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(54) ARRANGEMENT AND METHOD FOR ESTIMATING TRAFFIC INTENSITY WITHIN A ROAD NETWORK

(57) A system and method for estimating traffic intensity uses data from a subset (SV_{1-n}) of connected vehicles equipped with positioning systems (1) and active safety sensor systems (2a, 2b) capable of determining vehicles travelling in an opposite direction within a road network (9). It is determined whenever a connected vehicle meets another vehicle, and a position of the connected vehicle and data regarding met vehicles is reported to a back end system (6) which also provide instructions. The positions and directions of travel of the connected vehicles are kept track of and it is also determined whenever two connected vehicles within the subset (SV_{1-n}) meet one another. The number of vehicles a connected vehicle meets is counted and the total number of vehicles that passes a position within the road network (9) in a given direction is estimated based on the positions and directions of travel of the connected vehicles and the associated vehicle counts.

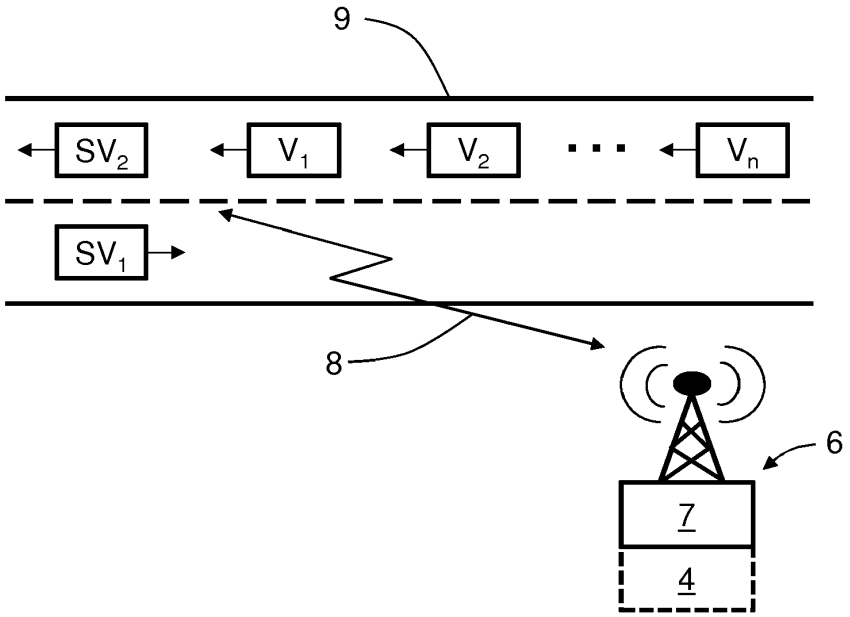

Fig. 1

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Description

Technical field

[0001] The present disclosure relates to a system for estimating traffic intensity using data from a subset of connected vehicles equipped with respective positioning systems and one or more respective active safety sensor systems capable of determining adjacent vehicles travelling in an opposite direction within a road network a traffic intensity of which is of interest.

[0002] The disclosure further relates to a method for estimating traffic intensity using data from a subset of connected vehicles equipped with respective positioning systems and one or more respective active safety sensor systems capable of determining adjacent vehicles travelling in an opposite direction within a road network a traffic intensity of which is of interest.

[0003] The disclosure further relates to a connected vehicle, suitable to form part of a subset of connected vehicles, the connected vehicle equipped with a positioning system and one or more active safety sensor systems capable of determining adjacent vehicles travelling in an opposite direction within a road network.

Background

[0004] Road authorities are frequently conducting traffic intensity measurements. Data from such measurements are frequently used as an important basis for decisions on future investments in infrastructure. Often, some temporary stationary equipment is mounted on a road or in the traffic environment of a road, to count the number of vehicles passing on the road. Conducting such measurements are usually both costly and cumbersome.

[0005] Road authorities are also concerned with the risks that its personnel are exposed to when mounting and demounting on the road or in the traffic environment of the road such stationary equipment to count the number of vehicles passing.

[0006] These types of measurements normally provide limited data sets as they are temporary, i.e. not permanent over time, and as they are limited to a few locations at a time.

[0007] It has been proposed to use data from cell phones as an alternative method to count passing vehicles. One advantage would be that such data would not require installation of stationary equipment in the road network. It is suggested to be based on the collection of localization data, such as e.g. speed, direction of travel and time information, from cell phones in vehicles that are being driven past a certain location or road segment in a road network. This would mean that every vehicle with an active cell phone would act as a sensor for the road network. Based on the acquired data it is suggested that traffic congestions could be identified, travel times could be calculated, and traffic reports could be generated.

[0008] However, since there is no way to collect cell phone data from every vehicle, this type of data source will only represent a portion of the vehicles that passes a certain location or a road segment in the road network and consequently this type of data will therefore be incomplete. Thus, due to the incompleteness of the data identification of traffic congestions, calculation of travel times etc. will inherently be flawed with uncertainty.

[0009] Thus there is a need for solutions to non-intrusively and cost efficiently more accurately conduct traffic intensity measurements without requiring installation of stationary equipment in the road network, solutions which also provide enhanced safety to road authority personnel by eliminating the need for performing such high-risk costly and cumbersome installations as discussed above.

Summary

[0010] Embodiments herein aim to provide an improved system for non-intrusively and cost efficiently more accurately and safely estimating traffic intensity.

[0011] This is provided through a system for estimating traffic intensity using data from a subset of connected vehicles equipped with respective positioning systems and one or more respective active safety sensor systems capable of determining adjacent vehicles travelling in an opposite direction within a road network a traffic intensity of which is of interest, where each respective vehicle in the subset of connected vehicles comprises: a vehicle logic arranged to determine, using data from one or more of its respective active safety sensor systems, whenever the vehicle meets another vehicle, and; a communication arrangement, arranged to communicate with a back end system to report a position of the connected vehicle and data regarding met vehicles and to receive instructions from the back end system; and the system for estimating traffic intensity further comprising: an estimation logic residing in the back end system and arranged to keep track of the positions and directions of travel of the connected vehicles within the subset and to determine whenever a connected vehicle within the subset meets another connected vehicle within the subset; and a counter, in each respective vehicle in the subset of connected vehicles or in the back end system, arranged to count, starting upon determination that a specific connected vehicle within the subset meets another connected vehicle within the subset or passes a specific geographical position within the road network, the number of vehicles this specific connected vehicle within the subset meets until it either meets yet another connected vehicle within the subset, passes a specific geographical position within the road network or until a pre-determined time period has passed; the estimation logic residing in the back end system further arranged to estimate the total number of vehicles that passes a specific geographical position within the road network in a given direction based on the positions and directions of travel of the connected vehicles

within the subset and the associated vehicle counts.

[0012] According to a second aspect is provided that the estimation logic residing in the back end system, in order to estimate the total number of vehicles that passes a specific geographical position within the road network, in a given direction, further is arranged to add the numbers whenever a connected vehicle within the subset passes the specific geographical position within the road network, such that the most recently counted number of vehicles ahead of that connected vehicle within the subset, either up to the preceding another connected vehicle within the subset or the most recently previously passed specific geographical position within the road network, is added to the total number of vehicles passing the specific geographical position within the road network.

[0013] The provision of adding the numbers whenever a connected vehicle within the subset passes a specific geographical position within the road network provides a simple and reliable estimation of the total number of vehicles that passes a specific position within the road network.

[0014] According to a third aspect is provided that the estimation logic residing in the back end system further is arranged to derive the present traffic density for a specific geographical position within the road network as number of vehicles over time using the delta time since the last connected vehicle within the subset passed that specific geographical position within the road network.

[0015] The provision of using the delta time since a last connected vehicle within the subset passed a specific geographical position within the road network provides a simple and reliable mechanism for deriving a present traffic density for a specific geographical position within the road network as the number of vehicles over time.

[0016] According to a fourth aspect is provided that the estimation logic residing in the back end system further is arranged to detect and keep track of an event where two connected vehicles within the subset meet each other, and whenever this happens either communicate to these connected vehicles within the subset a request to report their present count and subsequently reset their count to zero and restart their count, or to the counter in the back end system a request to report its present count and subsequently reset its count to zero and restart its count.

[0017] The provision of having an estimation logic residing in the back end system detect and keep track of an event where two connected vehicles within the subset meet each other in order to request that a present count is reported and the ongoing count reset to zero and restarted provides an efficient way of supervising the harvesting of data for the traffic intensity estimation.

[0018] According to a fifth aspect is provided that the estimation logic residing in the back end system further is arranged to manage the counted vehicles between the connected vehicle within the subset initiating the count and the connected vehicle within the subset terminating the count as a property of the connected vehicle within the subset terminating the count, the property representing the total number of vehicles between these connected vehicles within the subset, including the connected vehicle within the subset terminating the count.

[0019] The provision of managing the counted vehicles as a property of the connected vehicle within the subset terminating the count, including that vehicle, provides a simple and intuitive way of following the associated vehicle count data within the road network.

[0020] According to a sixth aspect is provided that the estimation logic residing in the back end system further is arranged to communicate to the connected vehicles within the subset instructions when to determine whenever the vehicle meets another vehicle and when to report data regarding met vehicles.

[0021] The provision of communicating to the connected vehicles within the subset instructions when to determine whenever the vehicle meets another vehicle and when to report data regarding met vehicles provides an efficient way of selectively managing the harvesting of vehicle count data for the traffic intensity estimation.

[0022] According to a seventh aspect is provided that the estimation logic residing in the back end system further is arranged to communicate to the connected vehicles within the subset instructions to selectively activate and deactivate the functionalities to determine whenever the vehicle meets another vehicle and to report data regarding met vehicles of one or more specific connected vehicles within the subset, such that only connected vehicles within the subset close to a geographical position of interest within the road network will determine and report data regarding met vehicles.

[0023] The provision of communicating instructions to selectively activate and deactivate the functionalities to determine whenever the vehicle meets another vehicle and to report data regarding met vehicles of one or more specific connected vehicles within the subset, such that only connected vehicles within the subset close to a geographical position of interest within the road network will determine and report data regarding met vehicles, provides an efficient way of selectively managing the harvesting of vehicle count data relevant to a geographical position of interest within the road network for the traffic intensity estimation.

[0024] Embodiments herein also aim to provide an improved method for non-intrusively and cost efficiently more accurately and safely estimating traffic intensity.

[0025] Thus, according to an eight aspect this is provided through a method for estimating traffic intensity using data from a subset of connected vehicles equipped with respective positioning systems and one or more respective active safety sensor systems capable of determining adjacent vehicles travelling in an opposite direction within a road network a traffic intensity of which is of interest, which method for each respective vehicle in the subset of connected vehicles comprises: determining, using a vehicle logic and data from one or more of its respective active safety sensor systems, whenever the

vehicle meets another vehicle, and; reporting, using a communication arrangement, to a back end system, a position of the connected vehicle and data regarding met vehicles and receiving instructions from the back end system; and the method for estimating traffic intensity further comprising: keeping track of the positions and directions of travel of the connected vehicles within the subset and determining whenever a connected vehicle within the subset meets another connected vehicle within the subset using an estimation logic residing in the back end system; and counting, using a counter in each respective vehicle in the subset of connected vehicles or in the back end system, starting upon determination that a specific connected vehicle within the subset meets another connected vehicle within the subset or passes a specific geographical position within the road network, the number of vehicles this specific connected vehicle within the subset meets until it either meets yet another connected vehicle within the subset, passes a specific geographical position within the road network or until a pre-determined time period has passed; estimating, using the estimation logic residing in the back end system, the total number of vehicles that passes a specific geographical position within the road network in a given direction based on the positions and directions of travel of the connected vehicles within the subset and the associated vehicle counts.

[0026] According to a ninth aspect is provided that the estimating, in order to estimate the total number of vehicles that passes a specific geographical position within the road network, in a given direction, further comprises adding the numbers whenever a connected vehicle within the subset passes the specific geographical position within the road network, such that the most recently counted number of vehicles ahead of that connected vehicle within the subset either up to the preceding another connected vehicle within the subset or the most recently previously passed specific geographical position within the road network is added to the total number of vehicles passing the specific geographical position within the road network.

[0027] The provision of adding the numbers whenever a connected vehicle within the subset passes the specific geographical position within the road network provides a simple and reliable estimation of the total number of vehicles that passes a specific geographical position within the road network.

[0028] According to a tenth aspect is provided that the estimating further comprises deriving the present traffic density for a specific geographical position within the road network as number of vehicles over time using the delta time since the last connected vehicle within the subset passed that specific geographical position within the road network.

[0029] The provision of using the delta time since a last connected vehicle within the subset passed a specific geographical position within the road network provides a simple and reliable mechanism for deriving a present traffic density for a specific geographical position within the road network as the number of vehicles over time.

[0030] According to an eleventh aspect is provided that it further comprises detecting and keeping track of an event where two connected vehicles within the subset meet each other, and whenever this happens either communicating to these connected vehicles within the subset a request to report their present count and subsequently reset their count to zero and restart their count, or to the counter in the back end system a request to report its present count and subsequently reset its count to zero and restart its count.

[0031] The provision of detecting and keeping track of an event where two connected vehicles within the subset meet each other in order to request a count report and a subsequent count reset and restart provides an efficient way of supervising the harvesting of vehicle count data for the traffic intensity estimation.

[0032] According to a twelfth aspect is provided that the estimating further comprises managing the counted vehicles between the connected vehicle within the subset initiating the count and the connected vehicle within the subset terminating the count as a property of the connected vehicle within the subset terminating the count, the property representing the total number of vehicles between these connected vehicles within the subset, including the connected vehicle within the subset terminating the count.

[0033] The provision of managing the counted vehicles as a property of the connected vehicle within the subset terminating the count, including that vehicle, provides a simple and intuitive way of following the associated vehicle count data within the road network.

[0034] According to a thirteenth aspect is provided that it further comprises arranging the estimation logic residing in the back end system to communicate to the connected vehicles within the subset instructions when to determine whenever the vehicle meets another vehicle and when to report data regarding met vehicles.

[0035] The provision of communicating to the connected vehicles within the subset instructions when to determine whenever the vehicle meets another vehicle and when to report data regarding met vehicles provides an efficient way of selectively managing the harvesting of vehicle count data for the traffic intensity estimation.

[0036] According to an fourteenth aspect is provided that it further comprises arranging the estimation logic residing in the back end system to communicate to the connected vehicles within the subset instructions to selectively activate and deactivate the functionalities to determine whenever the vehicle meets another vehicle and to report data regarding met vehicles of one or more specific connected vehicles within the subset, such that only connected vehicles within the subset close to a geographical position of interest within the road network will perform determining and reporting of data regarding met vehicles.

[0037] The provision of communicating instructions to

selectively activate and deactivate the functionalities to determine whenever the vehicle meets another vehicle and to report data regarding met vehicles of one or more specific connected vehicles within the subset, such that only connected vehicles within the subset close to a geographical position of interest within the road network can be activated, provides an efficient way of selectively managing the harvesting of vehicle count data relevant to a geographical position of interest within the road network for the traffic intensity estimation.

[0038] According to a final aspect is provided a connected vehicle, suitable to form part of a subset of connected vehicles, the connected vehicle equipped with a positioning system and one or more active safety sensor systems capable of determining adjacent vehicles travelling in an opposite direction within a road network, which connected vehicle comprises: a vehicle logic arranged to determine, using data from one or more of its respective active safety sensor systems, whenever the vehicle meets another vehicle, and; a communication arrangement, arranged to communicate with a back end system to report a position of the connected vehicle and data regarding met vehicles and to receive instructions from the back end system; and a counter, arranged to count the number of vehicles this specific connected vehicle within the subset meets when instructed to do so by the back end system.

[0039] A vehicle as above is able to cost efficiently provide the vehicle count data required for operating a system for estimating traffic intensity according to at least some embodiments described herein and in accordance with at least some embodiments of the method for estimating traffic intensity as described herein.

Brief description of the drawings

[0040] In the following, embodiments herein will be described in greater detail by way of example only with reference to attached drawings, in which

Fig. 1 is a schematic illustration of initiation of a vehicle count in a system according to embodiments herein.

Fig. 2 is a schematic illustration of termination of a vehicle count in a system according to embodiments herein.

Fig. 3 is a schematic illustration of a method according to embodiments herein.

Fig. 4 is a schematic illustration of a connected vehicle adapted for performing vehicle counting in embodiments of a system operating according to embodiments of the method described herein.

[0041] Still other objects and features of embodiments herein will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of illustration and not as a definition of the limits hereof, for which reference should be made to the appended claims. It should be further understood that the drawings are not necessarily drawn to scale and that, unless otherwise indicated, they are merely intended to conceptually illustrate the structures and procedures described herein.

Description of embodiments

[0042] The present disclosure proposes a solution such that vehicle data from a limited subset of connected vehicles SV_{1-n}, out of an assumed large fleet of connected vehicles, can be used to accurately estimate the traffic intensity non-intrusively, cost efficiently and safely. It is based on the use of vehicle data from contemporary active safety sensor systems, such as camera based sensor systems, LIDAR (Light detection and ranging) or RADAR (Radio Detection and Ranging) based sensor systems, or combinations thereof, such as e.g. so called RACam (Radar and Camera) sensor systems, in combination with logics to derive the traffic intensity.

[0043] Firstly will be described, and illustrated schematically in figures 1 and 2, a system for estimating traffic intensity using data from a subset of connected vehicles SV_{1-n} equipped with respective positioning systems 1, such as satellite based GPS (Global Positioning Systems) or similar, and one or more respective active safety sensor systems 2a, 2b, as described above, capable of determining adjacent vehicles V_{1-n} travelling in an opposite direction within a road network 9 a traffic intensity of which is of interest.

[0044] Each respective vehicle in the subset of connected vehicles SV_{1-n}, as further illustrated in figure 4, comprises a vehicle logic 3 arranged to determine, using data from one or more of its respective active safety sensor systems 2a, 2b, whenever the connected vehicle SV_1 in the subset of connected vehicles SV_{1-n} meets another vehicle V_{1-n} travelling in an opposite direction.

[0045] Further, each respective vehicle in the subset of connected vehicles SV_{1-n} also comprises a communication arrangement 5, such as an arrangement for wireless communication and in particular data communication over e.g. a cellular network or similar. The communication arrangement 5 is arranged to communicate with a back end system 6 to report a position of the connected vehicle and data regarding met vehicles and to receive instructions from the back end system 6. It is also possible, in some embodiments, that the communication arrangement 5 additionally provides for V2V (Vehicle-to-Vehicle) communication, V2I (Vehicle-to-Infrastructure) communication and any combinations thereof.

[0046] The system for estimating traffic intensity further comprises a cloud logic, hereafter called an estimation logic 7, residing in the back end system 6 and arranged to keep track of the positions and directions of

travel of the connected vehicles SV_{1-n} within the subset and to determine whenever a connected vehicle SV_1 within the subset of connected vehicles SV_{1-n} meets another connected vehicle SV_n within the subset of connected vehicles SV_{1-n}.

[0047] The system for estimating traffic intensity also comprises a counter 4, which in a first embodiment, as illustrated in figure 4, is arranged in each respective vehicle in the subset of connected vehicles SV_{1-n}. In a second, alternative embodiment, illustrated in figures 1 and 2, the counter 4 is arranged in the back end system 6. The above alternatives are illustrated by dashed lines in the respective figures.

[0048] The counter 4, is arranged to count, starting upon determination that a specific connected vehicle within the subset SV_{1-n} meets another connected vehicle within the subset SV_{1-n} or passes a specific geographical position within the road network 9, the number of vehicles this specific connected vehicle within the subset SV_{1-n} meets. This counting is arranged to be maintained until the specific connected vehicle within the subset SV_{1-n} either meets yet another connected vehicle within the subset SV_{1-n}, passes a specific geographical position within the road network 9 or until a pre-determined time period has passed.

[0049] Thus counting may as illustrated in figures 1 and 2, as a first alternative, be initiated upon determination that a specific connected vehicle SV_1 within the subset SV_{1-n} meets another connected vehicle SV_2 within the subset SV_{1-n}, as illustrated in figure 1, and terminated as the specific connected vehicle SV_1 within the subset SV_{1-n} meets yet another connected vehicle, illustrated by vehicle V_n in figure2, within the subset SV_{1-n}. For embodiments where the counter 4 is arranged in each respective vehicle in the subset of connected vehicles SV_{1-n} the estimation logic 7 residing in the back end system 6 should be arranged to inform the two connected vehicles within the subset SV_{1-n} that they have both met another of the connected vehicles within the subset SV_{1-n}.

[0050] As a second alternative, the counting may be initiated upon determination that a specific connected vehicle SV_1 within the subset SV_{1-n} passes a specific geographical position within the road network 9, illustrated by the position of SV_1 in figure 1, and terminated as the specific connected vehicle SV_1 within the subset SV_{1-n} passes another specific geographical position within the road network 9, illustrated by the position of SV_1 in figure 2.

[0051] As a third alternative, the counting may be initiated upon determination that a specific connected vehicle SV_1 within the subset SV_{1-n} passes a specific geographical position within the road network 9, illustrated by the position of SV_1 in figure 1, and terminated when a pre-determined time period thereafter has passed, the pre-determined time period in figure 2 illustrated to have passed once the specific connected vehicle SV_1 within the subset SV_{1-n} passes the SV_1 position as illustrated in figure 2.

[0052] For embodiments where the counter 4 is arranged in each respective vehicle in the subset of connected vehicles SV_{1-n} the communication arrangement 5 can be arranged to communicate with the back end system 6 to report data regarding met vehicles directly upon determining that the vehicle has met another vehicle or intermittently at a certain interval or upon an instruction to do so being received from the back end system 6.

[0053] The estimation logic 7 residing in the back end system 6 further arranged to estimate the total number of vehicles that passes a specific geographical position within the road network 9 in a given direction based on the positions and directions of travel of the connected vehicles within the subset SV_{1-n} and the associated vehicle counts.

[0054] As in a system for estimating traffic intensity as above, multiple connected vehicles within the subset SV_{1-n} could provide vehicle counts, the estimation logic 7 residing in the back end system 6 could be arranged to estimate the total number of vehicles that passes a specific geographical position within the road network through statistical analysis. The traffic density may e.g. be estimated as the number of vehicles over time that a connected vehicle within the subset SV_{1-n} have met divided by the corresponding time period, possibly with compensation for the effect of the travel velocity of the connected vehicle within the subset SV_{1-n}. A higher travel velocity of the connected vehicle within the subset SV_{1-n} would normally lead to an increasing over estimation of the traffic intensity whereas a stationary connected vehicle within the subset SV_{1-n} would yield a correct count.

[0055] Furthermore, if for some reason the data regarding met vehicles should be incomplete, the estimation logic 7 residing in the back end system 6 could be arranged to provide an estimate of the traffic intensity using the counted vehicles as a sample for this estimation.

[0056] If there are measurements from multiple connected vehicles within the subset SV_{1-n}, related to the same geographical starting point and during some limited time, the estimated vehicle density could be improved though an averaging of the measured data. Such a solution would relax the need for connected vehicles within the subset SV_{1-n} to meet each other to initiate counting and reporting of counted vehicles. This solution could enable estimation of the traffic density at a lower density of connected vehicles, i.e. with a smaller subset SV_{1-n} or fleet of connected vehicles.

[0057] According to some embodiments the estimation logic 7 residing in the back end system 6, in order to estimate the total number of vehicles that passes a specific geographical position within the road network 9, in a given direction, further is arranged to add the numbers whenever a connected vehicle SV_{1-n} within the subset passes the specific geographical position within the road network 9. In this way the most recently counted number

of vehicles ahead of that connected vehicle SV_{1-n} within the subset, either up to the preceding another connected vehicle SV_{1-n} within the subset or the most recently previously passed specific geographical position within the road network 9, is added to the total number of vehicles passing the specific geographical position within the road network 9. This provides a simple and reliable estimation of the total number of vehicles that passes a specific geographical position within the road network 9.

[0058] In still further embodiments the estimation logic 7 residing in the back end system 6 is further arranged to derive the present traffic density for a specific geographical position within the road network 9 as number of vehicles over time using the delta time since the last connected vehicle SV_{1-n} within the subset passed that specific geographical position within the road network 9. The back end system 6 will be arranged to keep track on such delta times for one or more geographical positions of interest within the road network 9. This provides a simple and reliable mechanism for deriving a present traffic density for a specific geographical position within the road network 9 as the number of vehicles over time.

[0059] In yet some further embodiments the estimation logic 7 residing in the back end system 6 is further arranged to detect and keep track of an event where two connected vehicles, e.g. SV_1 and SV_2, within the subset meet each other. And further, whenever two connected vehicles within the subset meet each other, for embodiments where a counter 4 is arranged in each respective vehicle in the subset of connected vehicles SV_{1-n}, communicate to these connected vehicles within the subset SV_{1-n} a request to report their present counts and subsequently reset their counts to zero and restart their counts. Conversely, for embodiments where the counter 4 is arranged in the back end system 6, communicate to the counter in the back end system a request to report its present count and subsequently reset its count to zero and restart its count. This provides an efficient way of supervising the harvesting of data for the traffic intensity estimation.

[0060] According to still some further embodiments the estimation logic 7 residing in the back end system 6 is further arranged to manage the counted vehicles between the connected vehicle within the subset initiating the count, in figure 1 illustrated as SV_1, and the connected vehicle within the subset terminating the count, in figure 2 illustrated as SV_n, as a property of the connected vehicle within the subset terminating the count SV_n. The property will thus be representing the total number of vehicles V_{1-n} between these connected vehicles within the subset SV_{1-n}, including the connected vehicle within the subset terminating the count SV_n. Through associating the count as a property of the connected vehicle within the subset terminating the count SV_n will provides a simple and intuitive way of following the associated vehicle count data within the road network 9 as the connected vehicle within the subset terminating the count SV_n travels within the road network 9.

[0061] In some further embodiments the estimation logic 7 residing in the back end system 6 is further arranged to communicate to the connected vehicles within the subset SV_{1-n}, e.g. using an associated wireless communications network, illustrated by arrow 8, instructions when to determine whenever the vehicle meets another vehicle and when to report data regarding met vehicles. This provides an efficient way of selectively managing the harvesting of vehicle count data for the traffic intensity estimation.

[0062] According to yet some further embodiments the estimation logic 7 residing in the back end system 6 is further arranged to communicate to the connected vehicles within the subset SV_{1-n}, e.g. using an associated wireless communications network, illustrated by arrow 8, instructions to selectively activate and deactivate the functionalities to determine whenever the vehicle meets another vehicle and to report data regarding met vehicles of one or more specific connected vehicles within the subset SV_{1-n}. In this way it will be possible to ensure that only connected vehicles within the subset SV_{1-n} close to a geographical position of interest within the road network 9 will determine and report data regarding met vehicles. This provides an efficient way of selectively managing the harvesting of vehicle count data relevant to a geographical position of interest within the road network 9 for the traffic intensity estimation.

[0063] Still further, the present disclosure also proposes an improved method for non-intrusively and cost efficiently more accurately and safely estimating traffic intensity. This is provided through a method, as illustrated schematically in figure 3, for estimating traffic intensity using data from a subset SV_{1-n} of connected vehicles equipped with respective positioning systems 1 and one or more respective active safety sensor systems 2a, 2b, such as e.g. camera, RADAR, LIDAR, RACam based sensor systems or combinations thereof, capable of determining adjacent vehicles travelling in an opposite direction within a road network 9 a traffic intensity of which is of interest.

[0064] The method comprises, for each respective vehicle in the subset of connected vehicles SV_{1-n} the following actions:

- determining 10, using a vehicle logic and data from one or more of its respective active safety sensor systems 2a, 2b, whenever the vehicle SV_1 meets another vehicle;
- reporting 11, using a communication arrangement 5, to a back end system 6, a position of the connected vehicle and data regarding met vehicles and receiving instructions from the back end system 6; and

the method further comprises:

- keeping track 12 of the positions and directions of travel of the connected vehicles within the subset

SV_{1-n} and determining whenever a connected vehicle within the subset SV_{1-n} meets another connected vehicle within the subset SV_{1-n} using an estimation logic 7 residing in the back end system 7; and

- counting 13, using a counter 4 in each respective vehicle in the subset SV_{1-n} of connected vehicles or in the back end system 6, starting upon determination that the vehicle meets a connected vehicle within the subset SV_{1-n} or passes a specific geographical position within the road network 9, the number of vehicles this specific connected vehicle within the subset SV_{1-n} meets until it either meets yet another connected vehicle within the subset SV_{1-n}, passes a specific geographical position within the road network 9 or until a pre-determined time period has passed; and

- estimating 14, using an estimation logic 7 residing in the back end system 6, the total number of vehicles that passes a specific geographical position within the road network 9 in a given direction based on the positions and directions of travel of the connected vehicles within the subset SV_{1-n} and the associated vehicle counts.

[0065] According to some embodiments the estimating 14, in order to estimate the total number of vehicles that passes a specific geographical position within the road network 9, in a given direction, further comprises adding the numbers whenever a connected vehicle within the subset SV_{1-n} passes the specific geographical position within the road network 9. This is done such that the most recently counted number of vehicles ahead of that connected vehicle within the subset SV_{1-n}, either up to the preceding another connected vehicle within the subset SV_{1-n} or the most recently previously passed specific geographical position within the road network 9, is added to the total number of vehicles passing the specific geographical position within the road network 9.

[0066] In yet some further embodiments the estimating further comprises deriving the present traffic density for a specific geographical position within the road network 9 as number of vehicles over time using the delta time since the last connected vehicle within the subset SV_{1-n} passed that specific geographical position within the road network 9. Thus, in such embodiments the method comprises arranging the back end system 6 to keep track of such delta times for one or more geographical positions of interest within the road network 9. This provides a simple and reliable mechanism for deriving a present traffic density for a specific geographical position within the road network 9 as the number of vehicles over time.

[0067] According to yet some further embodiments the method further comprises detecting and keeping track of an event where two connected vehicles within the subset SV_{1-n} meet each other, and whenever this happens either communicating to these connected vehicles within the subset SV_{1-n} a request to report their present counts and subsequently reset their counts to zero and restart their counts, or to the counter 4 in the back end system 6 a request to report its present count and subsequently reset its count to zero and restart its count.

[0068] An example hereof is illustrated in figure 2 by the meeting of two connected vehicles within the subset SV_1 and SV_n. This provides an efficient way of supervising the harvesting of vehicle count data for the traffic intensity estimation.

[0069] In still some further embodiments, where both initiation and termination of the count is triggered by the meeting of two connected vehicles within the subset SV_{1-n}, the estimating further comprises managing the counted vehicles between the connected vehicle within the subset initiating the count SV_2 and the connected vehicle within the subset terminating the count SV_n as a property of the connected vehicle within the subset terminating the count SV_n, the property representing the total number of vehicles between these connected vehicles within the subset SV_{1-n}, including the connected vehicle within the subset terminating the count SV_n. This provides a simple and intuitive way of following the associated vehicle count data as the connected vehicle within the subset terminating the count SV_n travels within the road network 9.

[0070] According to yet some embodiments the method further comprises arranging the estimation logic 7 residing in the back end system 6 to communicate to the connected vehicles within the subset SV_{1-n}, e.g. using an associated wireless communications network, instructions when to determine whenever the vehicle meets another vehicle and when to report data regarding met vehicles.This provides an efficient way of selectively managing the harvesting of vehicle count data for the traffic intensity estimation.

[0071] In still some embodiments the method further comprises arranging the estimation logic 7 residing in the back end system 6 to communicate to the connected vehicles within the subset SV_{1-n}, e.g. using an associated wireless communications network, instructions to selectively activate and deactivate the functionalities to determine whenever the vehicle meets another vehicle and to report data regarding met vehicles of one or more specific connected vehicles within the subset, such that only connected vehicles within the subset close to a geographical position of interest within the road network 9 will perform determining and reporting of data regarding met vehicles. This provides an efficient way of selectively managing the harvesting of vehicle count data relevant to a geographical position of interest within the road network 9 for the traffic intensity estimation.

[0072] It is also envisaged that the vehicle count data be combined with localization data, speed, direction of travel and time information from the involved connected vehicles within the subset, in order to further enhance the estimation provided by the estimation logic 7 of the back end system 6 of the system for estimating traffic

intensity as described herein and in accordance with the method for estimating traffic intensity as described herein.

[0073] Finally, the present disclosure also proposes a connected vehicle SV_1, suitable to form part of a subset of connected vehicles SV_{1-n}, the connected vehicle SV_1 equipped with a positioning system 1 and one or more active safety sensor systems 2a, 2b capable of determining adjacent vehicles travelling in an opposite direction within a road network 9. The connected vehicle SV_1 comprises a vehicle logic 3 arranged to determine, using data from one or more of its respective active safety sensor systems 2a, 2b, whenever the vehicle meets another vehicle. The connected vehicle SV_1 also comprises a communication arrangement 5, arranged to communicate, e. g. using an associated wireless communications network, with a back end system 6 to report a position of the connected vehicle and data regarding met vehicles and to receive instructions from the back end system. The connected vehicle SV_1 further also comprises a counter 4, arranged to count the number of vehicles this specific connected vehicle SV_1 within the subset SV_{1-n} meets when instructed to do so by the back end system6. A connected vehicle SV_1 as described above is able to cost efficiently provide the vehicle count data required for operating a system for estimating traffic intensity according to some embodiments described herein and in accordance with some embodiments of the method for estimating traffic intensity described herein.

[0074] The above-described embodiments may be varied within the scope of the following claims.

[0075] Thus, while there have been shown and described and pointed out fundamental novel features of the embodiments herein, it will be understood that various omissions and substitutions and changes in the form and details of the devices illustrated, and in their operation, may be made by those skilled in the art. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are equivalent. Moreover, it should be recognized that structures and/or elements and/or method steps shown and/or described in connection with any disclosed form or embodiment herein may be incorporated in any other disclosed or described or suggested form or embodiment as a general matter of design choice.

Claims

1. A system for estimating traffic intensity using data from a subset of connected vehicles (SV_{1-n}) equipped with respective positioning systems (1) and one or more respective active safety sensor systems (2a, 2b) capable of determining adjacent vehicles travelling in an opposite direction within a road network (9) a traffic intensity of which is of interest, **characterized in that** each respective vehicle in the subset of connected vehicles (SV_{1-n}) comprises:

   a vehicle logic (3) arranged to determine, using data from one or more of its respective active safety sensor systems (2a, 2b), whenever the vehicle meets another vehicle, and;
   a communication arrangement (5), arranged to communicate with a back end system (6) to report a position of the connected vehicle and data regarding met vehicles and to receive instructions from the back end system (6); and
   the system for estimating traffic intensity further comprising:

      an estimation logic (7) residing in the back end system (6) and arranged to keep track of the positions and directions of travel of the connected vehicles within the subset (SV_{1-n}) and to determine whenever a connected vehicle within the subset (SV_{1-n}) meets another connected vehicle within the subset (SV_{1-n}); and
      a counter (4), in each respective vehicle in the subset of connected vehicles (SV_{1-n}) or in the back end system (6), arranged to count, starting upon determination that a specific connected vehicle within the subset (SV_{1-n}) meets another connected vehicle within the subset (SV_{1-n}) or passes a specific geographical position within the road network (9), the number of vehicles this specific connected vehicle within the subset (SV_{1-n}) meets until it either meets yet another connected vehicle within the subset (SV_{1-n}), passes a specific geographical position within the road network (9) or until a pre-determined time period has passed;
      the estimation logic (7) residing in the back end system (6) further arranged to estimate the total number of vehicles that passes a specific geographical position within the road network (9) in a given direction based on the positions and directions of travel of the connected vehicles within the subset (SV_{1-n}) and the associated vehicle counts.

2. The system according to claim 1, **characterized in that** the estimation logic (7) residing in the back end system (6), in order to estimate the total number of vehicles that passes a specific geographical position within the road network (9), in a given direction, further is arranged to add the numbers whenever a connected vehicle within the subset (SV_{1-n}) passes the specific geographical position within the road network (9), such that the most recently counted number of vehicles ahead of that connected vehicle within the subset (SV_{1-n}), either up to the preceding another

connected vehicle within the subset (SV_{1-n}) or the most recently previously passed specific geographical position within the road network (9), is added to the total number of vehicles passing the specific geographical position within the road network (9).

3. The system according to claim 2, **characterized in that** the estimation logic (7) residing in the back end system (6) further is arranged to derive the present traffic density for a specific geographical position within the road network (9) as number of vehicles over time using the delta time since the last connected vehicle within the subset (SV_{1-n}) passed that specific geographical position within the road network (9).

4. The system according to any one of claims 1 to 3, **characterized in that** the estimation logic (7) residing in the back end system (6) further is arranged to detect and keep track of an event where two connected vehicles within the subset (SV_{1-n}) meet each other, and whenever this happens either communicate to these connected vehicles within the subset (SV_{1-n}) a request to report their present count and subsequently reset their count to zero and restart their count, or to the counter (4) in the back end system (6) a request to report its present count and subsequently reset its count to zero and restart its count.

5. The system according to any one of claims 1 to 4, **characterized in that** the estimation logic (7) residing in the back end system (6) further is arranged to manage the counted vehicles between the connected vehicle within the subset (SV_{1-n}) initiating the count and the connected vehicle within the subset (SV_{1-n}) terminating the count as a property of the connected vehicle within the subset (SV_{1-n}) terminating the count, the property representing the total number of vehicles between these connected vehicles within the subset (SV_{1-n}), including the connected vehicle within the subset (SV_{1-n}) terminating the count.

6. The system according to any one of claims 1 to 5, **characterized in that** the estimation logic (7) residing in the back end system (6) further is arranged to communicate to the connected vehicles within the subset (SV_{1-n}) instructions when to determine whenever the vehicle meets another vehicle and when to report data regarding met vehicles.

7. The system according to any one of claims 1 to 6, **characterized in that** the estimation logic (7) residing in the back end system (6) further is arranged to communicate to the connected vehicles within the subset (SV_{1-n}) instructions to selectively activate and deactivate the functionalities to determine whenever the vehicle meets another vehicle and to report data regarding met vehicles of one or more specific connected vehicles within the subset (SV_{1-n}), such that only connected vehicles within the subset (SV_{1-n}) close to a geographical position of interest within the road network (9) will determine and report data regarding met vehicles.

8. A method for estimating traffic intensity using data from a subset (SV_{1-n}) of connected vehicles equipped with respective positioning systems (1) and one or more respective active safety sensor systems (2a, 2b) capable of determining adjacent vehicles travelling in an opposite direction within a road network (9) a traffic intensity of which is of interest, **characterized in that** it for each respective vehicle in the subset (SV_{1-n}) of connected vehicles comprises:

determining (10), using a vehicle logic and data from one or more of its respective active safety sensor systems (2a, 2b), whenever the vehicle meets another vehicle, and;
reporting (11), using a communication arrangement (5), to a back end system (6), a position of the connected vehicle and data regarding met vehicles and receiving instructions from the back end system (6); and
the method for estimating traffic intensity further comprising:

keeping track (12) of the positions and directions of travel of the connected vehicles within the subset (SV_{1-n}) and determining whenever a connected vehicle within the subset (SV_{1-n}) meets another connected vehicle within the subset (SV_{1-n}) using an estimation logic (7) residing in the back end system (6); and
counting (13), using a counter (4) in each respective vehicle in the subset of connected vehicles (SV_{1-n}) or in the back end system (6), starting upon determination that a specific connected vehicle within the subset (SV_{1-n}) meets another connected vehicle within the subset (SV_{1-n}) or passes a specific geographical position within the road network (9), the number of vehicles this specific connected vehicle within the subset (SV_{1-n}) meets until it either meets yet another connected vehicle within the subset (SV_{1-n}), passes a specific geographical position within the road network (9) or until a pre-determined time period has passed;
estimating (14), using the estimation logic (7) residing in the back end system (6), the total number of vehicles that passes a specific geographical position within the road network (9) in a given direction based on

the positions and directions of travel of the connected vehicles within the subset (SV_{1-n}) and the associated vehicle counts.

9. The method according to claim 8, **characterized in that** the estimating (14), in order to estimate the total number of vehicles that passes a specific geographical position within the road network (9), in a given direction, further comprises adding the numbers whenever a connected vehicle within the subset (SV_{1-n}) passes the specific geographical position within the road network (9), such that the most recently counted number of vehicles ahead of that connected vehicle within the subset (SV_{1-n}) either up to the preceding another connected vehicle within the subset (SV_{1-n}) or the most recently previously passed specific geographical position within the road network (9) is added to the total number of vehicles passing the specific geographical position within the road network (9).

10. The method according to claim 9, **characterized in that** the estimating (14) further comprises deriving the present traffic density for a specific geographical position within the road network (9) as number of vehicles over time using the delta time since the last connected vehicle within the subset (SV_{1-n}) passed that specific geographical position within the road network (9).

11. The method according to any one of claims 8 to 10, **characterized in that** it further comprises detecting and keeping track of an event where two connected vehicles within the subset (SV_{1-n}) meet each other, and whenever this happens either communicating to these connected vehicles within the subset (SV_{1-n}) a request to report their present count and subsequently reset their count to zero and restart their count, or to the counter (4) in the back end system (6) a request to report its present count and subsequently reset its count to zero and restart its count.

12. The method according to any one of claims 8 to 11, **characterized in that** the estimating (14) further comprises managing the counted vehicles between the connected vehicle within the subset (SV_{1-n}) initiating the count and the connected vehicle within the subset (SV_{1-n}) terminating the count as a property of the connected vehicle within the subset (SV_{1-n}) terminating the count, the property representing the total number of vehicles between these connected vehicles within the subset (SV_{1-n}), including the connected vehicle within the subset (SV_{1-n}) terminating the count.

13. The method according to any one of claims 8 to 12, **characterized in that** it further comprises arranging the estimation logic (7) residing in the back end system (6) to communicate to the connected vehicles within the subset (SV_{1-n}) instructions when to determine whenever the vehicle meets another vehicle and when to report data regarding met vehicles.

14. The method according to claim 13, **characterized in that** it further comprises arranging the estimation logic (7) residing in the back end system (6) to communicate to the connected vehicles within the subset (SV_{1-n}) instructions to selectively activate and deactivate the functionalities to determine whenever the vehicle meets another vehicle and to report data regarding met vehicles of one or more specific connected vehicles within the subset (SV_{1-n}), such that only connected vehicles within the subset (SV_{1-n}) close to a geographical position of interest within the road network (9) will perform determining and reporting (11) of data regarding met vehicles.

15. A connected vehicle (SV_1), suitable to form part of a subset (SV_{1-n}) of connected vehicles, the connected vehicle (SV_1) equipped with a positioning system (1) and one or more active safety sensor systems (2a, 2b) capable of determining adjacent vehicles travelling in an opposite direction within a road network (9), **characterized in that** it comprises:

a vehicle logic (3) arranged to determine, using data from one or more of its respective active safety sensor systems (2a, 2b), whenever the vehicle meets another vehicle, and;
a communication arrangement (5), arranged to communicate with a back end system (6) to report a position of the connected vehicle and data regarding met vehicles and to receive instructions from the back end system; and
a counter (4), arranged to count the number of vehicles this specific connected vehicle within the subset (SV_{1-n}) meets when instructed to do so by the back end system.

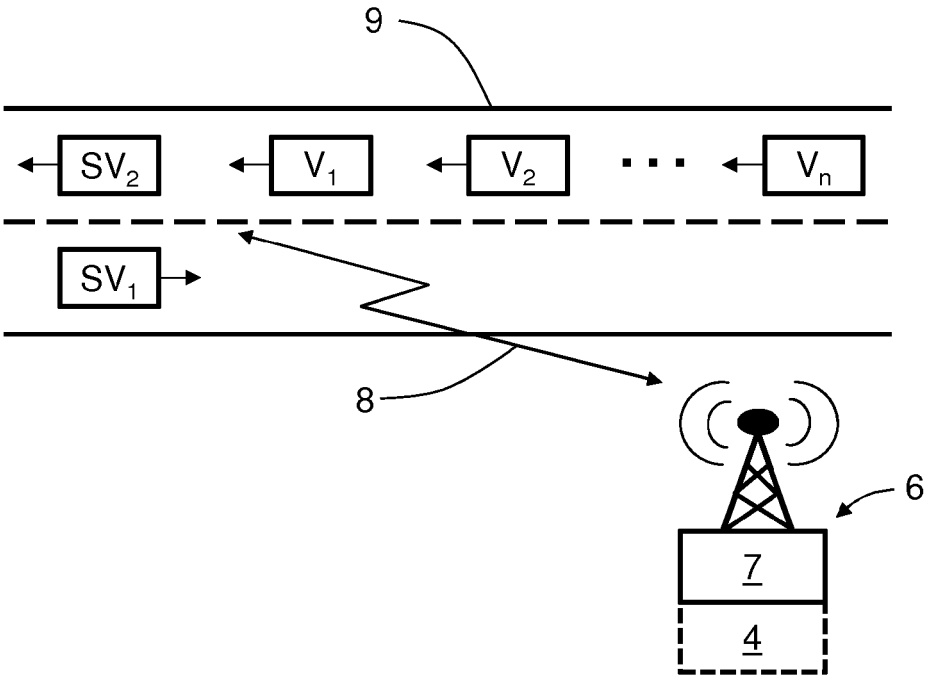

Fig. 1

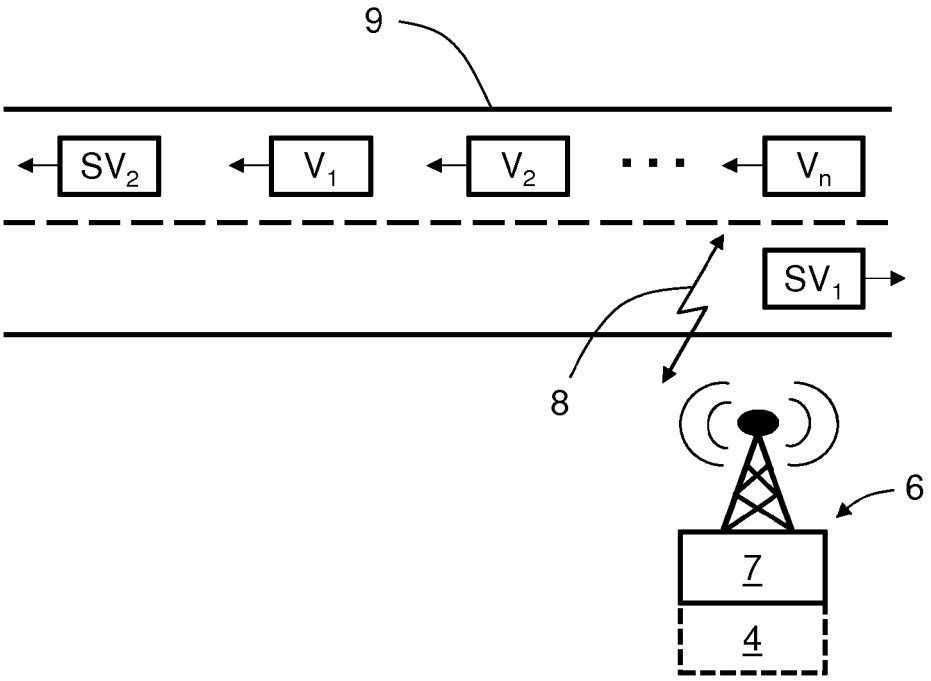

Fig. 2

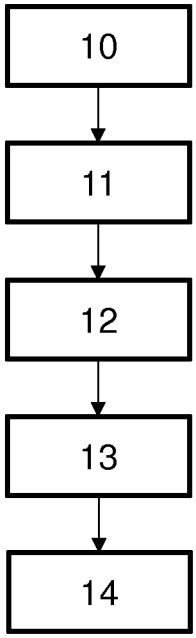

Fig. 3

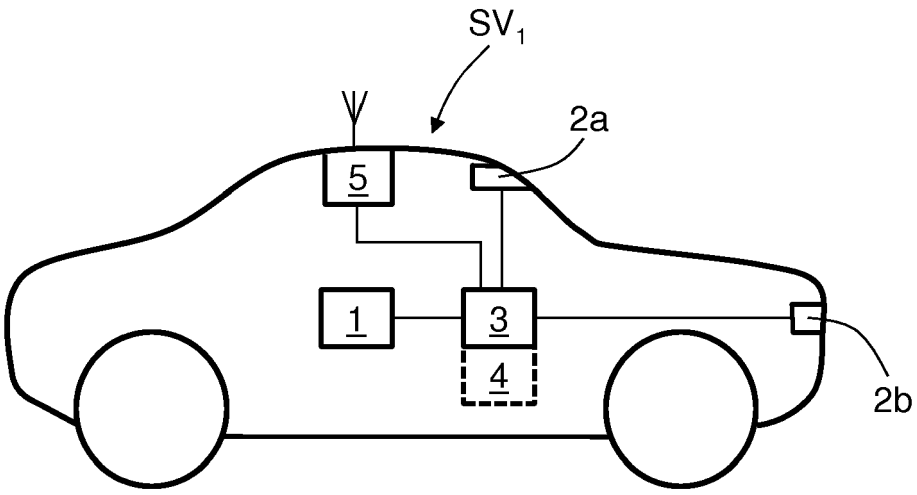

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 15 19 4409

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	WO 01/09857 A1 (HAIWOOL CO LTD [KR]; LEE HEUNG SOO [KR]) 8 February 2001 (2001-02-08) * page 2, lines 12-14 * * page 3, lines 4-20 * * page 4, lines 1,2 * * page 10, lines 7-12 * * page 10, line 17 - page 11, line 9 * * page 12, lines 8-14 * * page 15, lines 1,2; figure 7 * * page 17, line 9 - page 18, line 19; figure 8 * * page 24, lines 14-19; figure 13a * * page 25 - page 5, line 17; figure 13b *	1-3, 8-10,15 4-7, 11-14	INV. G08G1/01 G08G1/065
X A	EP 2 881 924 A1 (KUHN ANDREAS [AT]; KUHN BIRGIT MAG [AT]) 10 June 2015 (2015-06-10) * paragraphs [0005], [0007], [0019], [0020], [0022] - [0027], [0029] - [0032], [0034], [0037], [0043] *	1-3, 8-10,15 4-7, 11-14	
A	US 2013/162445 A1 (BESSLER SANDFORD [AT] ET AL) 27 June 2013 (2013-06-27) * paragraphs [0001], [0005], [0007] - [0011], [0027], [0040] - [0044], [0057]; figure 1 *	1-15	TECHNICAL FIELDS SEARCHED (IPC) G08G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	11 May 2016	Fagundes-Peters, D

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 19 4409

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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11-05-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0109857 A1	08-02-2001	AU 6187100 A	19-02-2001
		KR 20010016712 A	05-03-2001
		WO 0109857 A1	08-02-2001
EP 2881924 A1	10-06-2015	AT 515188 A1	15-06-2015
		EP 2881924 A1	10-06-2015
US 2013162445 A1	27-06-2013	CA 2794990 A1	27-06-2013
		EP 2610815 A1	03-07-2013
		ES 2540866 T3	14-07-2015
		US 2013162445 A1	27-06-2013

EPO FORM P0459

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