January 2020

AIR GESTURE RECOGNITION

Jung Hong

Xu Guo

Jove Yuan

AIR GESTURE RECOGNITION

ABSTRACT

A system is described that enables a computing device (e.g., a mobile phone, a smartwatch, a tablet computer, etc.) to take actions based on a user input received at an interface element, such as a direction of an air gesture input or a duration of the air gesture input. The computing device may use a radio detection and ranging (radar) system to detect air gestures as inputs. An air gesture input refers to any non-touch input detected by the computing device including, for example, any gesture performed in the "air" above or below a surface of the computing device using any finger, hand, body part, stylus, or any other object that may be detected by the computing device as described herein. The computing device may record gesturing data or typing data and may use the recorded data to train a machine-learned model. In response to recognizing an air gesture, the computing device may determine a specific action to perform. In some examples, the computing device may detect air gestures (e.g., swipe left, swipe right, swipe up, swipe down, etc.) to navigate media content (e.g., a video, an audio, a picture, a slideshow, etc.) in forward or backward direction (e.g., next, previous, fast forward, rewind, etc.). In some examples, the computing device may track a finger or other object approaching a touchscreen of the computing device or hovering over a virtual keyboard displayed on the touchscreen and may predict a landing spot of the object on the touchscreen. The computing device may enlarge or magnify a keyboard letter, a button, or other graphical element displayed at the predicted landing spot. In other examples, the computing device may magnify and edit (e.g., cut, copy, paste, delete, etc.) content or text based on the detected air gestures.

DESCRIPTION

A user may interact with applications executing on a computing device (e.g., a mobile phone, a tablet computer, a smartphone, a desktop computer, or the like). In some examples, a computing device may include or communicate with a radio detection and ranging (RADAR) system that may enable a user to interact with applications executing on the computing device using air gesture inputs.

FIG. 1 is a conceptual diagram illustrating an example computing device configured to receive an air gesture input and output a corresponding action based on the input. The air gesture input may be performed using any finger, thumb, hand, body part, or any object that may be detected by the computing device. In the example of FIG. 1, computing device 100 represents an individual mobile or non-mobile computing device. Examples of computing devices 100 include a mobile phone, a tablet computer, a laptop computer, a desktop computer, a server, a mainframe, a set-top box, a television, a wearable device (e.g., a computerized watch, a computerized eyewear, a computerized glove, etc.), a home automation device or system (e.g., an intelligent thermostat or home assistant device), a personal digital assistant (PDA), a gaming system, a media player, an e-book reader, a mobile television platform, an automobile navigation or infotainment system, or any other type of mobile, non-mobile, wearable, and non-wearable computing device that contains a radar-based gesture-recognition system which configured to detect air gesture inputs, and perform corresponding actions based on the detected input.

Computing device 100 includes processors 102, applications 106, and radar-based gesture-recognition system 110. Applications 106 can be executed by processors 102 to provide various functionalities (e.g., control music forward/backward, magnify keyboard letter, edit text, etc.).

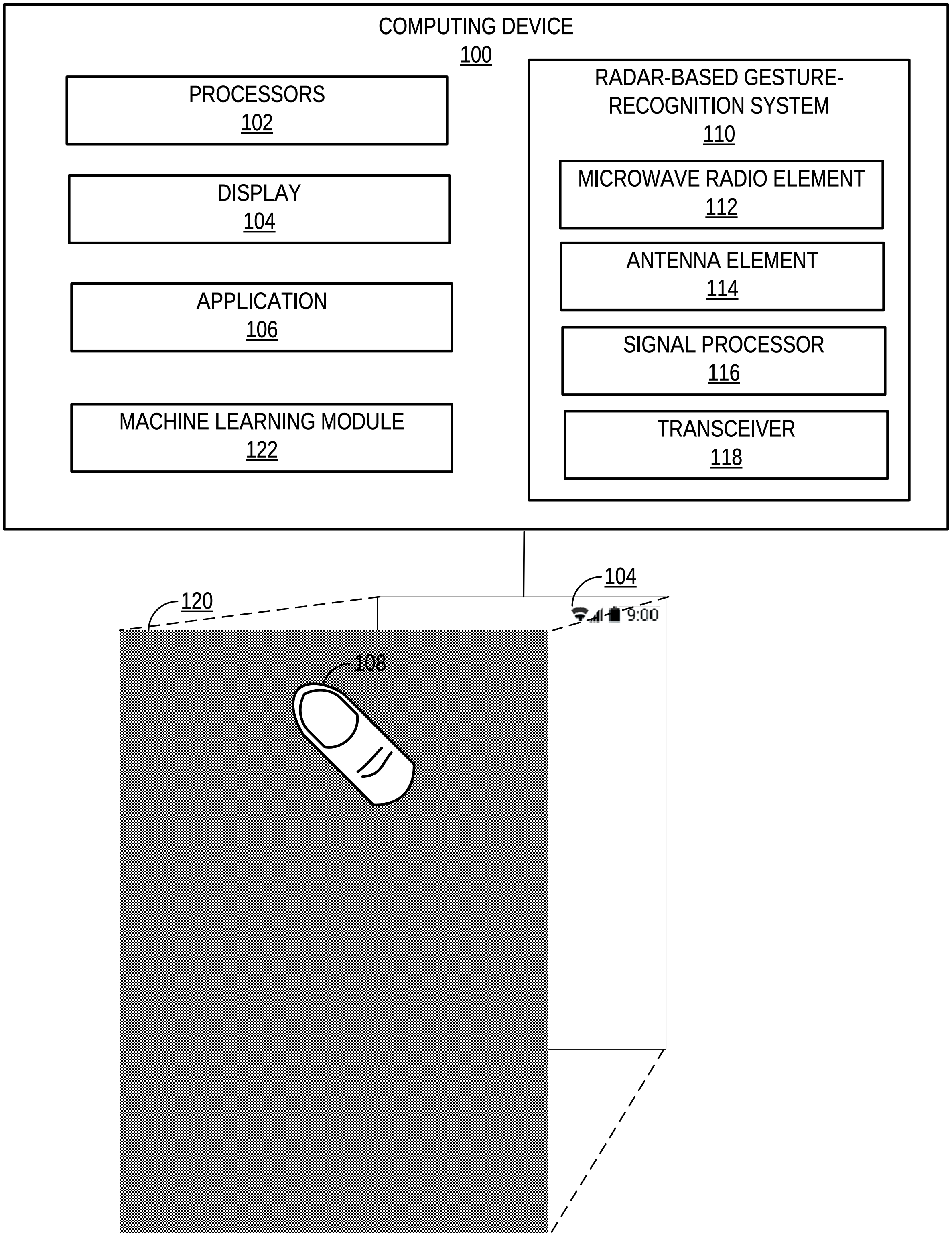
COMPUTING DEVICE
100
PROCESSORS
102
DISPLAY
104
APPLICATION
106
MACHINE LEARNING MODULE
122
RADAR-BASED GESTURE-RECOGNITION SYSTEM
110
MICROWAVE RADIO ELEMENT
112
ANTENNA ELEMENT
114
SIGNAL PROCESSOR
116
TRANSCEIVER
118
104
120
9:00
108

FIG. 1

Computing device 100 also includes display 104 (e.g., a visual display unit (VDU), a liquid crystal display (LCD), a thin-film transistor display (TFT), an organic light emitting diode display (OLED), etc.), though this is not required. In some examples, display 104 may be a small presence-sensitive screen (e.g., a resistive touchscreen, a surface acoustic wave touchscreen, a capacitive touchscreen, a projective capacitance touchscreen, a pressure-sensitive screen, an acoustic pulse recognition touchscreen), which may present some challenges to users, as the size for selecting inputs, and can make interaction difficult and time-consuming. However, radar-based gesture-recognition system 110 may provide localized radar field 120, which the users may make interact with to provide input to computing device 100. As shown in FIG. 1, localized radar field 120 may provide an area which is substantially larger than the area provided by display 104. While shown as a square shape, the localized radar field 120 can be any shape or size. For example, the localized radar field may be equal to or smaller than the size of display 104 and may be shaped as hemisphere, superposition of hemispheres, or other shapes or combination of shapes.

Radar-based gesture-recognition system 110 is configured to detect air gestures. As shown in FIG. 1, a thumb finger gesture 108 is shown interacting with localized radar filed 120. Radar-based gesture-recognition system 110 includes microwave radio element 112, antenna element 114, signal processor 116, and transceiver 118. Microwave radio element 112 may continuously emit modulated radiation, ultra-wideband radiation, or sub-millimeter-frequency radiation to provide localized radar field 120. Antenna element 114 may detect interactions in localized radar field 120. Antenna element 114 may include one or many sensors, such as an array of radiation sensors. The number in the array may be based on a desired resolution, and whether the field is a surface, plane, or volume. Signal processor 116 may process the detected interactions in localized radar field 120 to provide gesture data usable by machine learning module 122 to determine a gesture. Signal processor 116 may also determine a control input based on the determined gesture. Transceiver 118 may transmit the control input to control applications 108.

In response to a user enabling radar-based gesture-recognition system 110, computing device 100 may request the user to perform certain air gestures, collect gesture data generated, and use the collected gesture data to train machine learning module 122 to more accurately recognize the user's air gestures. For example, machine learning module 122 may generate an initial machine-learned model using a set of gesture data that describe various air gesture characteristics. Computing device 100 may collect the user's gesture data by requesting the user to perform certain air gestures (e.g., swipe left, swipe right, pause, pinch, spread, etc.) and machine learning module 122 may apply collected user's gesture data to the initial machine-learned model to refine the machine-learned model using various machine learning algorithms (e.g., clustering algorithms, decision-tree algorithms, regression algorithms, etc.). In this way, computing device 100 may train machine learning module 122 to recognize a user's typing style and typing behavior to more accurately recognize the user's air gestures.

Radar-based gesture-recognition system 110 may be coupled with various applications. In one of the examples, radar-based gesture-recognition system 110 may detect left thumb swipe or right thumb swipe and may control music forward or backward based on the detection. A different gesture, such as double tapping with the thumb, may be used to pause and play music.

Radar-based gesture-recognition system 110 may also detect a user moving the thumb towards display 104 and provide detected gesture data to machine learning module 122 to predict a landing spot of the thumb on display 104. For example, computing device 100 may learn the user's typing style or typing behavior by requesting the user to type in certain words on a keyboard. Antenna element 114 may detect interactions in localized radar field 120 as the user typing in the certain words on the keyboard. Signal processor 116 may process the detected interactions in localized radar field 120 to generate gesture data and machine learning module 122 may use the gesture data to predict the landing spot on the keyboard. If the predicted landing spot is a location at which a graphical element, such a character key in a graphical keyboard, is displayed, radar-based gesture-recognition system 110 may enlarge the size of the character key, and may highlight the keyboard letter using a bright color as the finger is moving towards or hovering over the character key.

Radar-based gesture-recognition system 110 may also provide a better cut, copy, paste, and edit experience for a user. When reading text on a small screen, text may appear small and may be difficult to read. Magnifying or zooming text can make it easier to read. Radar-based gesture-recognition system 110 may detect thumb swipes and thumb pauses and may select and magnify text based on the detection. For example, in response to a user hovering the thumb over display 104, radar-based gesture-recognition system 110 may determine a location of the thumb and correlate the location of the thumb with a cursor location on display 104. Radar-based gesture-recognition system 110 may further detect and recognize thumb gestures and take actions based on the recognized thumb gestures. As shown in FIG. 2, below, a user may position his/her finger over the letter "T," pause for at least a threshold amount of time, swipe right, and pause on the letter "a" for at least another threshold amount of time. In response to detecting this set of movements, radar-based gesture-recognition system 110 may select and magnify the text "Text on a" displayed on the screen.

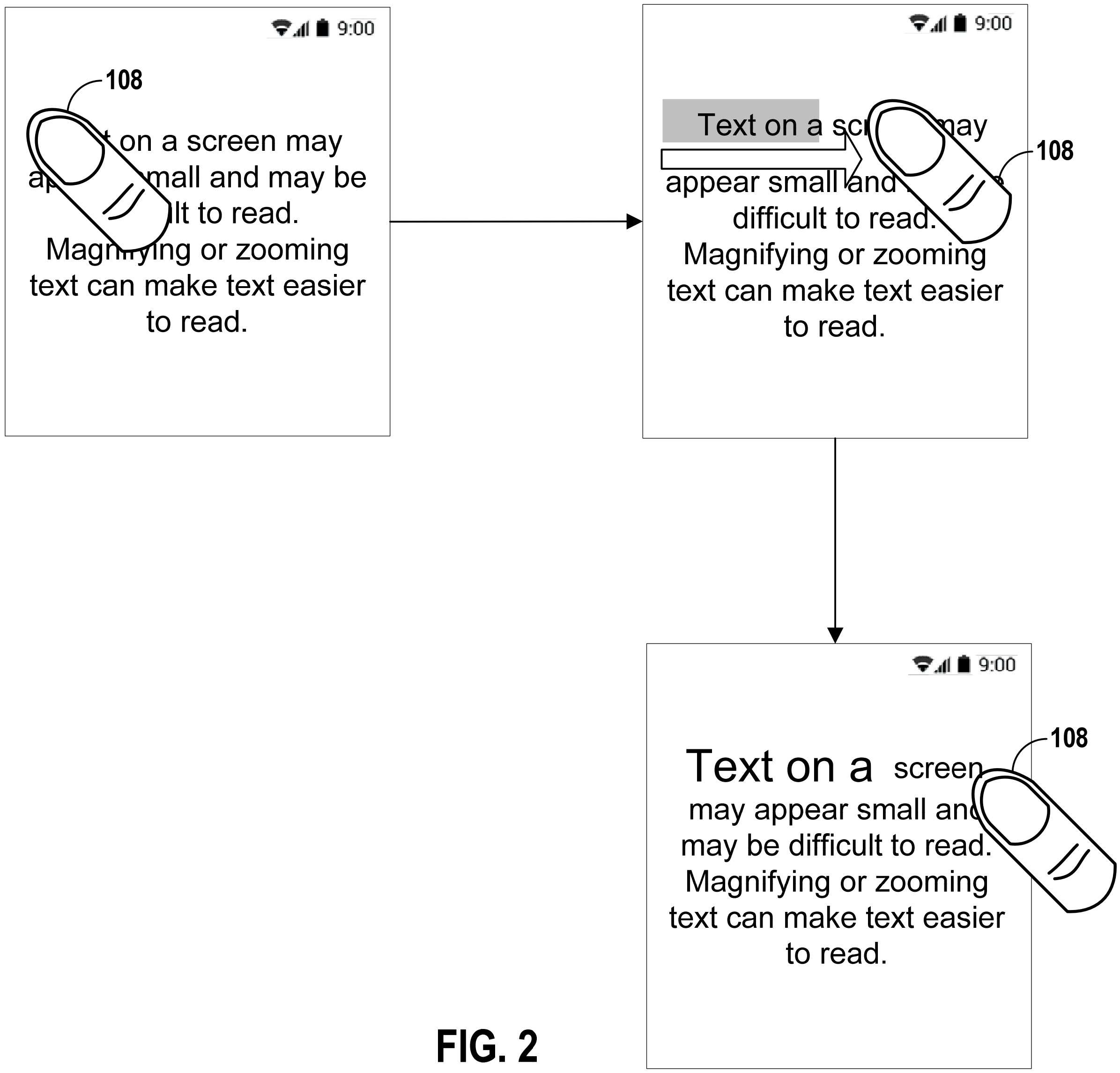

FIG. 2

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. Patent Publication 2018/0181199 A1. As another example, the techniques of this disclosure may be combined with the techniques described by Brendan McMahan and Daniel Ramage “Federated Learning” available at https://ai.googleblog.com/2017/04/federated-learning-collaborative.html.