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A NEW DETAIL EXTRACTION TECHNIQUE FOR VIDEO SEQUENCE CODING USING MORPHOLOGICAL LAPLACIAN OPERATOR

수리형태학적 Laplacian 연산을 이용한 새로운 동영상 Detail 추출 방법

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Abstract

In this paper, an efficient detail extraction technique for a progressive coding scheme is proposed. The existing technique using the top-hat transformation yields an efficient extraction scheme for isolated and visually important details, but yields an inefficient results containing significant redundancy extracting the contour information. The proposed technique using the strong edge feature extraction property of the morphological Laplacian in this paper can reduce the redundancy, and thus provides lower bit-rate. Experimental results show that the proposed technique is more efficient than the existing one, and promise the applicability of the morphological Laplacian operator.

요 약

본 논문에서는 동영상 압축 기법을 향상시키기 위하여 효율적인 detail 추출 기법을 제안한다. 기존의 top-hat 변환을 이용한 기법은 고립되어 있고 시각적으로 중요한 detail의 추출에는 효율적이지만, 영역의 경계에서는 비효율적이다. 제안된 기법은 수리형태학적 Laplacian 연산의 영역경계 정보추출의 성질을 이용하여 압축을 향상시키고 저비트율을 제공한다. 실험결과를 통해서 제안된 기법이 기존 기법보다 효율적임을 보이고 수리형태학적 Laplacian 연산 적용의 타당성을 설명한다.

keyword : morphological Laplacian, detail extraction,post-it transformation, segmentation-based video coding,hierarchical segmentation

I. INTRODUCTION

In the frame work of very low bit-rate coding techniques, there is an increasing interest in second-generation compression techniques. These techniques eliminate redundant information within and

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between frames, taking advantage of the properties of the human visual system. In particular, segmentation-based coding methods try to describe the scenes in terms of uniformly textured regions surrounded by contours, in such a way that the regions correspond, as faithfully as possible, to the objects in the scene. The underlying image model takes into account probably the most significant feature picked up by the visual system: discontinuities or edge information that separates regions or objects. Much effort is put on extracting and coding these "contour". The remaining features are seen as "texture" and coded roughly as some type of homogeneous distributions of grey level values.

The partition of original image is coded roughly by approximating the inside of the region using mean value. Then small visual features are extracted perceptually and coded. For perceptual coding images, small visual features called "details" are considered apart from the segmentation structure of adjacent non-overlapping regions. Coding only the most significant details improves the performance of segmentation-based schemes at very low bit-rates.

Some mathematical morphology tools are very useful for high compression ratios in this framework. Several detail extraction techniques have been proposed using the morphological top-hat transformation [6], post-it transformation (top-hat transformation followed by marker extraction procedure) [7], modified post-it transformation (post-it transformation applied to coding residue) [1], and a new method using morphological Laplacian.

The paper is organized as follows. In next section segmentation-based coding scheme that will be used as reference for the application of the proposed technique is described. Section three is devoted to the description of the detail extraction technique, which is based on tools from mathematical morphology. In section four proposed detail extraction technique that will be able to improve the performance in the sense of compression and visual quality is presented. In section five, experimental results compared with the performance of the method described in section three are shown. Finally the last section gives some concluding remarks.

II. MORPHOLOGICAL SEGMENTATION -BASED CODING ALGORITHM

The video coding algorithm is based on a three dimensional morphological segmentation scheme [2] and on a contour-texture approach for the coding of the segmented sequence. An outline of the segmentation step and of the coding of contours and texture is provided below for completeness purposes.

2.1 Hierarchical Segmentation

The segmentation scheme is hierarchical in the sense that it leads to a set of segmented sequences ranging from coarse to fine. This feature is particularly attractive for progressive coding and transmission.

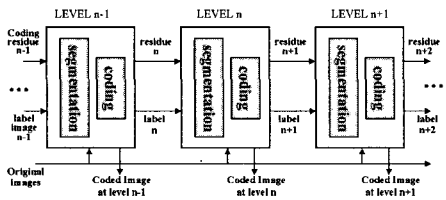


Fig. 1. Hierarchical structure of segmentation-based scheme

그림 1. 분할기반 압축 기법의 계층적 구조

The selected video coding algorithm produces, in a first step, a coarse coded sequence with only a few regions. Then the successive level of the algorithm improve the quality of the segmentation by introducing new regions so that the rough segmentation in the first level is refined in the next levels using more local information.

At each level of the hierarchy the same four basic steps are performed: simplification, feature extraction,

decision, and coding.

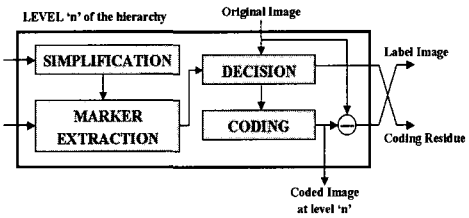


Fig. 2. Basic step of morphological segmentation-based coding algorithm
그림 2. 수리형태학적 분할기반 압축 기법의 기본단계

These steps are carried out by means of morphological tools. In particular, the simplification step follows a size criterion while, for the decision step, a very efficient tool, the watershed algorithm, locates the precise contours of the regions. The information to be coded in each level consists of new regions that are extracted from the current coding residue that is difference between the original image and the reconstructed image. In order to compute the coding residue, the sequence is actually coded by contour and texture coding. The coding residue is transmitted to the next level as an input image, which has components that have not been properly segmented and coded in previous level.

2.2 Contour-Texture Coding

There are two different kinds of information to be taken into account for coding: the partition of the segmented image and the inside(the grey-level or color information) of the regions. In order to perform coding the partition contour coding methods are used and texture coding methods are used for coding the inside of the regions. In this approach and in order to obtain very low bit-rates, the region is approximated using the mean value within the entire volume of the region.

III. DETAIL EXTRACTION

Segmentation-based coding methods describe the scenes in terms of uniformly textured regions surrounded by contours, in such way that the regions correspond, as faithfully as possible, to the object in the scene. As a result, the encoder involves a segmentation step, which defines a partition of the image, followed by a coding step, which codes the contour of the partition and the gray-level or color information of the each region (called texture).

The inside of the segmented regions can be coded using some approximation function. To obtain very low bit rate, the region is approximated using the mean value within the entire volume of the region. This method does not sufficiently describe small and visually important regions. To overcome the drawback, details (a number of meaningful small features) are considered. Both texture and the most significant details are then coded. It was claimed that coding of details improves the performance of segmentation-based scheme at very low bit-rate [1].

The morphological top-hat transform [6] is defined as the residue or difference between the identity operator and the opening or, in the dual case, the closing and identity. Reconstruction top-hat using the opening or closing by reconstruction is used for preserving contours. Some improvements are needed for these filters in order to use them as detail extractors. Post-it transform [7] is based on the selection of significant details from the reconstruction top-hat and the computation of the true amplitude values for the selected details form the morphological top-hat. In the previous coding scheme, the information to be coded in the next level of the hierarchical consists of new regions that are extracted from the current coding residue. The detail extraction algorithm should be able to identify details from the coding residue as well, in order to improve the subjective quality of the coded segmentation. For extracting details from the coding

residue modified post-it has been proposed [1].

Here we claim that the techniques [6, 7, 1] yields an efficient extraction scheme for isolated and visually important details, but yields an inefficient result extracting the contour information. Our preliminary experiments show that precise contour description provides better reconstruction in the sense of image quality. The main focus of this paper is concentrated on extracting details with precise contour information.

The morphological Laplacian is known as a good tool to extract strong edge features for image coding. Therefore we claim that morphological Laplacian could be used to extract the details with precise contour information.

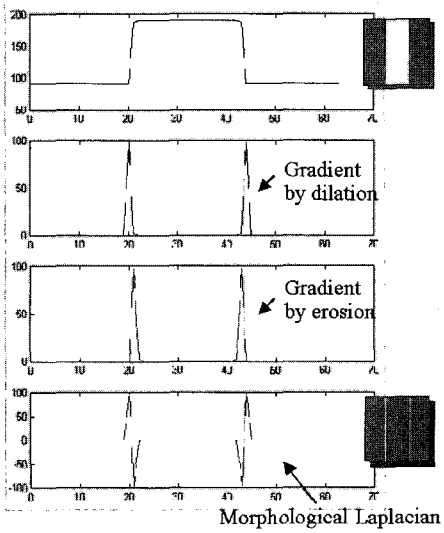
IV. MORPHOLOGICAL LAPLACIAN AND ITS APPLICATION TO DETAIL EXTRACTION

The morphological Laplacian, $L(f)$, is defined as the residue of the gradient by dilation, $g^{+}(f)$, and the gradient by erosion, $g^{-}(f)$, that is:

$$g^{+}(f)=\delta(f)-f$$
$$g^{-}(f)=f-\varepsilon(f)$$
$$L(f)=g^{+}(f)-g^{-}(f)$$

The morphological Laplacian is greater than zero at the lower edge of the transition and smaller than zero at the upper edge. In flat surfaces or slanted planes without convexity changes, it cancels out. Fig. 3 shows that the morphological Laplacian is an approximation of the signal second derivative. The extrema of the second derivative locate the points with largest curvature values. These points occur at the upper and lower sides of the transitions bringing information about the transition width and intensity change.

The strong edge feature extraction property [5] of the morphological Laplacian provides an effective tool for extracting the contour information which could not be sufficiently coded in modified post-it transformation



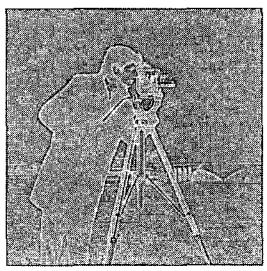


그림 3. morphological Laplacian의 성질

Fig. 3. Property of morphological Laplacian

Furthermore the "marker" image, from which the details are to be extracted using a simple threshold in modified post-it transformation technique, contains significant redundancy. The strong edge feature extraction property of the morphological Laplacian can also reduce the redundancy in marker image, and thus provides lower bit rate. However, the morphological Laplacian is inefficient to extract small isolated details comparing to top-hat transformation techniques.

Consequently we propose here a hybrid detail extraction technique using the top-hat transformation and morphological Laplacian simultaneously. Fig. 4 show

the proposed algorithm.

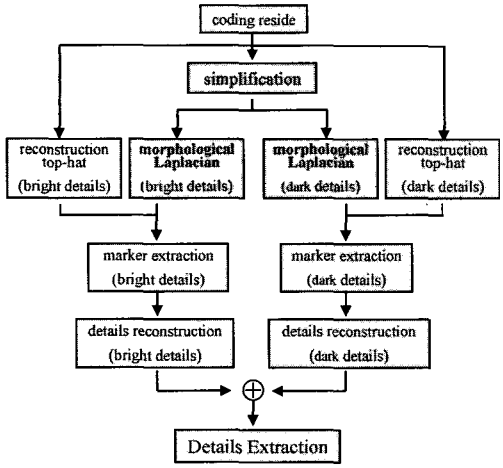


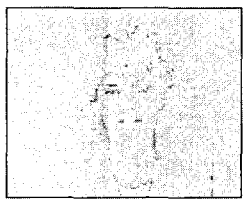
Fig. 4. Modified post-it using the top-hat transformation and morphological Laplacian
그림 4. top-hat 변환과 morphological Laplacian 연산을 이용한 변형 post-it 변환

V. EXPERIMENTAL RESULT

Fig. 5 shows extracted details and reconstructed images for using top-hat, morphological Laplacian, and top-hat with morphological Laplacian.

(a) original image

(b) partiton image



(c) detail image (top-hat)

(d) reconstructed image (top-hat)

(e) detail image (Laplacian)

(f) reconstructed image (Laplacian)

(g) detail image (top-hat+Laplacian)

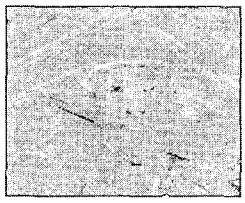
(h) reconstructed image (top-hat+Laplacian)

Fig. 5. Extracted details and reconstructed images for using top-hat, morphological Laplacian, and top-hat with morphological Laplacian (Miss America 48 regions)
그림 5. top-hat 변환, morphological Laplacian 연산 그리고 top-hat과 morphological Laplacian을 동시에 적용한 변환을 이용하여 detail을 추출한 결과 (MissAmerica 48 영역)

Fig. 6 shows same results using Foreman image.

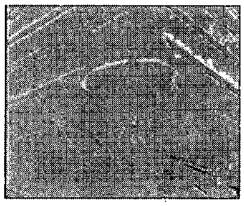
(a) original image

(b) partiton image



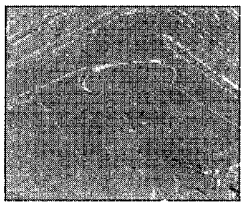
(c) detail image (top-hat)

(d) reconstructed image (top-hat)



(e) detail image (Laplacian)

(f) reconstructed image (Laplacian)



(g) detail image (top-hat+Laplacian)

(h) reconstructed image (top-hat+Laplacian)

Fig. 6. Extracted details and reconstructed images for using top-hat, morphological Laplacian, and top-hat with morphological Laplacian (Foreman 80 regions)

그림 6. top-hat 변환, morphological Laplacian 연산 그리고 top-hat과 morphological Laplacian을 동시에 적용한 변환을 이용여 detail을 추출한 결과 (Foreman 80 영역)

Table 1. Extracted details and PSNR of reconstructed images

표 1. 복원된 영상의 추출된 detail 수와 PSNR

Segmented images (QCIF)		Top-hat		Laplacian		Top-hat + Laplacian	
		details	PSNR	details	PSNR	details	PSNR
Miss America	43 regions	538	29.15	444	29.26	540	29.33
	48 regions	537	29.15	455	29.18	483	29.58
Foreman	80 regions	692	27.96	601	28.00	473	28.84
	125 regions	613	28.56	586	28.59	451	28.75

Table 1 shows pixel number of extracted details and PSNR of reconstructed images for using top-hat, morphological Laplacian, and top-hat with morphological Laplacian.

Experimental result shows that the proposed hybrid transformation technique provides better reconstruction quality in the sense of PSNR preserving almost same number of details.

Table 2. Comparison of the compression effect at the same PSNR

표 2. 같은 PSNR에서 압축효율 비교

Segmented images (QCIF)		Top-hat	Laplacian	Top-hat + Laplacian
		details (byte)	details (byte) (decrease ratios)	details (byte) (decrease ratios)
Miss America	48 regions PSNR : 29.15	536	436 (18.7%)	226 (57.8%)
Foreman	125 regions PSNR : 28.56	605	512 (15.4%)	391 (34.9%)

Table 2 shows that the proposed technique provides less number of details preserving almost same reconstruction quality.

VI. CONCLUSION

In this paper, an efficient detail extraction technique for a progressive coding scheme is proposed. The existing technique using the top-hat transformation[1] yields an efficient extraction scheme for isolated and visually important details, but yields an inefficient results containing significant redundancy extracting the contour information. The proposed technique using the strong edge feature extraction property of the morphological Laplacian in this paper can reduce the redundancy, and thus provides lower bit-rate. Experimental results show that the proposed technique is more efficient than the existing one, and promise the applicability of the morphological Laplacian

operator.

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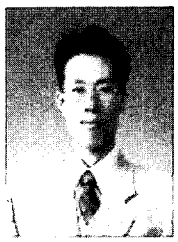

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