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doi:10.15199/48.2023.03.46

A New Cell Spreading Video Coding Based on Bandelet Transform and Lifting Scheme for Medical applications

***Abstract**. Through this research paper, we are interested in improving the quality of the tested medical video based on bandelet transformation, which allows the detection of complex geometric shapes in various frames. The lifting process is used to reduce the artificial effect. The resulting coefficients are encoded with the Set Partitioning in Hierarchical Trees (SPIHT) encoder. A new lifting scheme is used to improve the visual quality and reduce the computational complexity based on the Bandelet transform. The obtained results are very satisfactory for lower bitrate in objective parameters.*

Streszczenie. *Poprzez tę pracę badawczą jesteśmy zainteresowani poprawą jakości testowanego wideo medycznego w oparciu o transformację bandeletową, która umożliwia wykrywanie złożonych kształtów geometrycznych w różnych klatkach. W celu zmniejszenia sztucznego efektu stosuje się zabieg liftingujący. Otrzymane współczynniki są kodowane za pomocą kodera Set Partitioning in Hierarchical Trees (SPIHT). Zastosowano nowy schemat podnoszenia, aby poprawić jakość wizualną i zmniejszyć złożoność obliczeniową w oparciu o transformatę Bandeleta. Uzyskane wyniki są bardzo zadowalające dla niższych przepływności w parametrach obiektywnych.* (***Nowe kodowanie wideo rozprzestrzeniania komórek oparte na schemacie transformacji i podnoszenia Bandelet do zastosowań medycznych***)

Keywords: Bandelets, Set Partitioning in Hierarchical Trees Coding, Lifting Scheme, Medical video.
Słowa kluczowe: kodowanie, Bandelet, transmisja danych medycznych

Introduction

Recently, the world, especially underdeveloped countries, has experienced many incurable diseases and epidemics that have become a significant menace to human health. The increased number of patients has put significant pressure on various hospitals and medical centers, especially with limited medical capacity and a lack of doctors specializing in disease diagnosis. Therefore, the need to find ways that help to reduce the huge volume of medical information without changing the content has become more than necessary, and this is what facilitates the process of storing and transmitting information, especially in light of all the technologies currently available such as magnetic resonance imaging, scanner, and ultrasound, which as a whole depend on high-quality videos and images. Currently, the new techniques of computer vision seem to have an excellent future for medicine, which are developed initially in the field of medical imaging, with the remarkable development of digital technologies, which has allowed an investigation and visualization of a part of the human body or a human organ through the use of radiological systems, In the medical field, there is a large number of imaging modalities (conventional X-ray, single-photon emission tomography (SPECT), X-ray CT, ultrasound, magnetic resonance imaging (MRI), positional emission tomography (PET), etc.).). Of course, the physician remains the reader and the referee. Still, the irruption of the machine in the diagnostic field plays a significant role in revealing the anatomy, facilitating the diagnostic operation, guiding a therapeutic gesture, analyzing different biological tissues, etc. The compression demonstrates that even the lossy compression may present an undesirable effect as an artifact. In general, compression is based on three essential steps (1). the transformation is an operation based on the localization of information, (2) the quantization is used for eliminating unnecessary data, and (3) the coding is based on the use of known algorithms such as Huffman coding and arithmetic coding. In such a case, several algorithms of transformations have been proposed, such as Discrete cosine transform [1], Wavelet [2], Ridgelet [3], Curvelet [4], and Contourlet [5], Wedgelet [6]. However, the Discrete Bandelet transforms (DBT) are still suitable for detecting complex geometric [7-11]. For example, among the known image compression standards, we find JPEG and JPEG2000 are based on DCT and Wavelet, respectively, and H.264, H.265, etc., for video. In this work, the bandelet transform is followed by a lifting scheme as a new contribution to improve the visual quality and reduce computational complexity [12]. The generated coefficients from this transform are encoded with the modified version of Embedded Zero tree Wavelet (EZW) [13], namely, Partitioning Set in the Tree Hierarchical Encoder (SPIHT) [14]. The temporal redundancies are reduced with motion estimation techniques [15]. The PSNR, MSSIM, and VIF are used as objective parameters to judge the quality of the recovered video. The rest of the paper is organized as follows: The Bandelet transform is described in section 2. Section 3 gives the main concept of the lifting scheme. Section 4 presents the SPIHT algorithm. Then the proposed algorithm is detailed in section 5. The simulation results are given in Section 6. Finally, in Section 7, we give the conclusions.

The bandelet transform

This transformation was introduced by Pennec and Mallat [7]. It consists of deforming the complex directions of curves to obtain horizontal and vertical directions. This deformation facilitates its identification by wavelet decomposition. Due to the blocking artifacts result of segmentation operation, the second-generation Bandelet was applied [8]. The geometry search is done in each decomposed block.

Lifting scheme

In [16-17], the biorthogonal wavelet transform is implemented in the lifting scheme to reduce computational complexity. The block diagram is illustrated in Fig.1, mainly based on splitting, lifting, and scaling. In [18], the authors proposed an algorithm based on this scheme to enhance the medical image.

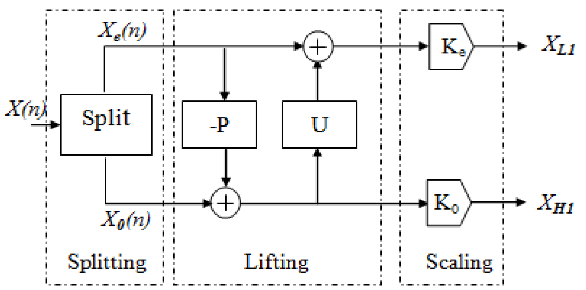


Fig.1. The lifting scheme

In Fig.1, the main steps of the lifting scheme are illustrated:

1. Splitting:

The input signal X is split into even samples $X_e(n) = X(2n)$ and odd samples $X_0(n) = X(2n+1)$.

2. Lifting:

Obtaining a detailed signal $d(n)$ X $X_0(n)$ is estimated $X_e(n)$ through prediction operation. The smooth $s(n)$ signal results from the addition between the update signal $d(n)$ $X_e(n)$ and.

3. Scaling:

The normalization factor K_e K_0 is used to produce the wavelet subband $X_{L1} = K_e \times s(n)$ $X_{H1} = K_0 \times d(n)$ and respectively.

SPIHT Algorithm

At the initialization step, the SPIHT is defined with three ordered lists:

A. List of insignificant pixels (LIP).
B. List of insignificant sets (LIS).
C. List of significant pixels (LSP).

The SPIHT encoder is based on the following principle [14]:

- The LSP contains no pixels at the beginning.
- LIP contains insignificant pixels from LIS.
- LSP receives effective pixels from LIP.
- LIS contains the set of effective pixels type A.
- Set A contains the set of type B and four sub-pixels.
- Set A undergoes a test of significance.
- LIP and LSP are filled by the significance test results of Set A in LIS.

Proposed algorithm

In Figure.2, we present the block diagram of the proposed method. The 2-D lifting-based CDF9/7 Wavelet (CDF: Cohen-Daubechies-Feauveau) is used to obtain approximation and details coefficients. The resulting coefficients of each frame are divided into four smaller dyadic blocks. Each block must respect the condition of Lagrangian:

$$\sum_j \left(\left\| f_j - f_{jR} \right\|^2 + \lambda \left(N_{jS} + N_{jG} + N_{jC} \right) \right) \quad (1)$$

where: $\lambda = \frac{3}{28}$: The Lagrange multiplier; N_{jS} : The number of dyadic sub-block bits; ; N_{jG} : The number of geometric bits; N_{jC} : The number of warped bits.

The horizontal and vertical directions are obtained through the warped operation. Then, SPIHT is used to encode produced coefficient of the 1-D lifting based on the CDF9/7 Wavelet.

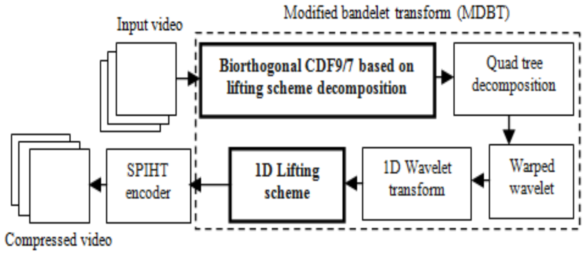


Fig.2. The block diagram of the proposed method

The suggested algorithm steps are summarized in the flowchart below in Fig.1:

1. Read the source video.
2. Perform the 2-D CDF9/7 Wavelet.
3. Apply the quadtree decomposition.
4. Warp the uniformed geometric flow.
5. Apply the warped curve operation.
6. Perform 1-D lifting based on CDF9/7 Wavelet.
7. Perform SPIHT encoder.

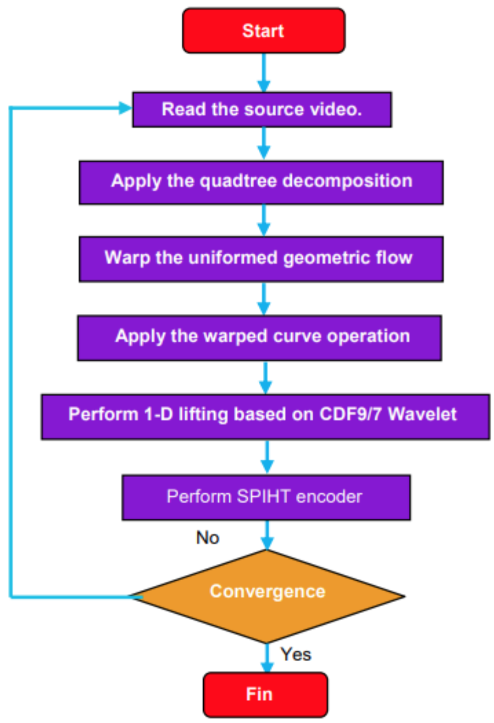


Fig.3. The proposed algorithm flowchart steps

Simulation Results and Discussion

To assess the performance of the suggested method, the DBT+SPIHT and DBT(LIFTING)+SPIHT algorithms are compared to compress the Cell Spreading (8 bits per pixel, grayscale) as we can apply it to other medical video sequences such as MRI, CT, and echography. The evaluation metrics (MSE, PSNR, and MSSIM) [19-20] are used to judge the quality of the compressed video. The tested video is decomposed into three-level using 2-D Bandelet based on CDF9/7. The proposed DBT (LIFTING)+SPIHT algorithms are very suitable for compressing this type of sequence video, which is significantly better than DBT+SPIHT algorithms, as proven in Table.1 and Figure.3 in terms of objectives parameters (MSE, PSNR, MSSIM). The decoded Cell Spreading video for tested algorithms at 0.5 Mbps is shown in Figure. 4. Indeed, Figure. 4. c is better than Figure. 4.b. At the same bitrate, the suggested algorithm's parameters values (PSNR and MSSIM) are higher than the DBT+SPIHT algorithm. From Table. 1, we can say that the gain values vary from 1 to 3dB. In addition, the proposed algorithm proves its efficiency in terms of computation time, which is 559.359090 seconds for DBT+SPIHT and 45.013049 seconds for DBT(LIFTING)+SPIHT while the gain reached to 500seconds. This means that our proposed method is less complicated, making it take less time than DBT+SPIHT.

Table.1 Comparative results between DBT+SPIHT and DBT(LIFTING)+SPIHT in terms **of** PSNR, MSSIM, and time (sec.)

Bitrate (Mbps)	DBT+SPIHT (1st ALG)				DBT(LIFTING)+SPIHT (2nd ALG)				GAIN between 2nd and 1st ALG		
	MSE	PSNR(dB)	MSSIM	Time(sec)	MSE	PSNR(dB)	MSSIM	Time(sec)	PSNR(dB)	MSSIM	Time(sec)
0.1	1.7245 e+03	24.2766	0.7295	578.452707	**805.7357**	**25.6354**	**0.8376**	**35.144883**	1.3588	0.1081	-543.307824
0.2	51.2823	31.3453	0.9370	579.690961	**54.8253**	**35.0930**	**0.9474**	**35.285786**	3.7477	0.0104	-544.405175
0.3	31.3148	37.2464	0.9663	579.337439	**7.3423**	**39.7842**	**0.9789**	**36.743064**	2.5378	0.0126	-542.594375
0.4	3.3147	43.4754	0.9863	580.128388	**2.1030**	**46.5991**	**0.9938**	**39.063896**	3.1237	0.0075	-541.064492
0.5	1.7891	48.5729	0.9952	559.359090	**1.6813**	**50.4103**	**0.9965**	**45.013049**	1.8374	0.0013	-514.346041

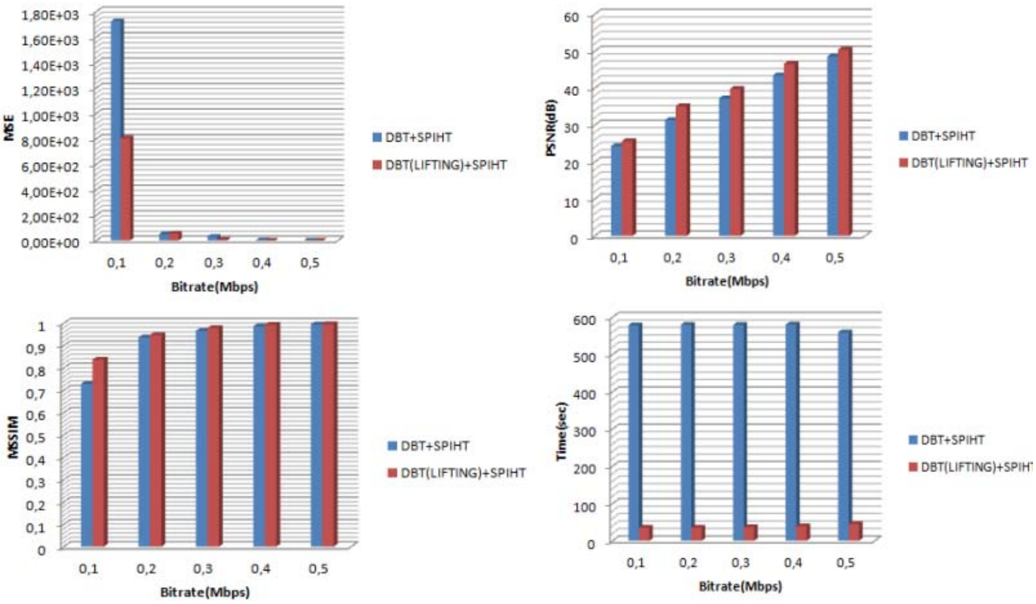
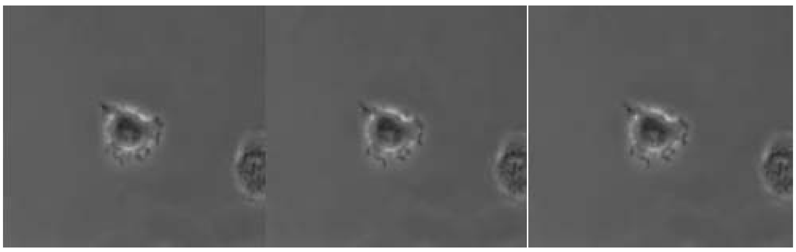
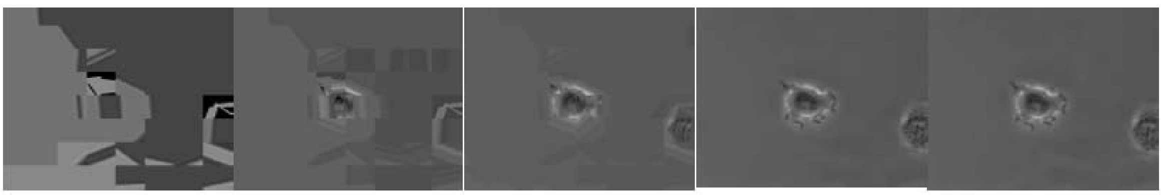


Fig..3 Comparison of MSE, PSNR, MSSIM, and time of compressed Cell Spreading video obtained using DBT(LIFTING)+SPIHT algorithms



(a) (b) (c)

Fig. 4. Performance of DBT+SPIHT and DBT(LIFTING)+SPIHT algorithms for Cell Spreading video at 0.5 Mbps: (a) Original video. (b) Reconstructed frame by DBT+SPIHT. (c) Reconstructed frame by DBT(LIFTING)+SPIHT



(a). Bitrate=0.1Mbps (b). Bitrate=0.2Mbps (c). Bitrate=0.3Mbps (d). Bitrate=0.4Mbps (e). Bitrate=0.5Mbps

Fig 5. The decoded frames using the BANDELET (LIFTING)+SPIHT algorithm at each bitrate

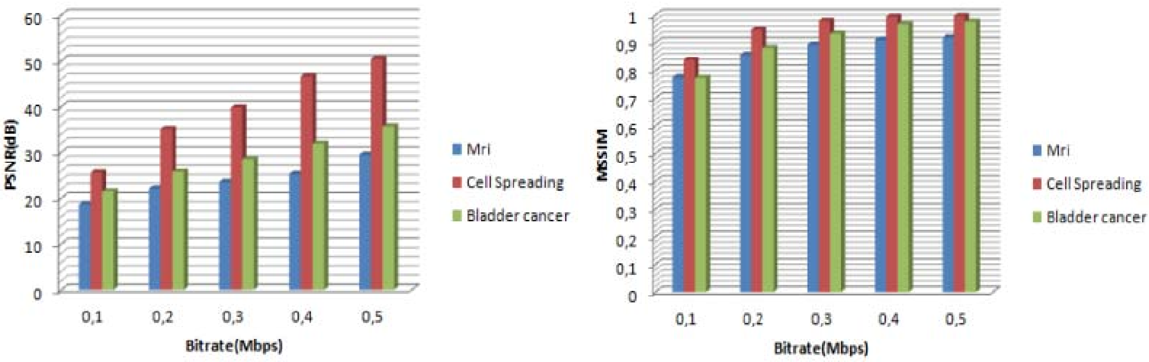


Fig 6. Comparative results of DBT(LIFTING) for different medical sequences video (MRI, cell spreading, and bladder cancer)

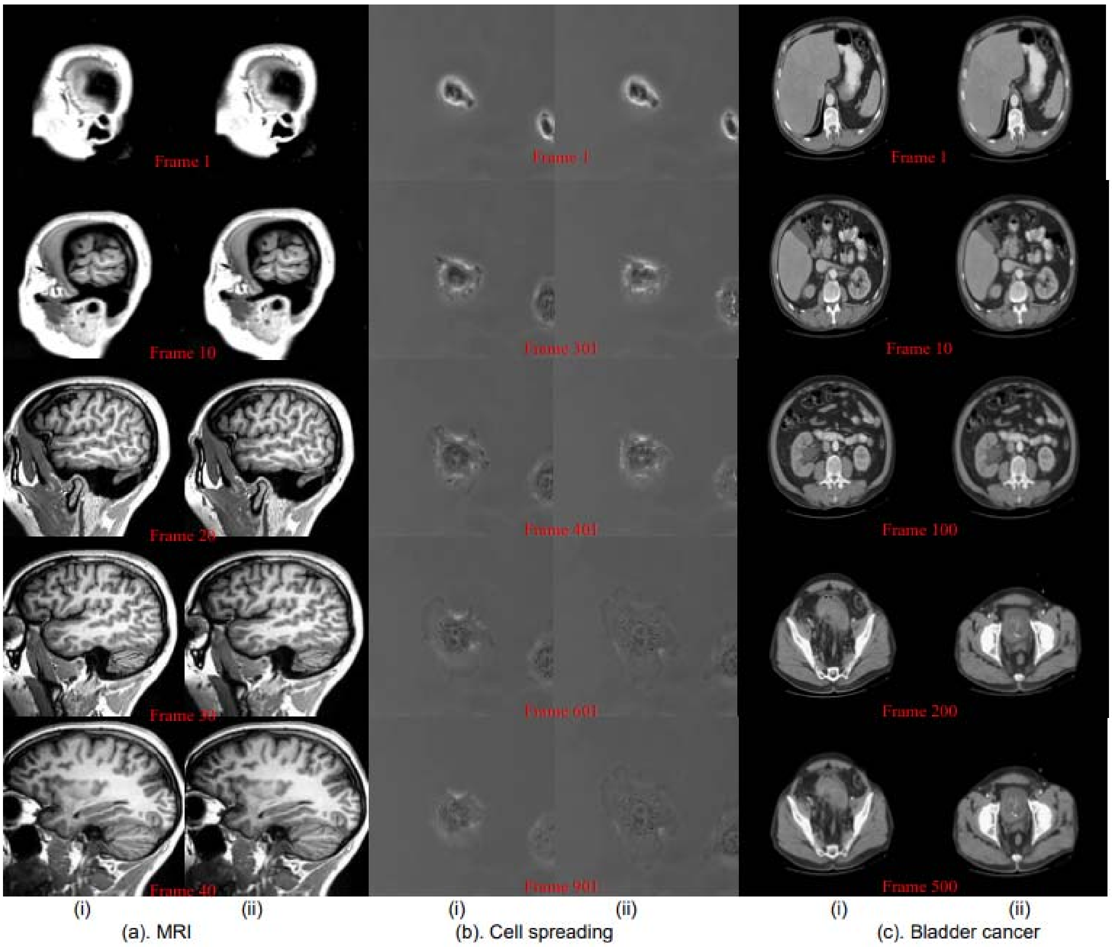


Fig 7. The visual quality of original (i) and decoded (ii) frames using BANDELET (LIFTING)+SPIHT for different medical sequences video at 0.5Mbps and different frames.

Table.2 Subjective assessment of medical video using the proposed method

Evaluation criteria		Medical sequences video		
		MRI	Cell spreading	Bladder cancer
Subjective evaluations of artifacts levels	Visible distortion	None	None	None
	Appearance of artifacts	None	None	None
	Vignetting	None	None	None
Subjective evaluations of diagnostic quality	Edges	Excellent	Excellent	Good
	Sharpness	Good	Excellent	Good
	Visual quality	Excellent	Excellent	Good

The decoded frames using the DBT(LIFTING)+SPIHT algorithm at each bitrate are depicted in Figure.5. On the other hand, our algorithm is applied to MRI, Cell spreading, and bladder cancer for different frames at 0.5Mbps to show in which sequences video the proposal gives a perfect result. From Figure.6 and 7, it is clear that DBT(LIFTING)+SPIHT is improved for Cell spreading compared to other medical videos.

To analyse the visual quality of the compressed medical videos and to help doctors in the diagnostic process, a subjective evaluation of all medical videos after the compression process was presented to assess any visual abnormalities that might appear. According to the following evaluation criteria, visible distortion, the appearance of artifacts, vignetting, edges, sharpness, and visual quality, the results are shown in Table 2. The assessment scale is classified as: "excellent", "good", "medium", and "poor". The level of distortion is also classified as "none," "slight," "medium," and "severe."

Conclusion

In this paper, we propose enhancing the medical video's visual quality based on the suggested algorithm. Based on the obtained results, the proposed algorithm proves its efficiency in medical video compression. The PSNR, MSSIM, and VIF values of the DBT(LIFTING)+SPIHT are acceptable compared to the DBT+SPIHT algorithm. The proposed algorithm proved the highest quality. In perspective, we want to apply this algorithm to the color medical video.

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