NBP-IWT-DCT-SVD-PSO Based Secure Image Watermarking

CH. Ravi Kumar, R. Surya PrakasaRao, P. Rajesh Kumar

Abstract: This paper proposes energetic photograph watermarking approach contingent upon entire wide variety Wavelet alternate, Discrete cosine change, unique well really worth Disintegration and Molecule Swarm Streamlining. PSO is implemented to get an extremely good watermarking predictable. further, to make the watermarked picture continually fiery to disenchantment and flinging assaults, in advance than introducing the Standardized square system is achieved to the host image. because the population duration assembles, GA cannot overhaul the gadget snappy, consequently the proposed watermarking plan mulled over PSO is for improve, diverse investigations have been pushed on the proposed manner to manipulate analyzezeth execution. The got results display that the proposed system is higher than customary strategies and is the general public of the more capably comfortable over Gaussian confusion, Salt and Pepper Commotion, middle Sifting, Trimming, Pivot, Complexity development, Scaling and Histogram Leveling attacks.

Index Terms: Digital image watermarking, IWT, DCT, SVD, GA, PSO, PSNR, NC, SSIM.

I. INTRODUCTION

the existing improvement driven economic framework realizes comfort and thought for digitization of the academic trinket. Propelled photograph Watermarking [1, 2] is the approach of expansion of picture watermark in media substance and its extraction, on every occasion required, for certification or ownership take a look at of media content. A propelled picture watermark is the records that is covered up authentically in media content material, it is immaterial to a human onlooker [3]. The realness of a computerized substance sensitive watermarking is applied whilst, with the end purpose of copyright assure, healthy watermarking is applied. This request is software-set up. Watermarking plans may be portrayed into outwardly weakened, semi-trance, and non-stupor getting ready. One more is potential relying at the hole of embedding of watermark: spatial and repeat. a specific look at of watermarking plans can be determined in [4, 5]. In programmed image watermarking, streamlining placing in constant to such an amount, that the watermarked image need to be possible and unpretentious freed from situation. commonly, the individual made mental aptitude approaches, as an instance, Hereditary figuring (GA), Molecule swarm streamlining (PSO), Subterranean insect territory improvement (ACO, and so on., systems might be used for headway capacities. In [6], by way of joining the every GA and PSO to get a sophisticated display, anyways, [6] breaks down the photograph through the maximum severe usually found out Discrete wavelet substitute (DWT) this is having simple difficulty of insights setback. In mild of the down investigating framework in DWT, the person of the watermark is probably decreased. In [7], a square plan watermarking is proposed based totally really as for Discrete Wavelet change (DWT) and particular well worth breaking down (DWT). The estimation band ended up supplied to SVD from the were given sub agencies. In light of GA, PSO method joins the host photo institutionalization and techniques for dealing with into squares to restrict upset and scaling assaults. At that aspect IWT is achieved on each square and the have been given wager band is discovered to institutionalized SVD. Embedding. The display emerge as evaluated for explicit assortments of moves. The rest of the paper is looked after out as seeks after: phase II outlines the nuances of associated paintings. portion III gives a have a look at more or less the starter musings used on this paper. Territory IV strains the nuances of proposed strategy. Fragment V diagrams execution appraisal nuances at last region VI shuts the paper.

II. RELATED WORK

In a robust picture watermarking plan investigators have accomplished in spatial and changed area that find out a replacement off amongst those targets. The spatial spot watermarking strategies truly embed with the manual of fixing the pixel regards in the watermark into the host image [8–11]. those methodologies for the maximum intense element are less floor-breaking to photo and banner adapting to ambushes and required low computational undertakings there are numerous trade territory watermarking frameworks, for instance, Discrete cosine changes (DCT) [12], discrete Fourier changes (DFT) [13–14], discrete wavelet adjustments (DWT) [15–17], and one among a kind nicely worth crumbling (SVD) [2, 18–20]. these techniques greater often than no longer deliver higher photo elusiveness The advent of watermarking strategies changed into additionally advanced by using uniting in any event alterations [21-33]. The singular nicely worth rot (SVD) is extensively implemented in image watermarking discipline. anyhow, unmistakable masters alluded to as regard for the manufactured super person trouble in SVD-fundamentally primarily based computations [7, 34–35]. Various

Revised Manuscript Received on 16 September, 2019.

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researchers have proposed advanced types of SVD-based totally actually photograph watermarking plans. A compelling photograph watermarking plan contingent upon SVD that embeds the full watermark is given in [20]. The vagary of a picture watermarking plan utilising rectangular mainly based totally SVD proposed in [19] is advanced by means of becoming a member of pay diversion, features, so a couple of visible fashions, as an instance, human substantive structure (HVS) can be combined in locating the right putting dependent on, an outwardly debilitated SVD-principally based watermarking plan is proven in [36]. The host photograph is segmented into non-masking squares then the putting squares are picked problem to the whole of visible and facet entropies. The watermark bits are hooked up through using converting the coefficients in the preeminent area of the left single vector pass section of the intention squares. It has ventured forward the relentless high quality of the watermarking yet surrendered the straightforwardness. In like manner, those plans are affordable handiest for the specifically differentiating watermark. A watermarking plan proposed in [32] depends upon on the SVD subspace can defend diverse realities about a image. along these fills, it would the important region, enlargement of left particular vector community On a similar idea, Run et al. [33] supplied a picture watermarking plan embedding the essential a chunk of the watermark in repeat area (DCT and DWT areas, resp.). also, an development method is actualized to get a appropriate scaling additives for putting in. in spite of the way that the functions remoted are healthy for such big portions of strikes, the viability of watermarking approach in like way depends upon the watermarking constant. PSO is a intelligent computation that the usage of the stochastic, populace essentially based laptop estimation for important addressing. Zheng [37] achieved the PSO to leaf through the embedding location of the overall range DCT coefficients in a rectangular to improve the crucial of vagary and energy in watermarking. Vahedi [38] utilized the PSO to carry down the absence of facts in the primary square.. It has ventured forward the relentless high quality of the watermarking yet surrendered the straightforwardness. In like manner, those plans are affordable handiest for the specifically differentiating watermark. A watermarking plan proposed in [32] depends upon on the SVD subspace can defend diverse realities about a image. along these fills, it would the important region, enlargement of left particular vector community On a similar idea, Run et al. [33] supplied a picture watermarking plan embedding the essential a chunk of the watermark in repeat area (DCT and DWT areas, resp.). also, an development method is actualized to get a appropriate scaling additives for putting in. in spite of the way that the functions remoted are healthy for such big portions of strikes, the viability of watermarking approach in like way depends upon the watermarking constant. PSO is a intelligent computation that the usage of the stochastic, populace essentially based laptop estimation for important addressing. Zheng [37] achieved the PSO to leaf through the embedding location of the overall range DCT coefficients in a rectangular to improve the crucial of vagary and energy in watermarking. Vahedi [38] utilized the PSO to carry down the absence of facts in the primary square. The in productivity with wavelet change is its incapacity to carry down the absence of facts in the primary photograph. as an instance, if any of the square of particular photograph having complete range pixel regards and changed via a floating point wavelet trade. The truncation of drifting factor regards will result in absence of certainties. To avoid this trouble, an invertible complete range to-quantity wavelet alternate contingent upon lifting [41] is implemented inside the proposed arrangement. It maps complete numbers to complete numbers and doesn’t motive any loss of information through ahead and in reverse alternative.

The in advance exchange of an ordinary lifting plan more noteworthy always than no longer consists of of 3 stages: split, estimate and supplant. take into account a sign: \( X = \{ x(n), n \in \mathbb{Z} \} \) with \( x(n) \in \mathbb{R} \). The implementation of the forward transform is illustrated as below:

1. **Split**: The original signal \( X \) is split into two subsets: even indexed samples \( x_e \) and odd indexed sample \( x_o \) by means of a sample operation:
   \[
   \begin{align*}
   x_e &= x(2n) \\
   x_o &= x(2n + 1)
   \end{align*}
   \]  

   (1)

   After the split operation is completed, the odd set and even set are obtained and the two sets are closely correlated.

2. **Prediction**: Given the odd indexed samples \( x_o \), a predictor \( P \) for the even indexed samples \( x_e \) can be designed:
   \[
   \bar{x}_o = P(x_e)
   \]  

   (2)

   The difference denoted as \( d \) between the predicted results and the odd samples is considered as the detail coefficients of the signal \( x(n) \), and it is expressed as:
   \[
   d = x_o - \bar{x}_o = x_o - P(x_e)
   \]  

   (3)

   3. **Update**: Knowing the even sample \( e_x \) and the detail coefficients \( d \), the approximation coefficients \( c \) are calculated using the updating operator \( U \) as:
   \[
   c = x_e + U(d)
   \]  

   (4)

   The inverse transform can immediately be derived from the forward transform by running the lifting scheme backwards. The block diagram of the lifting scheme is given in Figure 1.

![Lifting Scheme Diagram](image)

**B. Singular Value Decomposition (SVD)**

The singular value decomposition (SVD) [20] is a numerical analysis technique based on a theorem of linear algebra that decomposes a rectangular matrix into the

**III. PRELIMINARIES**

A. complete assortment Wavelet alternate (IWT)
product of three matrices: an orthogonal matrix \( U \), a
diagonal matrix \( S \), and the transpose of an orthogonal matrix \( V \). It may be considered as a method of
transforming correlated data set into uncorrelated one that
better explains the various relationships among the original
data. represented mathematically as
\[
A = USV^T, \tag{5}
\]
where \( UU^T = I_n \) and \( VV^T = I_n \); the columns of \( U \) are ortho
normal eigenvectors of \( AA^T \), the columns of \( V \) are ortho
normal vectors of \( A^TA \), and \( S \) is a diagonal matrix containing
the square roots of the eigen values from \( U \) or \( V \) in
descending order. If \( r \leq n \) is the rank of the matrix \( A \).the
diagonal matrix \( S \) satisfy the relation (6) and the matrix \( A \)
can be written as (7):
\[
\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_r > \lambda_{r+1} = \lambda_{r+2} = \ldots = \lambda_n = 0, \tag{6}
\]
\[
A = \sum_{k=1}^{r} \lambda_k u_k v_k^T \tag{7}
\]
Where \( u_k \) and \( v_k \) are the \( k \)th eigenvector of \( U \) and \( V \) and
\( \lambda_k \) is the \( k \)th singular value.

C. DCT

Discrete cosine transform (DCT) is popular rework
technique which transforms a sign from spatial domain to
frequency domain and it has notable power compaction
belongings.

D. Particle Swarm Optimization (PSO)

PSO [40] is encouraged from the social conduct of
organism along with chicken flocking or fish education.
Like other evolutionary algorithms the location of a particle
is laid low with each the best function visited through it and
the position of the pleasant particle in its community. The
high-quality particle in the population is denoted through
international nice (pbest), while the satisfactory position that
has been visited by using the present day particle is denoted
through local satisfactory (pbest).

\[
v_i(n + 1) = w_i v_i + c_1 r_1 \text{rand}_1 (pbest - x_i(n)) +
\]
\[
c_2 \text{rand}_2 (\text{pbest} - x_i(n)) \tag{8}
\]
\[
x_i(n + 1) = x_i(n) + v_i(n + 1) \tag{9}
\]
Where:

\( v_i(n + 1) \) and \( x_i(n) \) represent the current and the previous
positions of particle i

\( v_i(n + 1) \) and \( x_i(n) \) are the current and the previous
velocity of the particle i.

\( \text{rand}_1 \) and \( \text{rand}_2 \) are random numbers uniformly
distributed within [0,1].

\( W \) is an inertia weight which controls the momentum of
the particle.

Commonly the inertia weight is set according to the
following equation:
\[
w_i = w_{max} - \frac{w_{max} - w_{min}}{\text{iter}_{max}} \cdot \text{iter} \tag{10}
\]
Where: \( \text{iter}_{max} \) is the maximum number of iterations, and
\( \text{iter} \) is the current number of iterations. Each particle in PSO
shares the information with its neighbors. The updating
equations (4) and (5) combine both of the cognition
component

IV. PROPOSED WATERMARKING SCHEME

The proposed approach [14] is having two phases named
as embedding phase and extracting phase. The block
diagrams for embedding and extracting phases are as shown
in figure 2 and 3 respectively.

![Figure 2: Block diagram of embedding Unit for NBP-IWT-DCT-SVD-PSO](image)

![Figure 3: Block diagram of extracting Unit for NBP-IWT-DCT-SVD-PSO](image)
\[ WM^{3}_{LL}, WM^{3}_{LH}, WM^{3}_{HL}, WM^{3}_{HH} \]
\[ WM^{3}_{i} = u^{i} \ast s^{i} \ast (v^{i})^{T} \quad (17) \]

Where, \( WM^{3}_{i} \) is the modified \( i^{th} \) band, \( i \rightarrow \{ LL, LH, HL, HH \} \).

**Step 8:** Perform Inverse IWT over the obtained modified bands to get the watermarked image (WM) after Inverse DCT.

**Step 9:** Perform Inverse IWT over the obtained modified bands to get the watermarked image (WM) after Inverse DCT.

\[ WM^{3}_{LL} = ilwt2(WM^{3}_{LL}, WM^{3}_{LH}, WM^{3}_{HL}, WM^{3}_{HH}) \quad (18) \]
\[ WM^{3}_{i} = ilwt2(WM^{3}_{LL}, H^{3}_{LH}, H^{3}_{HL}, H^{3}_{HH}) \quad (19) \]
\[ WM = ilwt2(WM^{3}_{LL}, H^{3}_{LH}, H^{3}_{HL}, H^{3}_{HH}) \quad (20) \]

**Step 10:** Apply various attacks on the watermarked image.

**B. Extraction Procedure**

**Step 1:** Apply the normalized block processing on the distorted watermarked image (\( WM' \)) to obtain the distorted normalized watermarked image (\( WM'' \)).

**Step 2:** Apply 3-level IWT on the distorted & normalized watermarked image (\( WM'' \)) followed by DCT,

\[ \{(N_{WM}^{L})_{LL}, (N_{WM}^{L})_{LH}, (N_{WM}^{L})_{HL}, (N_{WM}^{L})_{HH}\} = lwt2(N_{WM}'') \quad (21) \]
\[ \{(N_{WM}^{L})_{LL}, (N_{WM}^{L})_{LH}, (N_{WM}^{L})_{HL}, (N_{WM}^{L})_{HH}\} = lwt2((N_{WM}^{L})_{LL}) \quad (22) \]
\[ \{(N_{WM}^{L})_{LL}, (N_{WM}^{L})_{LH}, (N_{WM}^{L})_{HL}, (N_{WM}^{L})_{HH}\} = lwt2((N_{WM}^{L})_{LL}) \quad (23) \]

**Step 3:** Perform SVD over the obtained all bands at third level of decomposition such as only on (\( N_{WM}^{L} \))

\[ [u^{LM}_{LM} s^{LM}_{LM} v^{LM}_{LM}] = svd((N_{WM}^{L})_{LL}) \]
\[ [u^{HM}_{LM} s^{HM}_{LM} v^{HM}_{LM}] = svd((N_{WM}^{L})_{LH}) \]
\[ [u^{LM}_{HM} s^{LM}_{HM} v^{LM}_{HM}] = svd((N_{WM}^{L})_{HL}) \]
\[ [u^{HM}_{HM} s^{HM}_{HM} v^{HM}_{HM}] = svd((N_{WM}^{L})_{HH}) \quad (24) \]

**Step 4:** Extract the distorted principal components \( W_{i}^{lu} \)

\[ W_{i}^{lu} = \frac{(u^{LM}_{i} - u^{LM}_{i})}{a} \quad i \in \{ LL, LH, HL, HH \} \]

Where \( W_{i}^{lu} \) are the distorted principal components of extracted watermark.

**Step 5:** The distorted bands are obtained as

\[ W_{i}^{d} = W_{i}^{lu} \ast (v^{m})^{T}, \quad i \in \{ LL, LH, HL, HH \} \quad (25) \]

**Step 6:** The final watermark can be extracted by applying inverse DCT and IWT on the obtained distorted wavelet sub-bands as

\[ W^{d} = ilwt2(W^{d}_{LL}, W^{d}_{LH}, W^{d}_{HL}, W^{d}_{HH}) \quad (26) \]

V. SIMULATION RESULTS

This section breaks down the exhibition of a proposed watermarking plan underneath different analyses. assorted investigate pictures are taken for exploratory evaluation.

The figures 3 (a) and 3 (b) are taken as host pictures while the figures 3 (c) and three (d) are taken in light of the fact that the watermark photograph.

The watermarked picture is exposed to attack of fourteen sorts. Standardized connection (NC) coefficient is utilized as a likeness measure between the bona fide and separated watermark photograph. that enables you to legitimize the general execution of the proposed plan, outcomes are in contrast with the conventional technique.

![Fig3(a) 3(b) 3(c) 3(d)](image)

**Figure 3:** (a) Lena host image (b) Baboon host image (c) Copyright Watermark image (d) NFU logo as watermark image

The performance of the proposed technique is evaluated for the take a look at instances of Lena is taken as host image and Copyright is taken as the watermark photograph [39], within the second take a look at case the Baboon image is taken as a host and the NFU logo photo is taken as watermark as like in base paper [40]. on this end result, first of all the received visual consequences (watermarked picture and Extracted watermark) for the proposed approach NBP-IWT-DCT-SVD-PSO depicted in the IV , after various attacks applied on watermarked picture.

<table>
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<tbody>
<tr>
<td>PSNR</td>
<td>NC</td>
<td>PSNR</td>
</tr>
<tr>
<td>WN (25%)</td>
<td>20.13</td>
<td>0.9068</td>
</tr>
<tr>
<td>SPA (3%)</td>
<td>20.62</td>
<td>0.9137</td>
</tr>
<tr>
<td>U (3%)</td>
<td>23.78</td>
<td>0.9898</td>
</tr>
<tr>
<td>GNF (3X3)</td>
<td>35.28</td>
<td>0.9615</td>
</tr>
<tr>
<td>MF (3X3)</td>
<td>33.94</td>
<td>0.9388</td>
</tr>
<tr>
<td>AF (3X3)</td>
<td>28.8</td>
<td>0.9461</td>
</tr>
<tr>
<td>SHF (3X3)</td>
<td>22.2</td>
<td>0.9639</td>
</tr>
<tr>
<td>JPEG (50%)</td>
<td>26.93</td>
<td>0.9898</td>
</tr>
<tr>
<td>BRIGHT (+20)</td>
<td>18.69</td>
<td>0.9639</td>
</tr>
<tr>
<td>DARKEN (-20)</td>
<td>18.55</td>
<td>0.9409</td>
</tr>
<tr>
<td>HE</td>
<td>16.99</td>
<td>0.9105</td>
</tr>
<tr>
<td>SA (25%)</td>
<td>33.72</td>
<td>0.9830</td>
</tr>
<tr>
<td>CA (25%)</td>
<td>13.38</td>
<td>0.8992</td>
</tr>
<tr>
<td>PAINTING (NFU)</td>
<td>13.26</td>
<td>0.9207</td>
</tr>
</tbody>
</table>

Based Secure Image Watermarking

![Image Watermarking](image)
Table 2: Performance metrics for the proposed methods (Lena with copyright image as watermark)

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>NA</td>
<td>44.18</td>
<td>46.89</td>
</tr>
<tr>
<td>GNA (0.01)</td>
<td>42.09</td>
<td>43.67</td>
</tr>
<tr>
<td>SPA (0.05)</td>
<td>41.26</td>
<td>42.85</td>
</tr>
<tr>
<td>MFA (3X3)</td>
<td>39.86</td>
<td>41.02</td>
</tr>
<tr>
<td>AFA (3X3)</td>
<td>37.28</td>
<td>38.94</td>
</tr>
<tr>
<td>HEA</td>
<td>39.51</td>
<td>41.26</td>
</tr>
<tr>
<td>CEA</td>
<td>37.90</td>
<td>38.79</td>
</tr>
<tr>
<td>JCA (50%)</td>
<td>42.19</td>
<td>44.23</td>
</tr>
<tr>
<td>RA (50%)</td>
<td>39.26</td>
<td>41.38</td>
</tr>
<tr>
<td>RSA (50%)</td>
<td>41.78</td>
<td>42.78</td>
</tr>
<tr>
<td>CA (35%)</td>
<td>34.82</td>
<td>34.35</td>
</tr>
<tr>
<td>FRA</td>
<td>39.24</td>
<td>41.26</td>
</tr>
<tr>
<td>FCA</td>
<td>41.68</td>
<td>42.07</td>
</tr>
<tr>
<td>TA (40X40)</td>
<td>41.03</td>
<td>41.63</td>
</tr>
</tbody>
</table>

Table 1 represents Performance comparative table for the test case of Baboon with NFU logo as watermark. The attacks are compared proposed (NBP-IWT-DCT-SVD-PSO) with Existing Method (SVR-SVD-PSO). Table 2 represents Performance metrics for the proposed methods (Lena with copyright image as watermark). The attacks are compared proposed Method Using NBP-IWT-DCT-SVD-PSO with Existing Method (NBP-IWT-DCT-SVD-GA).

Table 3 represents obtained results for the test case of Baboon with NFU logo as watermark. The attacks are compared proposed (NBP-IWT-DCT-SVD-PSO) with Existing Method (SVR-SVD-PSO).

VI. CONCLUSION

This paper has delineated the proposed NBP-IWT-DCT-SVD-PSO. Because the wager band passes on regularly substantial statistics, yet extra prominent defilement inside the concept of watermarked photo and along those traces it is actualized to leftover organizations separately. From the era effects, the proper watermarking steady for LL band and for terrific corporations is noticeable to be zero.05 and 0.1/2 as I would like to suppose. Numerous multiplications are completed over the proposed technique thru fluctuating host and watermark previews. In this imitation, it will in popular be gathered that the proposed system outmaneuvers the past proposed technique (NBP-IWT-DCT-SVD-GA) and everyday philosophy. On a commonplace the proposed strategy finished an increase of 2.0117 dB in PSNR and 0.013 in NC for the trial of Lena with Copyright over the proposed technique the usage of NBP-IWT-DCT-SVD-PSO.

From a comparable assessment of desk 1; it's far visible that the proposed technique were given an expansion of 18.695 dB in PSNR and 0.0095 in NC for the evaluation of Monkey with NFU logo over the proposed method the usage of NBP-IWT-DCT-SVD-PSO.

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