produce an error as shown in Fig 3 (b). Then the images are preprocessed with the dlib detector with default frontal face and MTCNN detector, and the output of the faces is normalized into 224x224 and depicted in Fig 3 (c) and (d). Dlib can detect faces truly than the harr detector and the mtcnn can detect the better.

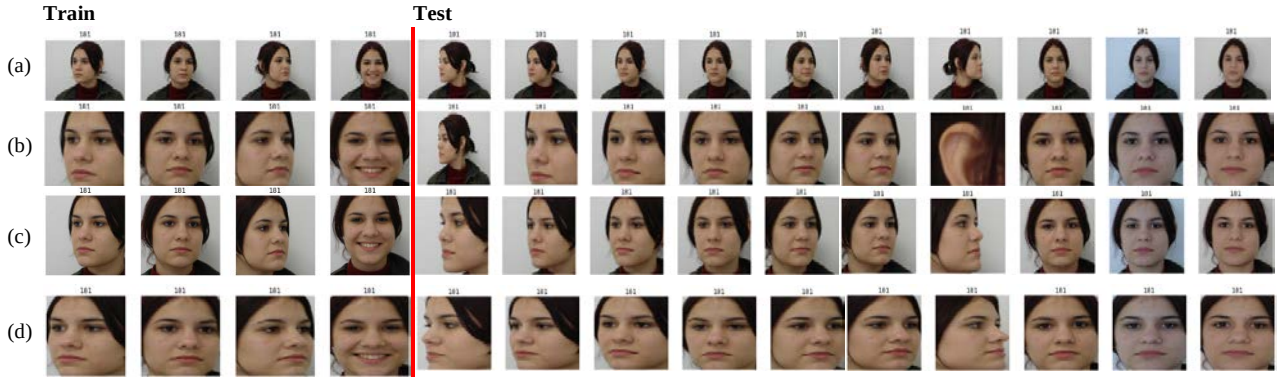

Fig 3. Different detectors results for sample image for both train and test: (a) Original images, (b) OpenCV Harr, (c) Dlib, (d) MTCNN

After the detector, the faces, the output of the preprocessing are ready to extract CNN features and recognize with the KNN neighbors for the class label and the accuracy of the systems are analyzed. The experiments are carried out on Intel core i7, 1.8 GHz, 8 GB Ram for recognition of each detector method. The detailed accuracy results and the time-taken are described in Table 1.

Table 1. Recognition results for different detectors

Method	Accuracy	Time (s)
OpenCV harr	0.7260	1112.83
Dlib	0.8515	945.86
Mtcnn	0.8680	2084.12

As can be seen from Table 1, although, the Mtcnn detector can produce better accuracy results, the time taken to detect is more than 2 times. Then the experiments are continued to find the exact results by converting the train and test set reversed. However, the results for reversed train and test set are increased accuracy for Dlib detector, and the time for MTCNN is still extremely large as shown in Table 2.

Table 2. Comparison between Dlib and MTCNN results

Method	Accuracy	Time (s)
Dlib	0.9988	908.13
Mtcnn	0.9962	2059.22

Finally, the experiments carry on to compare other existing works by preparing the same set for training and test set for each previously developed system. The reason for that be the previous works used various amount of training set and test set and produced the results. To compare the work in [18], the training set and test set are prepared for the proposed system as the same in that system and the results are produced. And the same producers have been done to compare other systems. As some of the system cannot be described the elapsed time and illustrated as (-), and cannot be compared with the proposed system. The detailed comparison with the previous works is described in Table 3.

Table 3. Comparison with the other existing works

Paper	**Method**	**Split set for Train and Test**	**Accuracy (%)**	**Time (s)**
[18] 2017	SVM	The 11th image of all the 200 people is considered for the training set and the remaining 13 images used as test set.	53.76	-
	KNN		77.83	-
	Multidistance		87.43	-
Proposed System			86.00	1014.02
[19] 2018	Deep CNN	9 poses (p03, p04, p05, p06, p07, p08, p11, p12, p13), 4 image randomly choose for train, the rest 5 are used for test	99.10	-
[20] 2020	hashing function		98.90±0.14%	-
Proposed System			99.10	583.51

[21] 2019	DTW	200 neural images are used for training and 200 smiling images are used for testing	94.5	2560.9
	greedy based warping		96	43.91
Proposed System			1.00	99.70
[22] 2020	LBPH	50% for training and 50% for testing	70.5	-
Proposed System			84.29	847.83

According to the result from Table 3, the proposed system can provide better accuracy and less time than all the previous systems except only for the multidistance approach in [18] which can perform more than about 1%.

5. Conclusion

This paper proposes Face Recognition, FR system based on deep learning of CNN architecture. The empirical evolution is carried out for face detection techniques and prepared various sets for the environments with the same of the other works. The results prove the success of the proposed structural architecture. The better performance for static images and extension for real-time and video recognition is the future works of us. The research works on this topic remain as hot as the essential requirements of this technology era.

References

[1] I. Berle, Face Recognition Technology, Law, Governance and Technology Series 41, https://doi.org/10.1007/978-3-030-36887-6_5

[2] Ali, W., Tian, W., Din, S.U. et al. Classical and modern face recognition approaches: a complete review. Multimed Tools Appl (2020). https://doi.org/10.1007/s11042-020-09850-1

[3] Oloyede, M.O., Hancke, G.P. & Myburgh, H.C. A review on face recognition systems: recent approaches and challenges. Multimed Tools Appl 79, 27891–27922 (2020). https://doi.org/10.1007/s11042-020-09261-2

[4] Chen H. et al. (2020) Research on Face Recognition Algorithms Based on Deep Convolution Generative Adversarial Networks. In: Wang Y., Fu M., Xu L., Zou J. (eds) Signal and Information Processing, Networking and Computers. Lecture Notes in Electrical Engineering, vol 628. Springer, Singapore. https://doi.org/10.1007/978-981-15-4163-6_13

[5] Selitskaya N. et al. (2020) Deep Learning for Biometric Face Recognition: Experimental Study on Benchmark Data Sets. In: Jiang R., Li CT., Crookes D., Meng W., Rosenberger C. (eds) Deep Biometrics. Unsupervised and Semi-Supervised Learning. Springer, Cham. https://doi.org/10.1007/978-3-030-32583-1_5

[6] Mingyu You, Xuan Han, Yangliu Xu, Li Li, Systematic evaluation of deep face recognition methods, Neurocomputing, Volume 388, 2020, Pages 144-156, ISSN 0925-2312, https://doi.org/10.1016/j.neucom.2020.01.023.

[7] Turker Tuncer, Sengul Dogan, Erhan Akbal, " Discrete Complex Fuzzy Transform based Face Image Recognition Method", International Journal of Image, Graphics and Signal Processing, Vol.11, No.4, pp. 1-7, 2019.

[8] Umarani Jayaraman, Phalguni Gupta, Sandesh Gupta, Geetika Arora, Kamlesh Tiwari, Recent development in face recognition, Neurocomputing, Volume 408, 2020, Pages 231-245, ISSN 0925-2312, https://doi.org/10.1016/j.neucom.2019.08.110.

[9] E. H. Hssayni and M. Ettaouil, "New Approach to Face Recognition Using Co-occurrence Matrix and Bayesian Neural Networks," 2020 IEEE 6th International Conference on Optimization and Applications (ICOA), Beni Mellal, Morocco, 2020, pp. 1-5, doi: 10.1109/ICOA49421.2020.9094501.

[10] G. Singh and A. K. Goel, "Face Detection and Recognition System using Digital Image Processing," 2020 2nd International Conference on Innovative Mechanisms for Industry Applications (ICIMIA), Bangalore, India, 2020, pp. 348-352, doi: 10.1109/ICIMIA48430.2020.9074838.

[11] Raveendra K, Ravi J, "Performance Evaluation of Face Recognition system by Concatenation of Spatial and Transformation Domain Features", International Journal of Computer Network and Information Security, Vol.13, No.1, pp.47-60, 2021.

[12] Chaudhuri A. (2020) Deep Learning Models for Face Recognition: A Comparative Analysis. In: Jiang R., Li CT., Crookes D., Meng W., Rosenberger C. (eds) Deep Biometrics. Unsupervised and Semi-Supervised Learning. Springer, Cham. https://doi.org/10.1007/978-3-030-32583-1_6

[13] Priya Gupta, Nidhi Saxena, Meetika Sharma, Jagriti Tripathi,"Deep Neural Network for Human Face Recognition", International Journal of Engineering and Manufacturing, Vol.8, No.1, pp.63-71, 2018.

[14] X. Ruan, C. Tian and W. Xiang, "Research on Face Recognition Based on Improved Dropout Algorithm," 2020 IEEE 5th Information Technology and Mechatronics Engineering Conference (ITOEC), Chongqing, China, 2020, pp. 700-703, doi: 10.1109/ITOEC49072.2020.9141891.

[15] D. Wang, H. Yu, D. Wang and G. Li, "Face Recognition System Based on CNN," 2020 International Conference on Computer Information and Big Data Applications (CIBDA), Guiyang, China, 2020, pp. 470-473, doi: 10.1109/CIBDA50819.2020.00111.

[16] Pranav K B, Manikandan J, Design and Evaluation of a Real-Time Face Recognition System using Convolutional Neural Networks, Procedia Computer Science, Volume 171, 2020, Pages 1651-1659, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2020.04.177.

[17] Duong Thang Long, " A Lightweight Face Recognition Model Using Convolutional Neural Network for Monitoring Students in E-Learning", International Journal of Modern Education and Computer Science, Vol.12, No.6, pp. 16-28, 2020.

[18] B. Belavadi, G. Sanjay, K. V. Mahendra Prashanth and J. Shruthi, "Gabor Features for Single Sample Face Recognition on Multicolor Space Domain," 2017 International Conference on Recent Advances in Electronics and Communication Technology (ICRAECT), Bangalore, 2017, pp. 211-215, doi: 10.1109/ICRAECT.2017.23.
[19] A. K. Jindal, S. Chalamala and S. K. Jami, "Face Template Protection Using Deep Convolutional Neural Network," 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), Salt Lake City, UT, 2018, pp. 575-5758, doi: 10.1109/CVPRW.2018.00087.
[20] T. M. Dang, L. Tran, T. D. Nguyen and D. Choi, "FEHash: Full Entropy Hash for Face Template Protection," 2020 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), Seattle, WA, USA, 2020, pp. 3527-3536, doi: 10.1109/CVPRW50498.2020.00413.
[21] B. Krishnaveni and S. Sridhar, "Face Recognition using a greedy based warping algorithm," 2019 11th International Conference on Advanced Computing (ICoAC), Chennai, India, 2019, pp. 253-258, doi: 10.1109/ICoAC48765.2019.247133.
[22] M. S. I. Sameem, T. Qasim and K. Bakhat, "Real time recognition of human faces," 2016 International Conference on Open Source Systems & Technologies (ICOSST), Lahore, 2016, pp. 62-65, doi: 10.1109/ICOSST.2016.7838578.
[23] Anwarul S., Dahiya S. (2020) A Comprehensive Review on Face Recognition Methods and Factors Affecting Facial Recognition Accuracy. In: Singh P., Kar A., Singh Y., Kolekar M., Tanwar S. (eds) Proceedings of ICRIC 2019. Lecture Notes in Electrical Engineering, vol 597. Springer, Cham. https://doi.org/10.1007/978-3-030-29407-6_36

Authors' Profiles

Htwe Pa Pa Win received her Ph.D (IT) from University of Computer Studies, Yangon, Myanmar in 2012. She is currently working as a Lecturer at the University of Computer Studies, Hpa-an, Myanmar. Her research interests include Image Processing, Speech processing and Digital Signal processing.

Phyo Thu Thu Khine received her Ph.D (IT) from University of Computer Studies, Yangon, Myanmar in 2012. She is currently working as a Lecturer at the University of Computer Studies, Hpa-an, Myanmar. Her research interests include Image Processing, Speech processing, Digital Signal processing, Database Management System and Big Data.

Khin Nwe Ni Tun is a professor of Information Science Department, University of Information Technology, Yangon, Myanmar. Her research interests include Image Processing, Database Management System, Big Data, Data Mining and Web Mining.

How to cite this paper: Htwe Pa Pa Win, Phyo Thu Thu Khine, Khin Nwe Ni Tun, " Face Recognition System based on Convolution Neural Networks", International Journal of Image, Graphics and Signal Processing(IJIGSP), Vol.13, No.6, pp. 23-29, 2021.DOI: 10.5815/ijigsp.2021.06.03