VLSI Implementation of Watermarking Algorithm Using Phase Congruency and Singular Value Decomposition

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Abstract: The watermarking of digital images is successful in avoiding different attacks. Both the watermark and the host are images and the proposed work aim to ensure the robustness of the embedded watermark. The need of real time watermarking is security and speed and it can be achieved by hardware implementation. By using MATLAB the performance of the algorithm is verified and finally the efficiency of the algorithm is tested in terms of device utilization parameters. The proposed scheme is resistant against the attacks, and it preserves the quality of the original image.

Index Terms: Watermarking, Singular Value Decomposition, Phase Congruency.

I. INTRODUCTION

Due to the rapid growth in the computer and communication networks, the need to protect the multimedia content from illegal works has been made more critical by the advent of digital technology. A common solution to encounter the unauthorized activities of copyrighted contents is applied by means of digital watermarking. The term watermark refers to information hiding techniques in which the secret information is embed inside the multimedia content.

II. SINGULAR VALUE DECOMPOSITION:

Singular value decomposition has a wide range of application in image processing. Singular value decomposition is an algebraic transform for image processing applications.

The signal (i.e.) the watermark which is added to the digital media can be detected and retrieved if necessary.

The basic watermarking algorithm consist of embedding the cover image into the watermark image (secret image) after this the embedded watermark is transferred to the communication channel during transferring there may be different attacks on the image such as geometric attack, forgery attack etc., And finally the detection stage consist of detection of watermark and separation of cover image and watermark image.

The robust watermarking algorithm is one in which the label is extracted with reasonable accuracy even when some attacks is performed on digital watermarked content. The use of singular value decomposition and phase congruency in image processing has also gained attention in the watermarking techniques.

This paper is structured as embedding and extraction process of watermarking in Matlab followed by VLSI design.

In the concept of linear algebra the SVD is a factorization of a rectangular real or complex matrix similar to diagonalization of symmetric square matrices using basic eigen vectors. consider the digital image \( A \) of size \( M \times N \) where \( M \geq N \) and it can be represented as follows

\[ A = U S V^T \]
\[ A_{M \times N} = [U]_{M \times M} [S]_{M \times N} [V]^T_{N \times N} \]

In which \( U \) is the \( M \times M \) orthogonal matrix, \( V \) is the \( N \times N \) orthogonal matrix \( T \) represents the transpose of the matrix and \( S \) is the \( M \times N \) matrix in which the diagonal elements represent the singular values \( S_i \) of \( A \). The columns of \( U \) is called as left singular vectors. It is represented by \( XX^T \), the columns of \( V \) is called the right singular vectors and it is represented by \( X^T X \). In the SVD decomposition of a matrix \( U \) and \( V \) are unitary orthogonal matrices. \( S \) is the diagonal matrix where the diagonal elements are arranged in decreased singular values.

A) Properties of SVD:

SVD is one of the reliable and robust orthogonal matrix decomposition method and some of the important properties of SVD are

1) Subspaces of SVD:

It consists of two subspaces namely orthogonal dominant and subdominant subspaces. Due to this attractive feature, it is used in watermarking and filtering of noise.

2) SVD architecture:

When an image undergoes SVD decomposition, the singular values of the image specify the Luminance of the image while the singular vectors represent the geometry of the image in which the noise in the image corresponds to the eigenimage with singular vectors.
3) Multiresolution in SVD:

Comparing to other transforms SVD has maximum energy transforms with the help of multiresolution the characteristics of the image is measured some of them are resolution, isotropy, self similarity under scaling and mean square error etc

III. PHASE CONGRUENCY:

An edge is the boundary between two different regions where there is a rapid change in the image intensity function. Edge points are pixels at or around which the image values undergo a sharp variations thus important features can be extracted from the edges of an image

The phase congruency model of features detection is a new kind of edge and corner detector. It has a reliable feature detection under varying illumination condition with fixed thresholds. The algorithm for phase congruency is given in the flowchart as follows,

![Fig 4. Flow diagram for algorithm for Phase congruency](image)

IV. WATERMARK EMBEDDING PROCESS:

In the watermark embedding process the watermark image has to be hided in the host image. The phase congruency of the host image is taken so that the watermark image can be resized according to it. Then SVD is taken for the host image in which the resized watermark is added to the $S$ value of the decomposed host image. Again the singular value decomposition is taken to get the embedded image

![Fig 7. Block Diagram For The Embedding Process](image)
V. WATERMARK EXTRACTION PROCESS:

The extraction process is just opposite to the embedding process, the watermark is extracted from the watermarked image (embedded image). By taking out the watermark from the ‘S’ value of singular value decomposition the watermark image which is hided is extracted. The block diagram for the extraction process is given below.

VI. PERFORMANCE EVALUATION AND EXPERIMENTAL RESULTS:

The watermarked image is then transmitted to the extraction process during the transmission process the watermarked image can be damaged or corrupted due to noise or some kind of attacks. The results after simulating different kinds of attacks are generally encountered in the watermarking process. Some of the results are given below.

<table>
<thead>
<tr>
<th>Attacked image</th>
<th>MSE</th>
<th>PSNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blurred image</td>
<td>1.02</td>
<td>36.7336</td>
</tr>
<tr>
<td>Compressed image</td>
<td>9.81</td>
<td>36.5678</td>
</tr>
</tbody>
</table>

Table 1. Robustness of the proposed algorithm against several attacks

VI. VLSI IMPLEMENTATION:

In VLSI implementation the algorithm’s operations are fully implemented in custom–designed circuitry. This investigates great advantages such as it reduces hardware scheme area, decrease power consumption and increase speed of performance.

A) VLSI Implementation of Singular Value Decomposition

The singular value decomposition of 8x8 matrix is simulated in xilinx 14.5 and the results are shown below.
VII. CONCLUSION

In this paper a new image watermarking method that is strong to common attacks was proposed a highly authenticated and secured algorithm for watermarking based on feature detection property of singular value decomposition and phase congruency to protect the copyright of digital contents is designed. The scheme utilizes lesser prominent image feature to hide the watermark image by the technique called phase congruency and singular value decomposition. The data hiding capacity and imperceptibility of the proposed algorithm is superior to other algorithms.

REFERENCES


