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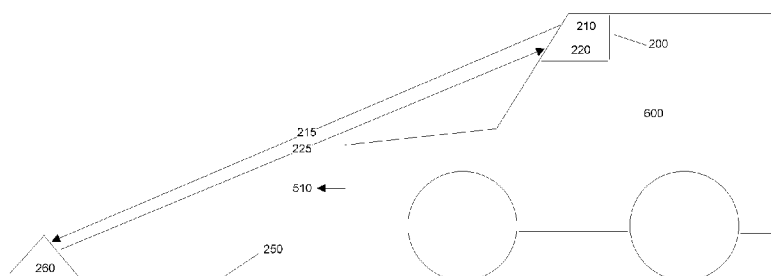


Fig. 2

(57) Abstract: Embodiments of the present invention provide a noise cancellation system for a vehicle, comprising noise cancellation parameter selection means for receiving optical signals indicative of one or more attributes of a terrain or road surface on which a vehicle is travelling and selecting one or more noise cancellation configuration parameters based thereon, and noise cancellation means for receiving one or more noise signals, determining an in-vehicle noise cancellation signal based on the one or more noise signals according to the one or more configuration parameters and outputting the in-vehicle noise cancellation signal for reducing noise in the vehicle.



APPARATUS AND METHOD FOR NOISE CANCELLATION

TECHNICAL FIELD

Aspects of the invention relate to an apparatus and method for noise cancellation.

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

BACKGROUND

- 10 Noise, especially within a vehicle, is troublesome for occupants the vehicle. Noise within the vehicle may distract a driver of the vehicle and may be tiring for the occupants of the vehicle, for example. Mechanical measures have been used to reduce noise within vehicles. However such measures are bulky and heavy. The use of active noise cancellation has been suggested. Active noise cancellation involves
- 15 the generation of a sound wave to cancel a noise sound wave thus making environment quieter for a listener. However it may be difficult to generate the sound wave appropriate for conditions of the vehicle.

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

SUMMARY OF THE INVENTION

- Aspects and embodiments of the invention provide a noise cancellation system, a method of generating a noise cancellation signal, a controller, a vehicle, and
- 25 computer software as claimed in the appended claims.

- According to an aspect of the invention, there is provided a noise cancellation system comprising terrain sensing means for receiving a radiation signal indicative of an attribute of the terrain. The radiation signal may be used to influence generation of an
- 30 in-vehicle noise cancellation signal. Advantageously the noise cancellation signal may be more effective for noise cancellation.

- According to an aspect of the invention, there is provided a noise cancellation system for a vehicle, the noise cancellation system comprising terrain sensing means
- 35 operable to receive an optical signal indicative of at least one attribute of a terrain and to output terrain data indicative thereof, noise cancellation parameter selection means operable to select one or more noise cancellation configuration parameters in

dependence on the terrain data, and noise cancellation means operable to determine an in-vehicle noise cancellation signal in dependence on the one or more configuration parameters and to output the in-vehicle noise cancellation signal for reducing reduce noise in a vehicle. Advantageously the noise cancellation signal may
5 be more effective for noise cancellation.

In an embodiment of the invention, the terrain sensing means comprises a laser for outputting laser light directed towards the terrain and receiving means for receiving the optical signal reflected from the terrain. Advantageously, a mapping of the terrain
10 can be produced via the laser with a high level of accuracy.

In an embodiment of the invention, the terrain sensing means is a LIDAR unit. Advantageously, the LIDAR unit allows for high-resolution mapping of the terrain.

15 In an embodiment of the invention, the terrain sensing means is arranged to determine a mapping of the terrain proximal to the vehicle and the noise cancellation parameter selection means is arranged to select the one or more noise cancellation configuration parameters in dependence on the mapping. Advantageously, the noise cancellation configuration parameters may be selected according to the mapping of
20 the terrain, allowing for improved noise cancellation.

Optionally the mapping is one or more of a phase map, an edge map, a cornerness map, or a pixel image.

25 In an embodiment of the invention, a scanning laser is arranged to output the laser light ahead of the vehicle, and the optical signal is indicative of the at least one attribute of the terrain ahead of the vehicle. Advantageously, the scanning laser may be used while the vehicle is in operation.

30 In an embodiment of the invention, the terrain sensing means is arranged to determine a relative elevation of the terrain ahead of the vehicle with respect to a current elevation of the vehicle, and the noise cancellation parameter selection means is arranged to select the one or more noise cancellation configuration parameters based on the relative elevation. Advantageously, by determining a
35 relative elevation of the terrain ahead, obstacles can be determined and the noise cancellation configuration parameters selected in dependence thereon.

In an embodiment of the invention, the terrain sensing means is arranged to determine a roughness of the terrain, and the noise cancellation parameter selection means is arranged to select the one or more noise cancellation configuration parameters based on the roughness. Advantageously, by determining the roughness of the terrain, the noise cancellation configuration parameters can be tuned to suit the terrain type, allowing for an improved noise cancellation signal.

In an embodiment of the invention, the in-vehicle noise cancellation signal is determined for a point in time ahead of a current time. Optionally, the point in time corresponds to a time at which the vehicle traverses the terrain corresponding to the determined attribute. Advantageously, the noise cancellation signal can be determined whilst the vehicle is in operation with respect to upcoming terrain features.

In an embodiment, the terrain data may comprise first terrain data corresponding to terrain to be traversed by a left hand side of the vehicle and second terrain data corresponding to terrain to be traversed by a right hand side of the vehicle. The noise cancellation parameter selection means may be configured to select the one or more noise cancellation configuration parameters in dependence on the first and second terrain data. Advantageously, the noise cancellation system may account for lateral variations in the terrain, i.e. where the wheel(s) on the left hand side of the vehicle will traverse a different sensed terrain to the wheel(s) on the right hand side of the vehicle.

In an embodiment, the terrain data may comprise first terrain data corresponding to terrain to be traversed by the front of the vehicle and second terrain data corresponding to terrain to be traversed by the rear of the vehicle. The noise cancellation parameter selection means may be configured to select the one or more noise cancellation configuration parameters in dependence on the first and second terrain data. Advantageously, the noise cancellation system may account for longitudinal variations in the terrain, i.e. where the wheel(s) at the front of the vehicle will traverse a different sensed terrain to the wheel(s) at the rear of the vehicle.

In an embodiment, the terrain data may comprise terrain data for each of one or more wheels of the vehicle. For example, the terrain data may comprise first terrain data corresponding to a first wheel of the vehicle, second terrain data corresponding to a second wheel of the vehicle, third terrain data corresponding to a third wheel of

the vehicle, and fourth terrain data corresponding to a fourth wheel of the vehicle. The noise cancellation parameter selection means may be configured to select the one or more noise cancellation configuration parameters in dependence on the terrain data for the or each wheel of the vehicle. Advantageously, the noise cancellation system may account for variations in the terrain traversed by the or each wheel of the vehicle, thereby accounting for both longitudinal and lateral variations in the terrain simultaneously.

In an embodiment, the noise cancellation system may be configured to receive an operational parameter signal indicative of one or more operational parameters of the vehicle. The operational parameters may include vehicle speed, or wheel speed, for example. In such embodiments, the noise cancellation parameter selection means may be configured to select the one or more noise cancellation configuration parameters in dependence on the one or more operational parameters of the vehicle. Advantageously, the noise cancellation system may account for a delay, for example, between the front wheel(s) of the vehicle and the rear wheel(s) of the vehicle traversing the same section of terrain.

In an embodiment of the invention, the noise cancellation parameter selection means is arranged to operatively select a pre-determined noise cancellation configuration, corresponding to the one or more noise cancellation configuration parameters, in dependence on the received terrain data. Advantageously, previously known noise cancellation configuration parameters can be re-used based on the received terrain data, reducing computation complexity.

In an embodiment of the invention, the one or more noise cancellation configuration parameters are associated with at least one function for determining the in-vehicle noise cancellation signal.

Optionally the one or more noise cancellation configuration parameters are associated with the at least one function are one or more filter coefficients.

Optionally the function is a speaker transfer function (STF) indicative of a transfer function associated with one or more audio output devices.

Optionally the function is a reference transfer function (RTF) indicative of a transfer function from one or more noise sensing means.

Optionally the noise sensing means is associated with a suspension of the vehicle. Advantageously, the noise cancellation signal may be configured to cancel noise communicated by the suspension.

- 5 According to an aspect of the invention, there is provided a method of generating a noise cancellation signal for a vehicle comprising receiving a signal indicative of at least one attribute of a terrain, selecting one or more noise cancellation configuration parameters based on the received signal indicative of the at least one attribute of the terrain, generating an in-vehicle noise cancellation signal in dependence on the one
10 or more configuration parameters, and outputting the in-vehicle noise cancellation signal for reducing noise in the vehicle.

In an embodiment of the invention, the method comprises receiving one or more noise signals indicative of noise within the vehicle, wherein the in-vehicle noise
15 cancellation signal is generated in dependence on the one or more noise signals.

In an embodiment of the invention, the optical signal indicative of the at least one attribute of the terrain is indicative of a mapping of the terrain.

- 20 In an embodiment of the invention, the mapping is one or more of a phase map, an edge map, a cornerness map, or a pixel image.

In an embodiment of the invention, the method comprises determining, in dependence on the optical signal, a relative elevation of the terrain ahead of the
25 vehicle with respect to a current elevation of the vehicle.

Optionally the method comprises determining, in dependence on the optical signal, a roughness of the terrain ahead of the vehicle.

- 30 In an embodiment, the method may comprise receiving first terrain data corresponding to terrain to be traversed by a left hand side of the vehicle and second terrain data corresponding to terrain to be traversed by a right hand side of the vehicle. In such embodiments, the method may comprise selecting the one or more noise cancellation configuration parameters in dependence on the first and second
35 terrain data. Advantageously, the method may account for lateral variations in the terrain, i.e. where the wheel(s) on the left hand side of the vehicle will traverse a different sensed terrain to the wheel(s) on the right hand side of the vehicle.

In an embodiment, the method may comprise receiving first terrain data corresponding to terrain to be traversed by the front of the vehicle and second terrain data corresponding to terrain to be traversed by the rear of the vehicle. In such embodiments, the method may comprise selecting the one or more noise
5 cancellation configuration parameters in dependence on the first and second terrain data. Advantageously, the method may account for longitudinal variations in the terrain, i.e. where the wheel(s) at the front of the vehicle will traverse a different sensed terrain to the wheel(s) at the rear of the vehicle.

10 In an embodiment, the method may comprise receiving terrain data for each of one or more wheels of the vehicle. For example, the received terrain data may comprise first terrain data corresponding to a first wheel of the vehicle, second terrain data corresponding to a second wheel of the vehicle, third terrain data corresponding to a third wheel of the vehicle, and fourth terrain data corresponding to a fourth wheel of
15 the vehicle. In such embodiments, the method may comprise selecting the one or more noise cancellation configuration parameters in dependence on the terrain data for the or each wheel of the vehicle. Advantageously, the method may account for variations in the terrain traversed by the or each wheel of the vehicle, thereby accounting for both longitudinal and lateral variations in the terrain simultaneously.

20 In an embodiment, the method may comprise receiving an operational parameter signal indicative of one or more operational parameters of the vehicle. The operational parameters may include vehicle speed, or wheel speed, for example. In such embodiments, the method may comprise selecting the one or more noise
25 cancellation configuration parameters in dependence on the one or more operational parameters of the vehicle. Advantageously, the method may account for a delay, for example, between the front wheel(s) of the vehicle and the rear wheel(s) of the vehicle traversing the same section of terrain.

30 In an embodiment of the invention the method comprises selecting a predetermined noise cancellation configuration in dependence on the received optical signal; optionally the noise cancellation configuration is selected from amongst a plurality of predetermined noise cancellation configurations.

35 Optionally the one or more noise cancellation configuration parameters are associated with at least one function for determining the noise cancellation signal in dependence on the one or more noise signals.

Optionally the one or more noise cancellation configuration parameters associated with the at least one function are one or more filter coefficients.

- 5 In an embodiment of the invention, at least one attribute of the terrain is a roughness of the terrain, and the one or more noise cancellation configuration parameters are selected in dependence on the roughness of the terrain.

- 10 In an embodiment of the invention, the noise cancellation parameter selection means is arranged to determine a further attribute of the terrain based on one or both of an amplitude and a spectral composition of the noise signal.

- 15 According to an aspect of the invention, there is provided a controller comprising input means for receiving terrain data determined from an optical signal indicative of at least one attribute of a terrain, and noise cancellation parameter selection means operable to select one or more noise cancellation configuration parameters in dependence on the terrain data.

- 20 Optionally the noise cancellation parameter selection means is arranged to operatively select a pre-determined noise cancellation configuration, corresponding to the one or more noise cancellation configuration parameters, in dependence on the received terrain data.

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

- 30 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 is 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.

- 35 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.

BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings, in which:

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

Figure 2 shows a system according to an embodiment of the invention arranged in use;

Figure 3 shows schematically illustrates a system according to an embodiment of the invention;

Figure 4 shows a system according an embodiment of the invention;

Figure 5 shows a method according to an embodiment of the invention; and

Figure 6 shows a vehicle comprising a system according to an embodiment of the invention.

DETAILED DESCRIPTION

Figure 1 illustrates a noise cancellation system 100 according to an embodiment of the invention. The system 100 may be used with a vehicle 600, such as shown in Figures 2 and 6, in particular a land-going vehicle. The vehicle 600 may be a wheeled vehicle having a plurality of wheels arranged to convey the vehicle over terrain. The terrain may be a surface intended for vehicles, for example having a hard surface such as concrete or tarmac or the like, such as a road. However, particularly in the case of vehicles suited for off-road use, the terrain may be natural i.e. formed by soil, grass, rocks, ruts, sand etc. Thus the term terrain encompasses a variety of surfaces over which the vehicle 600 may travel.

Noise is a significant issue within vehicles. A noisy environment with the vehicle is detrimental to occupant(s) of the vehicle, such as to enjoyment and comfort of the occupant(s). For example, the occupant(s) of the vehicle may become fatigued through exposure to noise within the vehicle. Furthermore, a characteristic of a premium vehicle is that an environment within the vehicle is relatively quiet. Noise cancellation may be used to reduce the noise experienced by one or more occupants within the vehicle. However it has been noted that the noise cancellation may not be effective across different varieties of terrain such as road surfaces. The noise cancellation system 100 may be arranged to selectively reduce noise arising from one or more predetermined sources such as, although not exclusively, road noise. The noise cancellation system 100 is arranged to adapt to one or more types of terrain proximal to the vehicle 600, in particular terrain ahead of the vehicle 600 in a direction of travel of the vehicle, as will be explained.

The system 100 comprises terrain sensing means 105, noise cancellation parameter selection means 110 and noise cancellation means 120. The terrain sensing means 105 is operable to determine one or more attributes of the terrain and to output a signal indicative thereof which provides terrain data 108 to the noise cancellation parameter selection means 110. The terrain sensing means 105 is arranged to determine the one or more attributes of the terrain based on a signal received from the terrain. In some embodiments, the signal is an optical signal reflected from the terrain, as will be explained. The signal may be received at a receiving means 155 which provides an electrical signal 150 corresponding thereto to the terrain sensing means 105. The receiving means 155 may be one or more receiver devices 155. In some embodiments the receiver devices 155 are arranged to receive optical radiation reflected from the terrain.

The noise cancellation parameter selection means 110 is arranged to receive the terrain data 108 and to select one or more configuration parameters of the noise cancellation means 120, as will be explained. In use, the noise cancellation parameter selection means 110 is arranged to determine one or more operational characteristics and to select the configuration parameters of the noise cancellation means 120 in dependence thereon in order to improve noise cancellation. In some embodiments the one or more configuration parameters are associated with at least one transfer function associated with the noise cancellation means 120, as will be

explained. Information indicative of the selected parameters is provided to the noise cancellation means 120 as signal 115.

5 The noise cancellation means 120 is operable to output an in-vehicle noise cancellation signal 145 to one or more to one or more audio output means 141, 142 for outputting audio corresponding to the noise cancellation signal 145. The noise cancellation signal 145 is generated by the noise cancellation means 120 based on based upon a noise signal 135 input from one or more noise input means 131, 132 according to the one or more configuration parameters selected by the noise
10 cancellation parameter selection means 110.

The terrain sensing means 105 may comprise a processor which operatively executes software instructions to determine the terrain data 108. Hereinafter the terrain sensing means 105 will be referred to as a terrain unit 105.

15 The noise cancellation parameter selection means 110 may be provided in the form of a processor which operatively executes software instructions to determine the one or more configuration parameters of the noise cancellation means 120. Hereinafter the noise cancellation parameter selection means 110 will be referred to as a noise
20 configuration unit 110.

Similarly, the noise cancellation means 120 may be one or more processing devices which are arranged, in use, to determine at least one noise cancellation signal 145 for reducing perceived noise in the vehicle and to provide the noise cancellation
25 signal 145 to one or more audio output means 141, 142, as will be explained. The audio output means 141, 142 may be one or more acoustic devices, such as speakers 141, 142. The at least one noise cancellation signal 145 may be determined based upon at least one noise signal 135 input from one or more noise input means 131, 132 as one or more reference signals. The one or more noise input
30 means 131, 132 may be one or more vibro-acoustic sensing devices such as microphones or accelerometers 131, 132. Hereinafter the noise cancellation means 120 will be referred to as a noise cancellation unit 120.

35 The noise cancellation unit 120 is arranged to reduce noise within one or more noise cancellations zones 10 within the vehicle. In one embodiment, substantially the entire interior of an occupant compartment of the vehicle 600 is determined as the noise cancellation zone 10. That is, there may be only one noise cancellation zone 10

within the vehicle 600. However, in some embodiments, a plurality of noise cancellation zones are located within the vehicle 600. In this case, the noise cancellation unit 120 may provide at least one specific noise cancellation signal 145 to audio output means 141, 142 within the respective noise cancellation zone. That is, different noise cancellation signals may be provided to each noise cancellation zone. The noise cancellation unit 120 may utilise different configuration parameters to determine the noise cancellation signal for each respective noise cancellation zone. Each of the one or more noise cancellation zones 10 within the vehicle 600 may be arranged proximal to an expected location of at least one occupant of the vehicle. For example, a first noise cancellation zone may be arranged proximal to an intended location of a driver of the vehicle. The intended location may correspond to a head location of the occupant. A second, and possibly further, noise cancellation zone(s) may be respectively arranged in relation to each potential further occupant within the vehicle and, in some embodiments, corresponding to an expected head location of each occupant. For example, a second noise cancellation zone may be arranged proximal to an intended head location of a front passenger of the vehicle.

One or more noise signals 135 received from the one or more noise input means 131, 132 may be provided, in some embodiments, to the noise configuration unit 110 as a parameter selection signal 165. In some embodiments, the noise configuration unit 110 is arranged to determine the noise cancellation configuration parameters based, in part, on the parameter selection signal 165. The noise configuration unit 110 is arranged to receive a signal in the form of the terrain data 108 which is indicative of at least one attribute of the terrain, such as a road surface on which the vehicle 600 may be travelling. The noise configuration unit 110 is arranged to determine the noise cancellation configuration parameters 115 based on the terrain data 108. Configuration information 115 indicative of one or more noise cancellation configuration parameters 115 is provided from the noise configuration unit 110 to the noise cancellation unit 120.

Figure 2 illustrates a vehicle 600 according to an embodiment of the invention. The vehicle 600 comprises an optical terrain sensing means 200. The vehicle 600 is illustrated as being located upon terrain 250 which may be a road or other surface such as an off road surface. The vehicle 600 may be travelling in a forward direction upon the terrain as indicated by arrow 510.

In some embodiments the optical terrain sensing means 200 comprises a radiation emitter 210 and a receiver 220. The receiver 220 may correspond to the receiving means 155 illustrated in Figure 1. The radiation emitter 210 is arranged to emit radiation 215 towards the terrain 250. The receiver 220 is arranged to receive reflected radiation 225 from the terrain and to provide an electrical signal corresponding thereto. As illustrated in Figure 1 the emitter 210 may direct radiation 215 to terrain 250 proximal to the vehicle 600. In particular, the emitter 210 may direct the radiation 215 to terrain generally in front of the vehicle 600 in a normal i.e. forwards direction 510 of travel to determine attributes of upcoming terrain 250 i.e. terrain 250 to be encountered by the vehicle in a determined time ahead of a current time.

As illustrated in Figure 2, the terrain 250 comprises a feature 260 which may be a ridge, a rock, a lump, a bump, or other feature 260 upwardly protruding from the surface. It will of course be realised that surface features may alternatively be indented into the surface 250. In use, radiation is reflected 225 from the feature 260 toward the receiver 220 such that the electrical signal output by the receiver 220 i.e. signal 150 illustrated in Figure 1, is indicative of the feature 260. The signal is provided to the terrain unit 105 such that terrain data 108 indicative thereof is provided to the noise configuration unit 110 for determining the configuration parameters in dependence thereon. It will be appreciated that the terrain data 108 may not only be indicative of surface features, but may be indicative of other attributes of the terrain 250 such as, for example, information about the elevation, roughness, or a mapping of the terrain. The elevation may be a relative elevation of the terrain with respect to a current elevation of the vehicle i.e. whether the terrain 250 curves upward or downward, such that the vehicle 600 when travelling over the terrain will experience a compression or extension of its suspension.

The optical terrain sensing means 200 comprising the radiation emitter 210 and the receiver 220 may be arranged as a single, integrated, unit. The terrain sensing means 200 may be, in some embodiments a LIDAR unit 200. The LIDAR unit 200 may be arranged to scan emitted radiation 215 across the terrain 250. In particular, the LIDAR unit 200 may be arranged to scan emitted radiation 215 from side to side ahead of the vehicle and scan the laser substantially in the direction of travel 510 of the vehicle across the terrain 250 over which the vehicle may travel. In some embodiments the radiation emitter 210 is moveably mounted to permit scanning of the emitted radiation 215 across the terrain 250. The receiver 220 may be moveably

mounted to move with the emitter 210 in order to receive reflected radiation from a location upon the terrain 250, 260 at which the emitted radiation 215 is directed. The emitter 210 may be arranged to emit laser light in the form of a beam 215. A portion of the emitted beam 215 is reflected and received by the receiver 220 from which one
5 or more attributes of the terrain 250 are determined therefrom for configuring the noise cancellation system 100.

The terrain sensing means 200 may be arranged to emit radiation 215 a predetermined distance forward of the vehicle 600. For example, the distance may
10 be 50m, 100m, 200m or 500m, although other distances may be used. Speed information indicative of a speed of travel of the vehicle 600 may be provided to the noise configuration unit 110. Based on the speed information and the predetermined distance, the noise configuration unit 110 is operable to provide the configuration information 115 to the noise cancellation unit 120 at an appropriate time, such that
15 the noise cancellation unit 120 is configured appropriately for the terrain 250, 260 at the time when the vehicle 600 is travelling over it. For example, the noise configuration unit 110 may be operable to provide the configuration information 115 to the noise cancellation unit 120, such that the noise cancellation unit 120 is configured firstly for the terrain 250, 260 at the time when the front wheels of the
20 vehicle 600 are travelling over it, and secondly and subsequently at a time when the rear wheels of the vehicle 600 are travelling over it. In this way, the system 100 may account for longitudinal variations in the terrain 250, 260 with respect to the vehicle 600 orientation.

Figure 3 illustrates an embodiment of the noise cancellation system 100 arranged in use. The noise cancellation system 100 is illustrated as communicably coupled to a first noise input means 131 and a first audio output means 141. It will be realised, however, that this is not limiting and that the system 100 may be connected to more than one input 131 and output 141 means, respectively. Furthermore it is not
25 necessary for the number of input means 131 to equal the number of output means 141. The first audio output means 141 may be associated with a first noise cancellation zone 300.
30

As noted above, the noise input means 131 is at least one acoustic sensing device
35 for providing the reference signal 135. In the example shown in Figure 3 the noise input means 131 is an accelerometer 131, although the noise input means 131 may be a microphone. The accelerometer 131 is arranged upon a component of a

vehicle to determine and output a signal indicative of structural vibration of a portion of the vehicle in use. In one embodiment the accelerometer 131 is arranged upon a suspension component of the vehicle 600, such as a knuckle or wheel hub carrier of the vehicle, although it will be realised that the accelerometer 131 may be mounted
5 elsewhere about the vehicle 600 and, in particular, the suspension thereof. The accelerometer 131 is arranged to, in use, output a signal 135 indicative of vibration applied thereto and, hence, noise caused within the vehicle. The signal 135 is received by the noise cancellation system 100. As will be appreciated, with the accelerometer 131 mounted about the suspension of the vehicle 600, vibrations
10 applied thereto are characteristic, at least, of a terrain or road surface being travelled upon by the vehicle and may also be characteristic of a speed of travel of the vehicle on the terrain 250.

The noise cancellation system 100 is also communicably coupled to a receiving
15 means 155 which provides an electrical signal 150 corresponding thereto to the terrain sensing means 105. The receiving means 155 may be one or more receiver devices 155. In some embodiments the receiver devices 155 are arranged to receive optical radiation reflected from the terrain. The noise configuration system 100 is arranged to determine the noise cancellation configuration parameters 115 for the
20 noise cancellation signal 145 based on the received signal 150.

The noise cancellation system 100 is arranged to output a noise cancellation signal 145 to the audio output means 141, wherein the audio output means 141 outputs an audible signal corresponding thereto. The audio output means 141 is, in one
25 embodiment, an audio output device such as a speaker arranged within an occupant compartment of the vehicle i.e. within an interior of the vehicle. The speaker 141 may be arranged within, for example, a dashboard, interior body panel or door panel of the vehicle, although it will be realised that these embodiments are not exhaustive. In one embodiment the speaker 141 is arranged within a headrest of the vehicle 600
30 proximal to an occupant's expected head position. The speaker 141 may be located within a noise cancellation zone indicated with dotted line denoted 300 in Figure 3.

As illustrated, in the noise cancellation system 100, first noise input means 131 and first audio output means 141 form an open-loop system. In some embodiments a
35 closed-loop system is formed by the inclusion of one or more feedback means 310. The feedback means 310 provides a feedback signal 315 to the noise cancellation system 100. The feedback signal 315 is indicative of noise within the noise

cancellation zone 300. Therefore the feedback signal 315 may be an error signal indicative of remaining noise present within the noise cancellation zone 300. The error signal 345 may correspond to a sum of the noise within the noise cancellation zone 300, the audible signal corresponding to the noise cancellation signal 145 and, in some circumstances, an intended audio signal within the noise cancellation zone such as audio output by an entertainment system of the vehicle such as music. It will be appreciated that the noise cancellation signal 145 may have a minus sign intended to cancel the noise within the noise cancellation zone 300. The feedback means 310 may be at least one microphone arranged within the noise cancellation zone 300. For example, in one embodiment, the feedback means 310 may be a microphone arranged within the occupant compartment of the vehicle. The microphone 310 may be arranged within a headrest of the vehicle, although other locations are envisaged. In a closed-loop system the determined noise cancellation configuration parameters may provide a starting point which the feedback signal from the feedback means 310 is used to optimise.

Figure 4 schematically illustrates a structure of the noise configuration unit 110 and the noise cancellation unit 120 according to an embodiment of the invention. In the embodiment illustrated in Figure 4, functionality of the terrain unit 105 is integrated with that of the noise configuration unit 110 into a single unit i.e. it is not necessary for these units to be functionally separated.

The noise configuration unit 110 comprises a processing unit 410 for operatively executing an algorithm for determining the one or more configuration parameters of the noise cancellation unit 120. The processing unit 410 comprises one or more processing devices for operatively executing an algorithm for determining the configuration parameters of the noise cancellation unit 120. The determined one or more configuration parameters are provided to the noise cancellation unit 120 as parameters 405.

The processing unit 410 is communicably connected to an interface 420 for receiving noise data 425 from one or more noise input means 131 such as one or more vibro-acoustic sensing devices which, as discussed above, may be microphones or accelerometers or a combination thereof arranged to each provide a noise signal. Each vibro-acoustic sensing device 131 provides respective noise data 425 via the interface 420 to the processing unit 410. The acoustic data 425 provided from each sensing device 131 may correspond to a predetermined portion of the vehicle, such

as a respective noise cancellation zone 300. The interface 420 may receive data from the noise input means 131 via a dedicated audio data communication bus in some embodiments.

- 5 The processing unit 410 may, in some embodiments, be communicably connected to an interface 430 for receiving data 435 corresponding optical signals indicative of an attribute of the terrain 250 such as the road or other surface on which the vehicle is travelling i.e. terrain data 435. As explained below, the processing unit 410 may be arranged to determine one or more attributes associated with the surface on which
- 10 the vehicle is travelling. The one or more attributes may be, for example, information about the elevation, roughness, or a mapping of the terrain or road surface. The interface 430 may be communicably coupled with a communication bus of the vehicle to receive electrical data 435 corresponding to the optical signal received by the receiver 220. The interface 430 may communicate with the LIDAR unit 200. The
- 15 interface 430 may also receive operational data 435 from other systems of the vehicle, such as a suspension control system, vehicle occupancy, gearbox control system, etc. For example the noise configuration unit 110 may use information about the vehicle suspension, in part, to determine the configuration information 405.
- 20 The one or more configuration parameters 405 provided to the noise cancellation unit 120 are determined by the processing unit 410 of the noise configuration unit 110 based on one or both of the received noise data 425 and the terrain data 435. The configuration parameters 405 may be a plurality of configuration parameters 405 for providing to the noise cancellation unit 120, as will be explained. The configuration
- 25 parameters may be associated with one or more transfer functions of the noise cancellation unit 120. In particular, the configuration parameters 405 may be one or more coefficients of one or more transfer functions of the noise cancellation unit 120. In one embodiment, the configuration parameters 405 may comprise a plurality of coefficients associated with at least one transfer function of the noise cancellation
- 30 unit 120.

The noise configuration unit 110 may comprise a parameter data store 440. The parameter data store 440 stores data representing a plurality of configurations of the noise cancellation unit 120. The processing unit 410 is arranged to select one of the

35 configurations according to the data 425, 435 received via one or both of interface 420, 430. That is, according to one or both of the noise data 425 and the terrain data 435. The data representing the plurality of configurations of the noise cancellation

unit 120 may comprise a plurality of sets of data for configuring the noise cancellation unit 120 to a respective configuration. The plurality of sets of data may be a plurality of tables of configuration data, although it will be realised that embodiments of the invention are not limited in this respect. In one embodiment, the parameter data store
5 440 stores a plurality of sets of the one or more coefficients of the one or more transfer functions of the noise cancellation unit 120 which are selected according to one or both of the noise data 425 and the terrain data 435.

In one embodiment, the noise cancellation unit 120 comprises a first data store 460
10 storing at least one reference transfer function (RTF) and a second data store 470 storing at least one speaker transfer function (STF). Although illustrated as first and second data stores 460, 470 it will be realised that the data stores may be unified i.e. the noise cancellation unit 120 may comprise only one data store including both RTF and STF. The noise cancellation unit 120 further comprises a processing unit 450
15 communicably connected to the data stores 460, 470. The processing unit 450 comprises one or more processing devices for operatively executing an algorithm for determining the noise cancellation signal which is output via an interface 455. The algorithm is based upon the one or more configuration parameters received from the noise configuration unit 110.

20 The RTF represents a transfer function from one or more sources of reference data to one or more noise cancellation zones. In particular, the RTF may represent a transfer function indicative of a transform of the reference information such as provided from the one or more vibro-acoustic sensing devices 131, 132. The RTF
25 may be indicative of a transformation of noise from the vibro-acoustic sensing devices 131, 132 to one or more noise cancellation zones 10, 300. A respective RTF may be provided for each cancellation zone 10, 300. The RTF may comprise a plurality of coefficients. The RTF may be used to configure a filter. The RTF represents how noise within the vehicle is caused by acoustic signals at the acoustic
30 sensing devices. For example, the RTF may place emphasis on acoustic signals in one or more frequency ranges resulting in noise within the noise cancellation zone 300.

The STF represents a transfer function from the one or more audio output devices
35 141, 142 to a location of a listener. The STF may represent a transfer function from an audio output device to a noise cancellation zone 300. A respective STF may be provided for each cancellation zone 300. Each STF may be configured according to

a respective number of occupants of the vehicle. That is, the number of occupants may influence a signal output by a speaker being received in the noise cancellation zone 300. Respective STFs may be provided for one or both of the number of occupants and seating positions of those occupants within the vehicle. The STF may
5 comprise a plurality of coefficients. For example, the STF may place emphasis on acoustic signals in one or more frequency ranges resulting in noise within the noise cancellation zone 300.

The configuration parameters 405 received at the noise cancellation unit 120 may
10 configure one or both of the at least one RTF or STF according to the operating conditions of the vehicle. In one embodiment a plurality of RTFs and/or STFs are stored within the noise cancellation unit 120 and are selected according to the configuration parameters 305 received from the noise configuration unit 110.

15 In some embodiments the noise cancellation unit 120 is operative based on a plurality of filter coefficients to determine the noise cancellation signal 145. Each acoustic device 141, 142 may be associated with one or more filter coefficients. In particular, each acoustic device may be associated with a plurality of filter coefficients where each filter coefficient corresponds to a respective reference acoustic pattern.
20 The filter coefficients may be represented as $w_{km}[i]$ which denotes a filter coefficient to drive an acoustic device m based on a k -th reference acoustic pattern.

In some embodiments the configuration parameters 405 received at the noise cancellation unit 120 configure utilisation of one or more noise input means 131, 132.
25 In particular, one or more noise input means 131, 132 may be selectively activated for use in determining one or more noise cancellation signals according to the configuration parameters. For example, when overtaking another vehicle, particularly a large vehicle, a lot of noise may be created and one or more noise input means 131, 132 may be activated or deactivated, appropriately, in order to optimise noise
30 cancellation within the vehicle. That is, noise signals from a subset of noise input means 131, 132 may be used to determine one or more noise cancellation signals according to the configuration parameters.

The noise configuration unit 110 is arranged to determine data indicative of an
35 attribute of a terrain or road surface the vehicle is travelling on.

As explained above, the noise configuration unit 110 is arranged to receive noise data 425. For example, the noise configuration unit 110 may receive an input from at least one vibro-acoustic sensing device, such as accelerometer 131, indicative of respective accelerations applied thereto. In some embodiments the noise configuration unit 110 is arranged to determine a characteristic of a surface on which the vehicle is operatively travelling from the noise data 425. The characteristic may be a roughness of the surface on which the vehicle is travelling. The surface roughness may be determined from one or both of an amplitude and a spectral composition of a signal output by the one or more vibro-acoustic devices 131, 132.

The noise configuration unit 110 may process the received noise data 425 such as by applying a Fourier transform to the received noise data 425 to determine one or more frequency components of the signal from which the surface roughness may be determined, at least in part. The determination may also be made based on the terrain data 435.

As explained above, in some embodiments the noise configuration unit 110 is further communicatively coupled to a communication bus of the vehicle to receive terrain data 435 indicative of an attribute of the terrain 250, such as the road surface the vehicle is travelling, from the communication bus of the vehicle 600. The communication bus may, for example, be a CAN bus or an Internet Protocol (IP) based communication bus of the vehicle, such as Ethernet-based, although it will be realised that embodiments of the invention are not limited in this respect.

One attribute of the terrain or road surface may be the relative elevation of terrain or road surface. The relative elevation may be usefully combined, in some embodiments, with the received noise data 425 as discussed above. In some embodiments one or more coefficients associated with the RTF may be selected based on the surface roughness and relative elevation. Determining the elevation of the terrain or road surface allows the noise cancellation unit 120 configuration to reduce an influence of vibrations induced by elevated obstacles on the terrain or road surface. In some embodiments one or more coefficients associated with the RTF may be selected based on the elevation of the terrain or road surface.

An attribute of the terrain or road surface may also be a mapping of the terrain or road surface. Examples of mapping may be an edge map, phase map, corneriness map, pixel image, etc. Determining the mapping of the terrain, such as the road surface, advantageously allows for determining particular sources of noise or

vibrations induced by elements of the terrain, thereby allowing the configuration of the noise cancellation unit 120 to reduce the influence of such elements. In some embodiments one or more coefficients associated with the RTF may be selected based on the mapping.

5

An attribute of the terrain or road surface may be a roughness of the surface on which the vehicle is travelling. Determining the surface roughness advantageously allows for configuration of the noise cancellation unit 120 to reduce an influence of vibrations induced by the roughness of the surface on which the vehicle is travelling.

10 In some embodiments one or more coefficients associated with the RTF may be selected based on the roughness of the terrain or road surface.

The received terrain data 435 may also be indicative of a terrain setting of the vehicle. In some vehicles, particularly vehicles adapted for off-road driving, the vehicle (or a unit thereof) may be arranged to determine the terrain which the vehicle is crossing. Alternatively, a terrain type may be manually selected by a driver of the vehicle. The terrain may be determined or selected from amongst a plurality of predetermined types such as sand/desert, mud/ruts, grass, snow, tarmac, gravel, rocks etc. The data may be indicative of an attribute of the terrain.

20

The received terrain data 108, 435 may comprise first terrain data and second terrain data with the noise cancellation parameter selection means 110 may be configured to select the one or more noise cancellation configuration parameters in dependence on the first and second terrain data. The first terrain data may correspond to terrain to be traversed by the left hand side of the vehicle 600, or the front wheel(s) of the vehicle 600, for example. Similarly, the second terrain data may correspond to terrain to be traversed by the right hand side of the vehicle 600 or the rear wheel(s) of the vehicle 600. In some embodiments one or more coefficients associated with the RTF may be selected based on the received first and second terrain data.

30

The terrain data 108, 435 may comprise terrain data for each of one or more wheels of the vehicle 600. For example, the terrain data may comprise first terrain data corresponding to a first wheel of the vehicle 600, second terrain data corresponding to a second wheel of the vehicle 600, third terrain data corresponding to a third wheel of the vehicle 600, and fourth terrain data corresponding to a fourth wheel of the vehicle 600. The noise cancellation parameter selection means 110 may be configured to select the one or more noise cancellation configuration parameters in

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dependence on the terrain data for the or each wheel of the vehicle 600. In some embodiments one or more coefficients associated with the RTF may be selected based on the received terrain data for the or each wheel of the vehicle 600.

5 As noted above, in some embodiments the noise configuration unit 110 operatively executes an algorithm for determining the configuration parameters of the noise cancellation unit 120. The algorithm is arranged to select one of the configurations stored in the parameter data store 440 according to the data 425, 435 received via one or both of interfaces 420, 330. That is, according to one or both of the noise data
10 425 and the terrain data 435. For example, in one embodiment the noise configuration unit 110 may select configuration data 405 according to one or more of a relative elevation of the terrain or road surface, a mapping of the terrain or road surface, a roughness of the terrain or road surface, and the received acoustic data 425.

15

The algorithm executed by the processing unit 410 of the noise configuration unit 110 may comprise a pattern matching algorithm for selecting the one or more configuration parameters 405 based on a similarity to previously measured operational characteristics. The pattern matching algorithm may be one of a k -means or nearest neighbour algorithm. As will be appreciated, the k -means algorithm
20 determines one of k clusters corresponding to n observations, where the n observations are the operational characteristics input to the noise configuration unit 110. Each cluster corresponds to a respective configuration of the noise cancellation unit 120. In another embodiment, the noise configuration unit 110 may comprise one or both of a neural network or support vector machine for selecting configuration
25 parameters for providing optimum noise cancellation performance according to a predetermined cost function. In some embodiments, principal components analysis may be used to reduce the dimensionality of the data indicative of the operational characteristics.

30

Figure 5 illustrates a method 500 according to an embodiment of the invention. The method 500 is a method of generating a noise cancellation signal 145. The method 500 may be performed by the noise cancellation system according to an embodiment of the invention as described above.

35

In step 510 one or more inputs are received. The inputs may comprise noise data 425 indicative of vibrations or acoustic signals, such as noise, at one or more vibro-

acoustic sensing devices 131, 132. The inputs comprise radiation 225 reflected from the terrain 250, 260.

5 In step 520, based on the one or more received inputs, the attributes of the terrain 250 are determined. In one embodiment the attributes may be the relative elevation of the terrain or road surface. The attributes may be determined by processing the one or more received inputs by a predetermined algorithm.

10 In step 530, based on the determination made in step 520, a configuration of the noise cancellation unit 120 is determined. The configuration may be selected from amongst a plurality of predetermined configurations. Each configuration may be represented by one or more configuration parameters which are provided from the noise configuration unit 110 to the noise cancellation unit 120. The one or more configuration parameters may be coefficients associated with one or more transfer
15 functions. The configuration parameters may configure one or more filters of the noise cancellation unit 120 according to the determined attributes of the terrain 250,260.

20 In step 540 a noise cancellation signal 145 is generated based on the configuration determined in step 530. The noise cancellation signal 145 is generated based on the output of the vibro-acoustic sensing devices 131, 132. In some embodiments, the noise cancellation signal may be further generated, in a closed-loop system, based on the feedback signal 315 to the noise cancellation system 100 indicative of noise within the noise cancellation zone 300.

25

Figure 6 illustrates a vehicle 600 according to an embodiment of the invention. The vehicle comprises a noise cancellation system such as described above in relation to the preceding figures.

30 Advantageously embodiments of the invention adapt a configuration of the noise cancellation system to terrain data 435 indicative of at least one attribute of a terrain or road surface, such that a noise cancellation signal is responsive to changes in operating environment. In this way noise cancellation may be improved.

35 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 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 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 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 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 noise cancellation system for a vehicle, the system comprising:

5 terrain sensing means operable to receive an optical signal indicative of at least one attribute of a terrain and to output terrain data indicative thereof;

10 noise cancellation parameter selection means operable to select one or more noise cancellation configuration parameters in dependence on the terrain data; and

15 noise cancellation means operable to determine an in-vehicle noise cancellation signal in dependence on the one or more configuration parameters and to output the in-vehicle noise cancellation signal for reducing reduce noise in a vehicle.

2. The noise cancellation system of claim 1, wherein the terrain sensing means comprises:

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a laser for outputting laser light directed towards the terrain; and

receiving means for receiving the optical signal reflected from the terrain.

25

3. The noise cancellation system of claim 2, wherein the terrain sensing means is a LIDAR unit.

4. The noise cancellation system of claim 1, 2 or 3, wherein:

30

the terrain sensing means is arranged to determine a mapping of the terrain proximal to the vehicle; and

35 the noise cancellation parameter selection means is arranged to select the one or more noise cancellation configuration parameters in dependence on the mapping.

5. The noise cancellation system of claim 4, wherein the mapping is one or more of a phase map, an edge map, a cornerness map, or a pixel image.

5 6. The noise cancellation system of claim 2 or any claim dependent thereon, wherein a scanning laser is arranged to output the laser light ahead of the vehicle, and the optical signal is indicative of the at least one attribute of the terrain ahead of the vehicle.

10 7. The noise cancellation system of any preceding claim, wherein:
the terrain sensing means is arranged to determine a relative elevation of the terrain ahead of the vehicle with respect to a current elevation of the vehicle; and

15 the noise cancellation parameter selection means is arranged to select the one or more noise cancellation configuration parameters based on the relative elevation.

20 8. The noise cancellation system of any preceding claim, wherein:
the terrain sensing means is arranged to determine a roughness of the terrain; and

25 the noise cancellation parameter selection means is arranged to select the one or more noise cancellation configuration parameters based on the roughness.

30 9. The noise cancellation system of any preceding claim, wherein the in-vehicle noise cancellation signal is determined for a point in time ahead of a current time; optionally the point in time corresponds to a time at which the vehicle traverses the terrain corresponding to the determined attribute.

35 10. The noise cancellation system of any preceding claim, wherein the noise cancellation parameter selection means is arranged to operatively select a pre-determined noise cancellation configuration, corresponding to the one or more noise cancellation configuration parameters, in dependence on the received terrain data.

11. The noise cancellation system of any preceding claim, wherein the one or more noise cancellation configuration parameters are associated with at least one function for determining the in-vehicle noise cancellation signal.
- 5 12. The noise cancellation system of claim 11, wherein the one or more noise cancellation configuration parameters are associated with the at least one function are one or more filter coefficients.
- 10 13. The noise cancellation system of claim 11 or 12, wherein the function is a speaker transfer function (STF) indicative of a transfer function associated with one or more audio output devices.
- 15 14. The noise cancellation system of claim 11 or 12, wherein the function is a reference transfer function (RTF) indicative of a transfer function from one or more noise sensing means.
- 15 15. The noise cancellation system of claim 14, wherein the noise sensing means is associated with a suspension of the vehicle.
- 20 16. A method of generating a noise cancellation signal for a vehicle, comprising:
- receiving a signal indicative of at least one attribute of a terrain;
- selecting one or more noise cancellation configuration parameters based on the received signal indicative of the at least one attribute of the terrain; and
- 25 30 30 generating an in-vehicle noise cancellation signal in dependence on the one or more configuration parameters; and
- outputting the in-vehicle noise cancellation signal for reducing noise in the vehicle.
- 35 17. The method of claim 16, comprising:
- receiving one or more noise signals indicative of noise within the vehicle;

wherein the in-vehicle noise cancellation signal is generated in dependence on the one or more noise signals.

- 5 18. The method of claim 16 or 17, wherein the optical signal indicative of the at least one attribute of the terrain is indicative of a mapping of the terrain.
19. The method of claim 18, wherein the mapping is one or more of a phase map, an edge map, a cornerness map, or a pixel image.
- 10 20. The method of any of claims 16 to 19, comprising determining, in dependence on the optical signal, a relative elevation of the terrain ahead of the vehicle with respect to a current elevation of the vehicle.
- 15 21. The method of any of claims 16 to 20, comprising determining, in dependence on the optical signal, a roughness of the terrain ahead of the vehicle.
- 20 22. The method of any of claims 16 to 21, comprising selecting a predetermined noise cancellation configuration in dependence on the received optical signal; optionally the noise cancellation configuration is selected from amongst a plurality of predetermined noise cancellation configurations.
- 25 23. The method of any of claims 16 to 22, wherein the one or more noise cancellation configuration parameters are associated with at least one function for determining the noise cancellation signal in dependence on the one or more noise signals.
- 30 24. The method of claim 23, wherein the one or more noise cancellation configuration parameters associated with the at least one function are one or more filter coefficients.
- 35 25. The method of any of claims 16 to 24, wherein the at least one attribute of the terrain is a roughness of the terrain, and the one or more noise cancellation configuration parameters are selected in dependence on the roughness of the terrain.
26. The method of any of claims 16 to 25, wherein the noise cancellation parameter selection means is arranged to determine the further attribute of the terrain based on one or both of an amplitude and a spectral composition of the noise signal.

27. A controller, comprising:

5 input means for receiving terrain data determined from an optical
signal indicative of at least one attribute of a terrain; and

 noise cancellation parameter selection means operable to select one
or more noise cancellation configuration parameters in dependence on the
terrain data.

10

28. The controller of claim 27, wherein the noise cancellation parameter selection
means is arranged to operatively select a pre-determined noise cancellation
configuration, corresponding to the one or more noise cancellation
configuration parameters, in dependence on the received terrain data.

15

29. A vehicle comprising the noise cancellation system as claimed in any of
claims 1 to 15, to perform a method as claimed in any of claims 16 to 28 or a
controller as claimed in claim 27 or 28.

20

30. Computer software which, when executed by a computer, is arranged to
perform a method according to any of claims 16 to 26; optionally the
computer software is stored on a computer-readable medium.

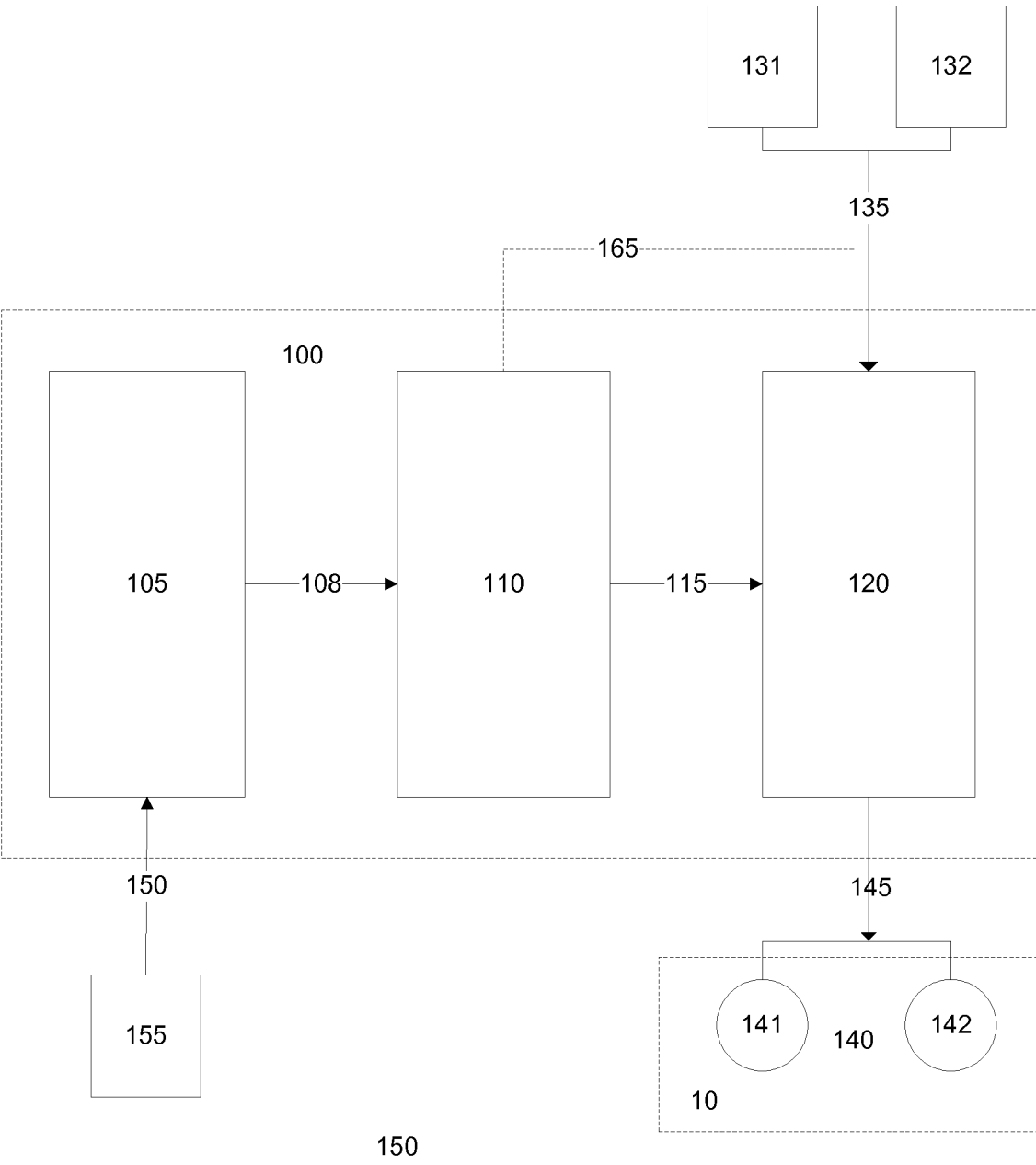


Fig. 1

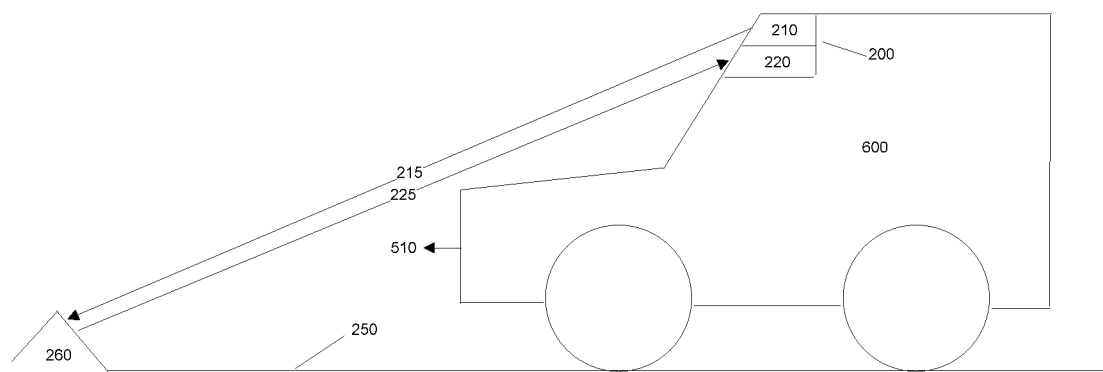


Fig. 2

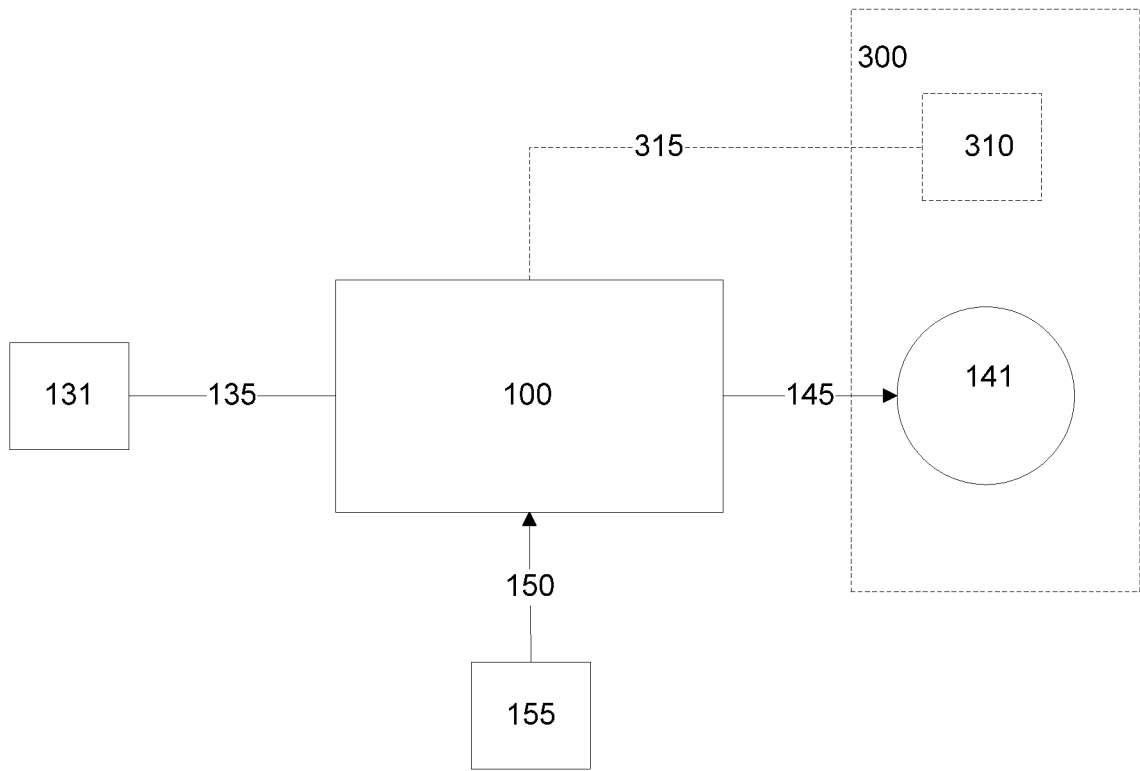


Fig. 3

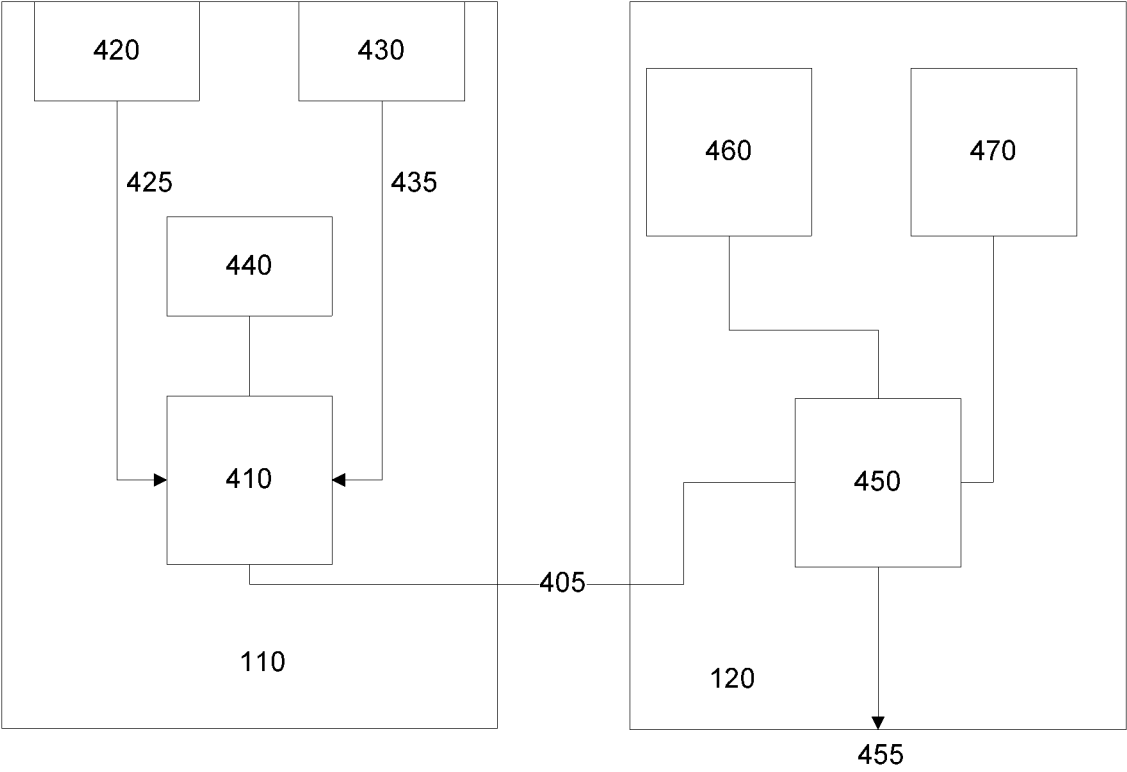


Fig. 4

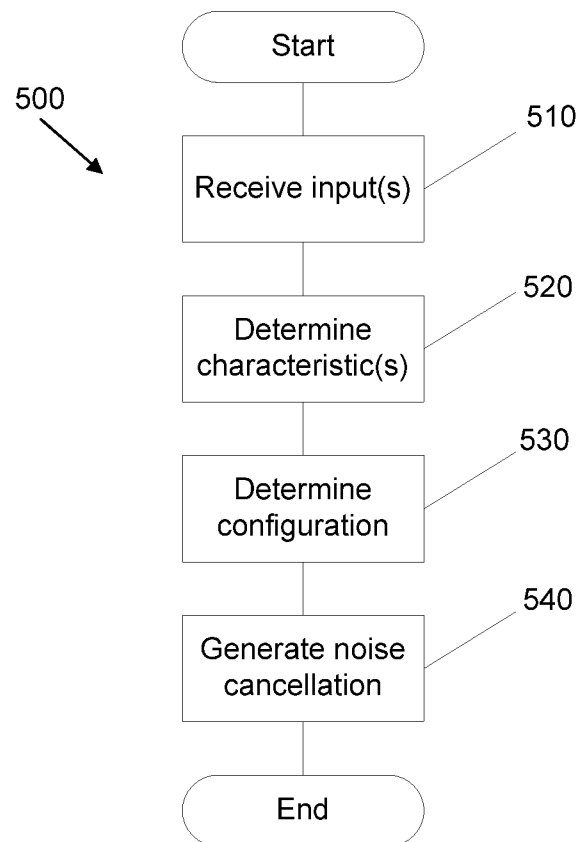


Fig. 5

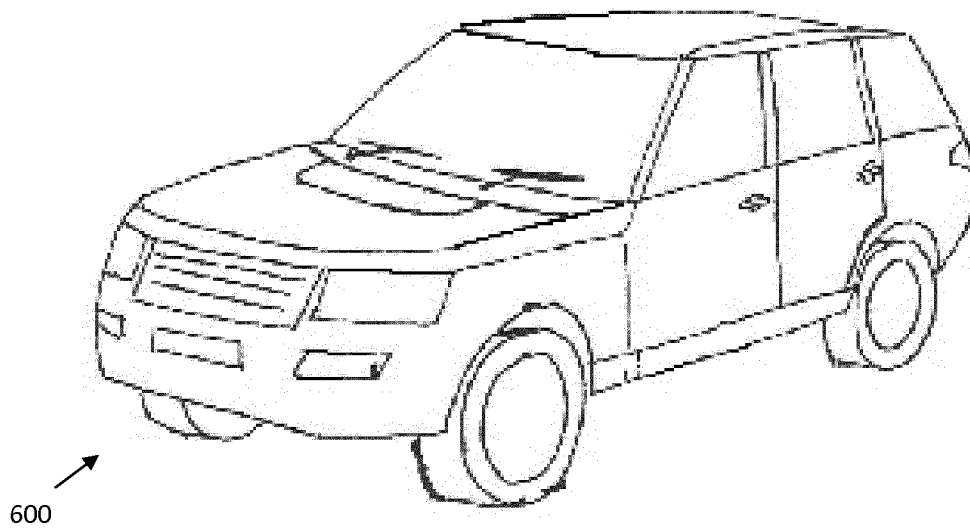


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/079906

A. CLASSIFICATION OF SUBJECT MATTER
INV. 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)
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, 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	JP H10 169700 A (HONDA MOTOR CO LTD) 23 June 1998 (1998-06-23) abstract; claims 1,2; figures 1,2 paragraph [0026] - paragraph [0038] paragraph [0044] paragraph [0009] paragraph [0006]	1-30
X	JP 2008 062804 A (HONDA MOTOR CO LTD) 21 March 2008 (2008-03-21)	16,17, 23-27, 29,30
A	abstract	1
X	US 2015/030175 A1 (ROGGENKAMP TIMOTHY J [US] ET AL) 29 January 2015 (2015-01-29)	16,17, 23-27, 29,30
A	abstract paragraph [0026]; figure 1	1
	-/--	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

22 March 2018

Date of mailing of the international search report

03/04/2018

Name and mailing address of the ISA/

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De Bekker, Ruben

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/079906

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2015/155113 A1 (JAGUAR LAND ROVER LTD [GB]) 15 October 2015 (2015-10-15) abstract; figures 3-5 page 7, line 6 - page 8, line 11 -----	1-30

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/079906

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
JP H10169700	A	23-06-1998	NONE	

JP 2008062804	A	21-03-2008	NONE	

US 2015030175	A1	29-01-2015	CN 104340142 A	11-02-2015
			DE 102014110446 A1	29-01-2015
			US 2015030175 A1	29-01-2015

WO 2015155113	A1	15-10-2015	AU 2015243670 A1	24-11-2016
			CN 106163896 A	23-11-2016
			EP 3129267 A1	15-02-2017
			GB 2526911 A	09-12-2015
			JP 2017510503 A	13-04-2017
			US 2017028996 A1	02-02-2017
			WO 2015155113 A1	15-10-2015
