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Image Processing Techniques to Detect and Filter Objectionable Images based on Skin Tone and Shape Recognition

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Abstract

In this paper we describe image-processing techniques to detect and categorize potentially objectionable images based solely on the image content. The techniques include a novel method of matching skin tones based on a fuzzy classification scheme and shape recognition techniques to match faces and other elements of the human anatomy. In particular the color matching technique is significantly more accurate than existing methods documented in literature. These techniques offer a means of filtering images, based solely on graphical content, for a new generation of home Internet appliances.

1. Introduction

In today's market we witness an emerging trend towards providing simplified Internet access to consumers on non-PC platforms. These new Internet appliances are designed for use in the home by non-technical users and have limited memory and functionality compared with a desktop PC.

One problem with such appliances is that they provide potentially unrestricted access to the Internet in a home environment. For example, it is generally not possible to install a "minder" program to filter content on such an appliance. Furthermore, as these appliances do not normally feature a hard drive, it is not possible to filter content by maintaining a local database of URLs or objectionable keywords. Although such databases may be maintained remotely this will greatly slow the response time required to evaluate the nature of Web content.

In this paper we describe image-processing techniques to detect and categorize potentially objectionable images based solely on the image content. This approach can be either client or server based. Moreover, the primary detection mechanism can be implemented as a relatively light set of image-processing algorithms, which makes it suitable for use in embedded systems.

These techniques include a novel method of matching skin tones based on a fuzzy classification scheme. This technique relies on transforming the color-coding of an image into LAB color space and matching a selection of image pixels with an optimized set of color prototypes. When a pixel is identified as a positive match to one of the skin prototypes a localized texture analysis is performed on the neighboring pixels to eliminate the

false alarms. If a sufficient number of pixels are positively matched then the image is subject to additional image processing to recognize which human anatomical elements are present. Note that this color matching technique is significantly more accurate than existing methods documented in the literature.

Additional techniques, which are then applied, include shape recognition techniques to detect faces or other elements of the human anatomy and erotic pose detection. A mix of these techniques, applied in sequence as shown in *Fig. 1*, allows a very high detection rate of objectionable images with relatively low levels of false detections. Our approach is based on a series of progressively more complex filters. Note we normally expect a high percentage of pictures to pass the skin tone filters – these algorithms can process 10-100 images per second depending on image size. The second stage filters are an order of magnitude slower and images, which are passed for advanced grading, would normally be presented to a human (parent) to evaluate manually. When combined together these techniques offer a means of filtering images, based solely on their graphical content.

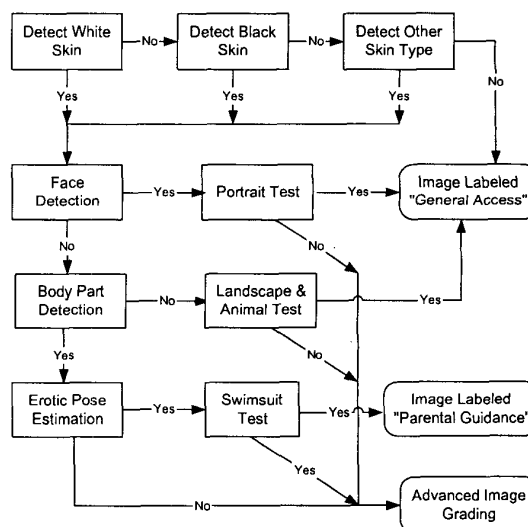


Fig 1 Typical detection steps for an incoming image.

As most of these techniques have relatively low resource requirements and the basic algorithms can be implemented in a small ROM footprint we believe that this approach is particularly suited for use in embedded Web browsing appliances. A significant number of these appliances are now coming to market and we believe that there will be strong demand from parents for some means of monitoring and filtering Web content on such appliances.

2. Implementations of the Technology

Several implementation of this technology are described in this paper. The first is a server-based system, which is suitable for screening large image repositories such as a Web photocommunity. In such a website users upload personal images to an account and organize them in groupings known as web-albums. They may then keep these pictures private or make them publicly available. When users choose the latter option the photocommunity becomes legally responsible for the nature of this publicly available content. It is desirable to screen all publicly available picture albums prior to allowing them to be displayed. This is a slow and costly process if undertaken by hand. In contrast our primary detection algorithm using color matching to a set of optimized prototypes allows a PC based server to scan and verify up to 100 images per second. In fact the limiting factor for JPEG images is the time required for decompression from JPEG format to RGB.

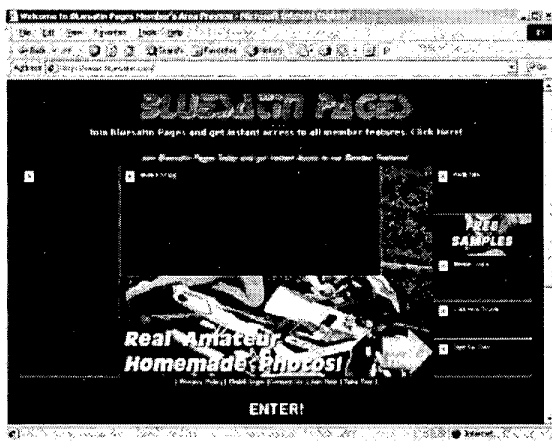


Fig.2 Typical web page content as it appears in the browser windows after filtering.

Moving into the home environment, these screening technologies can be implemented on home Internet appliances in two ways. Firstly the system can be implemented as pure client solution. To this end we describe in detail how the technology can be integrated with a Web browser such as Internet Explorer. In this

example images are screened and filtered prior to display in the browser window. An example is given in *Fig 2*.

An alternative approach involves implementing the detection and filtering on a Web proxy. In this second case all Web accessories are channeled through a web proxy on a separate Internet server. This proxy performs the images processing steps and the apparent result, from the perspective of the end-user, is identical to that seen in *Fig.2*.

3. Detection based on Skin Tone

The questionable image is first transformed into CIE-Lab color space, which properties provide a better representation for color analysis. Sampled pixels are randomly taken from the image and compared with skin color prototypes stored in a database. Pixels with colors closed to a prototype in terms of Euclidean distance are then subject to texture analysis to determine whether the pixel is an isolated color or is comparable with other pixels in its neighborhood: a condition indicating a skin pixels. If the number of skin pixels is above a threshold than the image is assigned as potentially objectionable and passed to the shape recognition filters. The skin color prototypes are obtained using fuzzy clustering scheme. A large number of skin samples were classified into 32 classes representative for the human skin color. Due to its computational efficiency and light hardware requirements this technique is very suitable for implementation on an embedded system.

4. Shape Detection Techniques

When an image has failed the color test, it is passed to the shape recognition filter that performs higher level image processing algorithms as shown in *Fig 1*. In this paper we focus on the face detection algorithm. Our technique relies on two-step process: the first detect the image regions that are likely to contain human faces based on color and the second which analyses these regions and based on their shape identifies the faces. The first stage is accomplished by using a skin segmentation technique based on the color filter described above. The latter stage makes use of the fact the human head outlines a roughly elliptic surface and this along with some other constraints such as the presence of the eye and lips can identify the face.

5. Other Detection Techniques

In addition to the color and shape matching techniques described above, we have also found other image processing techniques useful to identify and take decisions about different types of images. For example, many wildlife and landscape pictures can fail the initial color matching as they have similar tones to human skin. However by applying some basic texture analysis we can differentiate between these pictures.