July 2022

PREVENTING COLLISIONS

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ABSTRACT

Computing devices (e.g., a smartphone, a smart watch, etc.) may employ ultrawide band (UWB) technology (e.g., signals with a bandwidth higher than 20% of its center frequency, or signals with a bandwidth higher than 0.5 gigahertz (GHz)) to prevent collisions from happening. In some examples, the computing devices may use time-of-flight (e.g., a method for calculating location based on how long it takes for pulses of a signal to travel from one device to another) to determine the distance between the computing devices. Responsive to the distance-based measurements indicating that the computing devices are moving toward each other and within potential collision range of each other, the computing devices may output an alert to warn users of the computing devices of a potential collision. The users of computing devices may then react to the alerts accordingly (e.g., by stopping and looking around) to prevent the collision from happening.

DESCRIPTION

FIG. 1 below is a conceptual diagram illustrating an example system 10 including a computing device 100A and a computing device 100B (collectively, “computing devices 100”). As shown in FIG. 1, computing devices 100 are configured to communicate with each other via a network 102. Although system 10 is shown in FIG. 1 as only including computing device 100A and computing device 100B, system 10 may include any plurality of computing devices. For example, system 10 may include three, four, five, etc., computing devices. Thus, the example of FIG. 1 is for purposes of explanation and not intended to limit the scope of the techniques described here.

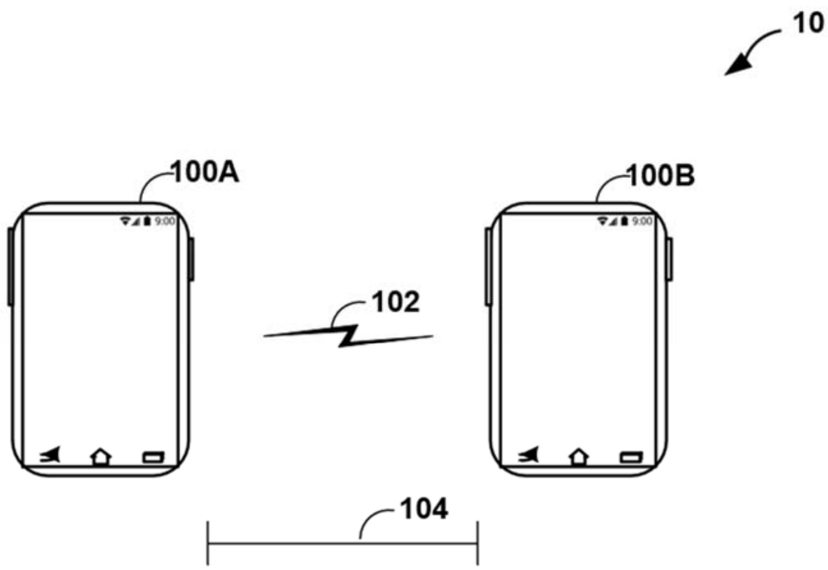

FIG. 1

In the example of FIG. 1, each of computing devices 100 may be a mobile or non-mobile computing device. Examples of computing devices 100 include, but are not limited to, a mobile phone, a smartphone, a desktop computer, a laptop computer, a tablet computer, a portable gaming device, a portable media player, an e-book reader, a watch (including a so-called “smart watch”), an add-on device (such as a casting device), smart glasses, a gaming controller, a mixed-reality (XR) headset (which includes virtual reality (VR) headsets, augmented reality (AR) headsets, and the like), smart speakers, smart televisions, a camera device, a television platform, an infotainment system, an automobile navigation system, a tag, and a wearable computing device (e.g., a computerized watch, computerized eyewear, computerized ring, computerized clothing, etc.).

Computing devices 100 may include communication components (“COMM components”). COMM components may receive and transmit various types of information over network 102. Examples of COMM components may include a an ultra-wideband (UWB) radio, a cellular radio, a third-generation (3G) radio, a fourth-generation (4G) radio, a fifth-generation (5G) radio, a Bluetooth® radio (or any other personal area network (PAN) radio), a near-field communication (NFC) radio, a WiFi® radio (or any other wireless local area network (WLAN) radio), etc. Examples of network 102 may include a personal area network (PAN), such as a Bluetooth® network (including various versions or, in other words, profiles of Bluetooth®, such as Bluetooth Low Energy (BLE)), a local-area network (LAN), a wide-area network (WAN) (e.g., the Internet), an enterprise network, a cellular network, a telephone network, a Metropolitan area network (e.g., WiFi®, WAN, worldwide interoperability for microwave access (WiMAX), etc.), etc.

When moving (e.g., walking, jogging, biking, driving, etc.), a person may accidentally collide into other people or objects. In general, the likelihood of such collisions may increase when the person is distracted. For example, if a person is staring at the person’s smartphone while walking, the person may not be aware of the person’s surroundings and bump into someone else. This issue may be exacerbated in scenarios where multiple people are distracted (e.g., by their smartphones) while moving. In some instances, the ramifications of a collision can be trivial, but in other instances, the consequences can be painful and/or costly.

In accordance with techniques discussed here, computing devices 100 may employ ultrawide band (UWB) technology to locate each other to help prevent collisions. In some examples, computing devices 100 may perform distance-based measurements via time-of-flight (ToF) (e.g., a method for calculating location based on how long it takes for pulses of a signal to travel from one device to another). Responsive to the distance-based measurements indicating that computing devices 100 are moving toward each other and within potential collision range of each other, computing devices 100 may output an alert warning users of computing devices 100 of a potential collision. The users of computing devices 100 may then react to the alerts accordingly (e.g., by stopping and looking around) to prevent the collision from happening.

Computing devices 100 may employ UWB technology by sending and receiving (e.g., via COMM components) UWB signals (which may include one or more packets of information). A UWB signal may be defined as a signal with a bandwidth higher than 20% of its center frequency, or a signal with a bandwidth higher than 0.5 gigahertz (GHz). In some examples, UWB technology may operate over a frequency range from 3.1 to 10.6 GHz.

Because UWB technology operates over a relatively wide bandwidth (e.g., compared to Bluetooth®), UWB technology may enable a high data rate connectivity. In other words, UWB technology may transmit data at a high data rate. High data rate connectivity may enable computing devices 100 to perform distance-based measurements via ToF with high accuracy and low latency. In contrast, other standards like BLE and Wi-Fi® may be incapable of transmitting data at the rate necessary for using time-of-flight. As a result, if computing devices 100 use those other standards, computing devices 100 may need to rely on less reliable and/or precise parameters than ToF (e.g., Received Signal Strength Indicator (RSSI) values) to determine distance.

As used here, ToF may refer to the period of time spanning from when a first computing device sends UWB signals that a second computing device receives to when the first computing device receives UWB signals from the second computing device that the second computing device sent in response. Because time-of-flight is correlated to distance, computing devices 100 may process the time-of-flight to determine the distance between computing devices 100.

As an example, computing device 100A (e.g., a smartphone) may periodically broadcast (e.g., send) a first UWB signal. Responsive to computing device 100B (or any other computing device configured in accordance with the techniques discussed here) receiving the first UWB signal, the computing device 100B may send a second UWB signal to computing device 100A. The second UWB signal may include one or more packets that include the time that computing device 100B received the first UWB signal and the time that computing device 100B sent the second UWB signal. Computing device 100A may determine, based on the send time and receive time of the first UWB signal and the send time and receive time of the second UWB signal to determine the distance between computing device 100A and computing device 100B. The computing device 100B (as well as any other computing device configured in accordance with the techniques discussed here) may similarly determine distance.

Computing devices 100 may determine distance-based measurements frequently (e.g., multiples times per second). Computing devices 100 may determine whether computing devices 100 (and in turn the users of computing devices 100) are moving towards each other based on changes in the distance-based measurements. For example, if a first distance-based measurement is 5 meters (m) and a second distance-based measurement (taken subsequent to the first distance-based measurement by a period of time) is 10 m, then computing devices 100 may determine that computing devices 100 are not moving towards each other. In another example, if a first distance-based measurement is 5 m and a second distance-based measurement is 5 m, then computing devices 100 may determine that computing devices 100 are not moving towards each other. In yet another example, if a first distance-based measurement is 5 m and a second distance-based measurement is 3 m, then computing devices 100 may determine that computing devices 100 are moving towards each other.

Additionally, computing devices 100 may determine whether computing devices 100 are within potential collision range of each other. Computing devices 100 may determine that computing devices 100 are within potential collision range of each other if the most recent distance-based measurement is equal to or less than a threshold. For example, if the most recent distance-based measurement is 5 m and the threshold is 2 m, then computing devices 100 may determine that computing devices 100 are not within potential collision range of each other. In another example, if the most recent distance-based measurement is 1.5 m and the threshold is 2 m, then computing devices 100 may determine that computing devices 100 are within potential collision range of each other.

In some examples, the threshold may vary based on the speed of computing devices 100. For example, the threshold may be proportional to the speed of computing devices 100 such that the threshold is greater when the speed is greater, and the threshold is lower when the speed is lower. This may be advantageous because people or objects (e.g., cars containing computing devices 100) that have greater momentum may require more distance to decelerate or otherwise avoid a collision. Computing devices 100 may include sensors configured to measure speed, such as accelerometers, geomagnetic field sensors, gyroscopes, etc.

In any case, responsive to the distance-based measurements indicating that computing devices 100 are moving toward each other and within potential collision range of each other, computing devices 100 may output an alert warning users of computing devices 100 of a potential collision. The alert may be an audio alert, a visual alert, a tactile alert, etc. For example, computing devices 100 may emit a sound, display a text notification, and/or vibrate to alert users of computing device 100 of a potential collision.

In some examples, computing devices 100 may output an alert warning users of computing devices 100 of a potential collision based on additional factors, such as the speed of computing devices 100. For example, if the distance-based measurements indicate that computing devices 100 are moving toward each other and within potential collision range of each other but the speed of computing devices 100 is low (e.g., less than 2 m/s), computing devices 100 may not output an alert warning users of computing devices 100. This may be advantageous because there are various times when it is safe for people to slowly approach each other (e.g., to shake hands). In another example, if the distance-based measurements indicate that computing devices 100 are moving toward each other and within potential collision range of each other and the speed of computing devices 100 is high (such that the consequences of a collision may be more serious), computing devices 100 may output an alert warning users of computing devices 100.

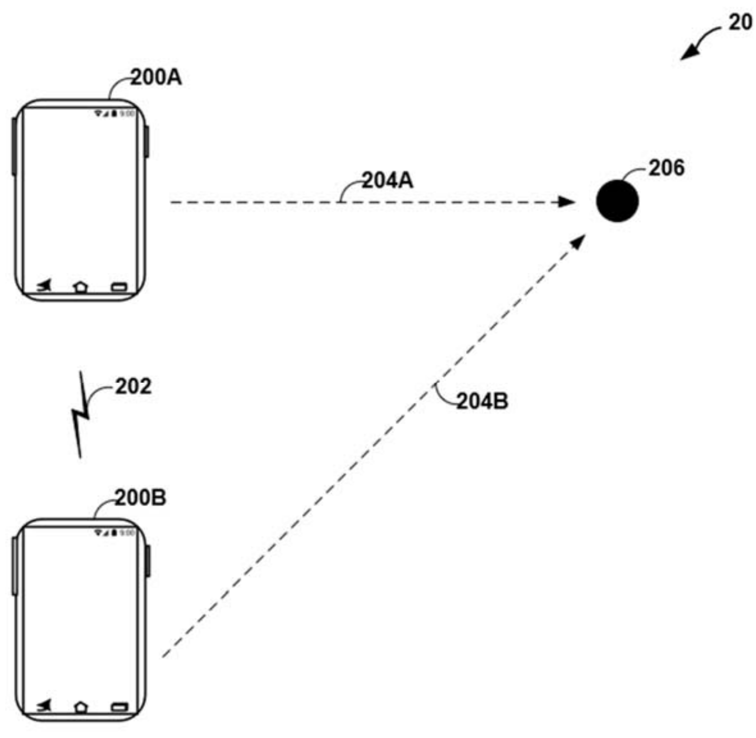

FIG. 2

FIG. 2 is a conceptual diagram illustrating an example system 20 including a computing device 200A and a computing device 200B (collectively, “computing devices 200”). System 20 may be substantially similar to system 10 of FIG. 1, except for any differences described here. In the example of FIG. 2, computing devices 200 use UWB technology (e.g., via a network 202) and sensors (e.g., accelerometers, geomagnetic field sensors, gyroscopes, etc.) to determine a vector (e.g., speed and direction) for each of computing devices 200. Computing devices 200 may then determine an estimated time of arrival (ETA) at an intersection 206 for each of computing devices 200 based on the vectors of computing devices 200.

Computing devices 200 may output an alert warning users of computing devices 200 of a potential collision based on the ETA of computing devices 200 at intersection 206. For example, computing device 200A may use sensors to determine a vector 204A of computing device 200A, and computing device 200B may use sensors to determine a vector 204B of computing device 200B. Computing devices 200 may periodically transmit vector 204A and vector 204B (collectively, “vectors 204”) to each other (e.g., via UWB) and the distances of computing devices 200 from intersection 206 (e.g., based on vectors 204 and time elapsed). If computing devices 200 determine, based on a vector 204A of computing device 200A and a vector 204B of computing device 200B, that the difference in the ETAs of computing devices 200 at intersection 206 is equal to or less than a threshold (e.g., 1 second), computing devices 200 may output an alert warning users of computing devices 200 of a potential collision.

Additionally, computing devices 200 may output an alert warning users of computing devices 200 of a potential collision whenever a distance between computing devices 200 is equal to or less than a threshold (e.g., 5 feet). As described above, computing devices 200 may employ UWB technology to determine the distance between computing devices 200 via ToF.

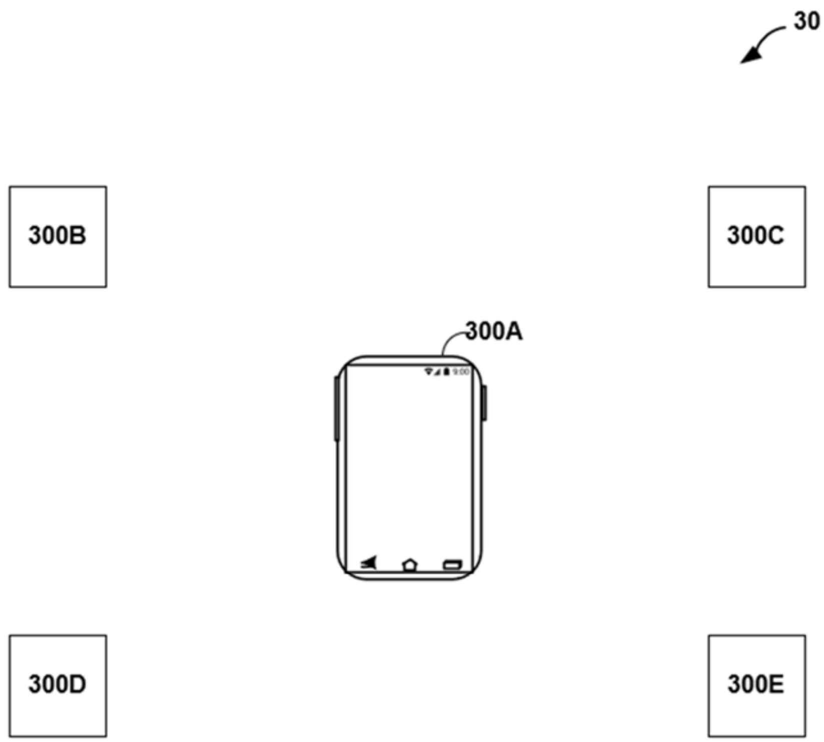

FIG. 3

FIG. 3 is a conceptual diagram illustrating an example system 30 including a large number of computing devices. FIG. 3 is substantially similar to system 10 of FIG. 1 and/or system 20 of FIG. 2, except for any differences described here. As shown in FIG. 3, system 30 includes computing devices 300A-300E (collectively, "computing devices 300"). However, it should be understood that system 30 may include fewer or more computing devices. In the example of FIG. 3, computing devices 300B-300E are tags, though other types of computing devices are possible.

In certain situations, a person may not be aware of the person's surroundings. For example, if the person is wearing a virtual reality headset, the person may be physically incapable of seeing physical reality. As a result, the person may accidentally collide with a person or object while wearing the virtual reality headset. In another example, if the person is visually impaired (e.g., blind), the person may likewise be physically incapable of seeing physical reality and accidentally collide with a person or object.

Computing devices 300 may output an alert warning a user of computing devices 300 of a potential collision based on the distance between computing devices 300. For example, if a user is carrying computing device 300A, then computing device 300A may output an alert warning the user of a potential collision whenever a distance between computing device 300A and any of computing devices 300B-E is equal to or less than a threshold (e.g., 3 feet). As described above, computing devices 300 may employ UWB technology to determine the distance between computing devices 300 via ToF.

It is noted that the techniques discussed here may be combined with any other suitable technique or combination of techniques. As one example, the techniques discussed here may be combined with the techniques described in DE102020114834. In another example, the techniques discussed here may be combined with the techniques described in DE102029132625. In yet another example, the techniques discussed here may be combined with the techniques described in WO2016115259. In yet another example, the techniques discussed here may be combined with the techniques described in Alemayehu Solomon Abrar et al., “Collision prediction from UWB range measurements,” October 9, 2020. In yet another example, the techniques discussed here may be combined with the techniques described in WO2017153979. In yet another example, the techniques discussed here may be combined with the techniques described in U.S. Patent Application Publication No. 2016/0349362A1.