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IN-VEHICLE SYSTEM FOR INDICATING DIRECTIONALITY OF DETECTED SOUNDS

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ABSTRACT

A vehicle system is described that enables an in-vehicle device (e.g., a steering wheel, a steering wheel cover, etc.) to provide visual and/or haptic alerts indicating the direction from which sounds are captured via various microphones or other audio sensors of the vehicle originated. The vehicle system may, after receiving explicit permission from a user (e.g., a driver, a hearing-impaired person, etc.), use user equipment (e.g., a mobile phone, a smartphone, a cellular phone, a portable device, a handheld device, a mobile terminal, a portable terminal, etc.) to detect noises (e.g., honking, sirens, crashes, accidents, pedestrian shouts/yells, etc.) outside the vehicle and cause the in-vehicle device to generate warning lights and/or vibrations based on the detected noises outside the vehicle. For example, the vehicle system may analyze audio data captured by microphones to determine if the audio captured is indicative of an alert-triggering event. Based on the analysis of audio data, the vehicle system may further determine a direction of the alert-triggering event and cause the in-vehicle device to generate warning lights and/or vibrations in a portion that corresponds to the direction of the triggering event for alerting.

DESCRIPTION

FIG. 1 is a conceptual diagram illustrating a side view of an interior of a vehicle 100 in which an example vehicle system 110 is configured to provide visual and/or haptic warnings based on audio data captured via various microphones in accordance with one or more aspects of the present disclosure. In the example of FIG. 1, vehicle system 110 includes processing circuitry 112, one or more microphone(s) 114, one or more haptic signal generator(s) 116, and one or more visual signal generator(s) 117. In FIG. 1, vehicle 100 is illustrated as an automobile.

However, it should be understood that vehicle 100 may include a motorcycle, a bus, an RV, a semi-trailer truck, a tractor or other type of farm equipment, a train, a plane, a helicopter, a truck, a boat, a personal transport vehicle, etc.

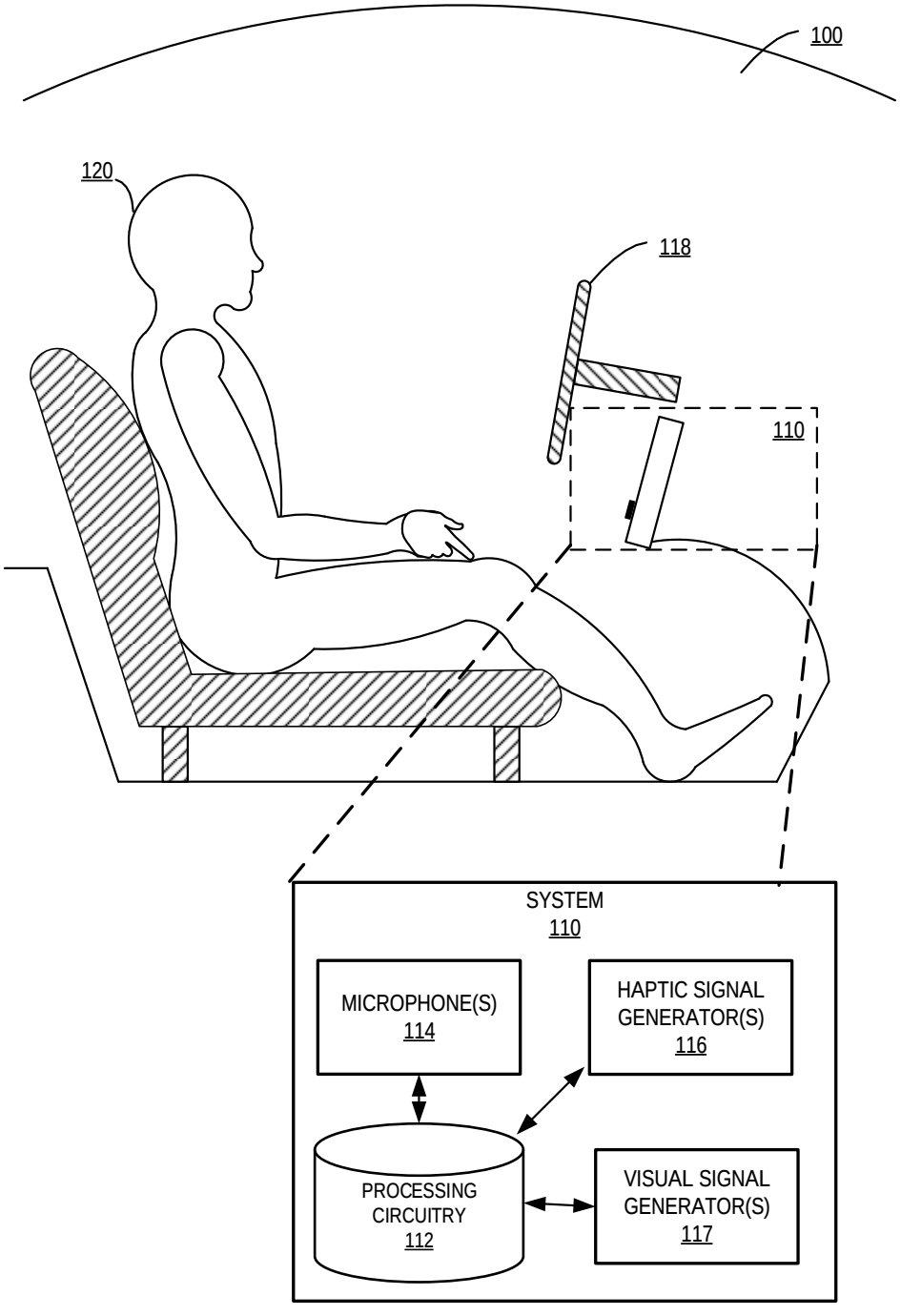

FIG. 1

Processing circuitry 112 may be included in a vehicle head unit, a mobile device (e.g., smartphone, tablet, etc.), and/or a remote server (e.g., a cloud computing system).

Microphone(s) 114 may include one or more microphones built into vehicle 100, one or more microphones included in devices, such as smartphones, located within the vehicle, etc. Haptic signal generator(s) 116 may include one or more vibrators built into an in-vehicle device 118. The haptic signal generator(s) can be located at any portion of in-vehicle device 118. For example, haptic signal generator(s) 116 can be located on an interior or exterior edge of the steering wheel of vehicle 100. As another example, haptic signal generator(s) 116 can be located on a front or back face of an ornamental cover of the steering wheel of vehicle 100. As another example, haptic signal generator(s) 116 could also be in seat bolsters (e.g., sides of the seat) of vehicle 100.

Visual signal generator(s) 117 may include one or more light elements built into an in-vehicle device 118. The light element may include, for example, a liquid crystal display (LCD), a thin-film-transistor display, an active-matrix display, a segmented display, a light-emitting diode (LED), a liquid crystal display, fluorescent, or any other suitable light element. Visual signal generator(s) 117 can be located at any portion of in-vehicle device 118. For example, visual signal generator(s) 117 can be located on an interior or exterior edge of the steering wheel of vehicle 100. As another example, visual signal generator(s) 117 can be located on a front or back face of an ornamental cover of the steering wheel of vehicle 100. In some examples, visual signal generator(s) 117 also be located in instrument cluster, head unit display, head's up display, etc. Visual signal generator(s) 117 can display a single color or multiple colors. For example, the exemplary LED can include a single color LED, a bi-color LED, or a tri-color LED.

In some examples, in-vehicle device 118 may include a steering wheel of vehicle 100, and haptic signal generator(s) 116 and/or visual signal generator(s) 117 may be built into the steering wheel of vehicle 100. In other examples, in-vehicle device 118 may include an ornamental cover disposed over a portion of steering wheel 118 of vehicle 100, and haptic signal generator(s) 116 and/or visual signal generator(s) 117 may be built into the ornamental cover. The ornamental cover contains control circuit and power supply circuit, which are powered from vehicle 100 or from a built-in battery.

In various instances, a user 120 of in-vehicle system 110 may wish to receive visual and/or haptic warnings indicating directionality of noises outside the vehicle 100. For example, vehicle 100 may be traveling through a noisy area, and user 120 may feel the noise masks the horn of vehicle 100. In such instances, user 120 may provide explicit permission to allow in-vehicle system 110 to capture and analyze audio data generated by in-vehicle system 110. After receiving explicit user permission, in-vehicle system 110 may capture audio data from microphone(s) 114.

In some examples, processing circuitry 112 may process the audio data to determine if the audio captured indicates a triggering event. Processing circuitry 112 may compare the audio data with audio data of stored triggering event sound samples. For example, processing circuitry 112 may extract the frequency of a sound from the audio captured, the amplitude of the sound, and other sound features, and compare the extracted sound features with sound features of a siren sound sample. If processing circuitry 112 determines that the frequency of sound and amplitude of sound from the audio captured matches the frequency and amplitude of a stored siren sound sample, processing circuitry 112 may determine the audio captured indicates the alert-triggering event.

Processing circuitry 112 may determine the direction of the noises outside the vehicle 100 based on the audio data. For example, processing circuitry 112 may determine the location of a sound based on characteristic differences in the sound as detected by a first microphone of microphone(s) 114 and at least one other microphone of microphone(s) 114, such as differences in time of arrival, time of flight, frequency, intensity, Doppler shifts, spectral content, correlation analysis, pattern matching, and triangulation, etc.

Processing circuitry 112 may cause one or more haptic signal generator(s) 116 of in-vehicle device 118 to generate a haptic alert in a portion of in-vehicle device 118 corresponds to the direction of the noises outside the vehicle 100. For example, in response to determining the noises outside the vehicle 100 is detected from the left front of vehicle 100, processing circuitry 112 may cause an upper left haptic signal generator 116 to generate a vibration that may be sensed through in-vehicle device 118 (e.g., a steering wheel, an ornamental cover of the steering wheel of vehicle 100, etc.) by user 120 of vehicle 100. If user 120 holds the steering wheel of vehicle 100 at the 10 and 2 positions, as envisioned on a clock, then user 120 may sense the vibration in the upper left of the left hand of user 120, indicating the noises outside the vehicle 100 is detected from the left front of vehicle 100.

Processing circuitry 112 may cause one or more visual signal generator(s) 117 of in-vehicle device 118 to generate a visual alert in a portion of in-vehicle device 118 corresponds to the direction of the triggering event. For example, in response to determining the noises outside the vehicle 100 is detected from the right front of vehicle 100, processing circuitry 112 may cause an upper right visual signal generator 117 installed on in-vehicle device 118 to display a warning light signal.

In some examples, processing circuitry 112 may determine the severity of a triggering event based on detected audio data and may convey the severity of the triggering event through the one or more haptic signal generator(s) 116 and/or one or more visual signal generator(s) 117. For example, processing circuitry 112 may detect a siren sound and may cause haptic signal generator(s) 116 to generate a gentle vibration and/or cause visual signal generator(s) 117 to alternate between blue and red lights to alert user 120 of vehicle 100. As another example, processing circuitry 112 may detect a car crashing sound and may cause haptic signal generator(s) 116 to generate a moderate vibration and/or cause visual signal generator(s) 117 to display bright orange lights. In some examples, processing circuitry 112 may further convey the severity of the triggering event through the one or more haptic signal generator(s) 116 using various vibration frequency and/or various vibration duration.

In some examples, processing circuitry 112 may further transmit the detected triggering event to a companion device for display, such as a mobile device or a display of vehicle 100. In some examples, the display of vehicle 100 may include a dashboard display. In some examples, the display of vehicle 100 may include a head-up display, which may project an indication of the detected triggering event on the windshield of vehicle 100.

The example vehicle system 110 may have numerous advantages. The one or more haptic signal generator(s) 116 provide haptic warnings, and the one or more visual signal generator(s) 117provide visual warnings to user 120 of vehicle 100 indicating directionality of noises outside vehicle 100, which serves to improve the safety of vehicle 100 in road traffic.

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 US 2018/0118089 A1. As

another example, the techniques of this disclosure may be combined with the techniques described by Hyundai, “The Quiet Taxi,” available at https://tech.hyundaimotorgroup.com/video/the-quiet-taxi/.