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FIRST RESPONDER FLESH TONE DETECTION ALGORITHMS FOR IMAGES

by Michael Hoeschele, William Gillam

Center for Education and Research in
Information Assurance and Security,
Purdue University, West Lafayette, IN 47907-2086

First Responder Flesh Tone Detection Algorithms for Images

Michael Hoeschele & William Gillam
Purdue University
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The algorithms in this document layout a method for the detection of flesh tones in images. These algorithms are focused on a first responder tool where complete accuracy is not the focus, but rather speed is paramount. The first algorithm presented detects flesh tones by individually scanning each pixel to determine if it is within a certain predetermined flesh tone range. If the percentage of pixels in a picture that fall in the flesh tone range is above a predetermined threshold (50% is used as an example) the picture is marked as containing flesh tones. Then all pictures are ordered by the last time they were viewed, or some other piece of temporal data associated with the picture. Next pictures are grouped with temporally adjacent pictures that are within a predetermined amount of time. This will group pictures into "viewing sessions," this is working on the assumption that people view pictures in groups, especially when pornographic in nature. Once the groups of pictures have been completed, if there are more than a predetermined percentage (70% is used for this example) of the pictures that are marked as having flesh tone the group is marked as having flesh tones. Clearly, groups marked as having flesh tone can then be presented to the first responder for closer analysis.

The second algorithm presented detects flesh tones by individually scanning each pixel to determine if it is within a certain predetermined flesh tone range. In this algorithm pictures are grouped by time of last view or some other temporal data associated with the picture. Next pictures are grouped with temporally adjacent pictures that are within a predetermined amount of time. This will group pictures into "viewing sessions," this is working on the assumption that people view pictures in groups, especially when pornographic in nature. Once the groups of pictures have been

completed, every pixel in the group of pictures is inspected to determine if it is within the predetermined flesh tone flesh tone range. Essentially, this algorithm treats a group of pictures as one big picture. So if there are more than a predetermined percentage of flesh tone pixels out of all pixels in the temporal group, it is marked as containing flesh tones. Clearly, groups marked as having flesh tone can then be presented to the first responder for closer analysis.

Some ideas for speeding up this process are as follows in this section. The first idea is early exit of an image inspection. This means if after scanning some percentage of the picture, and mathematically there is no chance to break the flesh tone threshold or if it has already been broken, to return below it, scanning will stop of the picture. This will be more difficult in the second algorithm. This idea could also be a problem if groups of images were to be ordered by how much flesh tone is present, which could be helpful to a first responder. Next is to only inspect images that are within a certain aspect ratio. There has been research that proves that the vast quantity of pornographic images fall within a certain aspect ratio range. The next optimization is to skip every other, or every few pixels when scanning for flesh tone. Whether or not this will yield successful results can only be determined through testing. The next optimization is also subject to testing to determine if it will work. The idea is to gather the metadata (temporal and aspect ratio for starters) of images first, and then scan the pixels. A final idea related to optimization is the use of certain types of optimization depending on the suspected target. For example, if the suspect is thought to be the photographer of the images on the computer it may be beneficial to use creation date and time from the camera instead of last viewed from the local machine. In general if may be beneficial to consider the date and time an

image was added to a system. This could be used in a potential downloader and photographer case. This is because a downloader probably downloaded more than one picture at a time, and a photographer probably uploaded many images off the camera at one time. Also it seems that if the general skin tone of the subject in the pictures is known, the range of skin tones could be shifted to focus on this.

First Algorithm

```
/*
This will result in finding groups of pictures with 70% or more of the
pictures being pornographic.  Pictures will be marked as pornographic
if they are 50% or more skin tone in them.  Each picture's propensity
to pornography is calculated individually.



p = current pixel under analysis
skin = current pictures number of pixels in the skin tone color range
pic = current picture under analysis
total = the total number of pixels in the current picture
highColor & lowColor = the color range that a pixel is considered to be
                       flesh if it is with in
g = group of pictures associated by temporal locality
gTotal = total number of pictures in the group
sTotal = total number of pictures marked as skin in the group
*/

analyze each picture pic {
    analyze each pixel p {

    if (p<highColor && p>lowColor) {
        skin = skin + 1;
    }

    total = total + 1;
    }
    // .5 is a value that has to be determined
    // from empirical analysis.  It is the threshold
    // at which a picture is consider pornographic

    if (skin/total < .5) {
    mark picture as skin;
    }

}

group pictures by time viewed;
// the threshold at which to group pictures by time also will be
//   determined by empirical analysis


analyze each group g {
    count total picture in group = gTotal;

    count number of skin pictures = sTotal;

    // .7 is the threshold of when a group is considered to contain
skin
    //   this value will have to be derived from empirical analysis
    if (sTotal/gTotal > .7) {
    mark group as skin;
    }
}
```

```
Second algorithm
/*
This algorithm will determine if there are 70% or more pixels that are
flesh toned in a group.  Basically all the pixels are inspected as a
group, not as single pictures.

pic = current picture under analysis
p = current pixel under analysis
total = total number of pixels in a picture
skin = total number of pixels in the skin tone range in a picture
g= current group under analysis
gTotal = total number of pictures in a group
gScore = the sum of all the pScore values from the pictures in the
group
highColor & lowColor = the color range that a pixel is considered to be
                       flesh if it is with in
*/


analyze each picture pic {
    analyze each pixel p {
    if (p<highColor && p>lowColor) {
        skin = skin +1;
    }

    total = total +1;
    }

    pScore = skin/total;
}

group pictures by time viewed;

analyze each group g {
    count total pics in group = gTotal;

    add up the pScore of all the pictures in the group = gScore;

    if ((gScore/100) / gTotal > .7) {
    mark g as skin;
    }
}
```