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(54) **TRANSFORMATION OF IMAGE DATA BASED ON USER POSITION**

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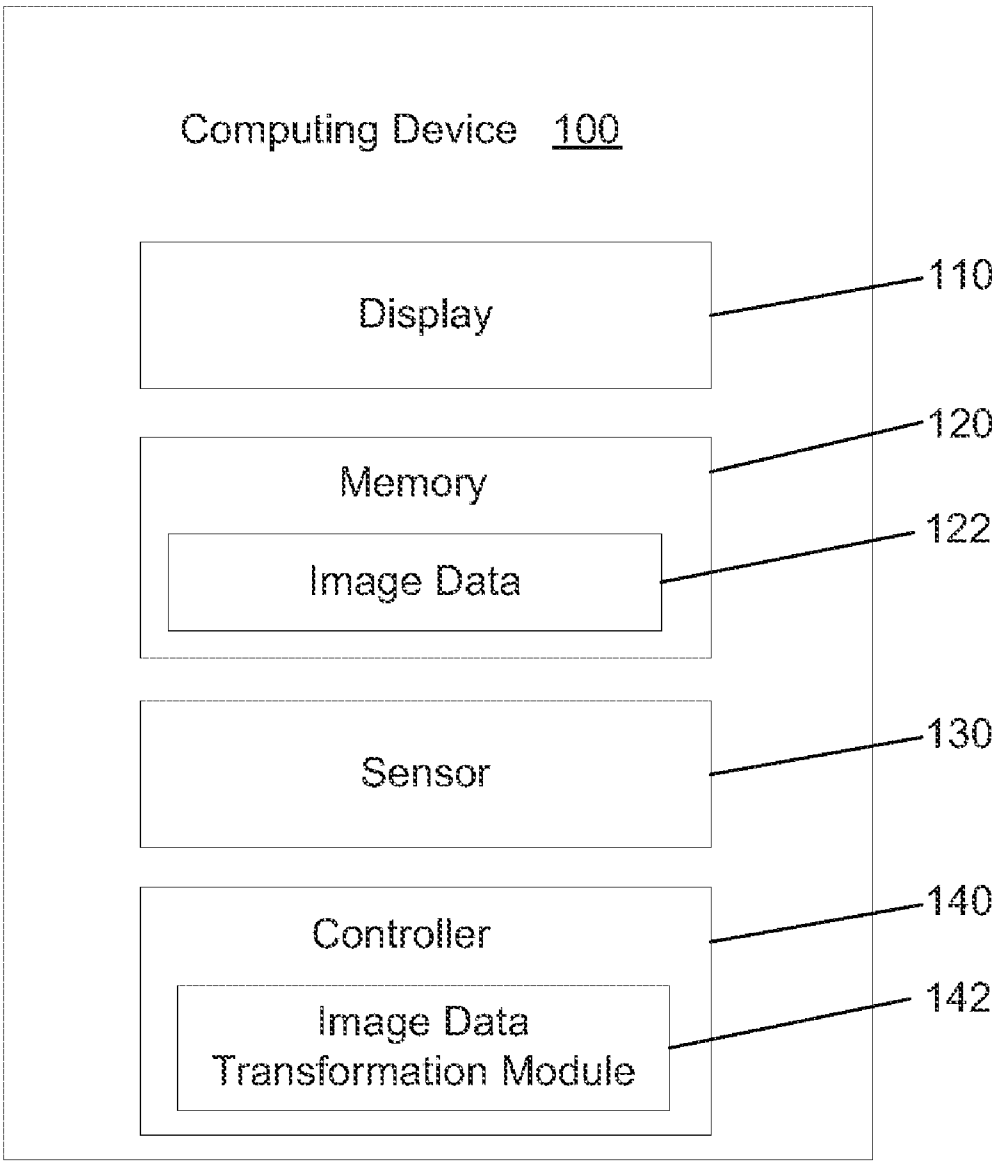
(57) **ABSTRACT**

A user position can be detected or determined using a sensor. A transformation can be applied to the image data based on the user position. The transformed image data can be displayed on a display.



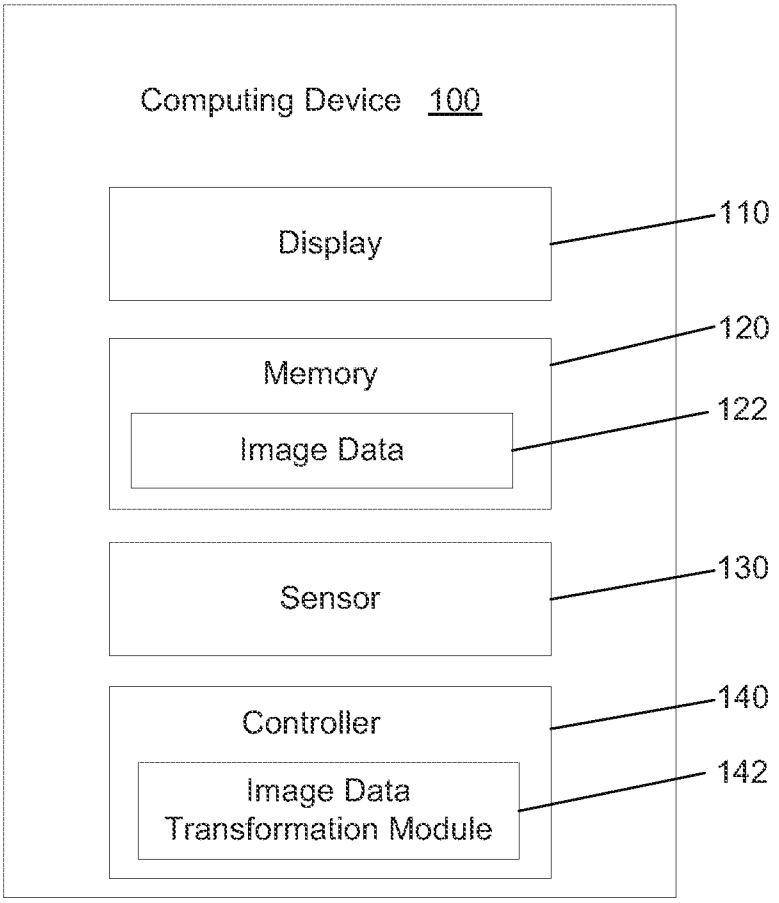

Computing Device 100
Display
110
Memory
120
Image Data
122
Sensor
130
Controller
140
Image Data Transformation Module
142

FIG. 1

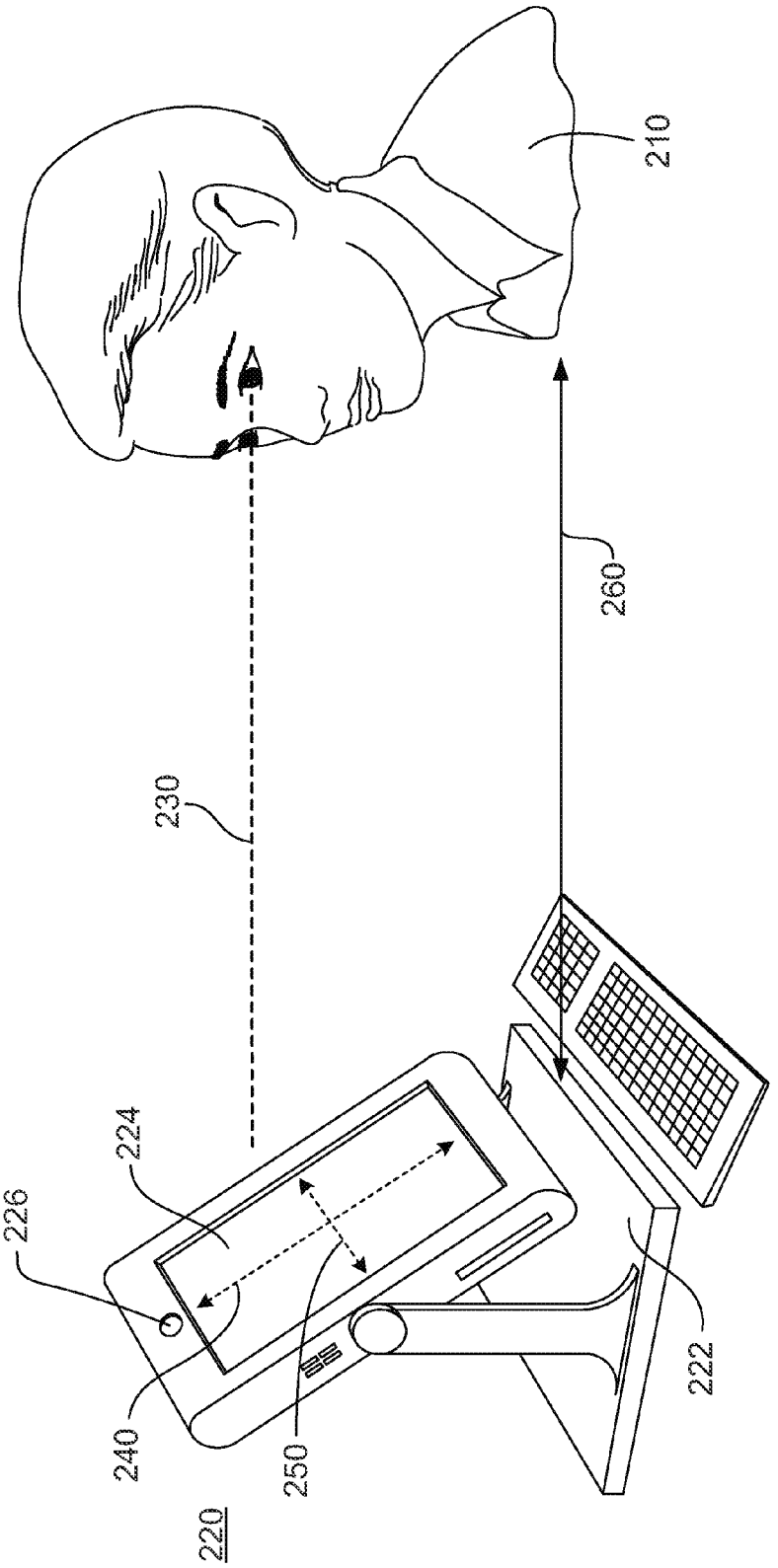


FIG. 2

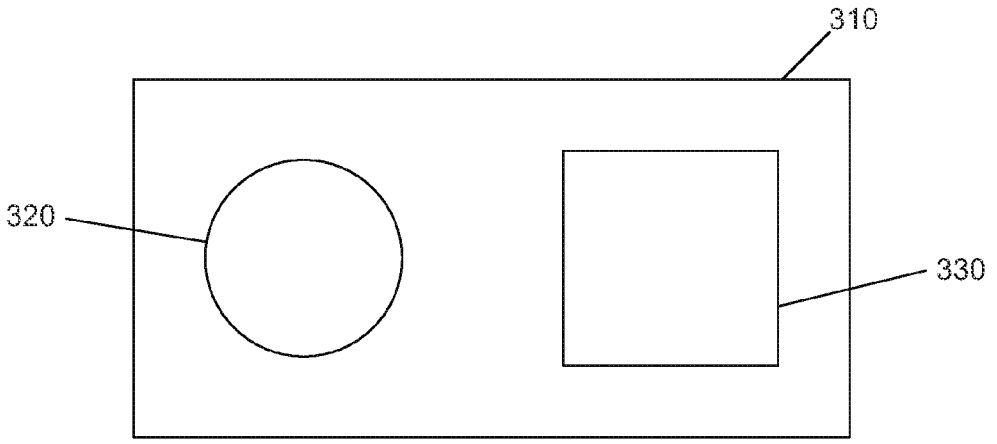


FIG. 3(a)

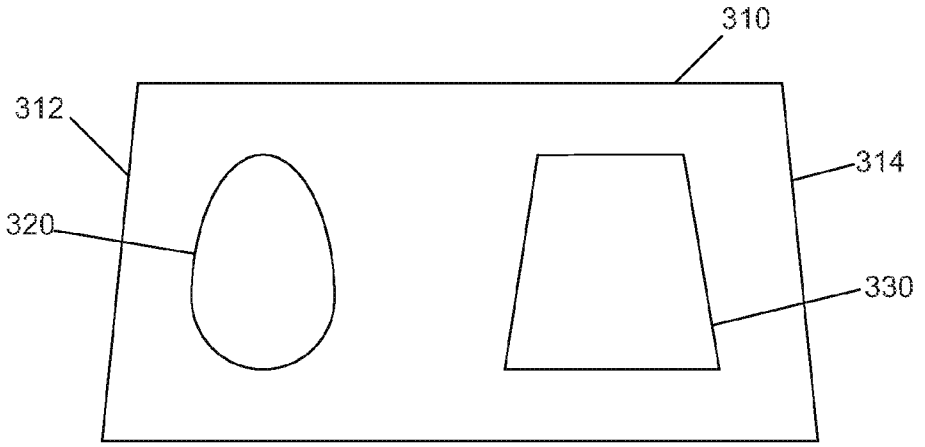


FIG. 3(b)

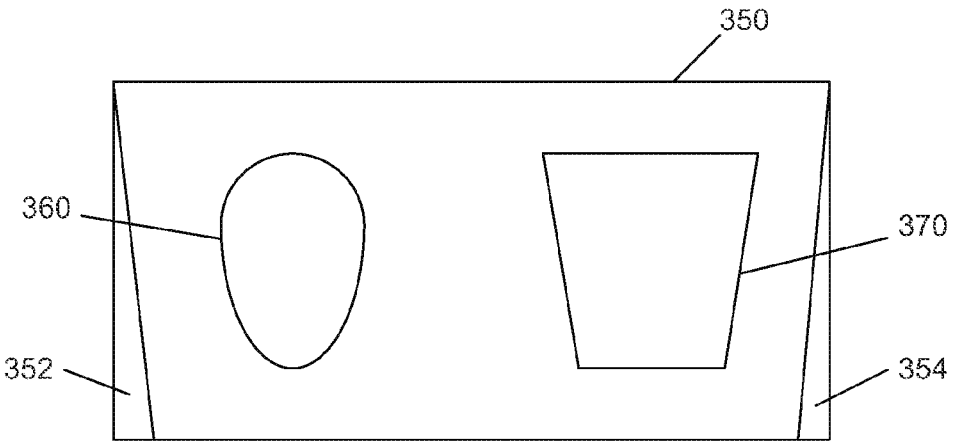


FIG. 3(c)

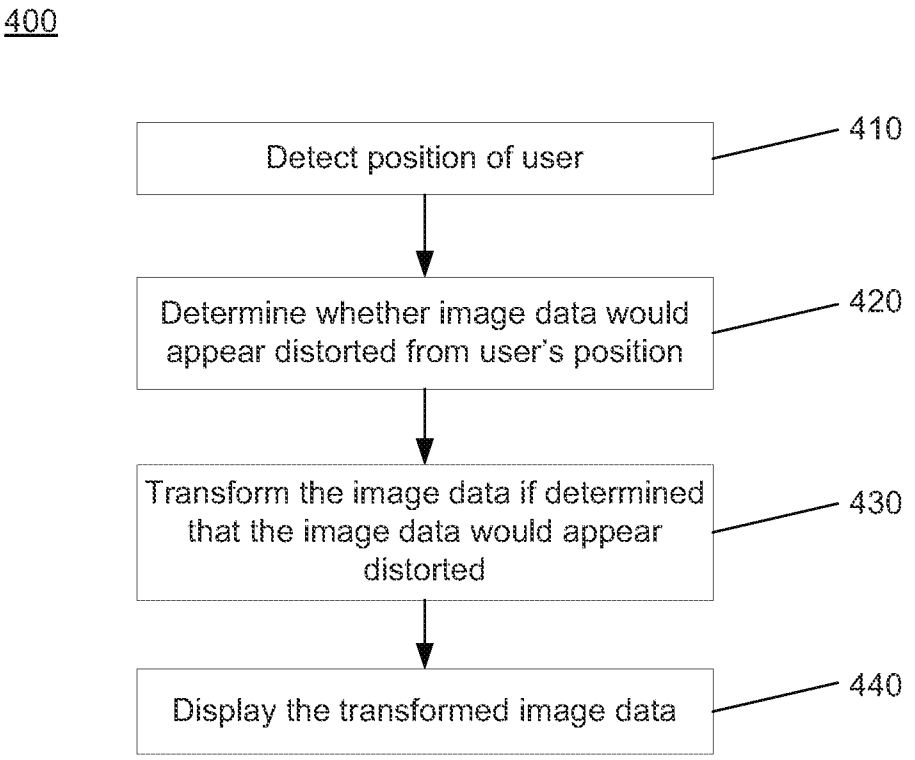

400
Detect position of user
410
Determine whether image data would appear distorted from user's position
420
Transform the image data if determined that the image data would appear distorted
430
Display the transformed image data
440

FIG. 4

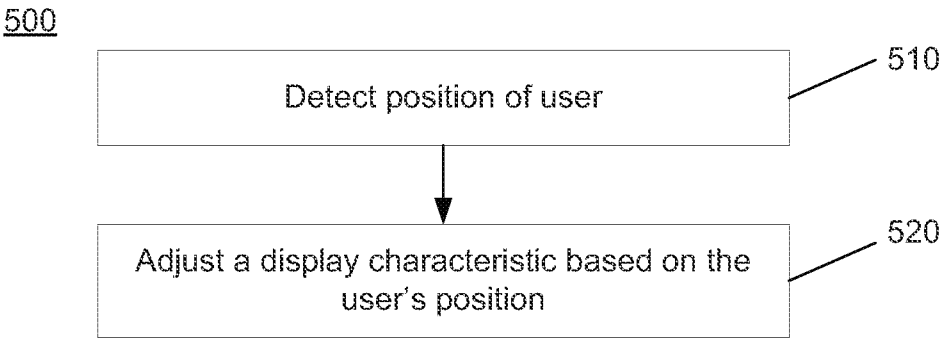


FIG. 5

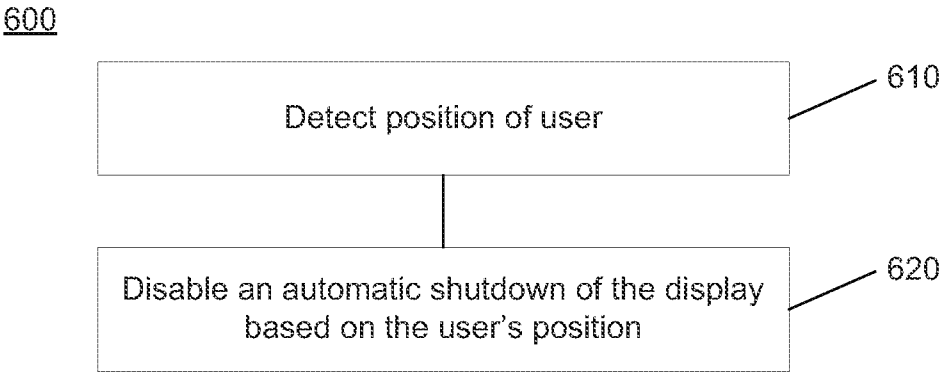


FIG. 6

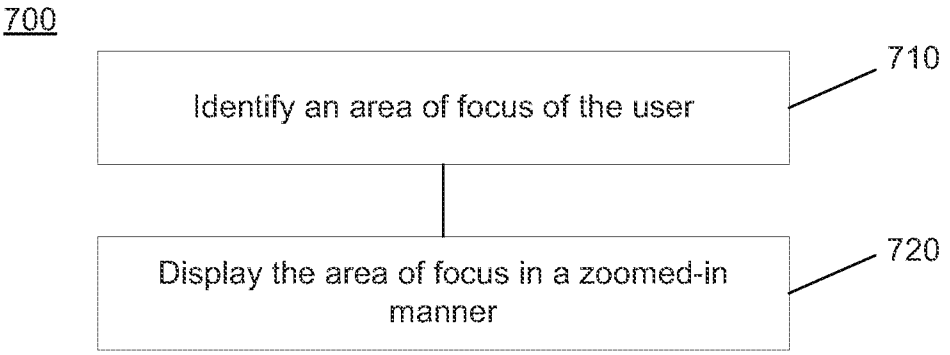


FIG. 7

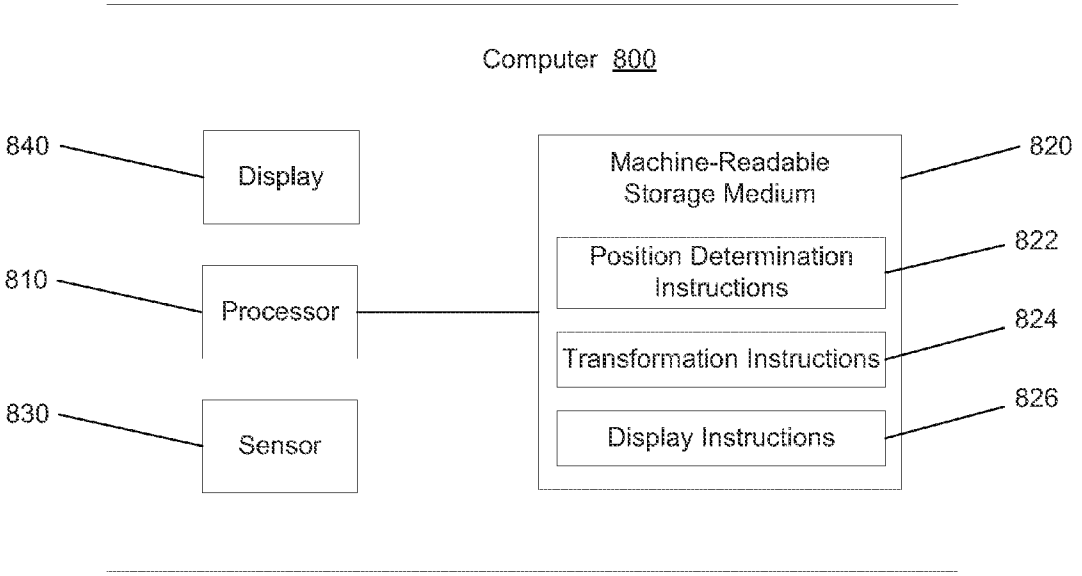

Computer 800
840
Display
810
Processor
830
Sensor
Machine-Readable Storage Medium
820
Position Determination Instructions
822
Transformation Instructions
824
Display Instructions
826

FIG. 8

TRANSFORMATION OF IMAGE DATA BASED ON USER POSITION

BACKGROUND

[0001] Many computing devices include a display for displaying text and images. For example, a display can be used to display graphical user interfaces, documents, photographs, images, and the like. Manufacturers of these devices are challenged with providing displays that accurately depict text and images to provide a satisfying user experience.

BRIEF DESCRIPTION OF DRAWINGS

[0002] The following detailed description refers to the drawings, wherein:

[0003] FIG. **1** is a block diagram illustrating a computing device including a display, a sensor, and a controller to transform image data, according to an example.

[0004] FIG. **2** is a depiction of a sample use case relating to devices and methods disclosed herein, according to an example.

[0005] FIG. **3**(*a*) is a depiction of image data as it is intended to appear from a first position relative to a display, according to an example.

[0006] FIG. **3**(*b*) is a depiction of the image data as it might appear from a second position relative to the display, according to an example.

[0007] FIG. **3**(*c*) is a depiction of the image data after transformation so as to reduce distortion when viewed from the second position, according to an example.

[0008] FIG. **4** is a flowchart illustrating aspects of a method for transforming image data, according to an example.

[0009] FIG. **5** is a flowchart illustrating aspects of a method for adjusting a display characteristic, according to an example.

[0010] FIG. **6** is a flowchart illustrating aspects of a method for disabling an automatic shutdown of a display, according to an example.

[0011] FIG. **7** is a flowchart illustrating aspects of a method for providing zoom-in functionality, according to an example.

[0012] FIG. **8** is a block diagram illustrating a computer including a machine-readable storage medium encoded with instructions to transform image data, according to an example.

DETAILED DESCRIPTION

[0013] Manufacturers of computing devices, such as smart phones, tablet and slate computers, laptop computers, and the like, are challenged with enabling consumer friendly usage of these devices. For example, manufacturers are challenged with providing displays that accurately depict text and images to provide a satisfying user experience. As described in detail below, various example embodiments relate to image transformation techniques that can enable the accurate depiction of image data on displays.

[0014] For example, during a computing session, a user may cause the display of his computing device to change position or may change his position relative to the display. For instance, a display may be tilted back or forward relative to a line of sight of the user, the user may change his position to the left or right of a centerline of the display, and/or the user may alter a distance between him and the display. Any of these things may be considered to change the user's position relative to the display. As a result of the change of position, image data displayed on the display may appear distorted. For instance, if a display is tilted back relative to a user's gaze, images displayed on the display may appear distorted (e.g., a square may appear as a trapezoid and a circle may appear as a lopsided ellipse).

[0015] According to an example embodiment, however, the user's position may be detected and the image data may be transformed. The image data may be transformed so that the transformed image data appears to the user from his position largely as the image data was intended to appear (e.g., as the untransformed image data likely would appear from a default position directly in front of the display). Thus, the transformation may reduce the appearance of distortion when the transformed image data is viewed from the user's position. For instance, in the example above the square may appear as a square rather than a trapezoid and the circle may appear as a circle rather than a lopsided ellipse. Accordingly, image data may be depicted in an accurate manner despite a change in user position, thus providing a satisfying user experience. Further details of this embodiment and associated advantages, as well as of other embodiments and applications, will be discussed in more detail below with reference to the drawings.

[0016] Referring now to the drawings, FIG. **1** is a block diagram illustrating an embodiment of a computing device **100** including a display **110**, a memory **120**, a sensor **130**, and a controller **140**. Computing device **100** may be any of a variety of computing devices. For example, computing device **100** may be a tablet or slate computer, a laptop computer, a desktop computer, a cellular telephone, or a smart phone, among others.

[0017] Computing device **100** may include a display. Display **110** may be any of various display screens. For example, the display may be a display integrated into computing device **100**, such as in the case of tablet computers and all-in-one computers. The display may also be a display remotely connected to computing device **100**, such as a LCD monitor. Furthermore, the display may be a touch sensitive display. Display **110** may be used for various purposes, such as to display a user interface, text, images, and movies.

[0018] Computing device **100** may include memory **120**, such as a machine-readable storage medium. The machine-readable storage medium may be any electronic, magnetic, optical, or other physical storage device that contains or stores data and/or executable instructions. Thus, the machine-readable storage medium may comprise, for example, various Random Access Memory (RAM), Read Only Memory (ROM), flash memory, and combinations thereof. For example, the machine-readable medium may include a Non-Volatile Random Access Memory (NVRAM), an Electrically Erasable Programmable Read-Only Memory (EEPROM), a storage drive, a NAND flash memory, and the like. Further, the machine-readable storage medium can be computer-readable and non-transitory.

[0019] Memory **120** may store various data. For example, memory **120** may store image data **122**. Image data **122** may be data that is to be displayed on display **110**. Image data **122** may include user interfaces, images, text, documents, photographs, videos, and the like.

[0020] Image data **122** may be configured such that it appears without distortion from a first position relative to display **110**. The term "without distortion" may mean "without noticeable distortion." Accordingly, "without distortion"

may signify that a user may not detect or perceive any visual distortion of the displayed image data if the user is viewing the image data from the first position.

[0021] The first position may correspond to a default user position. For example, the default user position may be a position in which the user's eyes are located directly in front of and in the center of display **110**. Additionally, the default user position may be one in which the angle of incidence of the user's gaze on the display surface of display **110** is zero degrees. Thus, when image data **122** is displayed on display **110**, it may appear without noticeable distortion when viewed from the first position.

[0022] Computing device **100** may include a sensor. Sensor **130** may be used to detect and/or determine a second position of a user relative to display **110**. The second position may represent a current position or perspective of the user. Sensor **130** may include any of various sensors to determine a position or perspective of the user.

[0023] For example, sensor **130** may be a digital camera integrated into computing device **100**, attached thereto, or integrated into or attached to a display associated with computing device **100**, such as display **110**. The camera may be or include an image sensor. For example, the image sensor may be a charge coupled device (CCD) image sensor or a complementary metal oxide semiconductor (CMOS) image sensor. The camera may include a processor, such as a digital signal processor, but may also be controlled by a separate processor in computing device **100**, such as controller **140**. In addition, the camera may be a stereo camera with multiple lenses and image sensors for capturing three-dimensional images. Sensor **130** may also be or include a tilt sensor. The tilt sensor may be embedded in or attached to display **110** and/or computing device **100** and may be configured to detect a degree of tilt of display **110**. Other sensors for detecting the position of the display or the user may be used as well, such as a sound detector (e.g., a microphone), a heat sensor (e.g., a thermographic camera), a vibration sensor (e.g., a gravimeter), an orientation sensor (e.g., an accelerometer), an infrared light sensor, and the like. Furthermore, a combination of sensors may be used.

[0024] Sensor **130** may include logic, such as machine-readable instructions, for detecting and recognizing objects in an image represented by image data, and determining the position of the objects. Thus, for example, facial recognition techniques may be used to detect a user's face in an image sensed by a digital camera. Furthermore, the location of the user's eyes and pupils may be determined using the facial recognition technology and/or eye detection technology, thus enabling a more accurate determination of a user's perspective. For instance, the user's line of sight may be determined in this manner. Another technique of determining a location of the user's eyes and pupils is to shine infrared light and sense a reflection of the light from the user's eyes. Alternatively, the location of the user's eyes may be estimated based on the location of the user's head. For instance, if a heat sensor is used, the location of the head of the user may be inferred from the heat image and the location of the user's eyes may be estimated based on statistical data regarding the average location of a human being's eyes on his head.

[0025] Sensor **130** and any associated logic may be implemented using controller **140**, using a digital signal processor of the camera, or using another processor, in combination with instructions stored in memory.

[0026] The second position determined or detected by sensor **130** may include one or more components corresponding to different aspects of a position of the user. For instance, the second position may include one or more values, vectors, or the like, each one representing an aspect of the position.

[0027] The second position may include as a component a degree of tilt of display **110** relative to a line of sight of the user. For example, a line of sight of the user may be determined using a camera, such as a digital or thermographic camera, and/or a tilt sensor. Other sensors, such as an accelerometer, may be used as well.

[0028] The second position may include as a component a location of the user relative to a centerline of display **110**. For example, the location of the user relative to a centerline of the display can be determined using a camera, such as a digital or thermographic camera. The location may represent a user's position to the right or left of a vertical centerline of the display. Additionally, the location may represent a user's position above or below a horizontal centerline of the display. These centerlines may be virtual centerlines represented in a grid which is created based on the sensor's field of view, for example. The grid may be represented as a bitmap. The formation of the grid may take into account a relationship of the display to the location of the camera, so that the center of the grid corresponds to a center of the display. The location of the user on the grid may be determined and compared to the centerlines of the grid. The location may be used to determine an angle of incidence of the user's gaze on the display surface. Other sensors, such as an infrared light sensor, may be used as well.

[0029] The second position may include as a component a distance of the user from display **110**. For example, the distance of the user from the display can be determined using a camera, such as a digital or thermographic camera. The distance can be estimated based on the size of the user in the grid, based on the size of the user relative to the user's surroundings, etc. Other sensors, such as a noise sensor, may be used as well.

[0030] The second position may include any one or all of these components. The user's position or perspective may be more accurately determined using all of the components. Other methods of determining a user's position or perspective may be used as well.

[0031] Computing device **100** may include controller **140** having image data transformation module **142**. Controller **140** may include a processor and a memory for implementing image data transformation module **142**. The memory may be any of various machine-readable storage mediums, such as described with respect to memory **120**. The processor may include at least one central processing unit (CPU), at least one semiconductor-based microprocessor, at least one digital signal processor (DSP) such as a digital image processing unit, other hardware devices or processing elements suitable to retrieve and execute instructions stored in memory, or combinations thereof. The processor can include single or multiple cores on a chip, multiple cores across multiple chips, multiple cores across multiple devices, or combinations thereof. The processor may fetch, decode, and execute instructions from memory to perform various functions, such as generating, processing, and transmitting image data. As an alternative or in addition to retrieving and executing instructions, the processor may include at least one integrated circuit (IC), other control logic, other electronic circuits, or combi-

nations thereof that include a number of electronic components for performing various tasks or functions.

[0032] Image data transformation module **142** may transform image data **122** based on the second position of the user determined by sensor **130**. The transformed image data may appear from the second position as image data **122** would appear from the first position. Thus, for example, the transformed image data may appear with less distortion than would have been visible had the image data not been transformed.

[0033] However, some distortion or visual defects may not be correctable by image data transformation module **142**. For example, if the display is tilted back relative to a user's line of sight, the display area (and, consequently, the image data) may appear with less height than if the display were viewed straight-on. Accordingly, the transformed image data appearing from the second position as the image data would appear from the first position is not meant to signify that the transformed image data appears (or is perceived by the user) exactly as the untransformed image data would appear (or be perceived) from the first position. Rather, it is meant to signify that the transformation reduces some distortion that results from the user's position or perspective relative to the display. Other distortions or defects beyond the one described above may exist that also may not be correctable by image data transformation module **142**.

[0034] Image data transformation module **142** may transform the image data using a matrix transformation, such as a perspective transformation. For example, position and angle vectors may be determined based on the second position detected by sensor **130**. For instance, the distance and angle between the detected position and the center of sensor **130**'s field of view or of display **110**'s display area may be determined. The center of sensor **130**'s field of view or of display **110**'s display area may be considered the first position. Accordingly, the change in position or perspective from the first position to the second position may be determined. A perspective transform may then be applied to the image data that is to be displayed on display **110** to accommodate for the change in position or perspective. The perspective transform may essentially correct, counteract, or reverse some of the distortion that would otherwise result from viewing the image data from the second position. Display **110** may then display the transformed image data.

[0035] Image transformations may be described as sets of mathematical transformation functions represented by mathematical equations. Each pixel in the image data may be transformed based on the mathematical transformation functions to obtain a set of output pixels, which together may represent the transformed image data. For example, each pixel may be associated with a pixel location represented by coordinates (x_{in}, y_{in}). An appropriate transformation function based on the type of distortion to be corrected (e.g., distortion due to a tilt of the display downwards, distortion due to a tilt of the display upwards, distortion due to a location of the user to the left of the vertical centerline, distortion due to a location of the user to the right of the centerline) may be selected. For example, if the display is tilted down, the appropriate transformation function may operate to foreshorten the image data, while if the display is tilted up/back, the appropriate transformation function may do the opposite. A perspective transformation may have one or more constants which determine the amount and smoothness of the perspective transformation effect. These constants may be determined based on the second position. For instance, the difference between the second position and the first position may be used to determine an appropriate value for the one or more constants in order to reduce the distortion. The output of the transformation may be a set of coordinates (x_{out}, y_{out}) for each pixel, which may represent the new location of each pixel. The image data may then be displayed in accordance with the new pixel locations.

[0036] In an example in which the second position includes a single component, such as a tilt of display **110**, a single transformation may be applied. For example, a perspective transformation based on the tilt of the display may be calculated and applied to the image data. This transformed image data may then be displayed on display **110**.

[0037] In an example in which the second position includes multiple components, such as a tilt of display **110** and a location of the user to the right or left of a vertical centerline, multiple transformations may be successively applied. For example, a perspective transformation based on the tilt of the display may be first calculated and applied to the image data. Then, a perspective transformation based on the location of the user to the right or left of the vertical centerline may be calculated and applied to the transformed image data. This twice-transformed image data may then be displayed on displayed **110**.

[0038] In some embodiments, the change in position or perspective (i.e., the difference between the first position and the second position) determined by controller **140** may be compared to a threshold value before applying a transformation. If the amount of change in position or perspective does not meet the threshold value, the transformation may not be applied. In one example, the different components of the position/perspective (e.g., angle of tilt of the display, location of the user relative to a centerline of the display, distance of user from the display) may be individually compared to a corresponding threshold to determine whether to apply a transformation. Accordingly, minor changes in position where distortion of the image data may be small or not detectable by the human eye may be ignored. This can save processing time.

[0039] In some examples, if the distance of the user from the display exceeds a threshold value, a perspective transform may not be applied. This is because the appearance of distortion of displayed image data may lessen as the distance of the user from the display increases. In addition, a perspective transform may not be applied if multiple users are detected by sensor **130**. This is because the position or perspective of the multiple users may be different, and thus it may be difficult to accommodate the positions/perspectives of both users.

[0040] Computing device **100** may include additional components and features as well, beyond those depicted in FIG. **1** and described above.

[0041] FIGS. **2** and **3**(*a*)-**3**(*c*) illustrate a sample use case and image data transformation.

[0042] In FIG. **2**, user **210** is looking at computer **220**. Computer **220** may be an all-in-one computer, in which the display and other computer components (e.g., processor, memory) are combined. Computer **220** has a base **222**, a display **224**, and a camera **226**. Computer **220** may also have a tilt sensor.

[0043] Display **224** is tilted back relative to a line of sight **230** of user **210**. The line of sight **230** may be detected using camera **226** by sensing an image of user **210** and the surroundings and using facial recognition techniques to determine a

location of the user's eyes and/or pupils. A line of sight from the user's eyes or pupils to a center of the display **224** or to a center of a field of view of camera **226** may be determined. The tilt of the display screen relative to the line of sight may be determined using an input from the tilt sensor in conjunction with the determined line of sight of the user. Alternatively, the tilt of the display screen relative to the line of sight may be determined using only the image data from camera **226** by using facial and object recognition techniques.

[0044] Camera **226** may also detect a location of user **210** relative to display **224**, such as relative to a centerline **240** and/or a centerline **250** of display **224**. Additionally, camera **226** may detect a distance **260** of user **210** from display **224**.

[0045] In this example, the location of the user relative to centerlines **240**, **250** and the distance **260** of the user from display **224** are within a threshold amount of a first position associated with image data to be displayed on display **224**. However, the tilt of the display relative to line of sight **230** of user **210** is determined to exceed a threshold value. Accordingly, a perspective transform may be used to reduce distortion that may otherwise result due to viewing the image data from the user's detected position.

[0046] FIG. **3**(*a*) depicts image data **310** including a circle **320** and a square **330** as the image data may appear to user **210** if user **210** is in a first position. The first position may be a default position in which displayed image data does not appear with noticeable distortion. For instance, the first position may be a position in which display **224** is not tilted relative to line of sight **230**, user **210** is located essentially in the center of centerlines **240**, **250**, and user **210** is located at a distance **260** that enables proper viewing of the displayed image data.

[0047] FIG. **3**(*b*) depicts image data **310** as it may appear to user **210** if user **210** is in a second position. The second position may correspond to the user's position as depicted in FIG. **2**, where display **224** is tilted back relative to user **210**'s line of sight **230**. Image data **310** appears with some noticeable distortion. Circle **320** appears as a lopsided ellipse, where the lower portion of circle **320** appears wider than the upper portion of circle **320**. Square **330** appears as a trapezoid, where the lower portion of square **330** appears wider than the upper portion of square **330**. Additionally, the edges **312**, **314** of image data **310** may appear to converge slightly due to the tilting of display **224**.

[0048] FIG. **3**(*c*) depicts transformed image data **350**, which is image data **310** after a perspective transform has been applied. To illustrate what happens to the image data as a result of the transformation, transformed image data **350** is shown in FIG. **3**(*c*) as it may appear when viewed on display **224** from a first position (e.g., the default position). In such a scenario, image data **350** may indeed appear distorted, as shown. For example, circle **360** appears as a foreshortened ellipse, where the lower portion of circle **360** appears narrower than the upper portion of circle **360**. Similarly, square **370** appears as a trapezoid, where the lower portion of square **370** appears narrower than the upper portion of square **370**.

[0049] However, when transformed image data **350** is viewed by user **210** on display **224** from the second position, in which the display is tilted back as shown in FIG. **2**, the image data may appear more like image data **310** as depicted in FIG. **3**(*a*). In other words, the transformation may reduce the appearance of distortion. Accordingly, due to the backward tilting of display **224**, circle **360** may appear as undistorted circle **320** in FIG. **3**(*a*) and square **370** may appear as undistorted circle **330** in FIG. **3**(*a*). User **210** may thus have a more satisfying experience since the displayed image data may appear closer to the way it is intended to appear.

[0050] Due to the perspective transformation, edges **352**, **354** may occur. Edges **352**, **354** may result from the slight convergence toward the bottom of image data **350** as a result of the perspective transformation. Edges **352**, **354** may be blacked out when image data **350** is displayed on display **224**, similar to the use of mattes in letterboxing, which is the practice of transferring film shot in a widescreen aspect ratio to standard-width video format while preserving the film's original aspect ratio. Alternatively, edges **352**, **354** may be filled out with additional image data, such as image data that was not originally displayed due to the size of the screen or image data replicated from neighboring pixels of image data **350**.

[0051] FIG. **4** is a flowchart illustrating aspects of a method **400** executed by a computing device for detecting a user position and transforming image data, according to an example. Although execution of method **400** is described below with reference to the components of computing device **100**, other suitable components for execution of method **400** can be used. Method **400** may be implemented in the form of executable instructions stored on a machine-readable medium or in the form of electronic circuitry. A processor, a machine-readable storage medium, other control logic, or a combination thereof can be used to execute method **400**.

[0052] Method **400** may start at **410** where a position of a user may be detected. For example, the position of the user relative to display **110** may be detected using sensor **130** of computing device **100**. At **420**, it may be determined whether image data would appear distorted from the user's position. For example, the image data may be image data that is to be displayed on display **110**. The image data may be stored in a memory, such as image data **122** in memory **120**. It can be determined whether the image data would appear distorted from the user's position using controller **140** by determining the differences between the user's position and another position, such as a default position from which the image data would presumably not appear distorted. For example, the differences may include an amount of tilt of display **110** relative to a line of sight of the user, a location of the user relative to one or more centerlines of display **110** or a center of a field of view of sensor **130**, and/or a distance of the user from display **110**. If the difference(s) between the detected position and the other position exceeds a threshold value, it may be determined that the image data would appear distorted from the user's position.

[0053] At **430**, the image data may be transformed if it is determined that the image data would appear distorted from the user's position. For example, a perspective transform may be used to transform the image data. In an example, controller **140** may transform the image data using image data transformation module **142**. The image data may be transformed using a perspective transformation based on the user's position. At **440**, the transformed image data may be displayed. For example, the transformed image data may be displayed on display **110**. As a result, the transformed image data may appear less distorted to the user when viewed from the user's position.

[0054] Additional functionality may be implemented based on the detection of the user's position. FIGS. **5-7** are flowcharts illustrating aspects of methods **500**, **600**, **700** that may be executed by a computing device, according to several

examples. Although execution of these methods is described below with reference to the components of computing device **100**, other suitable components for execution of the methods can be used. Methods **500**, **600**, **700** may be implemented in the form of executable instructions stored on a machine-readable medium or in the form of electronic circuitry. A processor, a machine-readable storage medium, other control logic, or a combination thereof can be used to execute these methods.

[0055] Method **500** may start at **510** where the position of the user may be detected. For example, the user's position may be detected using sensor **130** of computing device **100**. At **520**, a display characteristic may be adjusted based on the user's position. For example, the brightness of display **110** may be adjusted by controller **140**. For instance, if the user is positioned to one side of display **110**, the brightness may be increased so as to increase the visibility of displayed image data from the user's position. Other display characteristics that may be adjusted include contrast, color quality, and the like.

[0056] Method **600** may start at **610** where the position of the user may be detected. For example, the user's position may be detected using sensor **130** of computing device **100**. At **620**, an automatic shutdown of the display may be disabled based on the user's position. For example, controller **140** may disable an automatic shutdown of display **110**. Automatic shutdown of the display may mean that the display is dimmed or turned off (e.g., put to sleep). Automatic shutdown of the display may also include when the display is turned off as a result of a sleeping mode, a hibernation mode, or a shutdown mode of computing device **100**. The automatic shutdown may have been previously enabled and set by the user, or it may be a default setting of computing device **100**. Disabling the automatic shutdown may mean merely pausing or delaying an automatic shutdown action, resetting a time period at the end of which the automatic shutdown is set to occur, or temporarily or completely disabling the automatic shutdown feature. As a result of method **600**, a situation may be avoided where a user is actively using computing device **100** (though not necessarily inputting commands) and an automatic shutdown action disrupts his computing session.

[0057] Method **700** may start at **710** where an area of focus of the user may be determined. For example, the area of focus may be determined using sensor **130** of computing device **100**. In one example, a digital camera may be used to detect which portion of display **110** the user's pupils are focused on. Controller **140** may determine the area of focus using facial recognition techniques. Alternatively, sensor **130** may include a pupil tracker, such as on a pair of eye glasses or contact lenses. At **720**, the area of focus may be displayed in a zoomed-in manner. For example, display **110** may correlate the user's area of focus with certain image data which is displayed in the determined area of focus on display **110**. The correlated image data may be enhanced by zooming. This may permit the user to more easily view the image data that the user was focused on.

[0058] Various techniques of displaying the correlated image data may be used. For instance, the correlated image data may be enhanced such that the correlated image data occupies the entire display area of display **110**. In addition, other image data not visible on the screen may be scrolled into view and similarly enhanced by the user shifting his gaze up or down and/or to the left and right. Alternatively, the correlated image data may be enhanced such that it overlays the image data surrounding it. Other techniques may be used as well. In some examples, the image data may be again displayed normally (i.e., without zooming in) if the user shifts his gaze completely away from the display.

[0059] FIG. **8** is a block diagram illustrating aspects of a computer **800** including a machine-readable storage medium **820** encoded with instructions to transform image data, according to an example. Computer **800** may be, for example, a tablet computer, a slate computer, a laptop computer, a desktop computer, a smart phone, a personal digital assistant, or the like.

[0060] Computer **800** may include a processor **810**. Processor **810** may be at least one central processing unit (CPU), at least one semiconductor-based microprocessor, at least one digital signal processor (DSP) such as a digital image processing unit, other hardware devices or processing elements suitable to retrieve and execute instructions stored in machine-readable storage medium **820**, or combinations thereof. Processor **810** can include single or multiple cores on a chip, multiple cores across multiple chips, multiple cores across multiple devices, or combinations thereof. Processor **810** may fetch, decode, and execute instructions **822**, **824**, **826** to implement image data transformation. As an alternative or in addition to retrieving and executing instructions, processor **810** may include at least one integrated circuit (IC), other control logic, other electronic circuits, or combinations thereof that include a number of electronic components for performing the functionality of instructions **822**, **824**, **826**. Accordingly, processor **810** may be implemented across multiple processing units and instructions **822**, **824**, **826** may be implemented by different processing units in different areas of computer **800**.

[0061] Machine-readable storage medium **820** may be any electronic, magnetic, optical, or other physical storage device that contains or stores executable instructions. Thus, the machine-readable storage medium may comprise, for example, various Random Access Memory (RAM), Read Only Memory (ROM), flash memory, and combinations thereof. For example, the machine-readable medium may include a Non-Volatile Random Access Memory (NVRAM), an Electrically Erasable Programmable Read-Only Memory (EEPROM), a storage drive, a NAND flash memory, and the like. Further, the machine-readable storage medium **820** can be computer-readable and non-transitory. Machine-readable storage medium **820** may be encoded with a series of executable instructions for transforming image data.

[0062] The instructions **822**, **824**, **826**, when executed by processor **810** (e.g., via one processing element or multiple processing elements of the processor) can cause processor **810** to perform processes, for example, the processes depicted in FIGS. **4-7**. Furthermore, computer **800** may be similar to computing device **100** and may have similar functionality and be used in similar ways, as described above.

[0063] Position determination instructions **822** may cause processor **810** to determine a position of a user using sensor **830**. Sensor **830** may be or include a digital camera, a thermographic camera, a tilt sensor, or the like. Other sensors may be used as well. The determined position can be relative to display **840**. Display **840** may be integrated into computer **800** or attached or remotely connected to computer **800**. Display **840** may be a touch screen. The user's position can include multiple components. For example, the position may include a degree of tilt of display **840** relative to a line of sight

of the user, a location of the user relative to display **840**, and a distance of the user from display **840**.

[0064] Transformation instructions **824** may cause processor **810** to apply a transformation to image data. The image data can be image data that is to be displayed on display **840**. The transformation can be based on the user's position. For instance, the transformation may be a perspective transformation designed to reduce an appearance of distortion of the image data from the user's position. In some examples, the transformation may be applied to the image data only if the user's position differs from another position by a threshold amount. For example, the other position may be a default position. The default position may be a position from which the image data would likely appear without distortion.

[0065] Display instructions **826** may cause processor **810** to display the transformed image data on display **840**.

What is claimed is:

1. A computing device comprising:
- a display;
- a memory storing image data, wherein the image data appears without distortion from a first position relative to the display;
- a sensor to determine a second position of a user relative to the display; and
- a controller to transform the image data based on the second position so that the transformed image data appears from the second position as the image data would appear from the first position,
- the display configured to display the transformed image data.

2. The computing device of claim **1**, wherein the second position of the user relative to the display comprises a degree of tilt of the display relative to a line of sight of the user.

3. The computing device of claim **1**, wherein the second position of the user relative to the display comprises a location of the user relative to a center line of the display.

4. The computing device of claim **1**, wherein the second position of the user relative to the display comprises a distance of the user from the display.

5. The computing device of claim **1**, wherein the controller is configured to transform the image data based on the second position using a perspective transformation.

6. The computing device of claim **1**, wherein the controller is configured to not transform the image data if more than one user is sensed by the sensor.

7. The computing device of claim **1**, wherein the controller is configured to not transform the image data if a distance of the user from the display exceeds a value.

8. The computing device of claim **1**, wherein the sensor comprises a camera.

9. A method comprising:
- detecting a position of a user relative to a display using a sensor;
- determining whether image data to be displayed on the display would appear distorted from the position of the user;
- transforming the image data using a perspective transformation if determined that the image data would appear distorted from the position of the user; and
- displaying the transformed image data on the display.

10. The method of claim **9**, wherein the perspective transformation is designed to reduce an appearance of distortion of the transformed image data when viewed from the position of the user.

11. The method of claim **9**, further comprising:
- adjusting a display characteristic of the display based on the detected position of the user.

12. The method of claim **9**, further comprising:
- disabling an automatic shutdown of the display based on the detected position of the user.

13. The method of claim **9**, further comprising:
- identifying an area of focus of the user using the sensor; and
- displaying the area of focus in a zoomed-in manner on the display.

14. A non-transitory machine-readable storage medium encoded with instructions executable by a processor of a computer, the machine-readable medium comprising:
- instructions to determine a position of a user using a sensor;
- instructions to apply a transformation to image data based on the user's position to reduce an appearance of distortion from the user's position; and
- instructions to display the transformed image data on a display.

15. The machine-readable medium of claim **14**, wherein the transformation is applied to the image data only if the user's position differs from a default position by a threshold amount.

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