A General Review of Face Hallucination Methods

Sudhir Kumar **VikramMutneja**

***Abstract*—In this paper various approaches for face hallucination has been studied. Face hallucination transform a low resolution face image into high resolution face image by enhancing the low resolution part of the image, a low resolution image can be developed from HR image by the process of down sampling, but if a low resolution image has to convert into HR image that is not so easy process. Face hallucination utilizes various approaches that have been used to transform low resolution image into high resolution. In this paper different algorithms have been reviewed for face hallucination.**

***Index Terms*— Face hallucination,Super-resolution (SR), Non negative matrix factorization (NMF), Principal component analysis (PCA).**

I. INTRODUCTION

A. Face Hallucination

Face Hallucination is a super resolution technique by which we obtain a higher resolution image by taking lower resolution version of the same image as an input. It is connected in face recognition systems for recognizing a face speedier and feasible. As a result of the centrality of face image in various applications, face hallucination has become a very interesting field of research.

Face hallucination is a zone specific super- resolution issue with the goal to deliver high-resolution (HR) images from low-resolution(LR) inputs, which finds different vision applications. Since a LR image can be modeled from a HR image by a linear convolution process with down sampling process, the hallucination issue can be seen as an opposite task to reconstruct the high frequency specific details. While late work focuses on the flat super-resolution issue, critical less thought is paid to facial excursion. In this paper, we propose a facialcomputation task of specific image structures to create HR results with high commitment.

Manuscript received April, 2015.

Sudhir Kumar, *M.Tech. Scholar, ECE department SBSSTC Ferozepur, PB, IN.*

VikramMutneja, *Assistant Professor, ECE department SBSSTC, Ferozepur, PB, IN.*

Mostly facial images have different sub-parts (eyes, nose, mouth…), curves and smooth areas. A point of reference area figuring is utilized to spot facial sections, and strategy facial plan in both frontal appearances and those at changed postures.In this work, the model face dataset contains both LR face images and the relating HR ones.

Face hallucination algorithm must be based in three constraints as explained below:

*Data constraint:*The output image should be nearly to the original image when it is smoothed or down-sampled.

*Global constraint:*The output image always contains some common features in both input and output i.e. eyes, nose, mouth, symmetry etc. The facial features must be coherent always.

*Local constraint:*The output image must have very specific features of the face image having resemblance with photorealistic local features. Without this constraint, the resulting image could be too smooth.

B. Methods

Face mental trip taking into account Bayes hypothesis

This system was proposed by Baker and Kanade, the launching of face visualization procedure. The figuring is in context of Bayesian MAP definition and utilization point plunge to streamline as far as possible and it conveys the high rehash purposes of excitement from a gatekeeper structure with the assistance of arranging samples.

Super-resolution from various perspectives utilizing learnt image models

Capel and Zisserman was the first to propose the nearby by face image SR method. It partitioned the face image into four key parts: the eyes, nose, mouth and cheek regions. For every region, it takes in an alternate Principal Component Analysis (PCA) to visualize and copies the locale openly. On the other hand, the reproduced face images in this system have obvious obsolete rarities between unmistakable areas.

ISSN: 2278 – 1323

Face Hallucination through Sparse Coding

This framework was proposed by J. Yang and H. Tang and it is arranged in fantasizing of High-Resolution face image by taking Low-Resolution input face. The framework uses the facial highlights by using a Non negative Matrix factorization (NMF) approach to manage learn limited part-based sub space. That subspace is fruitful for super-resolution the approaching face.

Face Hallucination by Eigen change

This technique was proposed by Wang and Tang and it utilizes an eigen change. This structure sees the strategy as a change between contrasting styles of image and uses a supervisor part examination (PCA) connected with the low-resolution face image. By selecting the measure of "Eigen goes up against", we can consider measure facial image data of low resolution and unfilled the confusion. In the Eigen change calculation, the fantasized face image is organized by the direct blend of high-resolution get prepared images and the mix coefficients start from the low-resolution face images utilizing the principal part examination's system. The figuring enhances the photograph resolution by get-together some high-rehash face purposes of eagerness from the low repeat facial data by abusing the relationship between the two ranges. As an outcome of the fundamental likeness among face images, in multi-resolution examination, there exists solid relationship between the high-rehash band and low-rehash band. For high- resolution face images, PCA can unimportant this related data onto a touch number of key areas. By then, in the Eigen change handle, these vital parts can be aggregated from the central segments of the low-resolution go up against by mapping between the high- and low- resolution arranging sets.

Figure 1. Image of face Hallucination

II. RELATED WORK

Chen Caikou et al [1]"A matching pursuit based similarity measure for face recognition"Inadequate representation can't simply reveal the vital or critical semantic information of a case, also have a couple ofpurposes of enthusiasm, for instance, direct, versatile and so on. Differentiated and other inadequate representation computations, organizing enthusiasm considering greedy iterative computation is additionally convincing, this article takes it to pick neighbors. All the planning tests are used to fabricate the over complete word reference, Author have to find the most pertinent cases serve as an adjacent neighbor of the case. Next another thought called similarity measure is proposed. Author center the greatness of the neighbor system by differentiating three components: the asked for summary of dictionary parts, the game plan of coefficients and the store made from arranging intrigues gauge; finally it gets the perfect projection subspace by minimizing the Objective limit. Differentiated and the other highlight extraction technique, the proposed method have a prevalent recognition influence and all the more intense. The AR and FERET face imagedatabase show that it is effective.

Ptucha, R. et al [2]"LGE-KSVD: Flexible Dictionary Learning for Optimized Sparse Representation Classification"inadequate representations have successfully been used for the progression of significantly exact classifiers. Tragically, these classifiers are computationally heightened and subject to the unpleasant effects of coefficient defilement, where for example mixtures in carriage may impact character and surge recognition. We propose a strategy, called LGE-KSVD that addresses both issues and accomplishes front line results for face and movement portrayal issues. Specifically, LGE-KSVD utilizes varieties of linear development of Graph Embedding to redesign K-SVD, an iterative framework for little yet over complete word reference learning. The dimensionality diminish network, deficient representation word reference, sparse coefficients, and sparsity-based direct classifier are commonly adjusted through LGE-KSVD. The particle improvement methodology is renamed to have variable support using graph embedding techniques to make a more versatile and dazzling dictionary learning count. Results are gotten for a wide arrangement of facial and activity recognition issues to demonstrate the force of the proposed system.

Junjun Jiang et al[3] "Support-driven sparse coding for face hallucination" By fusing the earlier of positions, position patch based face mental trip techniques can create fantastic results and spare processing time. Given

ISSN: 2278 – 1323

a low-resolution face image, the key issue of these techniques is the way to encode the information low-resolution patch. Then again, because of security and precision issues, the coding methodologies proposed so far are not palatable. In this paper, Author show a novel scanty coding system by means of abusing the bolster data on the coding coefficients. Specifically, the bolster data is portrayed by the region of the imagepatch complex, which has been demonstrated to be basic in information representation and examination. As indicated by the separations between the data fix and bases in the word reference, Author first dole out diverse weights to the coding coefficients and afterward get the coding coefficients by tackling a weighted scanty issue. Our proposed strategy misuses the non-direct complex structure of patch tests and the inadequate property of the repetitive information, prompting steady and precise representation. Trials on generally utilized databases show that our system beats cutting edge.

Ran He et al[4] "Half-Quadratic-Based Iterative Minimization for Robust Sparse Representation" Hearty inadequate representation has shown colossal potential in dealing with testing issues in PC vision, for instance, biometrics and visual observation. But a couple of fiery small models have been proposed and promising results have been gotten, they are either for slip change or for failure ID, and taking in a general framework that efficiently unites these two edges and examines their association is still an open issue. In this paper, we add to a half-quadratic (HQ) framework to handle the solid deficient representation issue. By describing different sorts of half-quadratic limits, the proposed HQ framework is material to performing both botch correction and slip recognizable proof. More especially, by using the included substance kind of HQ, we propose a ℓ1-regularized slip-up alteration procedure by iteratively recovering debased data from botches achieved by noises and abnormalities; by using the multiplicative sign of HQ, we propose a ℓ1-regularized screw up ID framework by picking up from uncorrupted data iteratively. Author also exhibit that the ℓ_1-regularization lit up by fragile thresholding limit has a twofold relationship to Huber M-estimator, which speculatively guarantees the execution of generous lacking representation with respect to M-estimation. Investigations on vivacious face recognition under compelling obstruction and degradation acknowledge our frame work.

Junjun Jiang et al[5] "Nearest feature line embedding for face hallucination" New complex method, called closest highlight line embedding, for face visualization is proposed. While various complex learning based face dream computations have been proposed starting late, most of them apply the conventional nearest neighbor metric to focus the subspace and may not effectively portray the geometrical information of the examples, especially when the amount of planning samples is compelled. This reported work proposes using the NFL metric to portray the region relations between face tests to improve the imparting power of the given get ready examples for redoing. The estimation spares the straight relationship in a tinier neighborhood space than standard complex learning based schedules, which better mirrors the method for complex learning theory. Test outcomes display that the framework is convincing at ensuring unequivocal visual information.

Xiaofeng Wang et al[6] "A novel method for instance based face super-resolution" Face super- resolution is the specific super-resolution issue considering the property of facial images, which changes a high-resolution facial imagefrom low- resolution information. Considering the observation that faces are embodied a couple for the most part free parts, for instance, eyes, noses and mouths, Author propose a case based face dream framework which consolidates association propelled non-negative cross section factorization (CCNMF) estimation and High-dimensional Coupled NMF (HCNMF) computation. Differentiated and existing procedures, the proposed CCNMF estimation can make worldwide face more like the ground truth defy by taking in a parts-based and confined representation of facial images. Likewise, development pay by using HCNMF can take in the association between high- resolution store and low- resolution development to better defend lost high repeat unobtrusive components. Test outcomes check the reasonability of our method.

Jeong-Seon Park et al [7] "An Example-Based Face Hallucination Method for Single-Frame, Low-Resolution Facial Images" This paper proposes a facehallucination method for the reconstruction of high-resolution facial images from single-frame, low-resolution facial images. The proposed method has been derived from example-based hallucination methods and morph able face models. First, we propose a recursive error back-projection method to compensate for residual errors, and a region-based reconstruction method to preserve characteristics of local facial regions. Then, we define an extended morphableface model, in which an extended face is composed of the interpolated high-resolution face from a given low-resolution face, and its original high-resolution equivalent. Then, the extended face is separated into an extended shape and an extended texture. We performed various hallucination experiments using the MPI, XM2VTS, and KF databases, compared the reconstruction errors, structural similarity index, and recognition rates, and showed the

ISSN: 2278 – 1323

effects of face detection errors and shape estimation errors. The encouraging results demonstrate that the proposed methods can improve the performance of face recognition systems. Especially the proposed method can enhance the resolution of single-frame, low-resolution facial images.

Xiang Xu et al[8]"Face hallucination: How much it can improve face recognition" Facehallucination has been a popular topic in image processing in recent years. Currently the commonly used performance criteria for facehallucination are peak signal noise ratio (PSNR) and the root mean square error (RMSE). Though it is logically believed that hallucinated high-resolution face images should have a better performance in face recognition, we show in this paper that this `the higher resolution, the higher recognition' assumption is not validated systematically by some designed experiments. First, we illustrate this assumption only works when the image solution is sufficiently large. Second, in the case of very extreme low resolutions, the recognition performance of the hallucinated images obtained by some typical existing facehallucination approaches will not improve. Finally, the relationship of the popular evaluation methods in facehallucination, PSNR and RMSE, with the recognition performance is investigated. The findings of this paper can help people design new hallucination approaches with an aim of improving face recognition performance with specified classifiers.

Zhongyuan Wang et al [9] "Face Hallucination Via Weighted Adaptive Sparse Regularization" Sparse representation-based face hallucination approaches proposed so far use fixed ℓ1 norm penalty to capture the sparse nature of face images, and thus hardly adapt readily to the statistical variability of underlying images. Additionally, they ignore the influence of spatial distances between the test image and training basis images on optimal reconstruction coefficients. Consequently, they cannot offer a satisfactory performance in practical face hallucination applications. In this paper, Author propose a weighted adaptive sparse regularization (WASR) method to promote accuracy, stability and robustness for face hallucination reconstruction, in which a distance-inducing weighted ℓq norm penalty is imposed on the solution. With the adjustment to shrinkage parameter q, the weighted ℓq penalty function enables elastic description ability in the sparse domain, leading to more conservative sparsity in an ascending order of q . In particular, WASR with an optimal $q > 1$ can reasonably represent the less sparse nature of noisy images and thus remarkably boosts noise robust performance in face hallucination. Various experimental results on standard face database as well as real-world images show that our proposed method outperforms state-of-the-art methods in terms of both objective metrics and visual quality.

Asavaskulkeit, K et al [10] "The Color Face Hallucination with the Linear Regression Model and MPCA in HSV Space" This paper proposes a novel hallucination technique, color face images reconstruction of HSV space with a regression model in multilinear principal component analysis (MPCA). From hallucination framework, many color face images are explained in HSV space. Then, they can be naturally described as tensors or multi linear arrays. This novel hallucination technique can perform feature extraction by determining a multi linear projection that captures most of the original tensorial input variation. In this contribution we show that our hallucination technique can be suitable for color face images both in HSV space. By using the tensor MPCA subspace with regression model, we can generate photorealistic color face images. Our approach is demonstrated by extensive experiments with high quality hallucinated color faces. In addition, our experiments on face images from FERET database validate our algorithm.

YonggangJin et al[11]"Face hallucination revisited: A joint framework" The paper presents a joint framework for facehallucination incorporating facedeblurring and registration. The joint framework not only directly hallucinates low resolution faces, but also deblurs and aligns low resolution faces iteratively to improve the performance of facehallucination. Without the need for accurate face registration and prior knowledge of blurring kernels, it is robust to errors in face registration and blurring kernel. Experimental results demonstrate the robust performance of the proposed method.

YuanhongHao et al [12] "Modified neighbor embedding-based face hallucination using coupled mappings of partial least squares" Neighbor embedding based facehallucination usually assumes that the two manifolds formed by the small patches in the low-resolution (LR) and corresponding high-resolution (HR) images share the same local geometric structure. However, since there are generally multiple HR images that can be reduced to the same LR image, the assumption does not hold always. Therefore, facehallucination directly based on the assumption may result in blurring and artifacts. To enhance the consistency relationship in facehallucination, we employ partial least squares (PLS) to learn coupled mappings simultaneously and to map the original HR and LR image patches onto a unified feature space, where the distinction between LR and HR image patches pairs is minimized. Then, the k nearest neighbors searching and the computation of optimal reconstruction weights is performed in the unified

ISSN: 2278 – 1323

feature space. Experimental results show that the proposed method outperforms some latest image hallucination algorithms.

Chih-Yuan Yang et al [13] "Structured Face Hallucination" The goal of facehallucination is to generate high-resolution images with fidelity from low-resolution ones. In contrast to existing methods based on patch similarity or holistic constraints in the image space, we propose to exploit local image structures for facehallucination. Each face image is represented in terms of facial components, contours and smooth regions. The image structure is maintained via matching gradients in the reconstructed high-resolution output. For facial components, Author aligns input images to generate accurate exemplars and transfer the high-frequency details for preserving structural consistency. For contours, Author teach statistical priors to generate salient structures in the high-resolution images. A patch matching method is utilized on the smooth regions where the image gradients are preserved. Experimental results demonstrate that the proposed algorithm generates hallucinated face images with favorable quality and adaptability.

Junjun Jiang et al [14] "Locality-constraint iterative neighbor embedding for face hallucination" Based on the assumption that low-resolution (LR) and high-resolution (HR) patch manifolds are locally isometric, the neighbor embedding based super-resolution algorithms try to preserve the local geometry of the patch manifold for the reconstructed HR patch manifold. However, due to "one-to-many" mappings between LR and HR images, the neighborhood relationship of the LR patch manifold can't reflect the inherent data structure. In this paper, we explore the data structure by both considering the LR patch and HR patch manifolds instead of only considering one manifold (LR patch manifold). By incorporating the position prior of face and local geometry of HR patch manifold, Author propose an improved neighbor embedding method to face hallucination, namely locality-constraint iterative neighbor embedding (LINE), in which we iteratively update the K-nearest neighbors (K-NN) and reconstruction weights based on the result (the hallucinated HR patch) from previous iteration, giving rise to improved performance compared with traditional neighbor embedding algorithms. Experimental results with application to face hallucination on simulated LR face images and real world ones demonstrate the effectiveness of the proposed method.

Tanveer, M. et al [15] "A Bayesian Approach to Face Hallucination Using DLPP and KRR" Low resolution faces are the main barrier to efficient face recognition and identification in several problems primarily surveillance systems. To mitigate this problem we proposes a novel learning based two-step approach by the use of Direct Locality Preserving Projections (DLPP), Maximum a posterior estimation (MAP) and Kernel Ridge Regression (KRR) for super-resolution of face images or in other words FaceHallucination. First using DLPP for manifold learning and MAP estimation, a smooth Global high resolution image is obtained. In second step to introduce high frequency components KRR is used to model the Residue high resolution image, which is then added to Global image to get final high quality detail featured Hallucinated face image. As shown in experimental results the proposed system is robust and efficient in synthesizing low resolution faces similar to the original high resolution faces.

Wenming Yang et al [16] "Face hallucination via position-based dictionaries coding in kernel feature space" In this paper, Author present a new method to reconstruct a high-resolution (HR) face image from a low-resolution (LR) observation. Inspired by position-patch based facehallucination approach, Author design position-based dictionaries to code image patches, and recovery HR patch using the coding coefficients as reconstruction weights. In order to capture nonlinear similarity of face features, we implicitly map the data into a high dimensional feature space. By applying kernel principal analysis (KPCA) on the mapped data in the high dimensional feature space, Author can obtain reconstruction coefficients in a reduced subspace. Experimental results show that the proposed method can effectively reconstruct details of face images and outperform state-of-the-art algorithms in both quantitative and visual comparisons.

III. APPROACHES USED

Super-resolution (SR) Model

SR Model is a class of strategies that upgrade the resolution of an imaging framework. In some SR procedures termed optical SR the diffraction furthest reaches of frameworks is risen above, while in others geometrical SR the resolution of advanced imaging sensors is upgraded. Since a percentage of the thoughts encompassing super-resolution raise key issues, there is need at the start to inspect the pertinent physical and data hypothetical standards.

ISSN: 2278 – 1323

Sparse Coding for Face Hallucination

Creator of this strategy is J. Yang and H. Tang, itaddress the problem of hallucinating a High-Resolution face image by taking Low-Resolution inputdata. The strategy uses the facial highlights by utilizing a Non negative Matrix factorization (NMF) way to deal with learn restricted part-based subspace. That subspace is powerful to super-determining the approaching face. For further upgrade the point by point facial structure by utilizing a neighborhood patch strategy taking into account scanty representation.

Bayes Theorem for Face hallucination

Creator of this strategy is Baker and Kanade, the spearheading of face visualization procedure. The calculation is taking into account Bayesian MAP definition and utilization inclination plummet to advance the target capacity and it produces the high recurrence points of interest from a guardian structure with the aid of preparing specimens.

Eigen transformation for Face Hallucination

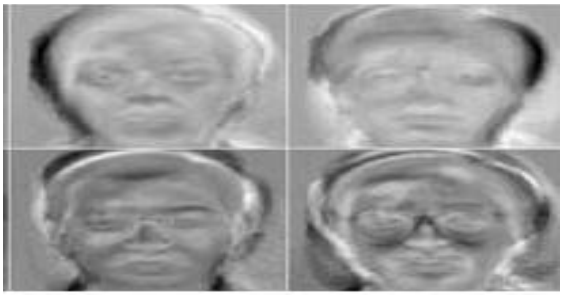

Figure 2. Eigen faces of face images

Creator of this technique is Wang and Tang. , it utilizes an Eigen change. This system sees the arrangement as a change between distinctive styles of imageand uses an important segment investigation (PCA) connected to the low- resolution face image. By selecting the quantity of "Eigen confronts", we can concentrate measure of facial imagedata of low resolution and evacuate the commotion. In the Eigen change calculation, the daydreamed face imageis blended by the straight blend of high- resolution preparing images and the mix coefficients originate from the low- resolution face images utilizing the central part investigation system. The calculation enhances the image resolution by deducing some high-recurrence face points of interest from the low recurrence facial data by exploiting the relationship between the two sections. Due to the auxiliary likeness among face images, in multi-resolution investigation, there exists solid relationship between the high-recurrence band and low-recurrence band. For high- resolution face images, PCA can minimal this related data onto a little number of chief parts. At that point, in the Eigen change transform, these chief segments can be deduced from the foremost parts of the low- resolution confront by mapping between the high- and low- resolution preparing sets.

IV. CONCLUSION

In this paper various approaches for face hallucination has been discussed. These approaches use different operators to enhance the quality of the image by traversing and convolution the low resolution image contents. Super-resolution model utilize different types of convolution and neighborhood pixel values that has been used to enhance the quality of image. Eigen face transformation converts the image coefficients to extract the Eigen values for development of Eigen faces. Bayes theorem divide image into several regions and enhance the quality of the image. Many successful experimental results prove that face hallucination can be applied in real applications to enhance the resolution of face for both recognition and editing.

REFERENCES

[1] Chen Caikou, Hou Yu "A matching pursuit based similarity measure for face recognition"*31st ChineseControl Conference (CCC), 2012*, pp. 3886 – 3890.
[2] Ptucha, R., Savakis, A. "LGE-KSVD: Flexible Dictionary Learning for Optimized Sparse Representation Classification" *IEEE Conference onComputer Vision and Pattern Recognition Workshops (CVPRW), 2013*, pp. 854 – 861.
[3] Junjun Jiang, Ruimin Hu , Zhongyuan Wang, ZixiangXiong" Support-driven sparse coding for face hallucination"*IEEE International Symposium onCircuits and Systems (ISCAS), 2013*, pp. 2980 – 2983.
[4] Ran He, Wei-Shi Zheng, Tieniu Tan, Zhenan Sun "Half-Quadratic-Based Iterative Minimization for Robust Sparse Representation"*IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 36, pp. 261 – 275, 2014.
[5] Junjun Jiang, Ruimin Hu, Zhen Han, Tao Lu *" Nearest feature line embedding for face hallucination" Electronics Letters* , vol. 49, pp. 536 – 538, 2014.
[6] Xiaofeng Wang. Hefei Ling, Xin Xu "A novel method for example-based face super-resolution"*International Conference onMultimedia Computing and Systems (ICMCS), 2014*, pp. 117 – 121.
[7] Jeong-Seon Park "An Example-Based Face Hallucination Method for Single-Frame, Low-Resolution Facial Images" *IEEE Conf. on Image Processing*, 2008, pp 1806 – 1816.
[8] Xiang Xu "Face hallucination: How much it can improve face recognition" *IEEE Conf. on Control Conference (AUCC)*, 2013, pp 93 – 98.
[9] Zhongyuan Wang "Face Hallucination via Weighted Adaptive Sparse Regularization" *IEEE Conf. on Circuits and Systems for Video Technology*, 2013, pp 802 – 813.

ISSN: 2278 – 1323

[10] Asavaskulkeit, K "The Color Face Hallucination with the Linear Regression Model and MPCA in HSV Space" *IEEE Conf. on Systems, Signals and Image Processing*, 2009, PP 1-4.
[11] YonggangJin "Face hallucination revisited: A joint framework" *IEEE Conf. onImage Processing (ICIP)*, 2013, pp 981 – 985.
[12] YuanhongHao "Modified neighbor embedding-based face hallucination using coupled mappings of partial least squares" *IEEE Conf. on Image Processing (ICIP)*, 2014, pp 3906 – 3909.
[13] Chih-Yuan Yang "Structured Face Hallucination" *IEEE Conf. no Computer Vision and Pattern Recognition (CVPR)*, 2013, pp 1099 – 1106.
[14] Junjun Jiang "Locality-constraint iterative neighbor embedding for face hallucination" *IEEE Conf. on Multimedia and Expo (ICME)*, 2013, pp 1 – 6.
[15] Tanveer, M. "A Bayesian Approach to Face Hallucination Using DLPP and KRR" *IEEE Conf. on Pattern Recognition (ICPR)*, 2010, pp 2154 – 2157.
[16] Wenming Yang "Face hallucination via position-based dictionaries coding in kernel feature space" *IEEE Conf. on Smart Computing (SMARTCOMP)*, 2014, pp 131 – 135.

AUTHORS PROFILE

Sudhir Kumar received the B. Tech. degree in Electronics and Communication Engineering from Guru Nanak Dev Engineering College, Ludhiana, Punjab in 2012. Currently he is a scholar of the M. Tech. from Shaheed Bhagat Singh State Technical Campus, Ferozepur. His research interest are in Super-resolution and Image Processing.

VikramMutnejareceived his B. Tech in ECE from GNDU, Amritsar, Punjab in June 1998, and completed M.Tech. under Punjab Technical University, Jalandhar in August 2008 from G. Z. S. College of Engineering & Technology, Bathinda . His work experience includes five years of industrial experience in the areas Networking & Embedded Systems development. He taught for two years as Lecturer in department of Electronics & Communication Engineering at BMS College of Engineering, Muktsar, Punjab and at present he is working as Assistant Professor, ECE at Shaheed Bhagat Singh State Technical Campus, Ferozepur since July 2005. He is pursuing his Ph.D. from Punjab Technical University in the area of image processing.

ISSN: 2278 – 1323