Video Color Adaptation for Mobile Devices

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ABSTRACT

A large number of videos cannot be visualized on mobile devices (e.g., PDAs or mobile phones) due to an inappropriate color depth of the displays. Important details are lost if the color depth is reduced. A major challenge is the preservation of the semantic content in spite of this fact. In this paper, we present a novel adaptation algorithm to enable the playback of videos on color-limited mobile devices. Dithering algorithms diffuse the error to neighbor pixels and do not work very well for videos. We propose a non-linear transformation of luminance values and use textures in combination with edges to reduce the color depth in videos.

Categories and Subject Descriptors

I.4.3 [**Image processing and computer vision**]: Enhancement; I.4.8 [**Image processing and computer vision**]: Scene analysis

General Terms

Algorithms

Keywords

video adaptation, dithering, transcoding

1. INTRODUCTION

Videos are no longer limited to television or personal computers due to the technological progress in the last years. Nowadays, many different devices such as Tablet-PCs, Handheld-PCs, PDAs, notebooks or mobile phones support the playback of videos. The specific features of a particular mobile device (e.g., the color depth of the display or the performance of the CPU) must be considered to achieve a reasonable playback quality of videos. In this paper, we focus on the color depth as one of the main features affecting the quality of videos.

Automatic video adaptation techniques facilitate the playback of videos especially for mobile devices. For such techniques, the most important goal is the preservation of the semantic information in the adapted video. Although much work was done on the transcoding of videos only few approaches focus on the *semantic* adaptation [1, 3, 4].

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2. ADAPTATION OF THE COLOR DEPTH

By reducing the color depth of an image large regions with identical colors appear, and it becomes much more difficult to recognize details in the images. Especially, the adaptation of videos for monochrome displays – where all pixels are represented with two different luminance values – is not easily archivable.

The conversion from color to grayscale is done without any computational effort because most video compression standards store luminance and color values separately. The number of different luminance values can be reduced by defining equal-sized intervals and linearly mapping all luminance values in each interval to a new value.

A *variable interval size* derived from the distribution of the luminance values in the source image improves the quality of the adapted image significantly. We use cumulated histograms $H_{kum}(i)$ to define the non-linear transformation of the luminance values:

$$L_{var}(i) = \lfloor \frac{N_C}{S_X \cdot S_Y + 1} \cdot H_{kum}(i) \rfloor \in [0, N_C - 1]. \quad (1)$$

The width S_X and height S_Y of the image normalize the cumulated histogram. The transformation of the luminance i to the new value $L_{var}(i)$ depends on the distribution of the histogram values and the number of different colors N_C in the adapted image. Figure 1 (b) exemplifies adapted images with $N_C = 8$ different luminance values by applying a linear transformation with equal-sized intervals (equal-sized bins). Fine structures and details are lost. Much more details are discernible if a variable interval size is applied compared to the linear transformation (see Figure 1 (c)).

An extension for the *adaptation of videos* is considered in the following. Significant luminance changes are visible if we analyze the cumulated histograms for each frame. Therefore, we calculate one aggregated cumulated histogram for all frames of a shot. The histogram describes the distribution of the luminance values of this shot. Suitable parameters $L_{var}(i)$ can be derived from the cumulated histogram.

The *adaptation for binary displays* is considered in a second step. The problem to represent a color image with few different colors is well known from printing. One method is called *Halftoning*: Different colors are combined to create the illusion of a new color.

In 1975, the well-known *Floyd/Steinberg dithering algorithm* was published that reduces the perceptible error when the color depth of an image is reduced [2]. The algorithm maps each pixel to a new value and diffuses the error to

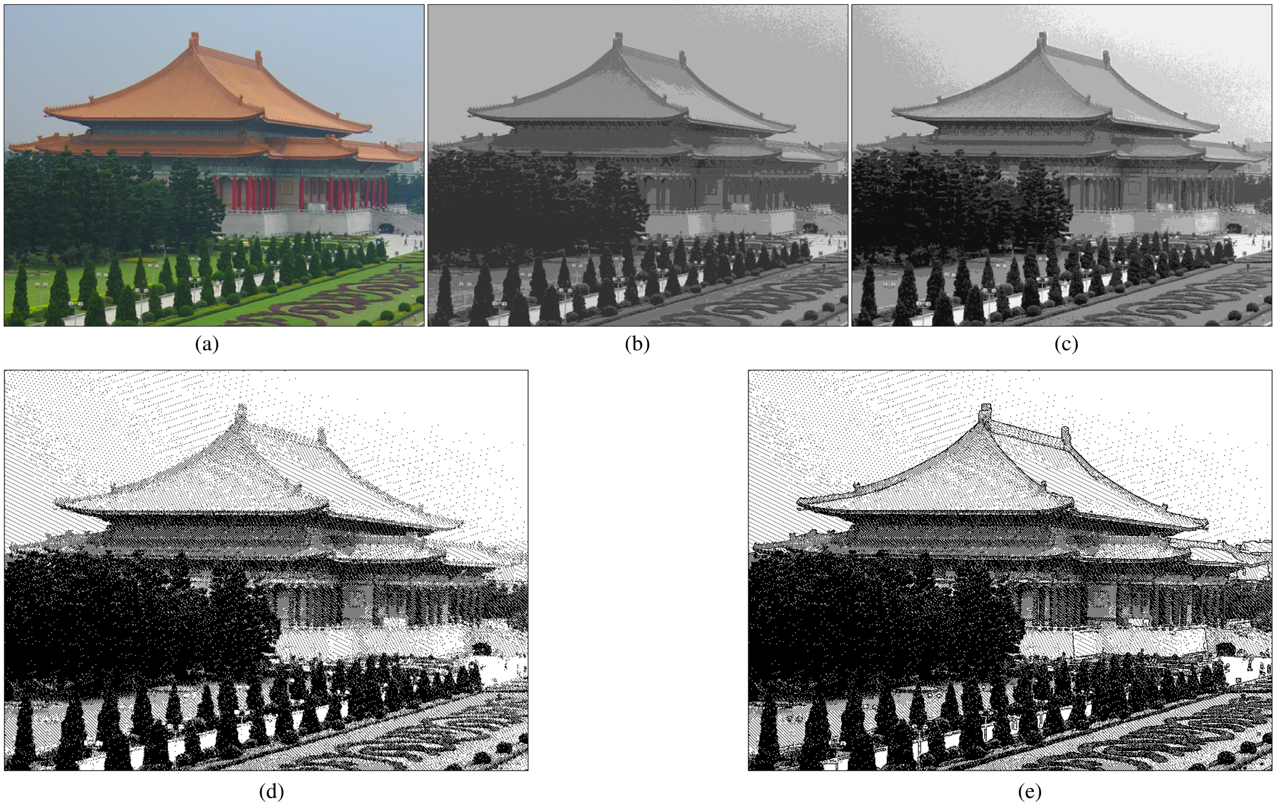

Figure 1: Transformation of a color image (a) into grayscale images (eight luminance values) using linear (b) and non-linear adaptation (c). Transformation of a color image into a binary image. The semantic adaptation with textures (d) in combination with an enhancement of edges (e) visualizes the content very well.

neighbor pixels. In spite of the good results for images, this algorithm *cannot be applied* for video sequences because many pixels change between adjacent frames due to the diffusion of errors. Hence, the content in such videos is no longer recognizable.

In the following, we describe the details of our algorithm which uses binary *textures* to substitute the pixels of an image. A grayscale image with $N_C = 16$ different luminance values is constructed with cumulated histograms, and each value is substituted with pixels from the corresponding texture. In some cases, the differences between two adjacent regions are quite low. This leads to good results for gradual transitions (e.g., the sky in Figure 1 (d)) but strong edges in the image are lost. We compensate the loss of details by overlaying the textured image with an edge image. This approach emphasizes significant edge pixels (e.g., the roof in Figure 1 (e)).

3. CONCLUSIONS

We presented an algorithm to reduce the color depth of images while original semantics are preserved. Furthermore, our novel algorithm transcodes videos so that they can be displayed on monochrome displays. We have shown the performance of our approach by examples in this paper. Video clips that visualize the results of our video adaptation algorithm and a video demo are available on our website [5]. Additionally, the source code of our novel algorithm is also available.

4. ACKNOWLEDGMENTS

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