Research on Error Concealment for Video Communication

Yan Zhang and Xiangqun Li

College of Electrical Engineering, Northwest Minzu University, Lanzhou 730124, China
Email: 819349885@qq.com; 27600963@qq.com

Abstract. The video sequence restoration described in this article has been extended to many areas of our lives today. People use it to perform various restoration tasks, making it possible for some pictures that were impossible to restore in the past. This paper uses experimental methods to study the error concealment and traditional image restoration in video compression, and mainly studies the CDD model algorithm, TV model algorithm and error mode. This article also has a very important meaning for the related research of video communication error control, that is, the research of digital image restoration technology, in the post-processing of film and television works, the fuzzification of network video, and the restoration of old documentaries.

Keywords. Error concealment; video coding; image inpainting.

1. Introduction

With the widespread application of streaming media and the increasing demand for high-performance parallel computing, it is difficult for the existing single-core DSP structure to build a video encoding hardware platform to meet the increasing computing demand. In order to improve the fault tolerance of video coding, variable macro block order (FMO) technology is proposed in video coding standard, which can be divided into the following six types, as shown in figure 1.

For efficient video communication, studying various optimization algorithms to continuously improve compression coding efficiency and reducing the original bit rate is only one of the important aspects. Another important aspect is to deal with the errors and losses of video information caused by network transmission. Current video coding standards are mostly based on block-based hybrid coding technologies, which use motion compensation prediction, intra-frame prediction, and variable-length coding to remove spatial, temporal, and statistical correlations of images to compress data. With the reduction of redundant information, the encoded video stream is extremely sensitive to errors in network transmission. Once a bit error or data loss occurs in the received code stream, a bit error may cause the entire data packet to be decoded incorrectly. Video coding standards mostly use error concealment technology based on the decoding side for error concealment. This chapter mainly studies the intra-frame error concealment technology of the HEVC video coding standard, which uses the information that has been correctly received to analyze the intra-frame coded video caused by the transmission error of the video stream. The loss of image data is reconstructed to achieve the purpose of restoring the decoded video quality.

Video sequence refers to the arrangement of multiple video images connected in time and space in a certain order [1]. We can understand the restoration of video sequences as the restoration of image sequences in a fundamental sense. The work of image restoration is to reshape the image that needs to be repaired or remove the superfluous things. In short, it is to restore the original state of the image. Image repair technology can be traced back to the Renaissance [2]. In order to restore the damaged
picture to its original appearance, people use the method of filling in the cracks to repair the picture. Bertalmio first proposed that a mathematical expression can be used to simplify image restoration [3]. When the damaged area of the image to be repaired is not too large, we mainly use image repair technology based on non-texture structure to repair it, such as using a high-order partial differential equation (PDE) algorithm to repair the image [4]. The main principle of this method is that each damaged area of the image to be repaired has its edge information. We can use its edge information to determine its diffusion information and direction, and conclude that the boundary of the damaged area diffuses into the image [5]. The image algorithm of non-texture structure does not have any restriction on the structure of the damaged area that needs to be repaired, which means that several areas.

(a) Interweaving mode (b) Decentralized mode (c) Foreground mode

(d) Box-out mode (e) Raster scan mode (f) Erasure scanning

**Figure 1.** FMO modes in video coding standard.

Under the premise of satisfying visual connectivity, the known area information of the image is copied to the damaged area that needs to be repaired to synthesize a new image area. However, it should be noted that this method cannot completely repair the geometric information of the objects in the image, and excessive unnaturalness will produce artificial boundaries [6].

At present, people have made great gains in the field of image processing. More and more image restoration methods are also coming out. However, image restoration inherently has many limitations, such as image enhancement cannot be guaranteed, image restoration results are not satisfactory, etc. [7]. Each of us has different standards, so the results of image restoration methods cannot meet everyone’s needs. The development of science is getting faster and faster, and people's requirements are becoming more and more demanding. A technology that has just been developed today may not be able to catch up with the trend of science and technology tomorrow, so the proposal and improvement of image restoration methods is still a long way to go. The research on image restoration still has very important practical significance to this day [8-9].

For efficient video communication, studying various optimization algorithms to continuously improve compression coding efficiency and reducing the original bit rate is only one of the important aspects [10]. Another important aspect is to deal with the errors and losses of video information caused by network transmission [11]. Current video coding standards are mostly based on block-based hybrid coding technologies, which use motion compensation prediction, intra-frame prediction, and variable-length coding to remove spatial, temporal, and statistical correlations of images to compress data [12]. With the reduction of redundant information, the encoded video stream is extremely sensitive to errors in network transmission [13]. Once a bit error or data loss occurs in the received code stream, a bit error may cause the entire data packet to be decoded incorrectly.
2. Image Restoration Method Based on CDD Model

The CDD model, the full name of Curvature driven diffusion, is translated into Curvature Driven Diffusion Model in Chinese, as shown in figure 2. It was developed by CHAN and others on the basis of the TV model, introducing the curvature diffusion term \( k \), so that the large curvature in the damaged image can be diffused rapidly, and the connection can be achieved. The function of the large fracture site.

\[
I_D^0(x) = I(x)_{\Omega\setminus D} + n(x)
\]  
\[
I_{\Omega\setminus D}^0(x) = I(x)_{\Omega\setminus D} + n(x)
\]  
\[
div\left[\frac{f(k) \cdot \nabla I}{|\nabla I|}\right] + \lambda_D(x)(I - I^0) = 0
\]  
\[
div\left[\frac{f(k)^{2-q} \cdot \nabla I}{|\nabla I|^{2-p}}\right] + \lambda_D(x)(I - I^0) = 0
\]

If the image caused by noise is not considered, the values of the adaptive model \( p \) and \( q \) can be considered by the limit method. The limits of \( q \) and \( p \) can be (1) and (2). Then, they can be combined into 4 different situations:

1. When \( p=2, q=2 \), it means that the area to be repaired is a flat area with relatively small curvature and gradient. Its repair model is:
This model is called the harmonic model and has the characteristics of isotropic properties. It is often used to repair flat areas. It has a better repair effect than the anisotropic diffusion model.

(2) When \( p=2, q=1 \), it means a smooth edge area with small curvature and large gradient. The repair model is:

\[
\frac{\partial I}{\partial t} = \Delta t
\]

(4)

This is the TV model mentioned above, which belongs to anisotropic diffusion, because it can only diffuse at the edge of the image, so the edge can be well protected. At the same time, since the curvature is small, the curvature has little effect on the repair effect, so the calculation of the curvature is omitted, which greatly reduces the repair time. In this area, the repair speed is better than the CDD model.

(3) When \( p=1, q=2 \), it is a flat area with small gradient, large curvature and large image change, the repair model is:

\[
\frac{\partial I}{\partial t} = \nabla (f(k), \nabla I)
\]

(5)

(4) When \( p=1, q=1 \), it indicates the edge information with large gradient and curvature and strong changes. The repair model is:

\[
\frac{\partial I}{\partial t} = \nabla \left( \frac{f(k)}{\nabla I} \right)
\]

(6)

(7)

This is the basic CDD model. The disadvantage is that the repair speed is slow due to too many iterations. But in some cases, such as when the curvature and gradient are large, the repair effect is better. The repair example can refer to the 3.

3. The Repaired Processing and Results

Image information has a strong spatial correlation, as shown in figure 3. Image restoration technology also uses this feature, as shown in figure 4. It uses neighboring pixel values in spatial domain to interpolate the missing information or use techniques such as growth algorithms to estimate and estimate the texture details of the missing blocks restore, as shown in figure 5. Compared with traditional intra-frame error concealment algorithms, the average quality of video objective restoration is significantly improved, as shown in table 1.

![Figure 3. The source area is 96x96 pixels in size and repaired image.](image-url)
However, the spatial correlation of an image is greatly affected by the distance between pixels. As the distance increases to a certain extent, the correlation between pixels will be very small or no correlation.

![Original image](source1.png) ![Repaired image](source2.png)

**Figure 4.** The source area is 128×128 pixels in size and repaired image.

![Original image](source3.png) ![Repaired image](source4.png)

**Figure 5.** The source area is 192×192 pixels in size and repaired image.

| Sequences   | Source area limit (pixels) | Damaged image (PSNR(dB)) | Repaired image (PSNR(dB)) |
|-------------|----------------------------|--------------------------|---------------------------|
| FourPeople  | 96×96                      | 26.7                     | 42.7                      |
|             | 128×128                    | 26.7                     | 41.1                      |
|             | 160×160                    | 26.7                     | 39.1                      |
|             | 192×192                    | 26.7                     | 38.4                      |
|             | 96×96                      | 29.4                     | 42.7                      |
| ParkScene   | 128×128                    | 29.4                     | 45.5                      |
|             | 1920x1080                  | 29.4                     | 45.2                      |
|             | 160×160                    | 29.4                     | 45.2                      |

**Table 1.** The result of the repaired image.

### 4. Conclusions

This paper applies image restoration technology to video coding error concealment algorithms, and solves the problem of poor restoration effect due to too large coding units. In this paper, a simulation experiment is performed on the algorithm, and the results of the simulation experiment are given. The
computational complexity of the proposed algorithm is greatly reduced. At the same time, it also gives its own suggestions on the research directions that can be further improved.

Acknowledgments
This study was supported by “the Fundamental Research Funds for the Central Universities of Northwest Minzu University (Project number:31920170016 and 31920190039)”.

References
[1] Lin C 2008 Research on Video Repair Problems (Zhejiang University) Chapter 1 pp 11-15.
[2] Zhang Z 2007 Research on Image Enhancement Algorithm in Video Image Restoration (Zhejiang Normal University) Chapter 1 pp 13-24.
[3] Ji C 2010 Digital Image and Video Restoration (Xi’an University of Technology) Chapter 1 pp 2-9.
[4] Fang Q Y 2011 A New Digital Video Restoration Algorithm (Hangzhou Dianzi University) Chapter 2 pp 21-35.
[5] Liu S 2007 Research on Digital Image and Video Restoration Technology (Zhejiang University) Chapter 1 pp 9-15.
[6] Huo X 2013 Research on Several Methods in Digital Video and Image Restoration (Hefei University of Technology) Chapter 2 pp 21-29.
[7] Zheng H Y 2009 Research on Image Restoration and Video Restoration Algorithms (Jilin University) Chapter 2 pp 16-25.
[8] Aign S and Fazel K 1995 Temporal and spatial error concealment techniques for hierarchical MPEG-2 video codec IEEE International Conference on Communications ICC Seattle pp 1778-1783.
[9] Suh J W and Ho Y S 1997 Error concealment based on directional interpolation IEEE Transactions on Consumer Electronics (2) 295-302.
[10] Zhang Y and Lin Y 2014 Improving HEVC intra prediction with PDE-based inpainting Annual Summit and Conference on Asia-Pacific Signal and Information Processing Association pp 1-5.
[11] Zhang J and Yu Y 2011 An improved BSCB image inpainting method Journal of System Simulation (4) 95-99.
[12] Patel H M and Desai H L 2014 A review on design, implementation and performance analysis of the image inpainting technique based on TV model International Journal of Engineering Development and Research (5) 191-195.
[13] Duan Y, Huang W and Zhou J 2014 A two-stage image segmentation method using Euler’s Elastic regularized Mumford-Shah model 2014 22nd International Conference on Pattern Recognition pp 118-123.