

NSCT based Watermarking Method for E-Healthcare

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Abstract—One of the key difficulties in telemedicine is the safe transmission of medical images. The majority of medical images have a crucial component known as a Region of Interest (ROI). When communicating, intruders or noise may disrupt the ROI of a medical image. The ROI data is typically embedded utilizing watermarking into the image's Region of Non-Interest (RONI) in order to convalesce the ROI. In order to provide higher embedding capacity and to verify the correctness of the extracted data before using the extracted data for recovering the ROI, this work introduces a unique watermarking technique employing the Nonsubsampled Contourlet Transform (NSCT). According to experimental findings, the proposed method can provide a higher embedding capacity, identify tampered locations inside the ROI, and recover the ROI.

Index Terms— Telemedicine, E-healthcare, ROI, RONI, NSCT.

I. INTRODUCTION

The current COVID-19 pandemic has created a significant need for electronic healthcare systems. It increased doctors' virtual accessibility at trying times and also brought them digitally closer to patients, especially in remote areas. With the rapid development of computer science in many fields, the use of medical imaging has increased substantially. Medical images are used by doctors to diagnose the diseases, and researchers use them to study disease prevention and treatment. During transmission, the medical images may be attacked by noise. A life-threatening course of therapy could be taken as a result of a misdiagnosis brought on by damaged medical images. In this situation, protecting medical images is far more crucial than before. For this reason, various watermarking techniques have been proposed. The main elements that affect a watermarking method's effectiveness are its capacity, robustness, and invisibility.

Medical image watermarking methods can be categorised into three categories depending on the application: integrity and authenticity control approaches, data-hiding strategies, and combinations of both. Assuring the validity and integrity of the source image is the main objective of the integrity and authentication control technique. The right source may be identified using this technique, and tampered regions can be located and restored [1]. The main goal of the data concealing technique is to keep the cover image highly imperceptible while hiding sizeable amounts of data [2]. The third design, which combines both, guarantees that the e-healthcare system satisfies all requirements.

In this research, we suggest an innovative watermarking technique to accomplish the succeeding objectives:

- To provide for a greater embedding capacity to embed all ROI data inside the image's RONI.
- To confirm the ROI's integrity before using the medical image for additional processing.

- To ensure the integrity of extracted data before utilising the extracted data to restore the image.
- To recover the ROI when it is tampered.

The remaining sections of this paper are structured as follows: The thorough literature review is presented in Section II. A detailed explanation of the suggested method is provided in Section III. The experimental findings are covered in Section IV, to demonstrate the effectiveness of the suggested approach. Paper is concluded in Section V.

II. LITERATURE REVIEW

Swaraja K et al. [3] created a watermarking system by combining the DWT-Schur hybrid transformation and the PSBFO optimisation strategy. Using visual and edge entropy, the best blocks to conceal the compressed version of the ROI inside the image's RONI are identified. This method facilitates ROI recovery and gives robustness to the embedded data. This method's lack of great imperceptibility is one of its disadvantages.

To ensure the reliability and accuracy of the medical data and image, Dhivya et al. [4] developed a watermarking technique using IWT and integrated chaotic map. The significant contribution of the paper consists of four phases: watermark creation and data embedding, authentication, tamper detection, and lossless recovery. This procedure distinguishes the tampered blocks inside the ROI with 100% accuracy and recuperates the tampered ROI segments with 0% MSE.

Zhaoning et al. [5] recommended a fragile watermarking method for medical images. This technique separates the medical image into ROI and RONI, then uses the JPEG-LS algorithm to compress the ROI. Embeds the reduced ROI into the full medical image. Uses the technique of the POB number to boost security. This approach offers tamper detection and recovery but falls short in providing robustness for the hidden data.

Qingdan Li et al. [6] suggested a method based on the permutation ordered binary (POB) number system and block compression to safeguard the information integrity of the medical images. Uses JPEG-LS to compress the ROI of medical image. Embeds the compressed ROI in both the low-plane and the high-plane of the image. Uses POB to generate the authentication bits. This method resists multiple assaults such as content exchange, text insertion, and text cropping. This method's limitations include the distortion of ROI and the inability to give the robustness to hidden data.

In order to allow tamper detection, tamper localisation, and ROI recovery, Rishi Sinhal et al. [7] created a multipurpose watermarking technique for medical images. This technique embeds a robust watermark into the host image using SLT. The ROI recovery data is compressed using the LZW methodology, and the hash keys are generated using the SHA-256 method. It hides both the hash keys and the ROI recovery data using an LSB technique in a few specific RONI places. This method's limitations include its failure to give robustness to the concealed data and distortion of ROI.

A technique for tamper detection and recovery using POB and JPEG-LS was developed by Hang et al. [8]. This technique extracts the image's ROI before dividing the image into non-overlapping blocks. JPEG-LS is used to compress the blocks. The compressed data is divided into high and low 4-bit planes using shuffle and combination to produce two plane pictures. The data of each plane is concealed in the entire image. Creates two bits of authentication data for each pixel and embeds them into the pixel itself. The resulting 10-bit data is then converted into an 8-bit value using POB. This method's limitations include its failure to give robustness to the concealed data and distortion of ROI.

Using the Fast Discrete Curvelet Transform (FDCT), Singular Value Decomposition (SVD), and Radon Transform (RT), Ahmed A. M. et al. [9] suggested a unique watermarking technique. To create high and low frequency coefficients, FDCT is applied to the image. After that, SVD is used to embed the watermark on both the high- and low-frequency components. The watermarked image's PSNR is higher than 55 dB. This approach improves robustness but distorts ROI and does not facilitate tamper detection and recovery.

III. PROPOSED METHOD

A. Nonsampled Contourlet Transform (NSCT)

Nonsampled Contourlet Transform (NSCT) is used in the proposed technique. The NSCT was proposed by Cunha et al. [10] to improve shift-invariance, direction selectivity, and get rid of spectral aliasing. The NSCT cancels the down- and up-samplers while decomposing and reconstructing the image. Using the Nonsampled Pyramid (NSP) and Nonsampled Directional Filter Bank (NSDFB), NSCT was developed. The image is divided into a low frequency image and a series of high frequency images by NSP (multi-scale decomposition). NSDFB divides each high frequency image into a number of directional sub-bands. As a result, several scale and

direction sub-bands are created. The watermarking system's capacity is increased by NSCT when the data is hidden in every sub-band.

B. Marking the ROI and generating the ROI recovery data

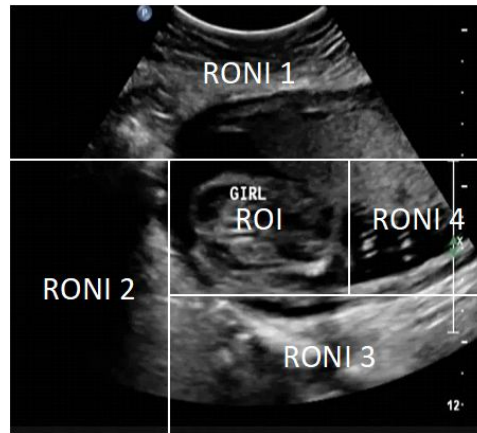


Figure. 1. Segmentation of ROI into four parts

As seen in Fig. 1, the suggested method divides the medical image into two regions: ROI and RONI pixels. The ROI area, which is depicted in Fig. 1 as an enclosing rectangle, is designated by the physician. For easier region identification and to perform operations or transformations on the various regions separately, the RONI can be further divided into a number of sections. As seen in Fig. 1, the proposed method divides the image's RONI into four portions. Following the marking of the ROI, the pixels inside the ROI are converted to binary form, and the ROI recovery data is produced by concatenating the converted pixels into a binary string.

C. Embedding Algorithm

The embedding algorithm's input is the medical image to be conveyed to the far-off doctor. The embedding algorithm's precise steps are as follows:

- Step 1: Segment the medical image into ROI and RONI regions using the procedure outlined in section III.B.
- Step 2: Use the SHA-256 technique to calculate the ROI hash code (w_1).
- Step 3: Create the ROI recovery data (w_2) using the procedure outlined in section III.B
- Step 4: As shown in figure 1, divide the RONI region into four portions.
- Step 5: Apply NSCT on RONI1 to generate sub-bands.
- Step 6: Embed one bit of w_2 in the decimal part of each coefficient in each sub-band generated in step 5.
- Step 7: Apply inverse NSCT on RONI1.
- Step 8: Use the SHA-256 technique to calculate the RONI1 hash code (w_3).
- Step 9: Apply NSCT on RONI2 to generate sub-bands.
- Step 10: Embed one bit of w_1 in the decimal part of each coefficient in each sub-band generated in step 9.
- Step 11: Apply inverse NSCT on RONI2.
- Step 12: Apply NSCT on RONI3 to generate sub-bands.
- Step 13: Embed one bit of w_3 in the decimal part of each coefficient in each sub-band generated in step 12.
- Step 14: Apply inverse NSCT on RONI3.

The resulting watermarked image is sent to the remote physician.

D. Extraction Algorithm

The detailed steps of the algorithm are as follows:

- Step 1: Segment the medical image into ROI and RONI regions using the procedure outlined in section III.B.
- Step 2: As shown in figure 1, divide the RONI region into four portions.
- Step 3: Apply NSCT on RONI2 to generate sub-bands.
- Step 4: Extract one bit from the decimal part of each coefficient in each sub-band.
- Step 5: Concatenate the extracted bits to generate w_1 .
- Step 6: Use the SHA-256 technique to calculate the ROI hash code (h).
- Step 7: Compare w_1 with h . If they match, stop the algorithm and use the medical image for the diagnosis. If

- not, proceed to Step 8.
- Step 8: Apply NSCT on RONI3 to generate sub-bands.
- Step 9: Extract one bit from the decimal part of each coefficient in each sub-band.
- Step 10: Concatenate the extracted bits to generate w3.
- Step 11: Use the SHA-256 algorithm to calculate the RONI1 hash code (h1).
- Step 12: Compare w3 with h1. If they don't match, stop the algorithm and inform the sender to resend the medical image again. If not, proceed to Step 13.
- Step 13: Apply NSCT on RONI1 to generate sub-bands.
- Step 14: Extract one bit from the decimal part of each coefficient in each sub-band.
- Step 15: Concatenate the extracted bits to generate w2.
- Step 16: Replace ROI with w2.
- Step 17: Use the resulting or recovered medical image for making decisions regarding the diagnosis.

IV. EXPERIMENTAL RESULTS

TABLE 1. SAMPLE IMAGES USED IN THE EXPERIMENTS

Modality of image	Size of image	PSNR
CT	198x254	45.62
MRI	225x225	46.81
Ultrasound	200x198	47.35

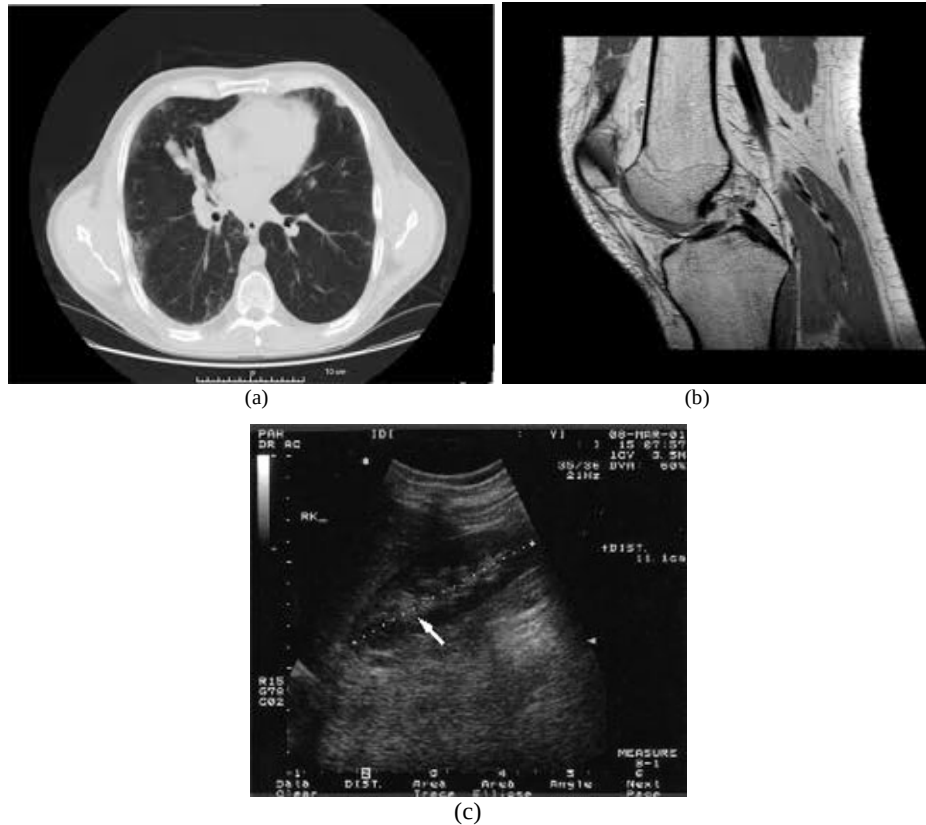


Figure. 2. Cover images: (a) CT of chest (b) MRI of knee (c) Ultrasound of liver

Medical images of various modalities and sizes were used in the experiments. The recital evaluation of the suggested technique takes into account the following factors:

- Imperceptibility
- Embedding capacity
- Authentication
- Tamper detection and recovery



Figure 3. Watermarked images: (a) CT of chest (b) MRI of knee (c) Ultrasound of liver

A. Imperceptibility

Fig. 2. displays three of the images that were utilised in the tests, while Fig. 3. shows the images that were produced after the embedding technique was used. Table 1 depicts the details of the images used in the experiments. The PSNR value for all medical images of all modalities and sizes is above 40 dB, demonstrating the effectiveness of the suggested technique. The recommended approach thus meets the criterion for imperceptibility.

B. Embedding capacity

By utilizing NSCT, the suggested technique provides the high embedding capacity. The RONI section is divided into a low frequency and a number of high frequency images when the NSCT is applied to it. The high frequency images are later split up into a variety of directional sub-bands, creating a lot of sub-bands as a result. One bit is embedded in each coefficient of each of the generated sub-bands, resulting in a high embedding capacity.

C. Authentication

The SHA-256 technique is used to calculate the hash value of ROI for authenticating purposes. The ROI hash code calculated at the sender's end and the ROI hash code recalculated at the receiver's end are compared. Before using the medical image to make a diagnosis, the ROI must be replaced if the hash codes do not match.

Before using the ROI recovery data to recover the tampered ROI, the hash code of RONI1 embedded in RONI3 at the sender's end is extracted, and then compared with the recalculated hash code of RONI1 at the receiver's end. If the two codes don't match, the ROI recovery information hidden in RONI1 can't be used to get the ROI back. Otherwise, ROI recovery data is taken out from RONI1 and used to recover the ROI.

D. Tamper Recognition and Recovery

To test how well the suggested system can detect and undo manipulation, the ROI of the watermarked photos in Fig. 3. has been altered in some spots as depicted in Fig. 4. The suggested method as shown in Fig. 5. located the modified blocks inside the ROI and restored the original ROI.

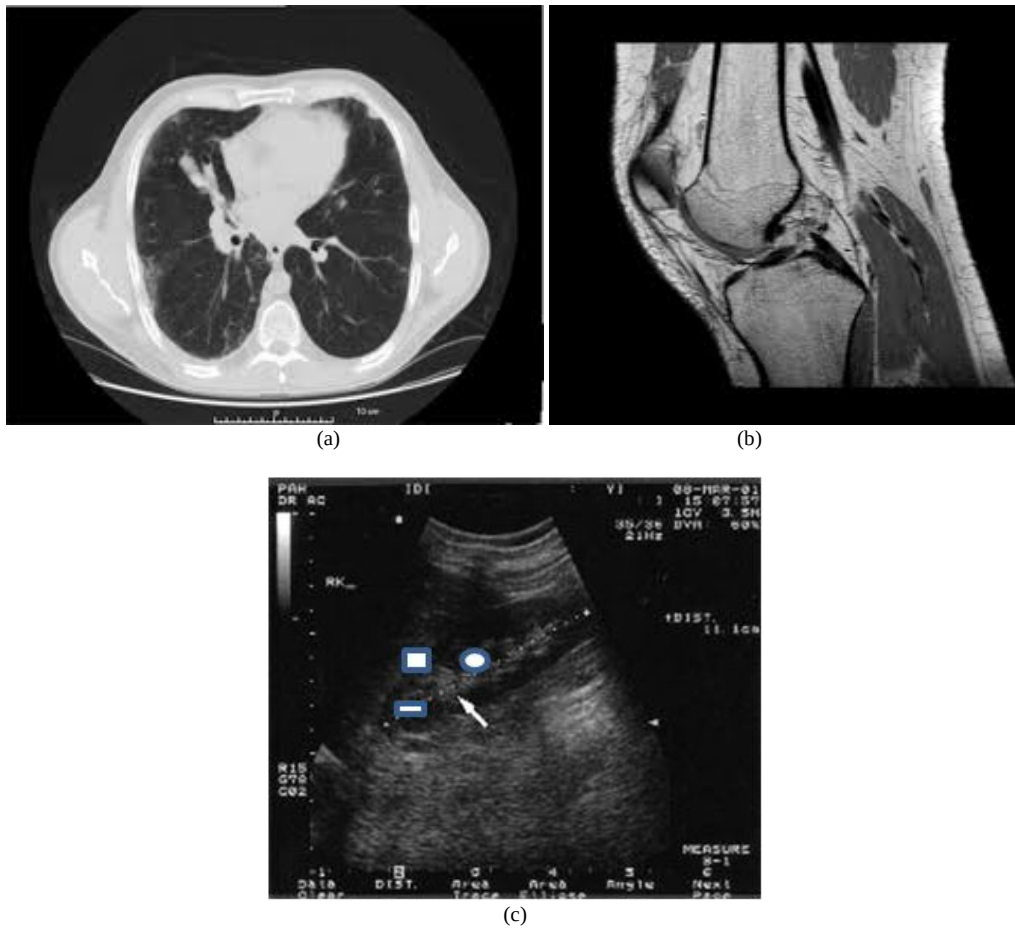


Figure. 4. Watermarked images with tamperers inside ROI: (a) CT of chest (b) MRI of knee (c) Ultrasound of liver

V. CONCLUSIONS

An innovative watermarking method for telemedicine is suggested in this research. The suggested technique recognises the tampered areas inside the ROI and supports high embedding capacity. Before using the recovery data to recover the ROI, it additionally confirms the integrity of the data. The proposed method recovers the ROI when the ROI has been altered. The suggested approach is applicable to a variety of modality and size medical images.





(c)

Figure. 5. Recovered images: (a) CT of chest (b) MRI of knee (c) Ultrasound of liver

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