A Study of the Development of a Fuzzy Inference System Using Image Watermarking

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ABSTRACT

The primary purpose of this research is to develop a non-blind image watermarking system that is both robust and unnoticeable using wavelet transforms and fuzzy inference. The emphasis is on developing discrete wavelet transform, human visual system, and fuzzy inference system-based picture watermarking that makes optimal use of human vision constraints. The purpose of this research is to develop a novel technique for embedding perfect measure watermark data into the host image without creating perceptual damage. The methodology is to combine discrete wavelet transforms, the human visual system, and fuzzy inference to enable the utilisation of human vision limits in a viable manner. Additionally, the idea is to insert a significant logo as a watermark rather than the more traditional pseudorandom paired grouping for robust image watermarking. The purpose of this project is to develop image watermarking using the discrete wavelet transform. The objective is to investigate wavelet basis functions that are ideal for picture watermarking and to empirically estimate the strength of the watermark in order to inject the maximum amount of watermark information into the host image without degrading its perceptual quality. To model and execute various assaults on watermarked photos in order to degrade their quality in order to assess performance for resilience. Additionally, performance is evaluated in the presence of the maximum potential degradation of the watermarked image in order to define effective robustness requirements. To evaluate the performance of suggested approaches based on DWT, DWT-HVS, and DWT-HVS-FIS image watermarking, as well as to compare the proposed approach's performance to that of existing approaches utilising performance parameters.

KEYWORDS: Fuzzy Inference system, Image watermarking, host image, human visual system

INTRODUCTION

The remarkable rise of digital networks and multimedia applications over the last decade has resulted in a considerable increase in digital media transmission, including picture, audio, and video. In today's technology-driven economy, the digital revolution has resulted in a massive expansion of knowledge, encouraging, attracting, and motivating the digitalization of intellectual artefacts. Digital media is made up of a series of binary digits that travel at the speed of light, whereas print media is anchored in physical space. It is impossible to tell the difference between original and copy media since digital data has no variation in quality between the original and a copy. Authors, singers, photographers, artists, and producers now have chances to advertise their work over the internet. However, this has made copyright infringement more accessible than ever before. With the introduction of compression techniques for multimedia data such as the MPEG and JPEG standards, digital data is fast spreading throughout the world. The increase in network data transmission speed has enabled widespread use of digital data. During multimedia transmission, this data is easily copied, replicated, edited, altered, tampered with, or fabricated. As a result, it is necessary to establish a suitable framework for protecting digital media.

A digital watermark is a pattern of bits placed in host media that enables the creator's copyright information to be identified. It is a visible or invisible identification code placed within the host image that uniquely identifies its owner. Invisible digital watermarks are used in steganography to conceal data. The term "media" refers to a digital image in this study endeavour because the emphasis is on establishing digital image watermarking.

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LITERATURE REVIEW

N. Nikolaidis et al. [2] offer a robust spatial domain picture watermarking technique. Watermark inserted in image is resistant to JPEG compression and low pass filtering. K. Aboutammam et al. [3] created a novel spatial decomposition approach for content-based watermarking of images. Phen-Lan Lin [4] proposes a solution for transparent image watermarking that incorporates spatial mechanisms.

J.R. HernaHndez et al. [5] devised a method for optimising the efficiency of spatial domain image watermarking via channel coding. Hernandez et al. embed bit sequences in digital images using two-dimensional multi-pulse amplitude modulation and SST and construct an excellent detector.

DFT is a worldwide or full frame transform. Researchers have examined this domain in relation to image watermarking. There are two distinct ways for DFT-based watermark embedding. The first method includes directly inserting the watermark, whereas the second method utilises a template-based embedding. The direct embedding method embeds the watermark by altering the phase information in the DFT. To estimate the transformation factor using template-based embedding, the template is embedded in the DFT domain. Once the image has been transformed, this template is used to restore the image's synchronisation.

Kang Xiao and Jun Dong [6] offer a watermarking algorithm based on picture segmentation and DFT with the purpose of enhancing security and robustness against geometric attacks.

DISCRETE WAVELET TRANSFORM (DWT)

The Discrete Wavelet Transform (DWT) depicts an image in both spatial and frequency terms. In contrast to the standard Fourier transform, this transformation cycle retains only ephemeral data. Wavelets are constructed by interpreting and expanding a fixed capacity known as the mother wavelet

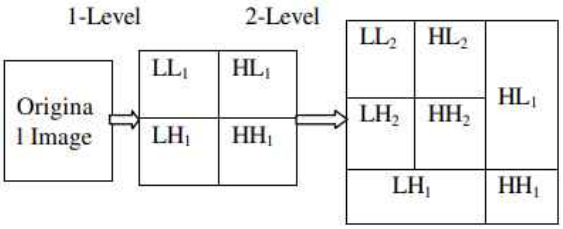


Figure 1 Discrete Wavelet Transformations

The Wavelet transform breaks the image down into three spatial subdivisions: flat, vertical, and inclining. The wavelet's multi-goal capability enables communication with a picture on more than one goal level. At each degree of decomposition, the magnitude of DWT coefficients is greatest in the lowest bands (LL) and is least in the distinct groups HH, LH, and HL. Subgroups with a high objective assist in quickly locating edge and surface examples in a picture. In comparison to other transforms such as DFT and DCT, the wavelet transform can precisely depict the Human Visual System (HVS). This enables the installation of greater energy watermarks in places where the HVS is less sensitive. By including a watermark in these areas, we can increase the watermark's resilience without jeopardising image devotion. DWT supports several goals for an image, with the purpose of handling the image sequentially from low to high goal. The advantage of this system is that the highlights of an image that are unlikely to be noticed at one aim can easily be recognised at another.

1 Dynamic Fuzzy Inference System (DFIS)

The Dynamic Fuzzy Inference System (DFIS), on the other hand known as the Dynamic Fuzzy Expert System, is a broadly perceived enlistment structure that depends on the notable ideas of fluffy set speculation, fluffy likelihood rules, and fluffy thinking. The DFIS is respected to give principal fluffy strategies to arranging starting with one bunch of commitments then onto the next set of yields without broad utilization of mathematical showing ideas. For the most part, a DFIS is made out of four unmistakable limit obstacles: a fuzzifier, a data base, a fluffy derivation engine, and a defuzzifier, as found in figure 1.2..

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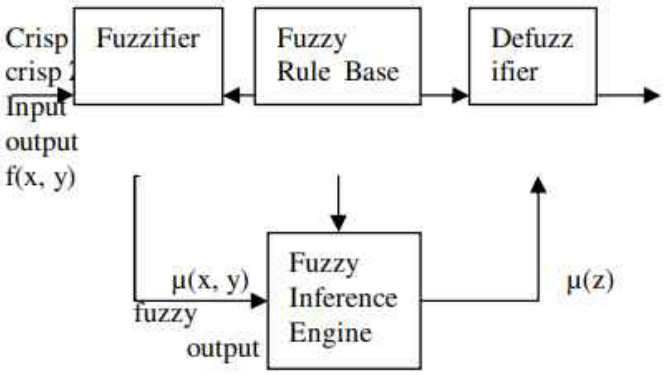


Figure 2 Dynamic Fuzzy Inference Systems

The Fuzzifier adds new passages to fluffy sets. The Knowledge Base incorporates a data store and a standard vault. The data base characterizes the semantic component enlistment components. The standard base is comprised of an assortment of IFTHEN choices that can be given by a human expert or can be found from the data's etymological portrayal. If a standard has a reason, a typical fills a similar need. The fluffy rule base of this Mamdani type DFIS is as per the following: If the information is 'f', the result is 'z', where 'f' addresses fluffy data and 'z' addresses quantized yield. The surmising Engine is a universally useful control framework that utilizes the fluffy guidelines and fluffy sets characterized in the Knowledge Base to show up at a goal. The Defuzzifier is utilized to change over fluffy yields related with fluffy standards to new yield values. The Mamdani type DFIS model is appropriate to depicting the way of behaving of a non-direct framework since it overcomes any issues between a few straight models. Accordingly, the Mamdani type DFIS is reasonable for showing the watermark weighting ability, as it coordinates the fluffy and nonlinear parts of human vision.

WATERMARK EMBEDDING

This article fosters an extensive advanced picture watermarking methodology in light of DWT and DFIS. The basic characteristic of this methodology is that the Mamdani type DFIS model is utilized to create a sensible estimate for each DWT coefficient's quantization step. Also, the HVS ascribes are shown utilizing the Haar wavelet to expand the flexibility and vagary of the watermark. This information is used in the estimation to produce the watermark's weighting limit, which empowers the watermark to be hearty and imperceptible. The center guideline fundamental the fluffy rationale is that variable qualities are words or semantic parts instead of numbers; their utilization is more natural. By mishandling the inclination to endure imprecision, non-literal language diminishes the expense of plan. Watermarking in view of fluffy rationale is utilized to separate data about the natural eye's affectability. Haar wavelet creates two inconsistent watermark parts, one of which is set into the cover picture and the other of which is held as a transmit key for watermark extraction. The watermark is placed into the wavelet change's high and focus recurrence subgroups, regardless of the way that this clearly modifies the picture's dedication. The upside of the HVS model is that the watermark is applied cautiously without debasing the detectable nature of the picture. The HVS utilizes the wavelets' surface affectability and multi-objective design to introduce the watermark without hindering the picture's recognizable quality. The elusiveness of the watermark in a watermarked picture is constrained by an onlooker a few times the picture's size away.

The nuance of a watermarked picture is relative to the picture's surface affectability. The affectability of a surface not entirely settled by quantizing the DWT coefficients in an image utilizing quantization values. The outcome is then adjusted to the closest number. Following that, the quantity of non-zero coefficients is found. The going with formula can be utilized to decide the surface's affectability.

$$S_j = \sum_j round\left[(T_{j+key})/Q\right]$$

Where round [(Tj+key)/Q] takes the adjusted value of [(Tj+key)/Q] and returns '1' if the value is not equal to zero, or '0' in all other cases. The inference system makes use of a collection of rules that are largely based on present realities:

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1. The eye is less sensitive to commotion in areas of the image where brightness is high or low.
2. The eye is less sensitive to turbulence in exceptionally finished areas, but is more sensitive on the boundaries of them.
3. The eye is less sensitive to turbulence and alterations in areas of extreme brilliance and extraordinarily dark districts.

The following rules are created in this work based on the affectability of the surface.

Whenever the input is low, the output is also low.

When the input is medium, the output is also medium.

When the input is high, the output is also high.

The system's overall output will be obtained as a weighted normal of al rule outputs in the following manner.

$$O_i = \frac{\sum_i^n w_i z_i}{\sum_i w_i}$$

Where'refers to the number of rules depicted, 'wi'refers to the bordering force that loads the output 'zi'of rule I.

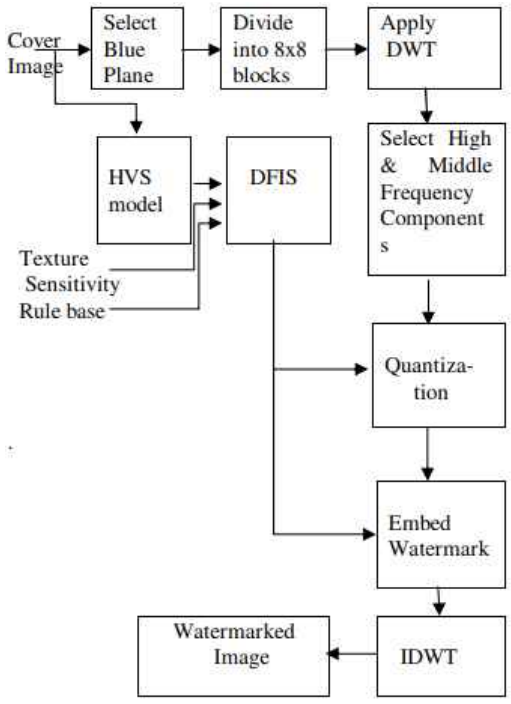


Figure 3 Watermark Embedding

Watermark Embedding Algorithm:

1. Read a NxN shading image.
2. Resize the shading image to 512x512 pixels and choose the Blue plane for the watermark installation.
3. As a watermark, select a 64x64 bitmap.
4. Conduct a three-level DWT on the cover image to obtain the frequency subparts HH1, HL1, LH1, HH2, HL2, LH2, HH3, HL3, LH3, and HH3, HL3, LH3.
5. Utilizing the discharge key, select the primary circumstance in which to embed the watermark.
6. Work out the surface affectability of the sections into which the watermark will be embedded and apply the subsequent coefficients to DFIS.
7. Utilizing fluffy induction strategies, produce a watermark weighting factor from DFIS.
8. Utilizing the accompanying formula, embed a watermark into the host picture's low recurrence DWT coefficients.

$$T'_{j+key} = DFIS(\sum_j round(\frac{T_{j+key}}{Q})) + X_j$$

Where Xj is watermark sequence

Q is quantization value

T'j+key is coefficient of watermarked image

1. Perform IDWT on every coefficient to get watermarked image.

Watermark Extraction

The watermark extraction cycle is the inverse of the watermark implantation cycle. The watermark is erased by comparing the DWT coefficients of the watermarked image to the DFIS output coefficients.

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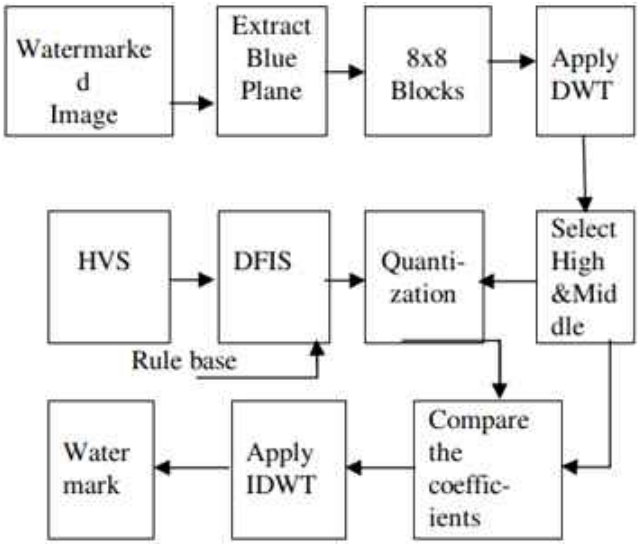


Figure 4 Watermark Extractions

CONCLUSION

The current research focuses on improving the imperceptibility and robustness of nonblind picture watermarking. To attain this goal, a narrative technique for digital image watermarking utilising DWT, HVS, and FIS is proposed. It is designed to embed a watermark in the host image without introducing recognisable visual artefacts or degrading the image. There is no discernible difference between an unwatermarked photograph and one that has been watermarked.

The cooperative power of these three techniques aids in increasing the indistinctness and robustness characteristics of picture watermarking, which require conflicting requirements. FIS is used to construct the HVS model by establishing bury connections between the HVS boundaries in order to select the optimal watermark load at each degree of wavelet decomposition. This creates a tension between intangibility and robustness. The flow research is carried out in three steps. The primary stage involves the creation of image watermarking using the discrete wavelet transform. This step comprises experimenting to determine the optimal strength of the watermark in order to get the desired subtlety. The presentation metric used to assess subtlety is PSNR, which is numerically registered, whereas the execution metric used to assess robustness is CRC.

Following that, image watermarking is generated using DWT, just as it is with HVS. The boundaries of the human visual system are established to ensure the impalpability of watermarked images when barriers to human vision are successfully used for picture watermarking. The strength of the embedded watermark varies across the host image's multiple regions in accordance with HVS borders. This stage establishes the robustness and impalpability boundaries for target analysis.

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