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Operational rules to manage power consumption for content display

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ABSTRACT

The display is often responsible for a large proportion of the overall power consumed by a device. The total power consumption of a display depends on a number of factors such as the number of pixels that need to be switched on, the color and brightness of the pixels, and the rate at which the on-screen content is updated. Displays that draw high amounts of power can deplete the available power resources of a device relatively quickly, thus shortening the amount of time a user can operate the device without needing to charge or replace the device battery. This disclosure describes techniques to specify and enforce a system of rules that dictate the operation of display pixels while rendering the content to be displayed. The rules describe upper or lower bounds for various pixel-related parameters such as switched on state, color, brightness, refresh rate, etc.

KEYWORDS

- Device display
- Power consumption
- Battery life
- Power optimization
- Augmented Reality (AR)
- Virtual Reality (VR)
- OLED
- MicroLED
- MicroOLED

BACKGROUND

The display is often the most important part of a device such as a smartphone, a virtual reality device such as VR glasses, etc. The operation of the display usually requires substantial amounts of power. As a result, the display is responsible for a large proportion of the overall power consumed by a device.

The power consumed by displays made from MicroOLEDs or MicroLEDs is dependent on the content being rendered on the display. The total power consumption depends on a number of factors such as the number of pixels that need to be switched on, the color and brightness of the pixels, and the rate at which the on-screen content is updated. For instance, blue pixels consume substantially more power than red or green pixels, and brighter pixels draw more power than dimmer ones.

Devices that operate on battery power, such as mobile devices, Augmented Reality (AR) or Virtual Reality (VR) glasses, etc. are typically severely constrained in terms of power resources. Displays that draw high amounts of power can deplete the available power resources of these devices relatively quickly, thus shortening the amount of time a user can operate the devices without needing to charge or replace their batteries. To reduce this shortcoming, some displays provide the capability to adjust the power consumption profile depending on the content being rendered on the display. Alternatively, some devices allow users to switch to a display profile that consumes less power, such as a dark mode, available on some mobile devices.

DESCRIPTION

This disclosure describes techniques to manage the power consumption of device displays such as those made from MicroLEDs, MicroOLEDs, etc. The techniques include specifying and enforcing a system of rules that dictate the characteristics of the content being

rendered on the display. The rules involve specifications regarding the operation of the pixels that comprise the display. Specifically, the rules describe upper or lower bounds for various pixel-related parameters such as switched on state, color, brightness, refresh rate, etc.

At any given time, the content shown on the display can be controlled by applying one or more of such rules. For instance, display operation can be managed by making sure that each rendered frame adheres to all of the rules in the following set:

- At most 80% of the pixels can be turned on.
- At most 5% of the pixels can be fully bright.
- At most 25% of the pixels that are turned on can be blue in color.

The rules leverage the relationship between pixel operation and display power consumption such that the total power consumed by the display is dependent on the number of pixels that are switched on, the color and brightness of the pixels that are switched on, and the rate at which the displayed content is updated.

Controlling the display such that the rendered content stays within the parameter boundaries specified by the rules in effect allows managing the power consumed by the display. The rules can be adjusted such that the corresponding pixel operation results in the display consuming lower power that the theoretical maximum power that can be drawn by the display, thus helping conserve power when power resources are constrained. In contrast, when sufficient power is available, e.g., when the device is plugged in or has a battery charge meeting a threshold, the rules can be relaxed accordingly to permit the display to draw higher power as appropriate for the content being shown.

The implementation, validation, and/or enforcement of the rules can be performed at one or more of several phases of the system development and operation cycle. For instance, checking

whether the specified rules are followed at the appropriate times can be done during the design phase by verifying that the user interface (UI) design complies with the rules, during the testing phase via tests that check for compliance with the rules, during operation by examining frames of content displayed as the device is being used, etc.

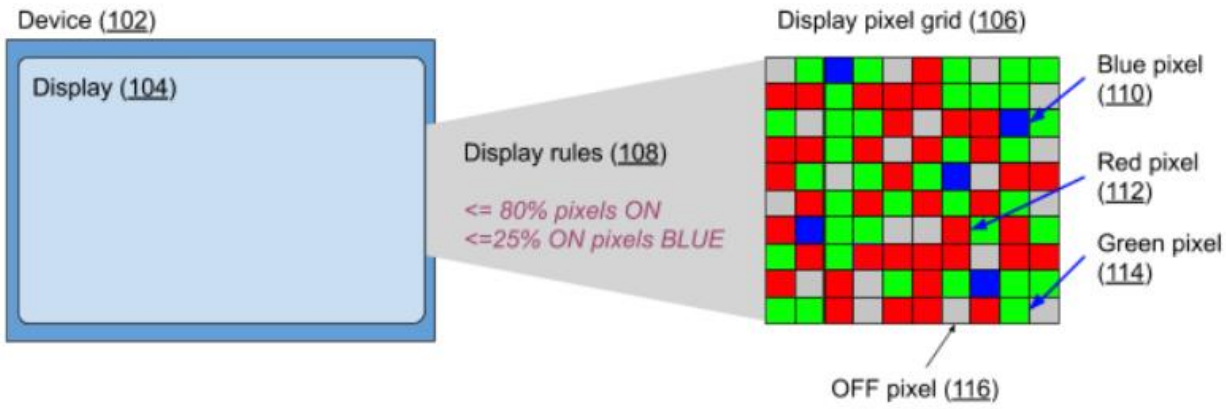

Fig. 1: Applying rules to control operation of display pixels while rendering content

Fig. 1 illustrates a device (102) which incorporates a display (104). The display is operated in the form of a grid of pixels (106). The operation of the display conforms to the specified display rules (108) such that the power consumption of the display is reduced. The rules in the example Fig. 1 ensure that at least 20% of the pixels are off (116) and no more than 25% of the switched on pixels are blue (110). The remaining switched on pixels in Fig. 1 are red (112) or green (114).

Application of the techniques described above can result in reduction in the power drawn by a device display, consequently improving the time for which a device can operate on battery power without requiring recharge. Moreover, the described rule-based approach serves to set an operational maximum value for the display power consumption, thus making it possible to design operational parameters of the software and the device battery without needing to take into

account the theoretical maximum power consumption of the display. These design improvements coupled with reduced power consumption can improve the user experience (UX) of using the device.

The described techniques can be implemented directly on the device. Alternatively, or in addition, the techniques can be made available to application developers, e.g., as an Application Programming Interface (API) and/or a Software Development Kit (SDK). The techniques can be applied to manage the power consumption profile of the display of any device including smartphones, laptops, AR/VR goggles, etc.

CONCLUSION

This disclosure describes techniques to specify and enforce a system of rules that dictate the operation of display pixels while rendering the content to be displayed. The rules describe upper or lower bounds for various pixel-related parameters such as switched on state, color, brightness, refresh rate, etc. Controlling the display such that the rendered content stays within the parameter boundaries specified by the rules allows managing the power consumed by the display. The implementation, validation, and enforcement of the rules can be performed at one or more of several phases of the system development and operation cycle. Application of the techniques described above can result in reduction in the power drawn by a device display and improve the time for which a device can operate on battery power without requiring recharge.