Using Spiral Scan Technique for Medical Image Watermarking with Tamper Detection and Recovery

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Abstract

This paper will study the spiral scan technique for Medical Image Watermarking with Tamper Detection and Recovery by Jasni Mohd Zain (2006).The spiral algorithm in clockwise and anti-clockwise direction is presented to test when the tamper is made near to the centre of image. For ultrasound image, this is highly likely because the region of interest (ROI) happens to be in the centre of the image. Using spiral technique, we show that the block spiraling and starting in the middle will have a greater chance of recovery compared to the simple raster scan technique which is start from left to right starting at the top-left corner and reverse raster scan technique. Besides, we present the recovery rate of spiral scan technique in 6 X 6 block size of image with 2 X 2 and 4 X 4 block tamper. Recommendations will then be made to enhance the technique especially in the aspect of recovery or reconstruction rate for medical images.

Introduction

Authentication watermarking with Tamper Detection and Recovery (AW-TDR) is a digital watermarking method for image tamper detection and reconstruction or recovery proposed by Zain and Fauzi[1]. The contribution of this method is the integration of four concepts; 1) block-based[2]; 2) separating authentication bits and recovery[3]; 3) hierarchical[4]; and 4) average intensity as image feature[5]. The method is efficient as it only uses simple operations, such as a parity check and comparison between average intensities. It is effective because the scheme inspects the image hierarchically with the inspection view increasing along with the hierarchy so that the accuracy of tamper localization can be ensured. This scheme can perform both tamper detection and recovery for tampered images. Tamper detection is achieved through a block-based, inspection and recovery of a tampered block. It relies on its feature information hidden in another block that can be determined by a one dimensional transformation. In this paper, we propose a watermarking scheme that can detect and localize tampered and recovered images that also will be made for a better distribution of watermark to minimize the distortion of the Region of Interest (ROI). The purpose is to verify the integrity and authenticity of medical images. In Section 2, we present the proposal of spiral scan techniques that could obtain the better result of recovery rather than the reverse raster scan technique. In Section 3, we present the expected result of recovery rate using spiral scan technique, describing the preparation of blocks using spiral algorithm. In Section 4, conclusion is made with some remarks.

Reconstruction

Reconstruction or recovery is achieved by embedding the recovery bits in a block some distance away from the original block[2]. In this section a case using intensity average comparisons and parity bits as the authentication watermark is presented. To localise tamper in a block, the watermark needs to be embedded directly into that block. If a block is being tampered locally, the intensities of the pixels involved will be changed. This will also change the average intensity of the block concerned. To ensure that this is not changed, a parity check will be used. However, a parity check alone will not guarantee that the block has not been changed, because local tampering usually causes burst error[6], meaning that if more than one bit has been changed, a parity check is no longer useful. ECC will help solve this issue, but again more watermark bits will be needed. To overcome this, the intensity comparison is used as another guard if a parity check fails. This feature will also be used to break block wise independent. To break block wise independent, the intensity of the block is compared to the intensity of a larger block.

LSB is suggested to minimise the degradation as medical images are very stringent with the quality. The recovered image however will not be considered authentic and will not be used for any clinical purposes. One possible purpose for recovery is to help in the investigation to find the motive and the person responsible for the tampering. A 3x3 sub block in a 6x6 block is suggested to accommodate two authentication bits and seven recovery bits to be embedded in the LSB of each pixel as shown in Fig. 1.

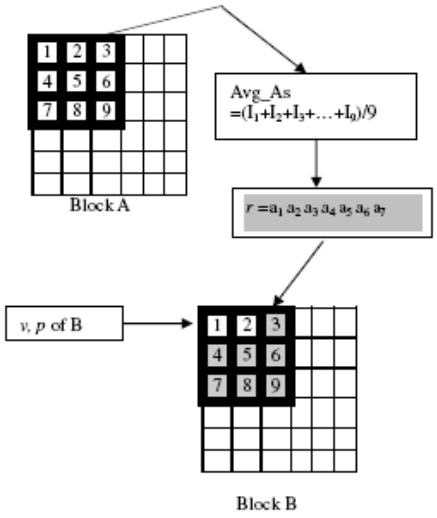

Fig. 1 Watermark generation and embedding location

Embedding

For each block B of 6x6 pixels, divide it into four sub-blocks of 3x3 pixels. The watermark in each sub-block is a 3-tuple (v, p, r), where both v and p are 1-bit authentication watermark, and r is a 7-bit recovery watermark for the corresponding sub-block within block A mapped to B. The following algorithm describes how the 3-tuple watermark of each sub-block is generated and embedded:

a) Set the LSB of each pixel within the block to zero and compute the average intensity of the block and each of its four sub-blocks, denoted by avg_B and avg B_s, respectively.
b) Generate the authentication watermark, v, of each sub-block
c) Generate the parity check bit, p, of each sub-block.
d) From the mapping sequence generated in the preparation step, obtain block A whose recovery information will be stored in block B.
e) Compute the average intensity of each corresponding sub-block As within A, and denote it avg_A_s.
f) Obtain the recovery intensity, r, of A_s by taking the seven MSBs in avg_A_s.
g) Embed the 3-tuple watermark (v, p, r), 9 bits in all, onto the LSB of each pixel in Bs.

Proposal of Spiral Scan Technique

Figure 2 shows an 8 X 6 block with blocks 1, 24 and 48 are tampered and the recovery bits stored in block 1, 24 and 48. There are some blocks that could not be recovered, the only block that will be recovered is block 24. The reason being that information for block 1 is embedded in block 24, which is tampered with resulting in a loss of information. The same applies to block 48, where the recovery bits were embedded in block 1 which has been tampered with. The recovery bits for block 24 however were embedded in block 25 that has not been tampered with. So, we will propose another scan technique to solve this problem, which is spiral scan technique.

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48

(a)

48	23	46	21	44	19	42	17
40	15	38	13	36	11	34	9
32	7	30	5	28	3	26	1
24	47	22	45	20	43	18	41
16	39	14	37	12	35	10	33
8	31	6	29	4	27	2	25

(b)

Fig. 2 a) An 8x6 block with blocks 1,24 and 48 are tampered (b) Recovery bits stored in block 1,24 and 48

Figure 3 shows the 8x6 numbering of blocks using reverse raster scan technique and the watermark embedding. Block 1,24 and 48 are tampered and the result of recovery is similar with simple raster scan technique in figure 2. From the preliminary analysis, simple raster and reverse raster technique will give the same result, means that the rate of recovery is equal.

48	47	46	45	44	43	42	41
40	39	38	37	36	35	34	33
32	31	30	29	28	27	26	25
24	23	22	21	20	19	18	17
16	15	14	13	12	11	10	9
8	7	6	5	4	3	2	1

(a)

25	12	27	4	29	6	31	8
33	10	35	12	37	14	39	16
41	18	43	20	45	22	47	24
1	26	3	28	5	30	7	32
9	34	11	36	13	38	15	40
17	42	19	44	21	46	23	48

(b)

Fig. 3 a) Reverse raster technique; an 8x6 block with blocks 1,24 and 48 are tampered (b) Recovery bits stored in block 1,24 and 48

Using spiral scan technique, the preliminary analysis shows that this technique could give a better chance of recovery rather than simple raster and reverse raster scan technique as shows in figure 4. The block of image are dividing the rows and columns by two (Row/2; Column/2) to get the centre of block of the image. Using the coordinate concept, the level of each block is determined and each block is mapped using equation; $Bx=[(k \text{ x } B)\text{mod } N_b]+1$.

48	31	32	33	34	35	36	37
47	30	13	14	15	16	17	38
46	29	12	3	4	5	18	39
45	28	11	2	1	6	19	40
44	27	10	9	8	7	20	41
43	26	25	24	23	22	21	42

(a)

25	18	41	16	39	14	37	12
2	43	36	11	34	9	32	35
27	20	13	46	21	44	7	10
4	45	38	23	48	19	30	33
29	22	15	40	17	42	5	8
6	47	24	1	26	3	28	31

(b)

Fig. 4 (a) Spiral numbering of blocks (b) mapping with k=23, shaded blocks will be recovered for 4x4 blocks tamper

The following algorithm describes how spiral number does its work[7]:

(a) Number of blocks is calculated based on an image chosen.

(b) Number of rows and columns is divided by 2 to get the centre block of image;(Row/2,Column/2)

(c) Key number is set using equation; k=max(primes(numblock/2))

(d) Numbering the block start from top-left block to top-right block (row by row) until all blocks is numbered using coordinate concept. For example, starting block is start from coordinate (1,1),then (1,2) and so on.

(e) Coordinate for each block is calculated[7,8] ; [column- centre of columns, row-centre of rows].

(f) Ring level of the blocks is determined, such as level 1 is for sequence number from number 2 until 9, level 2 is for sequence number from number 10 until 25, and so on. Please refer figure 3 (a) to get some idea of the level determination. From level, we could calculate the first number and last number of each level.

(g) After all blocks is numbered in spiral manner, each block is mapped (watermark embedding) using equation; $Bx=[(k \times B) \bmod N_b]+1$.

Expected Result

From algorithm applied, our preliminary result show that the block spiralling and starting in the middle will have a greater chance of recovery compared to our proposed method. If we tamper with the 2x2 block in the middle, with the spiral method we will have a 100% recovery as in figure 5(b). If we have 4x4 blocks tampered, the spiral method will give a higher recovery rate of 12/16 = 75% than simple raster and reverse raster technique which only have 5/16= 31% recovery rate.

48	31	32	33	34	35	36	37
47	30	13	14	15	16	17	38
46	29	12	3	4	5	18	39
45	28	11	2	1	6	19	40
44	27	10	9	8	7	20	41
43	26	25	24	23	22	21	42

(a)

25	18	41	16	39	14	37	12
2	43	36	11	34	9	32	35
27	20	13	46	21	44	7	10
4	45	38	23	48	19	30	33
29	22	15	40	17	42	5	8
6	47	24	1	26	3	28	31

(b)

Fig. 5(a) Spiral numbering of blocks with block 8,11,14 and 15 are tampered in the middle image (b) Recovery bits stored in the middle of image (block 11 and 15).

Conclusion

We evaluated watermarking scheme presented by Zain and Fauzi [1] and proposed a revised scheme that could detect and localise tampered and recovered images. The purpose was to verify the integrity and authenticity of medical images especially to minimize the distortion of the Region of Interest (ROI). We presented our proposal of spiral scan technique for Medical Image Watermarking with Tamper Detection and Recovery that included preparation of blocks algorithm, and the preliminary result of the recovery rate. The preliminary result show that this technique could give a better chance of recovery rather than reverse raster scan technique. If we tamper with the 2x2 block in the middle, with the spiral method we will have a 100% recovery. If we have 4x4 blocks tampered, the spiral method will give a higher recovery rate of 12/16 = 75% than reverse raster technique which only have 5/16= 31% recovery rate.

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