Expert Systems with Applications 42 (2015) 5811–5821

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Learning discriminant DCT coefficients driven block descriptor for digital dropout detection system in degraded archived media

Kiok Ahn [a], Md. Monirul Hoque [a], Gihun Song [a], M. Abdullah-Al-Wadud [b], Oksam Chae [a,*]

[a] Department of Computer Engineering, Kyung Hee University, 446-701 Youngin-si, Republic of Korea
[b] Department of Software Engineering, King Saud University, Riyadh, Saudi Arabia

ARTICLE INFO

Article history:
Available online 9 April 2015

Keywords:
Digital dropout
Degraded media archive
DCT
Genetic algorithm
Edge detection
Support vector machine

ABSTRACT

Digitization of old archived media is of great importance to preserve the originality of medium in terms of historical record as well as the means to quality improvement for reproduction purposes. However, digitization increases the exposure of the media to digital dropout error, thus presenting a significant degradation in perceptual quality of the converted video sequences. A numbers of mechanisms were investigated in the past to make these converted media more robust against digital dropout errors. Nevertheless, these techniques achieved little success, forcing manual quality check to assure standard quality. This paper presents an automatic solution to this problem based on discriminant DCT coefficients. Here, the idea is to build a block classification model by learning discriminant DCT coefficients first and utilize these coefficients along with an weighted neighborhood sampling strategy to formulate discriminant block descriptor so that within-class difference of the block features is minimized and between-class difference is maximized. This spatial detection is free from motion computation; thus performs accurately in presence of pathological motion (PM) and fast moving objects. Finally, the proposed method is compared against the existing methods to demonstrate improved detection accuracy using real degraded video archives.

1. Introduction

With the accelerated evolvement of visual digital media, the demand for better QoS has increased pressure on broadcasters to automate their error detection and restoration activities for preserving their archives. Now a days, relative unavailability of the contents is the main concern for broadcasters. Archiving contents can be degraded due to the chemical decomposition of the original material as well as the physical problems in repeated projection or playback. In order to retain the archived materials by converting these degraded contents to digital file, there is a possibility that noise or errors contained in the film or tape is either maintained or displayed in other forms. These errors and noise can reduce the quality of the generated files. As the amount of data is quite large, manual retouching is unfeasible (Kokaram, 2004). Consequently, automatic error detection in high quality image sequences has gained notable industrial awareness.

Digital dropouts are a major type of damage occurred due to the physical error in original tape. In that case, original video is not accessible which is no-reference approach, is a challenging research issue. While storing original AV content on digital video tape carriers or when converting this content to file based environments for future preservation, digital dropout are apparent as non-homogeneous blocks (typically, size of 8×8). Fig. 1 shows the example of dropout occurs in video archives.

Regardless of the practical urgency of digital dropout detection algorithms in digital video tapes (Digi Beta, IMX etc.), to the knowledge of the authors, there exists few scientific work focusing exactly on this kind of defect. Prior to 2014, among the closest related solutions, the method in Sun, Han, Wang, Xu, and Lei (2010) detects rectangular shaped blocks with homogeneous intensity appearing in the image by a combination of intensity and edge based features. Kaprykowsky (Kaprykowsky, Liu, & Ndjiki-Nya, 2009) focuses on the detection of frames heavily affected by Betacam dropout in analogue video by using local image histogram features organized in a quad-tree. This approach

* Corresponding author.
E-mail addresses: kiokahn@daum.net (K. Ahn), monirul@khu.ac.kr (M.M. Hoque), gihunsong@khu.ac.kr (G. Song), mwadud@ksu.edu.sa (M. Abdullah-Al-Wadud), oschae@khu.ac.kr (O. Chae).
URL: http://vision.khu.ac.kr (O. Chae).

http://dx.doi.org/10.1016/j.eswa.2015.04.004
0957-4174/

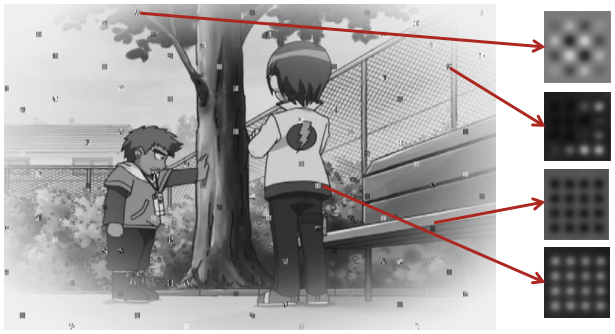

Fig. 1. Digital dropout due to tape error. [Courtesy: Korean Broadcasting System (KBS)].

is meant to detect large dropouts in analogue video, so its performance for digital dropout detection will likely be poor.

A numbers of transmission/compression related block error detection mechanisms (Farrugia & Debono, 2009; Khan, Lehmann, Gunji, & Ghanbari, 2004) are investigated in the past. In Khan et al. (2004), a number of computationally expensive features and heuristic thresholds are used to detect corrupted blocks at image level while in Farrugia and Debono (2009), the authors first utilize transport layer error detection capabilities to identify potentially corrupted group-of-blocks (GOBs) and then compute several spatio-temporal pixel and DCT features to identify error blocks within the GOBs. Despite showing superior performance in transmission related error detection, the assumptions and features used in these methods are designed for mostly homogeneous MBs/GOBs detection; thus fail to perform accurately in digital dropout detection. Furthermore, these methods depend on error detection capabilities of the decoder, transport layer protocol syntax, and semantic violation tests adopted by the codec to determine the potentially corrupted MBs/GOBs in the initial stage. In addition to that, as mentioned earlier, like any spatio-temporal/temporal models, these methods suffer from motion estimation failure in presence of pathological/fast motion. So dealing with pathological/fast motion remains an unresolved issue for those approaches. Fig. 2 illustrated mosaic like defects, betacam dropout defects, and block error respectively. Recently the authors in Hoque et al. (2015) propose a perceptually relevant spatial method based on DCT coefficient statistical features. Though this method shows significant detection accuracy in case of highly degraded error blocks but for slightly annoying error blocks, the accuracy is relatively lower.

In this paper, an automatic detection method of digital dropout defect, evident in digitized old archive media is proposed. Here, the proposed method identifies discriminant local discrete cosine transform (DCT) coefficients within a block, which can be effectively used in digital dropout error detection along with a support vector machine (SVM) (Hsu & Lin, 2002) at its core for classification. Furthermore, we seek to observe how the influence of certain neighbor inclusion can enhance the discriminative ability in block representation and adopted an weighted neighborhood sampling strategy to extract effective and robust block descriptors. Our spatial information based approach eliminates the presence of fast motion; thus also reduces computational load and complexity. Experimental results illustrates an error detection rate of 98.87% achieved by the proposed method with minimal false detection which ensures that no loss in quality is experienced in error-free video. Our proposed method also correlates highly with human subjective judgments of quality.

The major contributions of this paper are the following:

1. For digital dropout detection, we have identified the set of DCT coefficients which can be used in digital dropout error detection.
2. An optimal neighborhood weighted sampling strategy is utilized based on spatially correlated directional behavior.
3. Proposed spatial frame only method does not require any motion computation and/or temporal information; hence works independently in presence of fast/pathological motion.
4. Feature extraction operates entirely in the DCT domain, resulting in lower time complexity and computational load.
5. Finally, the method resembles highly with human subjective judgments of error and yields highly competitive performance.

This paper is organized as follows. The problem overview and details of the proposed error detection algorithm are presented in Sections 2 and 3, followed by the experimental results in Section 4. The final discussion, future research directions, and conclusion are presented in Section 5.

2. Problem overview

Digital drop-outs are caused by missing magnetic material or momentary loss of tape contact with the playback head or by flaws on the tape or other features that cause an increase in the head-to-tape spacing. The frequent appearance of dropout on playback is an indication that the tape or recorder is contaminated with debris

(a) (b) (c)

Fig. 2. (a) Mosaic like block error (Sun et al., 2010) (b) Betacam dropout error (Kokaram, 2004) (c) Block error where arrows indicate visually impaired region (Farrugia & Debono, 2009).