StableWatermarking for Geometrical Attacks

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Abstract- **In this paper, weponder a scheme which will protect medical images against geometrical invasions. This is based on identifying some character points based on Harris corner threshor and then applying Discrete Cosine Transform on these character points. In this work the scheme is fully automatic. The scheme is made for the purpose of security if any transformation invasion is done. Scheme secures the medical image from these invasions and without disturbing the original watermark.**

Keywords: **Watermarking, transformation, copyright**

I. INTRODUCTION

The possibility of several photo alteringtools in recent time has madeit easy for intruders and buccaneer to copy and modify the ascendancedata content. Distributed system in every fieldhas enhanced the threat for this content as the intruders can easily hack and changeowners digital data. Thus new problems have arisen foreffortlessaccess and circulationof digital data, particularly regarding thesecurity of sensitive medical data. An alternative optionis nowadays requiredfor the above said problems.

II. IMAGE STANDARDIZATION

The image will be first formalizedto form which have the attribute ofprocuring transformations geometrically. Converting the images into itsapprove form requiresdefining the genericizationparameters that are calculated from the "geometric moments" ofthe image. For digital image f (s,t) the geometrical moments and central moments are respectively

$$m_{pq} = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} s^p t^q f(x,y) \quad \ldots\ldots \; \ldots\ldots\ldots \; \ldots\ldots\; 1$$

and

$$\mu_{pq} = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (s-s')^p (t-t')^q f(s,t) \quad \ldots 2$$

$$\begin{bmatrix} s \\ t \end{bmatrix} = \begin{bmatrix} a11 & a12 \\ a12 & a22 \end{bmatrix} \begin{bmatrix} s \\ t \end{bmatrix} + \begin{bmatrix} d1 \\ d2 \end{bmatrix} \quad \ldots\ldots\ldots\ldots\ldots 3$$

The following formula is used for calculation of rotational distortion in the image.

$$\begin{bmatrix} s \\ t \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} \alpha & 1 \\ 1 & \delta \end{bmatrix} \begin{bmatrix} 1 & \beta \\ \gamma & 1 \end{bmatrix} \begin{bmatrix} s \\ t \end{bmatrix} + \begin{bmatrix} d1 \\ d2 \end{bmatrix} \quad \ldots\ldots\ldots\ldots 4$$

For the issue of ascendancytutelage of medical images for thegeometrical transformations, we ponder a durable image watermarking techniquewithaunified solutionhaving moment genericizationand primecharacter based watermarking in "Discrete CosineTransform (DCT)" domain. First, a novice watermarking scheme based on the second generation watermarking notion is pondered. We use primeprovinces based on Harris characterpoint thresher for watermark interposing and thresh process. Second, regarding thegeometrytransform invasions, we do not rely upon the rotatinggenericized disks which are not durableto other affine transform invasions like "shearing and flipping". We instead use whole imagegeneralization, which is ineffective to almost all affine transformations such as "scaling, translation, rotation, shearing and flipping". The durableness of the pondered approach has beenverified using both the facility and compoundedgeometricallyto transforminvasions.

The transform parameters can be obtained from their basic matrix equations. In our workwe adopt the genericization procedure pondered by "P. Dong et al.". After calculatingthe transform parameters, the generalization procedure is applied to input image whichgenerates the image in some generic form as shown in Fig. 3.2 (b). This generic form ofthe image will always have the same shape even image undergoes some facile or compoundedaffine transformations. Fig. 3 shows the generalized images for different distorted versionsof a CT scan image.

2.1 CORNER DETECTION

A Harris corner thresher first calculatesthe horizontal and the vertical diathesis of an image, G_x and G_y. Then two datasets, imagesare filtered by a low-pass filter to get G_x and G_y. Following matrix will define the shape modification parameter:

$$S(i,j) = \begin{bmatrix} \Sigma_{m,n} G_x'(m,n)^2 & \Sigma_{m,n} G_x'(m,n) G_y'(m,n) \\ \Sigma_{m,n} G_x'(m,n) G_y'(m,n) & \Sigma_{m,n} G_y'(m,n)^2 \end{bmatrix} \quad \ldots\ldots\ 5$$

Where (m, n) represents all pixel positions of a window area centred a pixel (I, j). Now we apply harris formula as per the following equation:

$$R(i,j) = \det(S(i,j)) - k.\mathrm{trace}(S(i,j)) \quad \ldots\ldots\ 6$$

here k is a usual constant. The magnitude of k has to be laid down empirically, and inthe literature values in the extent 0.03 - 0.14 have been reported as eventual. Character pointsextraction is obtained by searching for the response R (I, j) greater than the threshold T.

III.GENERATION OF UNALTERABLE PROVINCES

As explained in Section 2 above, ponderedscheme uses Harris character-based unalterableprovinces to interpose the watermark. For this purpose, we first standardize the image as discussedin Section 2 to make the image unalterable to therotation, scaling, translation, shearing, andflipping. Harris character points are then selected from thestandardized image. In order to threshwatermarks without the help of anoriginal image, we must look for character points that are considerable and can prevent various image processing arrangements and desynchronizing invasions. For this purpose, we find most stable character points from a set of threshedcharacter points.The following procedure is adopted for finding most stable character points. In these circular regions we measure the most stable circular region in respect of intensity value and then we keep only those circular region in which the intensity at the centre of the circle will remain constant. All the other circular regions will be discarded.

In fig 1 we can see the circular points. We shall now discard all those circles which are overlapped to each other. After that we shall identify the circles which are on the edges. Because these points on the edges cannot be stable enough, we shall discard all these points also. Rest of the points will be considered as stable points and can be used for detection of distortion. Again we shall count the number of black pixels into these regions. If the number of black pixels are more than 10 percent of the total pixels in the circular region we shall discard circle again.The finally selected character points used for interposing thewatermark.

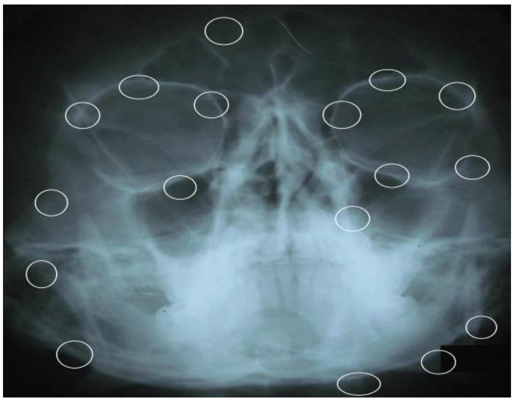

Figure 1:Locally most stable character points selected by Harris Corner Thresher

IV. BLOCK-BASED INTERPOSING

As mentioned earlier, the ponderedscheme uses character points for watermark synchronization;therefore, watermark interposing should not affect these character points. Keeping thispoint in mind, we ponder the block-based DCT-domain interposing instead of full-frameDCT-domain interposing and leave the middle block of thepatch without interposingany watermark information. This prevents the neighboring pixels around the character pointfrom modification. By using this we can get the exact watermark information. Fig. 2(a) shows the ponderedscheme of interposing based on block-based interposing in the patch and Fig. 2(b) shows the full-frameinterposing of thepatch as pondered in.

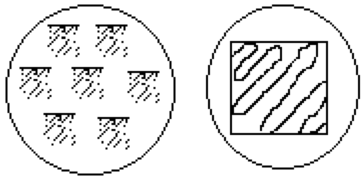

Figure 2: (a) Pondered block-based scheme of interposing (b) Watermarking interposing

V. PONDERED SCHEME

A. *Interposing procedure*

The block diagram of theinterposing procedure is shown in Fig. 3. Each step is explained asgiven below:

1. Standardize the image so that it becomes unalterable to affine transformations, as describedin Section 3;
2. Apply the Harris corner thresher to find the non-overlapped most stable character points;
3. Extract the rectangular speck from circular province based on each character point;
4. Divide the rectangular province into nine 8 × 8 blocks;
5. Divide the watermark into 8 equal parts;
6. Using the fig 2 we use to insert the watermark information which is zigzag in nature.
7. The interposing is performed by selecting 8 pairs of adjacent colligations from mid-frequency DCT colligations in each block;

8. We shall use the watermarking as per the following formulae where f_1 and f_2 are the Discrete Cosine Transforms and b_i is the watermark bit.

If $b_i = 1$ and $K = f1 - f2 < T$, then

$$f'_1 = f_1 + \frac{T-K}{2}$$

$$f'_2 = f_2 - \frac{T-K}{2}$$

else if $K = f1 - f2 > T$, do nothing

and

If $b_i = 0$ and $K = f_2 - f_1 < T$, then

$$f'_1 = f_1 + \frac{T-K}{2}$$

$$f'_2 = f_2 - \frac{T-K}{2}$$

else if $K = f_2 - f_1 > T$, No operation;

Repeat step 2 to 8 for all the blocks into the circular region.

9. Now we take another circular region, divide it into 8 blocks and repeat the above steps until all the watermarking information could be embed.

B. *Extraction procedure*

1. Input image
2. Apply the Harris corner thresher to find the non-overlapped most stable character points;
3. Get the square patch from circular province based on each character point;
4. Divide the squareprovince into nine 8 × 8 blocks;
5. Using the following equation we extract the watermark from the original image. As the centre of the circle is the relative point for the stability it remains unaltered.

$$b_i = \begin{cases} 1; & f_1 \geq f_2 \\ 0; & f_i < f_2' \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 7$$

6. We recombine the all the watermark information obtained from different blocks.
7. Repeat steps 3-6 until all character points are processed;
8. Calculate the standardized correlation (N_c) to evaluate the similarities between the interposed and extracted watermarks;

$$N_c = \frac{\Sigma_{i=1}^{n} b(i) b\prime(i)}{\sqrt{\sum_{i=1}^{n} b^2}\sqrt{\Sigma_{i=1}^{n} {b'}^2(i)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 8$$

where n is the watermark length and b and b' are the original and extracted watermarks respectively;

9. Decide the authenticity of theimage by considering the maximal Nc value from all thepatches.

VI. EXPERIMENTAL RESULTS AND DISCUSSIONS

The notion of affine transform distortions in medical images is new and few works arereported. However, the existing works addressing the issue of the affine transform distortions, report results on natural images. We, therefore, compare the pondered technique withexisting techniques on generic Lena image and then report results on medical images.

A. *Results on medical images*

In the second phase, we tested the pondered scheme on medical images. The pondered algorithmcan not be directly applied on medical images due to the following reasons:

1. Medical images are composed of theprovince of interest (ROI) and theprovince of non-interest (RONI).ROI is important for aphysician for making adiagnosis, so its integrity must not be compromiseddue to the watermark interposing process.
2. The amount of distortion should be minimum as possible.

Keeping these points in mind, we ponder to interpose the watermark information in the RONIonly. Also, in the ponderedscheme a small amount of distortion is introduced due to interpolationprocess when we standardize the image before interposing and inverselystandardizes after interposing.In order to get better tradeoff between the imperceptibility and durableness, we use watermark ofsmall size. For medical images, we also use the same watermark of 32 bits.In order to avoid the watermark interposing in ROI, we take the arbitrary shape for isolatingthe ROI from RONI. For CT scan images we take the actual lung parenchyma by segmenting theCT scan image into ROI and RONI while for other medical images we take the arbitrary circularwindow with aradius equal to 100 pixels. For finding the locally most stable character points afterstandardizing the medical image, we apply the Harris corner thresher with following two schemes.

- Thresher followed by Segmentation (DFS) scheme
- Segmentation followed by Thresher (SFD) scheme

(a) DFS Scheme

In this scheme, we first find character points by applying the Harris Corner thresher and then formaintaining the integrity of ROI we discard the character points lying in ROI. This scheme givesbetter results for images such as MRI, Ultrasound, and XRAY. However, in thecase of CT scan images,it was found that thresher was unable to find character points on most of the CT scan images, thusmaking the DFS scheme unsuitable for watermarking the CT scan images. This was due to thefact that the CT scan image contains the lung parenchyma which is ahighly textured province with clear edges. As Harris corner thresher mostly finds corners as character points, so most character pointsfound were concentrated in ROI. And as per requirement of RONI interposing, if we discard allthe character points lying in ROI, all character points found by DFS schemevanish from inputCT scan image and results in no character points selected for further watermark interposing. Thisscenario is shown in Fig. 5. In order to overcome this deficiency, we proceed for the SFD scheme.

Figure 5: (a) Character points selected by corner thresher on standardized image (b)Non-overlapped most stable character points selected (c) No character point selected byDFS scheme

(B) SFD SCHEME

In this scheme, we isolate the ROI first and then apply the Harris Corner thresher for extractingcharacter points. The detailed procedure is defined as under:

1. Mark the logical boundary on the standardized image for isolating ROI;
2. Extend the logical boundary by distance of r, where r is the radius of the circular window;
3. Crop the area bounded by the extended boundary;
4. This will generate the black hole in the image, which forces the thresher to find the characterpoints around the ROI.

The complete cycle of SFDscheme is depicted in Fig. 6

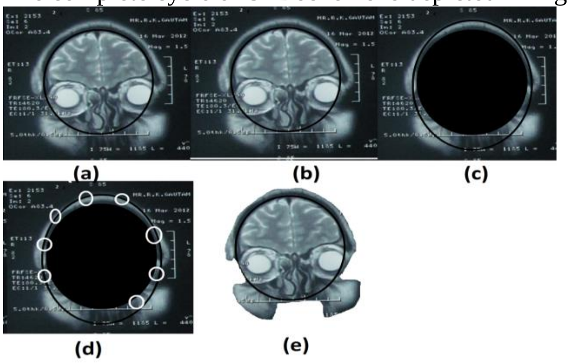

Figure 6: Complete cycle of SFD scheme:(a) Standardized imagewith ROI isolated (b) Logical boundary extended (c) Area cropped underlying extended logical boundary (d) Harris corner thresher applied (e) Finally selected character points shown on standardized image

We can easily see that SFD method gives good results after different geometrical transformations.We have done our experiment on thedifferent medical image of type, X-ray, MRI and ultrasound images obtained from the courtesy of Dr. Ram Manohar Lohia Hospital Lucknow. The circular region for protection of images will be taken as the size of 20 pixels in sizeThe watermark length will be taken as of size 32 bits The residual after segmentation is shown in fig 6 above. The distortion in the image has been measured in terms of PSNR value. From the data, we can easily see that the PSNR value is larger than 40 in all the cases which prove thegoodness of the method.

For checking our methods output, we performed a number of translation, rotation and scaling attacks following in combination also onto the image. The result is shown in table 3. For theoutcome of the method, we are taking correlation function. We can see that correlation function for translation is mostly near 1 which proves good for the method. For rotation invasions, up to 30 degrees most values of standardized correlation are higherthan 0.8. The ponderedscheme is durable to scaling, even when the watermarked image is scaleddown to half of the original size. When the image is zoomed in, most similarities are equal to oneor near to 1. This is because when the image is zoomed in, little information is lost. The scheme isalso durable to translation invasions. From Table 5, it can be observed that the ponderedschemeis also durable to shearinginvasions. When the image is sheared on either on x-axis or y-axis orboth on x-axis and y-axis, most similarities are equal to 1. The scheme is also durable to combinedinvasions such as Rotation plus shearing, Scaling plus shearing, Translation plus shearing. However,the scheme has not attractive results for shearing plus JPEG compression. All results of facileand combined invasions are given in Table 4 and Table 5

SFD SCHEME

Image	DFS Scheme	SFD Scheme
CT	0	11
MRI	6	13
Ultrasound	7	8
XRAY	4	14

Table 1: Showing the distortion introduced in cover image in terms of PSNR

Image	PSNR
CT	45.4549
MRI	47.7896
Ultrasound	49.0673
XRAY	45.9363

Table 2: Watermark durableness to geometric invasions on medical images

Type of Invasion	Standarized Correlation			
	CT	MRI	Ultrasound	X-Ray
R(1)	1.000	1.000	1.0000	1.000
R(5)	1.000	0.967	1.0000	0.968
R(10)	1.000	0.968	0.9643	1.000
R(15)	1.000	0.968	0.9333	1.000
R(30)	1.000	0.934	0.8543	0.933
R(45)	0.7893	0.9653	0.6064	0.8134
R(60)	0.796	0.854	0.4900	0.713
R(75)	0.689	0.754	0.3894	0.507
S(0.2)	0.580	0.645	0.3330	0.426
S(0.3)	0.539	0.453	0.4787	0.534
S(0.5)	0.733	0.533	0.6986	0.534
S(0.7)	0.932	0.605	0.8246	0.688
S(0.9)	1.000	0.651	0.9452	0.744
S(1.1)	1.000	0.876	0.9457	1.000
S(1.3)	1.000	0.985	1.0000	1.000
S(1.5)	0.823	1.000	0.9333	1.000
S(1.7)	0.854	1.000	0.7434	0.966
S(1.9)	0.743	0.975	0.6624	0.751
T(5)	1.000	0.856	1.0000	0.710
T(10)	1.000	0.700	1.0000	1.000
R(5)+S(0.8)	0.934	1.000	0.8555	0.956
R(10)+S(0.8)	1.000	1.000	0.9653	0.745
R(15)+S(0.8)	0.966	0.895	0.9393	0.965
R(30)+S(0.8)	0.876	0.986	0.8456	0.985

Table 3: Effect of distortion on medical image under different geometrical attacks

VII. SUMMARY

A blind durable watermarking scheme based on character point watermarking and image standardization technique has been pondered for the ascendancy of medical images. Several unalterableprovincesare extracted for conveying the ascendancy information. The initial image is standardized to make itunalterable against geometric distortions and other affine transformations. The circular provinces arethen extracted from the standardized image. On the basis of unalterableprovinces, thedurable watermarkingtechnique is designed. DCT domain is used for both watermark interposing and extraction. Theponderedscheme address the issue of affine transformations such as shearing, flipping and compoundedinvasions of affine transformations besides the basic transformations like rotation, scaling andtranslation.

In order to maintain the integrity of ROI in medical images, ROI is avoided from interposingthe watermark. The ponderedscheme can easily find the place in the medical data management,where geometric distortions are of great concern. One limitation of the ponderedscheme is theintroduction of distortion due to interpolation errors. Though ROI is prevented during the watermark interposing process, the interpolation errors generated during standardization and inversestandardization still cause distortion in the province of interest. The scheme can be improved by usingthe improved schemes of interpolation or segmenting the ROI part first from theoriginal cover imageand then standardization and characterthresher process can be performed. After inverse standardization, the image can be reconstructed by putting back original ROI, thus avoiding the errors in ROI which results in better quality of watermarked image.

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