Adaptive Watermarking using PSO and Fuzzy Logic Approach

Ashish Bansal, Neha Gupta

Abstract: ***Digital Watermarking with PSO and Fuzzy Logic is an attempt to find suitable locations for inserting watermark bits using PSO and Fuzzy Logic, by looking at the surrounding pixels and adaptively adjusting the pixel intensity values to encode the watermark bits. The result obtained in this technique indicate that following adaptive insertion on the pixels after finding location by PSO is even more effective to obtain better fidelity and robustness. The inverse tradeoff between robustness and fidelity is also demising.***

Index Terms: Digital Watermarking, Fuzzy Logic, PSO, Robustness, Fidelity, Digital Security.

I. INTRODUCTION

This technique divides the image into the blocks of pixels and watermark insertion is adaptively inserted into pixels of these blocks using fuzzy logic and inference system.

The selection of block is done using PSO and the locations of the blocks are chosen by Fuzzy Logic. The inputs to the fuzzy inference system are obtained from the fuzzified average intensity of the left and right adjustment block of the concerned block and the output of the inference system is the fuzzy intensity adjustment of the pixels of the center block which is then defuzzified to provide crisp value of the pixel intensity of the pixels of the central block.

During the watermark extraction stage the watermark bits of a particular block are extracted using the pixel intensity adjustment value of the block and the pixel intensity value of the same block from the original cover image. Then the watermark information of all the block are assembled to form the complete extracted

Watermark. In this scheme, PSO is used only for the selection of the block precisely the starting location of the block.

II. APPROACH FOR WATERMARK EMBEDDING

1. The cover image is divided into 4*4 block. The number of blocks should be sufficient to accommodate watermark image into the cover image.
2. The block for inserting the watermark is selected using PSO.
3. The left and right block of this block are identified. If it is not available this block is rejected and the next one is chosen.
4. The average pixel intensity are calculated in the left and right block.
5. This average values are fuzzified using five input membership functions black, light Gary, green, dark gray, white to the fuzzy inference system.
6. Fuzzy rules are applied to find the fuzzy adjustment the pixel intensity using the fuzzy block.
7. The fuzzy rules are framed using the following concept according to characteristic of HVS.

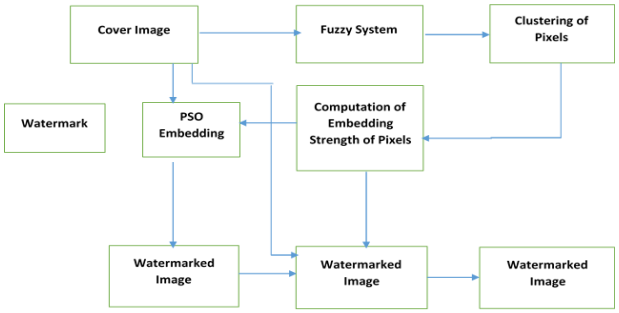
a. The combination BLACK & WHITE Gives MEDIUM pixel adjustment.
b. The combination of BLACK & LIGHT GRAY, GRAY & DARK GRAY gives MINIMUM pixel adjustment.
c. The combination of white with LIGHT GRAY, GRAY & DARK GRAY MAXIMUM pixel adjustment.
d. The combination of LIGHT GRAY & GRAY gives MEDIUM pixel adjustment. The combination of GRAY & DARK GRAY gives MEDIUM pixel adjustment.
e. The combination of LIGHT & DARK GRAY gives MEDIUM pixel adjustment.

8. The output of the fuzzy inference system is the adaptive pixel intensity adjustment value for the pixel of center block.
9. The crisp value of the output is obtained after defuzzification. Now the watermark is inserted adaptively into the central block

III. APPROACH FOR WATERMARK EXTRACTION

1. The block is selected from PSO system.
2. The watermark bits for all the pixels of this block are extracted using the pixel adjustment value of the watermark and the pixel intensity before and after watermark bits are inserted.
3. These are assembled to form the watermark information for this block.
4. The watermark information from all the blocks selected by the PSO are obtained and then assembled to create the complete watermark.

IV. BLOCK DIAGRAM OF WATERMARKING USING PSO AND FUZZY LOGIC



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V. ALGORITHM FOR WATERMARKING USING PSO AND FUZZY LOGIC

1. Set Parameters W_{min} ,W_{max}, C1 & C2 of PSO

2. Initialize population of particles having Position(X, Y) and Velocities (X,Y)=

$$[(X1,Y1),(X2,Y2) \dots \dots \dots \dots Xn\ ,Yn]^T$$

Each individual particle (Xi, Yi) is given as

[Xi, Yi] = $[(Xi\ Yi)_1,(Xi\ Yi)_2 \dots \dots (Xi\ Yi)_D]$

And V= $[Vi_1, Vi_{2\dots\dots}Vi_D]$ When

The index I varies 1 to N and the index J Varies from 1 to D.

3. Set iteration k=1
4. Calculate fitness of particles.

F_i^k = f$(Xi,Yi)^k$, ∀i and find index of best Particle b.

5. Select $Pbest_k^i$=$(Xi,Yi)^k$, ∀i and $Gbest^k$ = $(Xb,Yb)^K$

6. W =W_{max}-W_{min}/max

7. Update velocity and position of particles

$V_{i,j}^{k+1}$ = WV_{ij}^k + $C_1 * rand()$ $(best_{ij}^k - (X_i\ Y_i\ )_j^k)$

+ C_2 * rand() $(best_{ij}^k - (X_i\ Y_i\ )_j^k$ ∀i ,∀j)

$$(X_i\ Y_i\ )_{j+1}^{k+1} = (X_i\ Y_i\ )_j^k + V_{ij}^k \forall\ [\forall i\ ,\forall j]$$

8. Calculate fitness F_i^{k+1} = F(Xi , Y_i^{k+1}) ∀i and find index of best particle b_1

9. Update$P_{best}$of Population ∀i

If

F_i^{k+1}<F_i^k

$Pbest_i^{k+1}$ = X_i^{k+1} else $Pbest_i^{k+1}$ = $Pbest_i^k$

10. Update Gbest of population

If

F_b^{k+1}<F_b^k

$Gbest^{k+1}$ = $Pbest_b^{k+1}$ and set b=b1

Else

$Gbest^{k+1}$ = $Gbest^k$

11. If K<maxite then K=K+1

And goto step 6 else goto step 12.

12. Print optimum solution as $Gbest^k$ (parameter)

Initial WT = 0.9 to 0.4
Acc. Factors (C1 & C2): 2 to 2.05
Top size = 10 to 100
Maximum iteration (Maxite): 500 to 1000

VI. FITNESS FUNCTION USING INSIGNIFICANT PORTIONS OF THE PIXEL INTENSISTY VALUES AND PSO

1. Cover image X, Y is divided into 4*4 blocks. No of blocks = no of Pixels in watermarked image/4*4
2. Block for inserting a watermarked is selected.
3. The left & right block of this block are identified.
4. Average Pixel intensity are calculated in left & right block.
5. These average values are Fuzzified in to the fuzzy words in, BLACK, LIGHT GRAY, DARK GRAY, & WHITE and serves as an input to FUZZY inference system.
6. Fuzzy rules in point no 5 is applied to find Fuzzy Adjustment in pixel intensity of central block Based on Fuzzy inputs from left to right block,

   Fuzzy AND operator is performed with Min().The aggregation is performed with MAX function.

   a) For all 4*4 block of cover image repeat b to g
   b) Select adjacent left & right block if not available then selected next Block.
   c) Average intensity from left & right block are fuzzyfied & provided as inputs to FIS. Where FIS stands for Fuzzy Inference System
   d) Fuzzy output is obtained.
   e) Fuzzy output is defuzzified to get crisp values for the pixel intensity adjustment.
   f) For each pixel in selected block modified intensity

   P_2 = P + W * (Block_adjust_values)

   P = original Intensity values.

   P_2 = Modified Pixel intensity

   W = watermark intensity

   Block adjust value = adaptive adjustment

   Now PSNR is obtained

$$\Sigma e^2 = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(\text{Xij} - \text{Zij})^2$$

Now attack is done and NC is obtained

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VII. EXPERIMENTS AND RESULT

Cover Image	Watermark Image	PSNR (dB) of watermarked Image and NC of watermark extracted (no attack situation) PSNR, NC	Size of watermark inserted	Attack	PSNR(dB)of extracted watermark and NC after attack
		43.41 , 0.985	117*114 pixels with 256 grey values	Blurred (0.5%)	40.68,0.922
				3*3 averaging filter	41.42,0.922
				Cropped (30%)	43.7,0.985
				Contrast and Enhanced (40%)	40.89,0.964
				3*3 contrast enhancement filter	40.91,0.988
				Compressed CR = 10.75 QF= 50%	42.45,0.986
				Gaussian Noise(25%)	41.96,0.977
				with variance =0.1	40.87,0.967
				Sharpened (30%)	40.78,0.954
				3*3 lapacing filter	41.77,0.966
				Rotated(15 degree)	39.61,0.931
				Scaled (50%) (1-1/2-1)	41.55,0.956
				1-3-1	41.99,0.961

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VIII. TRADE OFF BETWEEN ROBUSTNESS & FIDELITY (ADAPTIVE WATERMARKING USING FUZZY LOGIC)

Sr. No	Fidelity-PSNR (dB) (watermarked Image) (un-attacked)	Normalized Correlation (Extracted Watermark) (Unattached)	Trade Off
1	42.21	0.985	NO
2	42.21	0.985	
3	42.21	0.986	

IX. DISCUSSON

Digital watermarking with PSO and fuzzy logic is an attempt to find the location using PSO and employing fuzzy logic by looking at the surrounding pixels and adaptively adjusting the pixel intensity value to encode the watermark bit. The result obtained in this technique indicate that following adaptive insertion on the pixels after finding location by PSO is even more effective to obtain better fidelity & robustness. The inverse tradeoff between robustness and fidelity is also demising.

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