United States Patent Application Publication	20250267245
Kind Code	A1
Publication Date	August 21, 2025
Inventor(s)	NAKAMURA; Seiji et al.

IMAGE SENSING DEVICE, IMAGE SENSING METHOD, AND RECORDING MEDIUM

Abstract

An image sensing device includes: a 2D camera that generates a 2D image; a 3D camera that includes a light source and generates a depth image based on reflected light of light emitted by the light source; and an image recognizer that performs recognition on a subject included in the 2D image, using at least one of the 2D image or the depth image; and a camera controller that controls on and off of an operation of the 3D camera. The camera controller turns on the operation of the 3D camera based on a result of the recognition using the 2D image when the 3D camera is in a standby state, and the 3D camera enters the standby state when the camera controller turns off the operation of the 3D camera after turning on the operation.

Inventors: **NAKAMURA; Seiji (Osaka, JP), KAWAI; Yoshinao (Kanagawa, JP), NAKAMURA; Kenji (Osaka, JP)**

Applicant: **Nuvoton Technology Corporation Japan** (Kyoto, JP)

Family ID: **1000008586145**

Appl. No.: **19/199790**

Filed: **May 06, 2025**

Foreign Application Priority Data

JP	2022-182785	Nov. 15, 2022

Related U.S. Application Data

parent WO continuation PCT/JP2023/039961 20231107 PENDING child US 19199790

Publication Classification

Int. Cl.: **H04N13/296** (20180101); **H04N13/254** (20180101); **H04N23/45** (20230101); **H04N23/61** (20230101); **H04N23/65** (20230101); **H04N23/67** (20230101)

U.S. Cl.:

CPC **H04N13/296** (20180501); **H04N13/254** (20180501); **H04N23/45** (20230101); **H04N23/61** (20230101); **H04N23/651** (20230101); **H04N23/67** (20230101);

Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS [0001] This is a continuation application of PCT International Patent Application No. PCT/JP2023/039961 filed on Nov. 7, 2023, designating the United States of America, which is based on and claims priority of Japanese Patent Application No. 2022-182785 filed on Nov. 15, 2022. The entire disclosures of the above-identified applications, including the specifications, drawings and claims are incorporated herein by reference in their entirety.

FIELD
[0002] The present disclosure relates to an image sensing device, an image sensing method, and a recording medium.
BACKGROUND
[0003] For example, Patent Literature (PTL) 1 discloses a device for personal authentication or determining the presence or absence of a person. In this device, a two-dimensional (2D) camera and a three-dimensional (3D) camera are both used. This makes it possible to prevent impersonation using a photograph and to detect only a target within a predetermined distance range.
CITATION LIST
Patent Literature
[0004] PTL 1: International Publication No. 2020/075525
SUMMARY
Technical Problem
[0005] However, since 3D cameras include a light emitting device (light source) for measuring a distance, when a 3D camera is used as in the device disclosed in PTL 1, power consumption increases with the light emission of the light source.
[0006] In view of the above, the present disclosure provides an image sensing device, etc. capable of achieving low power consumption while using both a 2D camera and a 3D camera.
Solution to Problem
[0007] An image sensing device according to the present disclosure includes: a two-dimensional (2D) camera that generates a 2D image; a three-dimensional (3D) camera that includes a light source and generates a depth image based on reflected light of light emitted by the light source; and an image recognizer that performs recognition on a subject included in the 2D image, using at least one of the 2D image or the depth image; and a camera controller that controls on and off of an operation of the 3D camera. In the above-described image sensing device, the camera controller turns on the operation of the 3D camera based on a result of the recognition using the 2D image, when the 3D camera is in a standby state in which the 3D camera has completed an initialization process after activation and the light source is not emitting light, and the 3D camera enters the standby state when the camera controller turns off the operation of the 3D camera after turning on the operation.
[0008] An image sensing method according to the present disclosure is an image sensing method

performed by an image sensing device. The image sensing device includes: a two-dimensional (2D) camera that generates a 2D image; and a three-dimensional (3D) camera that includes a light source and generates a depth image based on reflected light of light emitted by the light source. The image sensing method includes: performing recognition on a subject included in the 2D image, using at least one of the 2D image or the depth image; and controlling on and off of an operation of the 3D camera. In the above-described image sensing method, in the controlling, the operation of the 3D camera is turned on based on a result of the recognition using the 2D image, when the 3D camera is in a standby state in which the 3D camera has completed an initialization process after activation and the light source is not emitting light, and the 3D camera enters the standby state when the operation of the 3D camera is turned off in the controlling after turned on in the controlling.
[0009] A recording medium according to the present disclosure is a non-transitory computer-readable recording medium having a program recorded thereon for causing a computer to execute the image sensing method described above.
Advantageous Effects
[0010] With the image sensing device, etc. according to one aspect of the present disclosure, it is possible to achieve low power consumption while using both a 2D camera and a 3D camera.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0011] These and other advantages and features will become apparent from the following description thereof taken in conjunction with the accompanying Drawings, by way of non-limiting examples of embodiments disclosed herein.
[0012] FIG. **1** is a block diagram illustrating an example of an image sensing device according to Embodiment 1.
[0013] FIG. **2** is a sequence diagram illustrating a first example of an operation of the image sensing device according to Embodiment 1.
[0014] FIG. **3** is a sequence diagram illustrating a second example of the operation of the image sensing device according to Embodiment 1.
[0015] FIG. **4** is a sequence diagram illustrating a third example of the operation of the image sensing device according to Embodiment 1.
[0016] FIG. **5** is a sequence diagram illustrating a fourth example of the operation of the image sensing device according to Embodiment 1.
[0017] FIG. **6** is a block diagram illustrating an example of an image sensing device according to Embodiment 2.
[0018] FIG. **7** is a block diagram illustrating an example of an image sensing device according to Embodiment 3.
[0019] FIG. **8** is a flowchart illustrating an example of an image sensing method according to another embodiment.
DESCRIPTION OF EMBODIMENTS
[0020] Hereinafter, embodiments will be described in detail with reference to the Drawings.
[0021] It should be noted that the embodiments described below each show a general or specific example. The numerical values, shapes, materials, structural components, the arrangement and connection of the structural components, steps, the processing order of the steps, and so on, indicated in the following embodiments are mere examples, and therefore do not limit the present disclosure.
Embodiment 1
[0022] The following describes an image sensing device according to Embodiment 1 with referenced to FIG. **1** through FIG. **5**.

[0023] FIG. **1** is a block diagram illustrating an example of image sensing device **100** according to Embodiment 1. FIG. **1** illustrates a micro processing unit (MPU) **200** that processes information that has been output from image sensing device **100**. It should be noted that MPU **200** may be a structural component of image sensing device **100**.
[0024] Image sensing device **100** is a device for performing recognition on a subject included in an image, and includes two-dimensional (2D) camera **10**, three-dimensional (3D) camera **20**, image recognizer **30**, camera controller **40**, 2D output controller **51**, and 3D output controller **52**. It should be noted that, although FIG. **1** illustrates image recognizer **30** as a structural component included by camera controller **40**, image recognizer **30** need not necessarily be a structural component of camera controller **40**. In addition, in FIG. **1**, 2D output controller **51** and 3D output controller **52** are indicated collectively as output controller **50**.
[0025] Image sensing device **100** is a computer that includes a processor, memory, etc. Memory is read only memory (ROM), random access memory (RAM), or the like, and is capable of storing programs executed by a processor. Image recognizer **30**, camera controller **40**, and output controller **50** are each implemented by a processor or the like that executes the program stored in the memory.
[0026] 2D camera **10** is a camera that generates a two-dimensional (2D image). 2D camera **10** is, for example, a sensor such as an image sensor or an RGB sensor. It should be noted that the 2D image generated by 2D camera **10** may be a monochrome image.
[0027] For example, 2D camera **10** includes controller **11**. Controller **11** is a processing unit that controls the focus and exposure of 2D camera **10**. It should be noted that controller **11** need not necessarily be included in 2D camera **10**. It is sufficient if controller **11** is included in image sensing device **100**. For example, controller **11** controls the focus and exposure of 2D camera **10**, based on a control signal from camera controller **40**.
[0028] 3D camera **20** is a camera that includes light source **21** and generates a depth image based on the reflected light of light emitted by light source **21**. 3D camera **20** causes light source **21** to emit light at a predetermined timing (e.g., intermittent emission) when a signal for turning on its own operation is obtained, and generates a depth image from an exposed signal. When a signal for turning off its own operation is obtained, 3D camera **20** causes light source **21** to turn off emission and stops generating a depth image. In this case, the emission of light source **21** is constantly off. It should be noted that 3D camera **20** may cause light source **21** to emit light while a signal for turning on its own operation is obtained, and cause light source **21** to turn off emission when a signal for turning on its own operation is no longer obtained. 3D camera **20** is, for example, a camera that uses a time of flight (TOF) method or LiDAR (Light Detection And Ranging).
[0029] The power consumption of 3D camera **20** is high because light emission of light source **21** is necessary to generate the depth image. On the other hand, 2D camera **10** basically requires no light source, and thus the power consumption is low.
[0030] Image recognizer **30** performs recognition on a subject included in a 2D image, using the 2D image generated by 2D camera **10** or a depth image generated by 3D camera **20**. For example, recognition is to identify whether a predetermined object is included in a 2D image. The predetermined object is a target of recognition, and is set as appropriate according to an application or the like. For example, when a human face is to be recognized using image sensing device **100**, the predetermined object is a human face. For example, when a dog face is included in a 2D image, the result of recognition indicates that a human face is not included in the 2D image (it should be noted that it may be indicated that a dog face is included, depending on the performance of image recognizer **30**), and when a human face is included in a 2D image, the result of recognition indicates that a human face is included in the 2D image. It should be noted that a predetermined object is not limited to a human face.
[0031] Camera controller **40** controls on and off of the operation of 3D camera **20**. More specifically, when turning on the operation of 3D camera **20**, camera controller **40** outputs, to 3D camera **20**, a signal for turning on the operation of 3D camera **20**, and when turning off the

operation of 3D camera **20**, camera controller **40** outputs, to 3D camera **20**, a signal for turning off the operation of 3D camera **20**. It should be noted that camera controller **40** may keep outputting a signal, to 3D camera **20**, for turning on the operation of 3D camera **20** when the operation of 3D camera **20** is to be turned on, and may stop outputting the signal for turning on the operation of 3D camera **20** when the operation of 3D camera **20** is to be turned off. When 3D camera **20** is in the standby state, camera controller **40** turns on the operation of 3D camera **20** based on a result of recognition using a 2D image. The standby state of 3D camera **20** is the state in which 3D camera **20** has completed an initialization process after activation and light source **21** is not constantly emitting light. In other words, the standby state of 3D camera **20** is a state in which the power of 3D camera **20** is on but light source **21** is not constantly emitting light. 3D camera **20** enters the standby state when its operation is turned on by camera controller **40** and then turned off by camera controller **40**. As described above, controlling on and off of the operation of 3D camera **20** is not intended to control on and off of the power of 3D camera **20**.

[0032] For example, camera controller **40** turns on the operation of 3D camera **20** when 3D camera **20** is in the standby state and a result of recognition using a 2D image indicates that a predetermined object is included in the 2D image. In addition, when the operation of 3D camera **20** is on, camera controller **40** turns off the operation of 3D camera **20** based on a result of recognition using a 2D image. Specific examples of the operation of camera controller **40** will be described later.

[0033] 2D output controller **51** controls the output of a 2D image, based on the result of recognition using a 2D image or a depth image. For example, 2D output controller **51** extracts, and outputs to MPU **200**, a portion of the 2D image, based on a result of recognition.

[0034] 3D output controller **52** controls the output of a depth image, based on the result of recognition using a 2D image or a depth image. For example, 3D output controller **52** extracts, and outputs to MPU **200**, a portion of the depth image, based on the result of recognition.

[0035] Since a depth image of 3D camera **20** can be quite large data, there are problems of: a decrease in the processing speed of MPU **200** that performs analysis on a 2D image and a depth image or authentication using these images; and an increase in power consumption due to an increase in processing load. In view of this, for example, a control is performed such that a portion of the 2D image and depth image is output according to a result of image recognition, thereby making it possible to reduce the processing load on MPU **200**. As a result, the processing speed of MPU **200** can be enhanced and the increase in power consumption due to the increase in processing load can be inhibited.

[0036] MPU **200** is an output destination of a 2D image and a depth image, and a processing unit that performs analysis on the 2D image and the depth image, or authentication, etc. using the 2D image and the depth image. For example, when a subject included in a 2D image is recognized as a human face, MPU **200** performs face authentication by identifying the individual differences of the face. It should be noted that the face recognition is an example, and the target of authentication performed by MPU **200** is not particularly limited.

[0037] The following describes a specific example of the operation of image sensing device **100** with referenced to FIG. **2** and FIG. **5**.

[0038] First, a first example of the operation of image sensing device **100** will be described with referenced to FIG. **2**.

[0039] FIG. **2** is a sequence diagram illustrating the first example of the operation of image sensing device **100** according to Embodiment 1.

[0040] First, 2D camera **10** generates a 2D image of the surroundings (step S**101**).

[0041] At this time, 3D camera **20** is in a standby state and light source **21** is not emitting light (step S**102**).

[0042] 2D camera **10** outputs the 2D image generated (step S**103**). For example, 2D camera **10** outputs the 2D image to image recognizer **30** and 2D output controller **51**. 2D output controller **51** outputs the 2D image to MPU **200**. In the first example, 2D output controller **51** outputs the 2D image to MPU **200** as it is. For example, MPU **200** outputs the 2D image to a display or the like.

[0043] Image recognizer **30** performs recognition on the subject included in the 2D image, using the 2D image. More specifically, image recognizer **30** performs face recognition for identifying whether a predetermined object (a human face, for example) is included in the 2D image (step S**104**). For example, when a person moves into the viewing angle of 2D camera **10**, the result of recognition using the 2D image will indicate that a human face is included in the 2D image. For example, the predetermined object that is the target of recognition is set by MPU **200**.

[0044] When a face is detected in the 2D image, image recognizer **30** notifies camera controller **40** that a face is detected (step S**105**).

[0045] Camera controller **40** turns on the operation of 3D camera **20** upon receiving the notification that a face is detected (step S**106**). For example, camera controller **40** outputs a signal, to 3D camera **20**, for turning on the operation of 3D camera **20**. As described above, camera controller **40** turns on the operation of 3D camera **20** when 3D camera **20** is in the standby state and a result of recognition using a 2D image indicates that a human face is included in a 2D image. In other words, camera controller **40** does not turn on the operation of 3D camera **20** (stated differently, does not cause light source **21** to emit light) until the target of recognition is included in the 2D image, and turns on the operation of 3D camera **20** when the target of recognition is included in the 2D image, thereby enabling 3D camera **20** to generate a depth image. In this manner, it is possible to cause 3D camera **20** to be in the standby state (i.e., emission of light source **21** is constantly off) until a human face that is the target of recognition is included in the 2D image. As a result, it is possible to achieve low power consumption.

[0046] 3D camera **20** starts light emission and exposure upon receiving the signal for turning on the operation of 3D camera **20**, and generates (step S**107**) and outputs (step S**108**) a depth image of the surroundings. For example, 3D camera **20** outputs the depth image to image recognizer **30** and 3D output controller **52**. 3D output controller **52** also outputs the depth image to MPU **200**. In the first example, 3D output controller **52** outputs the depth image to MPU **200** as it is. For example, MPU **200** performs face authentication, etc. using the 2D image and the depth image.

[0047] Image recognizer **30** performs recognition on the subject included in the 2D image, using the 2D image or the depth image. More specifically, image recognizer **30** performs face recognition for identifying whether a predetermined object (a human face, for example) is no longer included in the 2D image (step S**109**). For example, when a person moves out of the viewing angle of 2D camera **10**, the result of recognition using the 2D image will indicate that a human face is not included in the 2D image.

[0048] When a face is not detected in the 2D image, image recognizer **30** notifies camera controller **40** that a face is no longer detected (step S**110**).

[0049] Camera controller **40** turns off the operation of 3D camera **20** upon receiving the notification indicating that a face is no longer detected (step S**111**). For example, camera controller **40** outputs a signal, to 3D camera **20**, for turning off the operation of 3D camera **20**. As described above, camera controller **40** turns off the operation of 3D camera **20** based on a result of recognition using a 2D image or a depth image when the operation of 3D camera **20** is on.

[0050] 3D camera **20** then enters the standby state again (step S**112**). As described above, when a human face that is the target of recognition is no longer included in the 2D image after the operation of 3D camera **20** was turned on, it is possible to turn off the operation of 3D camera **20** (i.e., it is possible to cause 3D camera **20** to be in the standby state) because the target of recognition is no longer present. As a result, the light emission of light source **21** is also off constantly, thereby making it possible to reduce the power consumption of 3D camera **20**.

[0051] Next, a second example of the operation of image sensing device **100** will be described with referenced to FIG. **3**.

[0052] FIG. **3** is a sequence diagram illustrating the second example of the operation of image

sensing device **100** according to Embodiment 1.
[0053] The processes from step S**201** to step S**207** illustrated in FIG. **3** are the same as the processes from step S**101** to step S**107** illustrated in FIG. **2**, and therefore the explanation will be omitted.
[0054] 3D camera **20** outputs the depth image generated (step S**208**). For example, 3D camera **20** outputs the depth image to image recognizer **30** and 3D output controller **52**.
[0055] After obtaining the depth image, 3D output controller **52** stands by without outputting the depth image until a signal indicating whether the depth image can be output is obtained (step S**209**).
[0056] Image recognizer **30** performs recognition on the subject included in the 2D image, using the 2D image and the depth image. More specifically, image recognizer **30** performs face recognition for identifying whether a predetermined object appearing in an image (a human face, for example) is included in the 2D image (step S**210**). For example, when an image (e.g., a photograph) in which a human face is appearing is present in the viewing angle of 2D camera **10**, a result of recognition using a 2D image and a depth image indicates that the human face appearing in the photograph is included in the 2D image. Since a photograph is flat but an actual human face has a depth, it is possible, by using a depth image, to identify whether a human face included in the 2D image is an actual human face or a human face appearing in the photograph.
[0057] When a photograph is detected in the 2D image, image recognizer **30** notifies camera controller **40** that a photograph is detected (step S**211**).
[0058] Camera controller **40** outputs an output stop signal to 3D output controller **52** upon receiving the notification that a photograph is detected (step S**212**). In this manner, 3D output controller **52** can discard the depth image obtained in step S**208** so as not to output the depth image to MPU **200**, and thus it is possible to reduce the processing load on MPU **200**.
[0059] Camera controller **40** turns off the operation of 3D camera **20** upon receiving the notification that a photograph is detected (step S**213**). For example, camera controller **40** outputs a signal, to 3D camera **20**, for turning off the operation of 3D camera **20**. In this manner, camera controller **40** turns off the operation of 3D camera **20** when the operation of 3D camera **20** is on and the result of recognition using a 2D image and a depth image indicates that a human face appearing in a photograph is included in the 2D image.
[0060] 3D camera **20** then enter the standby state again (step S**214**). As described above, after the operation of 3D camera **20** was turned on, if it turns out that the human face recognized is the human face appearing in the photograph, it is possible to turn off the operation of 3D camera **20** (i.e., it is possible to cause 3D camera **20** to be in the standby state) because the human face recognized is not an actual human face and thus not the target of recognition. As a result, the light emission of light source **21** is also off constantly, thereby making it possible to reduce the power consumption of 3D camera **20**.
[0061] It should be noted that, when a photograph is not detected, the processes of step S**109** and the subsequent processes described in the first example are performed.
[0062] Next, a third example of the operation of image sensing device **100** will be described with referenced to FIG. **4**.
[0063] FIG. **4** is a sequence diagram illustrating the third example of the operation of image sensing device **100** according to Embodiment 1.
[0064] The processes from step S**301** to step S**306** illustrated in FIG. **4** are the same as the processes from step S**101** to step S**106** illustrated in FIG. **2**, and therefore the explanation will be omitted. In the first example, it has been described that 2D output controller **51** outputs a 2D image to MPU **200** as it is. However, in the third example, 2D output controller **51** controls the output of a 2D image based on a result of recognition using the 2D image or a depth image.
[0065] When a predetermined object (e.g., a human face) is included in a 2D image, image recognizer **30** outputs, to 2D output controller **51** and 3D output controller **52**, the position

information of the portion in which the human face is included in the 2D image (step S**307**). For example, image recognizer **30** outputs, as the position information, the information indicating pixels corresponding to the region detected as a human face in the 2D image, to 2D output controller **51** and 3D output controller **52**.

[0066] 3D camera **20** starts light emission and exposure upon receiving the signal for turning on the operation of 3D camera **20**, and generates (step S**308**) and outputs (step S**309**) a depth image of the surroundings. For example, 3D camera **20** outputs the depth image to image recognizer **30** and 3D output controller **52**. In the first example, it has been described that 3D output controller **52** outputs a depth image to MPU **200** as it is. However, in the third example, 3D output controller **52** controls the output of a depth image based on a result of recognition using a 2D image or the depth image.

[0067] 2D output controller **51** outputs, to MPU **200**, the 2D image of the portion where the human face is included in the 2D image, based on the position information obtained (step S**310**). For example, 2D output controller **51** extracts, from the 2D image, the portion of the pixels corresponding to the region detected as a human face in the 2D image, and outputs the portion of the pixels in the 2D image to MPU **200**.

[0068] 3D output controller **52** outputs, to MPU **200**, the depth image of the portion where the human face is included in the 2D image, based on the position information obtained (step S**311**). For example, 3D output controller **52** extracts, from the depth image, the portion of the pixels corresponding to the region detected as a human face in the 2D image, and outputs the portion of the pixels in the depth image to MPU **200**.

[0069] In this manner, when the result of recognition using a 2D image or a depth image indicates that a predetermined object (e.g., a human face) is included in the 2D image, 2D output controller **51** outputs a 2D image of a portion where a human face is included in a 2D image, and 3D output controller **52** outputs a depth image of a portion where a human face is included in a 2D image. When a human face that is the target of recognition is included in a 2D image, it is possible to output only the 2D image of the portion where the human face is included (in other words, the 2D image from which the portion where the human face is not included is removed), and output only the depth image of the portion where the human face is included (in other words, the depth image from which the portion where the human face is not included is removed). As a result, it is possible to reduce the processing load on MPU **200**.

[0070] When a plurality of faces are detected in step S**304**, or when a human face in a 2D image is at a distant location, there are cases where face authentication is wished to be carried out within a certain distance. In such cases, image recognizer **30** outputs the information of the pixels corresponding to the region within a predetermined distance range out of the region detected as a human face in the 2D image, to 2D output controller **51** and 3D output controller **52**. In this manner, in step S**310**, 2D output controller **51** is capable of outputting, to MPU **200**, the 2D image of the portion where the human face within the predetermined distance range in the 2D image is included. In addition, in step S**311**, 3D output controller **52** is capable of outputting, to MPU **200**, the depth image of the portion where the human face within the predetermined distance range in the 2D image is included.

[0071] As described above, when the result of recognition using a 2D image and a depth image indicates that a human face is included in a predetermined distance range, 2D output controller **51** may output the 2D image of the portion where the human face is included in the 2D image, and 3D output controller **52** may output the depth image of the portion where the human face is included in the 2D image. When a human face that is the target of recognition is included in a 2D image and this human face is present within a predetermined distance range, only the 2D image of this portion can be output, and only the depth image of this portion can be output. As a result, it is possible to reduce the processing load on MPU **200**.

[0072] It should be noted that, although illustration is omitted in FIG. **4**, in the third example, the processes of step S**109** and the subsequent processes are performed in the same manner as the first example, or the processes of step S**209** and the subsequent processes are performed in the same manner as the second example.

[0073] Next, a fourth example of the operation of image sensing device **100** will be described with referenced to FIG. **5**.

[0074] FIG. **5** is a sequence diagram illustrating the fourth example of the operation of image sensing device **100** according to Embodiment 1.

[0075] The processes from step S**401** to step S**408** illustrated in FIG. **5** are the same as the processes from step S**101** to step S**108** illustrated in FIG. **2**, and therefore the explanation will be omitted.

[0076] Image recognizer **30** recognizes the depth to the human face included in the 2D image, based on the depth image, and outputs this depth information to camera controller **40** (step S**409**), and camera controller **40** outputs this depth information to 2D camera **10** (specifically, controller **11**) (step S**410**).

[0077] 2D camera **10** (controller **11**) controls the focus of 2D camera **10** based on the depth information obtained (step S**411**), and outputs the 2D image obtained by 2D camera that has undergone focus control (step S**412**).

[0078] In this manner, controller **11** controls the focus of 2D camera **10** based on the depth information indicating the depth to the human face included in the 2D image indicated by the depth image. Since it is possible to control the focus of 2D camera **10** at high speed according to the depth from image sensing device **100** to the human face included in the 2D image, the human face included in the 2D image can be more easily brought into focus. As a result, it is possible to increase the accuracy of recognition or authentication using this 2D image.

[0079] Controller **11** may further control the exposure of 2D camera **10** based on the position information of the human face included in the 2D image.

[0080] It should be noted that, although illustration is omitted in FIG. **5**, in the fourth example, the processes of step S**109** and the subsequent processes are performed in the same manner as the first example, or the processes of step S**209** and the subsequent processes are performed in the same manner as the second example.

[0081] As described above, it is possible to cause 3D camera **20** to be in the standby state until an intended result of recognition (detection of a human face, for example) is obtained by a 2D image generated by 2D camera **10**. 3D camera **20** in the standby state is activated (in other words, the power is on) but only consumes approximately the same amount of power as the standby power because light source **21** is not emitting light, and thus the power consumption of 3D camera **20** is low. Accordingly, it is possible to suspend light emission of light source **21** of 3D camera **20** to reduce the power consumption until an intended result of recognition is obtained by a 2D image, and when an intended result of recognition is obtained, the operation of 3D camera **20** is turned on to cause light source **21** to emit light, thereby making it possible to perform detailed recognition. When the operation of 3D camera **20** is subsequently turned off, 3D camera **20** enters the standby state again, making it possible to reduce the power consumption of 3D camera **20**. Accordingly, it is possible to achieve low power consumption while using both 2D camera **10** and 3D camera **20**. In addition, in image sensing device **100**, on and off of the operation of 3D camera **20** is controlled based on the result of recognition, but on and off of the power of 3D camera **20** is not controlled based on the result of recognition. As a result, it is possible to inhibit the initialization process from being performed every time the power of 3D camera **20** is repeatedly turned on and off, and thus a delay can be inhibited.

Embodiment 2

[0082] The following describes an image sensing device according to Embodiment 2 with referenced to FIG. **6**.

[0083] FIG. **6** is a block diagram illustrating an example of image sensing device **100***a* according to

Embodiment 2. In FIG. **6**, MPU **200** that processes information output from image sensing device **100***a* is illustrated. It should be noted that MPU **200** may be a structural component of image sensing device **100***a*.

[0084] Image sensing device **100***a* differs from image sensing device **100** according to Embodiment 1 in that image sensing device **100***a* includes 2D camera **10***a* in place of 2D camera **10**, includes a plurality of 3D cameras in place of 3D camera **20**, and includes camera controller **40***a* in place of camera controller **40**. The other points are the same as those described in Embodiment 1, and thus the description will be omitted.

[0085] Since image sensing device **100***a* includes a plurality of 3D cameras, it is possible to perform sensing in a wider range compared to the case where a single 3D camera is included. For example, image sensing device **100***a* can be used for an obstacle detection process or the like that requires sensing in a wide range.

[0086] As illustrated in FIG. **6**, image sensing device **100***a* includes 3D cameras **20***a* and **20***b*, for example, as the plurality of 3D cameras. 3D camera **20***a* includes light source **21***a* and generates a depth image based on the reflected light of light emitted by light source **21***a*. 3D camera **20***b* includes light source **21***b* and generates a depth image based on the reflected light of light emitted by light source **21***b*. It should be noted that image sensing device **100***a* may include three or more 3D cameras.

[0087] 2D camera **10***a* is a camera that generates a 2D image. 2D camera **10***a* is a camera with a wide viewing angle, for example. Image sensing device **100***a* includes a plurality of 3D cameras, and accordingly 2D camera **10***a* is a camera with a wide viewing angle.

[0088] In addition to the functions of camera controller **40** according to Embodiment 1, camera controller **40***a* has a function of selecting at least one 3D camera from among a plurality of 3D cameras based on a position of a subject included in a 2D image when the plurality of 3D cameras are in a standby state, and turning on the operation of the at least one 3D camera selected, based on a result of recognition using the 2D image. For example, when image recognizer **30** identifies that a subject included in a 2D image is present in a viewing angle, camera controller **40***a* selects 3D camera **20***a* out of 3D cameras **20***a* and **20***b*. Camera controller **40***a* then turns on the operation of 3D camera **20***a* selected when, for example, the subject included in the 2D image is a predetermined object (a human face, for example).

[0089] In this manner, out of 3D cameras **20***a* and **20***b*, the operation of only 3D camera **20***a* that is capable of generating a depth image at the position of the subject included in a 2D image is turned on, thereby achieving lower power consumption than the case where all of the operations of 3D cameras **20***a* and **20***b* are turned on. In addition, since it is possible to avoid outputting, to MPU **200**, the depth images from both of 3D cameras **20***a* and **20***b*, it is possible to reduce the processing load on MPU **200**. Accordingly, it is possible to improve the processing speed of MPU **200**, and to inhibit an increase in power consumption due to the increase of processing load.

[0090] It should be noted that image sensing device **100***a* according to Embodiment 2 may also have the functions of image sensing device **100** described in the first example through the fourth example according to Embodiment 1.

Embodiment 3

[0091] The following describes an image sensing device according to Embodiment 3 with referenced to FIG. **7**.

[0092] FIG. **7** is a block diagram illustrating an example of image sensing device **100***b* according to Embodiment 3. In FIG. **7**, MPU **200** that processes information output from image sensing device **100***b* is illustrated. It should be noted that MPU **200** may be a structural component of image sensing device **100***b*.

[0093] Image sensing device **100***b* differs from image sensing device **100** according to Embodiment 1 in that BW-TOF camera **110** is included in place of 2D camera **10** and 3D camera **20**. The other points are the same as those described in Embodiment 1, and thus the description will be omitted.

[0094] BW-TOF camera **110** is a camera in which a 2D camera and a 3D camera are integrally provided. In other words, BW-TOF camera **110** is a camera having the functions of both the 2D camera and the 3D camera.

[0095] BW-TOF camera **110** includes BW-TOF sensor **111** and light source **112**. BW-TOF sensor **111** includes a pixel (IR pixel) for generating a depth image and a pixel (BW pixel) for generating a 2D image (monochrome image), and is capable of generating a 2D image when light source **112** is not emitting light and generating both a depth image and a 2D image using reflected light of light emitted by light source **112**.

[0096] Here, BW-TOF camera **110** is described as an example of the camera in which a 2D camera and a 3D camera are integrally provided. However, the camera is not particularly limited as long as it is a camera in which a 2D camera and a 3D camera are integrally provided, in other words, a camera having the functions of both the 2D camera and 3D camera. For example, the camera in which a 2D camera and a 3D camera are integrally provided may be an RGB-TOF camera. The RGB-TOF camera, in contrast to BW-TOF camera **110**, is a camera capable of obtaining a color image instead of a monochrome image.

[0097] As described above, it is possible to achieve low power consumption while using both a 2D camera and a 3D camera, even in the case where the 2D camera and the 3D camera are integrally provided. In addition, the 2D camera and the 3D camera are integrally provided, and thus it is possible to downsize image sensing device **100***b*.

[0098] It should be noted that image sensing device **100***b* according to Embodiment 3 may also have the functions of image sensing device **100** described in the first example through the fourth example according to Embodiment 1.

OTHER EMBODIMENTS

[0099] Although the image sensing device according to one or more aspects of the present disclosure has been described above based on the embodiment, the present disclosure is not limited to the above-described embodiment. Other forms in which various modifications apparent to those skilled in the art are applied to the embodiments, or forms structured by combining structural components of different embodiments may be included within the scope of one or more aspects of the present disclosure, unless such changes and modifications depart from the scope of the present disclosure.

[0100] For example, although the foregoing embodiment has described an example in which the camera controller turns off the operation of the 3D camera based on a result of recognition using a 2D image or a depth image when the operation of the 3D camera is on, the present disclosure is not limited to this example. For example, the camera controller may turn off the operation of the 3D camera based on the result of an input from an external device when the operation of the 3D camera is on.

[0101] For example, the external device is a device that performs authentication on a subject included in a 2D image based on a result of recognition using the 2D image or a depth image, and is specifically, an MPU, etc. When the authentication process has been completed, the MPU outputs, to the image sensing device, a signal indicating that the authentication process has been completed. In this case, when the result of input from the MPU to the image sensing device indicates that the authentication process has been completed, no further recognition on the subject included in the 2D image is necessary, and thus it is possible to turn off the operation of the 3D camera. As a result, it is possible to reduce the power consumption of the 3D camera.

[0102] For example, although the embodiment described above has described an example in which the image sensing device includes a 2D output controller that controls output of a 2D image and a 3D output controller that controls output of a depth image, the image sensing device need not necessarily include the 2D output controller and the 3D output controller.

[0103] For example, although the embodiment described above has described an example in which the image sensing device includes a controller that controls the focus of the 2D camera, the image sensing device need not necessarily include such a controller.

[0104] For example, the present disclosure can be implemented not only as an image sensing device but also as an image sensing method that includes steps (processes) performed by the structural components that constitute the image sensing device.

[0105] FIG. **8** is a flowchart illustrating another example of the image sensing method according to other embodiments.

[0106] An image sensing method is a method executed by an image sensing device. The image sensing device includes a 2D camera that generates a 2D image and a 3D camera that includes a light source and generates a depth image based on the reflected light of light emitted by the light source. The image sensing method includes, as illustrated in FIG. **8**, an image recognition step (step S**11**) that performs recognition on a subject included in a 2D image, using the 2D image or a depth image, and a camera controlling step that controls on and off of the operation of the 3D camera. In the camera controlling step, when the 3D camera is in a in the standby state in which the 3D camera has completed the initialization process after activation and the light source is not emitting light, the operation of the 3D camera is turned on based on a result of recognition using the 2D image (step S**12**), and the 3D camera enters the standby state when the operation is turned off in the camera controlling step after turned on in the cameral controlling step.

[0107] For example, the present disclosure can be implemented as a program for causing a computer (processor) to execute the steps included in the image sensing method. In addition, the present disclosure can be implemented as a non-transitory computer-readable recording medium such as a compact disc-read only memory (CD-ROM) including the program recorded thereon.

[0108] For example, when the present disclosure is implemented by a program (software), each of the steps is performed as a result of the program being executed by utilizing hardware resources such as a CPU, memory, an input and output circuit, etc. of a computer. In other words, each step is executed by the CPU obtaining data from memory or an input and output circuit, etc., performing calculations, and outputting calculation results to memory or input and output circuit, etc.

[0109] It should be noted that, in the foregoing embodiments, each of the structural components included in the image sensing device may be configured as dedicated hardware, or may be implemented by executing a software program suitable for the structural component. Each of the structural components may be realized by means of a program executing unit, such as a CPU or a processor, reading and executing the software program recorded on a recording medium such as a hard disk or a semiconductor memory.

[0110] Some or all of the functions of the image sensing device according to the foregoing embodiments are typically implemented as LSIs which are integrated circuits. They may be implemented as a single chip one-by-one, or as a single chip to include some or all thereof. In addition, the integrated circuit is not limited to an LSI, and it may be implemented as a dedicated circuit or a general-purpose processor. A field programmable gate array (FPGA) that is programmable after an LSI is manufactured or a reconfigurable processor that is capable of reconfiguring connection and settings of circuit cells inside an LSI may be employed.

(Others)

[0111] The descriptions of the embodiments described above disclose the following techniques.

[0112] (Technique 1) An image sensing device that includes: a two-dimensional (2D) camera that generates a 2D image; a three-dimensional (3D) camera that includes a light source and generates a depth image based on reflected light of light emitted by the light source; and an image recognizer that performs recognition on a subject included in the 2D image, using at least one of the 2D image or the depth image; and a camera controller that controls on and off of an operation of the 3D camera. In the above-described image sensing device, the camera controller turns on the operation of the 3D camera based on a result of the recognition using the 2D image, when the 3D camera is in a standby state in which the 3D camera has completed an initialization process after activation

and the light source is not emitting light, and the 3D camera enters the standby state when the camera controller turns off the operation of the 3D camera after turning on the operation.
[0113] With this configuration, it is possible to cause the 3D camera to be in the standby state until an intended result of recognition is obtained by a two-dimensional image generated by the 2D camera. The 3D camera in the standby state is activated (in other words, the power is on) but only consumes approximately the same amount of power as the standby power because the light source is not emitting light, and thus the power consumption of the 3D camera is low. As a result, it is possible to suspend light emission of the light source of the 3D camera to reduce the power consumption until an intended result of recognition is obtained by a two-dimensional image, and when an intended result of recognition is obtained, the operation of the 3D camera is turned on to cause the light source of the 3D camera to emit light, thereby making it possible to perform detailed recognition. When the operation of the 3D camera is subsequently turned off, the 3D camera enters the standby state again, making it possible to reduce the power consumption of the 3D camera. It is thus possible to achieve low power consumption while using both the 2D camera and the 3D camera. In addition, in the image sensing device, on and off of the operation of the 3D camera is controlled based on the result of recognition, but on and off of the power of the 3D camera is not controlled based on the result of recognition. As a result, it is possible to inhibit the initialization process from being performed every time the power of the 3D camera is repeatedly turned on and off, and thus a delay can be inhibited. [0114] (Technique 2) The image sensing device according to Technique 1, in which the camera controller turns on the operation of the 3D camera when the 3D camera is in the standby state and the result of the recognition using the 2D image indicates that a predetermined object is included in the 2D image.
[0115] In this manner, it is possible to cause the 3D camera to be in the standby state until a predetermined object that is the target of recognition is included in the two-dimensional image. As a result, it is possible to achieve low power consumption. [0116] (Technique 3) The image sensing device according to Technique 1 or 2, in which the camera controller turns off the operation of the 3D camera based on a result of the recognition using the at least one of the 2D image or the depth image, when the operation of the 3D camera is on.
[0117] In this manner, it is possible to turn off the operation of the 3D camera based on a result of some sort of recognition using a two-dimensional image or a depth image, and the light emission of the light source is constantly off accordingly. As a result, it is possible to reduce the power consumption of the 3D camera. [0118] (Technique 4) The image sensing device according to Technique 3, in which the camera controller turns off the operation of the 3D camera when the operation of the 3D camera is on and the result of the recognition using the at least one of the 2D image or the depth image indicates that a predetermined object is not included in the 2D image.
[0119] For example, when a predetermined object that is the target of recognition is no longer included in the two-dimensional image after the operation of the 3D camera is turned on, it is possible to turn off the operation of the 3D camera because the target of recognition is no longer present. As a result, light emission of the light source is also off constantly, thereby making it possible to reduce the power consumption of the 3D camera. [0120] (Technique 5) The image sensing device according to Technique 3 or 4, in which the camera controller turns off the operation of the 3D camera when the operation of the 3D camera is on and a result of the recognition using the 2D image and the depth image indicates that a predetermined object appearing in an image is included in the 2D image.
[0121] For example, after the operation of the 3D camera was turned on, if it turns out that the object recognized is an object appearing in an image, it is possible to turn off the operation of the 3D camera because the object recognized is not an actual object and thus not the target of recognition. As a result, the light emission of the light source is also off constantly, thereby making it possible to reduce the power consumption of the 3D camera. [0122] (Technique 6) The image sensing device according to any one of Techniques 1 to 5, in which the camera controller turns off

the operation of the 3D camera based on a result of an input from an external device when the operation of the 3D camera is on.
[0123] For example, the external device is a device that performs authentication on a subject included in the two-dimensional image, based on a result of recognition using a two-dimensional image or a depth image. When the authentication process has been completed, the external device outputs, to the image sensing device, a signal indicating that the authentication process has been completed. In this case, when the result of input from the external device to the image sensing device indicates that the authentication process has been completed, no further recognition on the subject included in the 2D image is necessary, and thus it is possible to turn off the operation of the 3D camera. As a result, it is possible to reduce the power consumption of the 3D camera. [0124] (Technique 7) The image sensing device according to any one of Techniques 1 to 6 further includes: a 2D output controller that controls an output of the 2D image, based on a result of the recognition using the at least one of the 2D image or the depth image; and a 3D output controller that controls an output of the depth image, based on the result of the recognition using the at least one of the 2D image or the depth image.
[0125] Since a depth image of the 3D camera can be quite large data, there are problems of: a decrease in the processing speed of the device that is the output destination of a two-dimensional image and a depth image and performs analysis on the 2D image and the depth image or authentication using these images; and an increase in power consumption due to an increase in processing load. In view of this, for example, a control is performed such that a portion of the 2D image and depth image is output according to a result of image recognition, thereby making it possible to reduce the processing load on the device that is the output destination. As a result, the processing speed of the device that is the output destination can be enhanced and the increase in power consumption due to the increased processing load can be suppressed. (Technique 8) The image sensing device according to Technique 7, in which when the result of the recognition using the at least one of the 2D image or the depth image indicates that a predetermined object is included in the 2D image, the 2D output controller outputs a 2D image of a portion including the predetermined object in the 2D image, and the 3D output controller outputs a depth image of the portion including the predetermined object in the 2D image.
[0126] When a predetermined object that is the target of recognition is included in a 2D image, it is possible to output only the 2D image of the portion where this object is included (in other words, the 2D image from which the portion where the object is not included is removed), and output only the depth image of the portion where this object is included (in other words, the depth image from which the portion where the object is not included is removed). As a result, it is possible to reduce the processing load on the device that is the output destination. [0127] (Technique 9) The image sensing device according to Technique 7, in which when a result of the recognition using the 2D image and the depth image indicates that a predetermined object is included within a predetermined distance range, the 2D output controller outputs a 2D image of a portion including the predetermined object in the 2D image, and the 3D output controller outputs a depth image of the portion including the predetermined object in the 2D image.
[0128] When a predetermined object that is the target of recognition is included in a two-dimensional image and this object is present within a predetermined distance range, only the two-dimensional image of the portion where this object is included can be output, and only the depth image of the portion where this object is included can be output. As a result, it is possible to reduce the processing load on the device that is the output destination. [0129] (Technique 10) The image sensing device according to any one of Techniques 1 to 9 further includes: a controller that controls a focus of the 2D camera based on depth information that is indicated by the depth image and indicates a depth to the subject included in the 2D image.
[0130] With this configuration, since it is possible to control the focus of the 2D camera at high speed according to the depth from the image sensing device to the subject included in the 2D

image, the subject included in the 2D image can be more easily brought into focus. As a result, it is possible to increase the accuracy of recognition or authentication using this 2D image. [0131] (Technique 11) The image sensing device according to any one of Techniques 1 to 10, in which the image sensing device includes a plurality of 3D cameras each being the 3D camera, and the camera controller, when the plurality of 3D cameras are in the standby state, selects at least one of the plurality of 3D cameras based on a position of the subject included in the 2D image, and turns on an operation of the at least one of the plurality of 3D cameras selected, based on the result of the recognition using the 2D image.

[0132] For example, the image sensing device may be a device capable of performing sensing in a wide range, using a plurality of 3D cameras. In this case, the operation of only the 3D camera that is capable of generating a depth image at the position of the subject included in a two-dimensional image is turned on, thereby achieving lower power consumption than the case where a plurality of 3D cameras are turned on. In addition, since it is possible to avoid outputting the depth images from all of the plurality of 3D cameras to the device that is the output destination, it is possible to reduce the processing load on the device that is the output destination. As a result, the processing speed of the device that is the output destination can be enhanced and the increase in power consumption due to the increased processing load can be suppressed. [0133] (Technique 12) The image sensing device according to any one of Techniques 1 to 11, in which the 2D camera and the 3D camera are integrally provided.

[0134] As described above, the 2D camera and the 3D camera are integrally provided, and thus it is possible to downsize the image sensing device. [0135] (Technique 13) An image sensing method performed by an image sensing device. The image sensing device includes: a two-dimensional (2D) camera that generates a 2D image; and a three-dimensional (3D) camera that includes a light source and generates a depth image based on reflected light of light emitted by the light source. The image sensing method includes: performing recognition on a subject included in the 2D image, using at least one of the 2D image or the depth image; and controlling on and off of an operation of the 3D camera. In the above-described image sensing method, in the controlling, the operation of the 3D camera is turned on based on a result of the recognition using the 2D image, when the 3D camera is in a standby state in which the 3D camera has completed an initialization process after activation and the light source is not emitting light, and the 3D camera enters the standby state when the operation of the 3D camera is turned off in the controlling after turned on in the controlling.

[0136] In this manner, it is possible to provide an image sensing method capable of achieving low power consumption while using both the 2D camera and the 3D camera. [0137] (Technique 14) A program for causing a computer to execute the image sensing method according to Technique 13.

[0138] In this manner, it is possible to provide a program that enables achieving low power consumption while using both the 2D camera and the 3D camera.

[0139] Although only some exemplary embodiments of the present disclosure have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications are intended to be included within the scope of the present disclosure.

INDUSTRIAL APPLICABILITY

[0140] The present disclosure is applicable, for example, to devices that perform image recognition using both a 2D camera and a 3D camera.

Claims

1. An image sensing device comprising: a two-dimensional (2D) camera that generates a 2D image; a three-dimensional (3D) camera that includes a light source and generates a depth image based on reflected light of light emitted by the light source; and an image recognizer that performs recognition on a subject included in the 2D image, using at least one of the 2D image or the depth image; and a camera controller that controls on and off of an operation of the 3D camera, wherein the camera controller turns on the operation of the 3D camera based on a result of the recognition using the 2D image, when the 3D camera is in a standby state in which the 3D camera has completed an initialization process after activation and the light source is not emitting light, and the 3D camera enters the standby state when the camera controller turns off the operation of the 3D camera after turning on the operation.

2. The image sensing device according to claim 1, wherein the camera controller turns on the operation of the 3D camera when the 3D camera is in the standby state and the result of the recognition using the 2D image indicates that a predetermined object is included in the 2D image.

3. The image sensing device according to claim 1, wherein the camera controller turns off the operation of the 3D camera based on a result of the recognition using the at least one of the 2D image or the depth image, when the operation of the 3D camera is on.

4. The image sensing device according to claim 3, wherein the camera controller turns off the operation of the 3D camera when the operation of the 3D camera is on and the result of the recognition using the at least one of the 2D image or the depth image indicates that a predetermined object is not included in the 2D image.

5. The image sensing device according to claim 3, wherein the camera controller turns off the operation of the 3D camera when the operation of the 3D camera is on and a result of the recognition using the 2D image and the depth image indicates that a predetermined object appearing in an image is included in the 2D image.

6. The image sensing device according to claim 1, wherein the camera controller turns off the operation of the 3D camera based on a result of an input from an external device when the operation of the 3D camera is on.

7. The image sensing device according to claim 1, further comprising: a 2D output controller that controls an output of the 2D image, based on a result of the recognition using the at least one of the 2D image or the depth image; and a 3D output controller that controls an output of the depth image, based on the result of the recognition using the at least one of the 2D image or the depth image.

8. The image sensing device according to claim 7, wherein when the result of the recognition using the at least one of the 2D image or the depth image indicates that a predetermined object is included in the 2D image, the 2D output controller outputs a 2D image of a portion including the predetermined object in the 2D image, and the 3D output controller outputs a depth image of the portion including the predetermined object in the 2D image.

9. The image sensing device according to claim 7, wherein when a result of the recognition using the 2D image and the depth image indicates that a predetermined object is included within a predetermined distance range, the 2D output controller outputs a 2D image of a portion including the predetermined object in the 2D image, and the 3D output controller outputs a depth image of the portion including the predetermined object in the 2D image.

10. The image sensing device according to claim 1, further comprising: a controller that controls a focus of the 2D camera based on depth information that is indicated by the depth image and indicates a depth to the subject included in the 2D image.

11. The image sensing device according to claim 1, wherein the image sensing device includes a plurality of 3D cameras each being the 3D camera, and the camera controller, when the plurality of 3D cameras are in the standby state, selects at least one of the plurality of 3D cameras based on a position of the subject included in the 2D image, and turns on an operation of the at least one of the plurality of 3D cameras selected, based on the result of the recognition using the 2D image.

12. The image sensing device according to claim 1, wherein the 2D camera and the 3D camera are integrally provided.

13. An image sensing method performed by an image sensing device, the image sensing device including: a two-dimensional (2D) camera that generates a 2D image; and a three-dimensional (3D) camera that includes a light source and generates a depth image based on reflected light of light emitted by the light source, the image sensing method comprising: performing recognition on a subject included in the 2D image, using at least one of the 2D image or the depth image; and controlling on and off of an operation of the 3D camera, wherein in the controlling, the operation of the 3D camera is turned on based on a result of the recognition using the 2D image, when the 3D camera is in a standby state in which the 3D camera has completed an initialization process after activation and the light source is not emitting light, and the 3D camera enters the standby state when the operation of the 3D camera is turned off in the controlling after turned on in the controlling.

14. A non-transitory computer-readable recording medium having a program recorded thereon for causing a computer to execute the image sensing method according to claim 13.