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SMART WATCH POWER SAVING PREDICTION BASED ON CONTEXTUAL SIGNALS

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ABSTRACT

A wearable computing device (e.g., a smart watch), referred herein as a "wearable device" or "device," is described that utilizes contextual signals to predict when to toggle between a power savings mode (e.g., "Sleep Mode"), where one or more lower power processors control functionality of the device, and a higher power mode, where one or more higher power processors control functionality of the device. The wearable device may predict, based on contextual signals, when the user may not require full functionality of the wearable device and switches to the power savings mode. For example, the user may not require full functionality of the wearable device when the user is asleep, exercising, or when the device is on "Do Not Disturb" mode. The wearable device may also predict, based on contextual signals, when the user may require full functionality and may switch from a lower power mode, such as the power savings mode, to a higher power mode in advance of the predicted time or may prevent the wearable device from switching into the power savings mode from the regular power mode. The contextual signals may include state of the user, movement patterns, and context information such as location, time, user behavior history, device configuration information, calendar events, or other relevant data.

DESCRIPTION

A wearable computing device, such as a shown in the example of Figure 1 below, may include devices such as a smart watch. Due to the wearable devices' size restrictions, these devices have batteries with reduced capacities as compared to other, physically larger, mobile devices (e.g., smartphones, laptops). When a wearable device operates in a higher power mode, the wearable device activates relatively higher power processor(s) to execute instructions. In this higher power mode, the wearable device operates at full functionality and full access to all components but will have a higher rate of power consumption. In various instances, while operating in the higher power mode, the wearable device may increase sampling rate of various sensors, may refrain from powering down various radios in the wearable device, and may refrain from performing other power saving measures. The wearable devices may also operate in various power savings modes. When a wearable computing device operates in a power savings mode (e.g., Sleep Mode), the wearable device activates relatively lower power processor(s) to execute instructions. In this power savings mode, the wearable device will operate with reduced functionality (as compared to operating in the higher power mode) but will have a lower rate of power consumption.

During certain periods of time, such as when the user is asleep, exercising, or when the device is on "Do Not Disturb" mode, the user may want the device to switch to the power saving mode to reduce power consumption and then return to higher power mode when the user desires full functionality from the wearable device. However, the user may not always have the time, ability, or thought to manually toggle on/off power savings mode. Even if the user did manually configure the wearable device to operate in the power savings mode, the user would then need to manually configure the wearable device to operate in the higher power mode (e.g., by toggling the power savings mode off) and wait for the high-power processors to wake up and engage full functionality of the device. By requiring the user to manually configure the wearable device, the user may forget to configure the wearable device into the power savings mode, thereby reducing the battery life of the wearable device, or the user may have to wait for the wearable device to boot up when they interact with the wearable device after a period of inactivity.

Rather than requiring the user to manually configure a wearable device, the techniques of this disclosure enable a wearable device to analyze various contextual signals and automatically switch between operating in the power savings mode and operating in the higher power mode. The contextual signals may include a state of the user (e.g., whether the user set the device to available, busy, away, or do not disturb), motion detected by the wearable device, one or more applications currently executing on the wearable device, a current location, a current time, historical user behaviors, calendar events, audio and/or visual data being output by other devices proximate to the wearable device (e.g., companion devices, such as a smartphone linked to the wearable device, televisions, speakers, smart speakers, or other devices associated with a user of the wearable device), or other relevant data. Using contextual signals, the wearable device may predict future time periods when the wearable device may be switched from operating in the higher power mode to operating in the power savings mode or vice versa. By predictively switching between operating in the power savings mode and the higher power mode, the device may reduce power consumption when the user is only using a subset of the wearable device functionality while still providing full functionality when the user is predicted to start requiring additional functionality provided when the device is operating in the higher power mode without requiring the user to manually configure the device to switch between the power modes or to wait for the wearable device to switch between power modes.

Figure 1 is a block diagram illustrating an example wearable computing device 110 that may be configured to predict, based on user cues, when to switch between a power savings mode and a higher power mode. Wearable computing device 110 includes components including processors 112, input devices 114, user interface (UI) device 116, communication units 118, output devices 120, motion sensors 122, and storage devices 126. The components of wearable computing device 110 are interconnected and can communicate with each other through communication channels 124.

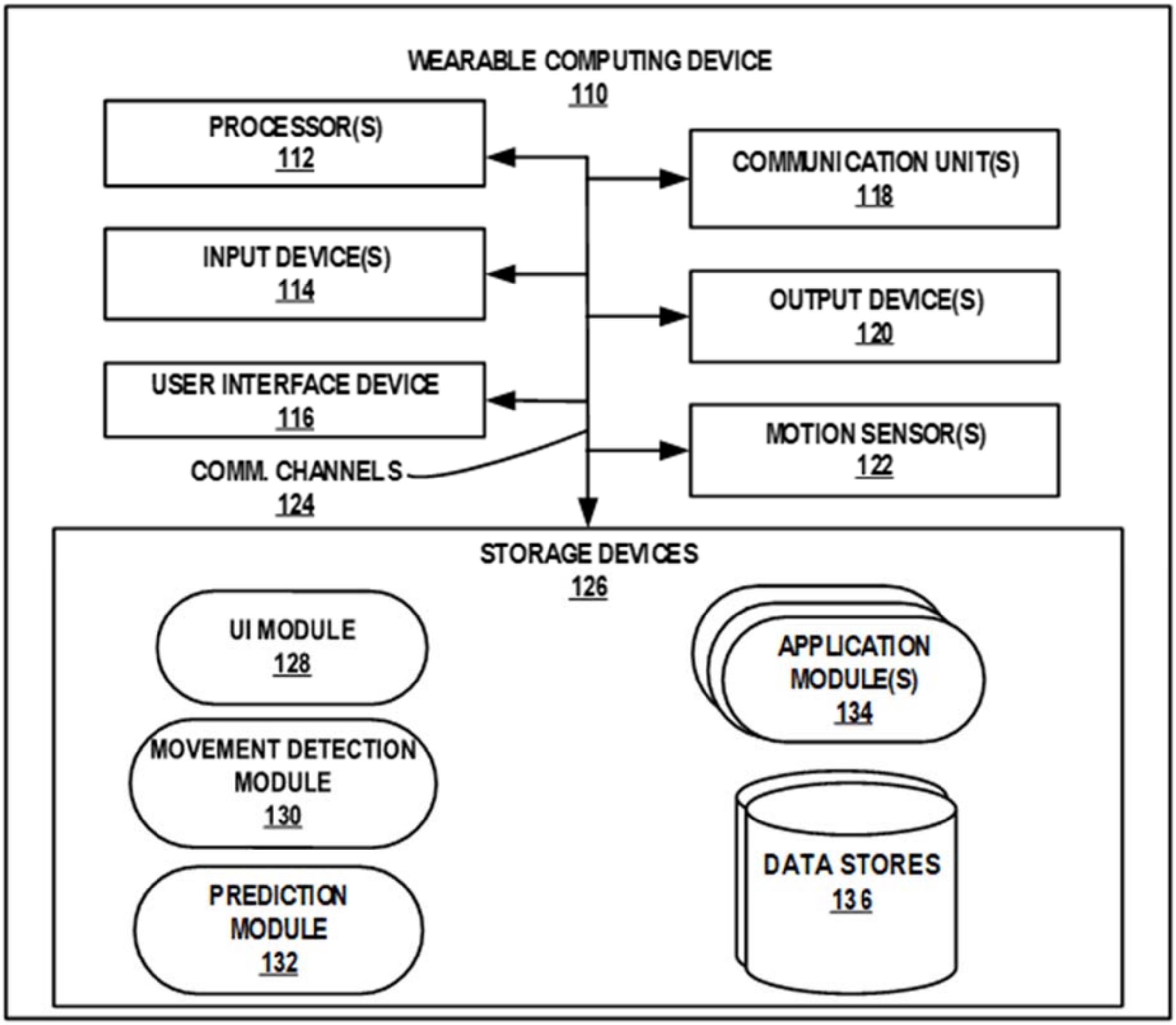

FIG. 1

Wearable computing device 110 includes processors 112, which may include one or more higher power processors and one or more lower power processors. The higher power processor may be referred to as “big” processors while the lower power processors may be referred to as “little” processors. While the present disclosure describes wearable computing device 110 as including one or more higher power processors and one or more lower power processors, the description of the one or more higher power processors using the term “higher power” does not imply that the one or more higher power processors are desktop-class or server-class processors. Instead, the one or more higher power processors are mobile-class processors designed for mobile computing devices such as mobile phones, wearable computing devices, and the like, that are relatively higher-powered compared with the one or more lower power processors.

The one or more lower power processors may have limited functionality compared with the one or more higher power processors. In some examples, the one or more lower power processors may have a much smaller cache memory compared with the one or more higher power processors. In some examples, the one or more higher power processors may be configured to execute a fully-featured mobile operating system, such as an operating system designed for a mobile phone or a wearable device, while the one or more lower power processors may not be able to execute such a fully-featured mobile operating system. Instead, the one or more lower power processors may be configured to execute a much more limited operating system having limited functionality with limited APIs compared with the fully-featured mobile operating system that the one or more higher power processors may be configured to execute. Thus, while the one or more higher power processors are able to execute instructions that are native to the fully-featured mobile operating system, the one or more lower power processors may not be able to execute instructions that are native to the fully-featured mobile operating system running on the one or more higher power processors and may instead may be limited to executing a subset of such instructions that are native to the fully-featured mobile operating system or may be limited to executing a different set of instructions.

Because the one or more higher power processors are relatively higher-powered compared to the one or more lower power processors, the one or more higher power processors may consume relatively more power when powered on and operating compared with the one or more lower power processors. As such, wearable computing device 110 may be able to reduce its power consumption by increasing the use of the one or more lower power processors to perform workloads while reducing the use of the one or more higher power processors.

Other components of wearable computing device 110 perform various other functions. Input devices 114 (e.g., touch-sensitive screen) receive various input from the user and communicates the input to other components in the device 110. Output device 120 (e.g., speaker, display) generates the output from the device for the user to receive. UI device 116 may include functionality of the input devices 114 and output devices 120 and generates a graphical user interface (GUI) for the user. Motion sensors 122 in wearable computing device 110 detect nearby movement or absence of movement and communicates the data to other components of wearable computing device 110.

Storage devices 126 may store information for processing during operation of wearable computing device 110. Storage devices 126 may include several modules, including user interface (UI) module 128, movement detection module 130, prediction module 132, one or more application modules 134, and one or more data stores 136. UI module 128 communicates with and receives data from UI device 116, input devices 114, and output devices 120. Movement detection module 130 may receive and interpret motion data from motion sensors 122 of wearable computing device 110. Application modules 134 include applications that wearable computing device 110 may execute. Application modules 134 may include both stand-alone applications as well as applications that are integrated with one another. Data stores 136 receives and stores data from other components of wearable computing device 110. Other components of wearable computing device 110 may retrieve and use data stored in data stores 136.

Prediction module 132 may receive data from other components of wearable computing device 110 and use the data to predict when wearable computing device 110 should switch between power modes (i.e., from operating in a power savings mode to operating in a higher power mode and vice versa). In order to facilitate such predictions, prediction module 132 may include a machine learning system that identifies recurring patterns in the data. For example, prediction module 132 may determine whether a user is sleeping by at least applying a machine learned model to motion data (e.g., generated by motion sensors 122), audio data (e.g., generated by input devices 114 based on audio captures by one of input devices 114), historical user behaviors, audio and/or visual data being output by other devices proximate to wearable computing device 110, the user's sleep history, and other contextual signals. In instances where prediction module 132 determines that the user is asleep, wearable computing device 110 may enter into a power savings mode, which causes wearable computing device 110 to deactivate higher power processors and activate lower power processors to provide functionality and execute instructions.

As another example, prediction module 132 may predict when a user is going to wake up and, in response, automatically switch from operating in a power savings mode to operating in a higher power mode. Similar to determining whether the user is asleep, prediction module 132 may analyze motion data, audio data, historical user behaviors, audio and/or visual data being output by other devices proximate to wearable computing device 110, the user's sleep history, and other contextual signals to predict when the user may wake up (e.g., by providing the contextual signal data to a machine learned model). In addition, prediction module 132 may analyze the user's previous sleep patterns, alarm settings, calendar events, etc. to predict when the user is likely to wake up. Based on the predicted wake-up time, wearable computing device

110 may automatically switch from operating in the lower power mode to operating in the higher power mode in advance of the user waking. That is, wearable computing device 110 may, without explicit user input to cause wearable computing device 110 to switch power modes, automatically switch into operating in the higher power mode in advance of the user requesting functionality of wearable computing device 110 that requires operating in the higher power mode. When wearable computing device 110 switches from a power savings mode to a higher power mode, lower power processors are deactivated and higher power processors activated to provide full functionality and execute instructions.

As another example, prediction module 132 may determine that the user is exercising and, therefore, may not require the full functionality of wearable computing device 110. Thus, wearable computing device 110 could enter into the power savings mode while the user is exercising. For example, if a user is jogging while wearing wearable computing device 110, motion detection module 130 may determine that the user is exercising based on motion data from motion sensors 122 and location data (e.g., current location, the user's distance from their home, user's velocity vector, etc.). Prediction module 132 may predict, based on contextual signals (e.g., current location, current time, user exercise history, etc.), when the user would finish exercising and predictively switch wearable computing device 110 to operating in the higher power mode prior to the user finishing exercising.

Responsive to the user activating "Do Not Disturb" (DND) mode on wearable computing device 110, wearable computing device 110 may switch to operating in the power savings mode. If wearable computing device 110 does switch to operating in the power savings mode, prediction module 132 may analyze various contextual signals to predict when the user will exit DND mode and predictively switch wearable computing device 110 to operating in the higher power mode. For example, prediction module 132 may predict when the user will deactivate DND mode based on the time and duration of previous instances when the user activated DND mode or the time and duration of any future scheduled DND modes, the user's calendar events, etc. Based on the predictions made by prediction module 132, wearable computing device 110 may predictively switch to a higher power mode in advance of when the user is predicted to deactivate DND mode.

Thus, as described herein, prediction module 132 of wearable computing device 110 may use contextual signals to predict times when wearable computing device 110 can predictively switch between power savings modes and higher power modes without requiring user input. By automatically switching between the power savings modes and higher power modes, wearable computing device 110 may reduce unnecessary power consumption and improve battery life.

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 PCT Patent Application Publication 2018/072453. As another example, the techniques of this disclosure may be combined with the techniques described in US Patent Publication 9798378 B2. As another example, the techniques of this disclosure may be combined with the techniques described in US Patent Publication 7711868 B2.