IJCSE International Journal of Computer Sciences and Engineering Open Access
Survey Paper Vol.-7, Issue-6, June 2019 E-ISSN: 2347-2693

Face Recognition Process: A Survey

Kavita Lodhi[1*], Vandan Tewari[2], Priyanka Bamne[3]

[1,2,3]Department of Computer Engineering, S.G.S.I.T.S. Indore (M.P.), India

[*]*Corresponding Author: kavitalodhi543@gmail.com*

DOI: https://doi.org/10.26438/ijcse/v7i6.9991005 | Available online at: www.ijcseonline.org

Accepted: 08/Jun/2019, Published: 30/Jun/2019

Abstract— Image identification plays an important role in various domains such as in bio-metrics for identification of a person, medical image processing, law enforcement and commercial application. In the field of bio-metrics, there are many reliable identification methods such as fingerprint, retina, iris scan and Face Recognition. These methods requires user cooperation whereas Face Recognition can work without user cooperation by taking image from camera. Face Recognition is a two step process, involving face detection and then recognition. In Face Detection process, face is located in a digital image or in a frame of video and in the Recognition process system identifies the face's identity on the basis of stored images. For the Face Recognition various techniques are available such as Principal Component Analysis, Local Binary Pattern, Independent Component Analysis and many deep learning based techniques FaceNet, FaceID, DeepFace etc. These techniques have their own advantages and disadvantages for example many techniques suffer from head rotation, pose, makeup, hair style and image quality. In this paper, we present a review of the previous work done in this field. Also discussion about the process of recognition, preprocessing for Face Recognition techniques, classification of face detection and recognition techniques and an analysis of existing work has been presented.

Keywords— Face Recognition, Face Detection, Deep learning, Image pre-processing, Bio-metrics, Principal Component Analysis.

I. INTRODUCTION

Human faces are a way of recognition for human interaction while machines or robots interact with people by means of some identification credentials. Based on certain credentials, users are identified and permitted or granted access rights. If these identification credentials are stolen by someone, it posses a threat to security of system. In this situation, machine will allow access to a person on the basis of identification credentials, without authenticating his/her validity. This problem of masqueraded users or stolen identities can be solved using Face Recognition techniques. Face Recognition Technology allows a person, who is authorized, an access to machine for interact with it. In robotics, bio-metrics and commercial applications, Face Recognition Technology plays crucial role.

In robotics, robots are provided with Face Recognition Techniques so that they can identify people and can interact with them. Real example is sophia humanoid robot, created by David Hanson, founder and CEO of Hanson Robotics. Sophia robot is provided Face Recognition Technology in her eyes to recognize people. In the field of bio-metrics it can be used in authentication. Many security applications based on it are commercially available and government is also using it in the criminal's video surveillance and patrol controlling. As use of this technology is growing in various described fields so the researchers are also making focus on that.

Face Recognition Process generally involves two stages:

Face Detection: Locating the faces in image by means of some specific patterns of face.

Face Recognition: Where that detected face is compared to the stored images of known faces, to decide the identity of face. Comparison is made on the facial feature extracted and stored in database for matching with incoming test image's facial feature.

Nowadays deep learning is playing important role in face recognition technology. There is some brief introduction of deep learning:
Deep learning is deeper version of Artificial Neural Network. It is sub field of machine learning in artificial intelligence. Machine learning provides machines to perform human activities such as watching, listening, making decision, object detection, speech recognition, natural language processing and face recognition. Deep learning makes use of huge amount of data and graphical processing unit to train a deep neural network.

Artificial Intelligence :

AI is the branch of computer science that emphasizes the creation of intelligent machine. Artificial Intelligence provide a machine to mimic the intelligence of humans. For which it uses machine learning technology, in which machine is said to be learning if it improves the performance in terms of number of examples that are provided to learning.

Machine learning :

Machine learning is the study of mathematical models and algorithms used by machines to improve their performance on a specific task. Machine learning is broadly classified in following categories:

Supervised learning : In supervised learning, machine learning algorithms build mathematical models by using the set of data containing both inputs and desired outputs. This data is known as training data. It learns from examples. Supervised algorithms include classification and regression.

Unsupervised learning : In unsupervised learning, machine learning algorithms build mathematical models by using the set of data containing only inputs and no desired outputs are available. Unsupervised learning algorithms include clustering and density estimation.

Artificial Neural Network is one of machine learning techniques uses supervised feature learning, in which features are learned using labeled input data. ANN is also known as connectionist system, inspired by the biological neural network that constitute the human brain. The neural network is not a algorithm, it is a framework for machine learning algorithms to work on complex data.
This survey paper is organized in six sections. Below is the brief description of the contents of each section.

Section I Introduction, gives an overview of problem description and proposed solution. Section II Motivation, explain the need and requirement of face recognition. Section III, Literature Review, briefly describes related work done by various researchers in the area of face recognition and the problems identified in their work. Section IV Face Recognition process steps, describes the each step of face recognition process. Section V classification of face detection and recognition algorithms, classifies the algorithms in respective categories. Section VI detail explanation of one face detection and recognition algorithm. Section VII Conclusion, concludes the dissertation along with the limitations of the proposed approach, possible future enhancements.

II. MOTIVATION

As in conventional access methods having pin, password and ids for authentication, the problem of masqueraded users or stolen identities can be solved using Face Recognition techniques. Also, in the field of law enforcement, this can be used for observing the activities of criminals and offenders without their knowledge in passive mode. It also provides automation to interact with computers and robots. Face recognition combining with other security measures can give better security. These applications motivated us to study about it to improve its performance.

III. LITERATURE REVIEW

Previous researches outlined in this section, has been done in the areas of face recognition, password security and pattern recognition. All the past studies reviewed below are motivated towards improving face recognition accuracy.

The very first work on face recognition was seen in 1950s in psychology [1] and then in the engineering literature in 1960s [2]. The earliest studies included on facial expression emotions by Darwin [3]. But research on automatic faces recognition by machine started in the 1970[4].

In the history of face recognition first semi-automated face recognition system was made by woodrow wilson bledsoe who was a computer scientist, a mathematician and one of the founders of artificial intelligence worked on pattern recognition. In 1964 bledsoe, helen chan wolf and charles bisson made a computer to recognize human faces under US government's Contract. For recognition user should have to mark certain landmarks on face in image such as corners of eyes, mouth and nose. After that system computes distances and made use for recognition. As user should had to provide marks on face image it is called semi-automated system. This system suffered from the variation in head orientation, scale, lighting intensity and angle [5].

In the 1970s, Goldstein, Harmon, and Lesk made a system which was also semi-automated but more accurate. Accuracy increased due to addition of some specific mark on face such as thickness of lips and hair color. Same as Bledsoe's system, Goldstein's system also was man-machine system [6].

In 1987 at Brown University, Sirovich and Kirby pioneered the eigenface approach based on linear algebra. Sirovich and Kirby performed feature analysis on a collection of facial images to generate a set of basic features. These basic features are the principal component of face and required only few numbers of values to represent a face image [7].

In 1991, the work on eigenface was expanded by Turk and Pentland and used this approach in face detection and recognition. As face detection and recognition performed by system so this was called fully automatic face recognition system. Noisy images and partially occluded faces degrade the gracefulness of system [8].

Local Binary Pattern extract the relevant facial feature and provide powerful feature for texture classification. Local Binary Pattern combined with the Histogram of oriented gradients (HOG) descriptor provide better performance on same data-sets [9].

The Defence Advanced Research Projects Agency (DARPA) and the National Institute of Standards and Technology (NIST) started the Face Recognition Technology (FERET) program in beginning of 1990s. The goals of program were sponsoring research, collecting FERET database and evaluation of algorithms. This provides a standard database to evaluate algorithms and to make comparison in order to provide directions for future research and encourage the commercial face recognition market. FERET database was collected in 15 sessions from 1993 to 1996. The objective was to motivate the development of face recognition algorithms and creating an standard database for evaluation.

In the early 2000s the NIST again started a program called Face Recognition Vendor Tests (FRVT) program. Building on FERET, FRVTs were designed to provide the Recognition Performance Test and the Product Usability Test. The Recognition Performance Test was aimed to perform tests on the same standard databases to compare competing techniques of facial recognition and the product usability test was aimed to examine system performing in access control. These evaluations provided the necessary information to law enforcement agencies and the U.S. government to determine the best ways to deploy facial recognition technology .

In [10] authors propose to partition face image database based on quality for investigating issues in unconstrained face recognition. They did it on two public face databases and used some deep learning method to evaluate on those partitioned databases. And they have shown that the variation in face image quality is challenge for deep learning in unconstrained FR.

3D face recognition using Hadoop propose a system that gives better recognition rate in the case of pose, expression and lighting variation [11].

IV. FACE RECOGNITION PROCESS STEPS

Face Recognition process comprises several sub-processes. The input for the face recognition system is an image or a frame of video. The output of the process is to identify who is the person in image or video frame.

The face recognition process goes through following steps:

1. Input image
2. Face Detection
3. Image processing
4. Feature Extraction
5. Recognition/Matching
6. Result

Face detection process can be defined as the process of locating the faces in image by means of some specific patterns of face. And when system finds those patterns it identify that image region as a face. Face detection can be used in many applications like expression recognition, emotion recognition, face tracking, pose estimation.

For better accuracy and quick response in face recognition, image processing is prior step to feature extraction, different processing techniques studied in [12]. face alignment, contrast enhancement and re-sizing the image are various image processing techniques. Image processing eliminate the effects of environmental noise, image contrast and lens effect etc.

The feature extraction step is reduction process which only extract distinguishable relevant facial features. These features represent the face properties like distance between eyes, lip thickness, and face components such as nose, eye, mouth etc. This step is very important for face recognition and other applications such as expression and emotion recognition. At the time of training these features for each image are stored in database with proper labeling.

After that for a test image these features are matched by using some similarity matching technique, to the stored features of face images present in database, the system recognizes the face if it found the most similar one satisfying some specified threshold measure.

Result is according to application of system if identification tells the identity, if verification verify the given person's identity and in attendance system it marks attendance.

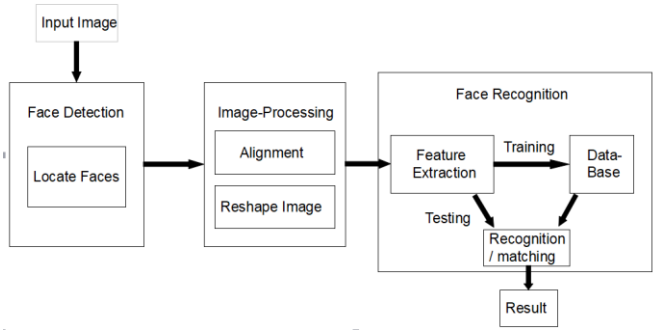

Figure 1. *A generic architecture of face recognition system*

V. CLASSIFICATION OF FACE DETECTION AND RECOGNITION ALGORITHMS

i. Face Detection:

Face detection process can be defined as the process of locating the faces in image by means of some specific patterns. So, when system finds those patterns it identifies that image region as a face. Face detection can be used in many applications like expression recognition, face tracking, pose estimation. Face detection methods are categorized into four categories. This classification is as follows:

1. **Knowledge-based methods:** Knowledge-based methods make set of rules based on our knowledge about faces. Such as eye region is darker then cheeks. It is very difficult to make appropriate set of rules. This leads to false positive if rules are general and false negative if rules are too specific. To overcome these limits we try to find the invariant features.

2. **Feature-invariant methods:** Feature-invariant algorithms deals with the invariant features of a face such as symmetry between eyes those does not depends on it's angle or position.
3. **Template matching methods:** These algorithms define face as a function and this function is general for all faces. This suffers from the pose variations and occluded face images. Work well in constrained environment.

recognition. As this field is being studied from many years so provided several techniques, broadly classified in following categories:

1. **Local feature based** such as Local Binary Pattern (LBP)[13], Elastic Map Matching(EMM)[14] and Binary Gradient Pattern (BGP)[15].
2. **Global feature based** such as linear discriminant analysis (LDA)[16], principal component analysis (PCA)[17], independent component analysis (ICA)[18] and other methods.
3. **Hybrid methods** combine both local features and global features.
4. **Machine learning based** methods are also available.

A comparative analysis of feature extraction techniques is studied in [19], shows that these are not suitable for pose-invariant face recognition.

VI. DETAIL EXPLANATION OF ALGORITHMS

i. Face Detection Algorithm

Here in this paper we are explaining Viola-Jones face detection method [20]. Viola-Jones Face detection method was firstly proposed by Paul Viola and Michael Jones in 2001. the main goal of this method was to achieve high detection rate and it achieve to detect faces from 15 frames per second. The main idea behind it was integral image representation of image which provides detector a high computation.

Viola Jones Face Detection Algorithm has 4 steps

1. **Haar feature extraction:** For haar feature extraction a window of 24*24 is taken, where it is searched from 2 pixels to all possible rectangles of haar features. This lead to having 16000+ features per window. The value of haar feature is calculated by subtracting the sum of dark pixels' intensity to sum of bright pixels' intensity.
2. **Integral image representation:** It helps in calculation of haar features. In this representation value of a pixel's intensity at (x',y') is kept as sum of pixels' intensity values those are left and above of that pixel having x<=x' and y<=y'.
4. **Appearance based methods:** Templates in this learned from training examples. These methods rely on statistical analysis and machine learning to find the face characteristics

ii. Feature Extraction:

The feature extraction step is reduction process which only extract distinguishable relevant facial features. That features represent the face properties like distance between eyes, lip thickness, and face components such as nose, eye, mouth etc. This step is very important for expression and emotion

How it helps in calculation of haar feature: Haar feature value of rectangle ABCD is calculated as D-(B+C)+A where A, B, C and D are pixels' intensities at each corner.

3. Ada-boost: Ada-boost machine learning is used to make a classifier which classify the relevant feature because not all the features are useful.
4. Cascade classifiers: A cascade of classifiers is used to test whether the input feature contribute to face or not.

ii. Feature Extraction Algorithm

Deep learning is cascade of layers in neural network which perform feature extraction, so it is also known as hierarchical learning. This learning can be supervised or unsupervised. Supervised learning for e.g. classification and unsupervised for patter recognition. Many companies like as google, facebook, amazon, baidu and other are using this technique and also providing frameworks. There are many deep learning based face recognition techniques available e.g. FaceNet, FaceID, DeepFace and more. For Face Recognition in this paper we are explaining deep learning, a convolution neural network.

Different approaches of deep learning:

Convolution Neural Network (CNN), Stacked Auto encoder, and Deep Belief Network (DBN). LeCun firstly proposed CNN and applied in handwriting recognition [21]. CNNs are type of deep neural networks consists of a input layer, output layer and multiple hidden layers. The hidden layers are convolution layers, pooling layers, ReLU layer, fully connected layers and normalization layers [22].

Convolution layer:

Convolution layer apply convolution operation on the input data. In this layer each convolution neuron processes data of only its receptive field. Receptive field is region of input image over which filter/kernel is applied. This produce a feature map or activation map in the output image.

Pooling layer:

Pooling layer reduces the dimension of input activation map but preserve the important information. In the pooling layer max pooling operation takes the maximum value from the

input values to each neuron, average in average pooling and minimum in min pooling.

ReLU layer:

Rectified linear Unit is a non-linear operation applied on output value of each neuron in order to make it zero in case of negative value.

Fully Connected Layer:

Fully Connected Layer connect every neuron from previous layer to each neuron in fully connected layer. It is similar to multi-layer perceptron neural network.

VII. CONCLUSION

This survey paper presents the introduction of face recognition technology and briefly explains steps included in this process. It then provides an extensive the review of past work in face recognition field and analyses existing work on face recognition.

In the early stage of face recognition technology, face recognition system used to be a man-machine systems or semi-automated systems. At that time face image had to be provided and also marked certain points on face image to processed which were processed by identification system. Those systems suffered from the variation in head orientation, scale and lighting intensity. Then first fully automated system was made in 1991 that itself detect the face and recognition the identity of face in image and resolve the men's interaction in face recognition process. But noisy images and partially occluded faces degraded the performance of system.

After the analysis of previous work done in Face Recognition some limitations were observed such as the technique of face recognition cannot work on platforms which do not have webcam or camera for taking taking input image. The image used for training should be clear in quality otherwise the performance would degrade. Also Face Recognition techniques suffer from limitations such as poses, illumination and occlusion on face.

In the field of Face Recognition, there are a lot of scope of improvement in techniques some of the future enhancements can be adding functionality of recognition multiple faces in single image, being performed on images having faces of different size. One of the focus area may be the time efficiency of algorithms used for face detection and recognition.

REFERENCES

[1] Bruner, I. S. and Tagiuri, R.. "The perception of people", In Handbook of Social Psychology, Vol. 2, G. Lindzey, Ed., Addison-Wesley, Reading, MA, 634–654.1954.

[2] Bledsoe, W. W. "The model method in facial recognition.", Tech. rep. PRI:15, Panoramic research Inc., Palo Alto, CA.1962

[3] Ekman, P. Ed., Charles Darwin's "The Expression of the Emotions in Man and Animals" Third Edition, with Introduction, Afterwords and Commentaries by Paul Ekman. Harper-Collins/Oxford University Press, New York, NY/London, U.K.1998

[4] Kelly, M. D. "Visual identification of people by computer" Tech. rep. AI-130, Stanford AI Project, Stanford, CA. 1970

[5] W. Bledsoe, "The Model Method in Facial Recognition" Panoramic research Inc. Palo Alto CA, PRI:15 August 1966.

[6] A Jay Goldstein, Leon Harmon, Ann B Lesk, "Identification of human faces", proceeding of the IEEE59(5), 748-760, 1971

[7] L. Sirovich and M. Kirby, "low-dimensional procedure for characterization of human faces", J opt. Soc. Am. A vol. 4, no. 3, 519-524 1987

[8] L.Turk and A. Pentlant, "Eigenfaces for recognition", jounral of cognitive Neuroscience, vol. 3, no. 1, 71-86 March 1991

[9] D.C. He and L.Wang(1990), "Texture Unit and Texture Spectrum and Texture Analysis", IEEE Transactions on Geo-science and Remote Sensing,vol. 28, pp.509-512 1990

[10] Guodong Guo and Na Zhang "What is the Challenge for Deep Learning in Unconstrained Face Recognition?", 13th IEEE International Conference on Automatic Face and Gesture Recognition, May 15-19, 2018

[11] Ms. G. Geetha, Ms. M Safa, Ms. C. Fancy and Ms. K. chital "3D Face Recognition using Hadoop", International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS-2017)

[12] Armin Hasanzadeh, Morteza Valizadeh and Sina Mirzapour "Fusion of several preprocessing approaches for improving the accuracy of face recognition systems in poor lighting conditions", IEEE 4th International Conference on Knowledge-Based Engineering and Innovation (KBEI) Dec. 22QG, 2017

[13] Ahonen T˙Hadid A˙Pietikainen M "Face Description with Local Binary Patterns: Application to Face Recognition", IEEE Trans on Pattern Analysis and Machine Intelligence.2006.28(12) 2037-2041

[14] Wiskott L, Fellous J-M, Krtiger N, et aL "Face Recognition by Elastic Bunch Graph Mathing", IEEE Transaction on Pattern Analysis and Machine Intelligence, 19(7) 775-779,1997

[15] Weilin Huang, Hujun Yin, "Robust Face Recognition with Structural Binary Gradient Patterns" Pattern Recognition , doi: 10.1016/j.patcog.2017.03.010,1997.

[16] Belhumeur P N, Hespanha J P, Kriegman D J, " Eigenfaees vs Fisherfaces : Recognition Using Class Specific Linear Projection", IEEE Transaction on PAMI, 19(7) 711-720,1997

[17] Turk M, Pentland "A Eigenfaces for Recognition", Journal of Congnitive Neuroscience, 3(1) 71-86,1991

[18] Comon P " Independent Component Analysis, A New Concept" Signal Processing, 36(3) 287-314,1994

[19] Saket Karve, Vasisht Shende and Rizwan Ahmed "A comparative analysis of feature extraction techniques for face recognition", 2018 International Conference on Communication, Information and Computing Technology (ICCICT), Feb. 2-3, Mumbai, India

[20] Paul Viola and Michael Jones "Rapid object detection using a boosted cascade of simple features" ,Computer Vision and Pattern recognition, 2001. Proceedings of the 2001 IEEE Computer Society Conference no. Vol. 1, 2001

[21] Y. LeCun, "Back propagation Applied to Handwritten Zip Code Recognition", Neural Computation, vol. 1, no. 4, pp. 541–551, Dec. 1989

[22] Musab Coúkun, Ayúegül Uçar, Özal Yildirim and Yakup Demir "Face Recognition based on Convolution Neural Network", 2017 IEEE

TABLE 1 : **ANALYSIS OF PAPERS**

YEAR	PAPER	TECHNIQUES USED	ACCURACY ACHIEVED	PERFORMANCE AND LIMITATIONS
2018	LBPH Based Improved Face Recognition At Low Resolution	• openCV : Haar cascade Classifier • Local binary pattern Histogram • DATASET (LR500) gray image	• LBPH 45PX : 94% • LBPH 35PX : 90%	Proposed approach work well on small size images. This is very useful in video surveillance observing people away from camera.
2018	Face Recognition Algorithm Based on Cascading BGP Feature Fusion	• Binary Gradient Pattern 1(BGP1) • Binary Gradient Pattern 2(BGP2) • Binary Gradient Pattern 3(BGP3) Yale and extended YaleB Database	Error rate •BGP1 9.1\% •BGP2 4.0\% •BGP3 3.2\%	BGP feature descriptor is robust to light, expression and occlusion. Due to cascading of BGP, recognition rate increases.
2018	Human Face Gender Identification System Based on MB-LBP	• Multi-Block Local Binary Pattern • Different support vector machine learning models • FERET face library	• Linear Kernel : 94.7\% • Polynomial Kernel(d=2) : 94.41\%	
2017	3D face recognition using Hadoop	• 3D Morph-able Model and Hadoop Image Processing Interface • Linear Discriminant Analysis •High-fidelity Pose and Expression Normalization (HPEN) method with 3D Morph-able Model (3DMM) which can robotically produce a natural face image in frontal pose and neutral expression and finding faces by color	• PCA 47.69% • LDA 35.42% • LDA-3D Morph-able Model 25.21%	Can use HIPI for object detection,anomaly detection and feature extraction.
2017	Fusion of several preprocessing approaches for improving the accuracy of face recognition systems in poor lighting conditions	PREPROCESSING METHODS: • Histogram Equalization (HE) • Adaptive Histogram Equalization (AHE) • Logarithmic Transform (LOG) • Contrast Limited Adaptive Histogram Equalization (CLAHE) • Difference of Gaussian(DoG) • k-NN classifier and personal face data-set	• HE : 83% • AHE : 88% • LOG : 78% • CLAHE : 90% • Proposed Method (CLAHE-DoG) : 93%	Proposed method provides the higher recognition rate and increases the efficiency. Very useful with reliable feature extraction technique for face recognition.
2017	A Face Recognition Hybrid Algorithm by combining LDA with PNN	• Linear discriminant analysis • Probabilistic neural network • Yale and ORL Data-set	RESULTS IN YALE DATABASE • PCA 63.01% • LDA 78.99% • LDA-PNN 82.06% RESULTS IN ORL DATABASE •PCA 81.09% •LDA 93.10% •LDA-PNN 93.49%	Pre-process the images before applying feature extraction and use good classification algorithm for improving the overall accuracy. Combined method gives better accuracy.
2014	Evaluation of LBP based face recognition techniques	• Local binary pattern(LBP) • Center symmetric Local binary pattern(CS-LBP) • Local binary pattern variance(LBPV) • complete Local binary pattern (CLBP) • JAFFE Data-set	IN IDEAL ENVIRONMENT • LBP 52.5% • CS-LBP 56.5% • LBPV 62% • CLBP 54% IN DIFFERENT CONTRAST • LBP 41% • CS-LBP 74% • LBPV 44% • CLBP 43%	Can use appropriate preprocessing technique.

Authors Profile

Ms. Kavita Lodhi completed Bachelor of Engineering from Rajiv Gandhi Prodyogiki Vishvavidyalaya, Bhopal in 2017. She is currently pursuing Master of Engineering in Department of Computer Engineering, Shri Govindram Seksaria Institute of Technology and Science, Indore.

Ms. Vandan Tewari pursued her graduation from Rajasthan Technical University. She completed her Master of Engineering and Ph.D from Rajiv Gandhi Prodyogiki Vishvavidyalaya, Bhopal. She is currently working as Associate Professor in Department of Computer Engineering, Shri Govindram Seksaria Institute of Technology and Science, Indore. She has 18 years of teaching experience.

Ms. Priyanka Bamne completed Bachelor of Engineering from Rajiv Gandhi Prodyogiki Vishvavidyalaya, Bhopal in 2013 and Master of Technology from Indian Institute of Technology, Bombay in 2015. She is currently working as Assistant Professor in Department of Computer Engineering, Shri Govindram Seksaria Institute of Technology and Science, Indore.

