SAR Images Watermarking Based on Multiwavelet and Curvelet Transforms

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Received on: 28/2/2016 & Accepted on: 22/6/2016

ABSTRACT
Protect the digital media and provide the copyright is a very important process to confirm their owners, digital watermarking play a vital role which is used to check the copyright contravention. In this paper, a new mixing watermarking algorithm is proposed by using discrete multiwavelet transform and curvelet transform on SAR images. The results showed that the proposed algorithm offers good performance in both subjective and objective tests. When the PSNR values equal to (19.1446, 20.7941, 19.4537 and 19.8802), they were increased in the proposed method to (22.8046, 23.7941, 22.5031 and 22.9106) respectively.
Keywords: Discrete Multiwavelet Transform, Discrete Curvelet Transform, Watermark, Synthetic Aperture Radar (SAR).

INTRODUCTION
Digital watermarking supply a solution to protect transferring Data and images through the Internet, and to identify the owner of this data and images in order to determine its owner and is done through encryption, decryption and hide information through watermarks [1]. Defining a watermark is masking a personal message (text or image) in order to establish the identity of the owner and watermark are visible and invisible types and is accomplished in the time domain or the frequency domain, which adding a lot of security [2].In this paper we perform the watermarking on Synthetic Aperture Radar (SAR) images. SAR is sensing system to notice objects in the pictures with a very high accuracy[3], performs data processing to guess the along-track, position of a scattered by using the modulation due to relative motion, SAR system records both the amplitude and the phase of the back scattered radiation. The reflected waves consists of contributions from different freelance scattering points [4].

The Digital Watermark
Digital image watermarking system consists of embedder and detector, at initially a watermark signal is hidden into a cover image to perform a stego image which then transmitted to the consumer, at last the detector is performed to determine whether the watermark is exist as shown in figure (1) [5]. There are two areas to represent the signal, time domain and frequency domain, when comparing these domains in order to perform the watermark, the watermark in time domain is weak compared to the watermark performed within a frequency domain which is more robustness and strong against the distortions [2].

https://doi.org/10.30684/etj.34.5B.15
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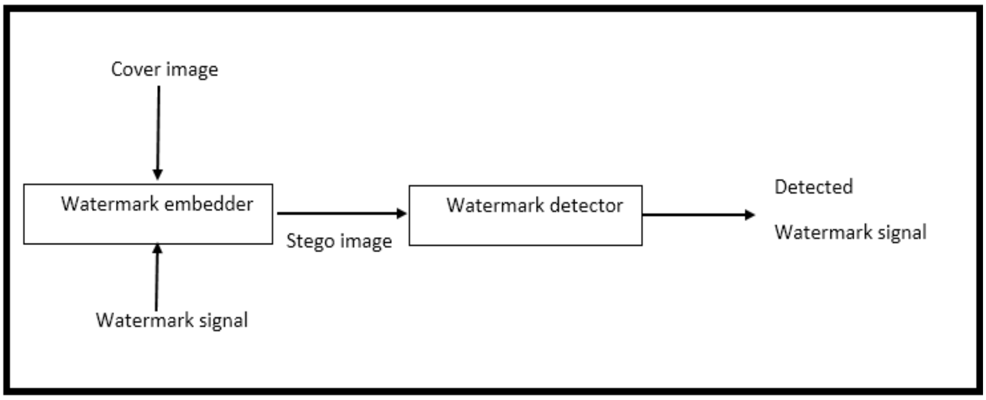


Figure (1): General watermarking system.

Transformation Techniques

Wavelets applications become common in scientific and engineering fields, but it ignore the geometric properties of structures and do not take advantage of the regularity of edges. So, wavelet computationally inefficient for geometric features which cause to oscillations unphysical leak of energy into neighboring scales obtaining an artificial of energy [6].

Multiwavelets are very similar to wavelets but it has more than one scaling and wavelet functions, which provide useful properties as symmetry, orthogonality and high order of approximation [7].

Curvelets are two dimensional waveforms that supply a new structure for multiscale analysis [8]. Curvelets are the technique of a non-adaptive multi-scale object performance which is a stretching of the wavelet concepts, which can represent edges and curves more efficiently and better than traditional wavelet. Curvelets has a changing width and changing length. The length and width of a curvelet can be found through the following equation [9]:

$$Width = (length)^2 \qquad \text{………… . (1)}$$

Curvelets split the frequency plan into dyadic coronae which are sub partitioned into corner wedges displaying the parabolic aspect ratio as shown in figure (2) [8].

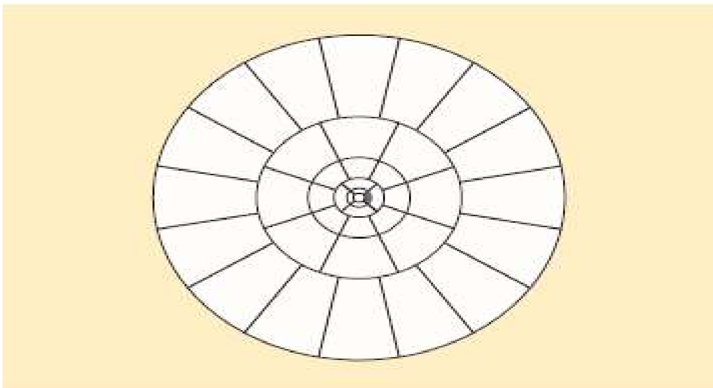


Figure (2): Curvelets in Frequency Domain.

Curvelets at scale 2^{-k}, are of rapid drop away from a spine of length $2^{-k/2}$ and width 2^{-k} and this is the effective support. The discrete curvelet transform is performed using wrapping algorithm. The curvelet coefficients Ck for each scale and angle is defined in Fourier domain by [9]:

$$c_k(r,\theta) = 2^{-3k/4}\, R(2^{-K}\, r)\, A(2^{(K/2)}\, 2\prod.\theta) \quad \ldots\ldots\ldots\ldots (2)$$

Where C_k represents polar wedge supported by the radial(R) and angular (A) windows.

The Proposed System

This paper combines the mixing between Multiwavelet and Curvelet transform to do watermarking on SAR images, each image are resized to 128×128, the main architecture of the proposed mixed method can be seen in figure (3), first the watermarking signal (Gaussian spread spectrum noise) is inserted into host SAR image using two dimensional Multiwavelet transform then perform inverse Multiwavelet transform to produce the watermarked Asset signal (which is used as a watermark signal to another SAR image), inserting these watermarked signal into another SAR image using two dimensional Curvelet transform, which is then inversed to produce the watermarked image which it then tested using PSNR and RMSE measurements. The algorithm of the proposed system can be seen in the algorithm (1).

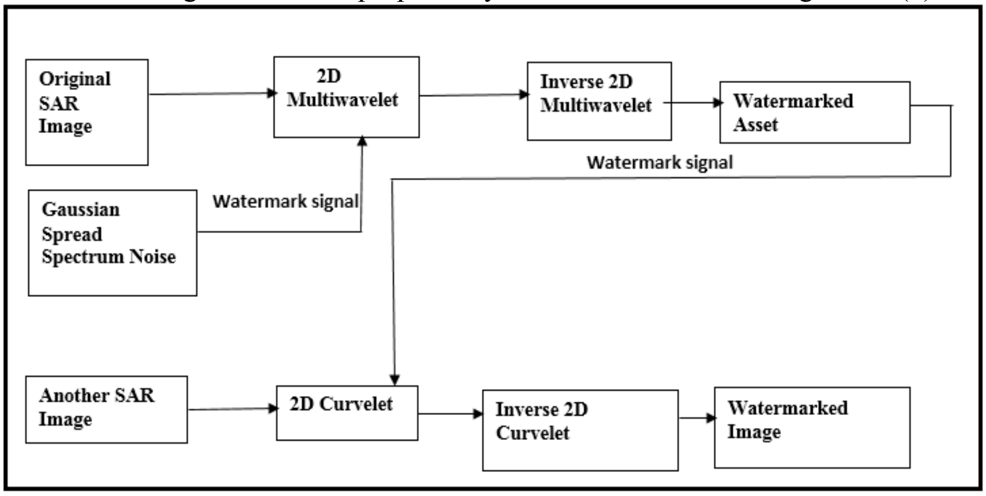


Figure (3): Architecture of the Proposed Watermarking System.

Algorithm (1): Proposed mixing transformation for Watermarking system.
Input: SAR images, Gaussian spread spectrum noise.
Output: Watermarked image.
Step1:- The host image is taken and 2D Multiwavelet transform is performed to the image which decomposes it into (L1L1, L1L2, L2L1, L2L2, L1H1, L1H2, L2H1, L2H2, H1L1 , H1L2, H2L1, H2L2, H1H1, H1H2, H2H1 and H2H2) bands.

Step2:- Generate a Gaussian spread spectrum noise to use as watermark signal and insert the watermark signal into the high frequency coefficients (choose 1000 biggest values from L1L1, L1L2, L2L1 and L2L2 sub bands)

Step3:- Inverse discrete Multiwavelet to produce the watermarked asset.
Step4:- Apply 2D Curvelet transform in to another host image.

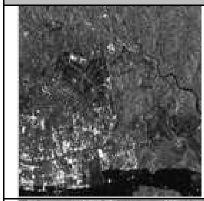
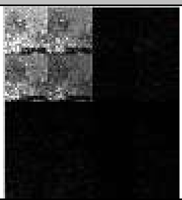
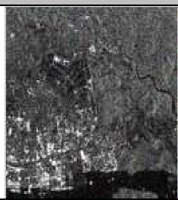
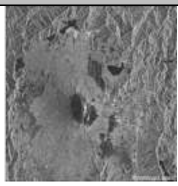
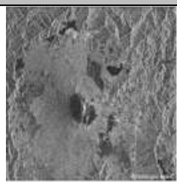
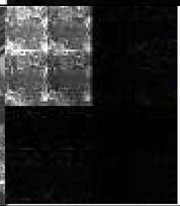
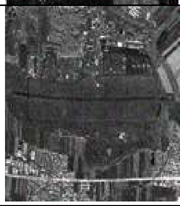
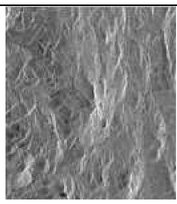
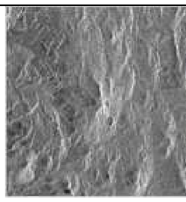
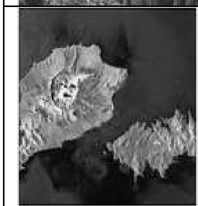
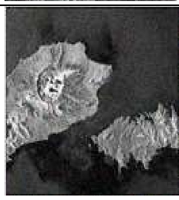
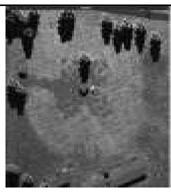
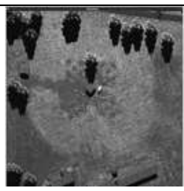
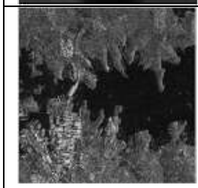
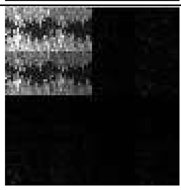
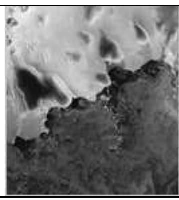
Step5:- Replacing the high frequency coefficients of the host image resulting from step 4 with the coefficients of the watermarked asset resulting from step 3.

Step6:- Perform inverse Curvelet transform to reconstruct the watermarked image.
Step7:- End.

Experiment Results

This work uses SAR images (which are taken from Google SAR images), the host image is watermarked by Gaussian noise signal using 2D Multiwavelet transform which is used as a watermark signal to another SAR image using 2D Curvelet transform as shown in table (1).

Table (1): The Watermarked Images using mixing transforms.

Host image	2D Multiwavelet	Watermarked image With 2D Multiwavelet	Host image	Watermarked image with 2D curvelet
				
				
				
				

The result of the measurement tests can be shown in table (2), which compare between two methods firstly by using 2D Multiwavelet only to do watermarking and secondly by using the proposed mixing transforms.

Table (2): The RMSE and PSNR obtain by applying SAR images watermarking.

Watermarking methods	SAR images	RMSE	PSNR
Multiwavelet method	Host image 1	2.6512	19.1446
	Host image 2	2.7426	20.7941
	Host image 3	2.6603	19.4537
	Host image 4	2.6391	19.8802
Proposed method	Host image 1	0.3502	22.8046
	Host image 2	0.2522	23.7941
	Host image 3	0.4608	22.5031
	Host image 4	0.2298	22.9106

As one can show from Table (2), the Peak Signal to Noise Ratio (PSNR) increased in the proposed method, on the other hand, the Root Mean Square Error (RMSE) decreased in the proposed method, as it is explicit in table (2).

CONCLUSIONS

This paper introduces watermarking algorithm for SAR image based on combining both Multiwavelet and Curvelet transforms, the experimental results in term of RMSE and PSNR shows that proposed method can performs the watermarking very well than watermarking based on multiwavelet only.

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