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Abstract

This work presents a new approach to detecting the scene change in the successive capture of photographs of a place within equal time interval. This method is based on a gray level histogram of every image. In this method the histogram of an image is processed to modify it for matching with the processed histogram of a reference image. The coefficient of correlation is taken as the measure of matching. As the method does not do any heavy signal processing, and the images are taken successively with a multi-shot digital still camera, it can be applied for real-time processing of such pictures for detection of a scene change. A multi-camera in multi-position approach is also shown to evaluate the change in scene simultaneously from different angles. Both multi-camera and single-camera approaches are compared in detecting a scene change.

1. Introduction

In many machine visions technique scene change detection is a fundamental module. Many video surveillance systems used a scene change module for reducing image data before any further processing [1],[2]. Scene change detections are used in industries, security surveillance systems, sports, etc. to sense whether an object is present in the image or not. There are many scene change detection algorithms in literature [3], [4], [5], [6].

Depending on the strategies used to find the objects in the scene, scene change detection algorithms can be classified as:

- Local techniques; or
- pixel based techniques.

In local techniques, the image is divided into square blocks and local features are used to detect the change in image.

In pixel-based techniques or punctual techniques, the differences between correspondent pixels are only used to take decisions regarding scene changes.

Recently, many different methods have been developed to solve scene change detection problems and these algorithms can be found in [7] and [8]; the most common techniques are:

- simple difference (pixel based);
- statistic geo-pixel (local);
- illumination [9](local); and
- quadratic approximation [10](local).

Local techniques lack in computational efficiency; this is a fundamental property in real-time video surveillance systems. As a result, local techniques are unpopular in real-time scene change detection problems. Punctual techniques are computationally more efficient and mostly used in real-time video surveillance systems [3]. In punctual techniques background and foreground images are taken and require continuous background updates. As a result, sufficient processing effort is required to update background images.
In this paper, a totally new technique is followed, where the histogram of every successive image is taken, processed and compared to detect the scene change in each successive image. This method does not require any background update or pre-processing of the captured image.

2. Image Acquisition

A Nikon CoolPix 4300 still digital camera was used to capture successive images with a capture speed of 5fps.

The camera can capture 16 images with a resolution of 568×426 pixel in a sequence (for example, Fig. 1 shows 16 images taken in a sequence). For scene change detection, a total of 20 sequences of scenes were evaluated in different real world places with and without scene changes (Fig. 2 gives some example of images taken at different locations).

3. Colour to Gray Scale Conversion

In this method, the gray scale colour histogram is taken as the primary information from the image. As the images were taken with a colour digital camera, all images were converted into a gray scale image with Equation 1 before any further processing [11]. Fig. 3 shows an image after gray scale conversion.

\[ I_{gr}(x, y) = 0.3R_c(x, y) + 0.59G_c(x, y) + 0.11B_c(x, y) \] (1)

4. Gray Scale Histogram

After converting the image into gray scale, a histogram of every image was taken Fig. 4 [11]. By taking the histogram of the image, all other information available in the image is discarded as the goal of the work is only the detection of a scene change.

5. Dividing the Histogram into Bins

After getting the histogram of an image, the histogram is divided into 64 equal bins of colours (1 bin = 4 consecutive colours) and the average of the number of pixels in every bin was taken Fig. 5 [11].
6. T-Distribution

The T-distribution of the average bin-histogram was calculated with Equation 2 [12]

\[ \bar{x} - t_{\alpha/2} \frac{s}{\sqrt{n}} < \mu < \bar{x} + t_{\alpha/2} \frac{s}{\sqrt{n}} \]  \hspace{1cm} (2)

Where, \( \mu \) is the mean, \( \bar{x} \) is the average number of pixels in every bin, \( s \) is the standard deviation of the bin-histogram generated from the histogram in the previous section, \( n \) is the number of samples in each bin (here the number of the sample is 4) and \( t_{\alpha/2} \) is the t-value with \( (1 - \alpha) \times 100\% \) confidence interval. \( \alpha \) is a number between 0 - 1. In this case the degree of freedom is \( \nu = n - 1 = 3 \), the confidence interval is \( (1 - \alpha) \times 100\% = 90\% \).

In this step, t-distribution was taken as the number of sample is less than 30. After estimating the range of each mean \( \mu \), a modified \( \hat{\mu} \) mean was calculated using Equation 3. Fig. 6 shows a graph of modified mean.

\[
\hat{\mu} = \frac{\bar{x} - t_{\alpha/2} \frac{s}{\sqrt{n}}}{3} + \frac{2 t_{\alpha/2} \frac{s}{\sqrt{n}} \times 0.3}{3} + \frac{2 t_{\alpha/2} \frac{s}{\sqrt{n}} \times 0.7}{3} + \frac{2 t_{\alpha/2} \frac{s}{\sqrt{n}} \times 0.1}{3}
\]  \hspace{1cm} (3)

Fig.6. Plot for modified mean \( \hat{\mu} \)

7. Calculation of Coefficient of Correlation for Matching

Fig.7 shows the pattern of image taken for analysis. Image sequences with scene change and without scene change were taken. The first image taken was considered as the reference image for all samples because the entering object or persons was absent in all initial images.

Therefore, the \( \bar{\mu} \) signal of the first image was considered as the reference signal for matching. All the signals of successive images after the initial image were correlated and the trend coefficient of correlation was evaluated.

After that, the best fitted straight line with the coefficient of correlation was taken as the result of comparison. Fig. 8 shows a straight line when there is no scene change (the blue line) and when there is a scene change in the sequence (red line).

Fig.7. Images with scene change and without scene change were taken.

Fig.8. Plot of coefficient of correlations for different cases

8. Evaluation from Multiple Angles

It was observed that if image sequences were taken from multiple angles and evaluated
in the above process the images from different positions of camera give different amounts of variations in the slopes of the slanted lines when any significant change occurs. Fig. 9 shows the difference in results from different angles.

Fig. 9. Image taken from different angles and the resultant straight lines.

It is seen from Fig. 9 that if the scene change is detected from certain positions simultaneously, the detection will be better.

9. Results

Twenty different sequences were analysed with this method. The maximum and minimum value of the correlation results in 4 of the 20 sequences with and without scene changes are shown in Table I.

<table>
<thead>
<tr>
<th>Image No.</th>
<th>Without Scene Change</th>
<th>With Scene Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
</tr>
<tr>
<td>Image1</td>
<td>0.999</td>
<td>0.979</td>
</tr>
<tr>
<td>Image2</td>
<td>0.998</td>
<td>0.995</td>
</tr>
<tr>
<td>Image3</td>
<td>0.999</td>
<td>0.998</td>
</tr>
<tr>
<td>Image4</td>
<td>0.997</td>
<td>0.991</td>
</tr>
</tbody>
</table>

As we can see in the table, in most cases the method gave good deviation. But in the case of Image 3 the variation is low. In fact Image 3 was an image taken in inadequate light. As a result, the deviation of the colour histogram was not strong enough to show high deviation like other images taken under sufficient light.

10. Conclusion

Although this method utilizes simple and lightweight image processing techniques to detect scene changes in real-world situations, the method suffers some limitations. In the case of insufficient luminance, this method does not perform as well as it performs under sufficient luminance. All of the objects or persons entering the scenes are large and this method will not be a good choice for long-distance surveillance systems. This method is very fast and effective in detecting real-time scene changes under sufficient light.

11. References