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(54) **System for determining the lane of travel of vehicles along a stretch of road with multiple lanes**

(57) Described herein is a system (1) for determining the lane of travel (4, 6) of a vehicle (3, 5) along a stretch of road (2) with a number of lanes, comprising electronic processing means (7, 8), which can be installed along the stretch of road (2) and are configured for transmitting search radio signals to the stretch of road (2), and electronic processing means (9) installed on board the vehicle

(3, 5), configured for receiving the radio signals and for transmitting radio signals of response to the first electronic processing means (7, 8); said system being characterized in that the first electronic processing means are configured for detecting the transit of said vehicle along the stretch of road (2) and for determining the lane of travel (4, 6) of the vehicle (3, 5) on the basis of the analysis of the radio signals of response.

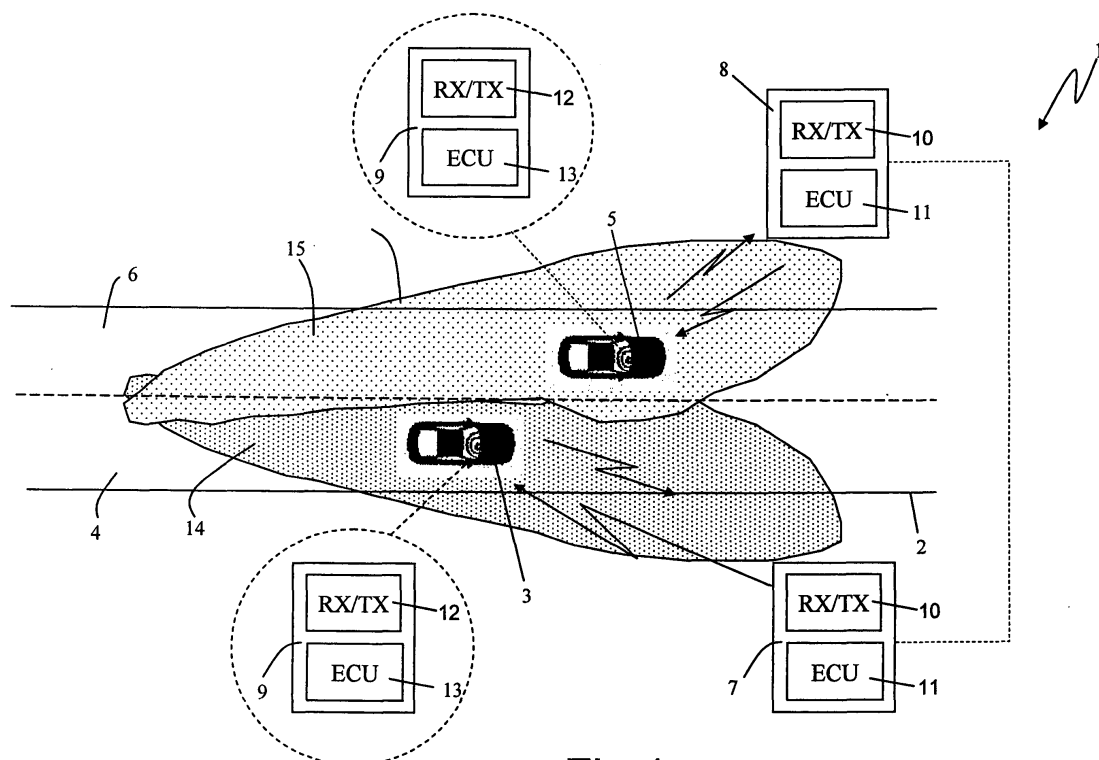


Fig.1

EP 1 850 302 A1

Description

[0001] The present invention relates in general to the monitoring of the transit of vehicles along a stretch of road, and more in particular to the determination of the lane of travel of vehicles along a stretch of road with a number of lanes, to which the ensuing treatment will make explicit reference without this implying any loss in generality.

[0002] For monitoring the transit of vehicles along a stretch of road, for example along preferential lanes of urban roads or motorways, it is known to use systems based upon video cameras that transmit the images acquired to a remote operating centre, where they undergo processing, for example in order to determine the conditions of practicability of the stretch of road or possible infractions of the highway code, or more simply in order to determine the number of vehicles that have travelled along the stretch in a given time range, etc.

[0003] The efficiency of said systems is, however, strictly linked to the quality of the images acquired, which, as is known, depends, among other things, upon the degree of visibility and external light and can thus be markedly jeopardized by external factors such as, for example, dark, fog, snow or dirt deposited on the optics of the video cameras.

[0004] To solve this type of problem systems have been developed based upon infrared telecameras that enable filming even in absence of light and in conditions of poor visibility, which present, however, the disadvantage of being particularly costly.

[0005] The aim of the present invention is to provide a system and a method for monitoring the transit of vehicles along a stretch of road, and more in particular for determination of the lane of travel of vehicles along a stretch of road with a number of lanes, which will operate in a reliable way, irrespective of the lighting and environmental conditions.

[0006] Provided according to the present invention is a system and a method for monitoring the transit of vehicles along a stretch of road, and more in particular for determination of the lane of travel of vehicles along a stretch of road with a number of lanes, as defined in the annexed claims.

[0007] For a better understanding of the present invention, a preferred embodiment thereof is now described, purely by way of non-limiting example, with reference to the attached plate of drawings, wherein:

- Figure 1 shows, in a schematic way, a first embodiment of the present invention; and
- Figure 2 shows, once again in a schematic way, a second embodiment of the present invention.

[0008] Designated as a whole by 1 in Figure 1 is a system for monitoring the transit of vehicles along a stretch of road 2 provided according to the present invention.

[0009] By way of non-limiting example, Figure 1 illustrates a stretch of road 2 constituted by a stretch of a carriageway with two lanes of a motorway, in which a first vehicle 3 is travelling along the right-hand lane 4 (normal transit) and a second vehicle 5 is travelling along the left-hand lane 6 (for overtaking).

The monitoring system 1 comprises, for each stretch of road to be monitored a first fixed detection station 7 and a second fixed detection station 8, set, respectively, along the right-hand lane 4 and the left-hand lane 6, and an electronic device 9, which is mounted on board the vehicles 3 and 5 that are travelling along the stretch of road 2 and is designed to receive radio signals coming from the fixed detection stations 7 and 8 as well as to transmit radio signals to the latter.

[0010] As illustrated in Figure 1, the fixed detection stations 7 and 8 both comprise a transceiver unit 10 and a processing unit 11 connected to the transceiver unit 10.

[0011] In particular, the transceiver unit 10 of the station 7 is designed to transmit radio signals to the right-hand lane 4 of the stretch of road 2 and to receive prevalently, but not exclusively, radio signals coming from the electronic devices 9 of vehicles that are travelling along the right-hand lane 4, for example the vehicle 3 illustrated in Figure 1, whilst the transceiver unit 10 of the station 8 is designed to transmit radio signals to the left-hand lane 6 and to receive radio signals coming prevalently, but not exclusively, from the electronic devices 9 of vehicles that are travelling along the left-hand lane 6, such as, for example, the vehicle 5.

[0012] The processing units 11 are, instead, designed to manage the operativeness of the fixed detection stations 7 and 8 and to determine, respectively, the lane on which the vehicles 3 and 5 are travelling.

[0013] The electronic device 9 of the vehicles 3 and 5, as shown in the enlargement within the dashed circle of Figure 1, comprises:

- a transceiver unit 12 designed to receive the radio signals coming from the fixed detection stations 7 and 8 and to transmit, in response to said signals, radio signals to the stations 7 and 8; and
- an electronic processing unit 13, connected to the transceiver unit 12 and designed to manage the operativeness of the electronic device 9.

[0014] According to the embodiment illustrated in Figure 1, the detection station 7 continuously transmits a directional signal having given spectral characteristics, namely, known transmitted power P_t (for example 2 W), given frequency f_q , and pre-set digital mode of modulation (for example FSK, GFSK, etc.), such as to create a range of reception 14 that covers the entire width of the right-hand lane 4 and at least part of the left-hand lane 6, and awaits reception of signals of response coming from vehicles that are travelling prevalently on the right-hand lane 4 and that traverse the range of reception 14.

[0015] In a similar way, the detection station 8 contin-

uously transmits a directional signal having given spectral characteristics, namely, known transmitted power P_t (for example 2 W), a given frequency f_q , and a pre-set digital mode of modulation (for example FSK, GFSK, etc.), such as to create a range of reception 15 that covers the entire width of the left-hand lane 6 and at least part of the right-hand lane 4, and awaits reception of signals of response coming prevalently from vehicles that are travelling along the left-hand lane 6 and that traverse the range of reception 15.

[0016] In particular, when the vehicle 3 is travelling on the right-hand lane 4 and traverses exclusively the range of reception 14 it receives, via the transceiver unit 12 of the electronic device 9, the signal transmitted by the station 7 and sends a radio signal of response, which also has given spectral characteristics, i.e., known transmitted power P_t (for example 2 W), pre-set frequency f_q , and pre-set digital mode of modulation, which is received by the station 7 and on the basis of which the station 7 determines the lane 4 as the one along which the vehicle 3 is travelling.

[0017] Likewise, when the vehicle 5 is travelling on the left-hand lane 6 and traverses exclusively the range of reception 15, it receives, via the transceiver unit 12 of the electronic device 9, the signal transmitted by the station 8 and sends a radio signal of response, which also has given spectral characteristics i.e., known transmitted power P_t (for example 2 W), pre-set frequency f_q , and pre-set digital mode of modulation, which is received by the station 8 and on the basis of which the station 8 determines the left-hand lane 6 as the one along which the vehicle 5 is travelling.

[0018] Determination of the lanes of travel of the vehicles 3 and 5 by the stations 7 and 8 can occur, for example, by measuring in a way in itself known the time of response of the signals sent by the devices 9 of the vehicles 3 and 5, i.e., the time that said signals take to reach, respectively, the stations 7 and 8, or else by measuring the power of the signals sent by the vehicles 3 and 5 and comparing said measured values with one or more pre-set threshold values that indicate whether the vehicle is travelling on the right-hand lane 4 or on the left-hand one 6.

[0019] In the case where a vehicle is covering the portion of the stretch of road 2 in which the ranges of reception 14 and 15 are superimposed and sends a signal of response that is received by both of the stations 7 and 8, in order to make the correct determination of the lane of travel of the vehicle, each station 7 and 8 compares the value of the signal received thereby with a minimum threshold value indicating the fact that the vehicle is travelling on its own lane and, in the case where the signal detected is below said threshold value, no determination of the lane of travel of the vehicle is made.

[0020] According to a particular embodiment of the invention, once again with reference to Figure 1, the stations 7 and 8 could also be configured to communicate with one another, for example via a wired or radio con-

nection, as illustrated by the dashed line of Figure 1.

[0021] In this particular embodiment, the procedure for determination of the lane of travel of the vehicles that are travelling along the stretch of road 2 could be implemented either exclusively by just one of the two stations 7 or 8, or else by one of the two stations 7 or 8 on the basis of a pre-defined criterion of selection of the station.

[0022] In the first case, one of the two stations, for example the station 8, could be configured for receiving the signals coming from the vehicles that are travelling along the left-hand lane 6 and for transmitting said signals to the station 7, which could instead be configured for receiving the signals coming from the vehicles that are travelling along the right-hand lane 4, for receiving the signals coming from the station 8, and for determining the lane of travel of all the vehicles that are travelling along the stretch of road 2, on the basis of all the signals received.

[0023] In the second case, instead, the system 1 could be configured in such a way that, whenever one of the two stations 7, 8 or both of the stations 7 and 8 receive signals coming from the vehicles that are travelling along the stretch of road 2, each station transmits to the other station the information contained in the signals received, on the basis of which the two stations 7 and 8 start a procedure of selection of the station that is to determine the lane on which the vehicles are travelling along the stretch of road 2.

[0024] In particular, the selection of the station that is to determine the lane of travel of the vehicles can occur, for example, on the basis of the number of vehicles that each of the two stations 7 and 8 is currently handling, or on the basis of a comparison between the powers and/or the times of flight of the signals transmitted by the devices 9 of the vehicles and received by the stations 7 and 8.

[0025] In the case of heavy traffic, for example if the station 7 is currently determining the lane of travel of a large number of vehicles, e.g., fifty, whilst the station 8 is determining the lane of travel of a smaller number of vehicles, e.g., ten, it could be useful to delegate to the station 8 the task of determining the lane of travel of the remaining vehicles that traverse the stretch of road 2, irrespective of whether they are travelling on the right-hand lane 4 or on the left-hand one 6, until the number of vehicles handled by the station 7 decreases sensibly, so as not to overload the station 7.

[0026] In the second case, instead, the system 1 can be configured in such a way that both of the stations 7 and 8 compare the values of the power of the signals received by them with the values of the power of the signals received by the other station, and on the basis of said comparison the station that has measured the values of power that are more precise with respect to the pre-set threshold values decides automatically to start the procedure for determining the lane of travel of the vehicles.

[0027] Furthermore, in order to guarantee a correct determination of the lane of travel of the vehicles, the system 1 is configured in such a way that the procedure for de-

termining the lane is repeated a certain number of times, for example five times, or else is repeated cyclically starting from when the vehicles enter the ranges of reception 14 and 15 and transmit for the first time a signal of response until they pass beyond the detection stations 7 and 8.

[0028] The embodiment of the system 1 of the invention illustrated in Figure 2 envisages, instead, the use of just one fixed detection station located along one of the two lanes that make up the carriageway of the stretch of road 2, for example the station 7 located along the right-hand lane 4, configured for transmitting continuously a directional signal having given spectral characteristics, namely, the known transmitted power P_t (for example 2 W), the given frequency f_q , and the pre-set digital mode of modulation (for example FSK, GFSK, etc.), such as to create a range of reception 16 that covers the entire width of the right-hand lane 4 and the entire width of the left-hand lane 6 for receiving signals of response coming from vehicles that are travelling along the stretch of road 2 traversing the range of reception 16, on the basis of which the station 7 determines the lane of travel of the vehicles that traverse the stretch of road 2.

[0029] In particular, also in this embodiment, determination of the lane of travel of the vehicles that traverse the stretch of road 2 occurs in a manner similar to the embodiment previously described and illustrated in Figure 1, i.e., by measuring also in this case (in a way in itself known) the time of response of the signals sent by the devices 9 of the vehicles 3 and 5 to reach the station 7 or else by measuring the power of the signals sent by the vehicles 3 and 5 and comparing said measured values with one or more pre-set threshold values indicating the fact that a vehicle is travelling on the right-hand lane 4 or on the left-hand one 6.

[0030] The system and the method described can be used, for example, to provide an automatic system of payment of the road toll without envisaging barriers or toll booths or for monitoring the intensity of the traffic present on each lane of a road.

[0031] In the first case, the earth stations 7 and 8 could be installed along a given toll point corresponding to an area and/or to a stretch of road subject to payment and could be configured for detecting the passage of a vehicle, detecting a code identifying the vehicle itself transmitted by the on-board device 9, determining the lane on which it is travelling and the total cost of the tolls to be charged to the user of the vehicle, and communicating to the on-board device 9 of the vehicle, during passage of the vehicle in a position corresponding to the detection station and hence to the toll point, a set of information regarding payment of the toll itself.

[0032] For this purpose, at least one of the two detection stations, for example the station 7, should be provided with a data base stored within the electronic processing unit 11, containing a plurality of information data such as, for example, a code identifying the vehicle 3, a number of credit card from which to withdraw the sum

expected for the toll or a pre-paid credit from which to deduct the sum corresponding to the toll.

[0033] A payment system of the toll provided according to the teachings of the invention could, for example, envisage, differentiated tariffs according to the lane on which the vehicles have travelled as far as the detection station, for example a high tariff for those vehicles that are travelling on the left-hand lane 6 and a lower one for the ones that are travelling on the normal right-hand lane 4.

[0034] Furthermore, in this embodiment, the on-board device 9 could be configured for generating an acoustic and/or visual warning signal that indicates to the user of the vehicle a condition of approach to a toll point associated to an area and/or to a stretch of road subject to payment, delimited by the detection stations.

[0035] In addition, both in the first embodiment and in the second embodiment of the system 1, all the detection stations, or at least one of them, could be configured to communicate with a remote operating centre (not illustrated in the figure) configured, for example, for managing the operations of payment of the toll or for monitoring the conditions of practicability of the individual lanes of a motorway.

[0036] The advantage of the system and of the method of the invention are a low infrastructural impact, and the economic advantages and reliability that derive from the use of a technology, operation of which does not depend upon climatic conditions or conditions of visibility.

[0037] Finally, it is clear that modifications and variations can be made to the system and to the method described and illustrated herein, without thereby departing from the sphere of protection of the present invention, as defined in the annexed claims.

Claims

1. A system (1) for determining the lane of travel (4, 6) of a vehicle (3, 5) along a stretch of road (2) with a number of lanes, comprising:

- first electronic processing means (7, 8), which can be installed along said stretch of road (2) and are configured for transmitting search radio signals to said stretch of road (2); and
- second electronic processing means (9) installed on board said vehicle (3, 5), designed to receive said radio signals and to transmit radio signals of response to said first electronic processing means (7, 8);

said system being **characterized in that** said first electronic processing means are configured for detecting the transit of said vehicle along said stretch of road (2) and for determining the lane of travel (4, 6) of said vehicle (3, 5) on the basis of the analysis of said radio signals of response.

2. The system according to Claim 1, in which said second electronic processing means are configured for determining the lane of travel (4, 6) of said vehicle (3, 5) on the basis of one of the following parameters characteristic of said signal of response comprised between the power and the time that said signal of response takes to reach said first electronic processing means (7, 8). 5
3. The system (1) according to Claim 2, in which said first electronic means comprise: 10
 - a first fixed electronic unit (7), which can be installed along a first lane (4) and is configured for determining the transit of said vehicle (3) on said first lane (4) on the basis of the analysis of said radio signals of response; and 15
 - a second fixed electronic unit (8), which can be installed along a second lane (6) and is configured for determining the transit of said vehicle (5) on said second lane (6) on the basis of the analysis of said radio signals of response. 20
4. The system (1) according to Claim 3, in which said first fixed electronic unit (7) is configured for transmitting search radio signals that cover an area of reception that extends over an area that comprises at least one portion of said first lane (4), and said second fixed electronic unit (8) is configured for transmitting search radio signals that cover an area of reception that extends over an area that comprises at least one portion of said second lane (6); said first fixed electronic unit (7) being configured for receiving and processing radio signals of response coming from vehicles that are travelling along said first lane, and said second fixed electronic unit (8) being configured for receiving and processing radio signals of response coming from vehicles that are travelling along said second lane. 25 30 35 40
5. The system according to Claim 3 or Claim 4, comprising means of interconnection and data exchange between said first unit and said second unit for exchanging data detected by the respective units and performing operations of data comparison. 45
6. The system (1) according to Claim 5, in which said operations of data comparison comprise the comparison of parameters characteristic of said radio signals of response detected by said respective first and second units with respective threshold values of said characteristic parameters. 50
7. The system (1) according to Claim 6, in which just one fixed electronic unit carries out said operations of control. 55
8. The system (1) according to Claim 6, in which said operations of comparison are both made by said first and second fixed electronic units.
9. The system according to Claim 1, in which said first electronic processing means (7, 8) continuously transmit said search radio signals.
10. The system according to Claim 1, in which said first electronic processing means (7, 8) transmit a search radio signal having pre-set power, frequency and mode of modulation.

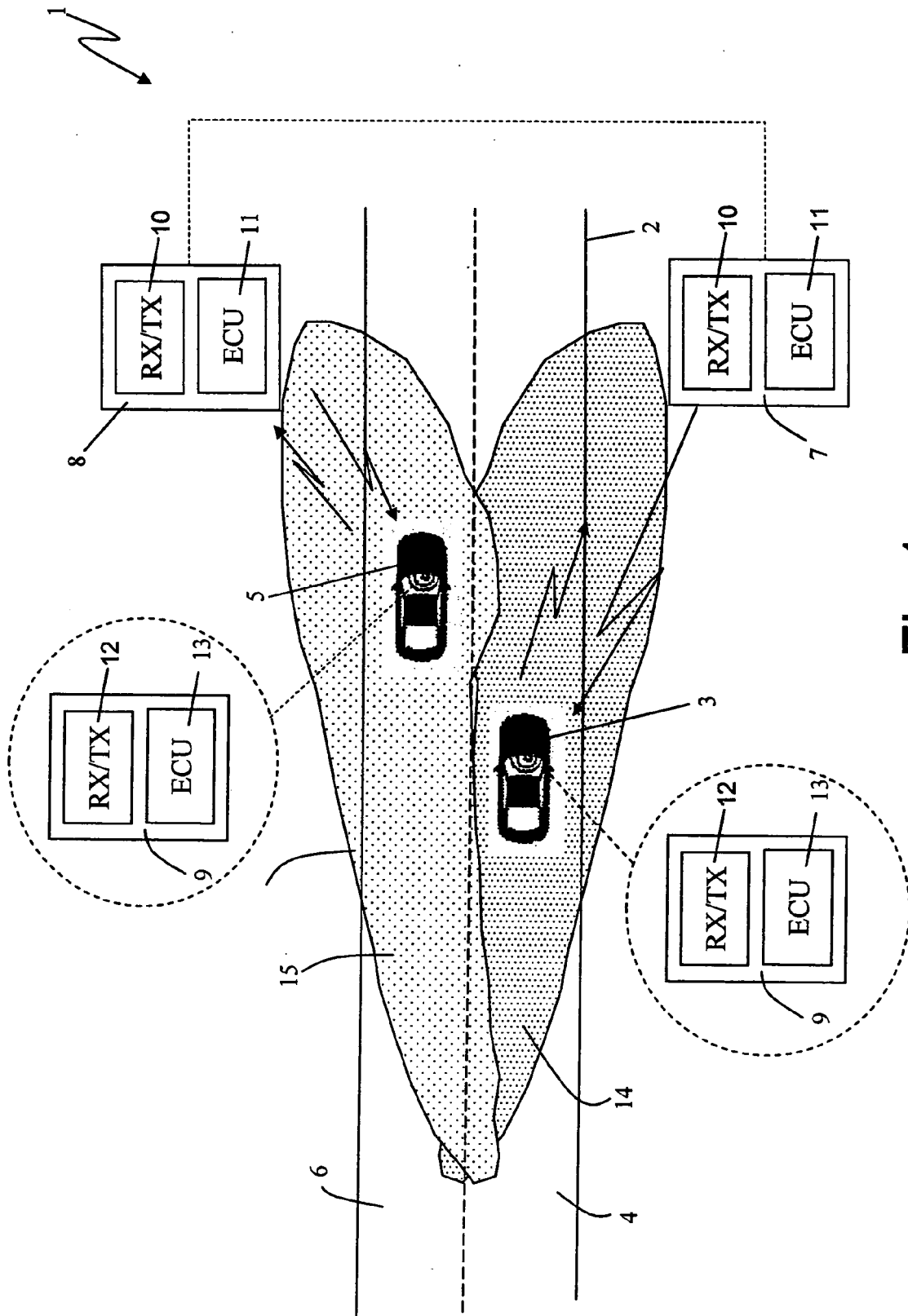


Fig. 1

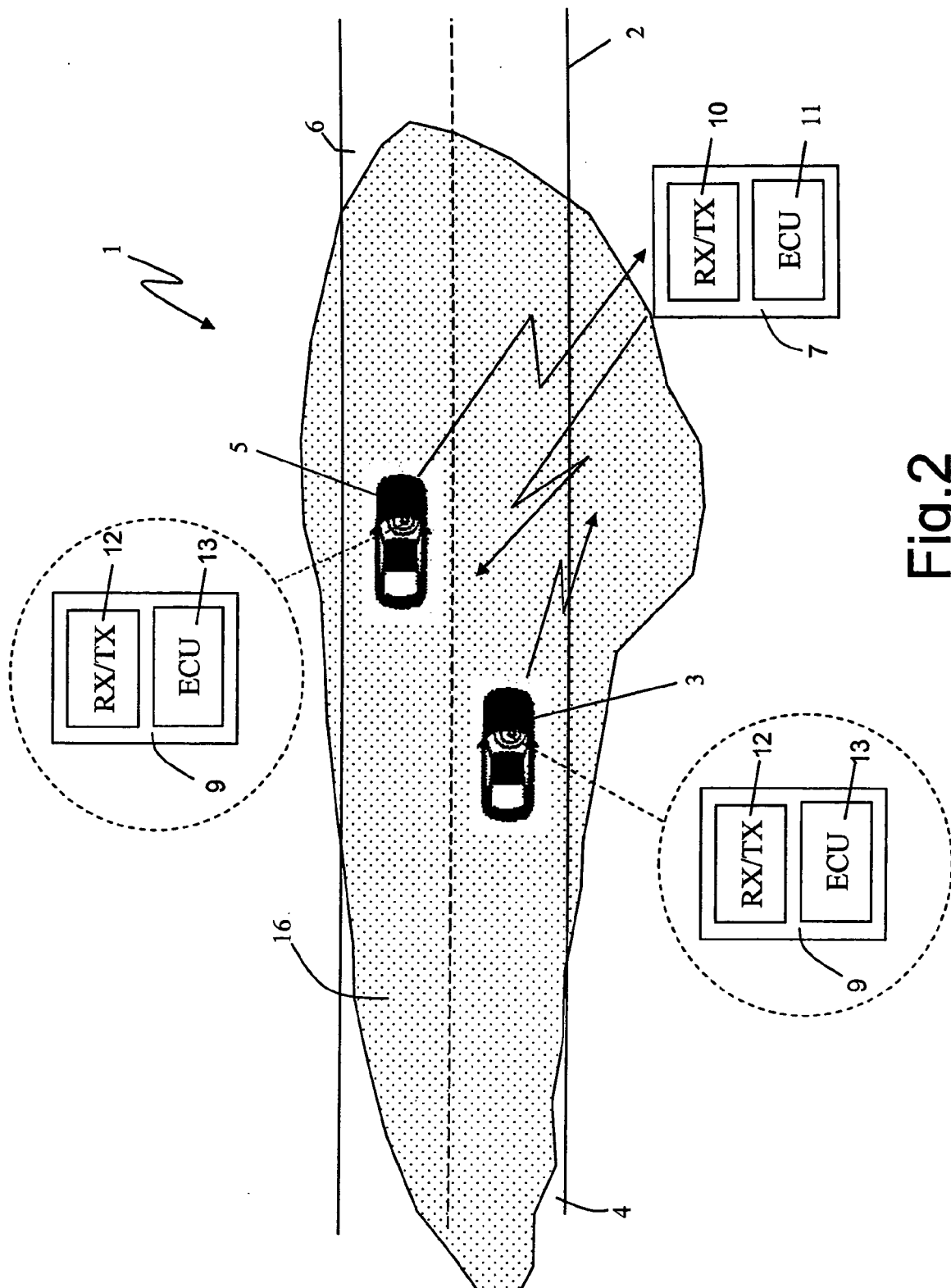


Fig.2



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 42 5284

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 September 2006	Examiner Seisdodos, Marta
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

2
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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 06 42 5284

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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21-09-2006

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