International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:5, No:7, 2011

Shape Error Concealment for Shape Independent Transform Coding

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***Abstract*—**Arbitrarily shaped video objects are an important concept in modern video coding methods. The techniques presently used are not based on image elements but rather video objects having an arbitrary shape. In this paper, spatial shape error concealment techniques to be used for object-based image in error-prone environments are proposed. We consider a geometric shape representation consisting of the object boundary, which can be extracted from the α-plane. Three different approaches are used to replace a missing boundary segment: Bézier interpolation, Bézier approximation and NURBS approximation. Experimental results on object shape with different concealment difficulty demonstrate the performance of the proposed methods. Comparisons with proposed methods are also presented.

***Keywords*—**error concealment, shape coding, object-based image, NURBS, Bézier curves.

I. Introduction

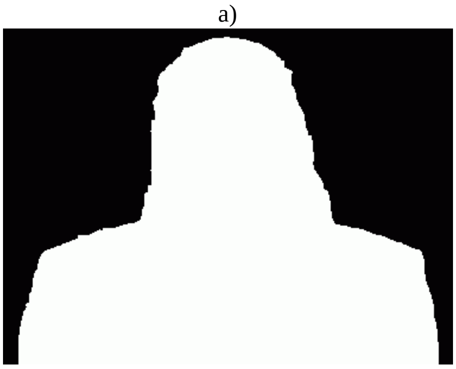
IN the wired and wireless networks the transmission of images may lead to loss. As retransmission of lost or damaged packets may incur delay, error resiliency methods have been developed to detect and correct transmission errors. Therefore error detection and concealment is used. For image coding standard JPEG 2000 various methods exist, an example is in [7].

The MPEG-4 object-based audiovisual coding standard [1] opened up the way for new video services, where scenes are understood as a composition of objects; this approach may have advantages in terms of coding efficiency as well as in terms of additional functionalities. However, to make these object-based services available in error-prone environments, such as mobile networks or the Internet, with an acceptable quality, appropriate error concealment techniques dealing with both shape and texture data are necessary.

Several techniques have already been proposed in the literature, which can be divided in three major categories, depending on the information that is used for the concealment process only use spatially adjacent shape information to perform the concealment. This makes these techniques especially useful when the shape changes greatly in consecutive time instants, such as when new objects appear or are uncovered. Additionally, they can also be used for still images. On the other hand, temporal error concealment techniques rely on shape information from other (typically previous) time instants to perform the concealment. These techniques usually achieve better concealment results when the shape does not change much in consecutive time instants. Techniques combining both temporal and spatial methods are referred to as spatio-temporal techniques.

In this paper, original spatial shape error concealment techniques will be presented. All techniques assume that the shape of the corrupted object is in the form of binary alpha plane and that some of the shape data is missing due to channel errors. Due to the missing some of the contour segments contour will be broken. The idea is to approximate the missing contours using NURBS. Many different approaches can be found in [2], [3], [4], [5], [6]. We propose a spatial error concealment technique based on a contour representation of the object shape, i.e., the boundary of its texture (Fig. 1).

a)



b)

Fig. 1 An object and its transmitted components: a) original image; b) image α-plane.

Error concealment includes the construction of a new curve that successfully replaces the missing boundary parts and joins smoothly with the received parts. The existing geometric concealment approaches build a polynomial concealment curve based on

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II. Spatial Shape Error-Concealment Scheme

The technique proposed in this paper is a spatial technique, in the sense that it does not rely on information from other temporal instants. Fig. 2 illustrates block diagram for the shape concealment technique. The input is corrupted alpha plane. Our proposed schematic process is shown in Fig. 3.

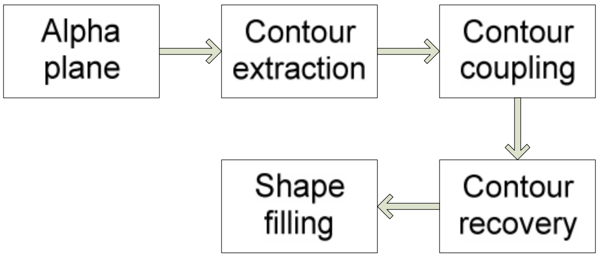


Fig. 2 Proposed shape-concealment process

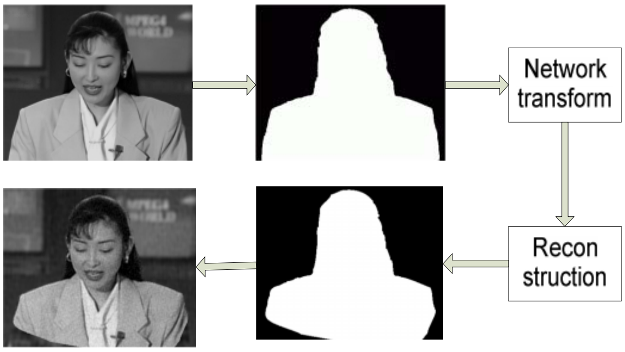


Fig. 3 Proposed schematic process

There are four main steps used in shape concealment technique [2]:

• Contour extraction— first the correctly decoded contour from the available binary alpha plane has to be extracted. There are many contour representations – edge, vertex and shape elements

• Contour coupling— the next step is to determine which of these contours actually define the missing area. The challenge in contour coupling is to establish the two appropriate consecutive contour parts for each contour gap, where it is generally assumed the contour does intersect itself and is closed [2].

• Contour recovery—the missing contours are approximated with Bézier curves and NURBS. Bézier and NUBS curves are easier to manipulate and much faster to compute which is especially important when video applications are considered.

For each pair of contour endings, the recovery of the contour inside the missing area with NURBS and Bézier curves is performed by following three steps.

1) Determination of the four points that fully specify the NURBS and Bézier curves relevant for the contour in question.

2) Definition of an analytical continuous expression of the NURBS and Bézier curves from the points determined in the previous step.

3) Finally, computation of a discrete representation of the continuous NURBS and Bézier curves determined in the previous step, in order to obtain the edge representation of the interpolating contour inside the lost area.

• Shape filling—after the lost contour parts have been recovered a new closed contour is obtained. The corresponding shape is then filled with shape level information, i.e. black.

III. Performance Evaluation

In order to evaluate the proposed shape-concealment technique, several MPEG-4 bitstreams have been tested, each bitstream containing one video object (according to the Core Visual Object Type [1]) encoded at a given bit rate. The exact bit rate value used is unimportant because it does not influence the quality of the shape since lossless shape coding was used.3 On the other hand; the quality of the texture data is highly dependent on the used bit rate. Since users are very sensitive to errors in the shape data, shape is typically coded in intra mode for every time instant. This way, after the concealment is done, if a given VOP still has some shape artifacts, these will not propagate to the following VOPs.

IV. Results

To test the proposed concealment method a number of experiments were performed, some of which are presented here. Examples showing the visual outcome are show besides numerical results. In order to quantify the performance of the proposed concealment method, we will use a relative measure, the ratio D_n of the number of different pixels in the original and reconstructed α-plane divided by the total number of object pixels in the original α-plane. In MPEG-4 is used this quality metric to evaluate shape coding techniques. We will compare our method to the error concealment method proposed by Soares and Pereira [2]. Finally, reconstructed α-planes and restored images will be illustrated for subjective evaluation.

There is one object shape used in our experiments, namely Akiyo. For this boundary we assumed a missing segment consisting of various points and applied the proposed method. After boundary reconstruction corresponding α-plane was extracted. The D_n values associated with every object are shown in Table I. As can be seen in Table I, only a small percentage of the reconstructed object pixels differ from the original ones. In most cases, such small differences are hardly visible. Comparing the results in Table I, Bézier interpolation gives the best results. NURBS improvement is greater in the case of smoother boundary. This is explained by the fact that cubic curves can be effective for complex boundaries.

a) b)

c)

Fig. 4 Examples of corrupted alpha plane: a) error pattern 1; b) error pattern 2; c) error pattern 3

a)

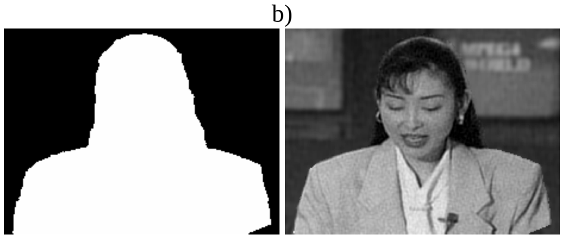
b)

c)

Fig. 5 Examples of concealed alpha (pattern 1 – Fig. 4a) plane for the first VOP and decoded VOP [0,4bpp]: a) NURBS; b) Bézier approximation; c) Bézier interpolation

a)

b)



c)

Fig. 6 Examples of concealed alpha (pattern 2 – Fig. 4b) plane for the first VOP and decoded VOP [0,4bpp]: a) NURBS; b) Bézier approximation; c) Bézier interpolation

a)

b)

c)

Fig. 7 Examples of concealed alpha (pattern 3 – Fig. 4c) plane for the first VOP and decoded VOP [0,4bpp]: a) NURBS; b) Bézier approximation; c) Bézier interpolation

In Table II comparison using objective criterion is shown. PSNR values are presented in decibels.

TABLE I
DN [%] VALUES FOR AKIYO

	NURBS	app_Bezier	int_Bezier
pattern1	3,25	3,27	2,88
pattern2	0,62	0,72	0,43
pattern3	0,67	0,69	0,51

TABLE II
PSNR VALUES FOR AKIYO [0,4BPP]

	NURBS	app_Bezier	int_Bezier
pattern1	26,77	26,57	27,18
pattern2	34,07	34,05	34,52
pattern3	36,05	35,85	36,34

V.CONCLUSION

Shape error concealment techniques for corrupted image boundaries from packet loss using NURBS and Bézier curves are proposed in this paper. Methods are based on the interpolation and approximation of the received boundary in a way that can represent its complexity level and preserve its direction at the connecting points. The key idea of this study is to use NURBS and Bézier curves to represent the portion of image data without corruption. The concealment curve is a cubic curve having the same direction at the connecting points. Our method leads to better objective and subjective results than the current state of the art.

As follow from experiment, Non-Uniform Rational B-Spline can be used for shape reconstruction and gain very good results.

ACKNOWLEDGMENT

Research described in the paper was financially supported by the Slovak Research Grant Agency: VEGA under grant No. 1/0602/11.

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