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December 2019

SMART DISPLAY COLOR INVERSION

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Recommended Citation
Herron, Laine, "SMART DISPLAY COLOR INVERSION", Technical Disclosure Commons, (December 06, 2019)
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SMART DISPLAY COLOR INVERSION

ABSTRACT

A color inversion module is described that enables a computing device (e.g., a personal computer, a mobile device, a tablet, etc.) to selectively invert colors of content (e.g., a desktop background, text, an image, a graphic, an animation, a video, etc.) to be displayed, and thereby potentially reduce an amount of light output by a display of the computing device. Reducing the amount of light emitted by the display may improve display clarity and reduce eye strain when using the computing device, particularly when using the computing device in low light conditions (e.g., at night in a dark or low ambient light condition).

DESCRIPTION

Night mode is a common feature for computing devices in which a computing device may invert colors of the content to be displayed on a display. One potential disadvantage of computing devices when configured according to the night mode is that the night mode may indifferently convert the entire area of the display, including elements or documents with a dark background. Such an indiscriminate application of color inversion may result in the display emitting more, not less, light, reducing the usefulness of the night mode.

Figure 1 below is a conceptual diagram illustrating an example computing device configured to selectively invert colors of content to be displayed on a display of the computing device to reduce the emission of light from the display. In the example of FIG. 1, computing device 100 represents an individual mobile or non-mobile computing device. Examples of computing devices 100 include a mobile phone (including a so-called smartphone), a tablet computer, a laptop computer, a desktop computer, a server, a mainframe, a set-top box, a

television (including a so-called “smart television”), a wearable device (e.g., a computerized watch, computerized eyewear, computerized gloves, etc.), a home automation device or system (e.g., an intelligent thermostat or home assistant device), a personal digital assistant (PDA), a gaming system, a media player, an e-book reader, a mobile television platform, an automobile navigation or infotainment system, a smartwatch, smart headphones, a virtual reality device, an augmented reality device, a mixed reality device, a head mounted display device, or any other type of mobile, non-mobile, wearable, and non-wearable computing device that contains a color inversion module which is configured to selectively invert colors of the content to be displayed on a display to reduce an amount of light emitted the display.

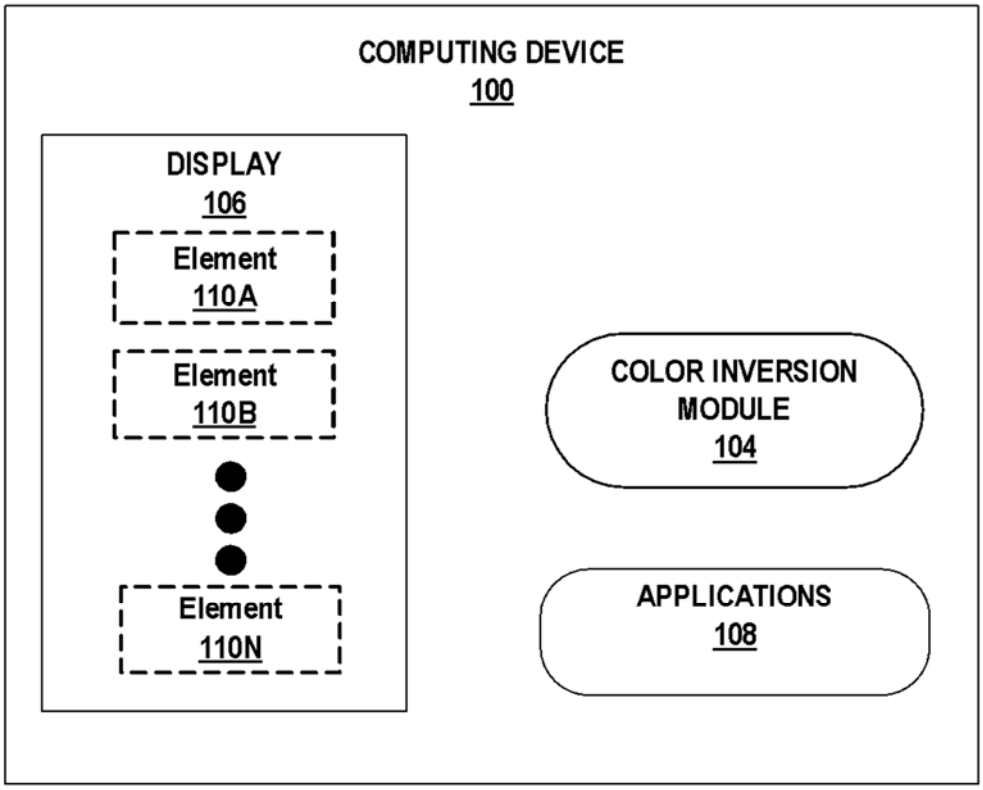

FIG. 1

Computing device 100 includes color inversion module 104, display 106, and one or more of applications 108. Display 106 may be a liquid crystal display (LCD), thin-film

transistor display (TFT), organic light emitting diode display (OLED), or any suitable display. Applications 108 may enable a user to interact with content, such as one or more of images, text, graphics, animations, videos, etc., having one or more elements (which may refer to different types of content embedded in one or more forms of the content noted above and as such may be referred to as "sub-content"). In the example of FIG.1, applications 108 may send instructions to display 106 that cause display 106 to display elements 110A-110N. Elements 110A-110N may include a desktop background, text (comprising alphanumerical characters), graphic, image, video, animation, etc.

Color inversion module 104 may apply color inversion to selectively invert colors of the content to be displayed on display 106 to reduce an amount of light emitted by display 106. Color inversion module 104 may represent an application, service, or component executing at or accessible to the computing device that enables computing device 100 to selectively invert colors of the content to be displayed on display 106 to reduce an amount of light emitted by display 106. Color inversion module 104 may be a native application provided by a first-party developer or by a third-party developer and may be pre-installed or downloaded from an application market. As an alternative, color inversion module 104 may be integrated into an operating system that provides an execution environment in which applications 108 execute.

Color inversion module 104 may determine a brightness index value based on the average pixel value of the content to be displayed on display 106. In one of the examples, the range of displayed pixel values may be mapped to 0-255. Pixel value 255 may represent a completely black color and pixel value 0 may represent a completely white color. If color inversion module 104 determines the brightness index value is less than 128, color inversion module 104 may invert the colors of invert colors of the content to be displayed on display 106

pixel by pixel. Color inversion module 104 may then calculate the inverted pixel value for each pixel as Y= 265-X, where X may represent the original pixel value and Y may represent the inverted pixel value. Figure 2 below illustrates an example of color inversion module 104 applying color inversion when color inversion module 104 determines the content to be displayed on display 106 has a bright background color. If color inversion module 104 determines the brightness index value X is equal to or greater than 128, color inversion module 104 may not invert the colors of the content to be displayed on display 106.

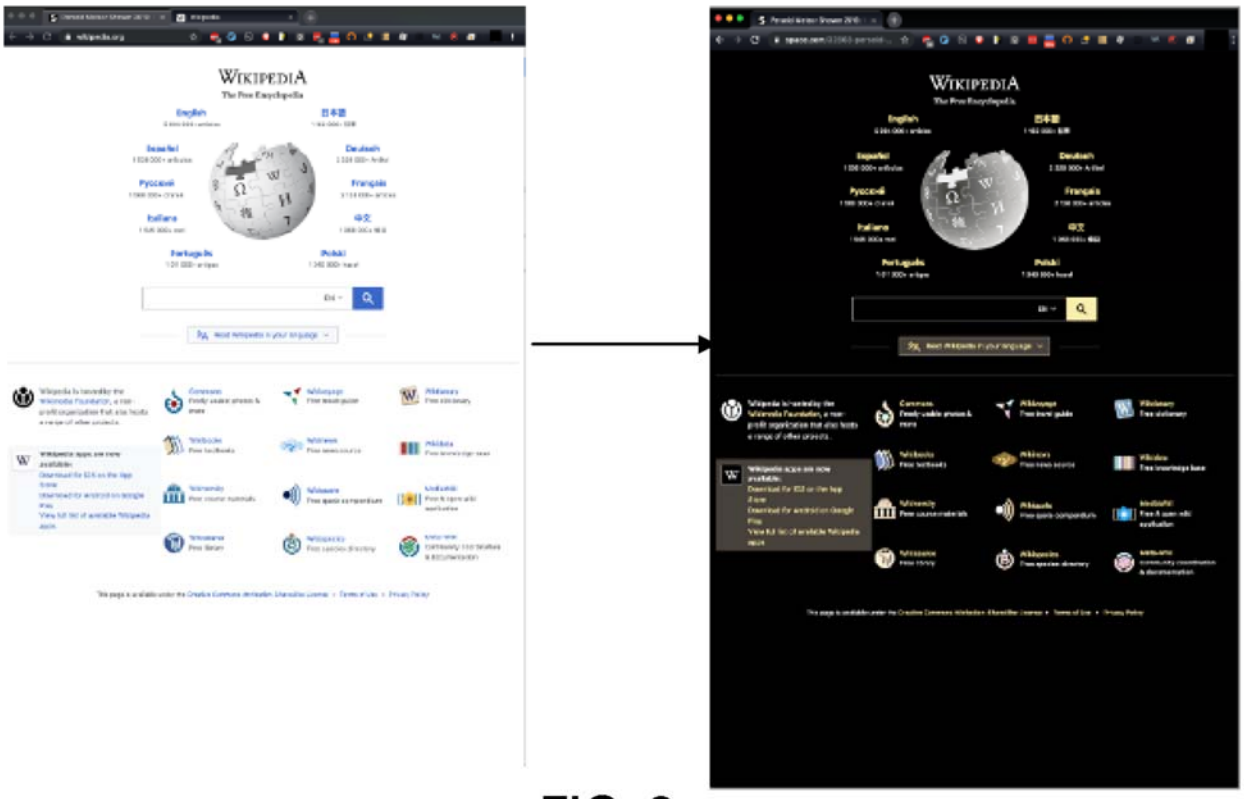

FIG. 2

Color inversion module 104 may include a submodule, such as an element identification module, to apply color inversion at an individual element level. The element identification module may interact with applications 108 to identify individual elements. For example,

element identification module may identify the content to be displayed on display 106 contains elements 110A-110N. Color inversion module 104 may then apply color inversion individually to each element of elements 1110A-110N. A brightness index value may be determined for each identified element based on the average pixel value of the element. Figure 3 below illustrates an example of applying color inversion at individual element level.

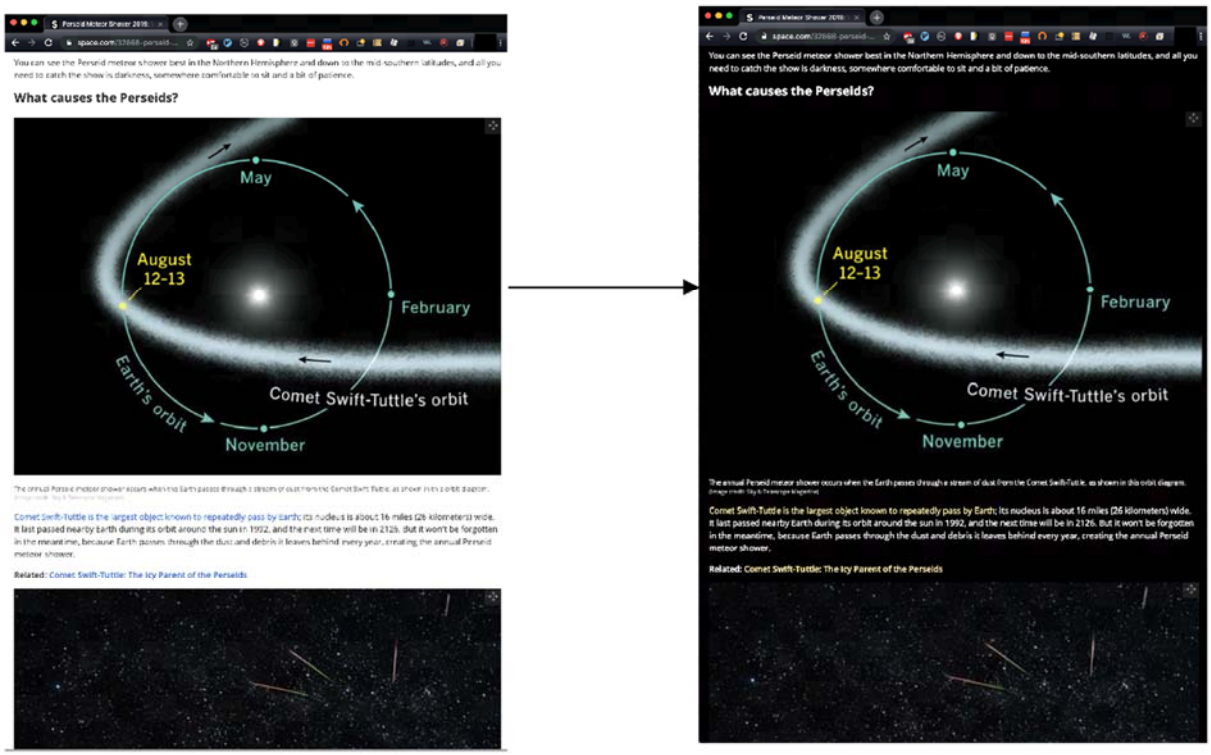

FIG. 3

It is noted that the techniques of this disclosure may be combined with any other suitable technique or combination of techniques. As one example, the techniques of this disclosure may be combined with the techniques described in “Deluminate” by A. Stiles available at http://deluminate.github.io/. As another example, the techniques of this disclosure may be

combined with the techniques described in “iOS 11’s new ‘Smart Invert Colors’ is the closest thing to Dark Mode yet” by Jordan Kahn available at https://9to5mac.com/2017/06/09/ios-11-dark-mode-smart-invert-colors-how-to-enable/.