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D E S C R I P T I O N

PHOTOSENSOR SYSTEM AND DRIVE CONTROL
METHOD THEREOF

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Technical Field

The present invention relates to a photosensor system having a photosensor array constituted by two-dimensionally arraying a plurality of photosensors, and a drive control method thereof.

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Background Art

Imaging apparatuses such as electronic still cameras, video cameras, and the like have come to be very widely used. These imaging apparatuses employ a solid-state imaging device, such as a CCD (Charge Coupled Device), which serves as a photoelectric converting device for converting an image of a to-be-photographed subject into an image signal. As well known, the CCD has a structure in which photosensors (light receiving elements) such as photodiodes, or thin film transistors (TFT: Thin Film Transistor) are arranged in a matrix, and the amount of electron-hole pairs (the amount of charge) generated corresponding to the amount of light entering the light receiving section of each sensor is detected by a horizontal scanning circuit and vertical scanning circuit to detect the luminance of radiation.

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In a photosensor system using such a CCD, it is



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necessary to respectively provide scanned photosensors with selective transistors for causing the scanned photosensor to assume a selected state. In place of the combination of the photosensor and the selective transistor, a photosensor (to be referred to as a double-gate photosensor hereinafter) is now being developed, which is formed of a thin film transistor having a so-called double-gate structure and has both a photosensing function and a selecting function.

FIG. 11A is a sectional view showing the structure of a double-gate photosensor 10. FIG. 11B is a circuit diagram showing the equivalent circuit of the double-gate photosensor 10.

The double-gate photosensor 10 comprises a semiconductor thin film 11 formed of amorphous silicon or the like, n^+ -silicon layers 17 and 18, source and drain electrodes 12 and 13 respectively formed on the n^+ -silicon layers 17 and 18, a top gate electrode 21 formed above the semiconductor thin film 11 via a block insulating film 14 and upper gate insulating film 15, a protective insulating film 20 provided on the top gate electrode 21, and a bottom gate electrode 22 provided below the semiconductor thin film 11 via a lower gate insulating film 16. The double-gate photosensor 10 is provided on a transparent insulating substrate 19 formed of glass or the like.

In other words, the double-gate photosensor 10

includes an upper MOS transistor comprised of the semiconductor thin film 11, source electrode 12, drain electrode 13, and top gate electrode 21, and a lower MOS transistor comprised of the semiconductor thin film 11, source electrode 12, drain electrode 13, and bottom gate electrode 22. As shown in the equivalent circuit of FIG. 31B, the double-gate photosensor 10 is considered to include two MOS transistors having a common channel region formed of the semiconductor thin film 11, TG (Top Gate terminal), BG (Bottom Gate terminal), S (Source terminal), and D (drain Terminal).

The protective insulating film 20, top gate electrode 21, upper gate insulating film 15, block insulating film 14, and lower gate insulating film 16 are all formed of a material having a high transmittance of visible light for activating the semiconductor thin film 11. Light entering the sensor from the top gate electrode 21 side passes through the top gate electrode 21, upper gate insulating film 15, and block insulating film 14, and then enters the semiconductor thin film 11, thereby generating and accumulating charges (positive holes) in the channel region.

FIG. 12 is a schematic view showing a photosensor system constituted by two-dimensionally arraying double-gate photosensors 10. As shown in this figure, the photosensor system comprises a sensor array 100.

that is constituted of a large number of double-gate
photosensors 10 arranged in an $n \times m$ matrix, top and
bottom gate lines 101 and 102 that respectively connect
the top gate terminals TG and bottom gate terminals BG
5 of the double-gate photosensors 10 in a row direction,
top and bottom gate drivers 111 and 112 respectively
connected to the top and bottom gate lines 101 and 102,
data lines 103 that respectively connect the drain
terminals D of the double-gate photosensors 10 in a
10 column direction, and an output circuit section 113
connected to the data lines 103.

ϕ_{tg} and ϕ_{bg} represent control signals for
generating a reset pulse ϕ_{Ti} and readout pulse ϕ_{Bi} ,
respectively, which will be described later, and ϕ_{pg}
15 represents a pre-charge pulse for controlling the
timing at which a pre-charge voltage V_{pg} is applied.

In the above-described structure, as described
later, the photosensing function is realized by
applying a predetermined voltage from the top gate
20 driver 111 to the top gate terminals TG, while the
readout function is realized by applying a predeter-
mined voltage from the bottom gate driver 112 to the
bottom gate terminals BG, then sending the output
voltage of the photosensors 10 to the output circuit
25 section 113 via the data lines 103, and outputting
serial data V_{out} .

FIGS. 13A to 13D are timing charts showing

a method of controlling the photosensor system, and showing a detecting period (i-th row processing cycle) in the i-th row of the sensor array 100. First, a high-level pulse voltage (reset pulse; e.g., $V_{tg} = +15V$) ϕ_{Ti} shown in FIG. 13A is applied to the top gate line 101 of the i-th row, and during a reset period T_{reset} , reset operation for discharging the double-gate photosensors 10 of the i-th row is executed.

Subsequently, a bias voltage ϕ_{Ti} of low level (e.g., $V_{tg} = -15V$) is applied to the top gate line 101 of the i-th row, thereby finishing the reset period T_{reset} and starting a charge accumulating period T_a in which the channel region is charged. During the charge accumulating period T_a , charges (positive holes) corresponding to the amount of light entering each sensor from the top gate electrode side are accumulated in the channel region.

Then, a pre-charge pulse ϕ_{pg} shown in FIG. 13C with a pre-charge voltage V_{pg} is applied to the data lines 103 during the charge accumulating period T_a , and after a pre-charge period T_{prch} for making the drain electrodes 13 keep a charge, a bias voltage (readout pulse ϕ_{Bi}) of high level (e.g., $V_{bg} = +10V$) shown in FIG. 13B is applied to the bottom gate line 102 of the i-th row. At this time, the double-gate photosensors 10 of the i-th row are turned on to start a readout period T_{read} .

During the readout period T_{read} , the charges accumulated in the channel region serve to moderate a low-level voltage (e.g., $V_{\text{tg}} = -15\text{V}$) which has an opposite polarity of charges accumulated in the channel region and is applied to each top gate terminal TG. Therefore, an n-type channel is formed by the voltage V_{bg} at each bottom gate terminal BG, the voltage V_{D} at the data lines 103 gradually reduces in accordance with the drain current with lapse of time after the pre-charge voltage V_{pg} is applied. More specifically, the tendency of change in the voltage V_{D} at the data lines 103 depends upon the amount of received light in the case where the charge accumulating period T_{a} is constant. As shown in FIG. 13D, the voltage V_{D} tends to gradually reduce when the incident light is dark, i.e., a small amount of light is received, and hence only small charges are accumulated, whereas the voltage V_{D} tends to suddenly reduce when the incident light is bright, i.e., a large amount of light is received, and hence large charges are accumulated. It is understood that the amount of radiation can be calculated by detecting the voltage V_{D} at the data lines 103 a predetermined period after the start of the readout period T_{read} , or by detecting a period required until the voltage V_{D} reaches a predetermined threshold voltage. An image reading sensitivity corresponds to the charge accumulating period T_{a} . Assuming that the

amount of light is constant, the amount of charge accumulated increases and the image reading sensitivity enhanced in accordance with an increase in the charge accumulating period T_a . Likewise, the amount of charge accumulated decreases and the image reading sensitivity degraded in accordance with a decrease in the charge accumulating period T_a .

Image reading is performed by sequentially executing the above-described drive-control for each line of the sensor array 100, by executing the control for each line in a parallel manner at different timings at which the driving pulses do not overlap.

Although the case of using the double-gate photosensor as a photosensor has been described above, even a photosensor system using a photodiode or phototransistor as a photosensor has operation steps: reset operation → charge accumulating operation → pre-charge operation → reading operation, and uses a similar drive sequence. The conventional photosensor system as above has the following problems.

(1) To read a subject image in various use environments in a photosensor system using the above-described photosensor, the image reading sensitivity (charge accumulating period) must be properly set. The proper image reading sensitivity changes depending on changes in ambient conditions such as the illuminance of external light in a use environment, and also

changes when the characteristics of the photosensor change. In the prior art, therefore, a circuit for detecting the illuminance of external light must be additionally arranged. Alternatively, for example, a subject image is read at different image reading sensitivities before the start of normal reading operation of that subject image, and an optimal image reading sensitivity must be determined on the basis of a read result. However, a reading sensitivity setting method of unconditionally and automatically setting a proper image reading sensitivity based on such a read result for every image reading sensitivity that is obtained by operations executed at different image reading sensitivities, has not been developed yet.

(2) If a foreign substance attaches to the sensing surface of a photosensor or a defect is generated in a photosensor element in setting the reading sensitivity based on the result of the sensitivity-adjusting reading operation, and a read result obtained for each image reading sensitivity obtained in the reading operation is directly used, an abnormal value is contained in the read result, leading to failure to set a proper image reading sensitivity and to inhibit accurate reading operation of a subject image. For example, when this photosensor system is applied to a fingerprint reading apparatus, the apparatus may malfunction in fingerprint recognition processing.

Disclosure of Invention

It is an object of the present invention to provide a reading sensitivity setting method of unconditionally and automatically setting a proper
5 image reading sensitivity in order to accurately read a subject image in various use environments in a photosensor system. The present invention is advantageous in that any malfunction in setting the image reading sensitivity is prevented even if a
10 foreign substance attaches to the sensing surface of a photosensor, or a photosensor element becomes defective.

To achieve the above advantage, a photosensor system according to the present invention comprises: a
15 photosensor array constituted by two-dimensionally arranging a plurality of photosensors; image reading means for reading a subject image by use of the photosensor array; sensitivity-adjusting reading means for changing the image reading sensitivity of the
20 photosensors of the specific row section of the photosensor array, stepwise and reading the subject image; optimal image reading sensitivity-extracting means for extracting an optimal image reading sensitivity suited to the image reading operation on
25 the basis of a predetermined measurement amount regarding an image pattern of the subject image read by the sensitivity-adjusting reading means; and reading

sensitivity-setting means for setting the optimal image reading sensitivity as a reading sensitivity of the image reading means.

5 In the system, the optimal image reading sensitivity-extracting means extracts an image reading sensitivity that allows the dynamic range of the measurement amount of each image reading sensitivity. The reading sensitivity-setting means sets the extracted image reading sensitivity as an optimal image
10 reading sensitivity. Thus, the time required for a sensitivity-adjusting reading operation may be reduced, and the amount of data subjected to the extraction processing of the optimal image reading sensitivity may be reduced and thus, the required time may be
15 reduced.

In this case, abnormal pixel determining means is provided for determining whether or not any abnormal pixel exists in the specific row section by checking if the measurement amount pertaining to the specific row
20 section and corresponding to each column changes when the image reading sensitivity is switched from one to another. Sensitivity-adjusting reading control means is also provided for executing sensitivity-adjusting reading operation for a specific row section other than
25 the specific row section where the abnormal pixel is determined to exist. With this structure, even if an abnormal pixel exists in the specific row section for

which the sensitivity-adjusting reading operation is performed, another specific row section is selected to avoid the adverse effects the abnormal pixel may have.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

Brief Description of Drawings

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.

FIG. 1 is a block diagram showing an arrangement of a photosensor system according to the present invention;

FIG. 2 is a block diagram showing an arrangement of a controller applied to the photosensor system according to the present invention;

FIG. 3 is a flow chart showing the operation of the first embodiment;

FIG. 4 shows a specific row section of a photosensor array for which the sensitivity-adjusting

reading operation is performed according to the first embodiment, the specific row section being illustrated in relation to a subject;

FIGS. 5A to 5E are graphs each showing changes in
5 lightness data in a specific row section that are obtained by the sensitivity-adjusting reading operation in the first embodiment, in relation to the number of times the reading operation is performed;

FIG. 6 is a graph showing how a dynamic range
10 changes in the first embodiment, in relation to the number of times the reading operation is performed;

FIG. 7 is a flow chart showing the operation of the second embodiment;

FIG. 8 shows a specific row section of a
15 photosensor array for which the sensitivity-adjusting reading operation is performed according to the second embodiment, the specific row being illustrated in relation to a subject image;

FIGS. 9A to 9E are graphs showing how lightness
20 data on a specific row section changes in the second embodiment, in relation to the number of times the reading operation is performed;

FIGS. 10A to 10L are timing charts showing the
embodiment of an image reading sensitivity setting
25 method applied to the sensitivity-adjusting reading operation executed in each of the first and second embodiments;

FIG. 11A is a sectional view showing the structure of a conventional double-gate photosensor;

FIG. 11B is an equivalent circuit diagram showing the double-gate photosensor;

5 FIG. 12 is a schematic view showing a photosensor system constituted by two-dimensionally arraying double-gate photosensors;

FIGS. 13A to 13D are timing charts showing a conventional drive method for the double-gate
10 photosensor system.

Best Mode for Carrying Out of the Invention

Methods of controlling a photosensor system according to the present invention will be described in detail with reference to the several views of
15 the accompanying drawings. Although in embodiments described below, a double-gate photosensor is applied as a photosensor, the present invention is not limited to the double-gate photosensor, but is also applicable to a photosensor system using another type of
20 photosensor.

FIG. 1 is a block diagram showing an arrangement of a photosensor system according to the present invention. The double-gate photosensor shown in FIG. 11A is used, and the arrangement of the
25 photosensor system shown in FIG. 12 will be referred to if necessary. The same reference numerals as in the photosensor system shown in FIG. 12 denote the same

parts.

As shown in FIG. 1, the photosensor system according to an embodiment comprises a photosensor array 100 including double-gate photosensors 10 shown in FIG. 11A that are arrayed two-dimensionally, a top gate driver 111 for applying a predetermined reset pulse to a top gate terminal TG of each double-gate photosensor 10 at a predetermined timing, a bottom gate driver 112 for applying a predetermined readout pulse to a bottom gate terminal BG of each double-gate photosensor 10 at a predetermined timing, an output circuit section 113 constituted by an amplifier 116, and a column switch 114 and pre-charge switch 115 for reading a data line voltage and applying a pre-charge voltage to each double-gate photosensor 10, respectively, an analog/digital converter (to be referred to as an A/D converter hereinafter) 117 for converting the read data voltage as an analog signal into image data as a digital signal, a controller 120 which is adopted to control the operation of reading a subject image by the photosensor array 100, and to exchange data with an external function section 200, and which controls sensitivity setting in the present invention, and a RAM 130 that stores, for example, read image data, data relating to setting of a reading sensitivity described later.

The structure including the photosensor array 100,

top gate driver 111, bottom gate driver 112, and output circuit section 113 is the same as and has the same function as the photosensor system shown in FIG. 12.

In addition to this structure, this embodiment adopts the A/D converter 117, controller 120, and RAM 130 to enable various types of control as described below.

The controller 120 outputs control signals ϕ_{tg} and ϕ_{bg} to the top and bottom gate drivers 111 and 112, respectively, which, in turn, output predetermined voltages (reset pulse and readout pulse) to the top gate terminal TG and bottom gate terminal BG of each double-gate photosensor 10 of the photosensor array 100, respectively. The controller 120 also outputs a control signal ϕ_{pg} to the pre-charge switch 115 to control execution of the operation of reading a subject image. A data line voltage read from the photosensor array 100 via the column switch 114 and amplifier 116 is converted into a digital signal by the A/D converter 117, and supplied as image data. The controller 120 also has a function of executing predetermined image processing for image data, writing or reading image data into or from the RAM 130. The controller 120 serves as an interface with the external function section 200 that executes predetermined processing such as image data identification, modification, and the like.

The controller 120 has another function of

controlling control signals to be output to the top and bottom gate drivers 111 and 112 to set an optimal reading sensitivity for reading a subject image in accordance with ambient environments such as the illuminance of external light, i.e., an optimal charge accumulating period for each double-gate photosensor 10.

As will be described below, photosensor system drive control methods according to embodiments of the present invention are based on the arrangement of this photosensor system.

<First Embodiment>

The first embodiment of the photosensor system drive control method according to the present invention will be described with reference to the several views of the accompanying drawings.

The first embodiment is characterized in that it changes an image reading sensitivity in relation to the photosensor in a specific row section of the photosensor array at a plurality of stages, and reads a subject image in relation to the specific row section.

FIG. 2 is a block diagram showing an arrangement of a controller 120 applied to the first embodiment. As shown in this FIGURE, the controller 120 comprises a device controller 121 for controlling a top gate driver 111, bottom gate driver 112, and output circuit section 113, a data controller 122 for managing various data

such as image data, write data, and readout data to the RAM 130, and a main controller 123 which supervises the controllers 121 and 122 and interfaces with an external function section.

5 The controller 120 further comprises a data comparator 124 for comparing the sizes of specific measurement data based on image data input as a digital signal from a photosensor array 100 via an A/D converter 117 to extract maximum and minimum values,
10 an adder 125 having a function of calculating, e.g., the difference between measurement data, a data selector 126 for receiving processed image data via the A/D converter 117, data comparator 124, and adder 125, and switching write/readout in/from the RAM, re-input
15 to the data comparator 124 and adder 125, and output to the external function section via the data controller 122 in accordance with the received data, and a sensitivity setting register 127 for changing control signals to be output from the device controller 121 to
20 the top and bottom gate drivers 111 and 112 so as to optimize the reading sensitivity of the photosensor array on the basis of a control signal from the data controller 122.

25 The operation of the first embodiment in the operation control method of the photosensor system using the above controller 120 will be explained with reference to FIG. 3. FIG. 3 is a flow chart showing an

operation executed up to the optimal image reading sensitivity setting, and FIG. 4 shows a specific row section of a photosensor array for which the sensitivity-adjusting reading operation is performed according to this embodiment, the specific row being illustrated in relation to a subject image. This operation will be described by properly referring to the arrangement of the photosensor system shown in FIGS. 1 and 2.

10 In S11 (sensitivity-adjusting reading operation) of FIG. 3, the main controller 123 controls to set an image reading sensitivity for sensitivity-adjusting reading operation in the sensitivity setting register 127 via the data controller 122, and executes the

15 sensitivity-adjusting reading operation of reading a subject image at a plurality of different sensitivities while changing the image reading sensitivity stepwise for respective specific row sections of the subject image. These operations are executed prior to the

20 normal reading operation of the subject image, for example. It should be noted that the sensitivity-adjusting reading operation applicable to the sensitivity adjusting method of the first embodiment is performed, using a photosensor array 100 in which

25 photosensors are arranged in units of a matrix pattern of 256 rows $\times$ 196 columns, as shown in FIG. 4. In this photosensor array, a central row (i.e., the $n/2$ -th row)

or several rows in the vicinity thereof are regarded as a specific row section, and the photosensors 10 corresponding to the specific row section are reset. Thereafter, precharge operation and readout operation are repeatedly executed at predetermined timings in such a manner that the charge accumulating period (image reading sensitivity) varies stepwise. In other words, the image reading sensitivity is made to vary in correspondence to the number of times reading operation is executed. Data are stored in a RAM 130, for example, in a table format of (the number of times of reading operation) vs (image reading sensitivity correspondence table). A specific method for setting the image reading sensitivity will be described later.

In S12 (image data conversion step) of FIG. 3, the image data read by the sensitivity-adjusting reading operation are converted into digital signals via an amplifier 116 and an A/D converter 117. The digital signal is supplied to a data comparator 124 of the controller 120 as lightness data corresponding to the bright/dark pattern of the subject image. The lightness data are expressed by, e.g., 256 gray levels. The image data corresponding to each reading operation are converted into a lightness data value in the range of 0 to 255 and stored in the data comparator 124. A specific example is shown in FIGS. 5A to 5E. FIGS. 5A to 5E show lightness data which are obtained when

reading operation has been executed a predetermined number of times in one row of the specific row section, and in which the image reading sensitivity increases with an increase in the number of times reading operation is executed. For example, FIGS. 5A to 5E show how lightness data change in the columns when reading operation has been executed 16 times (FIG. 5A), 32 times (FIG. 5B), 64 times (FIG. 5C), 96 times (FIG. 5D) and 128 times (FIG. 5E). The lightness data obtained when the reading operation has been executed 16 times and 32 times are data wherein the image reading sensitivity is low. Since the sensitivity is thus insufficient, there are columns in which the data value is "0" (lower limit). On the other hand, the lightness data obtained when the reading operation has been executed 96 times and 128 times are data wherein the image reading sensitivity is high. Since the sensitivity is too high, there are columns in which the data value is "255" (upper limit).

In S13 (the step of extracting a maximum value and a minimum value in relation to the number of times reading operation is executed) of FIG. 3, a maximum value and a minimum value in relation to the number of times reading operation is executed are extracted from the lightness data supplied to the data comparator 124. The extracted maximum and minimum values are output to the adder 125. In other words, the lightness data

value indicating a maximum value (i.e., the gray level of the brightest pixel) and the lightness data value indicating a minimum value (i.e., the gray level of the darkest pixel) are extracted each time reading operation is executed.

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Next, in S14 (the step of calculating a dynamic range in relation to the number of times reading operation is executed) of FIG. 3, the adder 125 calculates the difference between the maximum and
10 minimum values of lightness data in relation to the number of times reading operation is executed as a dynamic range. The result of this calculation is stored in the RAM 130 through the use of the data selector 126. This dynamic range calculation step is
15 executed each time reading operation is performed.

In S15 (the step of extracting a reading operation that exhibits a maximum dynamic range) of FIG. 3, the data selector 126 reads out dynamic ranges of reading operations from the RAM 130 in relation to the number
20 of times reading operation is executed, and the readout dynamic ranges are supplied to the data comparator 124. On the basis of the dynamic range changing tendency (FIG. 6) relative to the number of times of a reading operation is executed, a maximum value DLmax of the
25 dynamic range is determined in relation to the number of times a reading operation is executed, and the number RCa of times corresponding to the determined

maximum value is extracted. In the example shown in
FIGS. 5A to 5E, the lightness data obtained in the 16th
and 32nd reading operations have a minimum value
saturated at the lower limit (=0), and the lightness
5 data obtained in the 96th and 128th reading operations
has a maximum value saturated at the upper limit
(=255). In contrast, the lightness data obtained in
the 64th reading operation does not have a value that
is saturated at the upper or lower limit. As a result,
10 the dynamic range of the lightness data obtained in the
64th reading operation is greater than the dynamic
ranges of the other lightness data. Hence, the maximum
value is DLmax, and the number RCa of the reading
operation corresponding to that maximum value is 64.

15 Next, S16 (the step of referring to and extracting
a sensitivity) of FIG. 3 is executed on the basis of
the extracted number RCa of the reading operation. In
the step, the image reading sensitivity (i.e., the
charge accumulating period) corresponding to the number
20 RCa of the reading operation is extracted by referring
to the table stored in the RAM 130, i.e., the table of
[the number RCa of times of reading operation] vs
[image reading sensitivity correspondence table].

25 In S17 (the step of setting the extracted
sensitivity) of FIG. 3, the main controller 123 causes
the data controller 122 to rewrite the data in the
sensitivity setting register 127, so that the image

reading sensitivity of the sensitivity setting register
127 is set at the extracted image reading sensitivity.
This brings an end to the optimal image reading
sensitivity setting based on the sensitivity-adjusting
5 reading operation.

According to the sensitivity setting method of the
first embodiment, one or more specific rows (specific
row section) of the photosensor array are selected, and
the sensitivity-adjusting reading operation (which
10 repeatedly reads a subject image at predetermined
intervals) is executed in the selected specific row
section after resetting operation. Hence, the subject
image can be read, with the image reading sensitivity
(charge accumulating period) being varied stepwise.
15 Thereby the time needed for the sensitivity-adjusting
reading operation can be as short as possible.

In comparison with an optimal image reading
sensitivity is extracted on the basis of the
conventional read image data corresponding to one
20 frame, the first embodiment uses image data corre-
sponding to one or several specific rows (specific row
section). Thereby the amount of data used for the
extraction of an optimal image reading sensitivity can
be significantly reduced, resulting in a remarkable
25 decrease in the processing load. In addition, the time
needed for the setting of an optimal image reading
sensitivity can be significantly shortened.

Furthermore, the sensitivity-adjusting reading operation is limited to the specific row section. In comparison with the conventional case where the sensitivity-adjusting reading operation is executed for the entire light-receiving area of the photosensor array, the first embodiment has significantly lowered the probability of inclusion of an abnormal pixel (a missing point or a twinkling point), which may be caused by a foreign substance adhering to a target area, a defective element of a photosensor, or the like. Hence, there is a significantly lowered probability that an inappropriate image reading sensitivity will be set due to the existence of such an abnormal pixel. Accordingly, a malfunction is prevented in fingerprint recognition processing.

In the first embodiment, a specific row section is a central row ($n/2$ -th row) and several rows located in the vicinity thereof in a matrix of n rows $\times$ m columns ($n = 256$, $m = 196$). Needless to say, the present invention is not limited to this. The specific row section may be selected from any area as long as that area shows a clear brightness pattern (contrast) of a subject image. For example, the specific row section may be those located near the central row, or may be selected from another area.

<Second Embodiment>

The second embodiment of a photosensor system

drive control method according to the present invention will be described with reference to the accompanying drawings.

In the first embodiment described above, the
5 sensitivity-adjusting reading operation is executed for one or several rows of the specific row section. This significantly reduces the probability that an abnormal pixel exists in the target specific row section in comparison with the case where the entire light-
10 receiving area of a photosensor array or a selected area thereof is subjected to the reading operation. However, the probability that an abnormal pixel exists in the specific row section is in no way "zero."

Like the first embodiment, the second embodiment
15 is intended to reliably prevent the adverse effects an abnormal pixel may have when the sensitivity-adjusting reading operation is performed for one or several rows of the specific row section. The controller applied to the second embodiment is similar in structure to the
20 controller 120 employed in the first embodiment and is represented by the structural blocks shown in FIG. 2.

FIG. 7 is a flowchart illustrating how the controller 120 controls the operation of the
photosensor system in the second embodiment of the
25 present invention. In the flowchart, the operations executed up to the optimal image reading sensitivity setting are illustrated. FIG. 8 shows a specific row

section of the photosensor array for which the sensitivity-adjusting reading operation is performed according to the second embodiment, the specific row section being illustrated as Rp in relation to a subject image. In the description below, reference will be made to the structure of the photosensor system shown in FIGS. 1 and 2, if required. Similar or corresponding structural elements will be denoted by the same reference numerals as used in the description of the first embodiment, and a simplified description will be given of such structural elements.

The sensitivity-adjusting reading operation applied to the sensitivity adjusting method of the second embodiment is executed for a specific row section Rp of a photosensor array 100 in which photosensors are arranged in units of a matrix pattern of 256 rows $\times$ 196 columns, as shown in FIG. 8. In the description below, it is assumed that an abnormal pixel IL3 exists at the position of specific row section Rp and column Lq, and that the value of the lightness data at that position is "0", due to a foreign substance adhering to the sensing surface of the photosensor array, a defective element of the photosensor, or the like.

Step S21 (sensitivity-adjusting reading operation) of FIG. 7 is executed in a similar manner to that of S11 of the first embodiment. That is, the photosensors

corresponding to the specific row section Rp of the
photosensor array 100 shown in FIG. 8 are controlled in
such a manner that the charge accumulating period
(i.e., the image reading sensitivity) varies stepwise
5 at predetermined intervals. The sensitivity-adjusting
reading operation is performed for a subject image at a
plurality of image reading sensitivities, which
correspond to the number of times reading operation has
been executed. These operations are executed prior to
10 the normal reading of the subject image.

Step S22 (image data conversion step) of FIG. 7,
is executed in a similar manner to that of S12 of the
first embodiment. The image data read by the
sensitivity-adjusting reading operation are converted
15 into lightness data. The lightness data are supplied
to the controller 120 and stored in the RAM 130. A
specific example is shown in FIGS. 9A to 9E. Like
FIGS. 5A to 5E, FIGS. 9A to 9E show how lightness data
change in the columns when reading operation has been
20 executed 16 times (FIG. 9A), 32 times (FIG. 9B),
64 times (FIG. 9C), 96 times (FIG. 9D) and 128 times
(FIG. 9E), in the specific row section (for example one
row in this case). The lightness data include the
lightness data which represent the minimum value "zero"
25 at the number Lq of column by the abnormal pixel IL
shown in FIG. 8. The lightness data obtained when the
reading operation has been executed 16 times and

32 times are data wherein the image reading sensitivity is low. Since the sensitivity is thus insufficient, there are columns in which the data value is "0" (lower limit). On the other hand, the lightness data obtained when the reading operation has been executed 96 times and 128 times are data wherein the image reading sensitivity is high. Since the sensitivity is too high, there are columns in which the data value is "255" (upper limit).

Next, step S23 (the step of extracting and comparing the same-column data from the data of each reading operation) shown in FIG. 7 is executed. In this step, the data selector 126 extracts lightness data of the same column from the lightness data stored in the RAM 130 and corresponding to each reading operation. The extracted lightness data are supplied to the data comparator 124 so as to compare the lightness data of the same column.

Then, step S24 (the step of determining a variation in the same-column data) shown in FIG. 7 is executed. This step is for determining whether there is a column in which the lightness data remain the same after each reading operation.

If there is a column in which the lightness data do not changed, the pixels corresponding to this column are regarded as abnormal ones, and the specific row section for which the sensitivity-adjusting reading

operation is performed is determined as containing an abnormal pixel.

5 If there is not a column in which the lightness data remain the same, the specific row section for which the sensitivity-adjusting reading operation is performed is determined as not containing an abnormal pixel.

10 A result of this determination is supplied from the data comparator 124 to the main controller 123. In the example shown in FIGS. 9A to 9E, the abnormal pixel IL is present, and the lightness data corresponding to column number Lq are "0" irrespective of the number of times reading operation is executed. In other words, there is a column in which the lightness data remain
15 the same after each reading operation, and row Rq is determined to contain an abnormal pixel.

A description will be given of a specific method for checking the presence/absence of an abnormal pixel by detecting whether or not there is a column in which
20 the lightness data do not changed before and after each reading operation. For example, the sensitivity-adjusting reading operation may be controlled as follows: Flags are set for the respective columns on the basis of the lightness data on the columns obtained
25 by the first-time reading operation. The light data obtained by subsequent reading operations are compared with the lightness data obtained by the first-time

reading operation. This comparison is executed for each of the columns. If the lightness data on a column differ from the original lightness data, the flag corresponding to that column is reset. As long as a pixel is normal, the lightness data on the pixel vary in accordance with a change in the image reading sensitivity. Hence, the flag of the pixel is reset. On the other hand, if the pixel is abnormal, the lightness data on the column containing the abnormal pixel do not vary even when the image reading sensitivity changes. The value of the lightness data is an upper-limit value, a lower-limit value or a constant in between, for example. Hence, the flag continues to be in the set state. As can be seen from this, an abnormal pixel present in a specific row section for which the sensitivity-adjusting reading operation is to be executed can be detected by monitoring the states of the flags.

If step S24 (the step of determining a variation in the same-column data) determines that an abnormal pixel exists, step S25 (the step of changing the specific row section for which the sensitivity-adjusting reading operation) shown in FIG. 7 is executed. In this step, the main controller 123 causes the device controller 121 to change the specific row section for which the sensitivity-adjusting reading operation is to be executed. Thereafter, the

operations starting from S21 (sensitivity-adjusting reading operation) are executed again. It is only required that the specific row section for which the sensitivity-adjusting reading operation is newly
5 executed be a another specific row section other than the specific row section where the abnormal pixel IL is detected. For example, the another specific row section may be the one that is adjacent to row Rp in the upper or lower area, or may be the one that is away
10 from that row section by a predetermined number of rows. The processing in steps S21-S24 is repeatedly executed until the specific row section for which the sensitivity-adjusting reading operation is to be executed is determined as not containing an abnormal
15 pixel.

If step S24 (the step of determining a variation in the same-column data) determines that an abnormal pixel does not exist in the specific row section for which the sensitivity-adjusting reading operation is to
20 be executed, step S26 (the step of extracting a maximum value and a minimum value in each reading operation) shown in FIG. 7 is executed. In this step, maximum and minimum values are extracted from the lightness data obtained in each reading operation and supplied to the
25 data comparator 124, and output to the adder 125, as in step S13 of the first embodiment.

Subsequently, step S27 (the step of calculating a

dynamic range in each reading operation), step S28 (the step of extracting a reading operation that exhibits a maximum dynamic range), step S29 (the step of referring to and extracting a sensitivity) and step S30 (the step of setting the extracted sensitivity) shown in FIG. 7, are sequentially executed. These steps are similar to steps S14 to S17 of the first embodiment described above. That is, the dynamic range of the lightness data obtained in each reading operation is calculated by the adder, and then the data comparator 124 checks the dynamic range changing tendency (FIG. 31) relative to the number of times a reading operation is executed, and detects the reading operation in which the dynamic range is maximal. The image reading sensitivity (the charge accumulating period) corresponding to this reading operation is det in the sensitivity setting register 127, thereby bringing an end to the optimal image reading sensitivity setting based on the sensitivity-adjusting reading operation.

20 In the sensitivity setting method of the second embodiment, if an abnormal pixel, which is due to a foreign substance adhering to the sensing surface of the photosensor array, any defective element of the photosensor, or the like, is present in the specific row section for which the sensitivity-adjusting reading operation is to be executed, such an abnormal pixel can be easily detected. Based on this detection, the

sensitivity-adjusting reading operation is executed for another specific row section where no abnormal pixel exists. In this manner, lightness data corresponding to a specific row section containing no abnormal pixel is acquired as lightness data for sensitivity adjustment. Even if the specific row section originally selected for the sensitivity-adjusting reading operation contains an abnormal pixel, the adverse effects arising from such an abnormal pixel can be obviated.

In addition, an optimal image reading sensitivity is unconditionally determined on the basis of the dynamic range of light data acquired by the sensitivity-adjusting reading operation. Therefore, even when the sensitivity-adjusting reading operation is to be executed for a specific row section different from the originally selected specific row section, the image reading sensitivity is kept optimal. Normal reading operation for a subject image can be executed in a reliable manner irrespective of the ambient conditions, such as the illuminated state of the environment. Accordingly, a malfunction is prevented in fingerprint recognition processing or the like.

In the first and second embodiments described above, the specific row section for which the sensitivity-adjusting reading operation is to be executed is predetermined, for example, in the center

of the photosensor. The present invention is not limited to this. That is, the specific row section need not be designated beforehand. For example, the entire area of a subject image or a predetermined area thereof may be read at an arbitrary image reading sensitivity. In this case, a specific row section or an area most suitable for image reading is extracted, and one specific row section or several specific row sections may be determined on the basis of the extracted data.

An image reading sensitivity (charge accumulating period) setting method applicable to the sensitivity-adjusting reading operation in the above-described embodiments will be described with reference to the several views of the accompanying drawing. In the description below, reference will be made to the structure of the photosensor system shown in FIGS. 1 and 2 and the structure of the photosensor system shown in FIGS. 11 and 12, if required.

FIGS. 10A to 10L are timing charts illustrating an embodiment of the sensitivity-adjusting reading operation, which is applicable to the sensitivity-adjusting reading operation of the first and second embodiments. In the description below, it is assumed that the one specific row section for which the sensitivity-adjusting reading operation is to be executed is a row located in the center.

As shown in FIGS. 10A to 10E, the image reading sensitivity setting method of the embodiment initializes only the double-gate photosensors of a central row ($n/2$ -th row), i.e., a specific row, of the photosensor array shown in FIG. 12. More specifically, waves $\phi T1$ to $\phi Tn/2-1$ and $\phi Tn/2+1$ to ϕTn applied to the first to $(n/2-1)$ -th rows and $(n/2+1)$ -th to n -th rows, which are among the top gate lines 101 connected to the top gate terminals TG of the double-gate photosensors 10 in the row direction, are set at a low level, and a single reset pulse $\phi Tn/2$ is applied only to the $n/2$ -th row. In this manner, the reset period T_{reset} is started, and only the double-gate photosensors 10 of the $(n/2)$ -th row are initialized.

Then, the reset pulse $\phi Tn/2$ falls and the reset period T_{reset} ends. Thereafter, the charge accumulating period starts, and charges (holes) are generated and accumulated in the channel regions in accordance with the amount of light entering the double-gate photosensors 10 of the $n/2$ -th row from their top gate terminal (21) side.

Subsequently, as shown in FIGS. 10F to 10K, precharge signal ϕpg and readout pulse $\phi Bn/2$, which is predetermined for the bottom gate lines 102 of the $n/2$ -th row, are alternately applied at predetermined intervals T_{int} a number of times (x times, x : an integer larger than 1). Waves $\phi B1$ to $\phi Bn/2-1$ and

$\phi_{Bn/2+1}$ to ϕ_{Bn} applied to the bottom gate lines 102 of the first to $(n/2-1)$ -th rows and $(n/2+1)$ -th to n -th rows are set at a low level.

As shown in FIG. 10L, therefore, drain voltages
5 VD1, VD2, ..., VDM varying in correspondence to the charge accumulated in the charge accumulating periods TB1, TB2, ..., TBx, which are between the end of the reset period T_{reset} and the start of the readout time T_{read} (i.e., the application of the readout pulses
10 $\phi_{Bn/2}$), are sequentially read out.

By this sensitivity-adjusting reading operation, the charge accumulating period of a specific row section increases stepwise at predetermined time intervals T_{int} . Hence, image data is read from a
15 subject image, with the image corresponding to the specific row section being read at a plurality of different image reading sensitivities.

In the sensitivity-adjusting reading operation described above, the photosensors corresponding to one
20 specific row section are reset at a time, and reading operation is repeatedly executed with respect to them. In this connection, it should be noted that the amount of charge accumulated in each photosensor may be varied by the readout operation. To solve this problem, the
25 charge accumulating period of each reading operation may be corrected in accordance with an actual charge accumulating period on the basis of the correspondence

between the number of times reading operation is performed and the amount of charge accumulated.

As described above, according to the sensitivity setting methods of the above embodiments, sensitivity-adjusting reading operation is executed with respect to a subject image while simultaneously changing the image reading sensitivity stepwise. On the basis of the distribution of the dynamic ranges of the lightness data obtained at each image reading sensitivity, an image reading sensitivity which ensures an optimal image reading state is determined easily. This image reading sensitivity (charge accumulating period) can be used as an optimal sensitivity, so that the sensitivity setting can be made automatically. Moreover, since the sensitivity setting processing can be executed using an actual subject, it is not necessary to use a standard sample or the like. Even when the lightness of the subject image varies in response to changes in the environment light, an optimal image reading sensitivity can be set in accordance with the changes in the environmental light. This has eliminated the need to employ a circuit specially designed for sensing the environmental light. Further, even if the photosensors vary in characteristics, the image data obtained from these photosensors is used for determining an optimal sensitivity. Hence, the adverse effects arising from the characteristic variations can be remarkably

suppressed.

Only a specific row section of the photosensor array is used in the sensitivity-adjusting reading operation. Alternatively, the presence of an abnormal pixel is determined, and a specific row section that
5 does not contain an abnormal pixel is used for the sensitivity-adjusting reading operation. Therefore, the image reading sensitivity can be set at an optimal value without being adversely affected by an abnormal
10 pixel, which is due to a foreign substance adhering to the sensing surface of the photosensor array, a defect of the photosensor element, or the like.

In each of the embodiments described above, the sensitivity-adjusting reading operation is executed
15 prior to the normal reading operation. The present invention is not limited to this. For example, the sensitivity-adjusting reading operation may be executed in the standby state, i.e., the state where the photosensor system is operating but a subject has not
20 yet been placed.

In addition, the sensitivity-adjusting reading operation was described as being performed whenever the normal reading operation is executed for a subject image. The present invention is not limited to this.
25 For example, the sensitivity-adjusting reading operation may be performed only when there is a change in the use environment, or when a predetermined length

of time has elapsed.

The image reading sensitivity (charge accumulating period) setting method applied to sensitivity setting processing according to the present invention is not limited to the above embodiments. As far as image data of a subject image can be obtained at different reading sensitivities, e.g., a series of processes described in the prior art: reset operation → charge accumulating operation → pre-charge operation → readout operation can be repeated a plurality of number of times at different reading sensitivities, thereby obtaining image data at different reading sensitivities. Alternatively, any other methods may also be employed.

C L A I M S

1. A photosensor system characterized by comprising

a photosensor array (100) constituted by a plurality
5 of photosensors (10) arrayed in a number of columns and
a number of rows,

image reading means for reading a subject image at
a predetermined reading sensitivity by the photosensor
array (100):

10 sensitivity-adjusting reading means for reading
the subject image while changing an image reading
sensitivity at a plurality of stages in relation to
the photosensors (10) of a single row or a few rows among
a number of rows of the photosensor array (100);

15 optimal image reading sensitivity extracting means
for extracting an optimal image reading sensitivity
suitable for the image reading operation on the basis
of a predetermined measurement amount relating to
an image pattern of the subject image read by the
20 sensitivity-adjusting reading means; and

reading sensitivity setting means for setting
the optimal image reading sensitivity to a reading
sensitivity of the image reading means.

2. A system according to claim 1, the
25 photosensors (10) of the specific row section of the
photosensor array (100) are photosensors (10) of
several rows of the photosensor array (100).

3. A system according to claim 1, the photosensors (10) of the specific row section of the photosensor array (100) are photosensors (10) of one specific row of the photosensor array (100).

5 4. A system according to claim 1, characterized by further comprising abnormal pixel determining means for determining whether the specific row section contain an abnormal pixel by checking whether the measurement amount corresponding to one column of the
10 specific row section has changed each time the image reading sensitivities are switched from one to another.

 5. A system according to claim 4, characterized by further comprising sensitivity-adjusting read
controlling means for executing the sensitivity-
15 adjusting reading operation with respect to a specific row section other than the specific row section if the abnormal pixel determining means determines that the abnormal pixel exists in the specific row section.

 6. A system according to claim 1, characterized
20 in that the predetermined measurement amount in the optimal reading sensitivity extracting means is lightness data corresponding to the image pattern of the subject image read by the sensitivity-adjusting reading means.

25 7. A system according to claim 1, characterized in that the image reading sensitivity of the photosensor array (100) is set by adjusting a charge

accumulating period of the photosensor (10).

8. A system according to claim 1, characterized in that the optimal reading sensitivity extracting means comprises:

5 measurement amount comparing means for extracting maximum and minimum values of the measurement amount relating to the image pattern of the subject image for each image reading sensitivity on the basis of the subject image read by the sensitivity-adjusting reading
10 means;

dynamic range calculating means for calculating a dynamic range of the measurement amount on the basis of the maximum and minimum values of the measurement amount extracted for each image reading sensitivity;
15 and

maximum dynamic range extracting means for extracting an image reading sensitivity having a maximum dynamic range among dynamic ranges of measurement amounts calculated for each image reading
20 sensitivity.

9. A system according to claim 1, characterized in that

each of the photosensors (10) has a source electrode (12) and drain electrode (13) formed via a
25 channel region (14) made from a semiconductor layer, and a top gate electrode (21) and bottom gate electrode (22) formed at least on and below the channel region.

via insulating films,

either of the top gate electrode and bottom gate electrode is used as a light irradiation side, and charges corresponding to a light quantity irradiated from the light irradiation side are generated and accumulated in the channel region.

10. A drive control method for a photosensor system having a photosensor array (100) constituted by a plurality of photosensors (10) arrayed in a number of columns and a number of rows characterized by comprising the steps of:

executing a sensitivity-adjusting reading operation of reading a subject image in relation to the photosensors (10) in a single row or a few rows among a number of rows of the photosensor array (100) while changing an image reading sensitivity of the photosensor array (100) at a plurality of stages;

extracting an image reading sensitivity suitable for reading operation of the subject image on the basis of a predetermined measurement amount relating to an image pattern of the subject image read by the sensitivity-adjusting reading operation;

setting the extracted image reading sensitivity as a reading sensitivity in the reading operation of the subject image; and

executing image reading operation of reading the subject image at the set reading sensitivity.

11. A method according to claim 10, the photosensors (10) of the specific row section are

photosensors(10) of several rows.

12. A method according to claim 10, the photosensors (10) of the specific row section are photosensors(10) of one row.

5 13. A method according to claim 10, characterized by further comprising a step of determining whether the specific row section contains an abnormal pixel by checking whether the measurement amount corresponding to one column of the specific row section has changed
10 each time the image reading sensitivities are switched from one to another.

14. A method according to claim 13, characterized by further comprising a step of executing the sensitivity-adjusting reading operation with respect to
15 a specific row section other than the specific row section if the abnormal pixel determining step determines that the abnormal pixel exists in the specific row section.

15. A method according to claim 10, characterized
20 in that the predetermined measurement amount is lightness data corresponding to the image pattern of the subject image read by the sensitivity-adjusting reading operation.

16. A method according to claim 10, characterized
25 in that the image reading sensitivity of the photosensor array (100) is set by adjusting a charge accumulating period of the photosensor (10).

17. A method according to claim 10, characterized in that the extracting the image reading sensitivity comprises a steps of:

5 extracting maximum and minimum values of the measurement amount relating to the image pattern of the subject image for each image reading sensitivity on the basis of the subject image read by the sensitivity-adjusting reading operation;

10 calculating a dynamic range of the measurement amount on the basis of the maximum and minimum values of the measurement amount extracted for each image reading sensitivity; and

15 extracting an image reading sensitivity having a maximum dynamic range among dynamic ranges of measurement amounts calculated for each image reading sensitivity.

18. A method according to claim 10, characterized in that

20 each of the photosensors (10) has a source electrode (12) and drain electrode (13) formed via a channel region (14) made from a semiconductor layer, and a top gate electrode (21) and bottom gate electrode (22) formed at least on and below the channel region via insulating films,

25 either of the top gate electrode and bottom gate electrode is used as a light irradiation side, and charges corresponding to a light quantity

irradiated from the light irradiation side are generated and accumulated in the channel region.