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(54) System and method for adjusting a backlight level for a display on an electronic device

(57) The invention provides a system and method for calculating a backlight level for an image being displayed on an electronic device (10). In one aspect, a backlight adjustment module is provided. The backlight adjustment module controls a backlight system (64) that provides backlight for a display (14) in an electronic device. The backlight adjustment module provides: calculations of an average intensity for an image being displayed on the display on a running average basis (302) from a greys-cale value associated with the image corrected according to a gamma curve and to determine a backlight level for the image using the average intensity, where the darker the image the greater is the backlight level; and controls signals to the backlight system based on the calculations to generate a backlight for the image generated on the display.

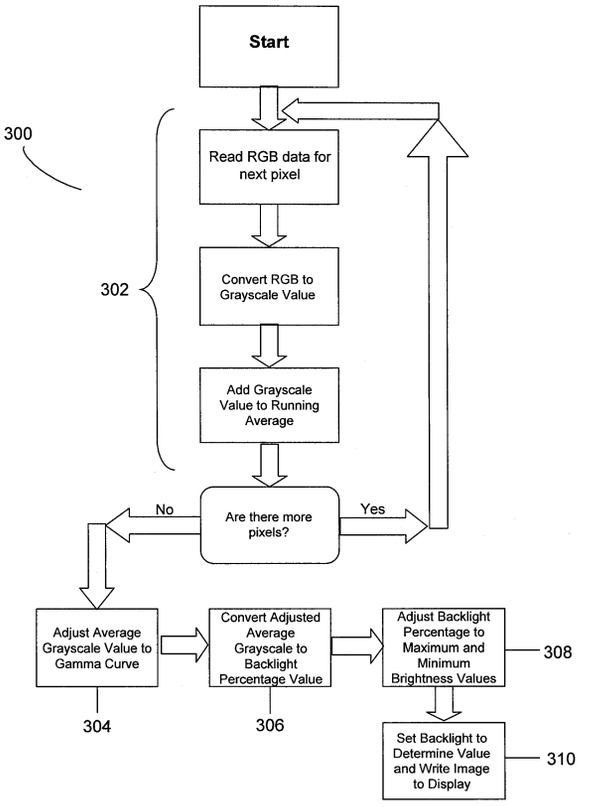

Fig. 3

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Description

[0001] The invention described herein relates to a system and method for controlling and adjusting a backlight level for a display on an electronic device. In particular, the invention described herein relates to controlling the backlight level by determining a current intensity of an image being shown on the display.

[0002] Current wireless handheld mobile communication devices perform a variety of functions to enable mobile users to stay current with information and communications, such as e-mail, corporate data and organizer information while they are away from their desks. A wireless connection to a server allows a mobile communication device to receive updates to previously received information and communications. The handheld devices optimally are lightweight, compact and have long battery life. U.S. Patent Publication no. 2001/0033260 discloses a system and method for adjusting the backlighting for a video feed and is directed towards backlight control for moving images, identifying several colour grades for video images, including the use of greyscales and weighing different colours in the greyscale with different values. It describes γ-correction, as well as an average intensity reading for an image and feeding this back to determine a luminance value.

[0003] Current devices are used in all types of ambient environments. In different environments, e.g. lightly or dimly lit environments, different amounts of backlighting may be needed. This may also be valid for the type of image, colourwise, that is being displayed. Present systems do not adjust the backlight level to adjust for the brightness of the currently displayed image.

[0004] There is a need for a system and method which addresses deficiencies in the prior art.

GENERAL

[0005] In a first aspect, a backlight adjustment module is provided. The backlight adjustment module controls a backlight system that provides backlight for a display in an electronic device. The backlight adjustment module provides: calculations of an average intensity for an image being displayed on the display on a running average basis from a greyscale value associated with the image corrected according to a gamma curve and to determine a backlight level for the image using the average intensity, where the darker the image the greater is the backlight level; and controls signals to the backlight system based on the calculations to generate a backlight for the image generated on the display.

[0006] In the backlight adjustment module, the greyscale value may be obtained from a weighted calculation in which green values are weighted most heavily.

[0007] In the backlight adjustment module, the backlight level is adjusted between minimum and maximum backlight levels for the display set for a completely white and a completely black image, respectively.

[0008] The backlight adjustment module may provide another calculation for another intensity value for another image when the image is replaced by the another image on the display.

[0009] The backlight adjustment module may provide a greater backlight level to the darker image between the image and another image.

[0010] In the backlight adjustment module, the image and another image may relate to a video signal.

[0011] In the backlight adjustment module, the running average may be computed by sequentially adding a greyscale pixel value to a running total.

[0012] In the backlight adjustment module, the running average may be computed according to the equation:

$$A_N = A_{N-1} - \frac{A_{N-1} - X}{N},$$

wherein, A_N is the new average, A_{N-1} is the previous average, X is the new grayscale value added to the average, and N is the number of values included in the average so far.

[0013] In the backlight adjustment module, the control signals may be provided to the backlight system when the image is provided to the display for generation on the display.

[0014] In the backlight adjustment module, the backlight level may be further responsive to a signal representing an amount of ambient light detected around the device whereby as the amount of ambient light increases, the backlight level increases.

[0015] In a second aspect, an electronic device is provided having the backlight adjustment module as provided above.

[0016] In a third aspect, a method of adjusting a backlight for images generated on a display of an electronic device is provided. The method comprises: calculating an average intensity of a first image on a running average basis from a greyscale value associated with the image corrected according to a gamma curve; determining a first backlight level for

the image based on the intensity level; providing the first backlight level to a backlight system for a display when the first image is generated on the display; calculating an average intensity of a second image on a running average basis from a greyscale value associated with the image corrected according to a gamma curve; determining a backlight level for the second image based on the intensity level; and providing the backlight level to the backlight system for the display when the second image is generated on the display, the darker of the first and the second image is provided with a greater backlight intensity.

[0017] In the method, the greyscale values may be obtained from a weighted calculation in which green values are weighted most heavily.

[0018] In the method, the backlight levels may be adjusted between minimum and maximum backlight levels the display set for a completely white and a completely black image, respectively.

[0019] In the method, the running averages may be computed according to the equation:

$$A_N = A_{N-1} - \frac{A_{N-1} - X}{N},$$

wherein, A_N is the new average, A_{N-1} is the previous average, X is the new value added to the average, and N is the number of values included in the average so far.

[0020] In yet another aspect, a backlight system for an electronic device is preferably provided. The system preferably comprises: a backlight adjustment module to calculate an intensity value of an image; a display for displaying the image; and a backlight system to provide a backlight for the display. The backlight system is preferably responsive to control signals generated by the backlight adjustment module. In the system, the intensity value represents an average intensity of the image.

[0021] In the system, the average intensity may be calculated from a greyscale value associated with the image and the greyscale value may have been corrected according to a gamma curve.

[0022] In the system, the average intensity may be calculated on a running average basis of pixels in the image.

[0023] In the system, the greyscale value may provide a weight to favour green colours in the image.

[0024] In the system, another calculation may be made for another intensity value for another image when the image is replaced on the display.

[0025] In the system, another calculation may be made for another intensity value for another image when the image is replaced by another image and if another image has changes over the image over more than a small portion of the display.

[0026] In a still yet aspect, a method of adjusting a backlight for a display for an electronic device is preferably provided. The method preferably comprises: calculating an intensity value of an image; determining a backlight level for the image based on the intensity level; and providing the backlight level to a backlight system for a display when the image is generated on the display. In the method, the intensity value preferably represents an average intensity of the image.

[0027] In the method, the average intensity may be calculated from a greyscale value associated with the image and the greyscale value may have been corrected according to a gamma curve.

[0028] In the method, the average intensity may be calculated on a running average basis of pixels in the image.

[0029] In the method, the greyscale value may provide a weight to favour green colours in the image.

[0030] In the method, another calculation may be made for another intensity value for another image when the image is replaced by the another image on the display. In the method, another calculation may be made for another intensity value for another image when the image is replaced by the another image and if the another image has changes over the image over more than a small portion.

[0031] In the method, the display may be displaying a video image comprising the image and another image; and another calculation may made for another intensity value for another image shown on said display after the image.

[0032] In other aspects, various sets and subsets of the above noted aspects are provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0034] Fig. 1 is a schematic representation of an electronic device having a display and a background light adjustment system for the display in accordance with an embodiment;

[0035] Fig. 2 is a block diagram of internal components of the device of Fig. 1 including the display and the background light adjustment system;

[0036] Fig. 3 is a flow chart of an algorithm executed by the backlight adjustment system of Fig. 1;

[0037] Fig. 4 is an extract of exemplary pseudocode to implement the algorithm of Fig. 3; and

[0038] Fig. 5 is a graph illustrating a backlight intensity level for various ambient lighting conditions used by an embodiment of Fig. 1.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0039] The description which follows and the embodiments described therein are provided by way of illustration of an example or examples of particular embodiments of the principles of the present invention. These examples are provided for the purposes of explanation and not limitation of those principles and of the invention. In the description which follows, like parts are marked throughout the specification and the drawings with the same respective reference numerals.

[0040] Referring to Fig. 1, an electronic device for receiving electronic communications in accordance with an embodiment of the invention is indicated generally at 10. In the present embodiment, electronic device 10 is based on a computing platform having functionality of an enhanced personal digital assistant with cellphone and e-mail features. It is, however, to be understood that electronic device 10 can be based on construction design and functionality of other electronic devices, such as smart telephones, desktop computers pagers or laptops having telephony equipment. In a present embodiment, electronic device 10 includes a housing 12, an LCD 14, speaker 16, an LED indicator 19, a trackwheel 20, an ESC ("escape") key 22, keypad 24, a telephone headset comprised of an ear bud 28 and a microphone 30. Trackwheel 20 and ESC key 22 can be inwardly depressed along the path of arrow "A" as a means to provide additional input to device 10.

[0041] It will be understood that housing 12 can be made from any suitable material as will occur to those of skill in the art and may be suitably formed to house and hold all components of device 10.

[0042] Device 10 is operable to conduct wireless telephone calls, using any known wireless phone system such as a Global System for Mobile Communications ("GSM") system, Code Division Multiple Access ("CDMA") system, Cellular Digital Packet Data ("CDPD") system and Time Division Multiple Access ("TDMA") system. Other wireless phone systems can include Bluetooth and the many forms of 802.11 wireless broadband, like 802.11a, 802.11b, 802.11g, etc. that support voice. Other embodiments include Voice over IP (VoIP) type streaming data communications that can simulate circuit switched phone calls. Ear bud 28 can be used to listen to phone calls and other sound messages and microphone 30 can be used to speak into and input sound messages to device 10.

[0043] Various applications are provided on device 10, including email, telephone, calendar and address book applications. A GUI to activate these applications is provided on display 14 through a series of icons 26. Shown are calendar icon 26, telephone icon 26, email icon 26 and address book icon 26. Such applications can be selected and activated using the keypad 24 and / or the trackwheel 20. Further detail on selected applications is provided below.

[0044] Referring to Fig. 2, functional elements of device 10 are provided. The functional elements are generally electronic or electro-mechanical devices. In particular, microprocessor 18 is provided to control and receive almost all data, transmissions, inputs and outputs related to device 10. Microprocessor 18 is shown schematically as coupled to keypad 24, display 14 and other internal devices. Microprocessor 18 controls the operation of the display 14, as well as the overall operation of the device 10, in response to actuation of keys on the keypad 24 by a user. Exemplary microprocessors for microprocessor 18 include Data 950 (trade-mark) series microprocessors and the 6200 series microprocessors, all available from Intel Corporation.

[0045] In addition to the microprocessor 18, other internal devices of the device 10 include: a communication subsystem 34; a short-range communication subsystem 36; keypad 24; and display 14; with other input/output devices including a set of auxiliary I/O devices through port 38, a serial port 40, a speaker 16 and a microphone port 32 for microphone 30; as well as memory devices including a flash memory 42 (which provides persistent storage of data) and random access memory (RAM) 44; clock 46 and other device subsystems (not shown). The device 10 is preferably a two-way radio frequency (RF) communication device having voice and data communication capabilities. In addition, device 10 preferably has the capability to communicate with other computer systems via the Internet.

[0046] Operating system software executed by microprocessor 18 is preferably stored in a computer readable medium, such as flash memory 42, but may be stored in other types of memory devices, such as read only memory (ROM) or similar storage element.

In addition, system software, specific device applications, or parts thereof, may be temporarily loaded into a volatile storage medium, such as RAM 44. Communication signals received by the mobile device may also be stored to RAM 44.

[0047] Microprocessor 18, in addition to its operating system functions, enables execution of software applications on device 10. A set of software applications 48 that control basic device operations, such as a voice communication module 48A and a data communication module 48B, may be installed on the device 10 during manufacture or downloaded thereafter.

[0048] Communication functions, including data and voice communications, are performed through the communication subsystem 34 and the short-range communication subsystem 36. Collectively, subsystem 34 and subsystem 36 provide

the signal-level interface for all communication technologies processed by device 10. Various other applications 48 provide the operational controls to further process and log the communications. Communication subsystem 34 includes receiver 50, transmitter 52 and one or more antennas, illustrated as receive antenna 54 and transmit antenna 56. In addition, communication subsystem 34 also includes processing module, such as digital signal processor (DSP) 58 and local oscillators (LOs) 60. The specific design and implementation of communication subsystem 34 is dependent upon the communication network in which device 10 is intended to operate. For example, communication subsystem 34 of the device 10 may be designed to operate with the Mobitex (trade-mark), DataTAC (trade-mark) or General Packet Radio Service (GPRS) mobile data communication networks and also designed to operate with any of a variety of voice communication networks, such as Advanced Mobile Phone Service (AMPS), Time Division Multiple Access (TDMA), Code Division Multiple Access CDMA, Personal Communication Service (PCS), Global System for Mobile Communication (GSM), etc. Communication subsystem 34 provides device 10 with the capability of communicating with other devices using various communication technologies, including instant messaging (IM) systems, text messaging (TM) systems and short message service (SMS) systems.

[0049] In addition to processing communication signals, DSP 58 provides control of receiver 50 and transmitter 52. For example, gains applied to communication signals in receiver 50 and transmitter 52 may be adaptively controlled through automatic gain control algorithms implemented in DSP 58.

[0050] In a data communication mode a received signal, such as a text message or web page download, is processed by the communication subsystem 34 and is provided as an input to microprocessor 18. The received signal is then further processed by microprocessor 18 which can then generate an output to the display 14 or to an auxiliary I/O port 38. A user may also compose data items, such as e-mail messages, using keypad 24, a thumbwheel associated with keypad 24, and/or some other auxiliary I/O device connected to port 38, such as a touchpad, a rocker key, a separate thumbwheel or some other input device. The composed data items may then be transmitted over communication network 68 via communication subsystem 34.

[0051] In a voice communication mode, overall operation of device 10 is substantially similar to the data communication mode, except that received signals are output to speaker 16, and signals for transmission are generated by microphone 30. Alternative voice or audio I/O subsystems, such as a voice message recording subsystem, may also be implemented on device 10.

[0052] Short-range communication subsystem 36 enables communication between device 10 and other proximate systems or devices, which need not necessarily be similar devices. For example, the short-range communication subsystem may include an infrared device and associated circuits and components, or a Bluetooth (trade-mark) communication module to provide for communication with similarly-enabled systems and devices.

[0053] Powering the entire electronics of the mobile handheld communication device is power source 62. Preferably, the power source 62 includes one or more batteries. More preferably, the power source 62 is a single battery pack, especially a rechargeable battery pack. A power switch (not shown) provides an "on/off" switch for device 10. Upon activation of the power switch an application 48 is initiated to turn on device 10. Upon deactivation of the power switch, an application 48 is initiated to turn off device 10. Power to device 10 may also be controlled by other devices and by internal software applications.

[0054] Display 14 has backlight system 64 to assist in the viewing display 14, especially under low-light conditions. A backlight system is almost invariably present in a LCD. A typical backlight system comprises a lighting source, such as a series of LEDs or a lamp located behind the LCD panel of the display, and a controller to control activation of the lighting source. The lamp may be fluorescent, incandescent, electroluminescent or any other suitable light source. As the lighting sources are illuminated, their light shines through the LCD panel providing backlight to the display. The intensity of the backlight level may be controlled by the controller by selectively activating a selected number of lighting sources (e.g. one, several or all LEDs) or by selectively controlling the activation duty cycle of the activated lighting sources (e.g. a duty cycle anywhere between 0% to 100% may be used).

[0055] To assist with one method of adjusting the backlight level, light sensor 66 is provided on device 10. Sensor 66 is a light sensitive device which converts detected light levels into an electrical signal, such as a voltage. It may be located anywhere on device 10, having considerations for aesthetics and operation characteristics of sensor 66. In one embodiment, an opening for light to be received by sensor 66 is located on the front cover of the housing of device 10 to reduce the possibility of blockage of the opening. In other embodiments, multiple sensors 66 may be provided and the software may provide different emphasis on signals provided from different sensors 66. The signal(s) provided by sensor(s) 66 can be used by a circuit in device 10 to determine when device 10 is in a well-lit, dimly lit or moderately-lit environment. This information can then be used to control backlight levels for display 14.

[0056] Brief descriptions are provided on the applications 48 stored and executed in device 10. Additional applications include calendar 48C which tracks appointments and other status matters relating to the user and device 10. Calendar 48C is activated by activation of calendar icon 26 on display 14. It provides a daily/weekly/month electronic schedule of appointments, meetings and events entered by the user. Calendar 48C tracks time and day data for device 10 using processor 18 and internal clock 46. The schedule contains data relating to the current accessibility of the user. For

example it can indicate when the user is busy, not busy, available or not available. In use, calendar 48C generates input screens on device 10 prompting the user to input scheduled events through keypad 24. Alternatively, notification for scheduled events could be received via an encoded signal in a received communication, such as an e-mail, SMS message or voicemail message. Once the data relating to the event is entered, calendar 48C stores processes information relating to the event; generates data relating to the event; and stores the data in memory in device 10.

[0057] Address book 48D enables device 10 to store contact information for persons and organizations. Address book 48D is activated by activation of address book icon 26 on display 14. In particular, name, address, telephone numbers, e-mail addresses, cellphone numbers and other contact information is stored. The data can be entered through keypad 24 and is stored in an accessible a database in non-volatile memory, such as persistent storage 70, which is associated with microprocessor 18, or any other electronic storage provided in device 10.

[0058] Email application 48E provides modules to allow user of device 10 to generate email messages on device 10 and send them to their addressees. Application 48E also provides a GUI which provides a historical list of emails received, drafted, saved and sent. Text for emails can be entered through keypad 24. Email application 48E is activated by activation of email icon 26 on display 14.

[0059] Calculator application 48F provides modules to allow user of device 10 to create and process arithmetic calculations and display the results through a GUI.

[0060] Backlight adjustment application 48G is an image processing module and instructions to an image that is about to be displayed on display 14 to be analyzed for its intensity. Based on the intensity (or luminosity), a backlight level can be calculated and set for the image. As such, when the image is actually displayed on display 14, the backlight level can be appropriately set for the image. Backlight adjustment application can generate an appropriate signal, such as a pulse width modulation (PWM) signal or values for a PWM signal, that can be used to drive a backlight in backlight system 64 to an appropriate level. If backlight system 64 utilizes a duty cycle signal to determine a backlight level, application 48G can be modified to provide a value for such a signal, based on inputs received. Further detail on calculations conducted by application 48G are provided below.

[0061] Further detail is now provided on notable aspects of an embodiment. An embodiment provides a system and method for dynamically adjusting the lighting intensity of the backlight on display 14. As a backlight system for a display tends to consume a large percentage of power required by a handheld device 10, using the backlight more efficiently can increase battery life for device 10. Backlight system 64 provides the lighting means to vary the intensity of the backlight provided to display 14. Backlight adjustment application 48G provides the software that controls the intensity of the backlight using various inputs and signals available to display 14 relating to an image that is currently generated on display 14. A basic algorithm provided by the embodiment is to first make a determination of an intensity of an image currently being displayed, then make any adjustment to the intensity to account for intensity characteristics of colours generated in the image and finally, adjusting a backlight level for the image being generated on the display based on the adjusted intensity. The intensity may be based on any type of intensity reading determined for the image. For example, an average intensity reading can be determined. Various types of averages can be used. Details of each are described in turn.

[0062] One feature of an embodiment is that the intensity of a backlight is dynamically calculated and adjusted as different images are displayed on display 14. This can have the effect of providing an efficient backlight value for each image, thereby reducing power consumption for backlight system 64 by adjusting its output to meet the current characteristics of the current image.

[0063] The embodiment utilizes difference in perceived brightness level in a displayed image versus the actual brightness level of the image. For example, an image having many dark pixels may appear to be less bright than an image having many lighter pixels. This apparent brightness level difference occurs because the liquid crystal in an LCD generally allows more light to pass through lighter pixels and less light passes through darker pixels. In an idealized image, all light would pass through a completely white image and no light would pass through a completely black image.

[0064] Referring to Fig. 3, further detail is provided on a calculation conducted by module 48G. Therein algorithm 300 comprises the above noted three main calculations: calculate an average greyscale value for an image in section 302; adjust a greyscale value in section 304; convert the adjusted greyscale value to a backlight percentage value in section 306; adjust the backlight values between minimum and maximum brightness values in section 308 and set the calculated backlight value and display the image in section 310. Each section is described in turn.

[0065] For section 302, an embodiment provides an algorithm implemented in software that executes on device 10 that calculates an average of greyscale values for an image being generated on display 14. The greyscale values are calculated as the image is read from memory or as the image is being written to the display 14. A greyscale value is derived from a photopic curve based calculation which combines three colour pixels (i.e. red, green and blue) into a single value. The average may be calculated on a running average basis, in order to minimize the processing of large numbers. As an image is being read from memory or as it is being written to the display the value of each pixel is computed into the running average. A conventional method of calculating an average is to first sum intensity values of all the pixels in an image and then divide by the total number of pixels. This computational method introduces large

numbers in the calculation method. As an alternative, an embodiment preferably sequentially adds a pixel value to a running average total. After every pixel value has been added to the total, the average value can be calculated by dividing by the total number of pixels.

[0066] For example, for a colour image having dimensions of 260x240 pixels, there are 62400 pixels. If each pixel is provided with a 5 bit greyscale pixel, then after converting the greyscale into a decimal number, the pixel greyscale value is between 0 and 31. For an example where an image in which every pixel is fully on, the greyscale of each pixel would be set at 31. During a conventional calculation of an average greyscale the running total of greyscale values would be 1934400 for an image the size of 260x240 pixels (i.e., image size x greyscale value of each pixel = 260 x 240 x 31). This running total value would cause an overflow of a regular 16-bit unsigned integer, which typically has a maximum value of 65535.

[0067] As such, to avoid such an overflow condition, the embodiment uses an average calculation that calculates a running average per equation 1:

$$A_N = A_{N-1} - \frac{A_{N-1} - X}{N} \qquad \text{Equation 1}$$

Therein, A_N is the new average, A_{N-1} is the previous average, X is the new value added to the average, and N is the number of values included in the average so far. Exemplary pseudocode for Equation 1 is provided in Fig. 4.

[0068] As the display 14 generates images in colour, in order to provide an intensity value for the image that can be compared against other intensity values for other images, it is preferable to convert the net colour value for the image into a greyscale value. It is preferable to convert each RGB pixel value into a greyscale value in order to provide a common value to base a calculation on every pixel. For example, in a given image, a pixel that is green at a given intensity is more luminous that a pixel that is red at the same intensity. By converting all colour values for all pixels to a greyscale, such differences are smoothed out, since during the conversion process, the luminosity of different colours is preferably taken into consideration.

[0069] Further detail on a greyscale conversion is provided. In an exemplary display 14 in device 10, a colour format used is RGB 565, meaning that there are 32 levels of resolution for red in five bits, 64 levels for green in six bits and 32 levels for blue in five bits. For the greyscale conversion, a first step is to drop the least significant bit (LSB) of the green pixel, in order to normalize all bit values for the red, green, and blue colours. As such, each of the three colours is represented by a number between 0-31. Next, the values for the three colours are converted into a single greyscale value by a weighted calculation. The weighting of each pixel colour is based on the photopic curve. The human eye does not perceive all wavelengths of light equally: generally green wavelengths are perceived to be more intense than red and blue wavelengths. Therefore when converting a red-green-blue image to a greyscale image, the green value in the image is preferably most heavily weighted. A commonly used (NTSC Standard) weighting is provided in Equation 2:

$$GRAY = 0.3 \times RED + 0.59 \times GREEN + 0.11 \times BLUE \qquad \text{Equation 2}$$

It can be seen that the green value is most heavily weighted with a scaling factor of 0.59, the red value is next most heavily weighted with a scaling factor of 0.3 and the blue value is least heavily weighted with a scaling factor of 0.11. In other embodiments, other scaling factors may be used.

[0070] Next, for section 304 the value of the intensity is adjusted using a gamma curve correction factor. A gamma curve can be used to correct the brightness of all pixel colours lying between white and black. The gamma curve is provided in Equation 3:

$$y = \left(\frac{x}{MAX} \right)^{\gamma} \qquad \text{Equation 3}$$

where y is the gamma-corrected pixel value, x is the original pixel value, MAX is the maximum pixel value and γ is the gamma correction value. For the instance of a pixel having 5-bit colour resolution, MAX is 31. The gamma value of a typical LCD is about 2.2. In order to simplify mathematical calculations, a gamma value of may be used 2: calculating a non-integral power (e.g. $x^{2.2}$) requires more calculations and longer time than calculating an integral power (i.e. x^2). However, if an embodiment has sufficient processing power, other values may also be used.

[0071] Next, for section 306, the average greyscale value is converted into a percentage based on a minimum brightness level (the level that would be set for a completely white image) and a maximum brightness level (the level that would be set for a completely black image). Between the minimum and maximum levels, a parabolic curve is used to determine a brightness of all images between white and black. The curve may be based on the gamma curve, as known in the art.

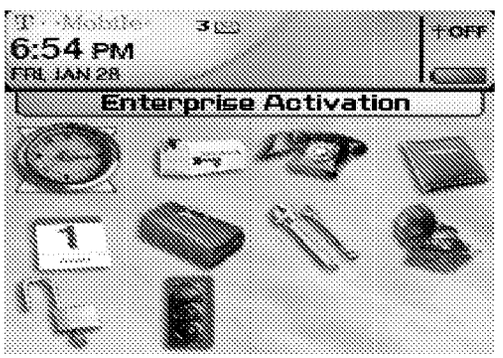
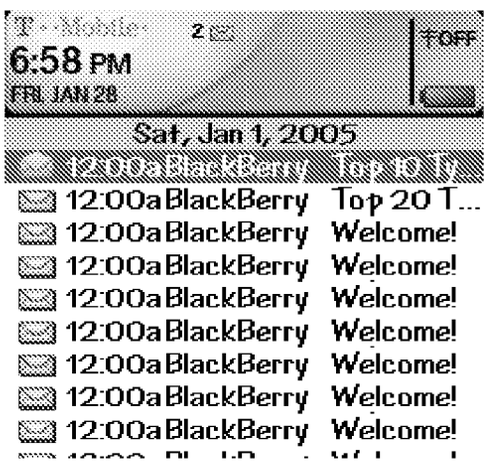
[0072] Next, for section 308, a range of minimum and maximum brightness levels for backlight system 64 is provided in order to provide practical operational boundaries for the brightness level signals provided by backlight system 64. The boundaries may vary on the characteristics of each device 10 and each type of display 14 provided therein.

[0073] Finally for section 310, once all backlight parameters are set, all control signals for the backlight system 64 are provided by application 48G to backlight system (e.g. as a PWM signal or a duty cycle signal), and backlight system 64 provides a backlight intensity corresponding to the signal provided. At the same time, the image is written itself to display 14.

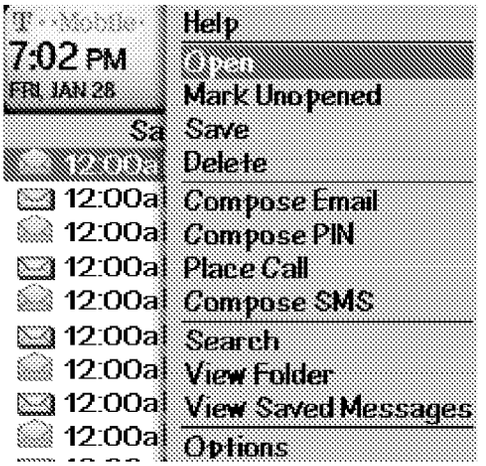
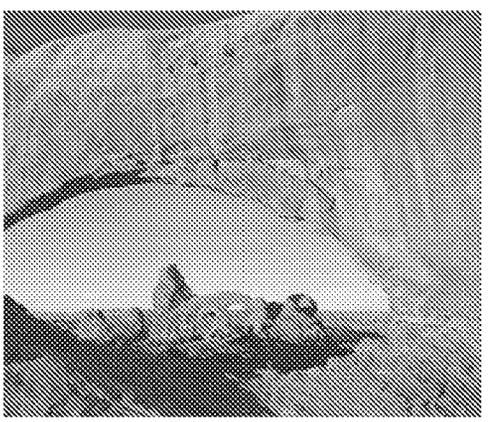
[0074] Fig. 4 provides a pseudo-code listing which may be used as a basis to implement flow chart 300 in software.

[0075] The following Table A provides an exemplary set of results of processing various images by an embodiment. Therein, six images are shown of varying colour intensities. The PWM signals shown in the right column represent the duty cycle calculated for a display 14 to provide sufficient and consistent backlighting among the six images when displayed on device 10.

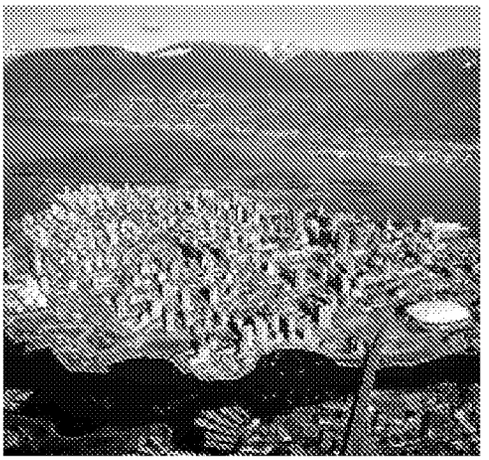
Table A

Image Number	Backlight intensity (where 0% is off, and 100% is full power)
Image 1: Third darkest image (fourth brightest image)	
	74%
Image 2: Fifth darkest image (second brightest image)	
	61%

(continued)

Image 3: Fourth darkest image (third brightest image)	
	68%
Image 4: Least dark image (Brightest image)	
From BlackBerry Subject: Top 10 Typing Tips You can find more typing tips in the on handheld help. In the menu of any program, click Help. You can also refer to the printed documentation that accompanied your handheld or the online User Guide for taping tips. 1 To type in a field using assisted taping, you only need to tress keys one time for each letter. Try to type the whole word before you make	54%
Image 5: Second darkest image (Fifth brightest image)	
	81%

(continued)

Image 6: Darkest Image (Least bright image)	
	91%

[0076] As long as an image remains generated on display 14, the backlight level preferably remains the same. The embodiment describes providing backlight calculations for images that are static on display 14. For video images, an embodiment can utilize the same techniques described herein on a frame-by-frame basis. Alternatively, for video applications, the backlight calculations may be done on an interval basis, for example, once every 2, 3, 5, 10, 15, 20, 30 ... frames. This interval may be based on the video CODEC used. Many CODECs only contain complete frame data only for one frame in an interval. Subsequent frames in the interval are composites of these full-data frames.

[0077] It will further be appreciated that for an electronic device, several static images may be displayed on device 10, even though minimal activity is apparent on device 10. For example, for a device that has a moveable displayed cursor, each instance of a movement of the cursor would cause a new image to be generated on display 14. As such, a new calculation may be done for each updated image. Also, a display on device 14 having a clock signal would be updated each time a digit changed on the clock signal. For such instances, if the change in the image affects only a relatively small portion of the entire screen, the system may selectively not conduct a recalculation of the intensity of the image.

[0078] The embodiment described herein provides an intensity calculation based on the entire display section of display 14. In other embodiments, different sections of display 14 may be used to calculate an average. For example, an average may be calculated based on alternating rows in display 14 or on a specific section of display 14 (e.g. its central area). Other averages may use only one or two of the colours (e.g. green and red, as they are the two most dominant colours). In other embodiments a combination of any of these alternative calculations may be used.

[0079] It will be appreciated that the embodiment can be used on monochrome displays. Therein, a greyscale value is already provided for the image being displayed on display 14.

[0080] In other embodiments, the intensity calculation provided above can be used with ambient lighting condition information provided by sensor 66 to make further adjustments to the intensity level.

[0081] Referring to Fig. 5, graph 500 shows a backlight level for display 14 on the y-axis compared against a level of ambient light surrounding device 14 on the x-axis. As is shown, graph 500 has in a low backlight level when display 14 is in a very dark environment. As the amount of ambient light increases, the backlight level increases as well. Graph 500 provides a linear increase in backlight level intensity to as the amount of ambient light increases. At a certain point, the ambient light conditions are very bright and as such, the backlight may not be very effective in those conditions. As shown in graph 500, at that point, backlighting may be turned off. It will be appreciated that in other embodiments for other LCDs, other graphs of backlight level progressions may be used, including step-wise progressions and non-linear progressions. A backlight level progression may be expressed as a formula, which may be used by software to determine an appropriate control signal for the controller of the backlight system for a given level of ambient light. In other embodiments, a backlight level progression may be stored as a table providing a set of backlight levels for a corresponding set of ambient light levels. In other embodiments, a series of different adjustment algorithms may be used.

[0082] Further aspects and advantages of the invention will be appreciated from the following numbered clauses.

1. A backlight system for an electronic device, comprising:

   a backlight adjustment module to calculate an intensity value of an image;

a display for displaying said image; and
a backlight system to provide a backlight for said display, said backlight system responsive to control signals generated by said backlight adjustment module based on said intensity value.

2. The backlight system as provided in clause 1, wherein said intensity value represents an average intensity of said image, said average intensity is calculated from a greyscale value associated with said image and said greyscale value has been corrected according to a gamma curve.

3. The backlight system as provided in clause 2, wherein said system is arranged to calculate said average intensity on a running average basis of pixels in said image.

4. The backlight system as provided in clause 3, wherein said greyscale value provides a weight to favour green values in said image.

5. The backlight system as provided in any one of clauses 1 to 4, wherein said system is arranged to make another calculation for another intensity value for another image when said image is replaced by said another image on said display.

6. The backlight system as provided in clause 5, wherein said image and said another image relate to a video signal.

7. A method of adjusting a backlight for a display for an electronic device, comprising:

calculating an intensity value of an image;
determining a backlight level for said image based on said intensity level; and
providing said backlight level to a backlight system for a display when said image is generated on said display.

8. The method as provided in clause 7, wherein said intensity value represents an average intensity of said image, said average intensity is calculated from a greyscale value associated with said image and said greyscale value has been corrected according to a gamma curve.

9. The method as provided in clause 8, wherein said average intensity is calculated on a running average basis of pixels in said image.

10. The method as provided in clause 9, wherein said greyscale value provides a weight to favour green values in said image.

11. The method as provided in any one of clauses 7 to 10, wherein another calculation is made for another intensity value for another image when said image is replaced by said another image on said display.

12. The method as provided in clause 10, wherein said another calculation is made for another intensity value for another image when said image is replaced by said another image on said display and said another image has changes over said image over more than a small portion of said image.

13. The method as provided in clause 10, wherein said display is displaying a video image comprising said image and another image; and another calculation is made for another intensity value for another image shown on said display after said image.

14. An electronic device having the backlight system as provided in any one of clauses 1 to 6.

15. A computer program product for adjusting a backlight for a display for an electronic device, said computer program product comprising a computer readable medium embodying program code means for implementing in an electronic device the method of any one of clauses 7 to 13.

[0083] The present invention is defined by the claims appended hereto, with the foregoing description being merely illustrative of a preferred embodiment of the invention. Those of ordinary skill may envisage certain modifications to the foregoing embodiments which, although not explicitly discussed herein, do not depart from the scope of the invention, as defined by the appended claims.

Claims

1. A backlight adjustment module (48G) to control a backlight system (64) that provides backlight for a display (14) in an electronic device (10), said backlight adjustment module (48G):

   providing calculations of an average intensity for an image being displayed on said display on a running average basis from a greyscale value associated with said image corrected according to a gamma curve and to determine a backlight level for said image using said average intensity, where the darker the image the greater is the backlight level; and
   providing controls signals to said backlight system based on said calculations to generate a backlight for said image generated on said display (14).

2. The module as claimed in claim 1, wherein said greyscale value is obtained from a weighted calculation in which green values are weighted most heavily.

3. The module as claimed in claim 1 or 2, wherein said backlight level is adjusted between minimum and maximum backlight levels for said display (14) set for a completely white and a completely black image, respectively.

4. The module as claimed in any one of claims 1 to 3, wherein said backlight adjustment module provides another calculation for another intensity value for another image when said image is replaced by said another image on said display (14).

5. The module as claimed in claim 4, wherein said backlight adjustment module provides a greater backlight level to the darker image between said image and said another image.

6. The module as claimed in claim 4 or claim 5, wherein said image and said another image relate to a video signal.

7. The module as in any of the previous claims, wherein the running average is computed by sequentially adding a greyscale pixel value to a running total.

8. The module as in claim 7, wherein the running average is computed according to the equation:

$$A_N = A_{N-1} - \frac{A_{N-1} - X}{N},$$

   wherein, A_N is the new average, A_{N-1} is the previous average, X is the new grayscale value added to the average, and N is the number of values included in the average so far.

9. The module (48G) as in any of the previous claims, wherein said control signals are provided to said backlight system when said image is provided to said display for generation on said display.

10. The module (48G) as in any of the previous claims, wherein said backlight level is further responsive to a signal representing an amount of ambient light detected around the device whereby as the amount of ambient light increases, the backlight level increases.

11. An electronic device having the module (48G) as claimed in any one of claims 1 to 10.

12. A method of adjusting a backlight for images generated on a display (14) of an electronic device, comprising:

    calculating an average intensity of a first image on a running average basis from a greyscale value associated with said image corrected according to a gamma curve;
    determining a first backlight level for said image based on said intensity level;
    providing said first backlight level to a backlight system (64) for a display when said first image is generated on said display (14);
    calculating an average intensity of a second image on a running average basis from a greyscale value associated with said image corrected according to a gamma curve; determining a backlight level for said second image

based on said intensity level; and
providing said backlight level to said backlight system (64) for said display when said second image is generated on said display (14), the darker of said first and said second image is provided with a greater backlight intensity.

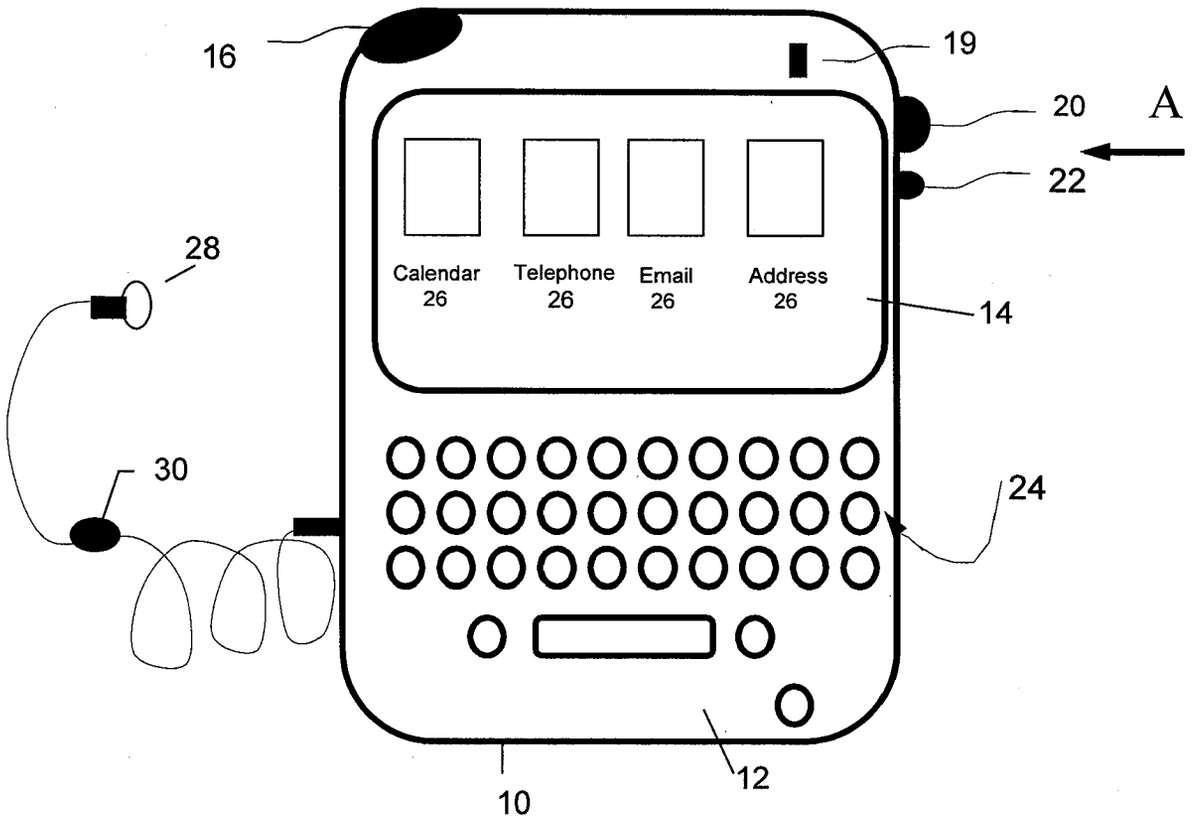
13. The method as claimed in claim 12, wherein said greyscale values are obtained from a weighted calculation in which green values are weighted most heavily.

14. The method as claimed in claim 12 or 13, wherein said backlight levels are adjusted between minimum and maximum backlight levels said display set for a completely white and a completely black image, respectively.

15. The method as in claimed in any one of claims 12 to 14, wherein the running averages are computed according to the equation:

$$A_N = A_{N-1} - \frac{A_{N-1} - X}{N},$$

wherein, A_N is the new average, A_{N-1} is the previous average, X is the new value added to the average, and N is the number of values included in the average so far.


16
19
20
A
22
28
Calendar
26
Telephone
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Email
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Address
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14
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24
12
10

Fig. 1

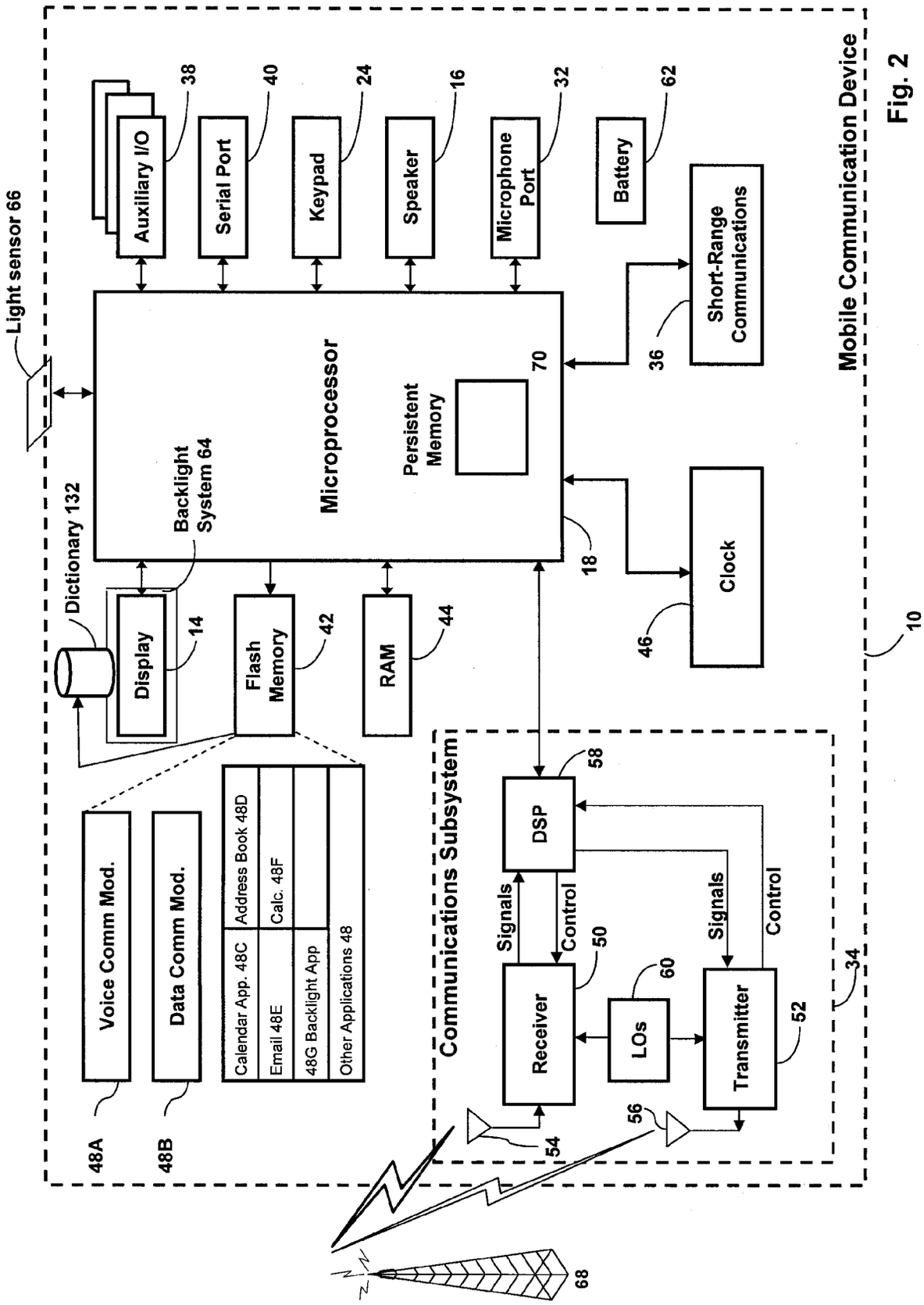
Mobile Communication Device
10
Light sensor 66
Auxiliary I/O
38
Serial Port
40
Keypad
24
Speaker
16
Microphone Port
32
Battery
62
Short-Range Communications
36
Microprocessor
Persistent Memory
70
Backlight System 64
Dictionary 132
Display
14
Flash Memory
42
RAM
44
18
Clock
46
Voice Comm Mod.
Data Comm Mod.
Address Book 48D
Calendar App. 48C
Calc. 48F
Email 48E
48G Backlight App
Other Applications 48
48A
48B
Communications Subsystem
DSP
58
Signals
Control
Receiver
50
LOs
60
Transmitter
52
34
54
56
68

Fig. 2

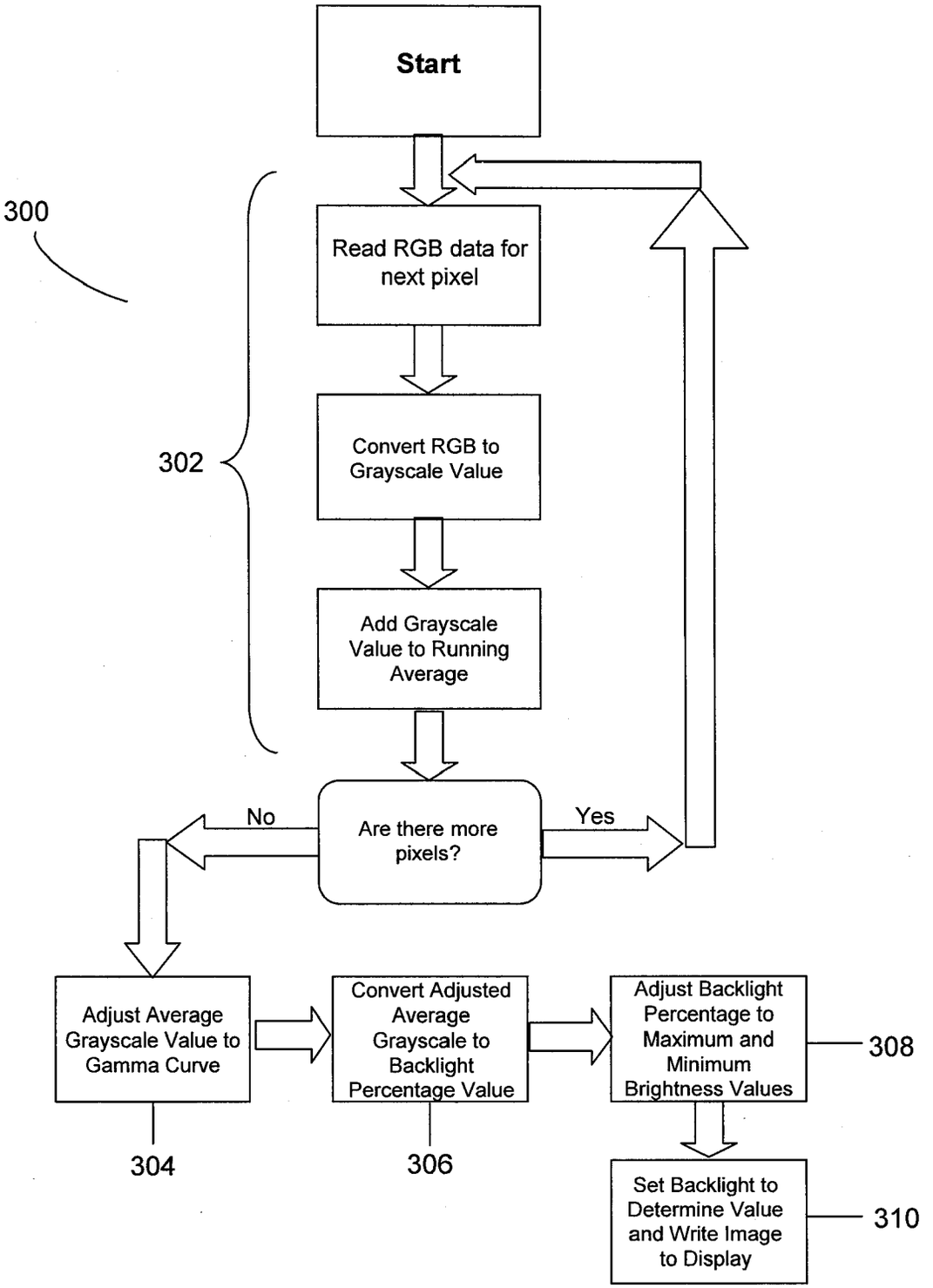
Start
300
Read RGB data for next pixel
302
Convert RGB to Grayscale Value
Add Grayscale Value to Running Average
No
Are there more pixels?
Yes
Adjust Average Grayscale Value to Gamma Curve
Convert Adjusted Average Grayscale to Backlight Percentage Value
Adjust Backlight Percentage to Maximum and Minimum Brightness Values
308
Set Backlight to Determine Value and Write Image to Display
310
304
306

Fig. 3

```
Define Number_Of_Pixels_On_Display = Display_Height_Pixels * Display_Width_Pixels


For i = 1 to Number_Of_Pixels_On_Display
        red_value = GetRedValue(i);
        green_value = GetGreenValue(i);
        blue_value = GetBlueValue(i);
        green_value>>1    ;    //shift right by one bit
        grey_value = 0.3 * red_value + 0.59 * green_value + 0.11 * blue_value;
        average_grey_value = RunningAverage(average_grey_value, grey_value, i);


Next i
gamma_corrected_value = (average_grey_value * average_grey_value) /
(grey_colour_depth * grey_colour_depth);
backlight_percent = 100 – (gamma_corrected_value * 100);
adjusted_backlight_percent = backlight_percent * (Max_Backlight_Percent –
Min_Backlight_Percent) / 100;


Function RunningAverage(average_value, new_value, total_values_in_average)
        return average_value – ((average_value – new_value)/total_values_in_average):
End Function
```

Fig. 4

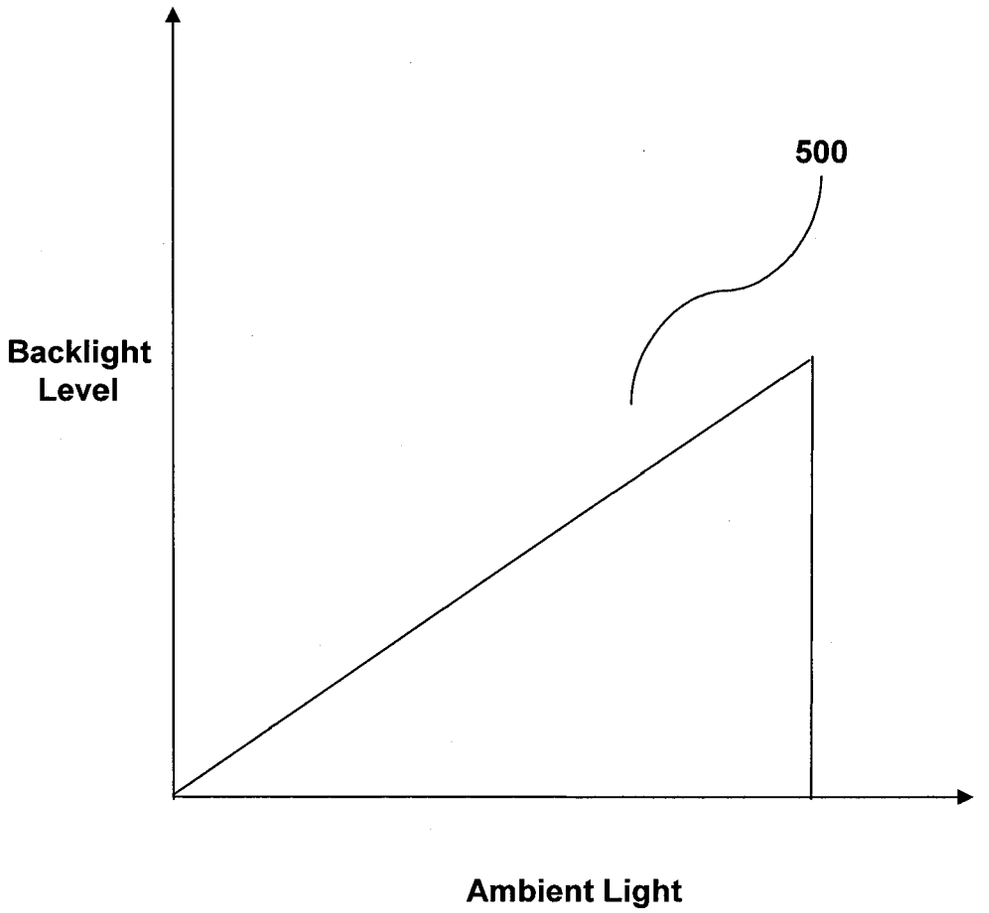

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 10 15 2602

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 03 179886 A (TOSHIBA CORP) 5 August 1991 (1991-08-05) * abstract * * figures 4,7 * -----	1,3-9, 11-12, 14-15	INV. G09G3/34
A	US 2001/033260 A1 (NISHITANI SHIGEYUKI ET AL) 25 October 2001 (2001-10-25) * paragraphs [0007] - [0010], [0059], [0060], [0066], [0075], [0102], [0103]; figures 3,4,22 * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

G09G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	24 March 2010	Fulcheri, Alessandro

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

1

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 10 15 2602

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24-03-2010

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JP 3179886 A	05-08-1991	NONE	
US 2001033260 A1	25-10-2001	TW 518882 B	21-01-2003
		US 2009040157 A1	12-02-2009

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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