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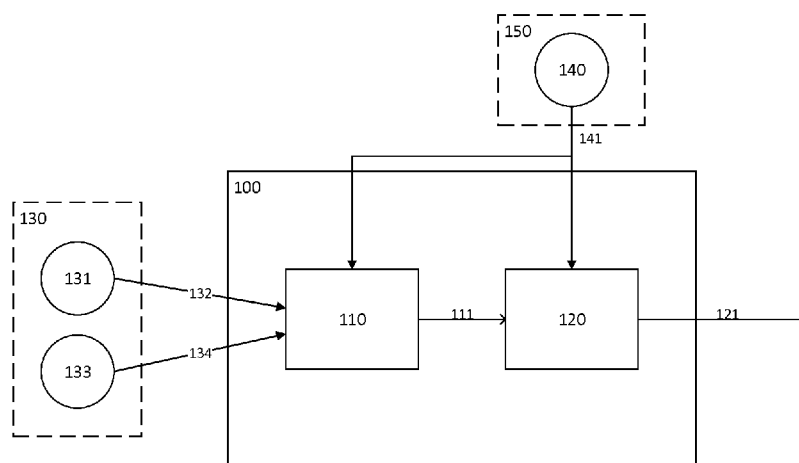


Fig. 1

(57) Abstract: Embodiments of the present invention provide a noise cancellation system for a vehicle comprising a noise prediction means (110) and an audio processing means (120) for outputting a noise-cancelled signal (121) based on received noise and audio signals (132, 134, 141) received from noise and audio input means (130, 140).



SYSTEM AND METHOD FOR NOISE CANCELLATION

TECHNICAL FIELD

The present disclosure relates to a system and method for noise cancellation.

- 5 Aspects of the invention relate to a noise cancellation system, a method of noise cancellation in a vehicle, a controller, a vehicle, and computer software arranged to perform a method of noise cancellation.

BACKGROUND

- 10 Noise, especially outside a vehicle, can be troublesome for occupants in the vehicle. The inclusion of audio input devices within vehicles, such as hands-free communication devices or voice command devices, is designed to improve passenger or driver experience by allowing the user to perform tasks without being distracted from the road. Hands free communication devices are often used to make
- 15 calls for example, and voice command devices (VCDs) are often used within the vehicle to receive speech for instructing commands, such as various telephony and infotainment functions. However, unwanted noise generated by vehicle operation or the ambient environment can lead to difficulties with device performance, such as reducing the quality of the call or masking a voice signal intended for the VCD.

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It is an object of embodiments of the invention to at least mitigate one or more of the problems of the prior art.

SUMMARY OF THE INVENTION

- 25 Aspects and embodiments of the invention provide a noise cancellation system, a method of noise cancellation in a vehicle, a controller, a vehicle, and computer software arranged to perform a method of noise cancellation according to an aspect of the invention.
- 30 According to an aspect of the invention, there is provided a noise cancellation system, comprising a noise input means, an audio input means, a prediction means for generating a prediction signal, and an audio processing means for outputting a noise-cancelled signal.
- 35 According to an aspect of the invention, there is provided a system for a vehicle, the system comprising noise input means for generating one or more noise signals indicative of ambient or operational noise, said noise input means located at a first

location; audio input means for generating one or more audio input signals, said audio input means located at a target area being at a second location remote from said first location; noise prediction means for receiving the one or more noise signals and generating a prediction signal in dependence on the one or more received noise signals, wherein the generated prediction signal comprises a signal indicative of noise at the target area, and audio processing means for receiving the one or more audio input signals and outputting a noise-cancelled signal in dependence on the received audio input signals and the generated prediction signal.

10 The system as described above, wherein:
the noise input means is a vibro-acoustic device;
the audio input means is a microphone;
the noise prediction means is an electronic processor; and
the audio processing means is an electronic processor, such as an audio
15 signal processor.

It may be that the noise prediction means and the audio processing means are provided by a single electronic processor. The noise prediction means and the audio processing means may comprise operational modules within a single electronic
20 processor.

The noise input means may be arranged to generate one or more noise signals indicative of ambient or operational noise. The audio input means may be arranged to generate one or more audio input signals. The prediction means may be arranged to receive the one or more noise signals. The prediction means may be arranged to generate a prediction signal in dependence on one of a sum or a weighted average of the received noise signals. The generated prediction signal may comprise a signal indicative of noise at a target area. Advantageously, this allows for noise reduction to be targeted towards a specific area. The audio processing means may be arranged to receive the one or more audio input signals and output a noise-cancelled signal based on the received audio input signals and the generated prediction signal. In some embodiments the audio processing means is arranged to output the noise-cancelled signal in dependence on one of a subtraction or addition of the generated prediction signal from/to the received audio input signal.

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Optionally the audio processing means is arranged to generate a prediction signal based on a weighted average of the received noise signals. Advantageously, this allows a more accurate prediction signal.

- 5 Optionally, at least one of the noise signals is generated from an audio system associated with the vehicle. Advantageously, this allows for an improved prediction signal to be generated by taking into account known noise inputs.

- 10 Optionally, the target area is located at the audio input means. Advantageously, this allows for reduction of noise specifically at the audio input means, thus facilitating a clearer audio input signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

- 15 Optionally, the generated prediction signal comprises an estimate of a sound pressure level.

- 20 Optionally, the prediction means is arranged to estimate one or more reference transfer functions, (RTFs). Optionally, the RTFs are indicative of a transfer function from a respective noise input means to the target area.

- 25 Optionally, the estimated reference transfer function (RTF) is determined in dependence on a relationship between at least a portion of the frequency spectrum of at least one of the received audio signals and a corresponding at least one portion of the frequency spectrum of at least one of the received noise signals.

- 30 Optionally, the prediction means is arranged to pass the generated noise signals through one or more filters which represent the estimated reference transfer function (RTF).

- 35 The prediction means may further comprise a feedback loop and the generated prediction signal is updated in dependence on the received noise signals at pre-defined intervals of time. Advantageously, this allows for an adaptive noise cancellation system.

The audio processing means may comprise an external processing unit. Optionally, the external processing unit is an externally located computing means. Advantageously, this allows for a more efficient use of computing resources.

- 5 It may be that the external processing unit is located external to the vehicle. For example, the external processing unit may be remote from the vehicle. It may be that the external processing unit is provided by a computing device, such as a computer server, located remotely from the vehicle. It may be that the vehicle is configured to wirelessly communicate, e.g. by way of a wireless network, with the external
10 processing unit. It may be that the vehicle is configured to wirelessly transmit (e.g. by way of a wireless network) the audio input signals to the external processing unit. It may be that the vehicle is configured to wirelessly receive (e.g. by way of a wireless network) the noise cancelled signal from the external processing unit.
- 15 It may be that the external processing unit is physically separate from the vehicle. It may be that the external processing unit is not integrated with the vehicle.

Optionally, at least one of the received audio signals is a voice signal.

- 20 It may be that the noise-cancelled signal comprises one or more audio signals based on the one or more audio input signals, the noise-cancelled signal having reduced ambient or operational noise compared to the one or more audio input signals. It may be that the noise-cancelled signal has a greater signal to noise ratio than the one or more audio input signals, the signal component of the noise-cancelled signal
25 comprising the said one or more audio signals based on the one or more audio input signals.

Optionally, at least one of the noise input means is configured to receive the one or more noise signals from outside the vehicle.

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At least one of the audio input means may be located on the exterior of the vehicle.

At least one of the audio input means may be configured to receive the one or more noise signals from inside the vehicle.

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It may be that the noise input means comprises noise input means located on the exterior of the vehicle.

It may be that the noise input means comprises noise input means configured to generate one or more noise signals from noise received from inside the vehicle.

- 5 It may be that the noise input means comprises noise input means for generating (or configured to generate) one or more noise signals indicative of operational noise of the vehicle. It may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of operational noise of the vehicle is provided proximate to the corresponding one or more sources of the operational
- 10 noise of the vehicle, such as adjacent to the corresponding one or more sources of the operational noise, or it may be that the noise input means for generating one or more noise signals indicative of operational noise of the vehicle is provided remote from the corresponding one or more sources of the operational noise of the vehicle. It may be that the noise input means for generating (or configured to generate) one
- 15 or more noise signals indicative of operational noise of the vehicle is provided outside of the vehicle cabin, or it may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of operational noise of the vehicle is provided inside the vehicle cabin.
- 20 For example, it may be that the noise input means comprises noise input means for generating (or configured to generate) one or more noise signals indicative of suspension noise from a suspension of the vehicle (e.g. noise caused by movement or vibration of the suspension). It may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of suspension noise
- 25 of the vehicle is provided proximate to the suspension of the vehicle, such as adjacent to the suspension of the vehicle, or it may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of suspension noise of the vehicle is provided remote from the suspension of the vehicle. It may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of suspension noise of the vehicle is provided outside of the vehicle cabin or it may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of suspension noise of the vehicle is provided inside the vehicle cabin. It may be that
- 30 the noise prediction means is for receiving (or is configured to receive) the one or more noise signals indicative of suspension noise of the vehicle and for generating (or configured to generate) the prediction signal in dependence on the one or more received noise signals indicative of suspension noise of the vehicle. In this way, the
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suspension noise of the vehicle can be accounted for in the noise prediction signal, and thus also in the noise-cancelled signal output by the audio processing means. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise from the suspension of the vehicle, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

In another example, it may be that the noise input means comprises noise input means for generating (or configured to generate) one or more noise signals indicative of engine noise from an engine of the vehicle (e.g. noise caused by operation of the engine, such as vibration of at least a part of the engine). It may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of engine noise of the vehicle is provided proximate to the engine of the vehicle, such as adjacent to the engine of the vehicle, or it may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of engine noise of the vehicle is provided remote from the engine of the vehicle. It may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of engine noise of the vehicle is provided outside of the vehicle cabin or it may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of engine noise of the vehicle is provided inside the vehicle cabin. It may be that the noise prediction means is for receiving (or is configured to receive) the one or more noise signals indicative of engine noise of the vehicle and for generating (or configured to generate) the prediction signal in dependence on the one or more received noise signals indicative of engine noise of the vehicle. In this way, the engine noise of the vehicle can be accounted for in the noise prediction signal, and thus also in the noise-cancelled signal output by the audio processing means. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise from the engine of the vehicle, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

In another example, it may be that the noise input means comprises noise input means for generating (or configured to generate) one or more noise signals indicative of transmission noise from a transmission of the vehicle (e.g. noise caused by

operation of the transmission). It may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of transmission noise of the vehicle is provided proximate to the transmission of the vehicle, such as adjacent to the transmission of the vehicle, or it may be that the noise input means
5 for generating (or configured to generate) one or more noise signals indicative of transmission noise of the vehicle is provided remote from the transmission of the vehicle. It may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of transmission noise of the vehicle is provided outside of the vehicle cabin or it may be that the noise input means for
10 generating (or configured to generate) one or more noise signals indicative of transmission noise of the vehicle is provided inside the vehicle cabin. It may be that the noise prediction means is for receiving (or is configured to receive) the one or more noise signals indicative of transmission noise of the vehicle and for generating (or configured to generate) the prediction signal in dependence on the one or more
15 received noise signals indicative of transmission noise of the vehicle. In this way, the transmission noise of the vehicle can be accounted for in the noise prediction signal, and thus also in the noise-cancelled signal output by the audio processing means. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise from the transmission of the
20 vehicle, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

In another example, it may be that the noise input means comprises noise input
25 means for generating (or configured to generate) one or more noise signals indicative of tyre noise from one or more tyres of the vehicle (e.g. indicative of noise generated from the interactions between one or more tyres of the vehicle and the surface on which the vehicle is provided). It may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of tyre noise of the
30 vehicle is provided proximate to a tyre of the vehicle or it may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of tyre noise of the vehicle is provided remote from the tyres of the vehicle. It may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of tyre noise of the vehicle is provided outside of the vehicle
35 cabin or it may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of tyre noise of the vehicle is provided inside the vehicle cabin. It may be that the noise prediction means is for receiving (or

is configured to receive) the one or more noise signals indicative of tyre noise of the vehicle and for generating (or configured to generate) the prediction signal in dependence on the one or more received noise signals indicative of tyre noise of the vehicle. In this way, the tyre noise of the vehicle can be accounted for in the noise prediction signal, and thus also in the noise-cancelled signal output by the audio processing means. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise from the one or more tyres of the vehicle, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

It may be that the noise input means comprises noise input means for generating (or configured to generate) one or more noise signals indicative of ambient noise. It may be that the noise input means for generating (or configured to generate) one or more noise signals indicative of ambient noise is provided external to the vehicle cabin or inside the vehicle cabin.

For example, it may be that the noise input means comprises noise input means for generating (or configured to generate) one or more noise signals indicative of noise associated with the surroundings of the vehicle, such as noise external to the vehicle, such as wind noise or noise generated by other vehicles in the vicinity of the vehicle (e.g. noise caused by the interactions of the tyres of the other vehicles and the surface on which they are provided). It may be that the noise prediction means is for receiving (or is configured to receive) the one or more noise signals indicative of noise associated with the surroundings of the vehicle and for generating (or configured to generate) the prediction signal in dependence on the one or more received noise signals indicative of noise associated with the surroundings of the vehicle. In this way, the noise associated with the surroundings of the vehicle can be accounted for in the noise prediction signal, and thus also in the noise-cancelled signal output by the audio processing means. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise from the surroundings of the vehicle, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

It may be that the noise input means comprises noise input means for generating (or configured to generate) one or more noise signals indicative of any one or more of: suspension noise from a suspension of the vehicle; engine noise from an engine of the vehicle; transmission noise from a transmission of the vehicle; tyre noise from one or more tyres of the vehicle; noise associated with the surroundings of the vehicle, such as noise external to the vehicle. It may be that the noise prediction means is for receiving (or is configured to receive) the one or more noise signals and for generating (or configured to generate) the prediction signal in dependence on the one or more received noise signals. In this way, the noise can be accounted for in the noise prediction signal, and thus also in the noise-cancelled signal output by the audio processing means. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

According to an aspect of the invention, there is provided a method of cancelling noise in a vehicle, the method comprising generating, at a first location, one or more noise signals indicative of ambient or operational noise, generating, at a target area being at a second location remote from said first location, one or more audio input signals, generating a prediction signal indicative of predicted noise at the target area in dependence on one or more of the received noise signals, and calculating a noise-cancelled signal in dependence on the generated prediction signal and one or more of the audio input signals.

Optionally, the generating of the prediction signal is in dependence on one of a sum or a weighted average of the noise signals.

Optionally, the generating of the prediction signal comprises estimating a sound pressure level.

The generating of the prediction signal may further comprise estimating one or more reference transfer functions (RTFs) indicative of a transfer function from a respective noise input means to the target area.

The estimating of the reference transfer function (RTF) determined in dependence on a relationship between at least a portion of the frequency spectrum of at least one of

the audio signals by at least a portion of the frequency spectrum of at least one of the noise signals.

5 Optionally, the generating of the prediction signal further comprises passing the noise signals through one or more filters representative of the estimated reference transfer function.

Optionally the noise-cancelled signal is calculated in dependence on a combination of the generated prediction signal from the received audio input signals.

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The generating of the prediction signal may further comprise a feedback loop, wherein the method of generating a prediction signal is updated in dependence on the noise signals at pre-determined intervals of time.

15 Optionally, the calculating of the noise-cancelled signal further comprises communicating with an external processing unit. Optionally, the external processing unit is an externally located computing means. It may be that the external processing unit is external to the vehicle. It may be that the external processing unit is remotely located with respect to the vehicle.

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It may be that the method comprises generating, at the first location, one or more noise signals indicative of operational noise of the vehicle. It may be that the first location is proximate to one or more corresponding sources of the operational noise of the vehicle, such as adjacent to one or more corresponding sources of the operational noise of the vehicle, or it may be that the first location is remote from one or more corresponding sources of the operational noise of the vehicle. It may be that the first location is inside the vehicle cabin or it may be that the first location is outside of the vehicle cabin.

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30 For example, it may be that the method comprises generating, at the first location, one or more noise signals indicative of suspension noise from a suspension of the vehicle (e.g. noise caused by movement or vibration of the suspension). It may be that the first location is proximate to the suspension of the vehicle, such as adjacent to the suspension of the vehicle, or it may be that the first location is remote from the suspension of the vehicle. It may be that the method comprises generating the prediction signal in dependence on the one or more noise signals indicative of suspension noise of the vehicle. In this way, the suspension noise of the vehicle can

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be accounted for in the prediction signal, and thus also in the noise-cancelled signal. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise from the suspension of the vehicle, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

In another example, it may be that the method comprises generating, at the first location, one or more noise signals indicative of engine noise from an engine of the vehicle (e.g. noise caused by operation of the engine, such as vibration of at least a part of the engine). It may be that the first location is proximate to the engine of the vehicle, such as adjacent to the engine of the vehicle, or it may be that the first location is remote from the engine of the vehicle. It may be that the method comprises generating the prediction signal in dependence on the one or more noise signals indicative of engine noise of the vehicle. In this way, the engine noise of the vehicle can be accounted for in the prediction signal, and thus also in the noise-cancelled signal. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise from the engine of the vehicle, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

In another example, it may be that the method comprises generating, at the first location, one or more noise signals indicative of transmission noise from a transmission of the vehicle (e.g. noise caused by operation of the transmission). It may be that the first location is proximate to the transmission of the vehicle, such as adjacent to the transmission of the vehicle, or it may be that the first location is remote from the transmission of the vehicle. It may be that the method comprises generating the prediction signal in dependence on the one or more noise signals indicative of transmission noise of the vehicle. In this way, the transmission noise of the vehicle can be accounted for in the prediction signal, and thus also in the noise-cancelled signal. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise from the transmission of the vehicle, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

In another example, it may be that the method comprises generating, at the first location, one or more noise signals indicative of tyre noise from one or more tyres of the vehicle (e.g. indicative of noise generated from the interactions between one or more tyres of the vehicle and the surface on which the vehicle is provided). It may be that the first location is proximate to a tyre of the vehicle, or it may be that the first location is remote from the tyres of the vehicle. It may be that the method comprises generating the prediction signal in dependence on the one or more noise signals indicative of tyre noise of the vehicle. In this way, the tyre noise of the vehicle can be accounted for in the prediction signal, and thus also in the noise-cancelled signal. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise from the one or more tyres of the vehicle, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

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It may be that the method comprises generating, at the first location, one or more noise signals indicative of ambient noise. It may be that the first location is external to the vehicle or inside the vehicle (e.g. inside a cabin of the vehicle).

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For example, it may be that the method comprises generating, at the first location, one or more noise signals indicative of noise associated with the surroundings of the vehicle, such as noise external to the vehicle, such as wind noise or noise of other vehicles in the vicinity of the vehicle (e.g. noise caused by the interactions of the tyres of the other vehicles and the surface on which they are provided). It may be

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that the method comprises generating the prediction signal in dependence on the one or more noise signals indicative of noise associated with the surroundings of the vehicle. In this way, the noise associated with the surroundings of the vehicle can be accounted for in the prediction signal, and thus also in the noise-cancelled signal. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise from the surroundings of the vehicle, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

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It may be that the method comprises generating, at the first location, one or more noise signals indicative of any one or more of: suspension noise from a suspension of the vehicle; engine noise from an engine of the vehicle; transmission noise from a

transmission of the vehicle; tyre noise from one or more tyres of the vehicle; noise associated with the surroundings of the vehicle, such as noise external to the vehicle. It may be that the method comprises generating the prediction signal in dependence on the one or more received noise signals. In this way, the noise can be accounted for in the noise prediction signal, and thus also in the noise-cancelled signal. A noise-cancelled signal can thus be provided which contains an audio signal based on the one or more audio input signals with reduced noise, thus providing a clearer audio signal, e.g. for processing by a VCD with reduced errors or for transmission to another party to a telephone conversation with improved audio quality.

According to an aspect of the present invention, there is provided a controller, comprising noise prediction means for receiving the one or more noise signals generated at a first location, and generating a prediction signal in dependence on the one or more received noise signals, wherein the generated prediction signal comprises a signal indicative of noise at the target area being at a second location, remote from said first location, and audio processing means for receiving the one or more audio input signals generated at the second location and outputting a noise-cancelled signal in dependence on the received audio input signals and the generated prediction signal.

According to an aspect of the invention, there is provided a vehicle comprising a noise cancellation system, controller or arranged to perform a method according to an aspect of the invention.

According to an aspect of the invention, there is provided computer software which, when executed by a computer, is arranged to perform a method according to an aspect of the invention. Optionally, the computer software may be stored on a computer readable medium. The software may be tangibly stored on the computer readable medium. The computer readable medium may be non-transitory.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly,

including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described by way of example only, with reference to the accompanying figures, in which:

Figure 1 shows a system according to an embodiment of the invention;

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Figure 2 shows a sub-system according to an embodiment of the invention;

Figure 3 shows a sub-system according to an embodiment of the invention;

15 Figure 4 shows a flowchart according to an embodiment of the invention; and

Figure 5 illustrates a vehicle 500 according to an embodiment of the invention.

DETAILED DESCRIPTION

20 Figure 1 illustrates a noise cancellation system 100 according to an embodiment of the present invention. The noise cancellation system 100 is arranged to operatively reduce noise at an audio input means 140, for example a microphone. The noise cancellation system 100 may be used in a vehicle, such as a land-going vehicle, although embodiments of the invention may also be used in water- or air-craft.

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The noise cancellation system 100 is arranged to receive one or more noise signals 132, 134 from at least one noise input means 130, and one or more audio input signals 141 from at least one audio input means 140. The noise cancellation system 100 is arranged to operatively output a noise-cancelled signal 121 indicative of the
30 audio input signal 141 having reduced noise.

The audio input means 140 may be at least one microphone 140. The microphone 140 may be part of a telephone, a voice command device (VCD) of a vehicle, a combination thereof, or another device. The audio input means 140 may be
35 integrated with the vehicle, or may comprise an external device to be electronically coupled with the vehicle, for example a portable computing device, such as a smartphone, having a microphone. It may be that such an external device (where

provided) of the audio input means 140 is external in the sense that it is not integrated with the vehicle, but it will be understood that the external device of the audio input means 140 may still be physically located within the vehicle (e.g. within the vehicle cabin). The use of audio input means 140 in a vehicle can be a useful tool
5 for occupants of the vehicle, for example in the provision of telephony or infotainment services whilst driving or travelling in the vehicle.

The noise cancellation system 100 comprises a noise prediction means 110 and an audio processing means 120. The noise prediction means 110 is arranged to receive
10 the one or more noise signals 132, 134. The one or more noise signals 132, 134 are output from the noise input means 130. The noise input means 130 may comprise one or more noise input devices 131, 133 for generating the respective noise signals 132, 134, wherein the noise signals 132, 134 may be indicative of ambient or operational noise at a respective location. In some embodiments, at least one of the
15 devices 131, 133 comprises a vibro-acoustic device such as a microphone or an accelerometer, or any other device suitable for outputting the noise signals 132, 134. In some embodiments, at least one of the devices 131, 133 comprising the noise input means 130 comprises an audio system associated with the vehicle. For example, the noise prediction means 110 may be arranged to receive a first noise
20 signal 132 indicative of ambient or operational noise from the noise input device 131, as well as a second noise signal 134 indicative of noise or sound generated by the vehicle audio system 133.

The noise prediction means 110 comprises one or more electronic processors
25 arranged to receive the one or more noise signals 132, 134 from the noise input means 130, and generate a noise prediction signal 111 based on the received noise signals 130. The noise prediction means 110 may be arranged to receive the at least one audio signal 141 from the audio input means 140. The at least one audio signal 141 may be provided for calibration purposes. The generated noise prediction signal
30 111 comprises a signal indicative of noise at a particular target area 150 within the vehicle. The noise signals 132, 134 are received by the noise prediction means 110, and the noise prediction signal 111 is generated by the noise prediction means 110 indicative of the resultant noise at or within the target area 150. For example, in some embodiments the noise input means 130 may be arranged to generate the noise
35 signal 134 via a vibro-acoustic device 133 associated with a suspension of the vehicle. In this case, it may be that the noise signal 134 is indicative of noise caused by operation (e.g. movement or vibration) of the suspension. It may be that the vibro-

acoustic device 133 is provided proximate to the suspension (e.g. proximate to the suspension outside of the vehicle cabin), or it may be that the vibro-acoustic device 133 is provided remote from the suspension, such as within the vehicle cabin. The target area 150 may be the location of the audio input means of a voice command device (VCD) of the vehicle. The noise signal 134 indicative of noise at the suspension is received by the noise prediction means 110, and the noise prediction means 110 operatively generates the noise prediction signal 111 in dependence on the noise signal generated by the suspension, as would be heard within the target area 150. Thus, the suspension noise of the vehicle can be accounted for in the noise prediction signal, facilitating a clearer audio input signal (see below) for processing by the VCD with reduced errors.

It will be realised by the skilled person that the noise input means 130 may also be arranged to generate noise signals indicative of noise generated by other areas on, within, or surrounding the vehicle, such as noise generated by the engine, transmission, road or tyres, but other sources of noise may be envisaged. For example, in some embodiments the noise input means 130 may be arranged to generate the noise signal 134 via a vibro-acoustic device 133 associated with an engine of the vehicle. In this case, it may be that the noise signal 134 is indicative of noise caused by operation (e.g. vibration) of the engine. It may be that the vibro-acoustic device 134 is provided proximate to the engine (e.g. proximate to the engine outside of the vehicle cabin), or it may be that the vibro-acoustic device 133 is provided remote from the engine, such as within the vehicle cabin. The target area 150 again may be the location of the audio input means of a voice command device (VCD) of the vehicle. The noise signal 134 indicative of noise at the engine is received by the noise prediction means 110, and the noise prediction means 110 operatively generates the noise prediction signal 111 in dependence on the noise signal generated by the engine, as would be heard within the target area 150. Thus the engine noise from the engine of the vehicle can be accounted for in the noise prediction signal, facilitating a clearer audio input signal for processing by the VCD with reduced errors.

In another example, the noise input means 130 may be arranged to generate the noise signal 134 via a vibro-acoustic device 133 associated with a transmission of the vehicle. In this case, it may be that the noise signal 134 is indicative of noise caused by operation of the transmission. It may be that the vibro-acoustic device 133 is provided proximate to the transmission (e.g. proximate to the transmission

outside of the vehicle cabin), or it may be that the vibro-acoustic device 133 is provided remote from the transmission, such as within the vehicle cabin. The target area 150 again may be the location of the audio input means of a voice command device (VCD) of the vehicle. The noise signal 134 indicative of noise at the transmission is received by the noise prediction means 110, and the noise prediction means 110 operatively generates the noise prediction signal 111 in dependence on the noise signal generated by the transmission, as would be heard within the target area 150. Thus the transmission noise of the vehicle can be accounted for in the noise prediction signal, facilitating a clearer audio input signal for processing by the VCD with reduced errors.

In another example, the noise input means 130 may be arranged to generate the noise signal 134 via a vibro-acoustic device 133 associated with one or more tyres of the vehicle, such as noise generated by the interaction of the one or more tyres of the vehicle and the surface on which the vehicle is moving. It may be that the vibro-acoustic device 133 is provided proximate to a tyre of the vehicle, or it may be that the vibro-acoustic device 133 is provided remote from the tyres of the vehicle, such as within the vehicle cabin. The target area 150 again may be the location of the audio input means of a voice command device (VCD) of the vehicle. The noise signal 134 indicative of noise associated with the one or more tyres is received by the noise prediction means 110, and the noise prediction means 110 operatively generates the noise prediction signal 111 in dependence on the noise signal associated with the one or more tyres, as would be heard within the target area 150. Thus the noise from the one or more tyres of the vehicle can be accounted for in the noise prediction signal, facilitating a clearer audio input signal for processing by the VCD with reduced errors.

In another example, the noise input means 130 may be arranged to generate the noise signal 134 via a vibro-acoustic device 133 associated with the surroundings of the vehicle, such as noise external to the vehicle, such as wind noise or noise of other vehicles in the vicinity of the vehicle (e.g. noise caused by the interactions of the tyres of the other vehicles and the surface on which they are moving). In this case, it may be that the noise signal 134 is indicative of the noise associated with the surroundings of the vehicle. It may be that the vibro-acoustic device 133 is provided external to the vehicle cabin, or it may be that the vibro-acoustic device 133 is provided within the vehicle cabin. The target area 150 again may be the location of the audio input means of a voice command device (VCD) of the vehicle. The noise

signal 134 indicative of noise associated with the surroundings of the vehicle is received by the noise prediction means 110, and the noise prediction means 110 operatively generates the noise prediction signal 111 in dependence on the noise signal associated with the surroundings of the vehicle, as would be heard within the target area 150. Thus the noise associated with the surroundings of the vehicle can be accounted for in the noise prediction signal, facilitating a clearer audio input signal for processing by the VCD with reduced errors.

It may be that the noise input means 134 is arranged to generate the noise signal 134 via a vibro-acoustic device 133 configured to detect any one or more of: suspension noise from a suspension of the vehicle; engine noise from an engine of the vehicle; transmission noise from a transmission of the vehicle; tyre noise from one or more tyres of the vehicle; noise associated with the surroundings of the vehicle, such as noise external to the vehicle. As above, the noise prediction means 110 in this case operatively generates the noise prediction signal 111 in dependence on the noise signal 134, as would be heard within the target area 150, facilitating a clearer audio signal for processing by the VCD with reduced errors.

In other examples, the clearer audio signal may be provided for transmission to another party to a telephone conversation, to thereby provide a better quality audio signal to that other party.

In some embodiments, the noise prediction means 110 is arranged to generate the noise prediction signal 111 based on a weighted average of the noise signals 132, 134 received from the noise input means 130. The generated noise prediction signal may comprise an estimate of a sound pressure level (SPL). For example, the noise prediction means 130 may be arranged to generate an estimate of the SPL at the target area 150 based on the one or more received noise signals 132, 134 from noise input means 132, 134.

As noted above, the system 100 may comprise the audio processing means 120. The audio processing means 120 may comprise one or more electronic processors arranged to receive the generated noise prediction signal 111 from the noise prediction means 110. The audio processing means 120 may be arranged to receive the audio signal 141 from the audio input 140 means located at the target area 150. The audio signal 141 may comprise a voice signal indicative of an occupant's voice. The audio input means 140 may be communicably coupled with the vehicle VCD or

communication device. For example, the audio input means 140 may comprise a vibro-acoustic device, such as a microphone, electrically coupled to the VCD (not shown) for receiving voice commands from the one or more occupants of the vehicle and generating electrical signals in response thereto.

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The audio processing means 120 is arranged to output the noise-cancelled signal 121 based on the received audio signal 141 and the generated noise prediction signal 111. For example, using parameters determined from the received noise prediction signal 111 and received audio signal 141, the audio processing means 120 may be arranged to output the audio signal 121, wherein the noise component has been reduced or removed. Advantageously, this allows for a better quality audio signal to be received by the VCD, which in turn facilitates improved audio command recognition and thus a better user experience.

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Figure 2 shows a noise prediction means 200 in more detail which may correspond to the noise prediction means 110 of Figure 1. In some embodiments, the noise prediction means 200 may comprise at least one data store 210 and one or more electronic processors (220) which operatively execute software instructions stored in an associated memory, which may be the data store (210) or may be a separate dedicated memory (not shown), so as to perform the functions described herein. In the described embodiment the noise prediction means 200 estimates a reference transfer function (RTF) indicative of a transfer function from the location of the at least one noise input means 130 to the target area 150 in order to generate the noise prediction signal 111. The estimation of the RTF may be performed by the one or more electronic processors 220. The estimated RTF may be stored in the data store 210.

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In some embodiments, the RTF is determined in dependence on a relationship between at least a portion of a frequency spectrum of at least one of the received audio signals 141 and a corresponding at least a portion of a frequency spectrum of at least one of the received noise signals 132, 134. In particular, in some embodiments, the RTF may be calculated by applying a transform, such as a Fourier transform, to the received noise 132, 134 and audio signals 141. The corresponding at least a portion of the frequency spectrum of at least one of the received audio signals 141 may be divided by at the at least a portion of the frequency spectrum of at least one of the received noise signals 132, 134. The RTF may be calculated by applying the Fourier transform to the noise signals 132, 134 separately or by

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summing the noise signals 132, 134 and applying the Fourier transform to the result. The resulting transfer function may then be applied to subsequently received noise signals 132, 134, either alone or in combination, in order to generate the noise prediction signal 111. In some embodiments, applying the RTF to received noise signals may comprise passing the received noise signals 132, 134 through one or more filters which approximates the estimated RTF. In some embodiments, a respective RTF may be determined for each noise signal 132, 134.

In some embodiments, the noise prediction means 200 may comprise a feedback loop, wherein at least a portion of the audio input signal 141 is returned to the noise prediction means 200 and used to calculate one or more subsequent noise prediction signals 111. In some embodiments, for example, the audio input signal 141 may be used to calibrate the transfer function of the noise prediction means 200. In some embodiments, the audio input signal 141 may be continuously fed back to the noise prediction means 200 for calibration or updating of the transfer function. A particular circumstance in which this may be useful, for example, is during periods of no user input to the audio input means 140. For example, in situations where no audio signals 141 from the user are generated, the noise prediction means 200 may update the transfer function, such that the error between the noise prediction signal 111 and the remaining audio signal 141, indicative of background noise at the target area 150, in the vehicle is minimised. Updating the transfer function may comprise updating the parameters of the RTF, such as one or more coefficients of the RTF. In other embodiments, the audio input signal 141 may be fed back to the noise prediction means 200 at specified intervals of time, such as periodically.

Figure 3 further illustrates an audio processing means 300 according to an embodiment of the present invention, which may correspond to the audio processing means 120 of Figure 1. The audio processing means 300 may comprise one or more electronic processors arranged to receive the noise prediction signal 111 from the noise prediction means 110. The one or more electronic processors may be the same one or more electronic processors of the noise prediction means 200. The audio processing means 300 is arranged to receive the audio signal 141 from the audio input means 140. The audio processing means 300 is arranged to operatively output the noise-cancelled signal 121 in dependence on the received audio signal 141 and generated noise prediction signal 111, wherein the noise-cancelled signal 121 comprises the received audio signal 141 with substantially reduced noise.

In some embodiments, the processing means 300 may be arranged to subtract the generated noise prediction signal 111 from the received audio signal 141 in order to output the noise-cancelled signal 121.

- 5 In some embodiments, the audio processing means 300 may comprise a signal processing means 310 for subtracting the generated noise prediction signal 111 from the received audio signal 141 to operatively produce the noise-cancelled signal 121. In other embodiments, the audio processing means 300 may include a network communication means 320 for offloading the audio processing to an optional external
- 10 processing unit 330. The external processing unit 330 may be provided external to the vehicle. The external processing unit 330 may comprise an externally located computing means, such as a server, for example. The external processing unit 330 may comprise a remotely located computing means, such as a server, for example. The external processing unit 330 may comprise part of a cloud computing system.
- 15 The communication means 320 may be a wireless communication device.

Figure 4 illustrates a method 400 according to an embodiment of the present invention. The method 400 is a method of processing an audio signal 141 received from an audio input means 140 within a vehicle. The method may reduce the noise

20 associated with the audio signal 141. The method 400 may be performed by the noise cancellation system 100, as described above, according to an embodiment of the present invention.

In step 410, one or more noise signals 132, 134 indicative of ambient or operational

25 noise are generated from at least one noise input means 131, 133 located at a first location. In some embodiments, the noise signals 132, 134 are indicative of noise generated by the operation of the vehicle, e.g. suspension noise, engine noise, transmission noise, tyre noise, other sources of noise may also be envisaged. In other embodiments, the noise signals may be indicative of noise associated with the

30 surroundings of the vehicle, such as noise external to the vehicle.

In step 420, one or more audio signals 141 originating from a target area 150 at a second location remote from the first location and within the vehicle are generated. In some embodiments, the one or more audio signals 141 are received from at least

35 one audio input means 140 within the vehicle. In some embodiments, the audio input means 140 may be a microphone associated with a VCD or telephony means of the vehicle. In some embodiments, the target area 150 comprises the location of the

audio input means 140 which may be within an occupant compartment or cabin of the vehicle. In cases where the audio input means 140 is associated with a VCD system, it will be appreciated by the skilled person that non-vocal audio signals may also be used in lieu of voice commands, such as sounds rather than spoken words.

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In step 430, a noise prediction signal 111 based on one or more of the received noise signals is generated. In some embodiments, the noise prediction signal 111 is indicative of the ambient or operational noise as heard at the target area 150. In some embodiments, the generation of the noise prediction signal 111 comprises
10 estimating a reference transfer function (RTF), wherein the RTF is indicative of a transfer function from the noise input means to the target area 150, and the noise prediction signal comprises the RTF applied to the one or more noise signals 132, 134. In some embodiments, a sum or a weighted average of the noise signals is used to calculate the noise prediction signal 111. In some embodiments, generating
15 the noise prediction signal comprises estimating a sound pressure level (SPL) at the target area 150.

In some embodiments, the estimating of the RTF comprises dividing at least a portion of the frequency spectrum of at least one of the audio signals 141 by at least
20 a portion of the frequency spectrum of at least one of the noise signals 132, 134. It will be appreciated, however, that other relationships between the audio signal 141 and the one or more noise signals 141, 142 may be used.

In some embodiments, the generation of the noise prediction signal 111 further
25 comprises passing the noise signals through one or more filters representing or approximating the estimated RTF.

In some embodiments, the RTF may further be calibrated or updated using the audio input signal 141 and the noise signals 131, 132. Said updating may be performed in
30 periods of time where no audio signals indicative of input from the user are received. The noise prediction signal may be updated such that the error between the noise prediction signal 111 and the remaining audio signal 141, indicative of background noise at the target area 150, in the vehicle is reduced. The updating may comprise updating the parameters or coefficients of the RTF. Such calibration may be
35 performed continuously, or periodically such as at pre-defined intervals at time.

In step 440, a noise-cancelled signal 121 based on the generated noise prediction signal 111 and one or more of the audio signals 141 is calculated. In some embodiments, the noise-cancelled signal 121 is calculated based on a combination of the noise prediction signal 111 and the audio signal 141, such as by adding or subtracting the noise prediction signal 111 from the audio signal 141. In some
5 embodiments, calculation of the noise-cancelled signal 121 may be offloaded to an external processing unit 330, which may comprise an externally located computing means, such as a processing unit 330 located externally to (and optionally remotely from) the vehicle.

10 Figure 5 illustrates a vehicle 500 according to an embodiment of the invention. The vehicle may comprise the noise cancellation system 100 as described above in relation to the preceding figures, or may be arranged to perform a method according to an embodiment of the invention, such as illustrated in Figure 4.

15 It will be appreciated that embodiments of the present invention can be realised in the form of hardware, software or a combination of hardware and software. Any such software may be stored in the form of volatile or non-volatile storage such as, for example, a storage device like a ROM, whether erasable or rewritable or not, or in the form of memory such as, for example, RAM, memory chips, device or integrated
20 circuits or on an optically or magnetically readable medium such as, for example, a CD, DVD, magnetic disk or magnetic tape. It will be appreciated that the storage devices and storage media are embodiments of machine-readable storage that are suitable for storing a program or programs that, when executed, implement
25 embodiments of the present invention. Accordingly, embodiments provide a program comprising code for implementing a system or method as claimed in any preceding claim and a machine readable storage storing such a program. Still further, embodiments of the present invention may be conveyed electronically via any medium such as a communication signal carried over a wired or wireless connection
30 and embodiments suitably encompass the same.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least
35 some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of any foregoing embodiments. The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed. The claims should not be construed to cover merely the foregoing embodiments, but also any embodiments which fall within the scope of the claims.

CLAIMS

1. A system for a vehicle, the system comprising:

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noise input means for generating one or more noise signals indicative of ambient or operational noise, said noise input means located at a first location;

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audio input means for generating one or more audio input signals, said audio input means located at a target area being at a second location remote from said first location;

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noise prediction means for receiving the one or more noise signals and generating a prediction signal in dependence on the one or more received noise signals, wherein the generated prediction signal comprises a signal indicative of noise at the target area; and

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audio processing means for receiving the one or more audio input signals and outputting a noise-cancelled signal in dependence on the received audio input signals and the generated prediction signal.

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2. A system as claimed in claim 1, wherein the noise prediction means is arranged to generate a prediction signal in dependence on one of a sum or a weighted average of the received noise signals.

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3. A system claimed in claim 1 or 2, wherein at least one of the noise signals is generated from an audio system associated with the vehicle.

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4. A system as claimed in any preceding claim, wherein the target area is located at the audio input means.

5. A system as claimed in any preceding claim, wherein the generated prediction signal comprises an estimate of a sound pressure level.

6. A system as claimed in any preceding claim, wherein the noise prediction means is arranged to estimate one or more reference transfer functions,

RTFs, indicative of a transfer function from a respective noise input means to the target area.

- 5 7. A system as claimed in claim 6, wherein the estimated reference transfer function, RTF, is determined in dependence on a relationship between at least a portion of the frequency spectrum of at least one of the received audio signals and a corresponding at least a portion of the frequency spectrum of at least one of the received noise signals.
- 10 8. A system as claimed in claim 6 or 7, wherein the noise prediction means is arranged to pass the received noise signals through one or more filters which represent the estimated reference transfer function, RTF.
- 15 9. A system as claimed in any preceding claim, wherein the audio processing means is arranged to output the noise-cancelled signal in dependence on the combination of the generated prediction signal and the received audio input signal.
- 20 10. A system as claimed in any preceding claim, wherein the prediction means comprises a feedback loop and the generated prediction signal is updated in dependence on received noise signals at pre-defined intervals of time.
- 25 11. A system as claimed in any preceding claim, wherein the audio processing means comprises an external processing unit; optionally the external processing unit is an externally located computing means; optionally the external processing unit is located external to the vehicle.
- 30 12. A system as claimed in any preceding claim, wherein at least one of the received audio input signals is a voice signal.
- 35 13. A system as claimed in any preceding claim, wherein at least one of the noise input means is configured to receive the one or more noise signals from outside the vehicle.
14. A system as claimed in any preceding claim, wherein at least one of the audio input means is configured to receive the one or more noise signals from inside the vehicle.

15. A system as claimed in any preceding claim, wherein the noise input means comprises noise input means for generating one or more noise signals indicative of any one or more of: suspension noise from a suspension of the vehicle; engine noise from an engine of the vehicle; transmission noise from a transmission of the vehicle; tyre noise from one or more tyres of the vehicle; noise associated with the surroundings of the vehicle.

16. A method of cancelling noise in a vehicle, the method comprising:

generating, at a first location, one or more noise signals indicative of ambient or operational noise;

generating, at a target area being at a second location remote from said first location, one or more audio input signals;

generating a prediction signal in dependence on one or more of the noise signals, wherein the prediction signal is indicative of noise at the target area; and

calculating a noise-cancelled signal in dependence on the generated prediction signal and one or more of the audio input signals.

17. A method of cancelling noise in a vehicle as claimed in claim 16, wherein the generating of the prediction signal is in dependence on one of a sum or a weighted average of the noise signals.

18. A method of cancelling noise in a vehicle as claimed in any of claim 16 or 17, wherein the generating of the prediction signal comprises estimating a sound pressure level.

19. A method of cancelling noise in a vehicle as claimed in any of claims 16 to 18, wherein the generating of the prediction signal comprises estimating one or more reference transfer functions, RTFs, indicative of a transfer function from a respective noise input means to the target area.

20. A method of cancelling noise in a vehicle as claimed in claim 19, wherein the estimating of the reference transfer function, RTF, is determined in

dependence on a relationship between at least a portion of the frequency spectrum of at least one of the audio input signals by at least a portion of the frequency spectrum of at least one of the noise signals.

5 21. A method of cancelling noise in a vehicle as claimed in any of claim 19 or 20, wherein the generating of the prediction signal comprises passing the noise signals through one or more filters representative of the estimated reference transfer function, RTF.

10 22. A method of cancelling noise in a vehicle as claimed in any of claims 16 to 21, wherein the noise-cancelled signal is calculated in dependence on a combination of the generated prediction signal from the audio input signals.

15 23. A method of cancelling noise in a vehicle as claimed in any of claims 16 to 20, wherein the generating of the prediction signal comprises a feedback loop, wherein the determined prediction signal is updated in dependence on the noise signals at pre-defined intervals of time.

20 24. A method of cancelling noise in a vehicle as claimed in any of claims 16 to 21, wherein the calculating of the noise-cancelled signal comprises communicating with an external processing unit; optionally the external processing unit is an externally located computing means; optionally the external processing unit is located externally to the vehicle.

25 25. A method of cancelling noise in a vehicle as claimed in any of claims 16 to 24 wherein the one or more noise signals are indicative of any one or more of: suspension noise from a suspension of the vehicle; engine noise from an engine of the vehicle; transmission noise from a transmission of the vehicle; tyre noise from one or more tyres of the vehicle; noise associated
30 with the surroundings of the vehicle.

26. A controller, comprising:

35 noise prediction means for receiving one or more noise signals generated at a first location, and generating a prediction signal in dependence on one or more received noise signals, wherein the generated prediction

signal comprises a signal indicative of noise at a target area being at a second location, remote from said first location; and

5 audio processing means for receiving one or more audio input signals generated at the second location, and outputting a noise-cancelled signal in dependence on the received audio input signals and the generated prediction signal.

10 27. A vehicle comprising a system as claimed in any of claims 1 to 15.

 28. A vehicle arranged to perform a method as claimed in any of claims 16 to 25.

 29. A vehicle comprising a controller according to claim 26.

15 30. Computer software which, when executed by a computer, is arranged to perform a method according to any of claims 16 to 25; optionally the computer software is stored on a computer-readable medium.

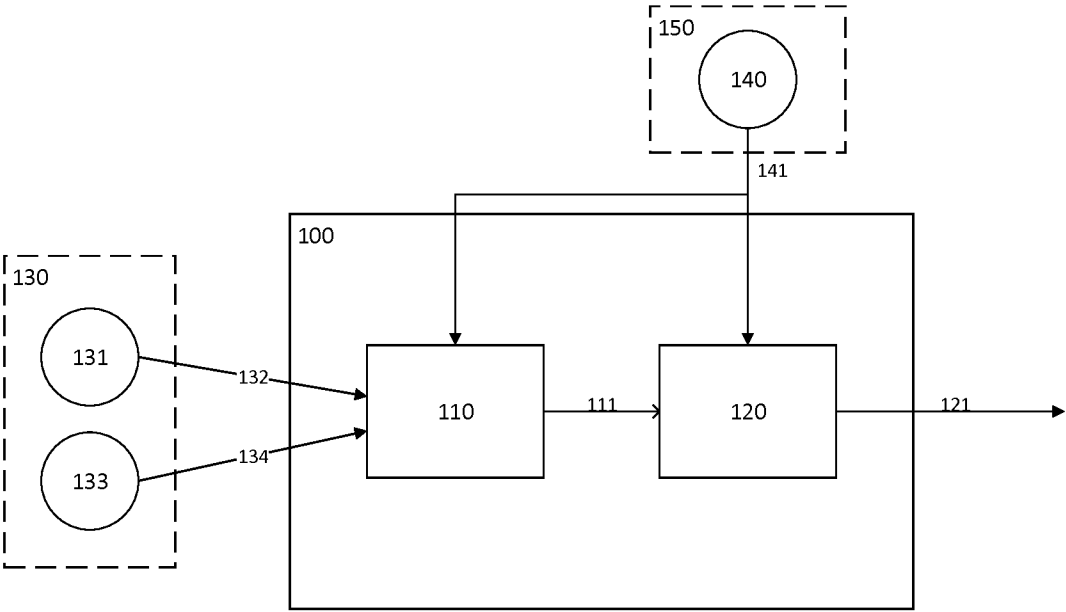


Fig. 1

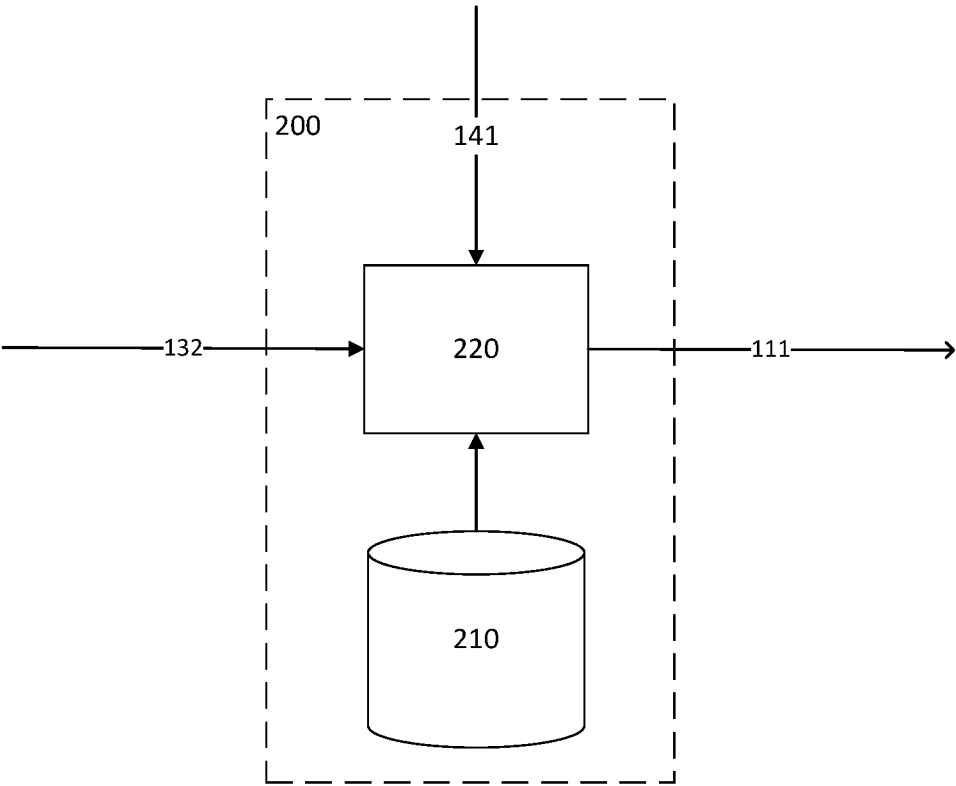


Fig. 2

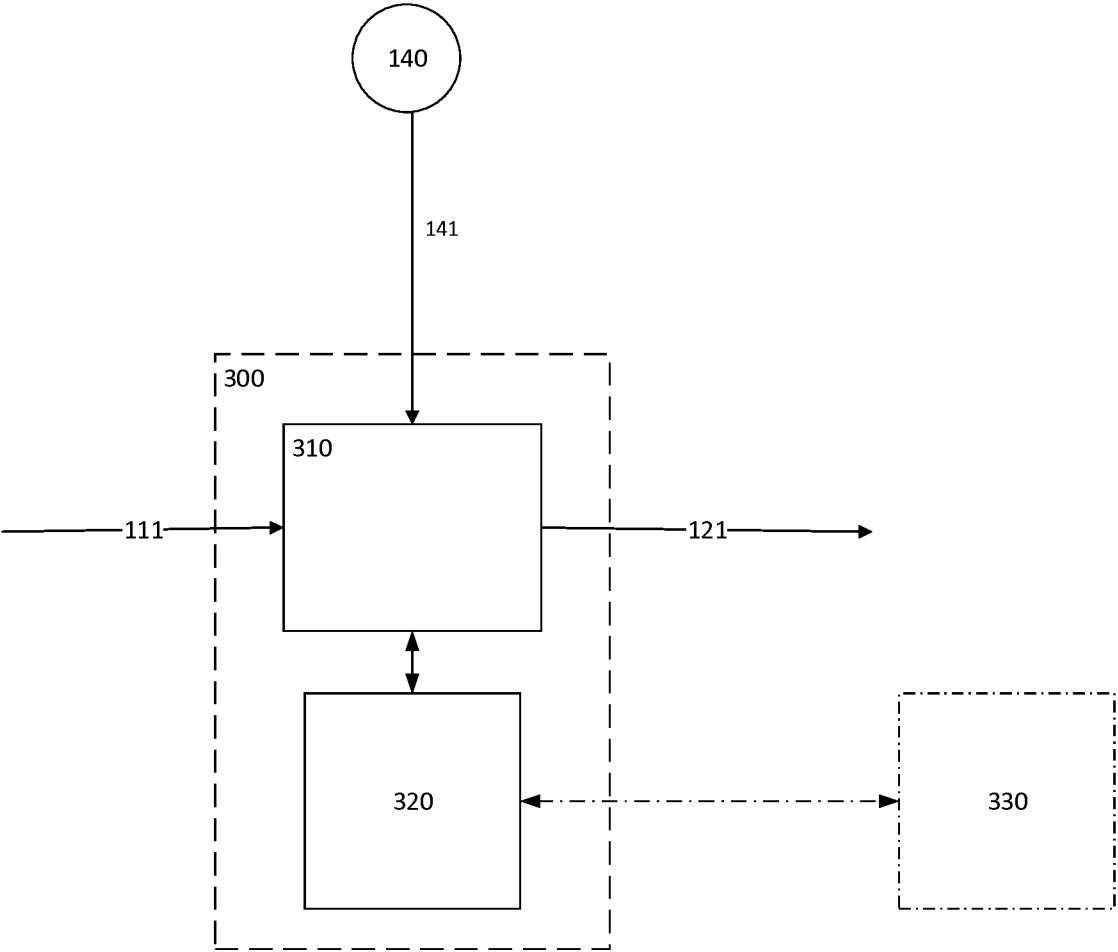


Fig. 3

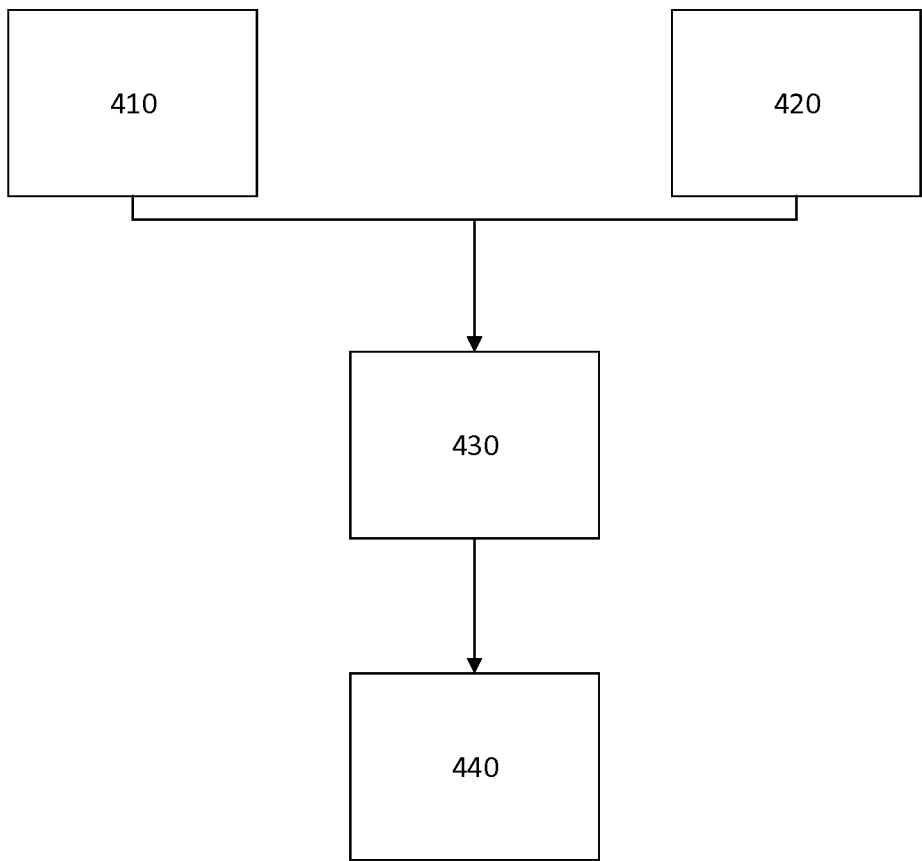


Fig. 4

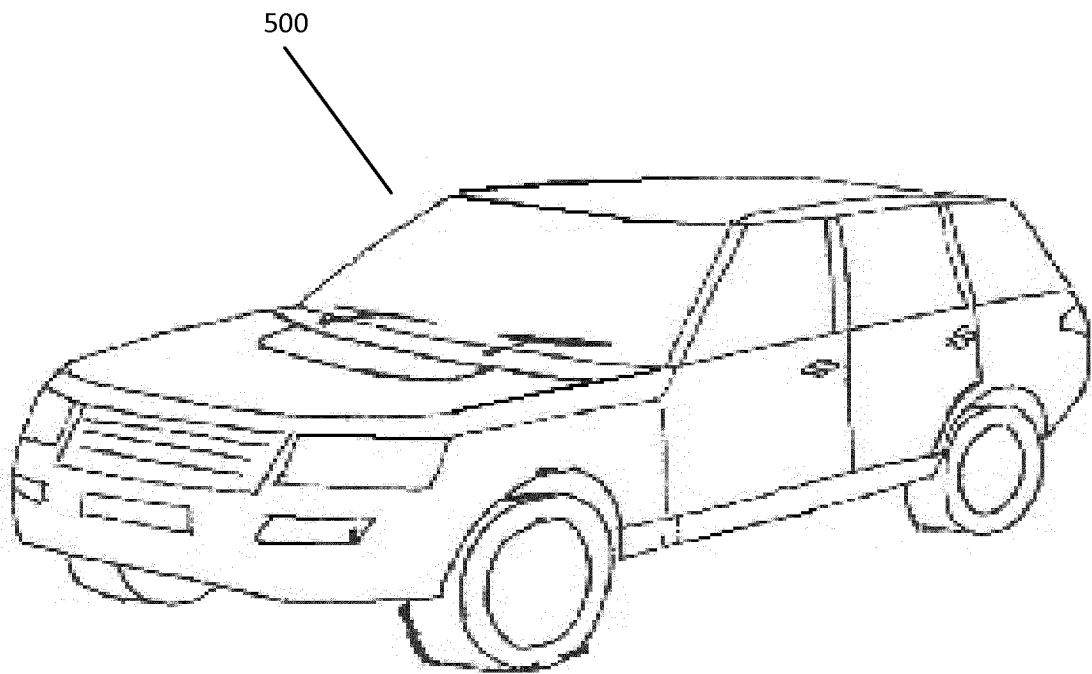


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/054876

A. CLASSIFICATION OF SUBJECT MATTER
INV. G10L21/0208 G10K11/178
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G10L G10K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, COMPENDEX, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 00/14731 A1 (ERICSSON INC [US]) 16 March 2000 (2000-03-16) figure 1 page 4, lines 11-13 page 5, line 27 page 7, lines 6,20-24 page 8, lines 4-8,14-18,23-27 page 9, lines 1-6,17-22 -----	1-30
X	JP H06 110474 A (MATSUSHITA ELECTRIC IND CO LTD) 22 April 1994 (1994-04-22) figure 1 -----	1,16, 26-30



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

25 April 2018

Date of mailing of the international search report

07/05/2018

Name and mailing address of the ISA/

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Authorized officer

Chétry, Nicolas

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2018/054876

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0014731	A1	16-03-2000	AU 6244399 A 27-03-2000
		WO 0014731 A1	16-03-2000
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