패킷에러로 인한 영상손실을 최소화하기 위한 블록기반의 인페인팅 알고리즘의 설계

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A Design of Block-wise Inpainting Scheme for Packet Error Concealment

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Abstract

In this paper, we describe an error concealment techniques based on image inpainting for the image impairments due to the packet loss. Image inpainting is to remove or restore the damaged sections from the images, which is usually old images, paintings, or video films. Inpainting has a long history which goes back to the era when the paintings come out. Manual inpainting is no more used, and we can use digital inpainting for the digitally impaired images and video sequences. In this paper, we review the error concealment techniques for the packet loss recovery and propose our inpainting based image impairment recovery scheme for video communication over packet networks.

1. Introduction

As we know, the damaged paintings and images are around our life and how to inpainting them is always been a hot topic. Even we do this as a manual work but in these days, the digital images and movies are more and more. It's not suit for now so the digital techniques are starting to be a widespread way of performing inpainting. It's almost have a similar way like choose the regions where will be inpainting and then use the algorithm to fills-in the regions by the information come from near. And this algorithm is not only can restore the image but also can replace the object which we don't want it being any more. Use this algorithm we can reach our aim automatic and simultaneously but we should mark the region by ourselves. About mark there are two ways like line scratch and choose it by manual. In this paper we just pay attention on how the algorithms work.

2. Related work

There are mainly three research focuses on digital image inpainting. The first one is film restoration mentioned by Kokaram [1]. It exploits the information from adjacent frames to restore the impairments in film. However, it does not work for the case when we have many frames to be inpainted with this method. The second one is based on texture synthesis mentioned by Hirani and Totsuka [2]. They use a simple way to inpainting such as texture selection which the region requires and the matching process which put the texture into the place. Even it is simple, it shows good result. Texture synthesis approach is not extended to the complex scenes, and it does not work for the images which are composed of many objects. The third one is related to dis-occlusion [3]. It uses the elastic minimizing curves to connect the junction on the same gray-level.

Decoder error concealment can rebuild the lost information which comes from the transmission errors. For the first main way is recovery texture information. We can use the motion compensated temporal prediction. It is based on the vector of MB; if the vector has been lost we must rebuild it first. Another method is named spatial interpolation to interpolate pixels from neighboring blocks. There is also the way like use maximizing the smoothness of resulting video to spatial and temporal interpolation; spatial interpolation by projection onto convex sets. Another main way is about recovery the coding modes and motion vectors. For coding modes we can estimate that the MB is only coded in the intra-mode and recovering the underlying blocks by spatial interpolation. For the lost MVs, we can use different MVs in the MB for different pixel regions.

There have been many researches on inpainting algorithms, and Bertalmio's algorithm is the basic algorithm. The algorithm defines a region Ω, which the region to be inpainted and the $\partial\Omega$ is the boundary of Ω. Bertalmio's algorithm proceeds as (1) make sure how to fill in the region of the picture, (2) let the outside pixel continue until go into theΩ, (3) define regions by contour lines and the last step is texture it. The general algorithm for $I^{n+1}(i,j)$ which is an updated vision of $I^{n}(i,j)$.can be written as equation (1).

$$I^{n+1}(i,j) = I^{n}(i.j) + \Delta t I_t^n(i,j), \forall(i,j) \in \Omega \qquad (1)$$

$$I_t^n(i,j) = \overrightarrow{\delta L^n}(i,j) \cdot \overrightarrow{N}^n\ (i,j) \qquad (2)$$

, where n means that inpainting "time", (i,j) are the coordinates of pixel, Δt is the rate of improvement and $I_t^n(i,j)$ is the update of the image $I^n(i,j)$. (i,j) is the pixel location within the region Ω. The information can be propagate from outside Ω into Ω. To know how many it changed and where it goes, we compute the equation (2).

$L^n(i,j)$ is the changing of information and $\overrightarrow{N}^n(i,j)$ is the direction. So we also can notice that if the two equations have been equality we can got that $I_t^n(i,j) = \overrightarrow{\delta L^n}(i,j) \cdot \overrightarrow{N}^n(i,j) = 0$. For $\overrightarrow{N}^n(i,j)$ we use a time varying estimation and got the discrete gradient vector$\nabla L^n(i,j)$. $\nabla L^n(i,j)$gives the direction of largest and have a 90 degrees rotation $\nabla^{\perp} L^n(i,j)$. It is the smallest so equal to the iso-phote direction. So $\overrightarrow{N}(i,j,n) = \nabla^{\perp} I^n(i,j)$.

To make sure the correct process, we use an anisotropic diffusion every few steps to avoid the lines of isophtropic crossing each other.

$$\frac{\partial I}{\partial t}(x,y,t) = \vartheta_{\epsilon}(x,y)\kappa(x,y,t)|\nabla I(x,y,t)|, \forall (x,y) \in \Omega^{\epsilon} \quad (3)$$

At here Ω^{ϵ} is a dilation of Ω with a ball of radius ϵ, κ is the Euclidean curvature of the isophotes of I and $\vartheta_{\epsilon}(x,y)$ is a smooth function in Ω^{ϵ} [4].

As we have known above can get the equation (2):

$$I_t^n(i,j) = \left(\overrightarrow{\delta L^n}(i,j) \cdot \frac{\overrightarrow{N}(i,j,n)}{|\overrightarrow{N}(i,j,n)|}\right) |\nabla I^n(i,j)|$$

3. Error Concealment Scheme based on Inpainting

We used the inpainting algorithm (a extension of Bertalmio's algorithm) to recover packet loss. To compute $\overrightarrow{\delta L^n}(i,j)$ which is a derivative of 2D smoothness estimation L, we use the following equation.

$$\overrightarrow{\delta L^n}(i,j) := (L^n(i+1,j) - L^n(i-1,j), L^n(i,j+1) - L^n(i,j-1))$$

$$L^n(i,j) = I_{xx}^n(i,j) + I_{yy}^n(i,j)$$

To compute the direction of L like $\overrightarrow{N}/|\overrightarrow{N}|$, we use the following equation.

$$\frac{\overrightarrow{N}(i,j,n)}{|\overrightarrow{N}(i,j,n)|} := \frac{(-I_y^n(i,j), I_x^n(i,j))}{\sqrt{(I_x^n(i,j))^2 + (I_y^n(i,j))^2}}$$

We compute the change of L along the direction $\overrightarrow{N}$, we call the result as β^n here.

$$\beta^n(i,j) = \overrightarrow{\delta L^n}(i,j) \cdot \frac{\overrightarrow{N}(i,j,n)}{|\overrightarrow{N}(i,j,n)|}$$

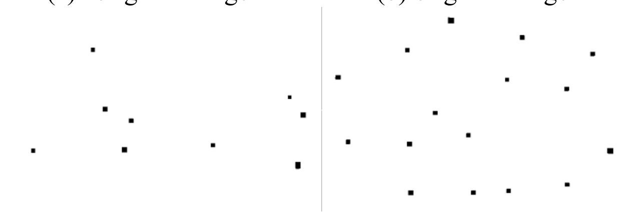
Finally, we multiply the result which just comes out by $|\nabla I|$, and note that $|\nabla I| = |\nabla^{\perp} I|$[5]. In this equation b is known as backward differences and f is known as forward differences. And the m and M is denote the minimum and maximum.

$$|\nabla I^n(i,j)| = \begin{cases} \sqrt{(I_{xbm}^n)^2 + (I_{xfM}^n)^2 + \left(I_{ybm}^n\right)^2 + \left(I_{yfM}^n\right)^2}, & \text{when} \beta^n > 0 \\ \sqrt{(I_{xbM}^n)^2 + (I_{xfm}^n)^2 + \left(I_{ybM}^n\right)^2 + \left(I_{yfm}^n\right)^2}, & \text{when} \beta^n < 0 \end{cases}$$

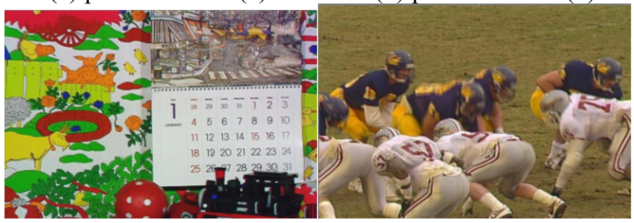
4. Experimental Results

We applied the inpainting algorithm to recover packet loss as shown in Figure 1. Figure 1 (c) and (d) shows the block impairment from the packet loss, which we make the location of packet loss to be random. Figure 1 (e) and (f) shows the recovered image sequence after applying inpainting algorithm to the block impairments.

(a) original image 1 (b) original image 2



(c) packet loss of (a) (d) packet loss of (b)



(e) recovery of (c) (f) recovery of (d)

(Figure 1) (a, b) original image sequence, (c, d) packet loss, (e, f) recovery of packet loss

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