Adaptive Display Power Management for Mobile Games

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I. Motivation

- With the widespread availability of 3G/4G cellular networks, and high end smartphones, mobile games are becoming very popular
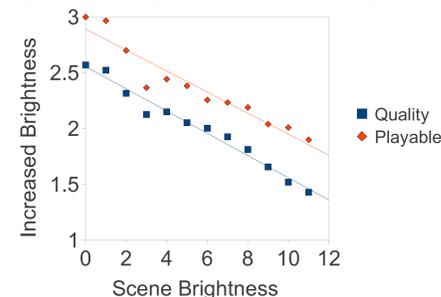
- The main power consuming elements on a mobile device are display, wireless and CPU, in that order.

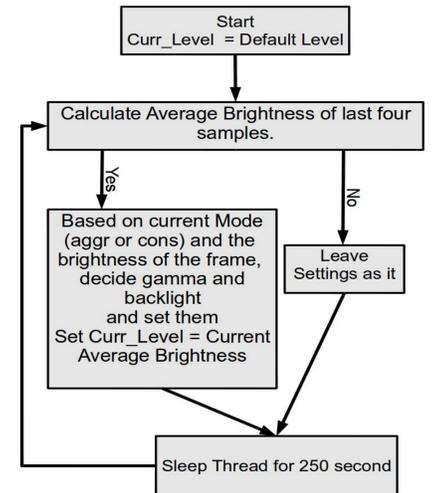- Power consumed by the LCD back-light is very large, especially during game sessions(45-95%).
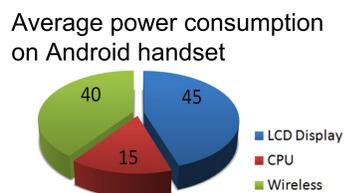
- We introduce a system which uses a novel technique to conserve a significant amount of power with little or no observable quality loss.

Average power consumption on Android handset

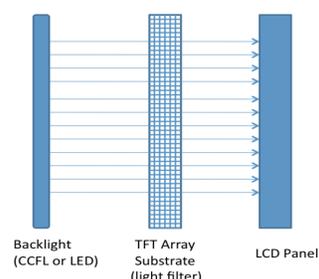
- 45 LCD Display
- 15 CPU
- 40 Wireless

II. System Design

Basic Idea:
Brighten the Scene + Reduce Backlight Intensity = Energy Savings

Methodology:
- Using OpenGL's Alpha Blending, the brightness of the Scene can be increased.
- Backlight intensity can be reduced, compensating for the increased brightness and **saving power.**
- This is because the power consumed is not dependant on the image being displayed.
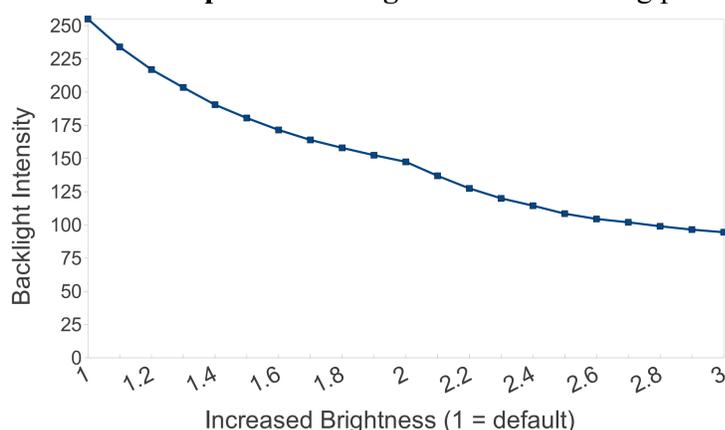

Backlight (CCFL or LED)   TFT Array Substrate (light filter)   LCD Panel

Details:
Several Steps are needed to ensure that the final system saves power while maintaining image quality:

I) We determined that **power consumed by an LCD display**(laptop) is nearly **linear** to the brightness of its **backlight**.
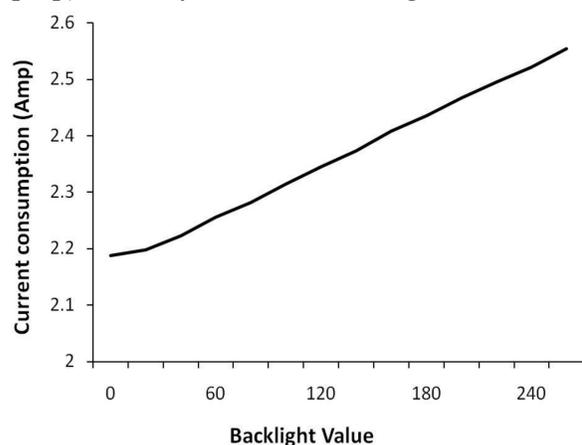
II) We then used **light sensors** to measure the **brightness increase** caused by our system at different levels, and the corresponding **decreased backlight intensity** level to **maintain overall perceived brightness** while saving power.

III) Scenes of different brightness will react differently to added brightness and thus, the brightness that the user can tolerate will be different. We conducted an informal user study to determine the **maximum brightness increase** for different scenes, where a) **quality** is good enough, b) game is still **playable**.

- Quality
- Playable

IV) Finally, during actual gameplay, we use the algorithm presented on the right

Start
Curr_Level = Default Level

Calculate Average Brightness of last four samples.

Based on current Mode (aggr or cons) and the brightness of the frame, decide gamma and backlight and set them
Set Curr_Level = Current Average Brightness

Leave Settings as it

Sleep Thread for 250 second

IV. Evaluation and Results

We do not have power numbers from an actual phone (**work in progress**). Instead, we present the results from an evaluation of the same game (Quake III) running on **LCD-based laptops**.

The laptop evaluation used **Gamma Correction** to increase Scene Brightness and we conducted two types of tests: a) **baseline power measurements**, and b) **playability user tests**.

Power Measurement:
In this chart "**Dynamic**" refers to our algorithm(step IV) while "**Static**" refers to static display settings.
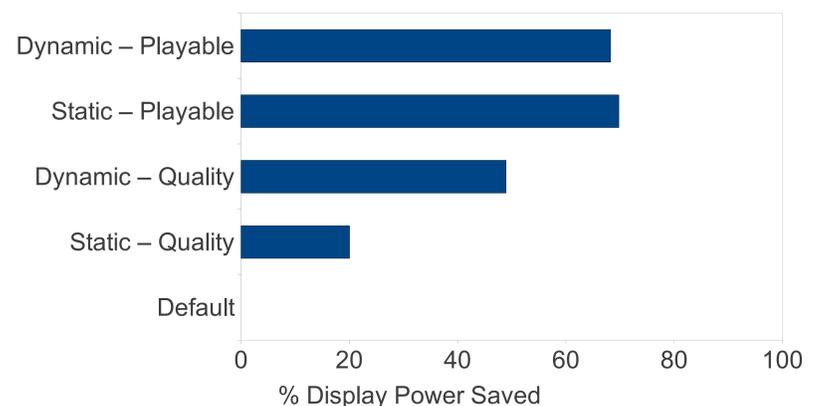
User Study:
A large scale user study (60+ users), was conducted with the users playing the above flavors of the game. We observed that they were **not able to differenciate** between the **conservative** flavors and the **default** game itself.

V. Future Work

We plan to address the following in the near future:
- Easier and more accurate calibration on mobile phones and laptops -- Steps II and III.
- Optimize for performance and low CPU load.
- Actual mobile phone power measurements
- Support other types of mobile displays such as AMOLED etc.

VI. Acknowledgement