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Digital Image Forgery Detection Based On SVD

Ms. Aarti S. Deshpande[1], Ms. Ashwini S. Shinde[2]
[1,2]*Departement of ENTC, AITRC Vita, Vita, India*

Abstract— ***Due to availability of powerful photo editing software like Adobe Photoshop, 3DS Max, GIMP, Coral Paint Shop it is very simple to manipulate the digital images. As a result digital evidences have not yet been accepted in criminal investigations & court as a proof. In copy-move type of forgery some part of images is copied and pasted to conceal a person or object in the scene or sometimes to clone an object. In this paper, we use an improved algorithm based on Singular Value Decomposition (SVD) to detect this image forgery. In this method after applying image pre processing operations the image is divided in number of overlapping blocks. The SV features are extracted from each block. All these SV features are then lexicographically sorted so the blocks with similar feature come near to each other. By using Euclidean distance & Shift vector concept we can locate the copy move region in the image.***
Keywords- Singular Value Decomposition (SVD), Lexicographic Sorting, Euclidean Distance.

I. INTRODUCTION

Digital image plays an important role in our daily life. Today most of the scientific journals, medical record , newspaper, magazine etc contains the digital images. Facebook alone has over three billion photos uploaded to its website every month. The growing use of digital images has also prompted the development of numerous image-processing software programs, many of which are free to general public. Due to availability of large number of free photo editing software it is very easy & simple to manipulate the digital images without leaving any traces of tampering. As a result of this, digital evidence have not yet been accepted as a proof in criminal investigation. The dictionary meaning of forgery is part of images is copied and pasted to conceal a person or object in the scene or sometimes to clone an object. Image forgery detection is probably one of the most interesting functions under digital image forgery due to its application which is generally much closer to the public. It deals with techniques or algorithm to detect traces of digital image tampering. The availability of any of these traces is proof that an image has been tampered. There are many algorithms or techniques for detecting tampered image. In general, these techniques can be
divided into two major groups; Active Method and Passive Method

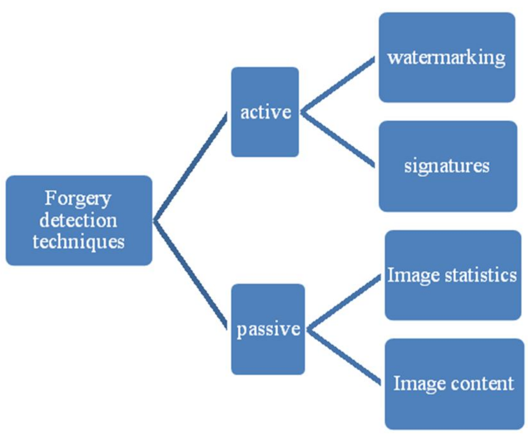

Fig1: Block diagram of forgery detection techniques.

Active Method requires that certain information is embedded inside an image during the creation. One of the techniques under active method is watermarking.

The problem with watermarking is that it requires special hardware or software in order to insert certain information to the image. Providing watermarking facility to digital camera makes it costlier one. Passive method on the other hand, does not require any pre-image distribution information to be inserted into digital image. Techniques in passive method for detecting image forgery can divided into two main category, one that is based on the pixel value of the image (Statistical Method) and one that tries to detect inconsistencies in the image itself based on visual cues (Visual Method). Statistical Method is more robust than Visual Method because it does not depend on the visual information of an image, but instead analyses an image based on the values of each of the pixels in an image.

II. PROPOSED METHOD

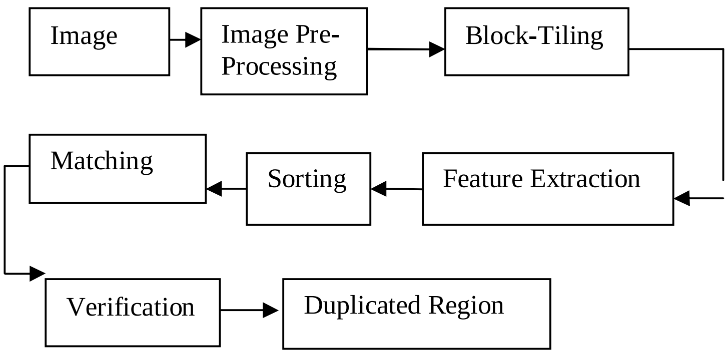

Fig.2: Block Diagram of Copy-Move forgery detection.

The detection step involves two main steps: 1) Image feature extraction 2) Block similarity matching

A. Image Feature Extraction

Here we use Singular Value Decomposition method to extract features from image. Singular Value Decomposition has three features mainly scaling property, stability, rotation invariance which represents algebraic and geometric invariant properties of an image. The basic theory of SVD is as follows:

The singular Value Decomposition (SVD) is widely used technique to decompose a matrix into several component matrices, exposing many of the useful and interesting properties of the original matrix. SVD is very useful technique in data analysis and visualization [3]. Any real valued matrix A can be decomposed into three components, one is left unitary matrix U, right unitary matrix V and diagonal matrix S having singular values on diagonal. Considering A is having n rows and m column then equation 1.1 is called as singular value decomposition.

$$A_{mxn} = U_{mxm} \bullet S_{mxn} \bullet V^{T}_{nxn} \quad \text{.... 1}$$

Where U = left unitary matrix,

V = right unitary matrix,

S = diagonal matrix having singular values on diagonal in descending order.

Since U and V are orthogonal matrices (and so their inverses are equal to their transpose), the above equation can also be written as:

$$S_{mxn} = U^{T}_{mxm} \bullet A_{mxn} \bullet V_{nxn} \quad \text{.... 2}$$

The structure of S matrix is given as follows:

$$S = \begin{bmatrix} \sigma_1 & 0 & \cdots & 0 & 0 & \cdots & 0 \\ 0 & \sigma_2 & \cdots & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_r & 0 & \cdots & 0 \\ 0 & 0 & \cdots & 0 & \sigma_{r+1} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 0 & 0 & \cdots & \sigma_n \\ 0 & 0 & \cdots & 0 & 0 & \cdots & 0 \end{bmatrix}$$

where $\sigma_1 \geq \sigma_2 \geq \sigma_3 \geq \cdots \geq \sigma_r \geq 0$.

Singular Value Matrix representation.

Where σ_i called as singular values which are arranged in decreasing order and r is the rank of matrix. All the singular values below

σ_r almost become zero. As S is diagonal matrix all diagonal elements are singular values and non diagonal elements are zero [4].

B. Block Similarity Matching

The main idea of this step is that a duplicated region consists of many neighbouring duplicated blocks. If we find two similar blocks in the analyzed space and if their neighbourhoods are also similar to each other, there is a high probability that they are duplicated and they must be labeled. The similarity measure s employed here is defined by formula:

$$S(B_i, B_j) = 1/(1 + p(B_i, B_j)) \quad \ldots\ldots 3$$

where p is a distance measure in Euclidean space.

$$p(B_i, B_j) = \left(\sum_{k=1}^{\dim} (B_i[k] - B_j[k])^2 \right)^{1/2} \quad \ldots. 4$$

Verification steps filters matching pairs that follows a common pattern. The most common criterion for the verification step is the recognition of same shift vectors. Not all similar block pairs are equally likely to come from two duplicated regions. Therefore we need to identify those similar blocks that come from two duplicated regions and remove those that are not. Assuming that the source and the target regions are larger than the block size, then all corresponding blocks in the source and target regions will have the same shift vectors. The shift vector between blocks B_i and B_j are given by

$$d' = (dx', dy') \quad \ldots\ldots 5$$

where $dx' = (x_i - x_j)$ and $dy' = (y_i, - y_j)$

where (x_i, y_i) and (x_j, y_j) are the upper left corner co-ordinates of block B_i and B_j respectively.

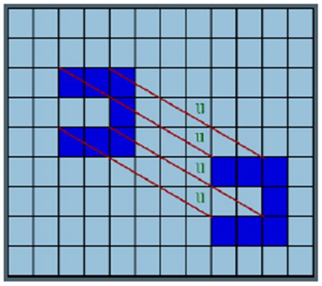

Fig.3:. Shift Vector Concept

III. COPY-MOVE FORGERY DETECTION STEPS

In this section we implement a novel algorithm for detection of copy-move forgery in digital images. The algorithm start with dividing the image into number of overlapping blocks, then features are extracted from image using SVD techniques. The similarity between the blocks is calculated and then duplicated region is marked on image.

Step 1: Initially some pre-processing steps are done on the given image. This pre-processing step includes the conversion of RGB image into Gray image.

Step 2: Consider a forged image with size of M×N. Then partition an image into small overlapping blocks. Determine a window with B×B size and slid it over the whole image one by one pixel at each time from upper left corner to bottom right corner. For given input image of size M×N the number of blocks, N_B created by this process can be calculated as:

$$N_B = (M-B+1) \times (N-B+1). \quad \ldots\ldots 6$$

In this process the block size affects the accuracy of the algorithm. When larger block sizes are used, mismatches are less likely to occur since more pixels are used for similarity evaluation. However fine details in the duplicated regions may not be detected when the block size is larger than the scale of fine details, conversely using smaller block sizes allows more details in duplicated regions to appear, but the algorithm will be more sensitive to mismatches due to the smaller area of comparison. For better result we choose block size as 16×16.

Step 3: For each block apply SVD and extract the image features using equation 1.2. Then sort all the features in matrix using

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lexicographic sorting. After lexicographic sorting similar feature vectors would come successively, i.e. we can say that the corresponding blocks whose feature vectors come successively would be the candidates of block duplicates.

Step 4: Block similarity matching is done using the concept of Euclidean Distance If the Euclidian distance $S(B_i, B_j) \leq P$ where P is the threshold value then perform the verification step. The verification is done using shift vectors concept. The copied & pasted region blocks have minimum Euclidean distance & similar shift vectors.

IV. PARAMETER ANALYSIS

In the system there are three main performance parameters present:

A. Matching Ratio (M.R)

$$\text{Matching ratio} = \frac{\text{Number of correct match}}{\text{Number of total match}} \quad \ldots. \ 7$$

For better results the value of matching ratio should be as high as possible. Let R_1 be copied region, R_i be the pasted region and B is he unchanged background.

B. False Positive Pixel Rate (F.P.R)

$$\text{F.P.R} = \frac{|\text{Matches in B}|}{|\text{B}|} \quad \ldots.. \ 8$$

C. False Negative Pixel Rate (F.N.R)

$$\text{F.N.R} = \frac{|\text{Missed matches in } (\cup_i R_i)|}{|\cup_i R_i|} \quad \ldots. \ 9$$

A lower rate of F.N.R & F.P.R indicates higher accuracy. As long as a copied region is detected, we consider high F.P.R rate to be worse than a high F.N.R rate. The reason is that high F.P.R rate lead to a highly confusing over-detection result.

V. EXPERIMENTAL RESULT AND ANALYSIS

The proposed method is implemented using MATLAB software .Experiments performed on various images and using different image post image processing operations. The images are downloaded from internet. For every image Fig.(a) shows original image, Fig.(b) shows tampered image and Fig.(c) shows result of detection by SVD method.

(a) Image 1

(b)

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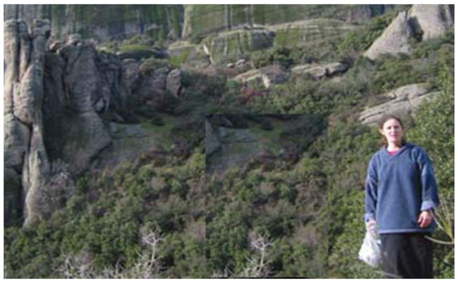
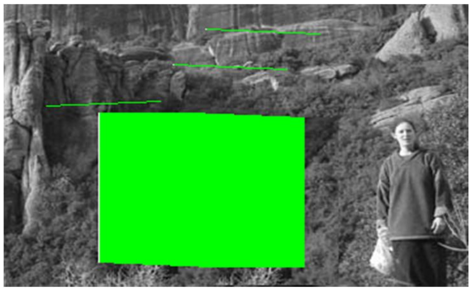
(c)

(a) Image 2



(b)



(c)

(a) Image 3

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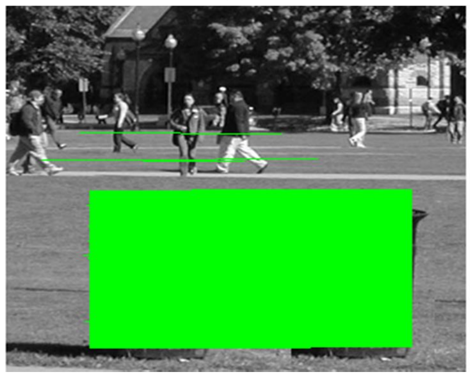
(b)

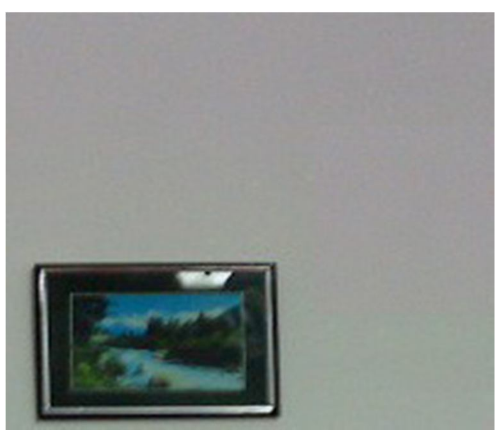


(c)

TABLE: I

A. Matching Ratio Of Tampered Images

Image(Size)	M.R	F.P.R	F.N.R	Computation Time
Image1(254×191)	0.98	Negligible	0.565	61.48 sec
Image 2 (239×356)	0.99	0.0005	0.364	248.84 sec
Image 3(308×308)	0.99	0.0005	0.28	316.57 sec



(a) Original Image

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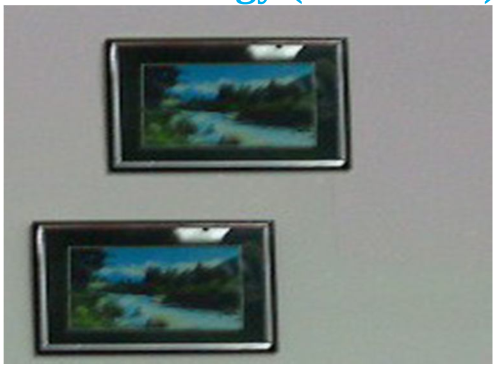
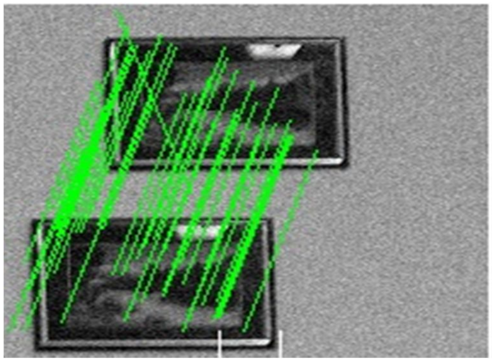
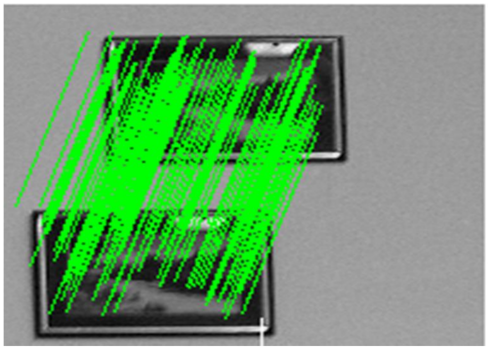
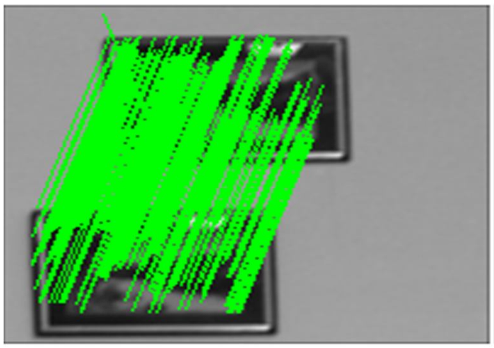

(b) Tampered Image


(c) Gaussian Noise 40 dB


(d) Gaussian Noise 75 dB


(e) Gaussian Blur radius 0.5

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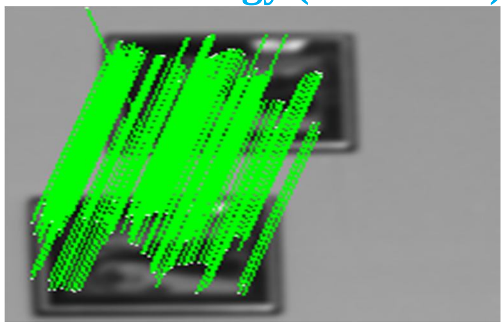
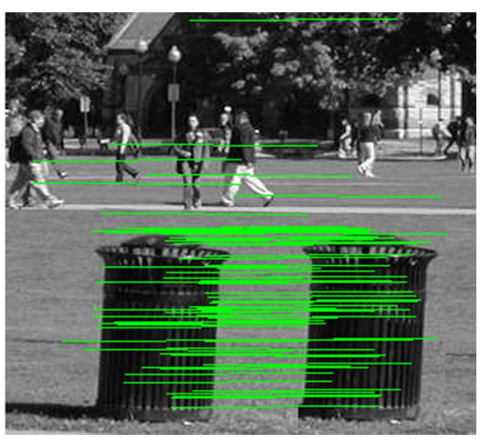


(f) Gaussian Blur radius 2.5

(a) Original Image

(b) Tampered Image



(c) JPEG compression with Q =50

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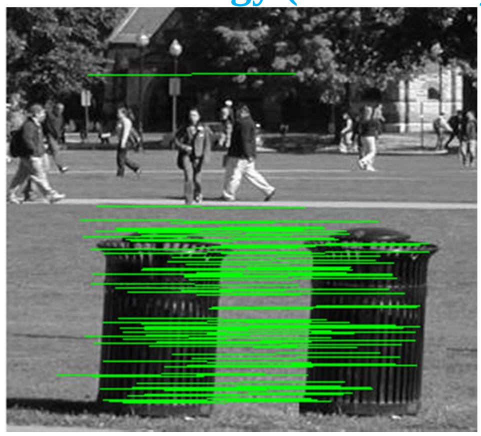
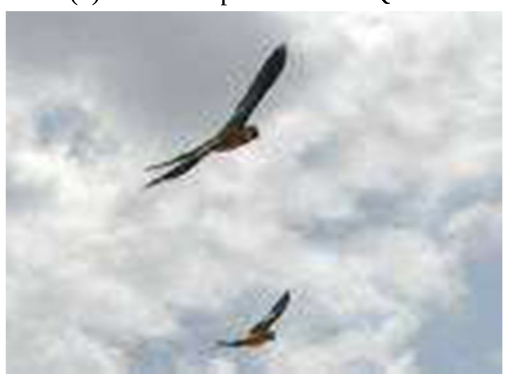


(d) JPEG compression with Q =70



(a) Original Image

(b) Tampered Image (Rotation by 90)

` (c) Rotation by 90 degree

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TABLE: II

B. MATCHING RATIO OF TAMPERED IMAGES WITH DIFFERENT POST IMAGE PROCESSING

Gaussian Noise (dB)	40	75
M.R	0.95	0.98
Gaussian Filtering (radius pixel)	0.5	2.5
M.R	0.98	0.96
JPEG Compres-sion(Quality Factor)	50	70
M.R	0.97	0.98
Rotation (degree)	90	180
M.R	0.98	0.997

VI. CONCLUSION

Copy-Move type of forgery can be easily and effectively detected by SVD. SVD algorithm requires lower time than PCA in detection method. It is more robust to post image processing operations and give proper results for naturally duplicated region. It has high value of matching ratio. As overlapping block size increases the total time required for detection decreases but false negative rate (F.N.R) increases.

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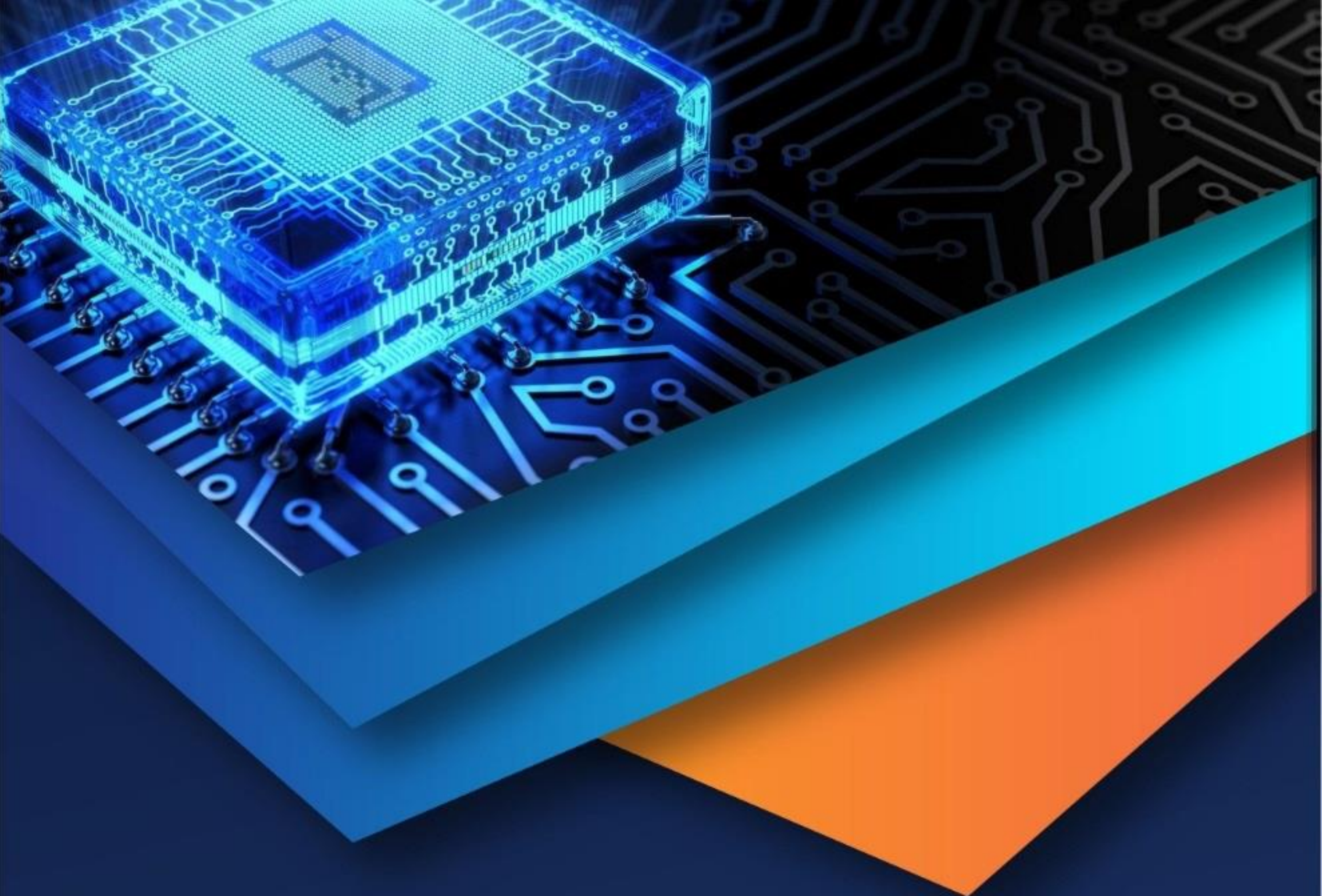
BIOGRAPHY

Ms. A. S. Deshpande received her B.E. degree in Electronics and telecommunication from Pune University in 2009 and received M.Tech in Electronics from Walchand College of engineering, Sangli in 2012. Her area of interest is Digital Image Processing and Communication Engineering. She published 1 International journal papers

Ms. A. S. Shinde received her B.E. degree in Electronics Engineering from Shivaji University at PVPIT, Budhgaon in 2009 and received M.Tech in Electronics Engineering from Walchand College of Engineering, Sangli in 2012. Her area of interest is embedded system. She published 1 International journal paper and 1 Ebook.



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