Applied Video Statistics

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Abstract

Although the picture quality of today's displays is very good already, a continuous improvement is desirable as the new larger display sizes increase the visibility of artifacts. A contributing factor for picture quality enhancement through smart video processing and algorithm design is the information gathered from video statistics.

Interesting parameters gathered from video statistics are e.g. the image- and display load, the usage of the color gamut, the estimated power consumption and the occurrence of static image parts.

Examples of applications that can benefit from video statistics are power calculations, color gamut mapping algorithms, dynamic backlight control for LCD panels and LED backlights for LCD panels.

1. Introduction

The use of video statistics can improve the design of displays and the video processing algorithms [1] [2] developed for these displays.

For example, the power consumption of an emissive display can be estimated from the display load of average video content. Also, it can be used to estimate the power in a dynamic backlight in a LCD display. Here, video statistics enable an analysis of how much power and contrast enhancement can be achieved if a dynamic backlight is used [3]. Examples of other display aspects that can benefit from video statistics are the size and shape of the color gamut and the lifetime characteristics of displays.

In this paper, we will give several examples of applied video statistics and the conclusions that can be derived from them.

2. Source Material

In order to capture the video statistics, a generic form of collecting video statistics has been developed at Philips Research. By using a PC and a real-time filter, a large amount of video material could be analyzed, i.e. more than 460 hours.

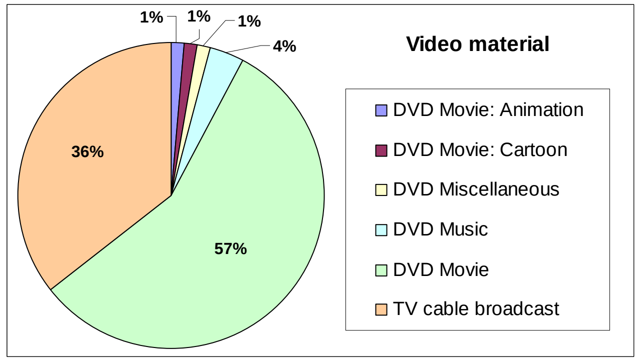


Figure 1: The video data can be divided into two main categories: DVD content (movies) and TV content (cable broadcasts).

Two main categories are distinguished from this set of video data, namely DVD material and TV cable broadcasts (see figure 1).

The first category (DVD) is subdivided into movies, music and miscellaneous. Movies can be subdivided into regular movies, animation movies (CGI) and cartoons. About 300 hours of DVD content (PAL and NTSC) has been analyzed. The second category is common TV broadcasts (165 hours of analyzed content) from a standard set of television stations available on the Dutch cable television (PAL).

Three different generic types of data are extracted from the content, namely 3D color-space histograms (YUV), temporal screen averages and screenshots. By means of post-processing, various characteristics (temporal and spatial) can be gathered from this statistical data.

3. Image Load and Display Load

The image load and display load are important for calculating the power consumption of an emissive display. The image load is the load of the video content itself (including the gamma correction present in the received video signal). The display load is a measure for the amount of light generated by the display and thus for the power consumption needed for light generation.

The display load is obtained by doing an inverse gamma correction per pixel to transform the picture to the linear light domain. We used a gamma of $\gamma = 2.2$ for the inverse gamma correction.

The average image load and average display load of all the processed content is shown in figure 2. It is clearly visible that there is a significant difference between DVD content and TV cable broadcast content [4].

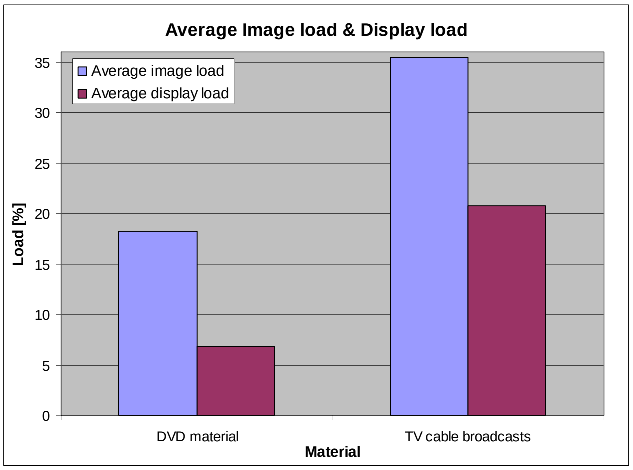


Figure 2: The average image load and average display load of DVD content and TV content.

A possible explanation of this difference can be the presence of black bars in some of the DVD material, namely all wide screen (letter box) movies have black bars at the top and bottom of the screen. However, the presence of the black bars does not entirely contribute to the large difference in the average image load and display load. Other explanations of the differences can be assigned to the presence of more saturated colors in TV material (highly saturated colors in many TV shows), the presence of artificial image content in TV material and the different recording conditions for DVD material.

This knowledge can be used in power calculations for display panels. For example, the power consumption of an emissive display like a PDP panel is dependant on the display load of the offered video material. LCD displays don't have this dependence, because the backlight is always on and the power consumption is not dependant on the offered video material [5] [6].

This means that it is possible that a PDP panel is more efficient if DVD material (low load) is used, but a LCD panel is more efficient in displaying computer graphics (high load). This is illustrated in figure 3.

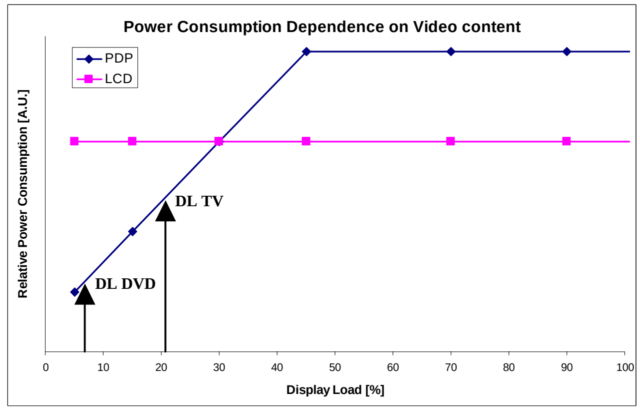


Figure 3: The power consumption dependence on video content compared for a Plasma Display Panel (PDP) and a Liquid Crystal Panel (LCD). This figure is only a schematic illustration.

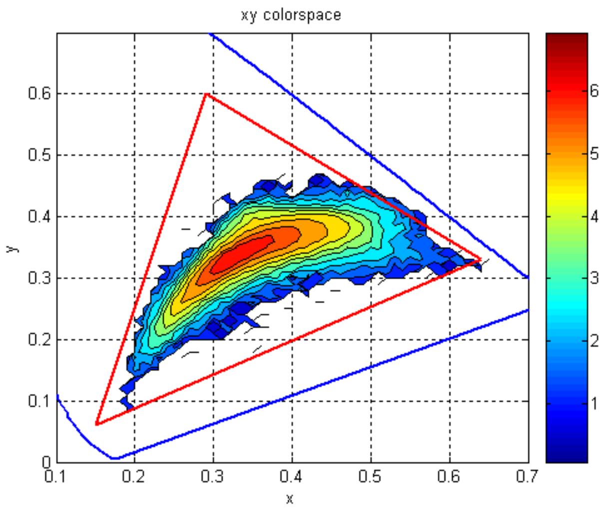
4. Color Gamut Usage

Another interesting topic to investigate is the color gamut usage. Besides considering the differences between DVD material and TV material, more general observations can be made as well.

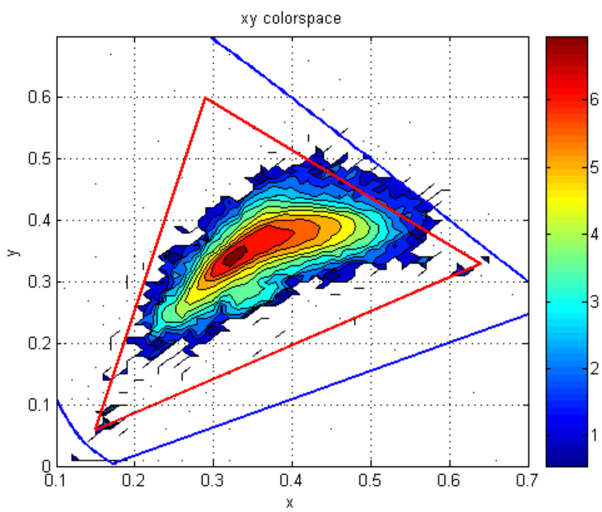
The EBU color gamut, as used in DVD encoding and TV broadcasts, is plotted in figure 4. Especially for orange and yellow colors, a significant difference is visible between DVD material and TV material. In particular, the red, orange and yellow colors are more present in TV material. A possible explanation is the presence of bright logos, flashy TV commercials and a lot of bright info-bars in TV broadcasts, which are typically lacking in DVD content.

Another observation that can be made involves out-of-gamut content. There is hardly any out-of-gamut content present in DVD material. On the other hand, TV material does contain a reasonable amount of out of gamut content, especially for orange and yellow colors. A possible explanation is the presence of noise in cable broadcast signals. Noisy low-luminance yuv colors can yield extreme chromaticity values, but that doesn't explain the bias towards yellow and orange colors.

Figure 4 also shows that especially the green part of the color gamut is rarely used. Most video content is concentrated in the center of the EBU space. In other words, typical video content is fairly unsaturated. This knowledge enables displays that have less saturated primaries than those of EBU to correctly display most of the colors by using a color correction algorithm [7] and helps to determine the choice and location of additional primaries for multi primary displays.



a) DVD content



b) TV content

Figure 4: A 2D xy representation of the video statistics. Shown in red is the EBU gamut and in blue the boundary of physical colors. The filled contour lines indicate the occurrence of colors in the histogram of the video material.

5. Dynamic Backlight for LCD

Conventional LCD panels have a disadvantage with respect to Plasma Display Panels (PDP) and Cathode Ray Tubes (CRT). The power usage in LCD panels is not dependant on the display load (see also figure 3). This is because conventional LCD panels have their backlight lit at a constant brightness continuously, which is not optimal with respect to power consumption.

It is possible to save power and improve the contrast by implementing a dynamic backlight for LCD panels [8]. A dynamic backlight is dimmed to a lower brightness if the video content allows a lower brightness for the backlight. This is the case if the maximum grey level in the picture is below 255. A smart algorithm [8] analyses the video data and lowers the brightness for the backlight. The video data is manipulated to obtain a correct picture. The algorithm uses a windowing function and uses a clipping threshold to achieve a lower power usage for the backlight.

An additional power saving can be achieved by dividing the backlight into segments. For example, a backlight with 8 lamps will be divided into 8 horizontal segments. Each segment can be dimmed to the maximal output value that occurs in that segment. It is obvious that the total power saving by implementing segments is bigger then only dimming the whole backlight. Figure 5 shows the gain achieved by implementing a dynamic backlight for LCD panels.

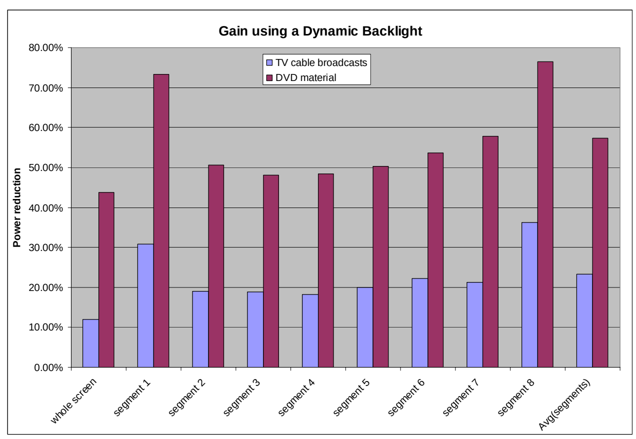


Figure 5: The reduction in power consumption that can be achieved if a dynamic backlight is used for a LCD TV. A reasonable gain is achieved with one backlight for the whole screen. More gain is achieved by using a backlight of 8 segments.

The total average gain that is achieved by using a dynamic backlight for the whole screen is 28% for both TV cable broadcasts and DVD material in the case of one backlight for the whole screen. A total average gain of 40% is reached by implementing a segmented backlight.

Figure 5 shows that the gain achieved differs between segments. Especially segment 1 (top segment) and segment 8 (bottom segment) differ from the other 6 segments. A logical explanation is that the action (bright part of screen) is in the middle of the screen. For DVD material, sometimes, black bars are present in the upper and lower segment of the screen, which can be dimmed more than other segments.

A further reduction of the power usage of a backlight can be achieved by implementing clipping. With clipping, a percentage of the pixels in the screen will be clipped to a lower output value with the result that the highest output value in the picture is equal or lower than the situation if the backlight is only dimmed and not clipped.

A disadvantage of clipping is that clipping in the picture may be visible. This will be the case if the percentage of clipping is too high and/or the pixels that are clipped are grouped together in the picture. For example, this is the case if a car headlight is clipped to a lower value.

The power usage with the use of clipping is plotted in figure 6. This figure shows the power reduction with respect to the situation without dimming and clipping.

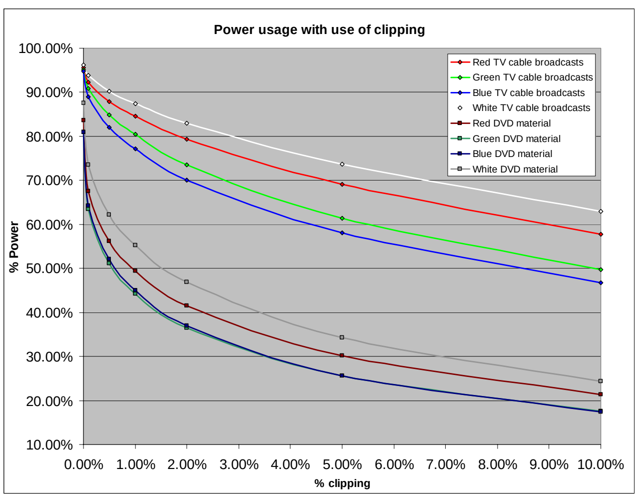


Figure 6: The power usage of a LCD panel with respect to normal operation mode (no dimming and no clipping). The power usage without clipping and with clipping (0.1%, 0.2%, 0.5%, 1%, 2%, 5%, 10%) is plotted.

If backlight dimming for the LCD panels is used with minimal clipping (2% or less), a reasonable power saving can be achieved. For TV cable broadcasts, a power saving of 17% can be gained and for DVD material, even a larger amount (53%) can be gained.

With the use of a color-separated backlight, e.g. a LED backlight, an extra reduction is reached if each color is dimmed separately. Figure 6 shows the power usage with the use of clipping for each color separately. Issues with implementing LED backlights with dimming and clipping are color cross talk and the efficiencies of the separate LEDs.

6. Conclusions

Applied video statistics show that there are numerous options to improve the quality of future displays by using this statistical data to design video processing algorithms and to improve system aspects. Examples of optimizations are power consumption, lifetime behavior and color gamut optimization.

In LCD-TVs, a gain of 28% can be achieved by implementing a dynamic backlight (40% gain achieved with 8 segments). If dimming and minimal clipping are used, a gain of 35% can be achieved without the use of segments and 42% gain can be achieved with the use of 4 segments.

7. References

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