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WEARABLE TILT-TO-ACTION IMPROVEMENT USING CAMERA

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ABSTRACT

Computing devices (e.g., a smartphone, a smart watch, smartglasses, smart headphones, a laptop computer, a tablet computer, a vehicle head unit, etc.) may use a specific movement, such as a tilting of the computing device to trigger an action. For example, tilting a wearable device (e.g., a smart watch) may trigger a display of the wearable device to turn on (tilt-to-wake), brighten (tilt-to-bright), or perform a particular action (tilt-to-act). For example, the computing device may use one or more sensors (e.g., accelerometers, gyroscopes, barometers, or other motion or non-motion sensors) to determine whether a user of the computing device has performed a gesture while wearing or holding the computing device. The computing device may incorporate a camera, or any other sensor with the capability of identifying whether a user is present to detect false positives and prevent the computing device from unnecessarily performing an associated action when a user of the computing device is not present. A computing device may initially determine one or more gestures or events of a user wearing or holding the computing device, such as a user lifting and rotating a wrist with a smart watch or other wearable computing device. In response to the computing device determining that a gesture or event has occurred, the computing device may capture an image using a camera of the computing device and determine whether the image includes a face (e.g., of the user) and, if the image includes a face, the computing device may perform the action.

DESCRIPTION

FIG. 1 below is a conceptual diagram illustrating a computing device 100 that may activate one or more processors to turn on display 106 or adjust the brightness of display 106 using sensor components 108, camera 110, and tilt-to-act module 112. Computing device 100 may be a mobile computing device, such as a mobile phone (including a smart phone), a laptop computer, a tablet computer, a wearable computing device, or any other computing device suitable for implementing tilt-to-act functions. Computing device 100 may also include a computerized watch, a computerized fitness band/tracker, computerized eyewear, computerized headwear, a computerized glove, or any other type of mobile computing device that can attach to and be worn on a person's body or clothing. As shown in FIG. 1, computing device 100 may include attachment component 102 and electrical housing 104. Housing 104 of computing device 100 includes a physical portion of a wearable computing device that houses a combination of hardware, software, firmware, and/or other electrical components of computing device 100. For example, FIG. 1 shows that withing housing 104, computing device 100 may include display 106, sensor components 108, camera 110, and tilt-to-act module 112.

Computing device 100 may include display 106. Display 106 may function as an input device for the computing device and an output device. Display 106 may be implemented using various technologies. For example, display 106 may function as an input device using a presence-sensitive input component, such as resistive touchscreen, a surface acoustic wave touchscreen, a capacitive touchscreen, a projective capacitance touchscreen, a pressure-sensitive screen, an acoustic pulse recognition touchscreen, or another presence-sensitive display technology. Display 106 may function as an output (e.g., display) device using any one or more display components, such as a liquid crystal display (LCD), dot matrix display, light emitting diode (LED) display, microLED, organic light-emitting diode (OLED) display, e-ink, or similar monochrome or color display capable of outputting visible information to a user of the computing device.

Computing device 100 may also include one or more sensor components 108. In some examples, a sensor component of sensor components 108 may be an input component that obtains environmental information of an environment that includes computing device 100. A sensor component may be an input component that obtains physiological information of a user of computing device 100. In some examples, a sensor component may be an input component that obtains physical position, movement, and/or location information of computing device 100. For example, sensor components 108 may include, but are not limited to: motion sensors (e.g., accelerometers, gyroscopes, etc.), heart rate sensors, temperature sensors, position sensors, pressure sensors (e.g. a barometer), proximity sensors (e.g., an infrared sensor), ambient light detectors, location sensors (e.g., Global Positioning System sensor), or any other type of sensing component. In some instances, sensor components 114 may include an accelerometer and gyroscope. An accelerometer sensor component may include any type of sensor (e.g., piezoelectric, piezoresistive, capacitive, etc.) coupled to computing device 100 with the capability of determining and/or monitoring acceleration of computing device 100. A gyroscope sensor component may include any type of sensor (e.g., vibration gyroscope, fiber-optic gyroscope, etc.) coupled to computing device 100 with the capability of determining rotational motion of computing device 100 and/or determining changes in the orientation of computing device 100 along any given axis. Sensor components 108 may be in the form of micro-electro-mechanical systems (MEMS) to allow each sensor component of sensor components 108 (e.g., an accelerometer and gyroscope) to be embedded in computing device 100.

Camera 110 of computing device 100 may be any type of camera with the capability of capturing light or other forms of radiation (e.g., thermal radiation) as frames and sufficient resolution for detecting the presence of a face. Camera 110 may be a low-resolution camera that may consume power on the order of microwatts. Camera 110 may be integrated in computing device 100 separately from the main processing components of computing device 100, such that camera 110 consumes the minimal amount of power necessary to capture facial features or other facial landmarks necessary to determine the presence of a face. As further described in this disclosure, tilt-to-act module 112 may determine whether to activate display 106 of computing device 100, adjust the brightness of display 106, or otherwise perform an action on computing device 100 or any other connected computing devices based on sensor data generated by one or more of sensor components 108 and data obtained from camera 110 of computing device 100.

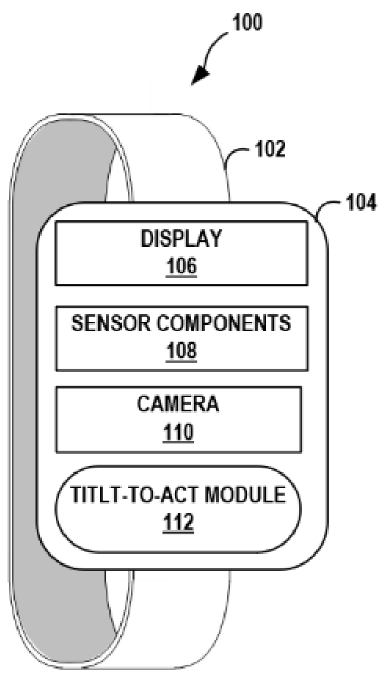

FIG. 1

In accordance with techniques of this disclosure, tilt-to-act module 112 may receive inputs from sensor components 108 and camera 110 to determine whether display 106 should be activated, toggled, or otherwise adjusted in response to gestures of a user using computing device 100. Computing device 100 may detect gestures of a user with sensor components 108. Computing device 100 may detect facial features or landmarks of a user based on frames captured by camera 110. In some instances, while display 106 is off or operating in a low power or standby mode, tilt-to-act module 112 may analyze data (e.g., motion data) received from one or more sensor components 108 (e.g., an accelerometer or a gyroscope) to determine whether a particular event or gesture has occurred according to any known tilt-to-act implementations (e.g., tilt-to-wake functions, tilt-to-bright functions, etc.).

In some examples, tilt-to-act module 112 may determine an event or gesture of computing device 100 has occurred based on thresholds assigned to values generated by sensor components 108. Tilt-to-act module 112 may define an event or gesture as one or more sensor components of sensor components 108 generating a value exceeding a corresponding threshold associated with a movement or gesture of computing device 100. For example, sensor components 108 may include an accelerometer and a gyroscope. Tilt-to-act module 112 may assign an acceleration value and a direction (e.g., computing device 100 accelerating vertically up) as the threshold value for the accelerometer and assign a rotational value (e.g., degrees or radians where a positive value indicates a clockwise rotation, and a negative value indicates a counterclockwise rotation) along any axis of computing device 100 as the threshold value for the gyroscope. Tilt-to-act module 112 may define an event or gesture as the combination of the threshold assigned to the accelerometer and the threshold assigned to the gyroscope (e.g., the gesture of a user checking the time may be defined as computing device 100 moving up at a given acceleration and rotated clockwise).

In some examples, tilt-to-act module 112 may analyze the data (e.g., motion data) captured from sensor components 108 to determine whether a user of computing device 100 has performed a particular gesture of a plurality of gestures based on one or more motion strokes derived from the data that represents movement of computing device 100. Tilt-to-act module 112 may generate a respective attribute vector (e.g., vectors of spatial attributes, temporal attributes, or relational attributes) for each respective stroke of the one or more motion strokes to classify each stroke. Tilt-to-act module 112 may also include a gesture library that stores the plurality of gestures, where each gesture may be assigned one or more attribute vectors. Tilt-to-act module 112 may determine whether the one or more motion strokes correspond to a gesture described in the gesture library by comparing the classifications of the one or more motion strokes to the on the one or more attribute vector assigned to the gesture. Tilt-to-act module 112 may determine whether an event or gesture has occurred according to any known tilt-to-act functions (e.g., tilt-to-wake, tilt-to-bright, etc.). Tilt-to-act module 112 may also map or assign particular events or gestures to a particular tilt-to-act action. For example, an event or gesture defined as a user of computing device 100 raising and rotating computing device 100 toward the user (e.g., orientation 116 of FIG. 2) may be mapped to a tilt-to-act action, while an event or gesture defined as a user of computing device 100 turning computing device 100 toward the user – without computing device 100 changing altitude – may be mapped to a tilt-to-bright action.

Responsive to tilt-to-act module 112 determining computing device 100 has performed an event or gesture, tilt-to-act module 112 may further analyze data captured by camera 110 to determine whether a human face is detected within a time frame (e.g., 100-300 milliseconds or 1-

3 seconds) after the event or gesture has occurred. Tilt-to-act module 112 may analyze data received from camera 110 to identify fundamental facial features or landmarks, such as human eyes, nose, chin, etc. Tilt-to-act module 112 may require that one or more facial features or landmarks be identified to determine that a face has been detected. Tilt-to-act module 112 may apply any standards or other well-known techniques to determine whether a face has been detected within a given frame captured from camera 110.

In response to tilt-to-act module 112 determining that an event or gesture has occurred and a face has been detected, tilt-to-act module 112 may cause one or more processors of computing device 100 to activate display 106 (e.g., switch from an off-display to an on-display), adjust the brightness of display 106 (e.g., switch from a dim brightness setting to an environment-appropriate brightness setting), or otherwise perform an action on computing device 100 or any other connected computing devices. If tilt-to-act module 112 only determines the occurrence of an event or gesture and tilt-to-act module 112 has not detected a face, display 106 may remain off or in standby mode and tilt-to-act module may discard the event or gesture.

Tilt-to-act module 112 activating a display or adjusting the brightness of a display only in response to a face being detected reduces power consumption resulting from false positives of current tilt-to-act implementations. Current tilt-to-act implementations trigger actions of computing devices solely based on determining the occurrence of an event or gesture of a computing device. However, computing devices implementing current tilt-to-act functions based solely on the occurrence of an event or gesture may unnecessarily consume power by using one or more processors of the computing device when a user of the computing device does not intend to interact with the computing device. To resolve the unnecessary consumption of power due to false positives of a computing device using current tilt-to-act implementations, the techniques described herein include an additional analysis of whether a face has been detected shortly after the occurrence of the event or gesture using a camera or other sensor capable of capturing frames with sufficient resolution to identify facial features or landmarks.

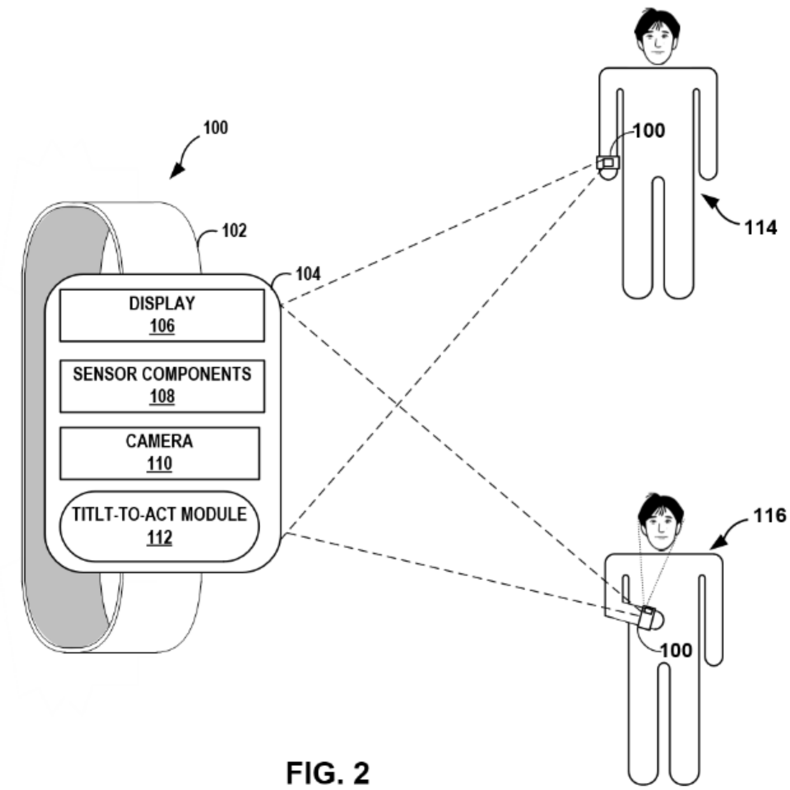

FIG. 2

FIG. 2 is a conceptual diagram of an example operation in accordance with the techniques of this disclosure. In this example, a user may be wearing computing device 100. Computing device 100 may include attachment component 102 to enable the user to wear computing device 100 and electrical housing 104. Housing 104 may include display 106, sensor components 108, camera 110, and tilt-to-act module which are equivalent to respective components described with respect to FIG. 1.

In the example of FIG. 2, the user wearing computing device 100 may be in a first orientation 114 in which computing device 100 may be at the user's side. While computing device 100 is in first orientation 114, computing device 100 may be in standby mode with display 106 turned off or in an otherwise dimmed state. In first orientation 114, tilt-to-act module 112 may continuously monitor sensor components 108 for an event or gesture to occur. Tilt-to-act module 112 may determine an event or gesture has occurred when computing device 100 has transitioned from first orientation 114 to second orientation 116 in which computing device 100 may be above the user's waist and rotated such that display 106 is facing the user. In response to tilt-to-act module 112 determining an event or gesture has occurred when computing device 100 has transitioned to second orientation 116, tilt-to-act module 112 may analyze frames captured from camera 110 while computing device 100 is in second orientation 116 to determine whether the user's face has been detected. If tilt-to-act module 112 determines that the user's face has been detected (e.g., by identifying facial features or landmarks within a frame captured by camera 110) while computing device 100 is in second orientation 116, tilt-to-act module 112 may activate display 106, turn up the brightness of display 106, or otherwise perform an action on computing device 100 or any other connected computing devices.

In some instances, tilt-to-act module 112 may perform an action on computing devices connected to computing device 100 in response to a gesture and a face being detected. For example, computing device 100 may be connected to another computing device such as smart glasses. Once tilt-to-act module 112 has detected a gesture and a face using sensors 108 and camera, respectively, tilt-to-act module may send instructions to a connected computing device (e.g., smart glasses) to open a user interface or application.

In accordance with techniques of this disclosure, the computing device requests permission from a user or owner of the computing device before using a camera to detect whether a face has been detected. In addition, the computing device only stores frames captured from the camera temporally by allocating a minimal amount of memory to store frames captured by the camera and consistently overwriting previously captured frames. The computing device does not send any frames captured by the camera to any outside sources and only stores captured frames locally. Generally, in situations in which the systems discussed here collect personal information about users, or may use of personal information, the users may be provided with an opportunity to control whether programs or features collect user information, or to control whether and/or how to receive content. In addition, certain data may be treated in one or more ways before it is stored or used, so that personally identifiable information is removed. Thus, the user may have control over how information is collected about the user and used by a content server.

It is noted that the techniques of this disclosure may be combined with any other suitable technique or combination of techniques. As one example, the techniques of this disclosure may be combined with the techniques described in U.S. Publication No. 2016-0048161 A1, U.S. Publication No. 2022-0249906 A1. In another example, the techniques of this disclosure may be combined with the techniques described in U.S. Publication No. 2015-0172539 A1 and/or U.S. Publication No. 2019-0222756 A1. In yet another example, the techniques of this disclosure may be combined with the techniques described in U.S. Publication No. 2018-0004275 A1, and/or Conti et. al. “Accelerated Visual Context Classification on a Low-Power Smartwatch” (February 2017).