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PI 2014000655 7 March 2014 (07.03.2014) MY(71) Applicant: -MIMOS BERHAD [MY/MY]; Technology
Park Malaysia, 57000 Kuala Lumpur (MY).(72) Inventors: CHUAN NGIP KHEAN; c/o Mimos Berhad,
Technology Park Malaysia, 57000 Kuala Lumpur (MY).
ASHOK A/L SIVAJI; c/o Mimos Berhad, Technology
Park Malaysia, 57000 Kuala Lumpur (MY).(74) Agent: YAP, Kah Hong; Pyprus Sdn Bhd, Suite 8-02, 8th
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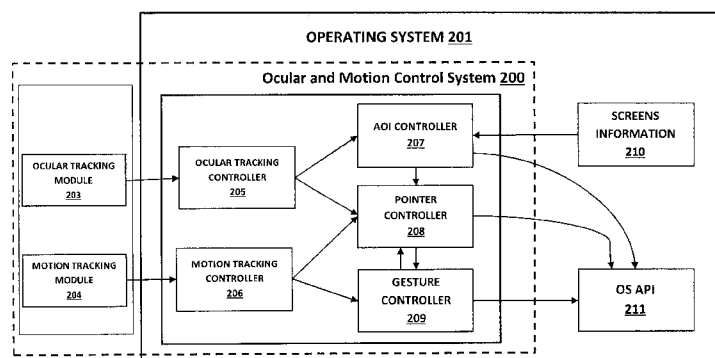
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FIG. 2

(57) Abstract: The present invention provides an ocular and motion controller system (200) for controlling interaction between a GUI and a user. The GUI is displayed on one or more display screens (102). The system (200) comprises an ocular tracking module (203) for capturing gaze data of the user's gaze to position a pointer at a corresponding location on the screen, a motion tracking module (204) for capturing gesture data of the user's gesture, wherein gesture data is process to determine its validity, and the valid gesture is used to turn on the motion tracking for taking over the gaze control. The system (200) processes the ocular and motion data that falls within the AOI to determine where the pointer should be positioned. A method thereof is also provided.

Method And Apparatus To Combine Ocular Control With Motion Control For Human Computer Interaction

Field of the Invention

[0001] The present invention relates human-computer interactions. In
5 particular, the present invention relates to a system and method for combining ocular
control with motion control for human computer interactions.

Background

[0002] Keyboard and mouse have been widely used as input interfaces to
interact with computers. As the computers and their applications are getting more
10 advances, there are increasing demands on new ways of interacting with computers
effectively and naturally.

[0003] Human-Computer Interaction (HCI) solely utilizing ocular controls is
relatively inaccurate and requires large ocular workload when compared to keyboard
and mice controls. Meanwhile, HCI solely utilizing motion control are relatively
15 inaccurate and requires large ergonomics workload when compared to keyboard and
mice controls. In the recent technological advancement, motion control is becoming
more common and the relevant device specifically adapted for detecting motion for
interacting with computer has becoming readily available in the market.

[0004] It is therefore desired that a combined ocular and motion control is
20 provided an interface with a more natural interaction between human and computer
through ocular and gesture of the user.

Summary

[0005] In accordance with one aspect of the present invention, there is provided a method for interacting with a graphical user interface (GUI) displaying on one or more display screens of a computer, the computer has an ocular tracking module and a motion tracking module. The method comprises receiving gaze data through ocular tracking module to compute a computed-ocular-point (COP); rendering an Area-of-Interest (AOI) based on the COP; positioning a pointer of the GUI to a position on the screen correspond to the COP; monitoring gestures captured by a motion tracking module that falls within a Pointer-Tracking-Area (PTA) of the motion tracking module, wherein the PTA is determined based on the AOI, detecting a tracked object from the gestures that fall within the PTA to extract command gestures therefrom; determining validity of the detected command gestures based on the pointer position and the computer state detected by the motion tracking module; and re-positioning the pointer according to a location of the tracked object determined within a Field-of-View (FOV) of the motion tracking module.

[0006] In one embodiment, computing the COP further comprises receiving gaze data from the ocular tracking module taken within a predefined period; storing all the gaze data taken within the predefined period; filtering the gaze data based on the validity of the detected command gesture; converting respective gaze data into a plurality of coordinate points in associating to the screen; and averaging the coordinate points and output the averaged result as the COP.

[0007] In another embodiment, computing the COP may further comprises determining AOI size based on COP value, an equipment profile and program setting

stored on the ocular tracking module; offsetting AOI according to a valid screen border values of the screen; and displaying the AOI on the screen.

[0008] In a further embodiment, positioning the pointer according to location of tracked object may further comprise receiving an enabler signal to enable a pointer
5 controller, and processing a type of gesture; matching the type of gesture with a shape point database to obtain an intended command gesture to obtain a shape point; calculating a new pointer position based on current AOI and the shape point; re-positioning the pointer at the shape point; and interacting the GUI according to the gesture command.

10 [0009] In yet a further embodiment, when the pointer controller is enabled by the gesture controller, gaze data from the ocular tracking controller is ignored and the pointer movement and interaction with the GUI is controlled by the gesture detected by the motion tracking controller.

[0010] In another aspect of the present invention, there is also provided an
15 ocular and motion controller system for controlling interaction between a GUI and a user, wherein the GUI is displayed on one or more display screens. The system comprises an ocular tracking module for capturing gaze data of the user's gaze; an ocular tracking controller operationally receiving the gaze data from the ocular tracking module to compute a COP; an AOI controller operationally receives the COP from the
20 ocular tracking controller to render an AOI; a pointer controller operationally position a pointer of the GUI on the screen; a motion tracking module for capturing gestures of the user; a motion tracking controller for receiving gestures falls within a PTA of the motion tracking module to detect a tracked object, wherein the PTA is determined based

on the AOI; and a gesture controller for receiving the tracked object to extract command gesture therefrom, wherein the detected command gestures based on the pointer position and a computer state, wherein the gesture controller enables a motion control on the pointer controller to reposition the pointer according to a location of the tracked object
5 determined within a FOV of the motion tracking module.

[0011] In one embodiment, the ocular tracking controller computes the COP based on the gaze data detected by the ocular tracking module within a predefined period, all the gaze data taken within the predefined period are stored on a gaze database, the gaze data are filtered based on the validity of the detected command
10 gestures, the filtered gaze data are converted into a plurality of coordinate points in associating to the screen and are averaged accordingly to obtain the COP.

[0012] In another embodiment, the ocular tracking controller further determines an AOI size based on COP value, an equipment profile and program setting stored on the ocular tracking module in order to offset the AOI according to a valid screen border
15 values of the screen, thereby displaying the AOI on the screen.

[0013] In another embodiment, the gesture controller further generates an enabler signal to enable the pointer controller and processes a type of gestures to match for an intended command gesture with a shape point database to obtain a shape point; wherein the pointer is repositioned based on a current AOI and the shape point for
20 interacting with the UI according to the gesture command.

[0014] In a further embodiment, when the pointer controller enabled by the gesture controller, gaze data from the ocular tracking controller is ignored and the

pointer movement and interaction with the UI is controlled by the motion tracking controller.

Brief Description of the Drawings

[0015] Preferred embodiments according to the present invention will now be
5 described with reference to the figures accompanied herein, in which like reference numerals denote like elements;

[0016] FIG. 1 illustrates a schematic diagram of an ocular and motion
controlling system for human-computer interaction according to one embodiment of the
present invention;

10 [0017] FIG. 2 illustrates a block diagram of an ocular and motion control
system 200 according to one embodiment of the present invention;

[0018] FIG. 3 illustrates a process for combining ocular and motion control in
accordance with one embodiment of the present invention;

[0019] FIG. 4 illustrates a flow diagram of a process for generating a computed-
15 ocular-point from gaze data received from ocular tracking module in accordance with
one embodiment of the present invention;

[0020] FIG. 5 illustrates a flow diagram of a process of computing and
rendering AOI based on the COP in accordance with one embodiment of the present
invention;

20 [0021] FIG. 6 illustrates the generation of the AOI in relation to the screen and
COP of one embodiment;

[0022] FIG. 7 is a flow diagram illustrating a process of translating the position of a tracked object in PTA onto the AOI in accordance with one embodiment of the present invention;

[0023] FIGs. 8A and 8B that illustrate the screen with reference to the AOI and
5 the FOV with reference to the PTA; and

[0024] FIGs. 9A-9K depict sequence of human-computer interaction utilizing the system and method of the above embodiments in accordance with the present inventions.

Detailed Description

10 [0025] Embodiments of the present invention shall now be described in detail, with reference to the attached drawings. It is to be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art
15 to which the invention relates.

[0026] FIG. 1 illustrates a schematic diagram of an ocular and motion controlling system for human-computer interaction according to one embodiment of the present invention. As shown in the upper half of the figure, the user 101 is interacting with a computer 100 having a display screen 102. Eye gaze 103 of the user 101 is
20 tracked by an ocular and motion-tracking device 106 that is placed in an appropriate location suitable for tracking the eye movements. The ocular and motion-tracking device 106 can be a dedicated or general purpose imaging device for capturing images

or video of the person to detect the eye moments. The ocular and motion-tracking device **106** captures the images of the user **101** and process accordingly to extract eyes movement information.

[0027] In this invention, ocular control means using eye (or eyes) as a control interface to control a desired means. Ocular control may utilize gaze detection to detect the point (i.e. scalar based) where the subject human eye is looking at. Where necessary, saccade detection (i.e. vector based) can also be adapted for ocular control, in accordance with another embodiment of the present invention. It is also possible that an ocular data, such as oculogram or the like, can be detected through a wearable device that directly detect the eye movement, or it can be a remote device for detecting the eye movement.

[0028] The ocular and motion-tracking device **106** collects ocular data from the user **101** and sends to the computer **100**. In one embodiment, the ocular and motion-tracking device **106** is an integrated device for detecting both ocular data and motion data. In an alternative embodiment, the ocular and motion-tracking device **106** can be stand-alone devices adapted respectively for ocular control and motion control. In yet another alternative embodiment, the ocular and motion-tracking device **106** can be adapted as an integrated device with detachable or remote peripheral sensors or detectors for capturing ocular data and motion data. Based on the ocular data, the computer generates a computed-ocular-point (COP) representing a pointer **105** on the display screen **102** where the user is looking at. The COP point as shown is presented in an arrow cursor, and in other embodiments, the point can be presented in other shapes, sizes and colors according to the settings of the computer **100**. Based on the

detected eye gaze position, the pointer **105** is positioned on the screen to indicate the location of the COP, in the absence of motion tracking input.

[0029] For purpose of the present application, the term “pointer” can be used interchangeably with “cursor” which is most commonly referred to an indicator to show
5 on one or an array of computer screens the position that will respond to the user’s input to interact with the computer.

[0030] An area-of-interaction (AOI) **104** is defined based on the COP, i.e. the pointer **105**. The AOI **104** limits the pointer **105** within a restricted area. With sufficient space available, the COP is by default set as the center of the AOI **104**, until
10 the AOI **104** reaches the boundary of the visible area on the computer screen(s). Mackenzie’s Fitts’ Law equation, for example, can be adapted herewith for determining the location of the AOI based on the COP.

[0031] As shown in the bottom half of the **FIG. 1**, once the AOI **104** is defined, the user **101** may enable pointer positioning via motion tracking by performing a
15 tracking gesture with user’s hand **107**. In one embodiment, the AOI **104** may be a boundary visible on the computer screen(s) for user reference. In another embodiment, it can also be a invisible boundary to the user. Similarly, the motion gestures are also detected through the device **106**. The data (such as images or videos or any detected ocular or motion data) captured through the device **106** is inputted on the computer **100**
20 for processing to identify shapes (e.g., hands, fingers, and head), shape points (e.g., fingertips, palm center, and nose tip) and gestures (e.g., position and movement of hands, fingers, and head) are recognized. Of all the identified features, one of the intended features is selected for controlling the pointer. As shown in **FIG. 1**, the tip of

index finger is to guide the pointer **105**. The motion-tracking module of the tracking device **106** may contain sensors that can capture depth and image data in the sensor field-of-vision (FOV). When motion tracking is enabled, the pointer position is mapped to the relative position of a shape point (e.g., index fingertip) in a pointer-tracking-area (PTA) **108** of the motion tracking hardware's field-of-vision. The shape point is selected from one point of the detected shape for carrying out the control. In the present illustration, a user motion gesture is initiated, as the user's hand **107** is raised within the FOV.

[0032] The PTA **108** is an imaginary area adapted to limit the interaction (i.e. between the user and the computer) within which for more efficient control and processing. The PTA **108** corresponds to the AOI **104** that is provided as the gesture control is detected. As the user's gesture (i.e. finger tip) moves within a corresponding position in the PTA **108**, the pointer **105** maneuvers in a corresponding position within the AOI **104** on the screen **102** in relation to the corresponding position in the PTA **108** as indicated by the line **109**. As mentioned earlier, the AOI **104** is provided to limit the area of interaction within that area, even when the user gesture moves out of the PTA **108**. Such implementation is found to be able to reduce jittery effect on pure gaze (or ocular) control. The AOI size may depends on gaze data accuracy. It is appreciated that different users and physical environment settings may influence the accuracy. By way of example, not limitations, the AOI size may be relatively bigger towards the edge of the screen than that when it is nearer to the center.

[0033] According to the embodiment of the present invention, the PTA **108** can be a 2D or 3D area depending on whether the user interface being used is 2D or 3D. Accordingly, the user **101** may position the pointer **105** on top of user interface (UI)

objects in the display **102** and perform command gesture to interact with these UI objects.

[0034] In this invention, motion data refers to data pertaining to the state or movement of the object of interest, for example. In one embodiment, the data can be generated by analysing and determining the position of object of interest. This is usually achieved by detecting an object shape over time. The object shape can be detected in two-dimensional (2D) (i.e. image data only) or it can be detected in three-dimensional (3D) (i.e. image data plus depth data). In one embodiment, image(s) captured by a Red-Green-Blue (RGB) and depth camera is to be processed through an object recognition module for identifying the object of interest. Such object recognition may be done through matching through a database. In a further embodiment, the detected object of interest may further be combined with gesture motion for more precise control. Gestures are derived from data pertaining the targeted object's shape and motion over time. In another embodiment, time-slide method that determine the differences between pictures to detect movements of the object of interest is also possible, save the effort to recognise the object shape. Preferably, the motion control referred herein is a control interface that uses shape, motion, and gesture detections to render the control command. As opposed to raw motion data to provide control, the motion control of the present invention offers a more precise and more diversify option allowing the user to interact with the computer **100** more ergonomically. Accordingly, the motion control can also herein after referred to as shape and gesture control, or the like. In one example, only part of the FOV, also known as Pointer Tracking Area, is utilized to move the pointer, whilst all the FOV is used for gesture recognition.

[0035] FIG. 1 illustrates only on display screen 102 only. But it is well understood to a skilled person that the present invention is implementable on a computer with multiple-display screens that are connected in array as extended screens to the main display screen without any limitation.

5 [0036] In other embodiments, the ocular and motion tracking capacities may be enabled by multiple devices. Yet in another embodiment, the ocular and motion tracking hardware may be integrated with the computer 100 or display 102.

[0037] Through the above, operationally, the user uses ocular motion to initiate the ocular and motion control of the present invention. The ocular motion places the
10 pointer at a proximate area to be interacted, where the gesture motion of the users further allows the user to precisely place the pointer at an intended location and to send commands to the operating system's application programming interface (API).

[0038] FIG. 2 illustrates a block diagram of an ocular and motion control system 200 according to one embodiment of the present invention. The ocular and
15 motion control system 200 comprises hardware modules and application modules. The hardware modules are provided to acquire the ocular and motion tracking parameters, wherein the application modules process the acquired parameters. The hardware modules comprise an ocular tracking module 203 and a motion tracking module 204. It is well understood to a skilled person that the hardware modules may be available in
20 many forms. In one embodiment, it can be a dedicated or proprietary hardware module adapted for functioning with the application module provided herewith to provide the ocular and motion controls.

[0039] The ocular tracking hardware **203** operationally tracks user's eye gaze and generated gaze data for feeding into the ocular tracking controller **205**. The ocular tracking controller **205** converts the gaze data and produces a computed-ocular-point (COP) that represent the point on the screen that user is looking at for the gaze data
5 collection duration. The AOI controller **207** receives the COP and generates the AOI base on COP and screen information **210** obtained from the operating system **201**. The AOI controller **207** may send the AOI information to the OS's API **211** to indicate on the screen where the AOI is rendered.

[0040] The pointer controller **208** is adapted to process the acquitted ocular data
10 and motion data to control the pointer. Operationally, it also receives the COP from the ocular tracking controller **205** for processing the pointer data. The pointer controller **208** is triggerable by the gesture controller **209**, which will be explained later. By default, the pointer controller **208** is triggered enable or triggered on, such that the pointer maneuvers according to the gaze data.

[0041] Returning to the motion-tracking module **204** that captures images or
15 depth images for use of shape and motion tracking. Depending on the integrated capabilities of the motion-tracking module **204**, data that send to the motion tracking controller **206** may be in raw images, shapes (e.g. identification of objects from images), shape points (e.g. fingertips, palm center, head center location, skeletal joints),
20 motion (e.g. movement history, velocity, and acceleration of shape points), or gestures (e.g. specific motions and shapes history) data. The motion-tracking controller **206** receives the data generated by motion tracking module **204** and collects the data for a specific amount of time. The motion-tracking controller **206** is capable of processing its

own shapes points data and gestures data or it may use the computed shape points and gestures of the software capabilities.

[0042] The gesture controller 209 receives gesture data from the motion-tracking controller 206. The gesture controller 209 identifies whether the gesture
5 indicates a command for the operating system 201 (i.e. command gesture) or a signal to enable pointer control by motion tracking (i.e. tracking gesture).

[0043] When a command gesture is detected, the gesture controller 209 evaluates the validity of the command gesture based on computer state, and the current position of the pointer. The valid command gesture is then translated into commands
10 that are sent to the OS API 211.

[0044] TABLE 1 below exemplifies relationships between command gesture and the computer state that may be adapted:

Command gestures	Computer state needed
Resize windows	A window is focused or pointer is hovering on a windows.
Grab window or file.	Pointer is hovering on a file or window.
Release window or file.	Pointer is hovering on a suitable place to place grabbed window or file.
Window content scrolling by eyes	A window is focused or pointer is hovering on a windows. Window content horizontal or vertical scroll is available.
Enable software keyboard and hid pointer	Pointer is hovering on a type-able area.
Control text cursor position with motion and gaze	Software keyboard mode enabled

TABLE 1: Examples of Command Gestures vs. Computer State Needed

[0045] It is understood that the examples in Table 1 is merely for illustration only, it is possible that computer state may change for different gestures commands according to the actual needs and applicable situations.

[0046] When a tracking gesture is detected, the gesture controller 209 produces
5 tracking gesture details to the OS API 211 and an enable or trigger signal to the pointer controller 208 to enable pointer control by the motion tracking. The pointer controller 208 then finds the shape point corresponding to the pointing gesture received from the shape point database received from the motion-tracking controller 206. The pointer controller 208 then maps the location of the shape point within the pre-defined PTA in
10 the motion tracking module 204 FOV to the AOI on screen and position the pointer at a corresponding location on the screen accordingly.

[0047] FIG. 3 illustrates a process for combining ocular and motion control in accordance with one embodiment of the present invention. This process is carried out by the system 200 of FIG. 2. At step 302, a COP is computed from the gaze data. At
15 step 304, an AOI is rendered based on the COP. At step 306, the pointer is moved to the COP. At step 308, the motion controller 206 monitors for any motion tracking gesture. At step 310, when a motion tracking gesture is detected, the pointer is moved to a location where the tracked object is associated at step 312. When no motion tracking gesture is detected at step 310, a command gesture from user will be received
20 at step 314. At step 316, the command gesture is checked for validity. When the command gesture is applicable (i.e. valid), the corresponding command gestures is executed on the operating system at step 318. Otherwise, the command gesture will be ignored at step 320.

[0048] FIG. 4 illustrates a flow diagram of a process for generating a computed-ocular-point from gaze data received from ocular tracking module in accordance with one embodiment of the present invention. In particular, the process includes a COP generation. In step 402, gaze data is received from hardware API, such as the ocular module API. The gaze data includes, but not limited to, eyes gaze location on screen, eyes gaze data validity level, distance of eyes from screen (or from the tracking module), and eyes ocular axis in sensor's FOV. At step 404, the gaze data is stored on a gaze data collection database 405. The data is stored at a pre-defined duration that approaches the user's response time (e.g. 200ms) so that overall ocular control interaction is not perceived as slow for the user. At step 406, the system checks if the gaze data is received at the pre-defined duration. If no data is received, the process returns to the step 402. If data is received, the gaze data is retrieved from the gaze data collection database 405 at step 408. At step 410, the gaze data is filtered based on its validity level and statistical analysis for outliers. At step 412, the filtered gaze data is then converted into coordinate points. The conversion determines the user's left and right eye positions relative to the screen. Offsets and correction factor may be added during the conversion. At step 414, the coordinate points are averaged out to obtain a COP. If multiple display units are utilised, the screen identification is included into the COP.

20 [0049] FIG. 5 illustrates a flow diagram of a process of computing and rendering AOI based on the COP in accordance with one embodiment of the present invention. At step 502, a COP is received or acquired from the ocular tracking module 203. At step 504, an AOI size is determined based on the COP value, equipment profile and settings, which can be acquired from the equipment profile and setting database

505. In one embodiment, it is known in the art that the AOI size can be adjusted at a bigger size to compensate decrease of accuracy in certain part of the screen (e.g. screen edge). In another embodiment, the AOI size can also be customised by the user as desired. The AOI size is directly proportional to the system workload when processing
5 motion control. It is important that a optimum AOI should take into account the accuracy of ocular control and motion control to provide interaction with lesser human effort.

[0050] While rendering the AOI size at the step 504, the equipment profile and settings may be taken from the ocular tracking module 203 and the motion tracking
10 module 204.

[0051] In another embodiment, user may manually configure parameters used to calculate AOI height and width. The modified parameters could be stored as part of user profile. It is known that the ocular tracking module 203 or device may comprise one or more eye tracker or tracking sensors. The accuracy level of the ocular tracking
15 module 203 can be based on the uncertainty of the ocular gaze angle, for example, ocular gaze angle uncertainty of less than or equal to about 0.5 degree, the accuracy level can be relatively high, and ocular gaze angle uncertainty of less than or equal to 1 degree may obtain only medium level of accuracy, whilst anything beyond 1 degree of the ocular gaze angle uncertainty generally gets low accuracy level.

20 [0052] Similarly, the motion-tracking module 204 may also include one or more motion trackers or tracking sensors. The accuracy level of the motion tracking module 204 depends on sensitivity of motion tracking. The sensitivity of the sensor is defined as

the minimum motion distance that the sensor can detect. In one given example, the sensitivity level of the motion tracking module 204 may be set as follows:

Accuracy level	Sensitivity
High	≤ 0.02 mm
Medium	≤ 0.2 mm
Low	> 0.2 mm

[0053] The effectiveness of motion tracking is, on the other hand, dependent on the percentage of instances the module is able to detect motion. The effectiveness level of the motion tracking module 204 can be set as follows:

Effectiveness level	Effectiveness
High	$\geq 90\%$
Medium	$\geq 50\%$
Low	$< 50\%$

[0054] Following the above, the accuracy of the module 204 may be rendered as follows:

		Effectiveness		
		High	Medium	Low
Accuracy	High	High	Medium	Medium
	Medium	Medium	Medium	Low
	Low	Medium	Low	Low

10 [0055] Through the above, the AOI size may be determined based on a lookup table as provided below:

		Eye tracking Accuracy		
		High	Medium	Low
Motion Tracking Accuracy	High	Medium	Medium	Small
	Medium	Big	Medium	Small
	Low	Big	Big	Medium

[0056] Following that, the AOI size level could be converted to user ocular view angle range based on the lookup table below:

AOI size level	User Ocular View Angle Range
Big	3 degree
Medium	6 degree
Small	9 degree

[0057] The AOI height in pixel could be calculated with following formula:

5 AOI height =
user Distance $\times$ tangent (Use Ocular View Angle Range) $\times$ screen pixel density

[0058] And the AOI width by default is 4/3 of the height for rectangular shaped AOI. It can be of other ratio such as on the screen aspect ratio.

[0059] Referring now to step 506 of FIG. 5, the AOI position is calculated
10 based on the COP. FIG. 6 illustrates the generation of the AOI in relation to the screen and COP. In the present embodiment, the AOI position can be rendered through the Formulae (1) and (2) as provided below:

$$[0060] \quad X_{AOI} = X_{COP} - \frac{h_{AOI}}{2} \quad (1)$$

$$[0061] \quad Y_{AOI} = Y_{COP} - \frac{w_{AOI}}{2} \quad (2)$$

15 [0062] where,

[0063] X_{AOI} = x-axis coordinate of AOI upper left corner;

[0064] X_{COP} = x-axis coordinate of COP upper left corner;

[0065] h_{AOI} = height of AOI;

[0066] Y_{AOI} = y-axis coordinate of AOI upper left corner;

[0067] Y_{COP} = y-axis coordinate of COP upper left corner; and

[0068] w_{AOI} = width of AOI.

[0069] At step 508, the AOI is offset according to a valid borders based on the
 5 screen settings 509. The AOI offset is calculated through the Formulae (3) and (4) as
 provided below:

$$[0070] \quad X'_{AOI} = \begin{cases} X_{AOI}, & X_{BorderLeft} \leq X_{AOI} \leq X_{BorderRight} \\ X_{BorderLeft}, & X_{AOI} < X_{BorderLeft} \\ X_{BorderRight} - w_{AOI}, & X_{AOI} > X_{BorderRight} \end{cases} \quad (3)$$

$$[0071] \quad Y'_{AOI} = \begin{cases} Y_{AOI}, & Y_{BorderTop} \leq Y_{AOI} \leq Y_{BorderBottom} \\ Y_{BorderTop}, & Y_{AOI} < Y_{BorderTop} \\ X_{BorderBottom} + h_{AOI}, & Y_{AOI} > Y_{BorderBottom} \end{cases} \quad (4)$$

[0072] X'_{AOI} = x-axis coordinate of actual AOI upper left corner;

10 [0073] $X_{BorderLeft}$ = x-axis coordinate of left (as relative to user) border of
 computer screen. This is usually value 0;

[0074] $X_{BorderRight}$ = x-axis coordinate of right (as relative to user) border of
 computer screen;

[0075] Y = y-axis coordinate of actual AOI upper left corner

15 [0076] $Y_{BorderLeft}$ = y-axis coordinate of upper (as relative to user) border of
 computer screen. This is usually value 0.

[0077] $Y_{BorderRight}$ = x-axis coordinate of bottom (as relative to user) border of computer screen.

[0078] As noted above in conjunction with illustrations in FIG. 6, it will be appreciated that the present invention is applicable on an irregular non-rectangular screen size with different top, right, bottom, and left borders. In the embodiments of the present invention, it is desired that the screen settings 509 is being monitored, computed and stored accordingly to cater for different screen configurations.

[0079] Once the AOI is computed, at step 510, the AOI is drawn on the display screen for user's reference. The AOI may be presented in different appearances of UI overlays based on data accuracy and user preference.

[0080] FIG. 7 is a flow diagram illustrating a process of translating the position of a tracked object in PTA onto the AOI in accordance with one embodiment of the present invention. At step 702, an enable signal is generated along with a tracking gesture type by the gesture controller 209. The enable signal is sent to pointer controller 208 to enable motion tracking for pointer positioning. The tracking gesture type allows the pointer controller to select a corresponding shape point. At step 704, the latest stored shape points list and PTA details are obtain from a database 705, which can be stored on the motion tracking controller. At step 706, the detected tracking gesture is used to find and match a desired shape point. At step 708, if no desire shape point is found, the process returns to the step 704 to wait for a new list of shape point. If a desire shape point is found at the step 708, at step 710, latest stored AOI details is obtained through AOI controller 207 from the AOI database 711. The AOI details are pre-stored on AOI database 711. At step 712, the pointer position is calculated. For

better illustrations, **FIGs. 8A** and **8B** that illustrate the screen with reference to the AOI and the FOV with reference to the PTA are provided. The pointer position is calculated as shown in the Formulae (5) and (6) as illustrated below:

[0081]
$$X_P = \frac{X_{Obj} - X_{PTA}}{h_{PTA}} \times h_{AOI} + X_{AOI} \dots\dots (5)$$

5 [0082]
$$Y_P = \frac{Y_{Obj} - Y_{PTA}}{w_{PTA}} \times w_{AOI} + Y_{AOI} \dots\dots (6)$$

[0083] where,

[0084] X_P = x-coordinate of pointer on computer screen;

[0085] X_{Obj} = x-coordinate a specific point on the tracked object depending on the shape of the object in the PTA;

10 [0086] X_{PTA} = x-coordinate of the upper left corner of PTA;

[0087] h_{PTA} = height of PTA;

[0088] h_{AOI} = height of AOI;

[0089] X_{AOI} = x-coordinate of AOI on screen;

[0090] Y_P = y-coordinate of pointer on computer screen;

15 [0091] Y_{Obj} = y-coordinate a specific point on the tracked object depending on the shape of the object in the PTA;

[0092] Y_{PTA} = y-coordinate of the upper left corner of PTA;

[0093] w_{PTA} = width of PTA;

[0094] w_{AOI} = width of AOI;

[0095] Y_{AOI} = y-coordinate of AOI on screen.

[0096] Once the pointer position is calculated based on the tracked gesture, the pointer is positioned at its corresponding location within AOI at step 714. Depending on
5 the gesture type, the pointer appearance may be changed, as the pointer is located according to the computer interface, at step 716.

[0097] FIGS. 9A-9K depict sequence of human-computer interaction utilizing the system and method of the above embodiments in accordance with the present inventions. As shown in FIG. 9A, as the user is gazing on the screen, an AOI 902 is
10 rendered. The pointer 901 is also moved from its original position to its new position within the AOI 902 according to the detected user's gaze. Preferable, the AOI 902 is a visible boundary to the user. Once the AOI 902 is presented, as shown in FIG. 9B, as the user rises one of his hands, a PTA 904 is formed within a FOV 906. The FOV 906 is limited by the hardware configurations of the ocular and motion-tracking device. The
15 PTA 904 boundary and position is defined based on the AOI 902. As shown in FIG. 9C, as the user's hand is moving within the PTA 904, the pointer 901 moves accordingly within the AOI 902. It is to be noted that the AOI 902 remains static in position as the pointer moves within the AOI 902.

[0098] As shown in FIG. 9D, the user raises the other hand as a gesture
20 command to fix the AOI 902 in place. As shown in FIG. 9E, the other hand that fixes the position of AOI 902 may further grasp his fingers as a grab gesture command to further fix the AOI 902. It accordingly disables the gaze control, and passes over the control of the AOI 902 to the other hand with the grab gesture as shown in FIG. 9F.

User may then interact with any GIU, such as window **908**, that falls within the AOI **902** with his right hand. For example, the user may move the window **908** to its new locations **908'** as the right hand is moving. The window **908** can be moved as far as the right hand is within the PTA **904**. If the right hand moves beyond the boundary of PTA **904**, the window **908** stops moving. As shown in **FIG. 9G**, the user may disable pointer tracking gesture, so that the window can be moved according to a gaze point **912**. To move the window **908** to user's gaze point **912**, the user simply needs to move his hand out of the FOV **906**.

[0099] As shown in **FIG. 9I**, as the window **908** is moved to its new position **908'**, the AOI **902** also moves to its new location. Similarly, the PTA **904** will be recomputed to correspond to the new AOI **902** location. As shown in **FIG. 9J**, the user right hand may rise again within the PTA **904** to disable the gaze control and the pointer will again change its position to correspond to the right movements. As shown in **FIG. 9K**, user releases the window from the "click-and-drag" mode by opening his hand so that he may again interact with the UI within AOI **902** as described above.

[00100] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations, and combinations thereof could be made to the present invention without departing from the scope of the invention.

CLAIMS

1. An ocular and motion controller system (200) for controlling interaction between a Graphical User Interface (GUI) and a user, wherein the GUI is displayed on one or more display screens (102), the system (200) comprising:
- 5 an ocular tracking module (203) for capturing gaze data of the user's gaze;
- an ocular tracking controller (205) operationally receiving the gaze data from the ocular tracking module (203) to compute a Computed Ocular Point (COP);
- an Area of Interest (AOI) controller (207) operationally receives the COP from the ocular tracking controller (205) to render an AOI (104);
- 10 a pointer controller (208) operationally position a pointer of the GUI on the screen (102);
- a motion tracking module (204) for capturing gestures of the user;
- a motion tracking controller (206) for receiving gestures falls within a Pointer-Tracking-Area (PTA) of the motion tracking module (204) to detect a tracked object,
- 15 wherein the PTA is determined based on the AOI (104); and
- a gesture controller (209) for receiving the tracked object to extract command gesture therefrom, wherein operationally, the command gestures is extracted based on the pointer position and a computer state, wherein the gesture controller (209) enables a motion control on the pointer controller (208) to reposition the pointer according to a
- 20 location of the tracked object determined within a Field-of-View (FOV) of the motion tracking module (204), wherein the user fixes a position of the AOI with one command gesture in order to disable the gaze control, which allows another command gesture to interact with the GUI within the AOI.

2. An ocular and motion controller system (200) according to claim 1, wherein ocular tracking controller (205) is adapted for computing the COP based on the gaze data detected by the ocular tracking module (203) within a predefined period, all the gaze data taken within the predefined period are stored on a gaze database, the gaze data
5 are filtered based on the validity of the detected command gestures, the filtered gaze data are converted into a plurality of coordinate points in associating to the screen information (210) and are averaged accordingly to obtain the COP.

3. An ocular and motion controller system (200) according to claim 1, wherein
10 ocular tracking controller (205) further determines an AOI size based on COP value, an equipment profile and program setting stored on the ocular tracking module (203) in order to offset the AOI according to a valid screen border values of the screen, thereby displaying the AOI on the screen.

15 4. An ocular and motion controller system (200) according to claim 1, wherein the gesture controller (209) is further adapted for generating an enabler signal to enable the pointer controller (208) and processes a type of gestures to match for an intended command gesture with a shape point database to obtain a shape point.

20 5. An ocular and motion controller system (200) according to claim 4, wherein the pointer is repositioned based on a current AOI and the shape point for interacting with the UI according to the gesture command.

6. An ocular and motion controller system (200) according to claim 1, wherein
25 when the pointer controller (208) is enabled by the gesture controller (209), gaze data

from the ocular tracking controller (205) is ignored and the pointer movement and interaction with the GUI is controlled by the motion tracking controller (206).

7. A method for interacting with a graphical user interface (GUI) displaying on one or more display screens (102) of a computer (100), the computer has an ocular tracking module (203) and a motion tracking module (204), the method comprising:
- receiving gaze data through the ocular tracking module (203) to compute a Computed-Ocular-Point (COP);
- rendering an Area-of-Interest (AOI) (104) based on the COP;
- positioning a pointer of the GUI to a position on the screen (102) correspond to the COP;
- monitoring gestures captured by the motion tracking module (204) that falls within a Pointer-Tracking-Area (PTA) of the motion tracking module (204), wherein the PTA is determined based on the AOI (104),
- detecting a tracked object from the gestures that fall within the PTA to extract command gestures therefrom;
- determining validity of the detected command gestures based on the pointer position and the computer state detected by the motion tracking module (204); and
- re-positioning the pointer according to a location of the tracked object determined within a Field-of-View (FOV) of the motion tracking module (204).

8. A method according to claim 7, wherein computing the COP further comprising:
- receiving gaze data from the ocular tracking module (203) taken within a predefined period;
- storing all the gaze data taken within the predefined period;

filtering the gaze data based on the validity of the detected command gesture;
converting respective gaze data into a plurality of coordinate points in
associating to the screen; and
averaging the coordinate points and output the averaged result as the COP.

5

9. A method according to claim 7, wherein computing the COP further comprising:
determining AOI size based on COP value, an equipment profile and program
setting stored on the ocular tracking module;

offsetting AOI according to a valid screen border values of the screen; and

10 displaying the AOI on the screen.

10. A method according to claim 7, wherein positioning the pointer according to
location of tracked object, further comprising:

receiving an enabler signal to enable a pointer controller, and processing a type
15 of gesture;

matching the type of gesture with a shape point database to obtain an intended
command gesture to obtain a shape point;

calculating a new pointer position based on current AOI and the shape point;

re-positioning the pointer at the shape point; and

20 interacting the UI according to the gesture command.

11. A method according to claim 10, wherein when the pointer controller (208) is
enabled by the gesture controller (209), gaze data from the ocular tracking controller
(205) is ignored and the pointer movement and interaction with the UI is controlled by
25 the gesture detected by the motion tracking controller (206).

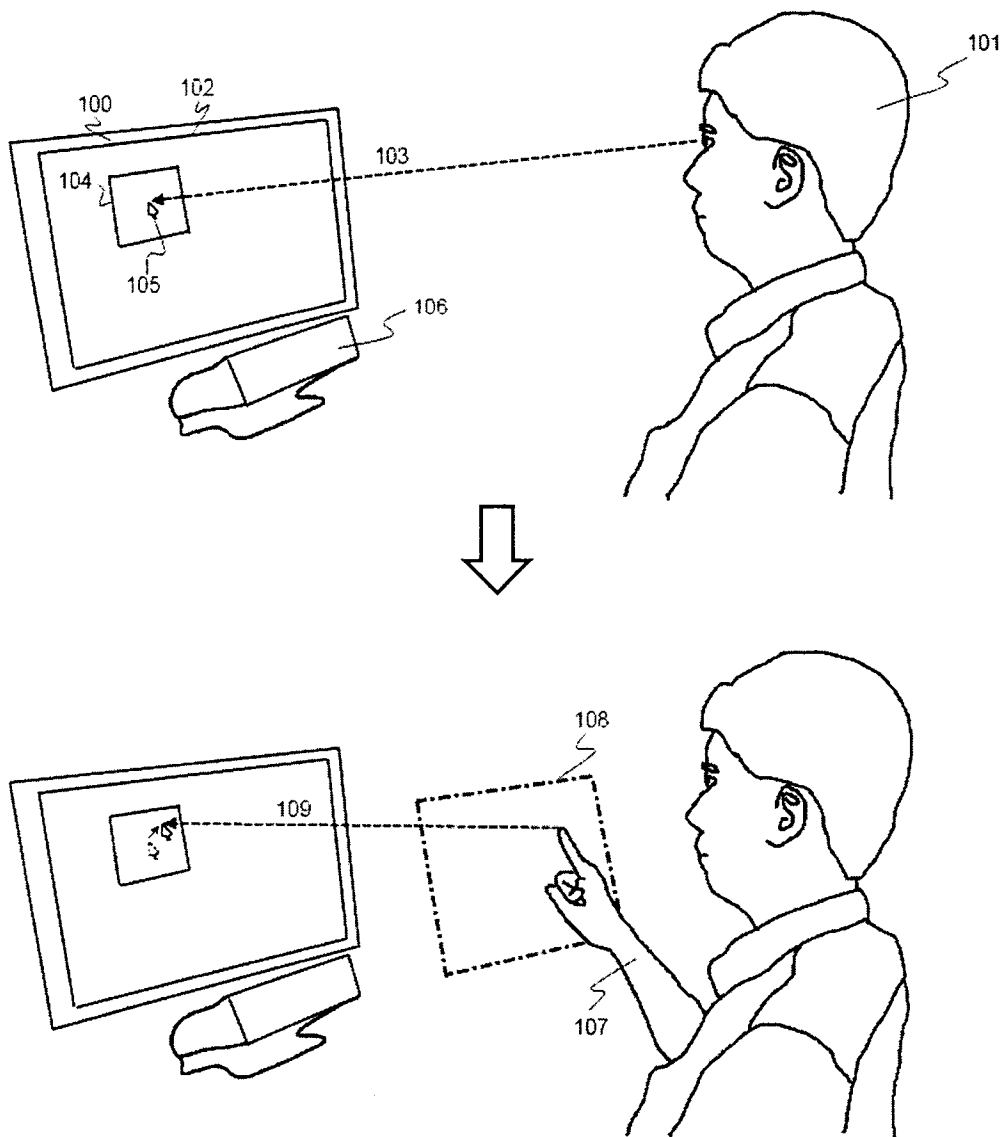


FIG. 1

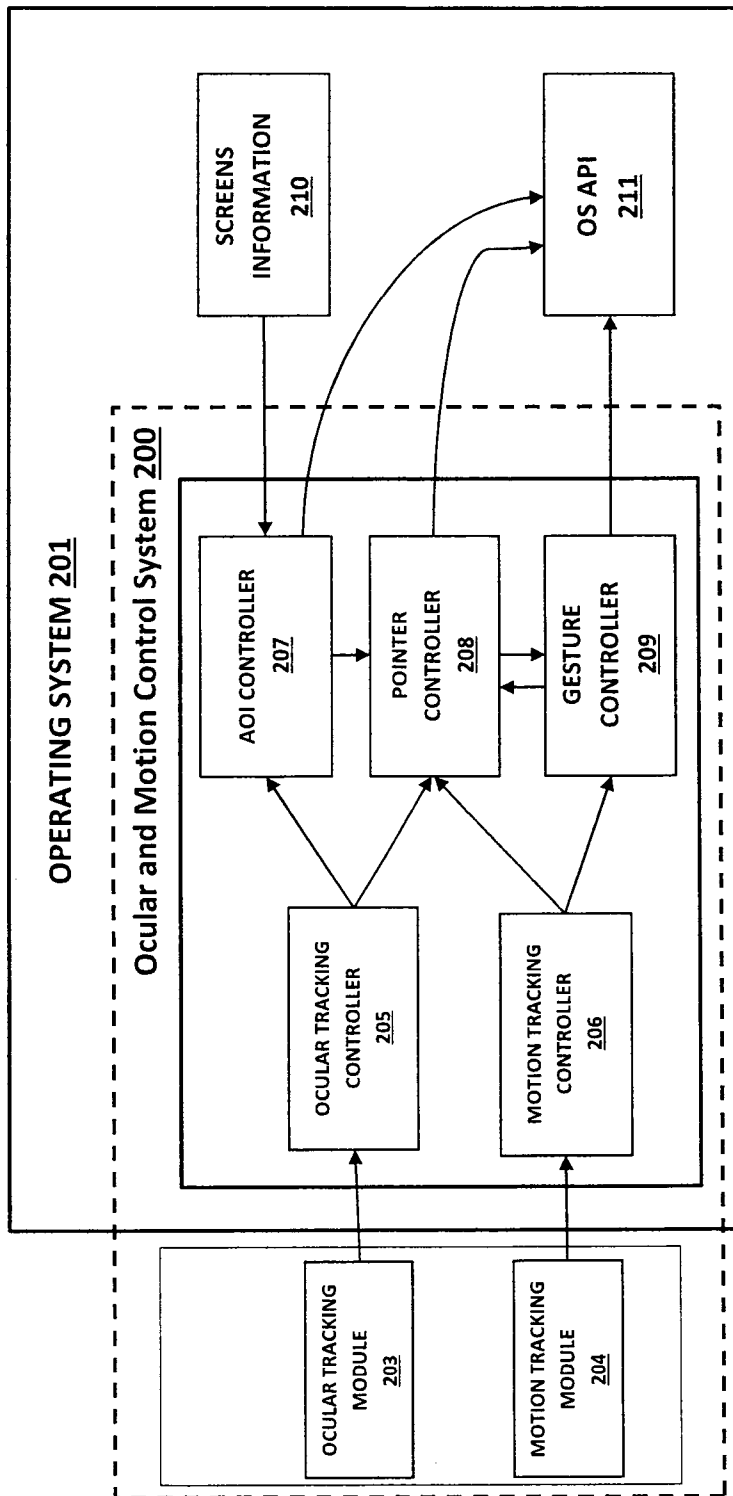


FIG. 2

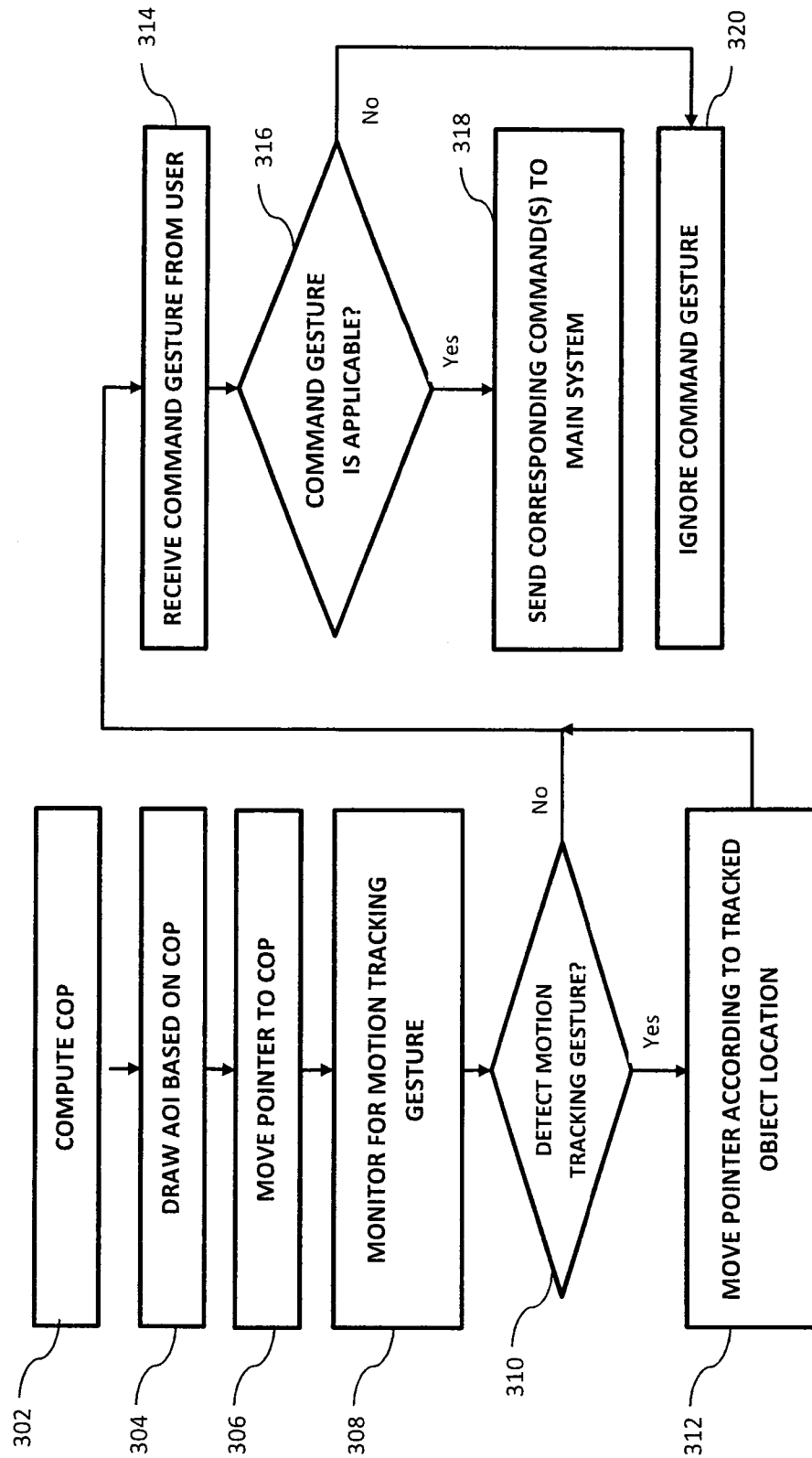
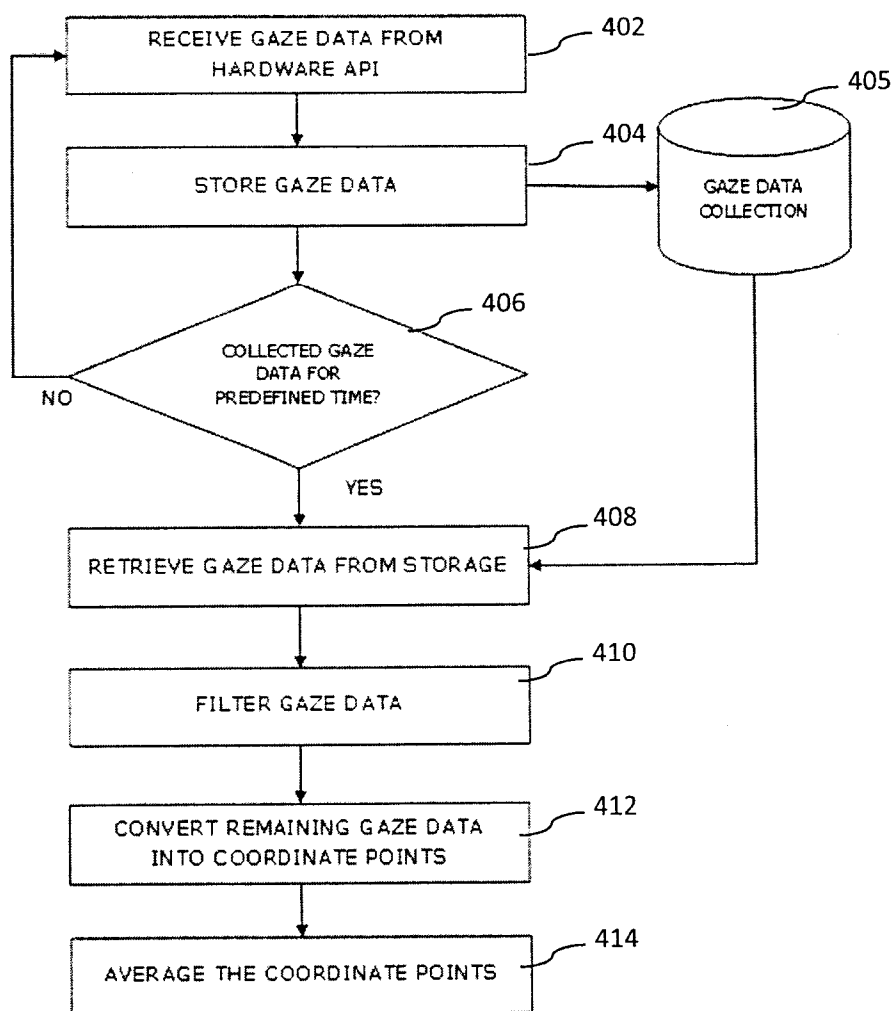


FIG. 3

**FIG. 4**

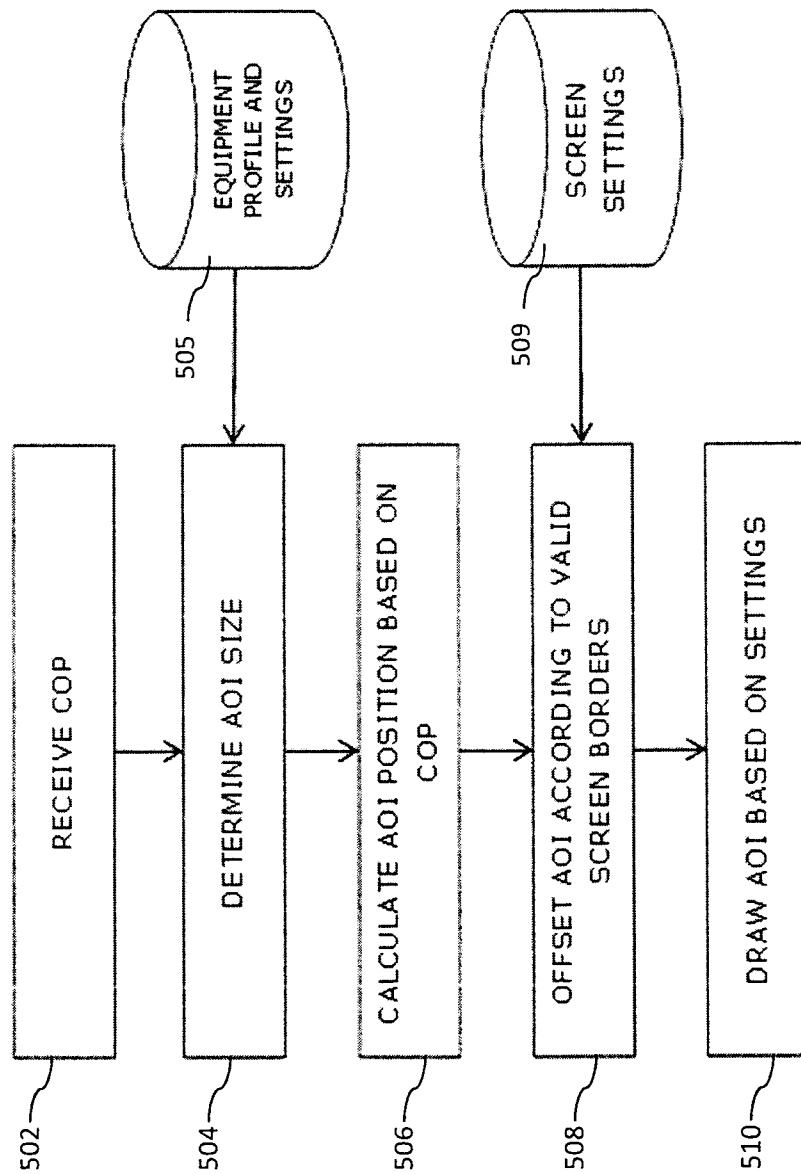


FIG. 5

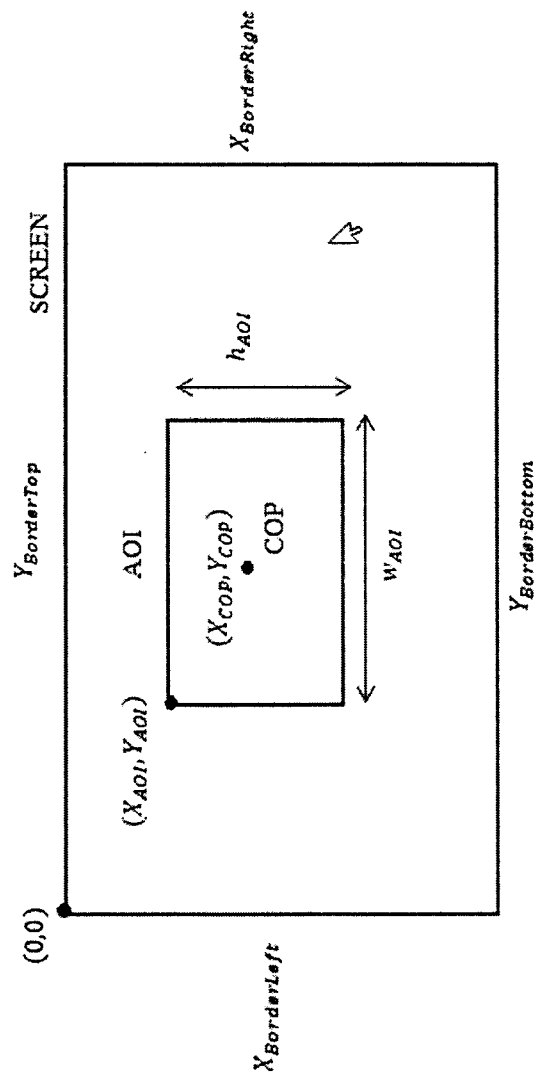


FIG. 6

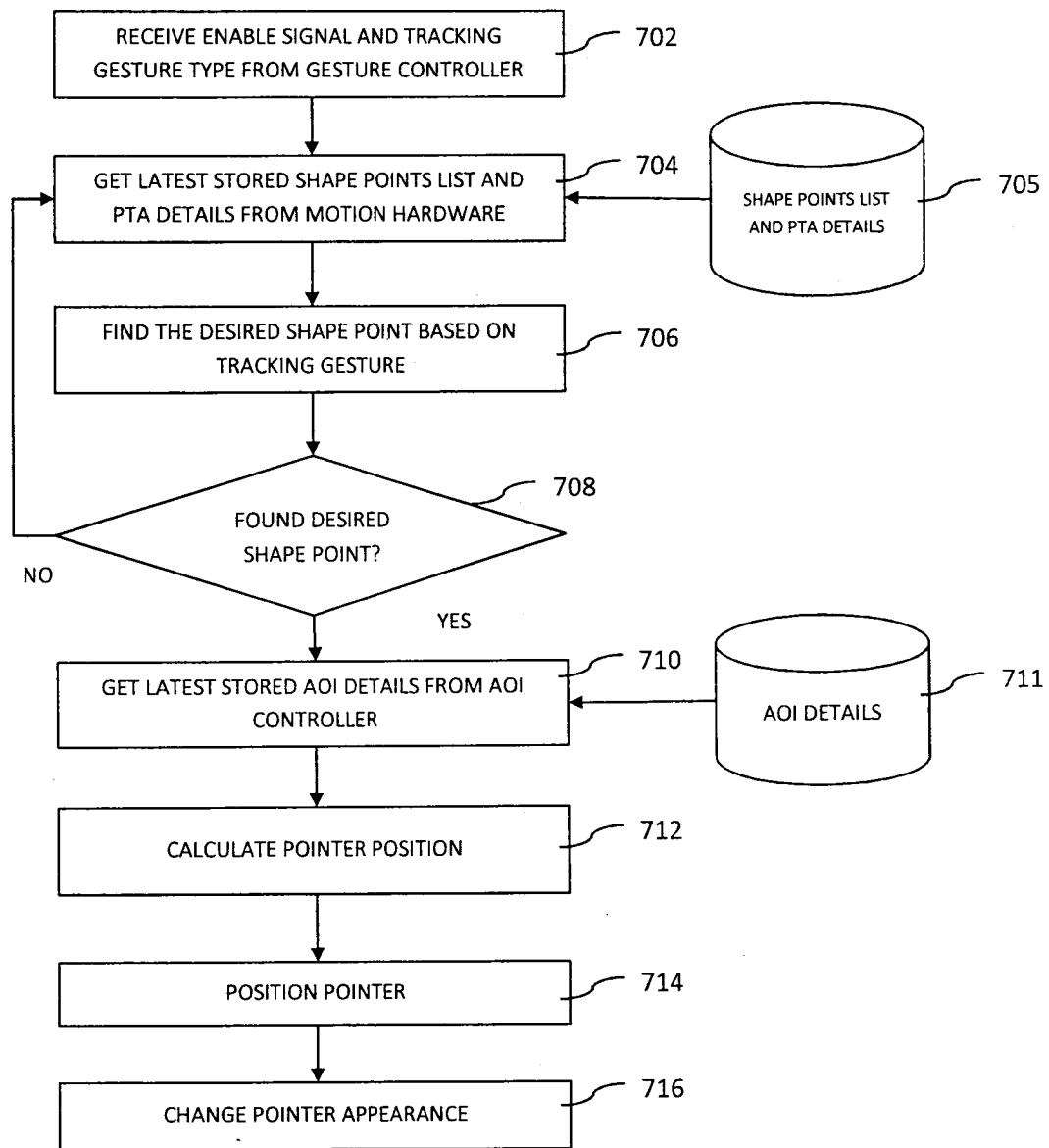


FIG. 7

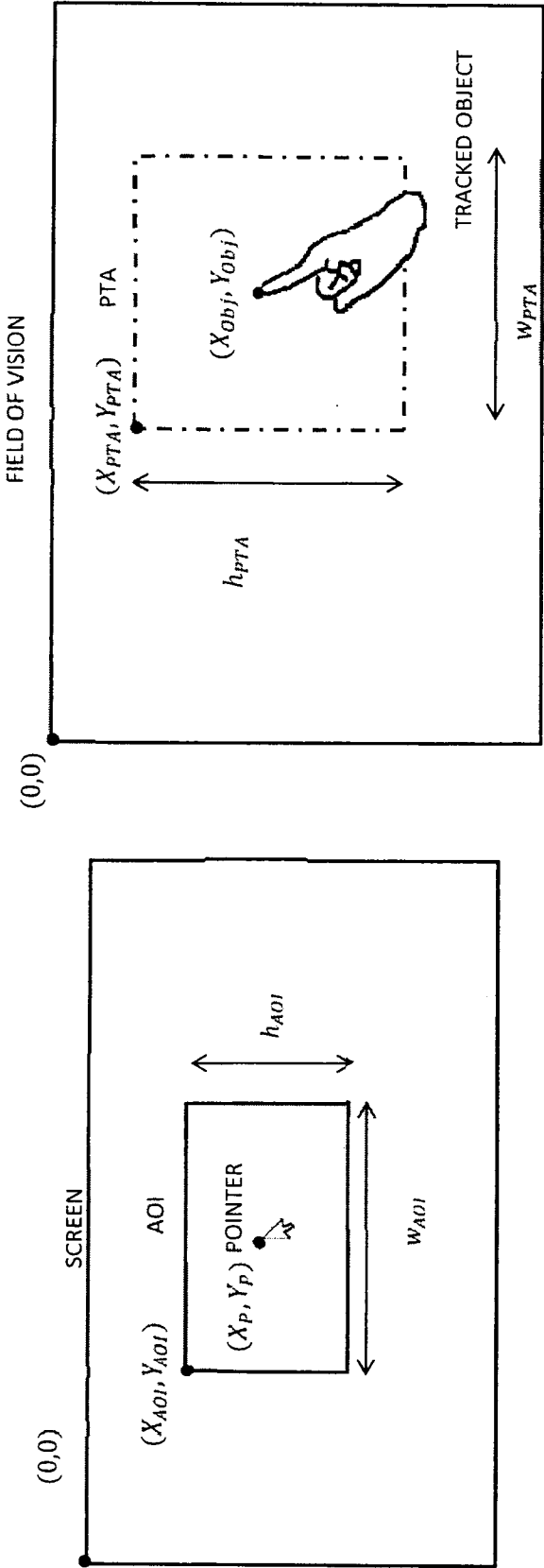


FIG. 8A

FIG. 8B

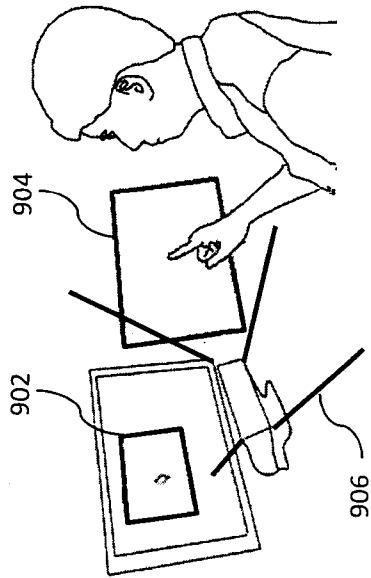


FIG. 9B

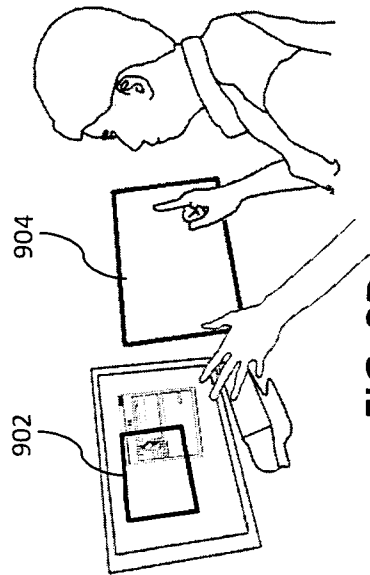


FIG. 9D

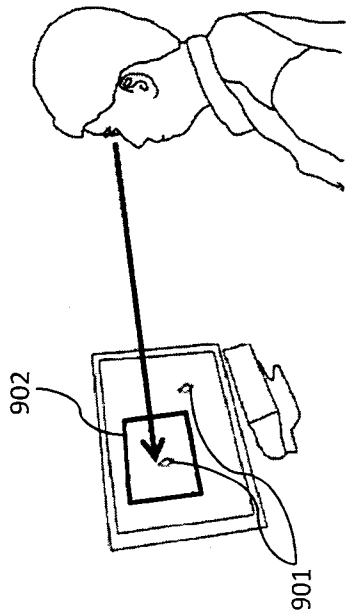


FIG. 9A

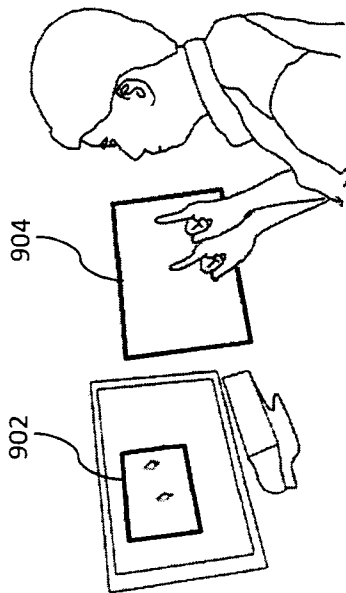
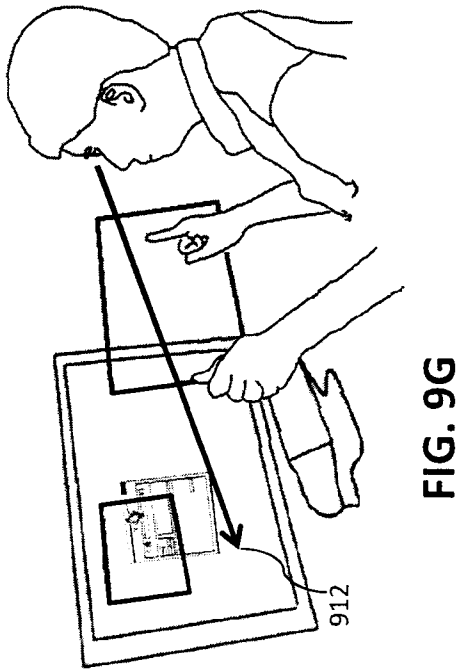
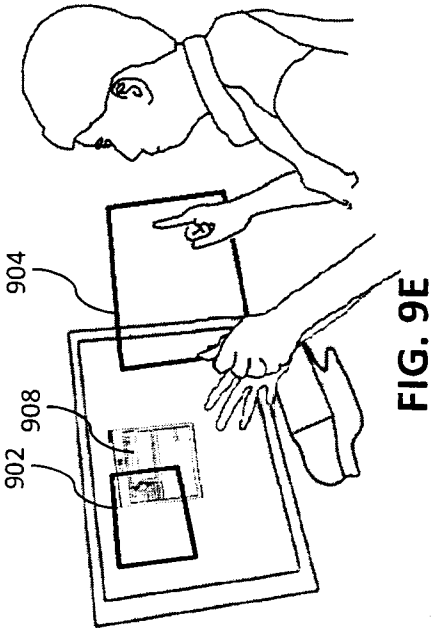
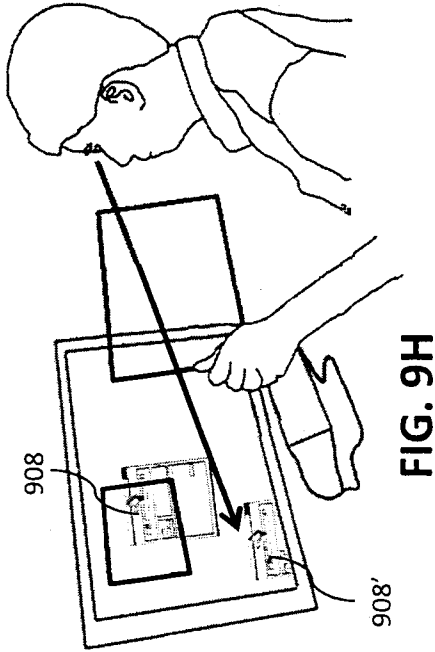
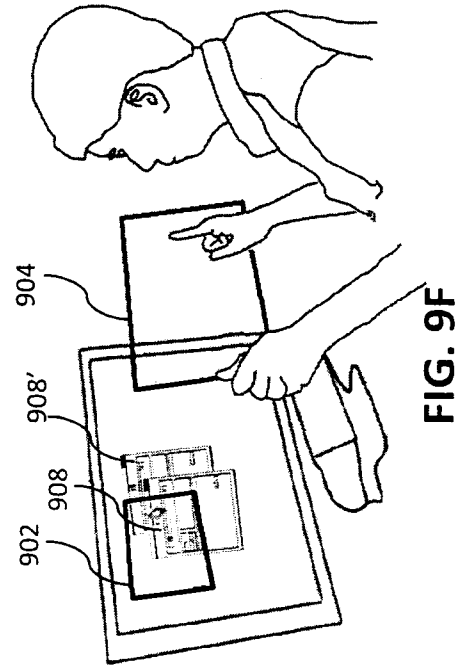


FIG. 9C



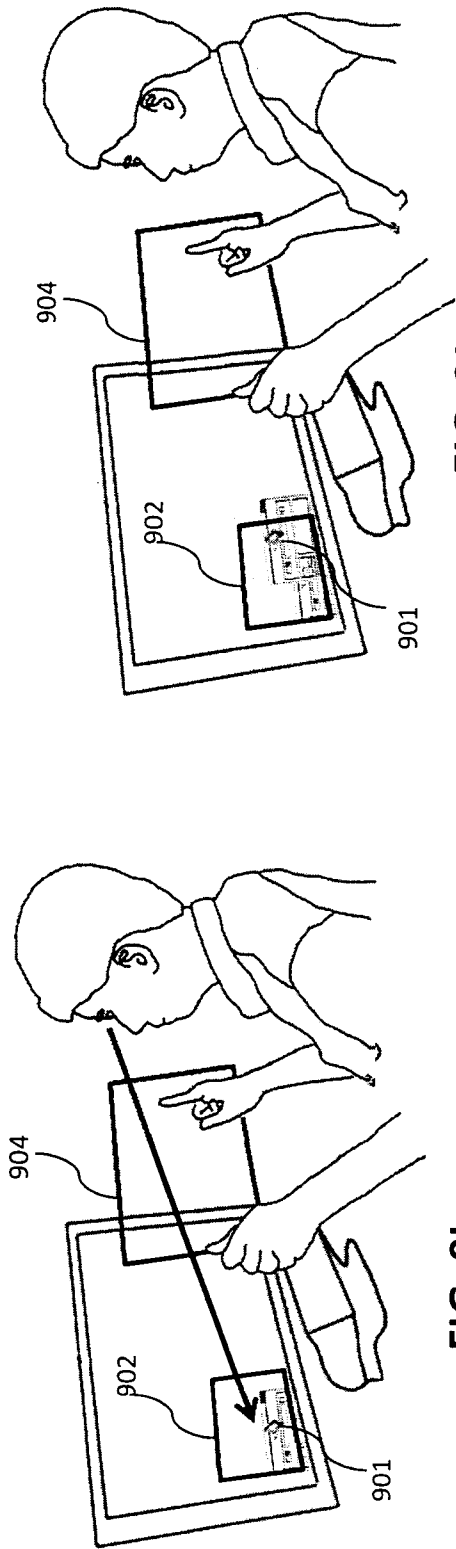


FIG. 9J

FIG. 9I

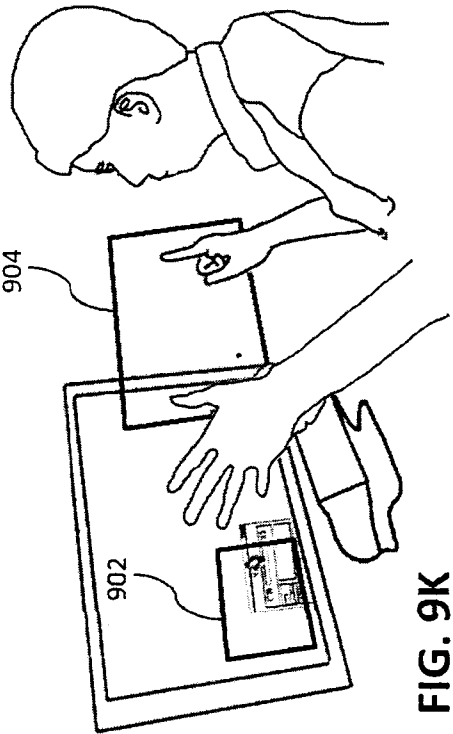


FIG. 9K

INTERNATIONAL SEARCH REPORT

 International application No.
PCT/MY2015/000017

A. CLASSIFICATION OF SUBJECT MATTER

G06F 3/01 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI, INSPEC- IPC, CPC (G06F 3/), Keywords (eye, gaze, control, pointer, gesture, detect, human computer interaction, GUI) and similar terms

GOOGLE PATENTS- Keywords same as above

GOOGLE PATENTS, ESPACENET, AUSPAT, Internal databases provided by IP Australia- Applicant/Inventor name search

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 2 July 2015	Date of mailing of the international search report 02 July 2015
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustalia.gov.au	Authorised officer Pradnya Satarkar AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832028

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/MY2015/000017
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/015521 A1 (NOKIA CORPORATION) 30 January 2014 Abstract, page 4 lines 2-5, page 6 lines 15-28, page 7 lines 3-12, 24-27, 31-36, figure 2	1-11
A	WO 2012/082971 A1 (SIEMENS CORPORATION) 21 June 2012 Abstract, Figure 8	1-11

INTERNATIONAL SEARCH REPORT Information on patent family members		International application No. PCT/MY2015/000017	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
WO 2014/015521 A1	30 January 2014	CN 104428732 A	18 Mar 2015
		EP 2877909 A1	03 Jun 2015
WO 2012/082971 A1	21 June 2012	CN 103443742 A	11 Dec 2013
		KR 20130108643 A	04 Oct 2013
		US 2013154913 A1	20 Jun 2013
End of Annex			
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001. Form PCT/ISA/210 (Family Annex)(July 2009)			