

(7)

- 1 -

IMAGE PICKUP SYSTEM

The present invention relates to an image pickup system provided with an image sensor.

5 The image sensor comprises a plurality of photodetectors disposed on a semiconductor chip. It is very difficult to manufacture an image sensor without defective photodetectors, which means that the yield of perfect image sensor is very low, and
10 hence the price of the perfect image sensor is very high. Accordingly, such an expensive image sensor cannot be used for general purposes.

The object of the present invention is to provide an image pickup device employing an image sensor,
15 which can be used as an image pickup device, even if the image sensor includes defective photodetectors.

According to the present invention, there is provided an image pickup system comprising:

an image sensor comprising a plurality of
20 photodetectors arranged in two dimensions and having output terminal means corresponding to the photodetectors;

an optical system for forming an image on said image sensor so that said image sensor produces a picture data signal at the output terminal means;

vibrator means for vibrating said image on said image sensor relative to the image sensor so that the picture data signal moves at the output terminal means in synchronism with the vibration;

scanning means having output terminal means and
30 operative in synchronism with the vibration of said image for rendering the moving picture data signal at the output terminal means of the image sensor stationary on a predetermined output terminal means thereof and for changing the signal into sequential
35 picture data signals at ~~the~~^{its} output terminal means;

memory means for storing said picture data signals;

means for determining reliable data from said picture data signals stored in said memory means and for producing picture data for said image on said image sensor.

Other objects and features of the present invention will become more apparent from the following description with reference to the accompanying drawings, in which:-

5 Figs. 1 and 2 are illustrations for explaining the principle of the present invention;

Fig. 3A schematically shows an embodiment of the present invention;

Fig. 3B shows another embodiment of the present invention;

10 Figs. 4A and 4B show majority logic circuits;

Fig. 5 schematically shows another embodiment of the present invention;

15 Figs. 6A to 6C show a vibration device for an image sensor and graphs showing data sampling and register thereof; and

Figs. 7A and 7B show systems for supplementing data by defective photodetectors with proper data.

Referring to Fig. 1, reference numeral 100 designates an image sensor comprising a plurality of photodetectors which are arranged on a semiconductor chip in two dimensional mosaic. An image 104 in a picked-up picture 102 corresponding to an object is formed in the image sensor. The image sensor has defective photodetectors D_1 , D_3 , D_5 , D_7 . In the image 104, defective photodetectors D_1 and D_3 are

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included to make the corresponding portion blank. If the image sensor 100 is shifted a small distance, the picture 102 is moved to a position in a picked-up picture 112 and an image 114 is formed in a corresponding position. In the shifted position, the image 114 includes defective photo-detector D_7 . If both images 104 and 114 ^{are} ~~is~~ superimposed, an image without blanks can be produced.

Figs. 2A to 2C show three pictures 202, 222, 242 which are picked-up at different portions of an image sensor, respectively. An image 201 includes defective photodetectors 204 and 206, an image 221 has a defective detector 228, and an image 241 has a defective detector 244. The defective photodetector 204 has the co-ordinates (5,5) in the picture 202 to make a blank at the position. However, in each of pictures 221 and 241, the position (5,5) is black. Positions of other defective detectors do not coincide with each other. Accordingly, if every picture elements (photodetectors) of three pictures are superimposed in accordance with the principle of majority rule, a complete image data 261 without blanks can be formed in a combined picture 262 as shown in Fig. 2D.

Fig. 3A shows schematically an embodiment of the present invention. An object 304 on a subject 302 is projected on an image sensor 316 through a lens 306 to form an image 317. The image sensor 316 is operatively connected to a plunger 314 of a vibrator 308. The plunger 314 is reciprocated by exciting a solenoid 312 which is excited by a vibration signal generator 310 in dependency on signal S_1 , so that the image sensor 316 is reciprocated. Thus the image 317 on the image

sensor is reciprocated in relation to the image sensor, although the position of the image does not change in the absolute co-ordinates.

Picture signals from the image sensor 316 are applied to a scanner 318, so that the vibrating signals are changed to fixed picture signals by a signal S_2 synchronizing with the signal S_1 . The fixed picture signals are applied to a majority logic circuit means 320 by which blanks by defective photodetectors in the image sensor are recovered. Thus, the majority logic circuit means 320 produces repaired picture data S_3 . The repaired picture data may be obtained in parallel or in series.

It is difficult to directly deal with analog data in accordance with the principle of majority rule, since the rule is not clearly defined. In this specification, various selecting methods are regarded as the majority rule. A first method is that analog data are sorted to a plurality of classes by amount of each data and sorted data having the highest frequency in amount are selected and the amount is regarded as the most reliable data.

A second method is that analog data are compared with a reference value by comparators so as to sort the data into a high level data and a low level data. Then, the data are dealt with a majority logic circuit to select a data. A third method is that analog data is converted to digital data by an analog-to-digital converter (A/D converter) in time division and the digital data are sequentially stored in memories. The digital data are dealt with in accordance with a principle of majority rule to select a data.

Fig. 4A shows an example of a majority logic circuit according to the above described second method. Each of data S_{11} , S_{12} , S_{13} has a high level or a low level. The data are dealt with three AND gates 410 and OR gate 411 which produces a repaired data S_{10} in accordance with the majority rule. Fig. 4B shows another example of a majority logic circuit for nine data S_{11} to S_{33} . The data are applied to a maximum and minimum data rejecting circuit 412, by which data having maximum value and minimum value are removed, in order to reduce the effect by such extremely deviated data. Further, the remaining seven data are converted to data N_1 to N_7 each having high or low level and are applied to a majority logic circuit comprising a plurality of AND gate or an OR gate to produce a repaired data S_{10} .

As another method of selecting a data, the above described third method can be used. That is, the remaining seven analog data are converted to digital data by an A/D converter and the digital data are stored in a digital memory. The stored digital data are sorted to form a histogram. From the histogram, a data having the highest frequency is selected as the most reliable data. Further, it is possible to select a data having a central value in accordance with method of least squares.

Fig. 5 shows a system according to the present invention, employing the third method. An image sensor 506 receiving an image I is vibrated by a vibrator 502 in accordance with a signal C_0 . Output data of the image sensor 506 are converted to fixed data by a scanner 508 in accordance with a signal C_1 . Output data of the scanner are converted to

digital data by an A/D converter 510 and then sequentially stored in a memory 514 or a data selecting unit 512 in accordance with signals C_2 and C_3 . The stored data are compared with various reference values by a comparator 516 so as to form a histogram. The histogram is stored in a memory 518 in dependency on a signal C_4 . From the stored data, most reliable data are selected by a data selecting circuit 520 by a principle of majority rule or method least squares in accordance with a signal C_5 . Thus, selected picture data are produced from the data selecting circuit 520.

Fig. 6A shows an example of a vibrator. The vibrator comprises a pair of piezoelectric vibrator element 602 and 604 disposed on both sides of a support plate 601 which is supported on a support 610. The piezoelectric vibrator element may be barium titanate, Rochell salt, rock crystal, and the like. Mounted on the vibrator element 602 is an electrode 622 on which an image sensor 606 is mounted. On the other hand, a counter balancer 608 is secured to an electrode 624 of the vibrator element 604. Accordingly, when both vibrator elements 602 and 604 are driven by a signal from a driving signal source 620, image sensor 606 and balancer 608 are reciprocated in the reverse direction. Thus, the vibration of the system is cancelled.

Fig. 6B shows the relationship between the displacement of the image sensor and the phase of data sampling. The system produces four picture data A, B, C and D by sampling clocks CLA, CLB, CLC, and CLD which are different in phase. As shown in Fig. 6C, those data A, B, C, D are registered in respective shift registers SRG A, SRG B, SRG C, and SRG D and

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shifted by clock signals CLS. The shift registers correspond to the memory 514 of Fig. 5. The registered data are applied to the data selecting unit 512 corresponding to the unit of Fig. 5, so that the most reliable output are selected.

5 Although the image sensor is vibrated in the direction of one dimension, it may be vibrated in two dimensions. Further, the sensor is vibrated in ^{the} ~~two~~ direction of the axis of a lens, so that data of clear image are selected to form a clear picture. As a ^{vibrator} ~~vibrator~~, various electromechanical
10 transducers such as a buzzer, electric motor can be employed. By vibrating an image sensor at random or pseudo-random, it is possible to disperse the probability of generation of the defective detector in an image in such a manner as white noise. The vibration at pseudo-random has amplitudes within
15 a predetermined range and frequency^{ies} ~~s~~ in a predetermined range.

As an image sensor, an image sensor of MOS solid type, CCD (charge-coupled device) type or BBD (Bucket brigade device) type may be employed. The image sensor, scanner, and other circuits such as majority logic circuit can be formed on one
20 chip.

Although in the above described embodiment, the image on an image sensor is vibrated by vibrating the image sensor, a system in which an image sensor is fixed and another element in the optical system, such as a lens is vibrated to
25 vibrate the image on the sensor can be provided in accordance with the present invention.

Fig. 3B shows another embodiment of the present invention in which a part of the optical system is vibrated. In the system, a prism 330 is provided in the optical system and

(24)

is adapted to be vibrated by the vibrator 308. Other components of the system are the same as Fig. 3A and identified by the same reference numerals. By vibrating the prism 330 in the direction of the arrow, the image 317 on the image sensor is vibrated. The image 317 is also vibrated by swinging the prism 330 about an axis 331. Moreover, it is possible to vibrate the image on the image sensor by vibrating the lens 306 or by swinging a mirror provided in the optical system.

10 In the above described systems, data sensed by a defective photodetector are used as it is. However, if the data by the defective detector the position of which is known is supplemented with a proper value, more reliable picture data can be produced. One of supplement methods is to supplement 15 the data of the defective detector with the data of an adjacent detector. The other method is to supplement with an average value of detectors at both sides.

Fig. 7A shows an example of the former method. A memory 701 corresponds to the memory 514 and a ROM 702 in which 20 data at addresses of defective detectors are stored is provided. The ROM is so arranged to produce a low level output A_0 , when an address signal ^{is} of a defective data. In the memory 701, data D_n at address n is defective. When the memory element at the address n is addressed, the address data n is 25 applied to the ROM 702, so that the ROM produces a low level A_0 output. Accordingly an AND gate 703 produces a data D_{n-1} which is previously stored at adjacent address. The data D_{n-1} is produced from an OR gate 704 as a data at the address n .

Fig. 7B shows an example of the latter method. The system is provided with an average value circuit 710 which produces an average value of data D_{n-1} and D_{n+1} at both sides of the defective address n . When the low level output A_0 of the ROM 702 is applied to the average value circuit 710, the circuit produces the average value which passes through AND gate 703. The OR gate 704 produces an output as a data for the defective detector. Thus, data by defective photo-detectors are supplemented by proper values, thereby producing more reliable picture data.

While the invention has been described in conjunction with preferred specific embodiments thereof, it will be understood that this description is intended to illustrate and not limit the scope of the invention, which is defined by the following claims.



CLAIMS

1. An image pickup system comprising:
an image sensor comprising a plurality of
photodetectors arranged in two dimensions and having
output terminal means corresponding to the photodetectors;
5 an optical system for forming an image on said
image sensor so that said image sensor produces a
picture data signal at the output terminal means;
vibrator means for vibrating said image on said
image sensor relative to the image sensor so that
10 the picture data signal moves at the output terminal
means in synchronism with the vibration;
scanning means having output terminal means and
operative in synchronism with the vibration of said
image for rendering the moving picture data signal
15 at the output terminal means of the image sensor
stationary on a predetermined output terminal means
thereof and for changing the signal into sequential
picture data signals at ~~the~~^{its} output terminal means;
memory means for storing said picture data signals;
20 means for determining reliable data from said
picture data signals stored in said memory means and
for producing picture data for said image on said
image sensor.

25 2. An image pickup system according to Claim
1 wherein said vibrator means is an electromechanical
transducer.

30 3. An image pickup system according to Claim
2 wherein said electromechanical transducer is a
piezoelectric element.

35 4. An image pickup system according to Claim
1 wherein the vibration of said image has amplitudes
within a predetermined range and frequencies within
a predetermined range at pseudo-random.

(54)



- 11 -

5. An image pickup system according to Claim 1 wherein the vibration of said image is in the plane of said image sensor.

5 6. An image pickup system according to Claim 1 wherein the vibration has a frequency.

10 7. An image pickup system according to Claim 5 wherein the vibration is further made in the direction of the axis of said optical system.

15 8. An image pickup system according to Claim 1 wherein said vibrator means is means for vibrating a part of said optical system.

9. An image pickup system according to Claim 8 wherein said part is a lens.

20 10. An image pickup system according to Claim 8 wherein said part is a prism.

25 11. The image pickup system according to Claim 1 wherein said determining means comprises a majority logic circuit for determining reliable data.

30 12. An image pickup system according to Claim 1 wherein said selecting means including a memory for storing data of positions of defective photodetectors in said image sensor and circuit means for replacing data of said defective photodetectors with other data.

35 13. An image pickup system according to Claim 12 wherein one of said other data is data of a photodetector adjacent to said defective photodetector.

14. An image pickup system according to Claim 12 wherein one of said other data is average data of photodetectors of both sides of said defective photodetectors.



15. An image pickup system according to Claim 12 wherein said memory for storing data of positions of defective photodetectors is a non volatile semiconductor memory.

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16. An image pickup system substantially as hereinbefore described with reference to, and as illustrated in, Figure 3A or 5, or Figures 3A and 4A, or Figures 5 and 6, or Figure 3B, or any one of 10 Figures 3A, 3B and 5 together with Figure 7A, or 7B, of the accompanying drawings.

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