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A NOISE REMOVAL ALGORITHM FOR THE RESTORATION OF VIDEO SEQUENCES

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Abstract

Video transmission is found today in many applications such as surveillance, video-on-demand, video conferencing, internet etc. The basic communication problem may be posed as conveying source data with highest possible accuracy. When video sequences are transmitted from source to destination, it actually gets transmitted frame by frame. The interference due to unavoidable energy called noise, degrades the quality of video during its transmission. So in order to improve the quality of video sequences at receiver section, optimum reduction of noise is needed. It consists of three parts, (a) Video shot detection (b) Key frame detection (c) Filtering. To compare the results of denoising algorithm usage for video filtering, near noiseless video sequences were used and the following step taken (1) Addition of artificial noise to video sequences, (2) Removal of noise from sequences using different denoising algorithms (3) Comparison of processed sequences with the originals.

Keywords: Impulse noise, Gaussian noise, Color homogeneity, Eigenvectors, Eigenspace, Spanning.

1. Introduction

Noise can be systematically introduced into an image during acquisition and transmission. A fundamental problem of image processing is to effectively remove noise from an image while keeping its features intact. In this paper we introduce a framework for creating a noise removal filter that is based on a simple statistic to detect impulse noise pixels in video sequences. Instead of applying the "detect and replace" methodology of most impulse noise removal techniques, we show how to integrate such a statistic into a filter designed to remove not only Gaussian noise but also impulse noise. The behavior of the filter can be adaptively changed to remove impulses while retaining the ability to smooth Gaussian noise. Additionally, the filter can be easily adapted to remove the mixture of Gaussian and impulse noise. The basic challenge is to improve the quality of degraded video frame. During video transmission impulse noise affect the quality of video frame. So in order to improve the quality, optimum reduction of noise is to be achieved. At present reduction of noise is achieved by many filters, such as Median filter, bilateral filter, SD-ROM filter etc. But the optimum noise reduction is possible by using the method introduced in this paper.

2. SYSTEM OVERVIEW

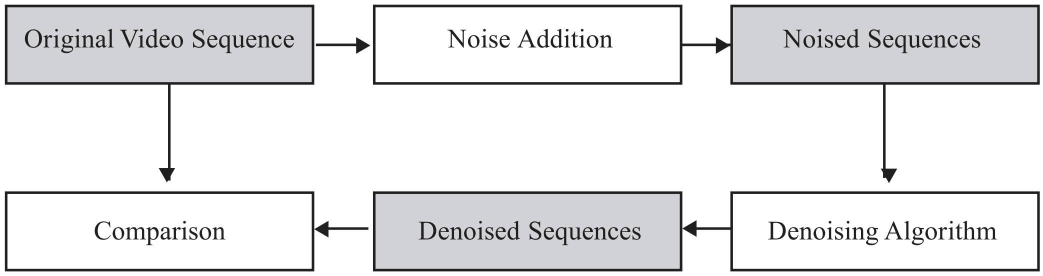
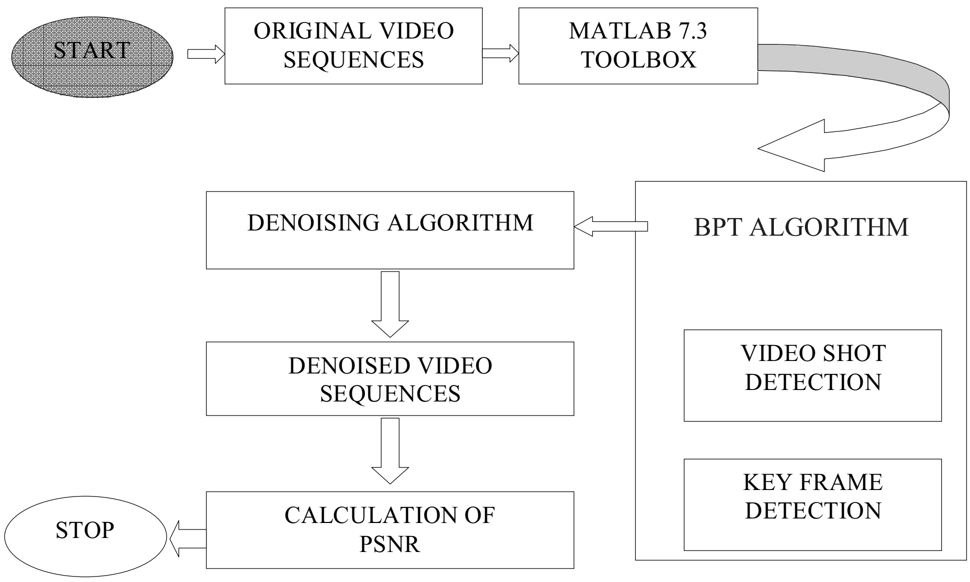


Figure 1: System Overview

The Fig.1 shows the block of system overview. The first block represents original video sequence of .avi format. In the next step we are artificially adding the impulse noise in the original video sequence. After this the noisy video sequence is given to the denoising algorithm which removes both mixed Gaussian and impulse noise. The output of filter is denoised sequence, which is compared with the original one.

Flowchart for the Restoration of Noisy Video



2.1. RSST (Recursive Shortest Spanning Tree)

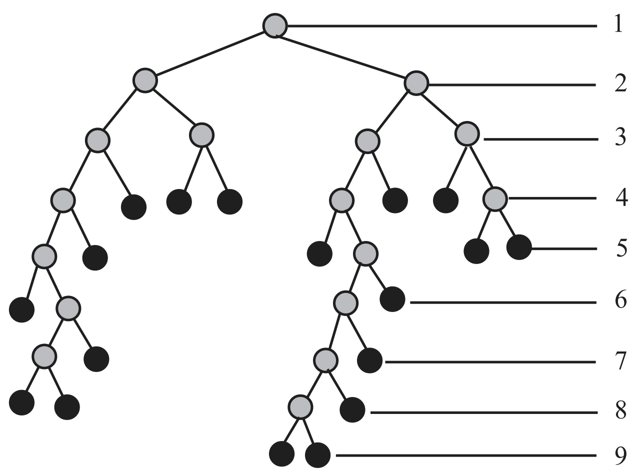
Due to its simplicity and efficiency the RSST algorithm can be considered as a very useful automatic algorithm for image segmentation. The RSST itself is a hierarchical algorithm in the sense that segmentation starts from the finest level (i.e. single pixel level) to coarsest level (i.e. a user-specified level). For this reason, the final number of regions has to be externally specified by the user thus fixing the merging criterion to that given value. Once it reaches the given value it terminates the region growing process thus resulting a partition with the user-specified number of regions. It should be noted that though the original RSST algorithm uses the number of regions as the merging criterion introducing Peak Signal to Noise Ratio (PSNR) criterion, is also straight forward but at the expense of excessive mathematical calculations.

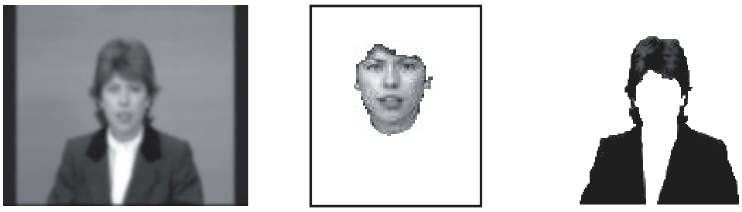
$$d(R_{i,}R_j) = \left\{ \left[Y(R_{i,}R_j)\right]^2 + \left[U(R_i) - U(R_j)\right]^2 + [V(R_i) - V(R_j)]^2 \times \left(\frac{N(R_i \times N(R_j)}{N(R_i) + N(R_j)} \right) \right\} \quad (1)$$

Where R_i and R_j are two candidate regions and $Y(R)$, $U(R)$, $V(R)$ represent their luminance and chrominance values. $N(R)$ represents the number of pixels in a region.

2.2. BPT (Binary Partition Tree)

The BPT creation process starts from a given initial partition. The regions belonging to the initial partition are represented in the leaves of the tree. The rest of the remaining nodes of the tree correspond to the regions created by the merging process. The merging of two regions at a time is done according to a defined merging order while maintaining the "Father" and "Children" nodes relationship. By keeping track of merging order of each region a final tree is created and each region is assigned a level thereby facilitating a hierarchical representation of the original image.





(a) (b) (c)

Figure 2: A BPT (a) Original Image (b) a Region Belonging to Level 4 (c) a Region Belonging to Level 3

Our approach can be divided into two parts. Firstly, a set of homogenous regions is created automatically using RSST and represented hierarchically using BPT. Secondly, any interesting regions are selected manually to group them into objects. The first part consists of running both RSST and BPT for a given number of regions which is supplied by the user. This parameter is provided to the RSST algorithm through a Graphical User Interface (GUI). The input to the BPT is provided from the RSST algorithm to create the binary tree. We use the same merging order and region model criteria for both the techniques. When creating the binary tree region, parameters such as area and color are calculated and they are attached to each node of the tree. Geometry descriptors such as shape, size, position and rotation are extremely useful for information retrieval applications and could be calculated and attached to these tree nodes, however, such methods are not used within this work as there is no need to use them in this context of object segmentation.

2.3 Covariance Matrix

According to the statistical description of eigenspace decomposition, eigenvectors give the most descriptive coordinate system for the working space by maximizing the variation of the data. We can define the similarity measure between two consecutive frames in the same shot by calculating the transformation between principal coordinate systems. Below we define the steps of our algorithm:

(1) Find 3×3-covariance matrix of the color space given by

$$C_{f_{i,j}} = \begin{bmatrix} R_{f_{i,j}} & G_{f_{i,j}} & B_{f_{i,j}} \end{bmatrix}^T \begin{bmatrix} R^T_{f_{i,j}} & G^T_{f_{i,j}} & B^T_{f_{i,j}} \end{bmatrix} \tag{2}$$

where R, G and B row vectors denote mean normalized red, green and blue components of i^{th} frame of j^{th} shot.

(2) Determine eigenvectors of the covariance matrix. For determining the shot boundaries, we use maximum eigen valued eigenvector, principal axis, because of its uniqueness and descriptive nature of the data.

(3) For finding the shots given a video stream, we use a "cluster seeking" approach commonly used among pattern recognition society,

$$S(X,Z) = (X^T * Z) \ / \ (\|X\| \bullet \|Z\|) \qquad (3)$$

Where X and Z are principal axes of succeeding frames color spaces and $S(X, Z)$ denotes the angle of rotation between these axes.

(4) Shots boundaries are defined by thresholding the rotation changes for the whole video stream.

4. Implementation and Testing

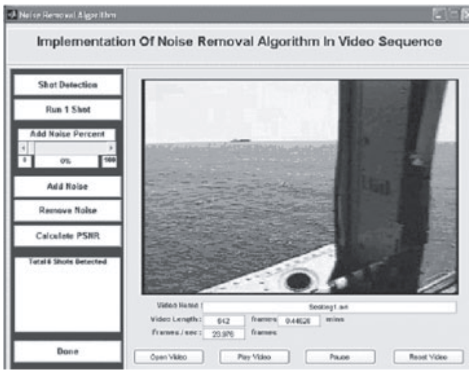
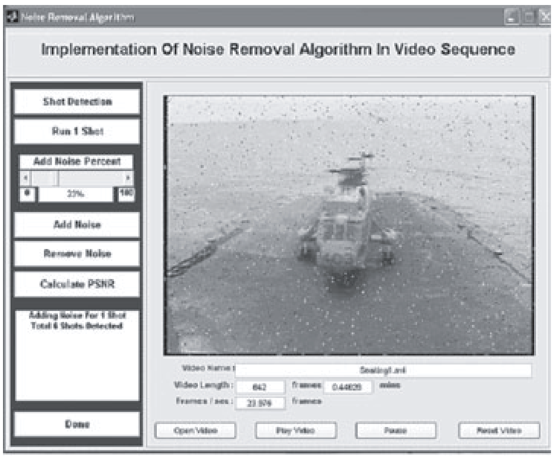


Figure 3: Shot Detection

Figure 4: Noise Preset

- Various shots in a video can be detected. A shot is an unbroken sequence of frame captured by a camera without changing its location.
- Variable percentage of noise can be added into the key frames of the video by the noise preset.



After selecting the desired percentage of noise, it can be added into the key frame of the video by using “Add Noise” button.

Figure 5: Noisy Video Sequence

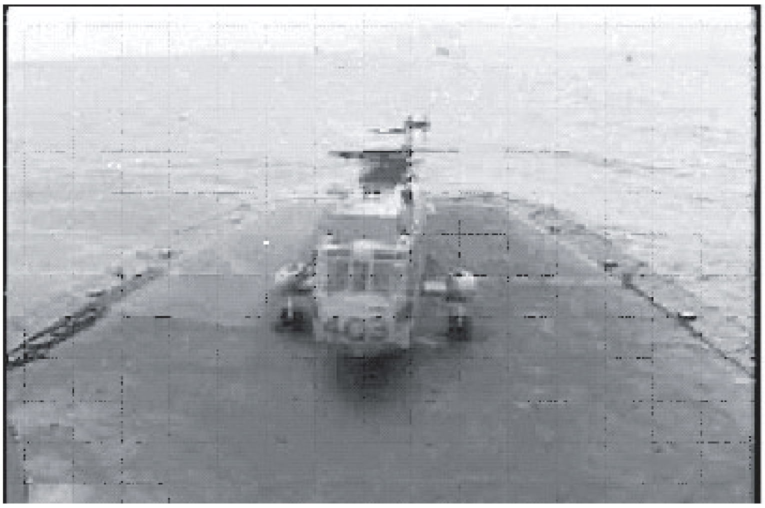


Figure 6: Denoisy Video Sequence

5. CONCLUSION

Many noise removal algorithms, such as the bilateral filtering, tend to treat impulse noise as edge pixels, and hence end with unsatisfactory results. In order to process impulse pixels and edge pixels differently, we introduce a new statistic based on rank ordered absolute differences (ROAD) in some neighborhood of a pixel. This statistic represents how impulse-like a particular pixel is in the sense that the larger the impulse, the greater the ROAD value. We then incorporate the ROAD statistic into the bilateral filtering by adding a third component to the weighting function. The new nonlinear filter is called the trilateral filter, whose weighting function contains spatial, radiometric, and impulsive components. The radiometric component combined with the spatial component smooth away Gaussian noise and smaller impulse noise; while the impulsive component removes larger impulses.

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