Efficient Energy Management for Video Data using Backlight Optimization

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Abstract— Screen and CPU are two main factors resulting in fast power drains of smartphones. The mobile screen stays on for a long time when it comes to the multimedia streaming applications. A lot of energy is consumed during this period which adversely reduces the life of the battery. Yet there are many other factors too which lead to large consumption of power. In this paper, we modeled a system which efficiently manages the phone energy while playing video. The aim of this system is to compensate the power dissipation typically during multimedia streaming which is achieved by adjusting the backlight level as per video data requirement in such a way that users visual experience doesn't get affected.

Key words: LCD Backlight, Power Management, SSIM Index, Mobile Devices, Mobile Streaming Applications

I. INTRODUCTION

The internet access capability of smartphones has made customers fond of smartphones. Users' preferences while choosing phones sometimes get affected by the display characteristics of a particular phone. The key feature a display defines of these pocket-sized devices is the display type, diagonal measurement, definition, and resolution. As a result, Video data streaming has emerged as an interest among users.

Though phones provide a wide range of facilities to the user, they have to face the challenge of limited battery life of these devices and hence, efficient management of power consumption should be done.

Studies have revealed that the backlight used in display consumes most of the energy when the screen is in active mode. Therefore, it has become a necessity to manipulate existing systems such that it will increase the lifespan of batteries.

In this paper, we have proposed a system in which while playing a video the backlight is adjusted such that the power expended to illuminate backlight source is less but at the same time users visual experience is also not affected.

Few works have been done for the same problem, but these systems provide service over the cloud. As Hadoop works over Big data very efficiently, it can be a new initiative for power management of mobile devices for large video data.

II. SYSTEM MODEL

Generally, a video is nothing but a series of image frames. We may optimize any video by adjusting the backlight for each individual frame. But this is not desirable approach as it may lead to fluctuations while watching the video. Also, hardware takes a considerable amount of time to adjust itself which is not comparable with the frame rate of the video. Hence we can adjust the backlight levels for a group of image frames. We use the SSIM [3] metric in order to calculate the backlight. Our algorithm will assign appropriate backlight levels and store in the backlight file and associate it with corresponding video's URL link.

Whenever user requests for some specific video through its link, video along with the generated backlight file can be downloaded by the user in order to watch the video with optimum brightness and reduce power consumption as well[4].

The user will have nothing to do with the backlight file generated. So neither it increases any sort of a headache or works for the user. Running video will be as simple as it always has been, just a fingertip far from user.

The SSIM is structural similarity index which comprises of luminance, contrast, and structure. To obtain SSIM index, first we compute the three parameters individually and then combine the results to get a final value.

III. INDENTATIONS AND EQUATIONS

Let (l) is the luminance of a frame to be evaluated, and N is number of image frames within a group

$$\mu_x = \frac{1}{N}\sum_{i=0}^{N-1} x_i \qquad \mu_y = \frac{1}{N}\sum_{i=0}^{N-1} y_i$$

Then, the function for calculating the luminance, l(x,y), is defined as follows:

$$l(x,y) = \frac{2\mu_x\mu_y + c_1}{\mu_x^2 + \mu_y^2 + c_1} \qquad (1)$$

Next, we need to calculate the standard deviations of the image, in order to obtain average contrast:

$$\sigma_x = \left(\frac{1}{N-1}\sum_{i=0}^{N-1}(x_i - \mu_x)^2\right)^{1/2} \quad \sigma_y = \left(\frac{1}{N-1}\sum_{i=0}^{N-1}(y_i - \mu_y)^2\right)^{1/2}$$

And now, the contrast is obtained by using the following function:

$$c(x,y) = \frac{\sigma_x\sigma_y + c_2}{\sigma_x^2 + \sigma_y^2 + c_2} \qquad (2)$$

The third variable is the structure, function s(**x**,**y**),

$$s(x,y) = \frac{\sigma_{xy} + c_3}{\sigma_x\sigma_y + c_3} \qquad (3)$$

$$\sigma_{xy} = \frac{1}{N-1}\sum_{i=0}^{N-1}(x_i - \mu_x)(y_i - \mu_y)$$

Finally, the puzzle of SSIM Index is solved as:

$$SSIM(x,y) = [l(x,y)]^{\alpha}.[c(x,y)]^{\beta}.[s(x,y)]^{\gamma} \quad (4)$$

The exponents α, β and γ are greater than zero, which are parameters used to calibrate the weight of the three functions in the measurement; typically, α = β = γ = 1, so the SSIM Index can be rewritten as follows:

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

IV. SYSTEM ARCHITECTURE

As per our proposed system, the user willing to download a video will request to the server engine by sending the URL link through prescribed mobile application. The server will download the video and create backlight file for the same and send the video along with its corresponding backlight file.

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Furthermore, a database can be maintained for all the backlight files of previously requested videos. So that when another user again demands the same video, rather than processing repeatedly, same backlight file can be sent to reduce overhead and respond quickly without wasting time.

Our system functionality is mainly divided into two parts. The first part will be responsible for establishing connection with the client and fulfill requests like creating account, accessing files, requesting and getting video url and downloading it. The second part which is basically hadoop part iteratively checks for new videos in the storage and if found perform the optimization algorithm and create a backlight file.

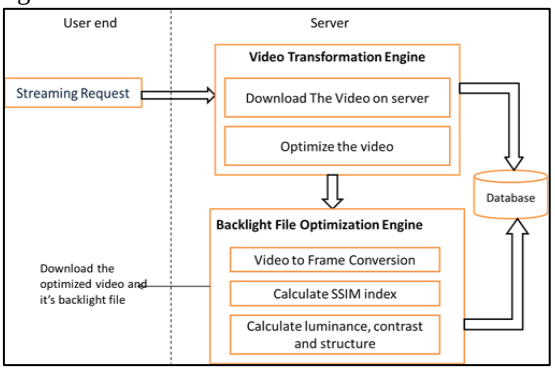

Fig. 1: System Architecture

At the user end, synchronization is maintained between the backlight file and video being played. This is necessary to support pause, play, fast-forward and other tools.

At the server end, as computation of each frame is independent of one another and it is a vast data (number of image frames for long videos) we have deployed server-side task over Hadoop. We extract the backlight level for frames by the SSIM index and further assigns the finest level of brightness as per algorithm.

YCbCr color model is considered in algorithm during the assignment operation. Also, display type of mobile device needs to be checked as it may not support backlight optimization

V. Result

As shown in image below, after successful download of video user gets notification displaying energy savings for corresponding downloaded video.

Energy Savings is obtained by subtracting Energy required at our calculated optimum brightness from Energy consumed by video at maximum brightness.

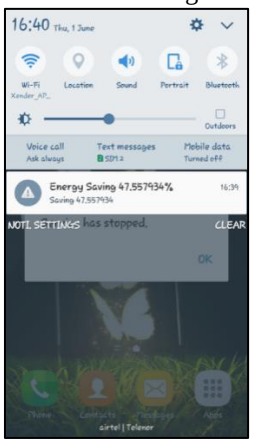

Fig. 2: Notification of Energy Savings

Here as we can see, Energy consumption is minimized by 47.55% approx. for downloaded video. Video gets downloaded along with its backlight file as shown in the following image.

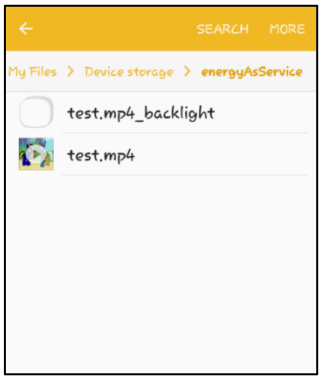

Fig. 3: Video and its backlight file on user's device

VI. Conclusion

The power breakdown of a mobile device is highly affected by the screen which is dominating while playing videos. We study that managing backlight of a device at critical levels such that users' visual experience is also not affected due to an excessive dimming of brightness will save energy considerably. Hadoop-based infrastructure enables the system to respond quickly while processing large video data.

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