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(54) **TOUCH DISPLAY APPARATUS AND TOUCH SENSING METHOD**

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(57) **ABSTRACT**

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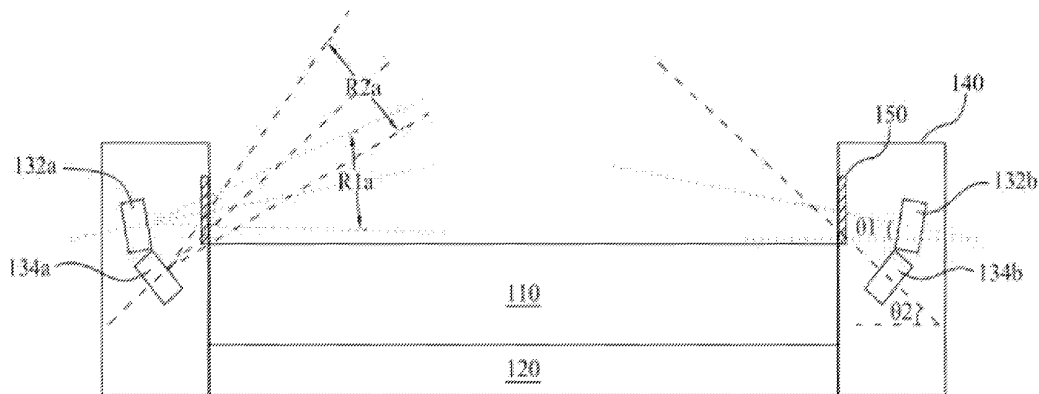
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A touch display apparatus includes a display panel, a frame and a plurality of sensing modules. The frame is disposed around the display panel and a plurality of apertures is arranged on the frame. The sensing modules are disposed at different height levels respectively. Each sensing module generates sensing data. Each sensing module includes a plurality of sensing units. The sensing units are disposed along the frame respectively and sense light which passes through the apertures. A touch sensing method is also disclosed herein.

(30) **Foreign Application Priority Data**

Mar. 20, 2014 (TW) 103110522

100



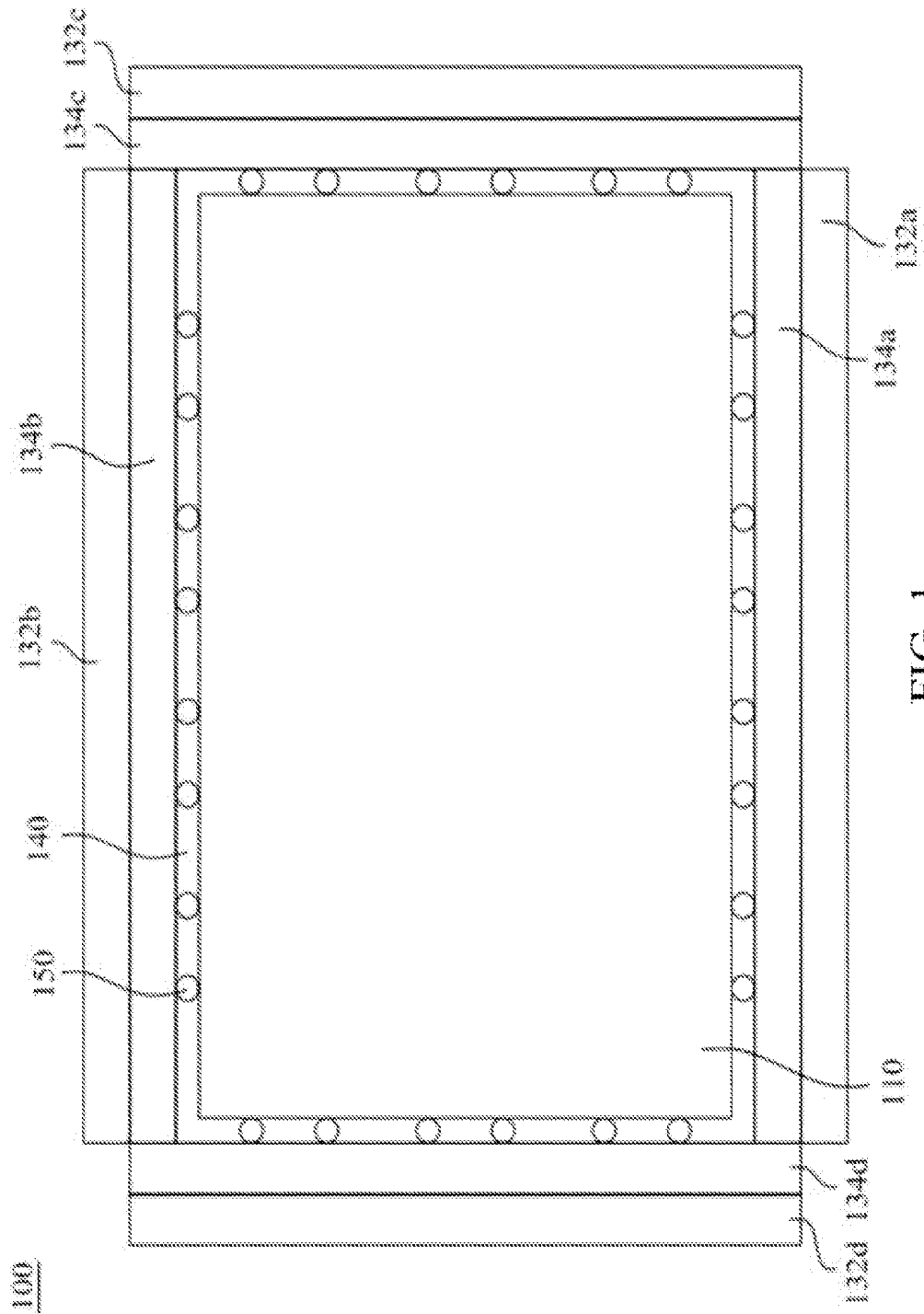


FIG. 1

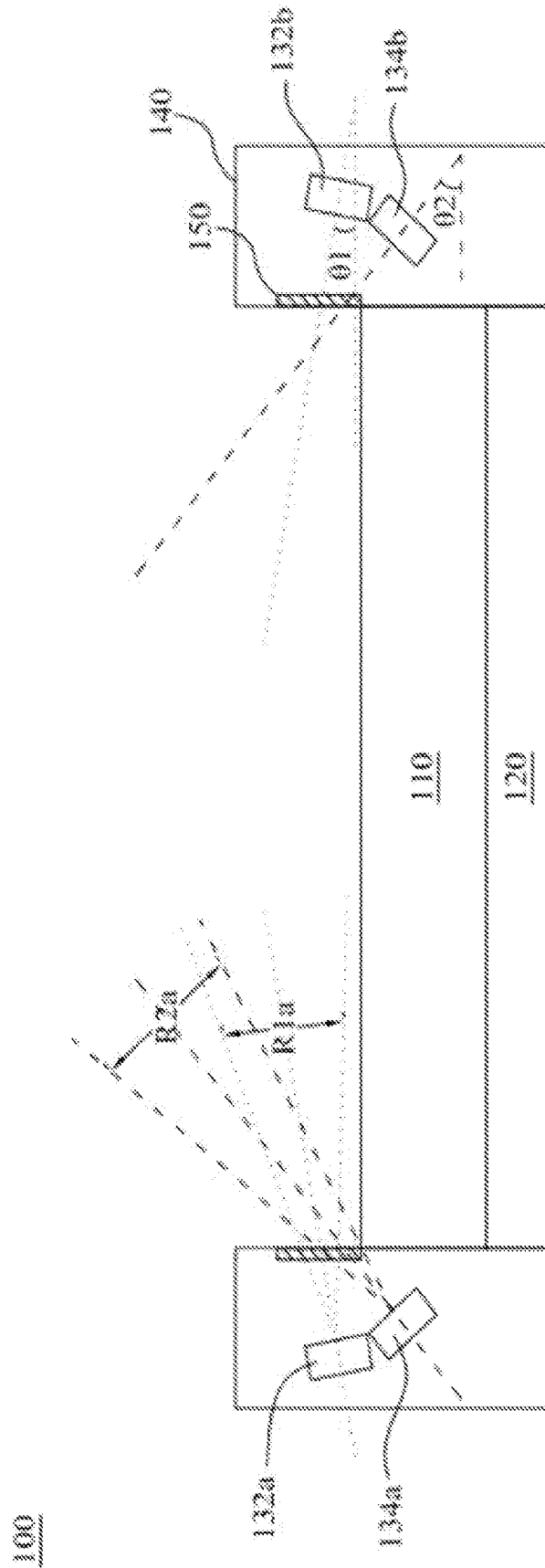


FIG. 2

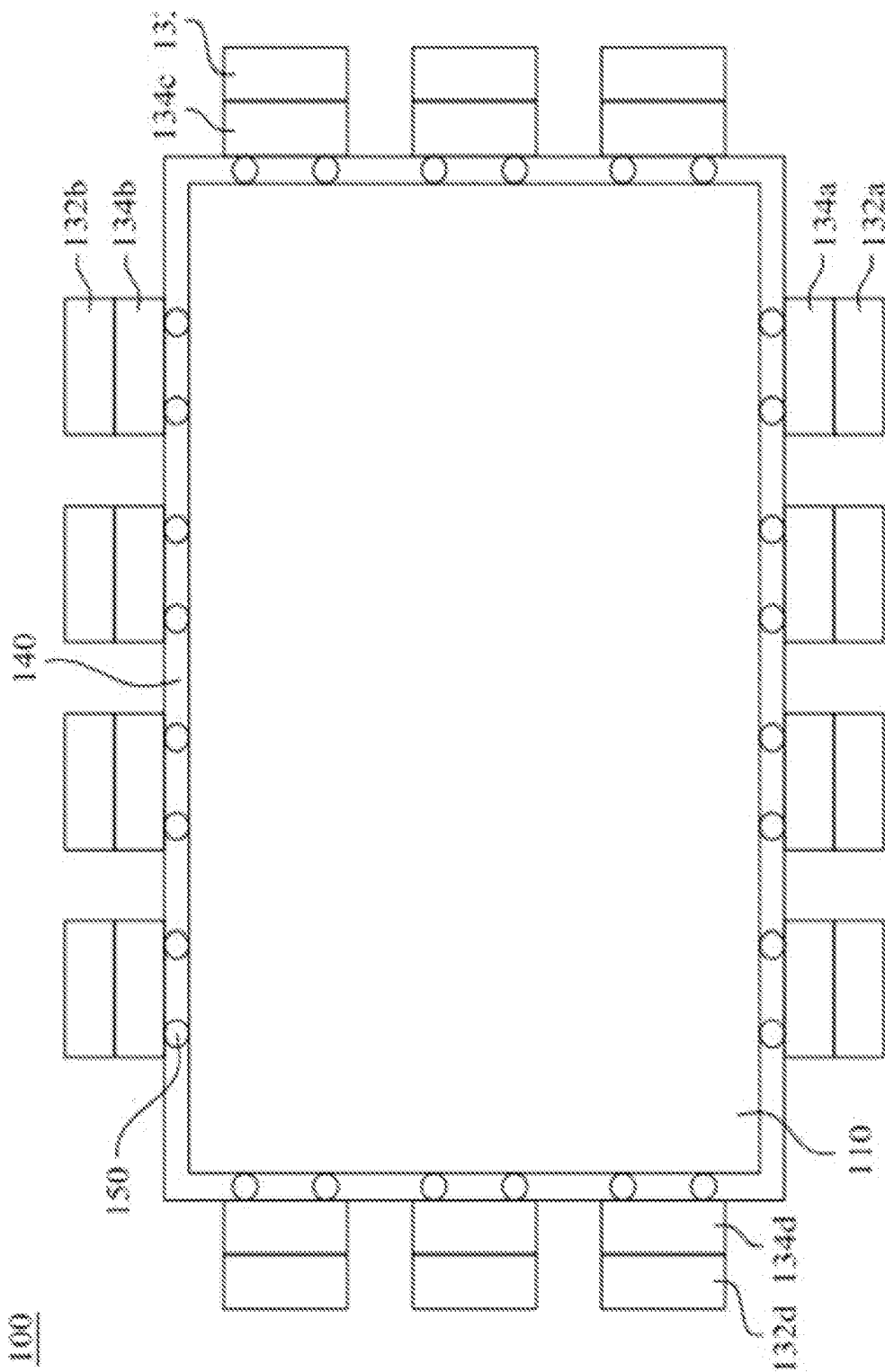


FIG. 3

400

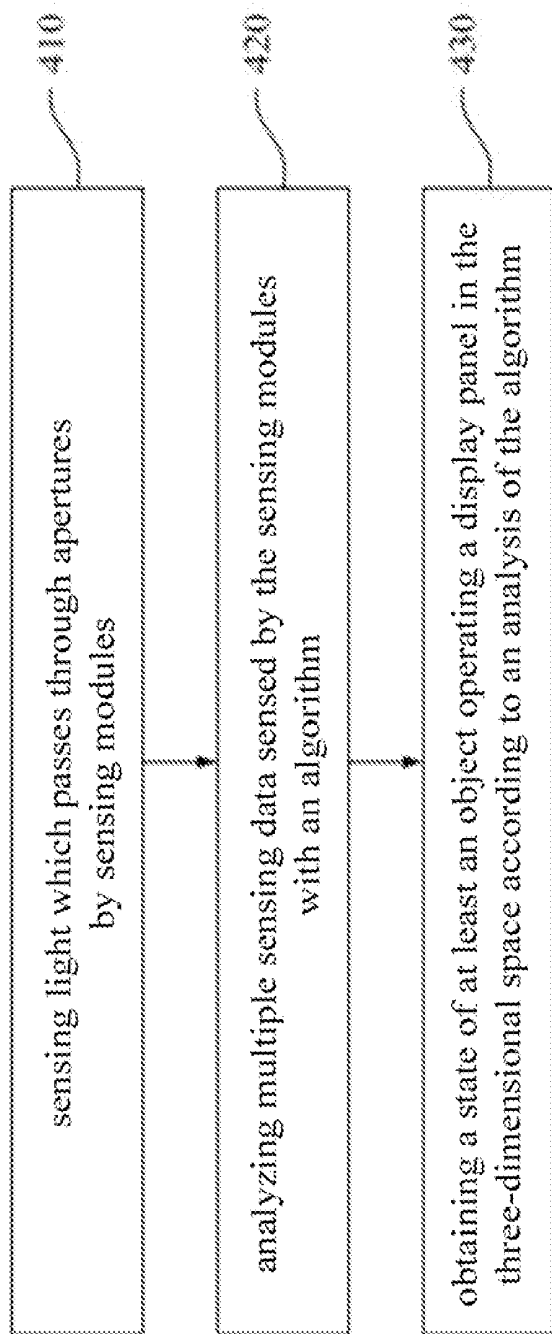


FIG. 4

TOUCH DISPLAY APPARATUS AND TOUCH SENSING METHOD

RELATED APPLICATIONS

[0001] This application claims priority to Taiwanese Application Serial Number 103110522, filed Mar. 20, 2014, which is herein incorporated by reference.

BACKGROUND

[0002] 1. Field of Invention

[0003] The present invention relates to a touch display apparatus. More particularly, the present invention relates to a touch display apparatus having sensing modules disposed around a display panel.

[0004] 2. Description of Related Art

[0005] As technologies have rapidly evolved in recently years, various touch sensing technologies are utilized to perceive user input in many electronic products nowadays. Generally, touch sensing technologies can be classified into capacitive sensing, resistive sensing and optical sensing. For resistive sensing, a user input can be obtained according to the pressure of a user pressing a touchscreen. For capacitive sensing, a user input can be detected according to a distortion of a touchscreen's electrostatic field resulted from a user touching a conductive layer coated on an insulation layer (e.g. glass) of the touchscreen. For optical sensing, a user input can be detected according to a principle of photo interruption.

[0006] However, an effective operation distance for resistive sensing or capacitive sensing is approximately 2 cm (centimeter) from a touchscreen. When a user's finger is away from a touchscreen for more than 2 cm the touch screen (e.g. the touchscreen can be a capacitive or a resistive touchscreen) is unable to detect the user input. In other words, resistive sensing and capacitive sensing cannot provide spatial depth information of the user's finger, so operations of the user's finger in a three-dimensional space cannot be accurately detected. Further, although optical sensing may detect a user operation in a three-dimensional space, optical sensing is limited by an angle of which a light source is captured. When a user is operating in a blind spot (e.g. a position that is close to the touchscreen) an optical touchscreen may be unable to detect the user's operation.

SUMMARY

[0007] The present invention provides a touch display apparatus. The touch display apparatus comprises a display panel, a frame and a plurality of sensing modules. The frame is disposed around the display panel. A plurality of apertures is disposed on the frame. The sensing modules are disposed at different height levels respectively. Each sensing module generates sensing data. Each sensing module comprises a plurality of sensing units. The sensing units are disposed along the frame respectively. The sensing units sense light which passes through the apertures.

[0008] An aspect of the present invention provides a touch sensing method for a touch display apparatus. The touch display apparatus comprises a frame and a plurality of sensing modules. The touch sensing method includes steps of: sensing light which passes through a plurality of apertures by sensing modules, wherein the apertures are disposed at different positions of the frame, the sensing modules are disposed at borders of the display panel and the sensing modules are disposed at different height levels so as to sense light

variations of different regions in a three-dimensional space; analyzing multiple sensing data sensed by the sensing modules by an algorithm; and obtaining a state of at least an object operating a display panel in the three-dimensional space according to an analysis of the algorithm.

[0009] In summary, the touch display device of the present invention comprises a plurality of sensing modules. The sensing modules are disposed at different height levels, so as to sense light variations in different regions in order to determine a state of at least an object in a three-dimensional space.

[0010] It is to be understood that both the foregoing general description and the following detailed description are by examples, and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention. In the drawings,

[0012] FIG. 1 is a diagram illustrating a top view of a touch display apparatus according to an embodiment of the present invention.

[0013] FIG. 2 is a diagram illustrating a cross-sectional view of a touch display apparatus according to an embodiment of the present invention.

[0014] FIG. 3 is a diagram illustrating a top view of a touch display apparatus according to another embodiment of the present invention.

[0015] FIG. 4 is a flowchart illustrating a touch sensing method according to an embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

[0016] Reference will now be made in detail to the present embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

[0017] Reference is now made to FIG. 1 and FIG. 2. FIG. 1 is a diagram illustrating a top view of a touch display apparatus according to an embodiment of the present invention. FIG. 2 is a diagram illustrating a cross-sectional view of a touch display apparatus according to an embodiment of the present invention. As shown in FIG. 1 and FIG. 2, the touch display apparatus 100 includes a display panel 110, a backlight panel 120, a first sensing module, a second sensing module and a frame 140.

[0018] The display panel 110 is disposed in the middle of the touch display apparatus 100. The display panel 110 can display an image according to a touch operation of a user.

[0019] As shown in FIG. 2, the backlight panel 120 is disposed under the display panel 110, in order to generate backlight with high luminance and uniform luminance distribution. The backlight panel 120 can be utilized as a light source for the display panel 110. The backlight panel 120 can be a light-emitting source that is composed with an LED (light-emitting diode) or a light source of any other form.

[0020] The frame 140 is disposed along borders of the display panel 110. A plurality of apertures 150 is disposed on the frame 140, so light can pass through the frame 140 via the apertures 150.

[0021] The first sensing module can generate sensing data. The first sensing module includes 4 first sensing units **132a**, **132b**, **132c** and **132d**. The first sensing units **132a**, **132b**, **132c** and **132d** are disposed along borders of the frame **140** respectively as shown in FIG. 1. The first sensing unit **132a** is disposed along a lower border of the frame **140**, so as to sense the light passing through the apertures **150** disposed on the lower border of the frame **140**. The first sensing unit **132b** is disposed along an upper border of the frame **140**, so as to sense the light passing through the apertures **150** disposed on the upper border of the frame **140**. The first sensing unit **132c** is disposed along a right border of the frame **140**, so as to sense the light passing through the apertures **150** disposed on the right border of the frame **140**. The first sensing unit **132d** is disposed along a left border of the frame **140**, so as to sense the light passing through the apertures **150** disposed on the left border of the frame **140**.

[0022] As shown in FIG. 1 and FIG. 2, the first sensing units **132a**, **132b**, **132c** and **132d** can be plane sensors of a rectangular shape. The first sensing units **132a**, **132b**, **132c** and **132d** are tilted along a first axis that passes through the aperture **150**s of a respective border of the frame **140**, respectively. The first axis has a first angle θ_1 with respect to the display panel **110**, so the first sensing unit **132a** can sense light that has passed through the respective apertures **150** and is within a sensing range **R1a**. Hence an effective sensing range of the first sensing unit **132a** is the sensing range **R1a**. In other words, when a finger of a user is operating in the sensing range **R1a**, light received by the first sensing unit **132a** varies accordingly, so an action of the user within the sensing range **R1a** can be obtained.

[0023] Similarly, the first sensing unit **132b** also has a sensing range so user operations within the sensing range of the first sensing unit **132b** can be sensed by the first sensing unit **132b**. Each of the first sensing units **132c** and **132d** also has a respective sensing range.

[0024] When a finger of a user hovers to operate the display panel **110**, the first sensing units **132a**, **132b**, **132c** and **132d** sense variations of spatial luminance and generate sensing data accordingly. An analyzing module (not illustrated) can analyze the sensing data and obtains actions of the user's finger (or fingers) operating the display panel **110** in a three-dimensional space.

[0025] Further, since the first sensing units **132a**, **132b**, **132c** and **132d** are disposed along the 4 borders of the display panel **110** respectively, actions of a user's finger in a three-dimensional space are unlikely to be blocked by other fingers of the user. Consequently the touch display apparatus **100** of the present invention can accurately sense actions of a plurality of fingers in a three-dimensional space.

[0026] The second sensing module also includes 4 second sensing units **134a**, **134b**, **134c** and **134d**. The second sensing units **134a**, **134b**, **134c** and **134d** are disposed along the borders of the frame **140** as shown in FIG. 1. Arrangements and operations of the second sensing units **134a**, **134b**, **134c** and **134d** are similar to those of the first sensing units **132a**, **132b**, **132c** and **132d**, so relative descriptions are omitted hereinafter.

[0027] As shown in FIG. 2, the second sensing units **134a**, **134b**, **134c** and **134d** can be plane sensors of a rectangular shape. The second sensing units **134a**, **134b**, **134c** and **134d** are tilted along a second axis that passes through the apertures **150** of a respective border of the frame **140**. The second axis has a second angle θ_2 with respect to the display panel **110**, so

the second sensing unit **134a** can sense light that has passed through the respective apertures **150** and is within a sensing range **R2a**. Hence an effective sensing range of the second sensing unit **134a** is the sensing range **R2a**. In other words, when a user's finger is operating in the sensing range **R2a**, light received by the second sensing unit **134a** varies accordingly, so an action of the user within the sensing range **R2a** can be obtained.

[0028] Similarly, the second sensing unit **134b** also has a sensing range so user operations within the sensing range can be sensed by the second sensing unit **134b**. Each of the second sensing units **134c** and **134d** also has a respective sensing range.

[0029] The first sensing units **132a**, **132b**, **132c** and **132d** and the second sensing units **134a**, **134b**, **134c** and **134d** are disposed at different height levels, as shown in FIG. 2. The first angle θ_1 corresponding to the first sensing units **132a**, **132b**, **132c** and **132d** is different to the second angle θ_2 corresponding to the second sensing units **134a**, **134b**, **134c** and **134d**. Hence, the first sensing units **132a**, **132b**, **132c** and **132d** and the second sensing units **134a**, **134b**, **134c** and **134d** can receive light from regions corresponding to different height levels, allowing the touch display apparatus **100** to sense light variations in regions corresponding to different height levels, so as to determine operation actions of multiple fingers of a user in a three-dimensional space.

[0030] Although embodiments of the present invention have illustrated the touch display apparatus is operated by a user's finger or fingers) in a three-dimensional space, those skilled in the art can choose another object (e.g. a stylus) to operate the touch display apparatus of the present invention according to practical needs, and is not limited thereto.

[0031] Further, although embodiments of the present invention have illustrated the touch display apparatus utilizes two sensing modules, and those skilled in the art can adjust a number of the sensing modules being utilized according to practical needs, and is not limited thereto. For instance, if high sensitivity is desired, more sensing modules can be disposed along the borders of the touch display apparatus, so actions of the user's fingers can be accurately sensed and analyzed.

[0032] In the above embodiments, sensing units of a sensing module are plain sensors of a rectangular shape, but the sensing units of the present invention are not limited to the above embodiments. The embodiment below describes how light in a three-dimensional space can be sensed by fragment sensors. Reference is now made to FIG. 3. FIG. 3 is a diagram illustrating a top view of a touch display apparatus according to another embodiment of the present invention.

[0033] The touch display apparatus **100** of the present embodiment includes a display panel **110**, a first sensing module, a second sensing module and a frame **140**. The first sensing module and the second sensing module include first sensing units **132a**, **132b**, **132c** and **132d** and second sensing units **134a**, **134b**, **134c** and **134d** respectively. Arrangements and operations of the first sensing units **132a**, **132b**, **132c** and **132d** and the second sensing units **134a**, **134b**, **134c** and **134d** are similar to those of the above embodiments, so relative descriptions are omitted hereinafter.

[0034] A difference between the present embodiment and the above embodiments is that the first sensing units **132a**, **132b**, **132c** and **132d** and the second sensing units **134a**, **134b**, **134c** and **134d** are composed by a plurality of fragment sensors respectively. As shown in FIG. 3, each "fragment" of

the first sensing units **132a**, **132b**, **132c** and **132d** and the second sensing units **134a**, **134b**, **134c** and **134d** is arranged to correspond to two apertures **150** of the frame **140** respectively, in order to receive light which passes through the respective two apertures **150**.

[0035] Further, in the present embodiment, the first sensing units **132a**, **132b**, **132c** and **132d** and the second sensing units **134a**, **134b**, **134c** and **134d** are disposed at different height levels. The first sensing units **132a**, **132b**, **132c** and **132d** and the second sensing units **134a**, **134b**, **134c** and **134d** are tilted along a first axis and a second axis respectively. The first axis and the second axis pass through apertures **150** of the respective borders of the frame **140** respectively. The first axis and the second axis has a first angle $\theta 1$ and a second angle $\theta 2$ with respect to the display panel **110** respectively. The first angle $\theta 1$ is different to the second angle $\theta 2$. Hence, the first sensing units **132a**, **132b**, **132c** and **132d** and the second sensing units **134a**, **134b**, **134c** and **134d** can receive lights from regions corresponding to different height levels, allowing the touch display apparatus **100** to sense light variations of regions corresponding to different height levels, so as to determine operation actions of fingers of a user in a three-dimensional space.

[0036] Reference is now made to FIG. 4. FIG. 4 is a flow-chart illustrating a touch sensing method according to an embodiment of the present invention. The touch sensing method **400** can be applied to the above embodiments, but is not limited thereto.

[0037] The sensing modules are utilized to sense the light which passes through the apertures (step **410**). An algorithm is utilized to analyze multiple sensing data sensed by the sensing modules (step **420**). A state of at least an object operating the display panel in a three-dimensional space is obtained according to the analysis of the algorithm (step **430**).

[0038] The apertures are disposed on different positions of the frame. The sensing modules are disposed along the borders of the display panel. The sensing modules are disposed at different height levels respectively, so light variations of different regions in a three-dimensional space can be sensed.

[0039] In another embodiment, one of the sensing modules is tilted along a first axis that passes through a respective aperture and the first axis has a first angle with respect to the display panel. Another one of the sensing modules is tilted along a second axis that passes through a respective aperture and the second axis has a second angle with respect to the display panel. The first angle is different to the second angle.

[0040] Unless specified otherwise, orders of the steps of the above embodiment can be adjusted, executed simultaneously or partially simultaneously, according to practical needs. The flowchart shown in FIG. 4 is merely an embodiment and is not meant to limit the present invention.

[0041] In summary, the touch display apparatus of the present invention can sense a variation of light passing through apertures of the frame via the sensing units disposed around the frame, in order to determine multi-touch operations performed to the touch display apparatus in a three-dimensional space.

[0042] Further, sensors of the present invention are disposed along the four borders of the display panel, so a situation of the sensor units being unable to sense correctly due to a user's fingers blocking each other when performing multi-touch operations can be effectively prevented.

[0043] Each of the sensor units of the present invention has an angle with respect to the display panel. By incorporating

such angles, the touch sensing device can sense light in different height levels above the display panel, so as to analyze actions of a user's finger(s) in a three-dimensional space.

[0044] Although the present invention has been described in considerable detail with reference to certain embodiments thereof, other embodiments are possible. Therefore, the spirit and scope of the appended claims should not be limited to the description of the embodiments contained herein.

[0045] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. A touch display apparatus, comprising:
 - a display panel;
 - a frame, disposed around the display panel, wherein a plurality of apertures is disposed on the frame; and
 - a plurality of sensing modules, disposed at different height levels respectively, each sensing module generating sensing data, and each sensing module comprising:
 - a plurality of sensing units, disposed along the frame respectively, the sensing units sense light which passes through the apertures.
2. The touch display apparatus of claim 1, wherein one of the sensing modules is tilted along a first axis that passes through the aperture, the first axis has a first angle with respect to the display panel, another one of the sensing modules are tilted along a second axis that passes through the apertures, the second axis has a second angle with respect to the display panel, and the first angle is different to the second angle.
3. The touch display apparatus of claim 2, wherein each of the sensing units is a plane sensor of a rectangular shape, disposed along a border of the frame.
4. The touch display apparatus of claim 3, wherein a length of each of the sensing units corresponds to a respective border of the frame.
5. The touch display apparatus of claim 2, wherein the sensing units are composed with a plurality of fragment sensors respectively, and the fragment sensors are disposed according to positions of the apertures.
6. The touch display apparatus of claim 1, further comprising:
 - an analyzing module, the analyzing module analyzing the sensing data to obtain a state of an object operating the display panel in a three-dimensional space, wherein the sensing modules disposed at different height levels sense light variations in different regions in the three-dimensional space respectively.
7. A touch sensing method for a touch display apparatus, the touch display apparatus comprising a frame and a plurality of sensing modules, the touch sensing method comprising:
 - sensing light which passes through a plurality of apertures by the sensing modules, wherein the apertures is disposed at different positions of the frame, the sensing modules are disposed at borders of the display panel and the sensing modules are disposed at different height levels so as to sense light variations of different regions in a three-dimensional space;
 - analyzing multiple sensing data sensed by the sensing modules with an algorithm; and

obtaining a state of at least an object operating a display panel in the three-dimensional space according to an analysis of the algorithm.

8. The touch sensing method of claim 7, wherein one of the sensing modules are tilted along a first axis that passes through the apertures, the first axis has a first angle with respect to the display panel, another one of the sensing modules are tilted along a second axis that passes through the apertures, the second axis has a second angle with respect to the display panel, and the first angle is different to the second angle.

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