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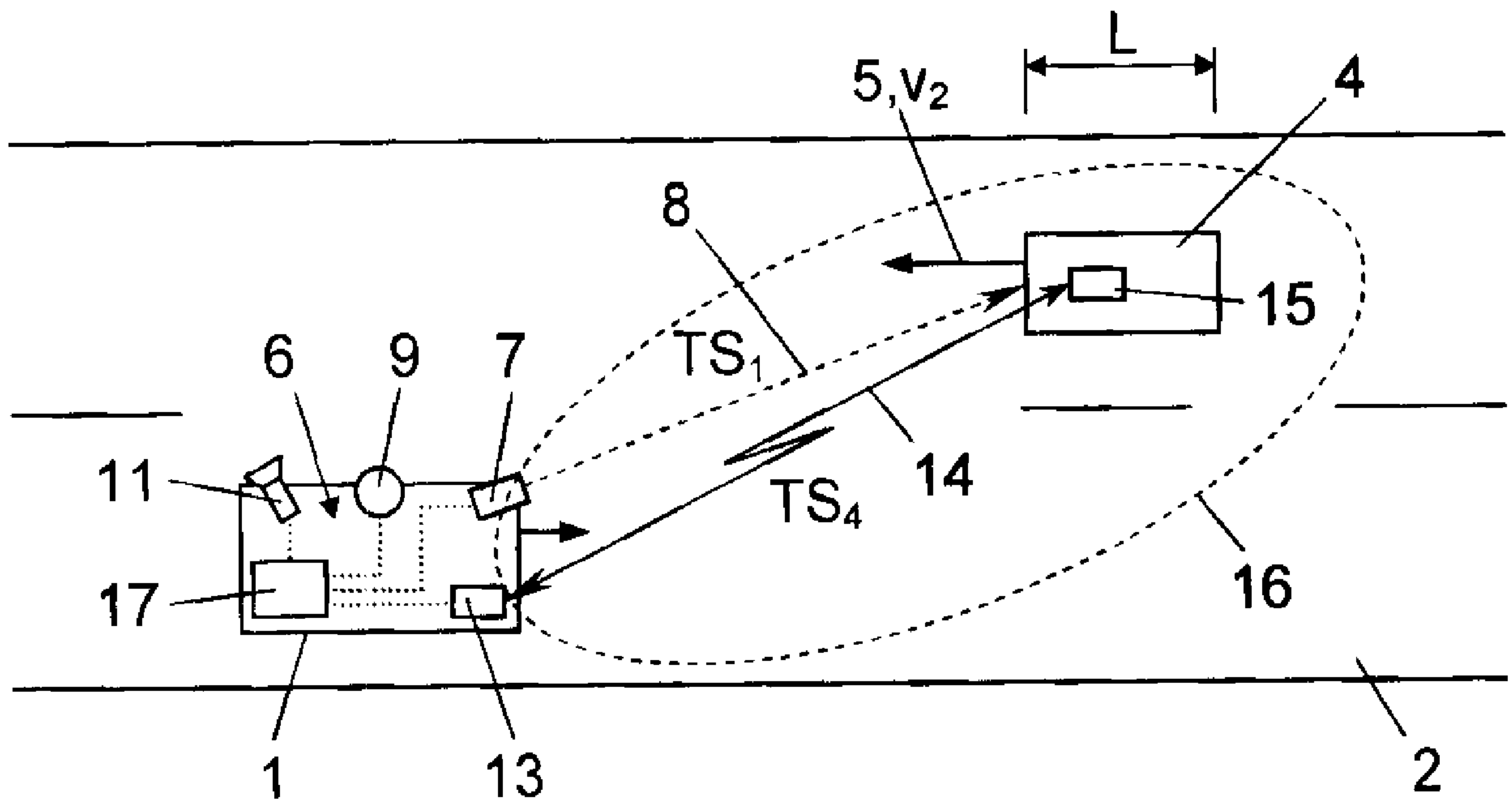
(54) **Titre : DISPOSITIFS ET PROCEDES DE SURVEILLANCE MOBILES POUR DES VEHICULES**
(54) **Title: MOBILE MONITORING DEVICES AND METHODS FOR VEHICLES**



(57) **Abrégé/Abstract:**
A method and a mobile monitoring device for monitoring vehicles, with a sensor for measuring the speed of vehicles passing through a first detection range, said sensor providing the speed measurement value (v_r) with a time stamp (TS1); a sensor for at least indirectly measuring the geometry of vehicles passing through a second detection range, said sensor providing the geometry measurement value (L) with a time stamp (TS_2); a camera for recording images (B) of vehicles passing through a third detection range, said camera providing each image (B) with a time stamp (TS_3); and an evaluation device connected to the camera and the said sensors, which calculates from the speed measurement value (171), time stamp (TS_1) and first detection range and also from the geometry measurement value (L), time stamp (TS_2) and second detection range, the place and time in or at which a passage of a vehicle is to be expected in the third detection range in order to determine the matching image (B) on the basis of its time stamp (TS_3) and third detection range therefrom.

Abstract

A method and a mobile monitoring device for monitoring vehicles, with a sensor for measuring the speed of vehicles passing through a first detection range, said sensor providing the speed measurement value (v_r) with a time stamp (TS_1); a sensor for at least indirectly measuring the geometry of vehicles passing through a second detection range, said sensor providing the geometry measurement value (L) with a time stamp (TS_2); a camera for recording images (B) of vehicles passing through a third detection range, said camera providing each image (B) with a time stamp (TS_3); and an evaluation device connected to the camera and the said sensors, which calculates from the speed measurement value (v_r), time stamp (TS_1) and first detection range and also from the geometry measurement value (L), time stamp (TS_2) and second detection range, the place and time in or at which a passage of a vehicle is to be expected in the third detection range in order to determine the matching image (B) on the basis of its time stamp (TS_3) and third detection range therefrom.

Mobile Monitoring Devices and Methods for Vehicles

The present invention relates to a mobile monitoring device for monitoring vehicles. The invention additionally relates to a method for such monitoring.

In the case of vehicle monitoring speed measurement values are often combined with recorded images of a vehicle so that this can be clearly identified for enforcement of traffic violations. If such monitoring operations are conducted from a mobile moving monitoring platform, this currently requires complex manual matching of the speed measurement values to the recorded images and vice versa, since the detection ranges of usual speed measurement sensors and image recording cameras never overlap precisely. Because of this and in view of the constantly changing relative speeds in flowing traffic, ambiguities can result between different recorded images and speed measurement values that make an absolute match impossible.

The set aim of the invention is to provide mobile monitoring devices and methods, which substantially enable vehicles to be monitored in an automated manner in flowing traffic, i.e. both with moving monitoring platforms and moving vehicles to be monitored.

This aim is achieved in a first aspect of the invention with a mobile monitoring device with
a sensor for measuring the speed of vehicles passing through a first detection range, said sensor providing the speed measurement value of a passage of a vehicle with a time stamp;
a sensor for at least indirectly measuring the geometry, preferably measuring the length, of vehicles passing through a second detection range, said sensor providing the geometry measurement value of a passage of a vehicle with a time stamp;
a camera for recording images of vehicles passing through a third detection range, said camera providing the image of each passage of a vehicle with a time stamp; and
an evaluation device connected to the camera and the said sensors, which is configured for calculating from the speed measurement value, its time stamp and the first detection range and also from the geometry measurement value, its time stamp and the second detection range, the place and time at which a passage of a vehicle is to be expected in the third detection range in order to determine the matching image on the basis of its time stamp and third detection range therefrom.

In a second aspect the invention achieves its aims with a method for monitoring vehicles, with the following steps in any desired sequence:
measuring the speed of a vehicle passing through a first detection range and providing the speed measurement value with a time stamp;
at least indirectly measuring the geometry, preferably the length, of a vehicle passing through a second detection range and providing the geometry measurement value with a time stamp;
recording images of vehicles passing through a third detection range and providing each image with a time stamp;
additionally with the subsequent steps:
calculating from the speed measurement value, its time stamp and the first detection range and also from the geometry measurement value, its time stamp and the second detection range, the place and time at which a passage of a vehicle is to be expected in the third detection range, and
determining the matching image on the basis of its time stamp and third detection range therefrom.

The invention takes into account the different detection ranges, which the individual sensors and cameras of a mobile monitoring device have, and calculates expected values for the movements of the monitored vehicle within the detection ranges, so that vehicle images recorded in one detection range can be automatically linked with speed measurement values originating from a different detection range therefrom.

The term "detection range" used here covers every segment of surrounding area that can be covered by means of sensors or cameras from the current location of the mobile monitoring device, whether this is a conical, pyramid-shaped, prismatic, linear, plane etc. segment of area or the like.

The calculation can also be conducted as post-processing, i.e. the detection ranges or time stamps can also be assigned after all individual measurements have been conducted and stored.

The use of further sensors, the sensor data of which are matched to the respective passing vehicle by the described method, is also conceivable in principle: exhaust gas sensors, sound volume sensors, temperature sensors for tyre or brake inspection, video sensors for tyre inspection, hazardous transport load markings, badges, stickers etc.

All images mentioned here can also each be a component of a video sequence.

A particularly preferred embodiment of the invention that serves to monitor vehicles equipped with DSRC OBUs (dedicated short-range communication onboard units), such as those used as part of DSRC road toll systems, for example, is distinguished by a DSRC transceiver for DSRC communication with DSRC OBUs of vehicles passing through a fourth detection range, said DSRC transceiver providing the DSRC communication of each passage of a vehicle with a time stamp, wherein the evaluation device is additionally configured to determine the matching DSRC communication to the determined image on the basis of its time stamp and fourth detection range.

The corresponding preferred embodiment of the method according to the invention is distinguished by the additional steps of conducting DSRC communications with the DSRC OBUs of vehicles passing through a fourth detection range and providing each DSRC communication with a time stamp; and determining the matching DSRC communication to the determined image on the basis of its time stamp and fourth detection range.

DSRC OBUs are used in DSRC road toll systems to conduct DSRC communications with roadside radio beacons (roadside equipment, RSE). The DSRC communications ultimately end in toll transactions in the road toll system. Mobile monitoring platforms are also used for monitoring vehicles with DSRC OBUs and these interrogate the DSRC OBUs of the vehicles in flowing traffic to retrieve data therefrom for monitoring of the toll transactions generated in the road toll system, or simply to check the presence of a operable DSRC OBU in a vehicle. This type of monitoring poses the additional problem that the transmit-receive ranges of the DSRC transceiver of the mobile monitoring device and the DSRC OBU of the monitored vehicle in its overlap range necessary for the radio communication form a detection range that can differ greatly from the detection ranges of the other sensors and cameras of the mobile monitoring device. This now results in a problem of matching between the DSRC radio communications, on the one hand, and the images recorded for enforcement purposes, on the other. The invention solves this problem by calculating expected values for the time and place when or where a vehicle, with which a DSRC communication has been conducted, is in the detection range of the camera to enable a clear match of an image to a DSRC communication.

It is understood that in this embodiment the determination of the speed measurement value is possibly only an interim result on the way to matching the DSRC communications to the images, i.e. does not represent an output signal or result of the monitoring device or monitoring method itself, but merely serves to calculate the said expected values and thus match the DSRC communications to the images.

The speed of the vehicles can in fact be measured on any manner known in the art. According to a first preferred embodiment of the invention that is intended for the DSRC systems, the speed is measured using the DSRC transceiver of the mobile monitoring device itself, that is preferably by Doppler measurement of the DSRC communications, i.e. evaluation of the relative speed-based Doppler effect that occurs in the radio communication. Accordingly, in this embodiment the first and the fourth detections areas are the same, because the speed measurement sensor is formed by the DSRC transceiver itself. Installation of a separate speed measurement sensor becomes unnecessary as a result of this embodiment.

In an alternative preferred embodiment also suitable for vehicles that are not equipped with DSRC OBUs, the speed is measured with a laser scanner from the mobile monitoring device, or by evaluating two consecutive images of a camera.

A geometry, e.g. the number of axles, length or height of a passing vehicle, can preferably also be detected with such a laser scanner. For example, the laser scanner can transmit a scanning beam onto the vehicle in a plane located normal to or on an angle to the direction of travel. From a number of axles or vehicle height detected in such a manner, for example, an associated geometry, e.g. the length, of the vehicle can be determined on the basis of a table of number of axles or vehicle heights and vehicle geometries typically associated therewith. Alternatively, the geometry measurement sensor can be formed by the DSRC transceiver, which receives vehicle data from the DSRC OBU as part of a DSRC communication, from which data it calculates a geometry, preferably the length, of the vehicle, in which case the second and the fourth detection range are the same. Moreover, the data of the geometry sensor can also be used for further plausibility checks such as determination of a vehicle volume, a vehicle class etc., against which the recorded images, speed measurement values and/or DSRC communications can be counterchecked for plausibility of the match.

Further features and advantages of the invention will be seen from the following description of a preferred exemplary embodiment with reference to the accompanying drawings:

Figures 1 to 3 show a mobile monitoring device mounted on a monitoring vehicle for monitoring vehicles in flowing traffic in three different positions of use, which at the same time illustrate three phases of the method of the invention.

With reference to Figures 1 to 3, a monitoring vehicle 1 is respectively shown therein that is moving on a lane of a road 2 in a direction of travel 3 at a speed v_1. The monitoring vehicle 1 serves to monitor other vehicles 4 in flowing traffic on the road 2, which in the example shown here are moving in an opposite lane of the road 2 in an opposite direction of travel 5 at a speed v_2 and are travelling in oncoming traffic past the monitoring vehicle 1. However, it is understood that the monitoring vehicle 1 can also monitor vehicles 4 travelling in the same direction, or that one or both vehicles 1, 4 can be temporarily at a standstill in stop and go traffic. The different directions of travel 3, 5 and speeds, v_1, v_2 of the monitoring vehicle 1 and the monitored vehicle 4 create time-variable conditions that render a firm geometric match between the monitoring vehicle 1 and the vehicle 4 impossible.

For monitoring the vehicle 4 the monitoring vehicle 1 carries a mobile monitoring device 6, which comprises the following components, some of which may also coincide:
a first sensor 7 for measuring the relative speed $v_r = v_2 - v_1$ of the vehicle 4 in relation to the monitoring vehicle 1 when said vehicle 4 is located in the detection range 8 of the sensor 7 or is passing therethrough;
a second sensor 9, which at least indirectly measures the geometry, here the length L, of the vehicle 4 when this is located in the detection range 10 of the sensor 9;
at least one camera 11 for recording an image B of the vehicle 4 when this is located in the detection range 12 of the camera 11 or is passing therethrough;
an (optional) DSRC transceiver 13, which can conduct a radio communication 14 with an (optional) DSRC OBU 15 of the vehicle 4, when this is located in the detection range 16 of the DSRC transceiver 13 or is passing therethrough;

the detection range 16 is the intersection from the transceiver range of the DSRC transceiver 13 and the transceiver range of the DSRC OBU 15; and
an evaluation device 17 connected to the above components.

During operation the sensor 7 measures the (relative) speed v_r of the passing vehicles 4 and provides each speed measurement value v_r with a respective time stamp TS_1 of the time at which it was detected. With knowledge of the inherent speed v_1 of the vehicle 1, conclusions can be made from the relative speed v_r as to the inherent speed v_2 of the vehicle 4.

In the same way, the sensor 9 measures at least one geometry of the passing vehicles 4, here the length L, and provides each geometry measurement value L with a time stamp TS_2 of the time at which it was detected. The camera 11 photographs the vehicles 4 passing through its detection range 12 and provides each recorded image 11 with a time stamp TS_3 of the time at which it was detected. Optionally, the DSRC transceiver 13 conducts DSRC communications 14 with the DSRC OBU 15 of the passing vehicles 4 and stores each conducted DSRC communication 15 with a time stamp TS_4 of when it was conducted.

The evaluation device 17 links the speed measurement values, geometry measurement values, camera images and DSRC communications received from the sensors 5, 9, the camera 11 and the optional DSRC receiver 13 taking their respective time stamps TS_1-TS_4 and detection ranges 8, 10, 12, 16 into account, so that they can be matched to one another. Since the respective detection ranges 8, 10, 12 and 16 are known in relation to the coordinate system of the monitoring device 6, e.g. defined by spatial angle, planes, sectors etc., from the speed measurement values, geometry measurement values, camera images and/or DSRC communications occurring at the respective times 15_1, 15_2, 15_3, 15_4 expected values can be calculated for the place and the time, in or at which a passage of a vehicle attributable to the vehicle 4 occurs in the detection range 12 of the camera 11, so that the images B recorded by the camera 11 in the detection range 12 with their time stamps TS_3 can be compared therewith. Thus, the respective matching image B to each speed measurement value v_r can be determined and vice versa, even when the detection ranges 8, 12 of the speed sensors 7 and the camera 11 do not overlap. The vehicle geometry, in particular the number of axles A and/or the vehicle length L, is also evaluated therewith to exclude ambiguities, e.g. to validate a vehicle 4 recorded in an image B on the basis of its length detected in the image compared to the length L measured by the sensor 9, or to distinguish between several vehicles 4, which were recorded in the very same image B because of dense traffic.

In an embodiment, the speed measurement value v_r or v_2 of the vehicle 4 determined in this manner can also be used only as an interim result on the way to matching a DSRC communication 14 to a recorded image B. Thus, with knowledge of the detection range 16 of the DSRC transceiver 13, the aforementioned speed and geometry measurement values of the sensors 7, 9, the detection ranges 8, 10 and the time stamps TS_1-TS_4, a DSRC communication with a vehicle 4 can also be matched to the respective image B of the vehicle 4. For this, the measured or calculated speed vector v_2 of the vehicle 4 and the known speed vector v_1 of the monitoring vehicle 1 are evaluated, for example, in association with the respective time stamps TS_1-TS_4 and detection ranges 8, 10, 11, 12, 16 in order to estimate or extrapolate the place and time in or at which the vehicle 4, with which a DSRC communication 14 took place, should appear in the detection range 12 of the camera 11 in order to match the image B of the camera 11, wherein the time stamp TS_3 and the position of the vehicle 4 recorded in the image B matches these detection values.

Any sensors known in the art can be used for the speed measurement sensor 7 and the geometry measurement sensor 9. In a first embodiment a laser scanner is used for the geometry measurement sensor 9 that, for example, transmits a scanning beam in a plane located normal to or on an angle to the direction of travel, i.e. its detection range 10 is a plane, and the vehicle 4 is scanned by the motion of the monitoring vehicle 1 and/or vehicle 4 in order to generate a 3D image of the vehicle 4.

The vehicle length L is frequently represented in a distorted manner in such a 3D image of the vehicle 4 because of the vehicle speed v_2. In this case, the vehicle length L can be determined indirectly therefrom: thus, from a correctly detected vehicle height (or the vehicle volume), for example, a conclusion can be drawn as to a specific class of vehicle such as automobile, lorry, lorry with trailer etc., for which specific typical vehicle lengths L can be determined. For this, the sensor 9 can contain e.g. a table of typical vehicle heights and associated typical vehicle lengths and can thus determine an appropriate - if only approximate - length L of the vehicle 4 on the basis of the measured vehicle height.

Alternatively, the sensor 9 could be a 3D laser scanner, for example, which very quickly provides a 3D image of a matching vehicle 4 - quasi photographically - in one action, from which a geometry, such as the vehicle length L, can be directly determined.

One more alternative would be, for example, that the sensor 9 determines the number of axles A of the vehicle 4, e.g. by laser scanning or LIDAR or radar Doppler measurement of the rotating wheels of the vehicle 4. The sensor 9 can then again contain a table of vehicle lengths L or dimensions typical for specific numbers of axles A, for example, and thus determine an associated - if only approximate - geometry such as the length L of the vehicle 4.

The speed measurement sensor 7 can also be formed by a laser scanner, e.g. in the manner of a LIDAR speed measurement gun. Alternatively, the speed of the vehicle 4 could also be measured with a 2D or 3D laser scanner, e.g. by means of two measurements in quick succession and determination of the local displacement of the vehicle 4 between the two measurements. Therefore, one and the same laser scanner can optionally be used for both the speed measurement sensor 7 and for the geometry measurement sensor 9.

In an alternative embodiment, the speed can also be measured with the aid of the optional DSRC transceiver 13. For this, Doppler measurements can be conducted on the DSRC communications 14, for example, to determine the relative speed v_r. Alternatively the speed can be measured using a transceiver 13 with infrared transmission during the course of the vehicle communication.

It would also be conceivable that the DSRC OBU 15 measures its speed itself and sends this to the DSRC transceiver 13 as part of a DSRC communication 14, which is also covered in the definition here that the DSRC transceiver 13 forms a speed measurement sensor.

If the speed is measured with the DSRC transceiver 13, it is understood that the first and the fourth detection range 8 and 16 coincide.

The DSRC transceiver 13 can, moreover, also form the geometry measurement sensor 9 if as part of a DSRC radio communication 14 it receives vehicle data from the DSRC OBU 15, from which it can calculate a geometry of the vehicle 4, e.g. the length L. For example, the

DSRC OBU 15 transmits information concerning the vehicle class or number of axles of the vehicle 4, from which - again by way of a table of typical vehicle geometries for typical vehicle classes or numbers of axles - the associated vehicle geometry can be calculated. If the geometry measurement sensor 9 and the DSRC transceiver 13 coincide, it is understood that the detection ranges 10, 16 also coincide accordingly.

Alternatively, the transceiver 13 can also be configured for a short-range transmission technology other than DSRC, e.g. infrared or any desired microwave technology.

Consequently, the invention is not limited to the represented embodiments, but covers all variants and modifications that come within the framework of the attached claims.

Claims:

WHAT IS CLAIMED IS:

1. A mobile monitoring device for monitoring vehicles, comprising:

   a speed measurement sensor for measuring the speed of vehicles passing through a first detection range, said speed measurement sensor providing the speed measurement value of a passage of a vehicle with a time stamp;

   a geometry measurement sensor for at least indirectly measuring the geometry of vehicles passing through a second detection range, said geometry measurement sensor providing the geometry measurement value of a passage of a vehicle with a time stamp;

   a camera for recording images of vehicles passing through a third detection range, said camera providing the image of each passage of a vehicle with a time stamp; and

   an evaluation device connected to the camera and the said sensors, which is configured for

   calculating from the speed measurement value, its time stamp and the first detection range and also from the geometry measurement value, its time stamp and the second detection range, the place and time at which a passage of a vehicle is to be expected in the third detection range in order to determine the matching image on the basis of its time stamp and third detection range therefrom.

2. The mobile monitoring device according to claim 1 wherein the measured geometry of vehicles passing through the second detection range is the length of the vehicles.

3. The mobile monitoring device according to claim 1 or claim 2 wherein the device is for monitoring vehicles equipped with dedicated short-range communication onboard units (DSRC OBUs), and wherein the device further comprises a dedicated short-range communication (DSRC) transceiver for DSRC communication with DSRC OBUs of vehicles passing through a fourth detection range, said DSRC transceiver providing the DSRC communication of each passage of a vehicle with a time stamp, and wherein the evaluation device is additionally

configured to determine the matching DSRC communication to the determined image on the basis of its time stamp and fourth detection range.

4. The mobile monitoring device according to claim 3, characterised in that the first and the fourth detection ranges are the same and the speed measurement sensor is formed by the DSRC transceiver.

5. The mobile monitoring device according to one of claims 1 to 3, characterised in that the speed measurement sensor is formed by a laser scanner.

6. The mobile monitoring device according to one of claims 2 to 5, characterised in that the second and fourth detection ranges are the same and the geometry measurement sensor is formed by the DSRC transceiver, which receives vehicle data from the DSRC OBU as part of a DSRC communication, from which it calculates a geometry, preferably the length, of the vehicle.

7. The mobile monitoring device according to one of claims 1 to 5, characterised in that the geometry measurement sensor is formed by a laser scanner.

8. The mobile monitoring device according to claim 7, characterised in that the laser scanner detects the vehicle height or number of axles, from which it determines the associated geometry of the vehicle on the basis of a table of vehicle heights or number of axles and associated vehicle geometries.

9. The mobile monitoring device according to claim 7 wherein the determined associated geometry of the vehicle is a length of the vehicle.

10. A method for monitoring vehicles, with the following steps in any desired sequence:
measuring the speed of a vehicle passing through a first detection range and providing the speed measurement value with a time stamp;
at least indirectly measuring the geometry of a vehicle passing through a second detection range and providing the geometry measurement value with a time stamp;

recording images of vehicles passing through a third detection range and providing each image with a time stamp;
additionally with the subsequent steps:
calculating from the speed measurement value, its time stamp and the first detection range and also from the geometry measurement value, its time stamp and the second detection range, the place and time at which a passage of a vehicle is to be expected in the third detection range, and determining the matching image on the basis of its time stamp and third detection range therefrom.

11. The method according to claim 10 wherein the measured geometry of the vehicle passing through the second detection range is a length of the vehicle.

12. The method according to claim 10 or 11 wherein the method is for monitoring vehicles equipped with dedicated short-range communication onboard units (DSRC OBUs), the method further comprising the steps of:
conducting a DSRC communication with the DSRC OBUs of vehicles passing through a fourth detection range and providing each DSRC communication with a time stamp; and
determining the matching DSRC communication to the determined image on the basis of its time stamp and fourth detection range.

13. The method according to claim 12, characterised in that the first and the fourth detection ranges are the same and the speed is measured by Doppler measurement of the DSRC communication.

14. The method according to one of claims 10 to 12, characterised in that the speed is measured with a laser scanner or by evaluation of two consecutive images of a camera.

15. The method according to one of claims 12 to 14, characterised in that the second and fourth detection ranges are the same and vehicle data from the DSRC OBU are received as part of a DSRC communication, from which data a geometry of the vehicle is calculated.

16. The method according to claim 15 wherein the calculated geometry of the vehicle is a length of the vehicle.

17. The method according to one of claims 10 to 14, characterised in that the geometry is measured with a laser scanner.

18. The method according to claim 17, characterised in that the vehicle height is detected with the laser scanner and from this the associated geometry of the vehicle is determined on the basis of a table of vehicle heights and associated vehicle geometries.

19. The method according to claim 18 wherein the determined associated geometry of the vehicle is a length of the vehicle.

20. The method according to one of claims 10 to 19, characterised in that it is conducted from a travelling monitoring vehicle.

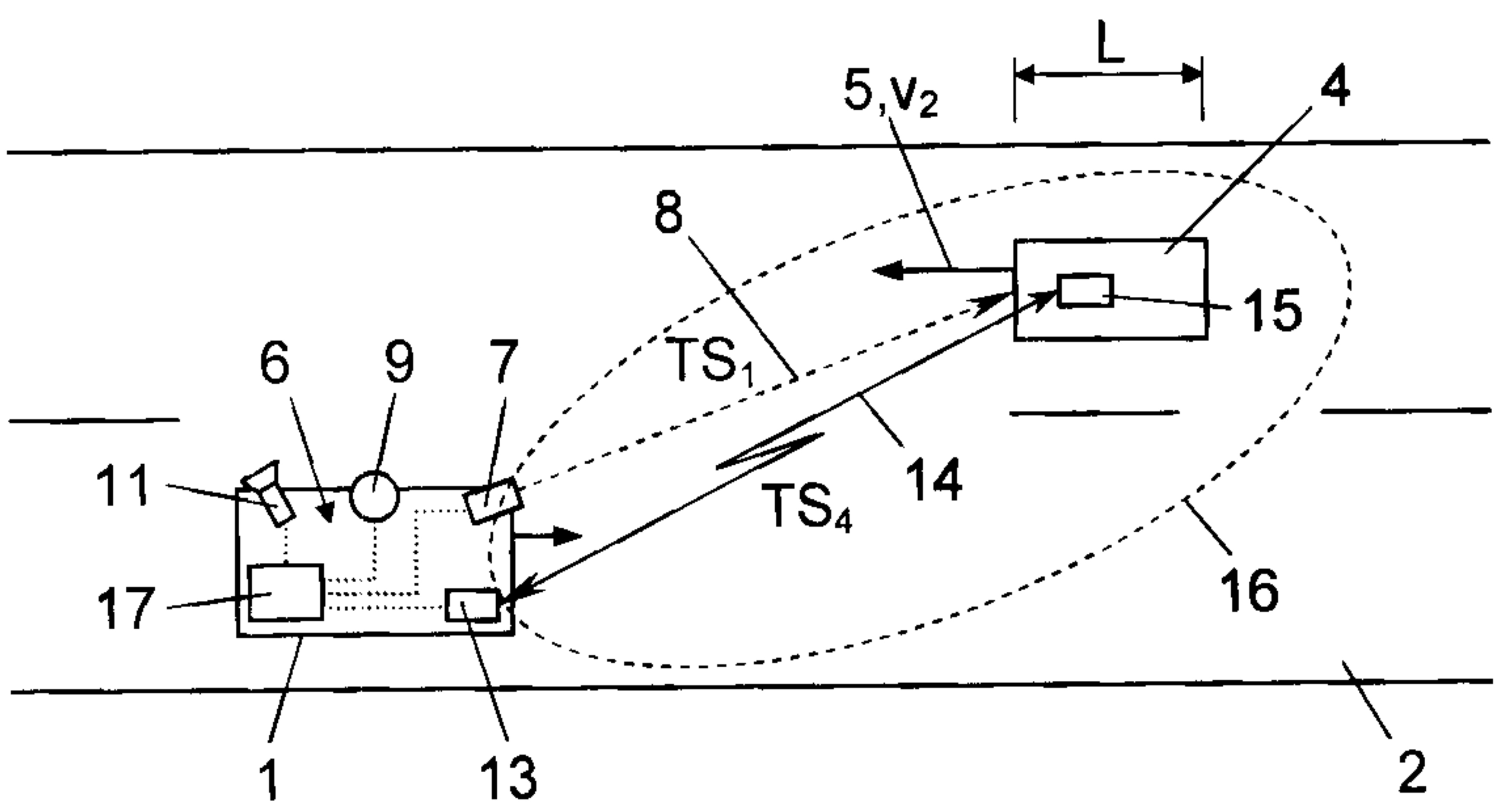


Fig. 1

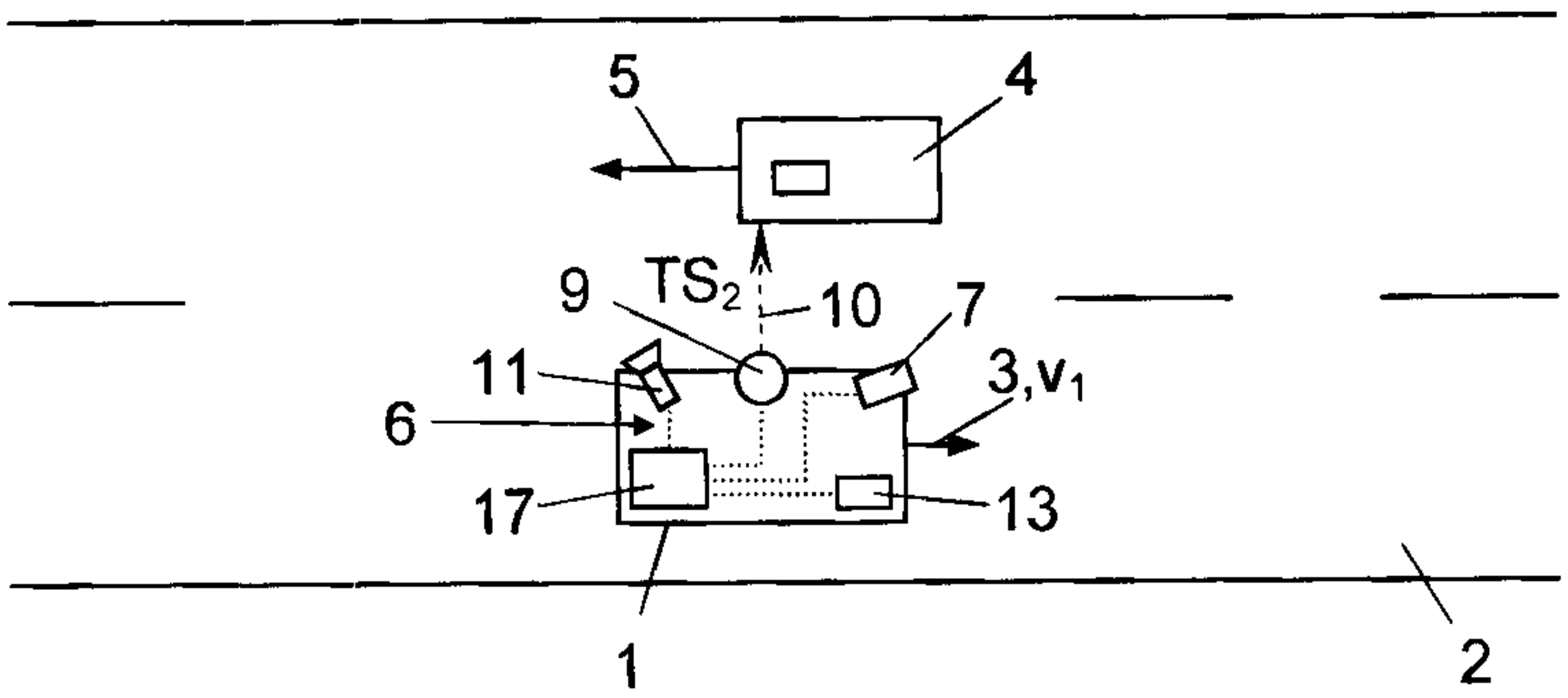


Fig. 2

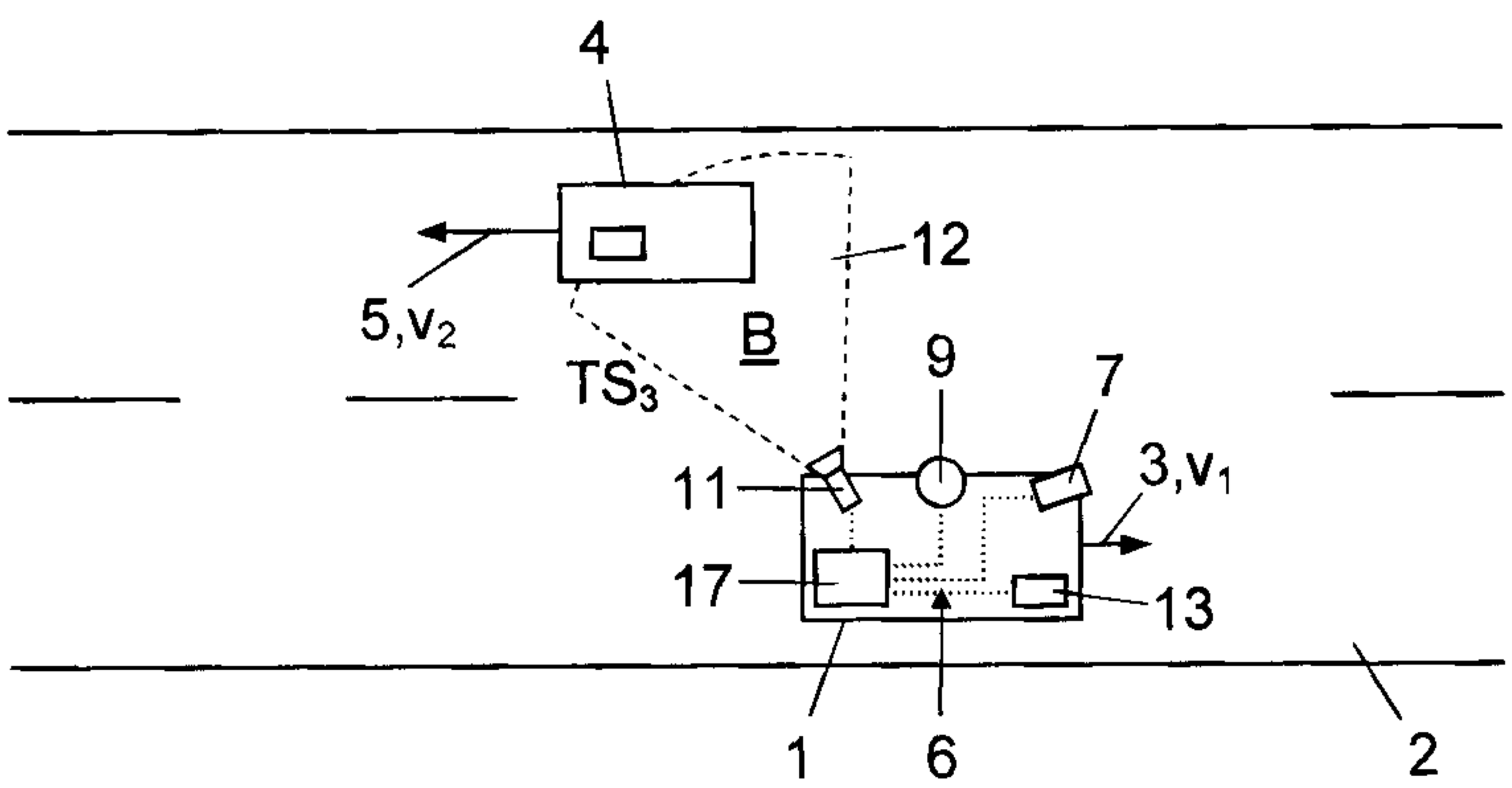


Fig. 3


L
5,v_2
4
8
15
TS_1
6
9
7
14
11
TS_4
16
17
1
13
2