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Gaze assisted input for an electronic device

Abstract

A computer implemented method and system for gaze-assisted input that includes displaying a plurality of display elements in a display space, tracking a user's point of gaze within the display space, receiving a speech input, identifying one of the plurality of display elements as a subject display element for the speech input based on the tracking, and automatically performing an action based on the subject display element and the speech input.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This is the first application for this disclosure.

BACKGROUND

(2) A person's eye movement is closely linked to his or her attention, behavior and cognition. Gaze estimation, a computer vision task which locates what a person is looking at, has received significant interest in recent years. Gaze estimation has been widely applied, especially in human-computer interaction. State-of-the-art gaze estimation can achieve high accuracy and precision (with angular error about 1°)

(3) Gaze estimation can, for example, be applied to estimate an (2D) x,y coordinate of a display as the location of a user's gaze, with the estimated location used as a basis for a user input. Typically, gaze estimation input for user interface applications require some bounding rectangle, such as a window, button or icon to be displayed on the screen of a device. In early applications, such devices were typically computer monitors, but more recently mobile devices, tablets, and AR/VR headsets also feature eye tracking.

(4) One class of scenarios for gaze estimation input in user interfaces is analogous to the point and click of a mouse, or touch of a finger on a touchscreen: a (calibrated) x,y coordinate is obtained from an eye tracker and made relative to a current screen or window. This coordinate is then mapped within a representation of the interactive element, for example a button. One of the problems of gaze estimation based point and click solutions is knowing when the user would like to execute a click (e.g., trigger a functionality associated with a region of interest). Several methods have been proposed to simulate the click of a mouse with the eyes, including the use of blinks (which is inadvisable because it involves closing the eye).

(5) Another method involves the trigger of the functionality after a defined gaze dwell time. Programmatically, a dwell time period is defined that determines how long the user must look at a region of interest for an action to take place. After expiry of the dwell time, a trigger associated with the functionality of the interactive element sends an event to a user interface (UI) event processing loop, which executes a method or function to execute the associated functionality. During the dwell time, an animation may provide feedback to the user that they are about to trigger the functionality associated with the region of interest.

(6) The problem with the use of dwell time is that if it is too short, the system would be overly responsive, producing a click every time the user looks at a region of interest. However, if the dwell time is too long, the system appears unresponsive.

(7) A similar point and click scenario can be played out in AR/VR applications. Here, the 2D coordinate of a gaze estimation input is matched to a 3D object displayed on a head mounted display (HMD). This object can then, after a defined gaze dwell time, trigger some kind of action in the virtual environment.

(8) A second method for detecting a "click input" is to have some other modality provide the click that triggers functionality. This other modality can take the shape of a physical button. Here, the user looks at the region of interest, and then presses a key on a keyboard or remote control.

(9) In the context of smart phones and tablet devices, gaze estimation has typically been limited to determining if a user is looking at a display or not, rather than any particular region of interest of the display.

(10) There is a need for improved gaze estimation solutions that can be applied to commonly available hardware devices.

BRIEF SUMMARY

(11) According to example implementations, the present disclosure describes a number of user interface techniques that utilize eye input in the form of an x,y Point-of-Gaze coordinate (POG) to trigger functionality on an electronic device. Processes to disambiguate between intentional and non-intentional voice commands by redundant coding of the command in the label of the user interface element are also disclosed.

(12) According to a first example aspect, a computer implemented method is disclosed that includes: displaying a plurality of display elements in a display space; tracking a user's point of gaze within the display space; receiving a speech input; identifying one of the plurality of display

- elements as a subject display element for the speech input based on the tracking; and automatically performing an action based on the subject display element and the speech input.
- (13) In some examples, tracking the user's point of gaze comprises determining coordinates for the user's point of gaze within a coordinate system of the display space.
- (14) In one or more of the preceding examples, a gaze region is determined within the display space based on the determined coordinates for the user's point of gaze, wherein the gaze region encompasses the user's point of gaze and a surrounding region of the display space.
- (15) In one or more of the preceding examples, identifying the subject display element is based on a predetermined minimum threshold spatial overlap between the gaze region and a sub-region of the display space occupied by the subject display element for a predetermined minimum threshold time of the speech input.
- (16) In one or more of the preceding examples, the method is performed by a first electronic device and the subject display element is a GUI element that represents a further device that is associated with the first electronic device, the method including: extracting a command from the speech input, and automatically performing the action comprises transmitting the command, using a network interface of the first electronic device, for processing by the further device.
- (17) In one or more of the preceding examples, the method includes causing the GUI element to move in the display space in response to motion of one or both of the further device or the first electronic device.
- (18) In one or more of the preceding examples, the subject display element corresponds to an application, and the method includes: extracting text from the speech input, and wherein automatically performing the action includes providing the extracted text for processing by the application.
- (19) In one or more of the preceding examples, the subject display element corresponds to a remotely hosted service, and the method includes: extracting a text search query or text prompt from the speech input, and automatically performing the action includes automatically providing the extracted text search query or text prompt via a communication network to the remotely hosted service and receiving a corresponding response from the remotely hosted service.
- (20) In one or more of the preceding examples, the subject display element corresponds to a word displayed in a text display field, and the method includes: extracting a replacement word from the speech input, and wherein automatically performing the action comprises replacing the word displayed in the text display field with the replacement word or phrase.
- (21) In one or more of the preceding examples, subject display element includes indicia indicating a meaning, and the method includes extracting a command from the speech input, and automatically performing the action includes comparing the extracted command to the meaning indicated by the indicia and causing an activity corresponding to the extracted command to be performed only when the extracted command matches the meaning indicated by the indicia.
- (22) According to a further example aspect is a computing system that includes one or more processors; and one or more memories storing instructions that, when executed by the one or more processors, configure the computing system to perform any one of the methods of preceding examples.
- (23) According to a further example aspect is a non-transitory computer-readable storage medium, the computer-readable storage medium including instructions that when executed by a computing system, cause the computing system to perform any one of the methods of preceding examples.
- (24) According to a further example aspect is a computer program product that stores instructions that when executed by a computing system, cause the computing system to perform any one of the methods of preceding examples.

Description

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

- (1) To easily identify the discussion of any particular element or act, the most significant digit or digits in a reference number refer to the figure number in which that element is first introduced.
- (2) FIG. 1 is a block diagram illustrating an example of an apparatus which may be used to implement examples of the present disclosure.
- (3) FIG. 2 illustrates an example of a gaze-assisted input event for directing a speech input to a remote device that is represented by a display element a display space of an electronic device in accordance with one embodiment.
- (4) FIG. 3 illustrates an example of a gaze-assisted input event for directing a speech input to a remote device that is represented by a moving display element in a display space in accordance with one embodiment.
- (5) FIG. 4 illustrates a further example of a gaze-assisted input event for directing a speech input to a remote device that is represented by a moving display element in a display space in accordance with one embodiment.
- (6) FIG. 5 illustrates an example of a gaze-assisted input event for directing a speech input to an application that is represented by a display element in a display space in accordance with one embodiment.
- (7) FIG. 6 illustrates an example of a gaze-assisted input event for confirming a speech input made in respect of a display element in a display space in accordance with one embodiment.
- (8) FIG. 7 illustrates an example of a gaze-assisted input event for correcting an error in accordance with one embodiment.
- (9) FIG. 8 illustrates a routine **800** in accordance with one embodiment.

DETAILED DESCRIPTION

(10) Example embodiments will now be described more fully hereinafter with reference to the accompanying drawings. The features and aspects presented in this disclosure may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Where possible, any terms expressed in the singular form herein are meant to also include the plural form and vice versa, unless explicitly stated otherwise. In the present disclosure, use of the term “a,” “an”, or “the” is intended to include the plural forms as well, unless the context clearly indicates otherwise. Also, the term “includes,” “including,” “comprises,” “comprising,” “have,” or “having” when used in this disclosure specifies the presence of the stated elements, but do not preclude the presence or addition of other elements.

(11) As used herein, statements that a second item (e.g., a signal, value, process, operation, or action) is “based on” a first item can mean that characteristics of the second item are affected or determined at least in part by characteristics of the first item. The first item can be considered an input to an operation or process, or a series of operations or processes that produces the second item as an output that is not independent from the first item.

(12) FIG. 1 is a block diagram illustrating a simplified example implementation of an Apparatus **142** that includes a computing system **100** and related components that are suitable for implementing embodiments described herein. For example, Apparatus **142** can be used in some examples to implement the Electronic device **204** described below. Examples of the present disclosure may be implemented in other computing systems, which may include components different from those discussed below.

(13) Although FIG. 1 shows a single instance of each component, there may be multiple instances of each component in the computing system **100**. Further, although the computing system **100** is illustrated as a single block, the computing system **100** may be a single physical machine or electronic device (e.g., implemented as a single computing device, such as a single workstation, single end user device, single server, etc.), and may include mobile communications devices (smartphones), laptop computers, tablets, desktop computers, vehicle driver assistance systems,

smart appliances, wearable devices, assistive technology devices, virtual reality devices, augmented reality devices, Internet of Things (IoT) devices and interactive kiosks, among others.

(14) Computing System **102** includes at least one Processor **104**, such as a central processing unit, a microprocessor, a digital signal processor, an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), a dedicated logic circuitry, a dedicated artificial intelligence processor unit, a graphics processing unit (GPU), a tensor processing unit (TPU), a neural processing unit (NPU), a hardware accelerator, or combinations thereof.

(15) The computing system **100** may include one or more input/output (I/O) Interfaces **106**, which may enable interfacing with Input Devices **134** and/or Output Devices **140**. In the example shown, the Input Devices **134** can include devices requiring physical user contact (e.g., a keyboard, a touchscreen, a keypad, and a Pointing Device **136**). In the present disclosure, a “pointing device” can refer to: a human-computer interface device that enables a user to input spatial data to a computer. In examples, a pointing device may be a handheld input device, including a mouse, a touch pad, a touch screen, a stylus, a joystick, or a trackball, among others. In examples, a pointing device may be used to control a cursor or a pointer in a graphical user interface (GUI) for pointing, moving or selecting displayed GUI elements such as text or objects on a display, among others. In examples, spatial data may be continuous and/or multi-dimensional data.

(16) Input Devices **134** can also include contactless input devices that do not require physical user contact to effect user input such as a Camera **126** and Microphone **130**. In the present disclosure, contact-free input or contactless input can refer to a user input to an electronic device that does not require a user to physically interact with a pointing device to select a display element (e.g., a contact-free input can be, but is not limited to a voice command, a mid-air gesture or body movement, inertial measurement unit (IMU) based tracking of overall motion of a device.)

(17) In the example shown, the Output Devices **140** can include a Display **118**, among other output devices (e.g., a speaker and/or a printer). In some example, some or all of Input Devices **134** and Output Devices **140** may be physically integrated into a common device with the Computing System **102**, such as in the case of a smart phone. In other examples, some or all of Input Devices **134** and Output Devices **140** can be housed separately from components of Computing System **102**. For example, Computing System **102** could comprise a video streaming box, connected to a video projector that projects images onto a passive Display **118**, with Camera **126** positioned adjacent to and facing outward from the Display **118**.

(18) The computing system **100** may include one or more Network Interfaces **108** for wired or wireless communication with other computing systems (e.g., other computing systems in a network connected via a Wireless Network Interface **138**). The Network Interfaces **108** may include interfaces for wired links (e.g., Ethernet cable) and/or wireless links (e.g., WiFi, Bluetooth, Cellular Data Networks) for intra-network and/or inter-network communications.

(19) The computing system **100** includes one or more Memories **110** (collectively referred to as “Memory **110**”), which may include a volatile or non-volatile memory (e.g., a flash memory, a random access memory (RAM), and/or a read-only memory (ROM)). The non-transitory Memory **110** may store software in the form of Instructions **114** for execution by the Computing System **102**, along with supporting Data **116**, such as to carry out examples described in the present disclosure. The Instructions **114** can include instructions for implementing an Operating System **112** and other Applications **120** or functions. In the illustrated example, the Operating System **112** includes Modules **132** that are used to process user inputs and route instructions based on such inputs to appropriate Applications **120**. In the present disclosure, a “module” can refer to a combination of a hardware processing circuit and machine-readable instructions (software and/or firmware) executable on the hardware processing circuit. A hardware processing circuit can include any or some combination of a microprocessor, a core of a multi-core microprocessor, a microcontroller, a programmable integrated circuit, a programmable gate array, a digital signal processor, or another hardware processing circuit. In some examples, “module” can refer to a

hardware processing circuit that is configured to perform a specific function. For example, Modules **132** can include modules for implementing a gaze assisted inputs according to the present disclosure, for example, Gaze Tracker **122**, Speech-To-Text Conversion **124** and Gaze/Speech Combiner **128**

(20) In some examples, the Computing System **102** may also include one or more electronic storage units (not shown), such as a solid state drive, a hard disk drive, a magnetic disk drive and/or an optical disk drive. In some examples, data and/or instructions may be provided by an external memory (e.g., an external drive in wired or wireless communication with the computing system **100**) or may be provided by a transitory or non-transitory computer-readable medium. Examples of non-transitory computer readable media include a RAM, a ROM, an erasable programmable ROM (EPROM), an electrically erasable programmable ROM (EEPROM), a flash memory, a CD-ROM, or other portable memory storage. The storage units and/or external memory may be used in conjunction with memory **120** to implement data storage, retrieval, and caching functions of the Computing System **102**. The components of the computing system **100** may communicate with each other via a bus, for example.

(21) FIG. **2** is a schematic diagram illustrating an example of gaze assisted input in the context of an Electronic device **204** according to an example implementation. In the example of FIG. **2**, the Electronic device **204** is a processor enabled handheld device such as a smartphone having a Display **118**, a Camera **126**, and a Microphone **130**. However, the gaze assisted input that is described could be applied to any number of different types of devices or combinations of devices, including but not limited to tablets, personal computers, laptops, televisions, augmented reality (AR)/virtual reality (VR) headsets, and smart glasses.

(22) FIG. **2** shows a User **206** (not to scale) interacting with Electronic device **204**. In the scenario where Electronic device **204** is a smartphone, the Electronic device **204** will be held in the user's hand and viewed by the User **206** with a Gaze Direction **214**. As noted above in respect of FIG. **1**, in example embodiments, Electronic device **204** is configured to implement Modules **132**, namely Gaze Tracker **122**, Speech-To-Text Conversion **124** and Gaze/Speech Combiner **128** modules, to enable gaze assisted input. By way of examples, these Modules **132** could be implemented by Operating System **112** to support a user interface (UI) event processing loop.

(23) In the illustrated example, the Electronic device **204** has Display **118** integrated into a front surface of the device. The Display **118** provides a two dimensional display space **224** on which text and graphical display elements can be presented to User **206**. In an example embodiment, the Gaze Tracker **122** performs an ongoing real-time gaze tracking function by repeatedly estimating a point of gaze (POG) **216** of User **206** that corresponds to a location within Display space **224**. In example embodiments, gaze tracking is implemented using video-based eye tracking, for example, using Camera **126** to capture face or eye images of User **206** and computing a POG from the face or eye images. In the present disclosure, "point of gaze (POG)" can refer to a location within a display space **224** where an individual is looking. For example, the POG can refer to an intersection of a gaze vector (e.g., Gaze Direction) with a scene that is shown in the display space **224**. In the case of a 2D display space **224**, a POG may correspond to a location on a 2D display where a visual axis intersects the 2D display screen. In such examples, a POG within the display space **224** may be described by a set of 2D coordinates (x, y) corresponding to a position on the display, relative to a display coordinate system. In some examples, a display may display 3D images in a representation of a 3D display space **224**. In such cases, the POG within the display space **224** may be described by a set of 3D coordinates (x,y,z) corresponding to a position in the 3D display space presented by the display.

(24) In example embodiments, Gaze Tracker **122** can also be configured to compute, in real-time, a gaze region **202** based on the estimated user's Point of Gaze **216**. For example, a gaze region **202** can be region of defined size that encompasses the Point of Gaze **216**. For example, gaze region **202** could be a bounding box that encompasses a user's point of gaze, for example, with rectangular

dimensions characterized by a width (w) and a height (h) and a center point (x, y) corresponding to the user's Point of Gaze **216**. In this disclosure, “gaze data” can refer to real-time Point of Gaze information as well as location information (e.g., gaze region) that is determined based on the Point of Gaze. Although the real-time computed Point of Gaze **216** and gaze region **202** are represented by a circle outline and a dashed rectangle, respectively, in the Figures, in many typical use scenarios neither of these computed gaze data features will actually be displayed in display space **706**.

(25) Gaze Tracker **122** can be implemented using a number of different eye tracking solutions that performs gaze estimation, including for example a calibration-free solution such as that disclosed in United States Patent Publication No. US-2022-0391012-A1 (Vertegaal et al.), entitled SYSTEMS, METHODS, AND MEDIA FOR EYE TRACKING USING STATISTICALLY DERIVED LINEAR FUNCTIONS. Other possible eye tracking solutions that can be used to implement Gaze Tracker **122** may include, for example, solutions disclosed in U.S. Pat. No. 6,152,563 (Hutchinson et. al.).

(26) Speech-To-Text Conversion **124** is configured to extract text from speech input that is received through a microphone (e.g., Microphone **130**) and can be implemented using any number of suitable speech-to-text solutions. The extracted text can include commands, words or phrases in various examples.

(27) Gaze/Speech Combiner **128** is configured to combine point-of-gaze based data from Gaze Tracker **122** and extracted text data from Speech-To-Text Conversion **124** to perform gaze-assisted input for Electronic device **204**, examples of which are described in greater detail below.

(28) In some examples, Gaze Tracker **122**, Speech-To-Text Conversion **124** and Gaze/Speech Combiner **128** are all implemented as Modules **132** resident on Electronic device **204**. However, in alternative embodiments, some or all of the functionality of these modules could be located on further electronic devices that communicate with Electronic device **204** through a Network Interface **108** or an I/O Interface **106**. For example, Speech-To-Text Conversion **124** could be performed on a further device such as a smart watch, headphones, head mounted display or smart glasses that communicate the extracted text to Computing System **102** of Electronic device **204**. Similarly, some or all of the functionality of Gaze Tracker **122** could be performed at a further camera enabled device that provides point-of-gaze based data to Computing System **102** of Electronic device **204**.

(29) In the example of FIG. 2, one or more of the Modules **132** cause an interactive graphical user interface (GUI) to be presented within the display space **224** provided by Display **118** of Electronic device **204**. The displayed GUI can include multiple windows or panes, including for example a Main Pane **218** and a Control Pane **220**. In the illustrated example, Control Pane **220** includes a set of display elements, for example, a Smart TV GUI element **208**, a Smart Speaker GUI element **210**, and a Smart Lamp GUI element **212**. Each of these GUI elements occupies a respective sub-region of the Control Pane **220**. Each GUI element represents a respective electronic device (for example a respective Internet of Things (IOT) device) that is connected to a common network (e.g., a smart home network) as the Electronic device **204**. For example, each GUI element can represent a respective electronic device registered with a smart home network that is pre-associated with user's Electronic device **204**. In the illustrated example, GUI elements **208**, **210** and **212** are shown as graphical icons, however they can be any suitable 2D or 3D display element that is presented for viewing by User **206**. The GUI elements **208**, **210** and **212** are associated with one or application program interfaces (APIs) that enable the Electronic device **204** to be used as an interface that enables User **206** to provide commands or other voice inputs to the respective electronic devices that are represented by the GUI elements **208**, **210** and **212**. In example embodiments, the Electronic device **204** is configured to transmit commands that are detected via a UI event processing loop in respect of a GUI element **208**, **210** or **212** to the respective IOT Device represented by the GUI element.

(30) Electronic device **204** is configured to monitor for user input events that occur as a result of user interactions with the respective GUI elements **208**, **210** or **212**. In one example, a contactless input event will be determined to have occurred in respect of one of the GUI elements **208**, **210** and **212** when a user's Point of Gaze **216** mapped to the GUI element coincides with a speech input **222** that includes content that is relevant to the IOT device that is represented by the respective GUI elements **208**, **210** or **212**. The Electronic device **204** is configured to perform an action in response to determining that a contactless input event has occurred, for example, route a command via Network Interface **108** for the subject IOT device.

(31) In particular, in an example implementation, Gaze Tracker **122** generates real-time gaze data (e.g., estimated real-time User's **206** Point of Gaze **216** and/or corresponding gaze region **202** information). Simultaneously, Speech-To-Text Conversion **124** extracts text from any received user speech inputs **222**. The extracted text and real-time gaze data are provided to Gaze/Speech Combiner **128** for processing. In an example implementations, Gaze/Speech Combiner **128** uses the gaze data to perform an on-going mapping function to identify which, if any, of the respective GUI elements **208**, **210** and **212** is the subject of user's Gaze Direction **214** during a time duration that coincides with a received speech input. In some examples, the identification of the subject display element is based on predetermined minimum threshold spatial overlap and time overlap between the gaze region and a respective display space **224** sub-region of the subject display element during the time duration. For example, a 70% physical overlap in display space **224** between the gaze region **202** and the display space **224** sub-region occupied by a GUI element for at least 50% of the time duration of the speech input will result in identification of that particular GUI element as the subject display element. The Gaze/Speech Combiner **128** is configured to then cause one or more predefined actions to be taken based on the identified subject display element (e.g., GUI elements **208**, **210** or **212**) and a content of the speech input **222**.

(32) By way of example, in a possible scenario represented by FIG. 2, a Microphone **130** of the Electronic device **204** captures an audio input that includes a speech input (e.g., “go to channel 24”) spoken by User **206**. During a time duration that coincides (e.g., overlaps at least partially) with the speech input, the user's Gaze Direction **214** is focused on the Smart TV GUI element **208**. Gaze/Speech Combiner **128** receives gaze data from the Gaze Tracker **122** and a text command “go to channel 24” that has been extracted from the content of the speech input by Speech-To-Text Conversion **124**. Gaze/Speech Combiner **128** maps the gaze data to the display space **224** sub-region that is occupied by Smart TV GUI element **208**, and furthermore, determines that the speech input for the command “go to channel 24” overlaps for a predefined time threshold with the mapping of the gaze data onto the Smart TV GUI element **208**. Accordingly, Gaze/Speech Combiner **128** identifies Smart TV GUI element **208** as the subject of user's Gaze Direction **214** during the time duration that coincides with the received speech input. Based on this identification, Gaze/Speech Combiner **128** causes the Electronic device **204** to take one or more predefined actions, including sending a command “go to channel 24” via Network Interface **108** to the Smart TV that is represented by Smart TV GUI element **208**.

(33) In the above example, User **206** is able to direct a channel change command “go to channel 24” simply by looking at Smart TV GUI element **208** at the same time as speaking the command, without providing any further verbal or physical inputs. Gaze/Speech Combiner **128** automatically determines the target device for the command based on context provided by the User **204**'s Gaze Direction **214** coinciding with the speech input. The User **206** does not need to verbally specify which IoT device the voice command is intended for and does not need to physically interact with a Pointing Device **136**.

(34) Similarly, voice command content extracted from the speech inputs can be automatically routed to a smart speaker represented by Smart Speaker GUI element **208** (e.g., “play classical music” or “add pepper to my shopping list”) or to a smart lamp represented by Smart Lamp GUI element **212** (e.g., “turn on from 7 PM until 11 PM tonight”), in response to User **206** gazing at the

Smart Speaker GUI element **210** or Smart Lamp GUI element **212**, respectively while uttering such commands.

(35) In some examples, upon identifying that a particular display element is a subject display element, the Electronic device **204** could also visually highlight or otherwise visually indicate for a defined duration the particular display element to indicate that the gaze data has been mapped to the display element and the speech input for that display element is being acted upon.

(36) Thus, in the example of FIG. 2, Point of Gaze **216** tracking is used to resolve which of a plurality of external IOT devices represented in a GUI or display space **224** are the target of a speech input **222**. In at least some examples, the extracted content of the speech input can also be used to confirm the subject display element. For example, in some scenarios, if content extracted from the speech input is determined to be not suitable (e.g., out of context) for the display element that has been identified as the subject of a Point of Gaze **216**, the Electronic device **204** can be configured to either ignore the speech input or, in some examples, to select an alternative display element as the subject display element for routing the command. For example, the display element next closest to the Point of Gaze **216** and that is a context match for the content of the speech input could be identified as the subject display element. By way of particular example, in the case of FIG. 2, a voice command speech input **222** “play classical music” coincident with Point of Gaze **216** being mapped to a left-edge of the Smart Lamp GUI element **212** could be re-mapped to Smart Speaker GUI element **210** upon a determination by Gaze/Speech Combiner **128** that the content extracted from the speech input **222** does not match a pre-defined set of commands suitable for the smart lamp but does match a further pre-defined set of commands suitable for a smart speaker.

(37) FIGS. 3 to 6 illustrate further respective examples of gaze-assisted input tasks that can be performed according to example implementations of Electronic device **204**.

(38) FIG. 3 illustrates an example that is similar to that of FIG. 2 except that in the case of FIG. 3, the GUI elements displayed in Display space **224** are dynamic elements that each move around in the Main Pane **218** of the display space **224** based on a location of the electronic devices that are represented by the GUI elements relative to the user's Electronic device **204**. By way of example, in the scenario of FIG. 3, Smart TV GUI element **208** represents a first smart TV that is located in a fixed location and is registered with a smart home network pre-associated with user's Electronic device **204**, and Smart TV GUI element **304** represents a second smart TV located in a second fixed location and is also registered with the smart home network. Operating System **112** (or a further Application **120**) of Electronic device **204** is configured to use any suitable positioning solution to track a location of Electronic device **204** relative to the known locations of the smart TVs that are represented by Smart TV GUI element **208** and Smart TV GUI element **304**. The position of Smart TV GUI element **208** and Smart TV GUI element **304** are caused to move within the Main Pane **218** as the Electronic device **204** moves relative to the physical Smart TVs. Distance indicators **308** (such as range circles) can be displayed on Main Pane **218** to indicate relative distances from the Electronic device **204** to each of the represented smart TVs. Lines **302** and **306** represent movement of the Smart TV GUI element **208** within the Main Pane **218** in response to movement of the Electronic device **204**. In the illustrated example, Electronic device **204** is located nearer to the smart TV represented by Smart TV GUI element **208** than the smart TV represented by Smart TV GUI element **304**.

(39) In the illustrated example, the User **206** desires to turn on the smart TV that they are the closest to as the user is moving within a room in their home. The User **206** looks at the Display **118** such that their Gaze Direction **214** tracks the Smart TV GUI element **208** as it moves in the display space **224** in response to movement of the Electronic device **204**, and simultaneously issues voice command “turn on”. Gaze Tracker **122** generates real-time gaze data (e.g., estimated real-time User's Point of Gaze **216** and/or corresponding gaze region **202** information). Simultaneously, Speech-To-Text Conversion **124** extracts the command “turn on” from the user speech input **222**. The extracted text and real-time gaze data are provided to Gaze/Speech Combiner **128** for

processing. In an example implementations, Gaze/Speech Combiner **128** identifies, based on the real-time gaze data, that the moving Smart TV GUI element **208** is the subject of the user's Point of Gaze **216** coincident with the spoken command “turn on”. As a result, Gaze/Speech Combiner **128** resolves the command “turn on” to the particular smart TV that is represented by Smart TV GUI element **208** and causes a “turn on” command to be communicated to that particular smart TV (as opposed to the smart TV that is represented by Smart TV GUI element **304**).

(40) Accordingly, in example embodiments, the Electronic device **204** is configured to use real-time gaze tracking to associate a voice command with a moving display element within the display space **224** and then direct the content of such command to a further electronic device that is represented by the moving display element.

(41) FIG. **4** illustrates another example of gaze based directing of speech input **222** based content to a further electronic device that is presented in a display space **224**. In the example of FIG. **4**, an application **120** running on the Electronic device **204** includes the ability to receive location data in respect of a plurality of remote location tracking enabled electronic devices that can be moving relative to the location of the Electronic device **204**. For example, each of the remote electronic devices may send GPS location data to a cloud based service that in turn provides location information via a Network Interface **108** to Electronic device **204**. Electronic device **204** in turn displays a respective GUI element **402**, **404**, **406** for each respective remote electronic device, with locations of the GUI elements in display space **224** representing respective geographic locations of the remote Electronic devices **204**. By way of example, the GUI elements **402**, **404**, **406** may be overlaid on a regional map display (for example a city map), with the GUI elements **402**, **404**, **406** shown at the map locations that correspond to the actual real-time (or periodically updated) locations of the remote electronic devices that they represent. In the illustrated examples, the remote Electronic devices **204**, which may be moving, is enabled to receive communications based on speech input **222** provided by User **206**. Remote electronic devices could for example be smart phones that are pre-registered along with user's Electronic device **204** as part of a friend or work messaging platform. In some examples, remote electronic devices could include smart tags or similar geo-location tracked devices that can receive messages or commands that originate from user's Electronic device **204** (e.g., commands that cause the remote electronic device to shut down or otherwise control an associated device, to sound an alarm, or increase frequency of GPS location reporting, or enter or exit a sleep mode).

(42) In an example scenario, the User **206** provides a speech input **222** while their Gaze Direction **214** tracks one of the display elements (for example, GUI element **402**), Gaze Tracker **122** generates real-time gaze data (e.g., estimated real-time User's Point of Gaze **216** and/or corresponding gaze region **202** information). Simultaneously, Speech-To-Text Conversion **124** extracts text content from the speech input **222**. The extracted text and real-time gaze data are provided to Gaze/Speech Combiner **128** for processing. In an example implementations, Gaze/Speech Combiner **128** identifies, based on the real-time gaze data, that the GUI element **402** is the subject of the user's Point of Gaze **216** that coincides with speech input **222**. As a result, Gaze/Speech Combiner **128** resolves the content of the speech input **222** to the particular remote electronic device that is represented by GUI element **402** and causes a message or command that is based the extracted text to be communicated for that particular remote electronic device. For example, the speech input and corresponding extracted text could be “meet me at 6 PM at the place”, which is then sent to the intended recipient (as determined by gaze tracking) as a text message.

(43) As described above, FIGS. **3** and **4** provide examples of implementations in which a GUI element is caused to move in the display space in response to motion of one or both of the further device or the first electronic device. Accordingly, it will be appreciated that in some implementations, a GUI element is positioned on a screen (e.g., display space) to reflect the real location of a further device relative to the user's Electronic device **204**. Any relative movement in

either the user's Electronic device **204**, or the further device then causes a resultant movement of the GUI element. This could implementation could for example be used in a mapping application that updates one or more items displayed in a display space as the user's Electronic device **204** is rotated, thereby providing a real-time representation of relative device and item locations in the actual world; e.g. items on the GUI move as the user's Electronic device **204** is rotated relative to the real world.

(44) In a further example, a local positioning system provides the locations of devices relative to the user's Electronic device **204** on a radar-like interface, as the user's Electronic device **204** moves relative to these devices, the icons representing them also move on the GUI.

(45) FIG. 5 illustrates a further example embodiment in which Gaze Direction **214** can be used to direct content extracted from a speech input **222** to a specific application. In the example of FIG. 5, Operating System **112** causes a plurality of display elements to be displayed in respective sub-regions of display space **224** as part of a Main Pane **218**. Each of the display elements can, for example be a respective GUI application icon that represents a respective application **120**. For example, icon **502** represents a first application A1; icon **504** represents a second application A2; icon **508** represents a third application A3; and icon **506** represents a fourth application A4. In a manner similar to that described above, the Gaze Tracker **122**, Speech-To-Text Conversion **124** and Gaze/Speech Combiner **128** collectively operate to resolve content extracted from speech input **222** to a specific icon **502**, **504**, **508**, **506** based on real-time tracking of a Point of Gaze **216** coinciding with the speech input **222**. Electronic device **204** then causes the extracted content to be directed to the application that is represented by the specific icon. In some examples, the represented applications can be executed solely on the Electronic device **204**, for example a calculator application. In some examples, the represented applications can be client-side application components of APIs for accessing remotely hosted services.

(46) In a first illustrated example, application icon **504** represents a client side of a cloud based service application program interface (API), for example a search engine such as Safari™ or Google™ or a AI-based prompt-response service such as ChatGPT™. User **206** desires to issue a text search input or prompt to the service that corresponds to the application represented by the application icon **504**. The User **206** looks at the Display **118** such that their Gaze Direction **214** is focused on application icon **504**, and simultaneously provides a speech input **222** that includes search query or prompt (e.g., “Explain black holes in common language”). Gaze Tracker **122** generates real-time gaze data (e.g., estimated real-time User's Point of Gaze **216** and/or corresponding gaze region **202** information). Simultaneously, Speech-To-Text Conversion **124** extracts the text of the search query or prompt from the user speech input **222**. The extracted text and real-time gaze data are provided to Gaze/Speech Combiner **128** for processing. In an example implementations, Gaze/Speech Combiner **128** identifies, based on the real-time gaze data, that the application icon **504** is the subject of the user's Point of Gaze **216** coincident with the speech input **222**. As a result, Gaze/Speech Combiner **128** resolves that the extracted text is intended for the application A2 represented by the application icon **504** and passes the extracted text to application A2, which in turn automatically sends the extracted text as a search query or prompt to the remotely hosted service that corresponds to application A2. In at least some examples, the Electronic device **204** will also automatically cause application A2 to be opened in a further window or pane the display space **224** such as to enable the response received from the remotely hosted service to be displayed in the display space **224**.

(47) In a second illustrated example, application icon **502** represents a calculator application A1 that is present on Electronic device **204**. User **206** desires to know the answer to a math problem, e.g., “112 multiplied by 26”. The User **206** looks at the Display **118** such that their Gaze Direction **214** is focused on calculator application icon **502**, and simultaneously provides a speech input **222** that includes the math problem (e.g., “112 multiplied by 26”). Gaze Tracker **122** generates real-time gaze data (e.g., estimated real-time User's Point of Gaze **216** and/or corresponding gaze region

202 information). Simultaneously, Speech-To-Text Conversion 124 extracts the text of the math problem (e.g., “112×26”) from the speech input 222. The extracted text and real-time gaze data are provided to Gaze/Speech Combiner 128 for processing. In an example implementations, Gaze/Speech Combiner 128 identifies, based on the real-time gaze data, that the calculator application icon 504 is the subject of the user's Point of Gaze 216 coincident with the speech input 222. As a result, Gaze/Speech Combiner 128 resolves that the extracted text is intended for the application A1 represented by the application icon 504 and passes the extracted text to calculation application A1, which in turn automatically performs the calculation. The Electronic device 204 will also automatically cause application A1 to be opened in a further window or pane the display space 224 such as to enable the calculated answer to be displayed in the display space 224.

(48) Thus, in the example of FIG. 5, the Electronic device 204 resolves the target of speech inputs at the application level through gaze tracking. The resulting text from the speech input is provided to the target application, enabling a hands-free method of querying applications, among other things. In such an implementation, text is extracted from speech and automatically provided text for processing by the target application. In some examples, the following steps are performed: a) determining if the extracted speech corresponds to a command associated with the gaze targeted application; b) converting the extracted speech to an input compatible with an API associated with the application; and c) providing the input to the API for execution of the command by the application. Illustrative examples can include: looking at an app icon representing an App Store and saying “drawing”, which is then is interpreted as a desire for search for a downloadable drawing application; and looking at a reminder App icon and saying: “pick up milk later”, which results in an creation of a corresponding reminder event.

(49) FIG. 6 illustrates another example of gaze-assisted speech input. In the example of FIG. 6, the main pane 218 shown in display space 224 displays a plurality of user selectable display elements in the form of buttons 602 and 604. Buttons 602 and 604 each occupy a respective sub-region of display space 224, and each button represents a specific command for an application that is running on the Electronic device 204. As illustrated in FIG. 6, each Button 602 and 604 includes visible indicia that indicates a meaning that is associated with the button, for example “OK” in the case of button 602 and “CANCEL” in the case of button 604. In the example of FIG. 6, Gaze/Speech Combiner 128 is configured to resolve a speech input 222 to a particular display element and cause a corresponding action to be taken when two conditions are met. First, the gaze data must map to a button coincident with the speech input 222. Second, the text command extracted from the speech input 222 must match the meaning of the indicia of the button that the Point of Gaze 216 is mapped to.

(50) In the illustrated example of FIG. 6, User 206 is presented with two display elements representing different command options for an underlying applications, namely “OK” button 602 and “Cancel” button 604. In an example scenario, User 206 desires to input an “OK” command, represented by button 602, to proceed with a task. The User 206 looks at the Display 118 such that their Gaze Direction 214 is focused on “OK” button 602, and simultaneously provides a speech input 222 that includes “OK”. Gaze Tracker 122 generates real-time gaze data (e.g., estimated real-time User's Point of Gaze 216 and/or corresponding gaze region 202 information). Simultaneously, Speech-To-Text Conversion 124 extracts the command “OK” from the speech input 222. The extracted text and real-time gaze data are provided to Gaze/Speech Combiner 128 for processing. In an example implementations, Gaze/Speech Combiner 128 identifies, based on the real-time gaze data, that the “OK” button 602 is the subject of the user's Point of Gaze 216 coincident with the speech input 222. Furthermore, Gaze/Speech Combiner 128 confirms that the command “OK” matches the meaning of the indicia displayed with the “OK” button 602. Based on these two conditions being met, the “OK” command is provided to the underlying application for execution.

(51) Accordingly, in the example of example of FIG. 6, Electronic device 204 can resolve ambiguity that can occur in point of gaze tracking when giving speech commands in respect of

display elements that are represented in small display space sub-regions. In particular, the spoken command must match pre-defined criteria (e.g., a displayed indicia such as text) associated with the display element that is the subject of a point of gaze in order for the command to be executed. The contextualization of speech input with point of gaze and vice versa further removes ambiguity in the unitary inputs (gaze or speech), for example, when looking at and speaking a command button. This reduces errors with small targets such as buttons.

(52) Accordingly, FIG. 6 shows an example in which a gaze-targeted display element includes indicia indicating a meaning. A command is extracted from speech input, and an action is automatically performed only when the extracted command matches the meaning indicated by the indicia. Further examples can include: sending a message that has been entered into a messaging application when a “send” button is the subject of a point of gaze and the speech input is “send”; and “deleting” selected or specified content from a text entry interface when a “delete” button is the subject of a point of gaze and the speech input is “delete”.

(53) FIG. 7 illustrates yet a further example of a gaze-assisted input event according to example embodiments. In illustrated example, Gaze Direction **214** can be used to select an erroneous text entry that is displayed in a display space, and speech input **222** of replacement text entry received to replace the erroneous text entry.

(54) By way of example, in FIG. 7, Main Pane **218** displays text that is being input by user through speech or other means for an application **120**. For example the application may be a messaging application and the input text is part of a text message. In the illustrated example, the input text is displayed in a text input region or field **708** that is displayed in display space **224**. The displayed text includes a plurality of discrete display elements in the form of words **702**, **704**, **706**. Each word **702**, **704**, **706** occupies a respective sub-region of the display space **224**. In the illustrated example, the word **704** (“QUACK”) is erroneous and requires correction. Accordingly, User **206** directs their Gaze Direction **214** towards word **704** (“QUACK”) and provides a speech inputs **222** that includes a replacement word (for example, “QUICK”). Gaze Tracker **122** generates real-time gaze data (e.g., estimated real-time User's Point of Gaze **216** and/or corresponding gaze region **202** information). Simultaneously, Speech-To-Text Conversion **124** extracts the replacement word “QUICK” from the speech input **222**. The extracted text and real-time gaze data are provided to Gaze/Speech Combiner **128** for processing. In an example implementations, Gaze/Speech Combiner **128** identifies, based on the real-time gaze data, that the word **704** (“QUACK”) is the subject of the user's Point of Gaze **216** coincident with the speech input **222** of replacement word “QUICK”. A resulting action is performed whereby the erroneous word **704** (“QUACK”) is replaced in the text input field **708** with the spoken replacement word “QUICK”.

(55) In the illustrated example, speech input can be used to correct error in word inputs by allowing edits through gaze-assisted speech input. Rather than resorting to a touch keyboard to correct dictation errors, which defeats the use of dictation as a hands-free method, gaze data used to indicate an erroneous speech detection and speech input is used to correct it.

(56) FIG. 8 illustrates an overview of a routine **800** that can be performed by an electronic device **102** in order to implement one or more of the examples described above in respect of FIGS. 2 to 7. In block **802**, routine **800** displays a plurality of display elements in a display space. In block **804**, routine **800** tracks a user's point of gaze within the display space. In block **806**, routine **800** receives a speech input. In block **808**, routine **800** identifies one of the plurality of display elements as a subject display element for the speech input based on the tracking. In block **810**, routine **800** automatically performs an action based on the subject display element.

(57) Although the present disclosure is described, at least in part, in terms of methods, a person of ordinary skill in the art will understand that the present disclosure is also directed to the various components for performing at least some of the aspects and features of the described methods, be it by way of hardware components, software or any combination of the two. Accordingly, the technical solution of the present disclosure may be embodied in the form of a software product. A

suitable software product may be stored in a pre-recorded storage device or other similar non-volatile or non-transitory computer readable medium, including DVDs, CD-ROMs, USB flash disk, a removable hard disk, or other storage media, for example. The software product includes instructions tangibly stored thereon that enable a processing device (e.g., a personal computer, a server, or a network device) to execute examples of the methods disclosed herein.

(58) The present disclosure may be embodied in other specific forms without departing from the subject matter of the claims. The described example embodiments are to be considered in all respects as being only illustrative and not restrictive. Selected features from one or more of the above-described embodiments may be combined to create alternative embodiments not explicitly described, features suitable for such combinations being understood within the scope of this disclosure.

(59) All values and sub-ranges within disclosed ranges are also disclosed. Also, although the systems, devices and processes disclosed and shown herein may comprise a specific number of elements/components, the systems, devices and assemblies could be modified to include additional or fewer of such elements/components. For example, although any of the elements/components disclosed may be referenced as being singular, the embodiments disclosed herein could be modified to include a plurality of such elements/components. The subject matter described herein intends to cover and embrace all suitable changes in technology.

(60) The contents of all publications referenced in this disclosure are incorporated by reference.

(61) The terms “substantially” and “approximately” as used in this disclosure mean that the recited characteristic, parameter, or value need not be achieved exactly, but that deviations or variations including for example, tolerances, measurement error measurement accuracy limitations and other factors known to those skilled in the art, may occur in amounts that do not preclude the effect the characteristic was intended to provide. In some examples, the terms “substantially” and “approximately”, can mean a range of within 10% of the stated characteristic.

Claims

1. A computer implemented method comprising: displaying a plurality of display elements in a display space; tracking a user's point of gaze within the display space by determining coordinates for the user's point of gaze within a coordinate system of the display space; determining a gaze region within the display space based on the determined coordinates for the user's point of gaze, wherein the gaze region encompasses the user's point of gaze and a surrounding region of the display space; receiving a speech input; identifying one of the plurality of display elements as a subject display element for the speech input based on a predetermined minimum threshold spatial overlap between the gaze region and a sub-region of the display space occupied by the subject display element for a predetermined minimum threshold time during the speech input; and automatically performing an action based on the subject display element and the speech input.
2. The method of claim 1 wherein the method is performed by a first electronic device and the subject display element is a GUI element that represents a further device that is associated with the first electronic device, the method comprising: extracting a command from the speech input, and wherein automatically performing the action comprises transmitting the command, using a network interface of the first electronic device, for processing by the further device.
3. The method of claim 2, further comprising causing the GUI element to move in the display space in response to motion of one or both of the further device or the first electronic device.
4. The method of claim 1 wherein the subject display element corresponds to an application, the method comprising: extracting text from the speech input, and wherein automatically performing the action comprises providing the extracted text for processing by the application.
5. The method of claim 1 wherein the subject display element corresponds to a remotely hosted service, the method comprising: extracting a text search query or text prompt from the speech

input, and wherein automatically performing the action comprises automatically providing the extracted text search query or text prompt via a communication network to the remotely hosted service and receiving a corresponding response from the remotely hosted service.

6. The method of claim 1 wherein the subject display element corresponds to a word displayed in a text display field, the method comprising: extracting a replacement word from the speech input, and wherein automatically performing the action comprises replacing the word displayed in the text display field with the replacement word or phrase.

7. The method of claim 1 wherein the subject display element includes indicia indicating a meaning, the method comprising: extracting a command from the speech input, and wherein automatically performing the action comprises comparing the extracted command to the meaning indicated by the indicia and causing an activity corresponding to the extracted command to be performed only when the extracted command matches the meaning indicated by the indicia.

8. A computing system comprising: one or more processors; and one or more memories storing instructions that, when executed by the one or more processors, configure the computing system to: display a plurality of display elements in a display space; track a user's point of gaze within the display space by determining coordinates for the user's point of gaze within a coordinate system of the display space; determine a gaze region within the display space based on the determined coordinates for the user's point of gaze, wherein the gaze region encompasses the user's point of gaze and a surrounding region of the display space; receive a speech input; identify one of the plurality of display elements as a subject display element for the speech input based on a predetermined minimum threshold spatial overlap between the gaze region and a sub-region of the display space occupied by the subject display element for a predetermined minimum threshold time during the speech input; and automatically perform an action based on the subject display element and the speech input.

9. The computing system of claim 8 wherein the subject display element is a GUI element that represents a further device that is associated with the computing system, the computing system being configured to: extract a command from the speech input, and wherein automatically performing the action comprises transmitting the command, using a network interface of the computing system, for processing by the further device.

10. The computing system of claim 8 wherein the subject display element corresponds to an application, the computing system being configured to: extract text from the speech input, and wherein automatically performing the action comprises providing the extracted text for processing by the application.

11. The computing system of claim 8 wherein the subject display element corresponds to a remotely hosted service, the computing system being configured to: extract a text search query or text prompt from the speech input, and wherein automatically performing the action comprises automatically providing the extracted text search query or text prompt via a communication network to the remotely hosted service and receiving a corresponding response from the remotely hosted service.

12. The computing system of claim 8 wherein the subject display element corresponds to a word displayed in a text display field, the computing system being configured to: extract a replacement word from the speech input, and wherein automatically performing the action comprises replacing the word displayed in the text display field with the replacement word or phrase.

13. The computing system of claim 8 wherein the subject display element includes indicia indicating a meaning, the computing system being configured to: extract a command from the speech input, and wherein automatically performing the action comprises comparing the extracted command to the meaning indicated by the indicia and causing an activity corresponding to the extracted command to be performed only when the extracted command matches the meaning indicated by the indicia.

14. A non-transitory computer-readable storage medium, the computer-readable storage medium

including instructions that when executed by a computing system, cause the computing system to: display a plurality of display elements in a display space; track a user's point of gaze within the display space by determining coordinates for the user's point of gaze within a coordinate system of the display space; determine a gaze region within the display space based on the determined coordinates for the user's point of gaze, wherein the gaze region encompasses the user's point of gaze and a surrounding region of the display space; receive a speech input; identify one of the plurality of display elements as a subject display element for the speech input based on a predetermined minimum threshold spatial overlap between the gaze region and a sub-region of the display space occupied by the subject display element for a predetermined minimum threshold time during the speech input; and automatically perform an action based on the subject display element and the speech input.

15. The method of claim 1, wherein the predetermined minimum threshold spatial overlap represents at least a percentage of overlap between the gaze region and the sub-region of the display space occupied by the subject display element for at least a percentage of the time duration of the speech input.

16. The method of claim 1, wherein the predetermined minimum threshold spatial overlap represents at least 70% of overlap between the gaze region and the sub-region of the display space occupied by the subject display element for at least 50% of the time duration of the speech input.

17. The method of claim 1, further comprising identifying the one of the plurality of display elements as the subject display element based on an extracted content of the speech input.

18. The computing system of claim 8, wherein the predetermined minimum threshold spatial overlap represents at least a percentage of overlap between the gaze region and the sub-region of the display space occupied by the subject display element for at least a percentage of the time duration of the speech input.

19. The computing system of claim 8, wherein the predetermined minimum threshold spatial overlap represents at least 70% of overlap between the gaze region and the sub-region of the display space occupied by the subject display element for at least 50% of the time duration of the speech input.

20. The computing system of claim 8, the computing system being configured to: identify the one of the plurality of display elements as the subject display element based on an extracted content of the speech input.
