

A device for preventing collision, for an urban public transport vehicle

The present invention relates to a collision prevention device for a public urban transport vehicle, in particular for a tram.

5 A collision prevention device comprising object detection means embedded in the vehicle is already known in the prior art. Such object detection means make it possible to detect whether an object is on, or close to, the trajectory of the vehicle.

 However, such object detection means have blind spots, and may not detect certain objects in low visibility, in particular mobile objects at an intersection with the track.

10 The invention aims, in particular, to remedy this defect, by providing a reliable collision prevention device that is effective even in case of low visibility from the vehicle.

 To this end, the object of the invention is, in particular, to provide a collision prevention device for an urban public transport vehicle, in particular a tram, intended to run on a track, characterized in that the prevention device comprises:

- 15 - first means for detecting a mobile object and for estimating the behavior of this mobile object, wherein the first object detection means are configured to be arranged close to the track,
- prediction means for predicting the risk of a collision between the public transport vehicle and a detected mobile object, based on data collected by
- 20 the first detection means,
- anti-collision measure-implementation means that are configured to be arranged on board the vehicle, and that are designed to be activated as a function of a command provided by the prediction means,
- wherein the first detection means are capable of estimating the speed and
- 25 trajectory of the mobile object, and
- wherein the anti-collision measure-implementation means are designed to implement at least one of the following measures: sending a warning signal to a driver of the vehicle and/or braking, wherein the intensity depends on the position and/or the speed of the vehicle.

30 The detection means arranged on the ground are able to reliably detect any object whose trajectory crosses the track, even in the case of low visibility from the vehicle.

 A collision prevention device according to the invention may further comprise one or more of the following characteristics, taken alone or in any technically-feasible

35 combination.

- The first collision detection means are designed to estimate a volume, a shape and a type of mobile object.
- The collision prevention device comprises information exchange means on the ground for exchanging information with the vehicle.
- 5 - The information exchange means comprise a plurality of beacons intended to be arranged along the track, and a receiver module configured to be arranged on board the vehicle, wherein the receiver module is designed to receive information transmitted by a nearby beacon.
- The information exchange means comprise a direct transmission module
- 10 configured to be arranged near the track, and a receiver module configured to be arranged on board the vehicle.
- The prediction means are designed to be arranged on board the vehicle, wherein the information transmitted by the information exchange means comprises the data collected by the detection means.
- 15 - The prediction means are designed to be arranged near the track, wherein the information transmitted by the information exchange means comprises the command to the anti-collision measure-implementation means.
- The collision prevention device comprises second object detection means fixed on the track, wherein the prediction means provide a command as a
- 20 function of the data collected by the second object detection means.

The invention also relates to a collision prevention method for an urban public transport vehicle, in particular a tram, intended to run on a track, characterized in that it is implemented by means of a prevention device such as previously defined, and wherein it comprises:

- 25 - a detection step wherein the first detection means arranged near the track detects the presence of a mobile object and estimates the probable behavior of this mobile object,
- a prediction step wherein the prediction means predict the risk of a collision between the public transport vehicle and a detected mobile object, according
- 30 to data collected during the detection step,
- an anti-collision measure-implementation step wherein the measure-implementation means arranged on board the vehicle implement a measure according to a command provided by the prediction means.

The invention will be better understood upon reading the description which follows, given solely by way of example and with reference to the appended figures, wherein:

5 Fig. 1 shows schematically the track of a public transport vehicle, equipped with a collision prevention device according to a first exemplary embodiment of the invention;

 Fig. 2 shows schematically the track of a public transport vehicle, equipped with a collision prevention device according to a second exemplary embodiment of the invention.

10 Fig. 1 shows a track 10 on which an urban public transport vehicle 12 travels, in particular a tram.

 The track 10 has intersections 14, wherein one of the intersections 14 is shown in Fig. 1.

15 In the present description, the term "intersection" refers to any area of the track 10 that may be traversed by mobile objects 18. Thus, an intersection may be, as shown, an intersection with a street 16, or, alternatively, the exit of a garage, or any other possible intersection.

20 Various objects 18 are in a position to travel in the street 16, and to cross the track 10. For example, the object 18 may be a car, or any other conceivable vehicle (truck, bus, bicycle, etc.).

 The purpose of the invention is, in particular, to prevent a possible collision between the vehicle 12 and the mobile object 18.

 For this purpose, the vehicle 12 and the track 10 are equipped with a device 20 for collision prevention.

25 The collision prevention device 20 comprises first detection means 22 for detecting a mobile object 18 and for estimating the behavior of this mobile object 18. These detection means 22 are configured to be arranged near the track 10, and, more particularly, at the intersection 14. Such first detection means 22 are advantageously arranged at each intersection 14.

30 Advantageously, the first detection means 22 are arranged on either side of the track 10 in order to detect objects 18 traveling on each side of this track 10 in the street 16.

 The first detection means 22 detect when a mobile object 18 crosses, or is about to cross, the track 10. To this end, the first detection means 22 collect various data

relating to the mobile object 18, in particular the speed and the trajectory of this mobile object 18.

All types of known detection means 22 are conceivable.

For example, the first detection means 22 comprising conventional means for
 5 measuring the speed of the mobile object 18 and conventional means for detecting crossing at traffic lights.

According to another example, the first detection means 22 are able to determine more precisely the position and the trajectory of the mobile object 18, its speed, and also, optionally, the volume, shape and/or type of mobile object 18.

10 The prevention device 20 also comprises prediction means for predicting the risk of a between the public transport vehicle 12 and the mobile object 18 as a function of data collected by the first detection means 22.

According to the first embodiment, the prediction means 24 are arranged on the ground close to the track 10.

15 Information concerning the speed and position of the vehicle 12 is also provided to the prediction means 24 in order to estimate the risk of collision with the mobile object 18. This information is provided by the vehicle 12 or by a central control station.

The collision prevention device 20 comprises information exchange means 26 on the ground for the exchange of information with the vehicle 12.

20 In the example described, the information exchange means 26 comprise a plurality of beacons 28 arranged along the track 10, and a receiver module 30 designed to be arranged on board the vehicle 12. The receiver module 30 is able to receive information transmitted by a beacon 28 located nearby.

The beacons 28 are arranged, for example, in a so-called danger zone. The
 25 danger zone corresponds, for example, to a portion of the track 10 just upstream of the intersection.

Advantageously, each beacon 28 is designed to detect the vehicle 12 when it passes close by, which makes it possible to know the position of the vehicle 12, as a function of the last beacon 28 it has passed.

30 The prediction means 24 compute the risk of a collision between the vehicle 12 and the object 18. When this risk exceeds a predefined threshold, the prediction means 24 provide a command to anti-collision measure-implementation means 32 arranged on board the vehicle 12 and which may be activated as a function of this command.

The anti-collision measure-implementation means 32 control the implementation
 35 of at least one measure selected from among sending an audio and/or light warning signal

to the driver of the vehicle 12 and/or activating automatic braking the intensity of which depends on the position and/or the speed of the vehicle 12.

For example, the command differs from one beacon 28 to the next in order to control the braking intensity which is all the stronger as the vehicle 12 passes a beacon 28 that is closer to the intersection 14.

In a first embodiment, the command for each beacon 28 is fixed, wherein, in particular, it has been predetermined. Alternatively, the command for each beacon 28 may evolve dynamically, for example, as a function of the risk of collision with the mobile object 18, the distance between the mobile object 18 and the track 10, and/or the speed of the vehicle 12.

For example, the command requires weak braking if the vehicle 12 is relatively far from the intersection 14 when the mobile object 18 is about to cross this intersection 14, while the command requires emergency braking if the vehicle 12 is close to the intersection 14 when the mobile object 18 is about to cross this intersection 14.

Advantageously, the prevention device 20 further comprises second means 33 for detecting a fixed object on the track. The prediction means 24 then provide a command as a function of data collected by the second detection means 33. These second object detection means 33 are generally arranged on the vehicle 12.

When the prediction means 24 compute different commands according to the measurements obtained by the first detection means 22 and the second detection means 33, then the strongest braking command is transmitted to the anti-collision measure-implementation means 32.

Fig. 2 shows a prevention device 20 according to a second exemplary embodiment of the invention. In this figure, elements similar to those of the preceding figures are designated by identical reference numerals.

In accordance with this second embodiment, the information transmission means 26 comprise a direct transmission module 34 arranged near the track 10, and a receiver module 36 arranged on board the vehicle 12. These information transmission means 26 use, for example, wireless communication technology, in particular 3G, 4G, 5G, Wi-Fi or any other conceivable technology.

Moreover, the prediction means 24 are arranged on board the vehicle 12. Thus, the information transmitted by the transmission module 34 comprises the data collected by the detection means 22.

The vehicle 12 also comprises conventional means for determining the position and the speed of this vehicle 12 and connected to the prediction means 24. The prediction

means 24 thus take into account the position and the speed of this vehicle 12 as well as the data collected by the detection means 22, in order to estimate the risk of a collision between the vehicle 12 and the mobile object 18.

5 In the event of the risk of a collision being detected, the prediction means 24 send a command to the anti-collision measure-implementation means 32, in order to implement an anti-collision measure, for example automatic braking of the vehicle 12.

The prevention device 20 makes it possible to implement the collision prevention method described as follows.

10 The method comprises a detection step to detect a mobile object 18 by the first detection means 22 arranged near the track, and to estimate the behavior of this mobile object 18. The estimate of the behavior of the mobile object 18 comprises, in particular, an estimate of the speed and the trajectory of this mobile object 18, as well as, optionally, an estimate of its volume, shape and type of mobile object.

15 In parallel, the method comprises, in a particular embodiment, the detection of a fixed object on the track 10 by the second detection means 33.

The data thus collected by the first detection means 22 are transmitted to the prediction means 24, either locally in the case of the first embodiment described with reference to Fig. 1, or remotely by means of the transmission means 26 in the case of the second embodiment described with reference to Fig. 2. The data collected by the second
20 detection means 33 are also transmitted to the prediction means 24.

The prediction means 24 also collect information concerning the position and the speed of the vehicle 12. In the case of the first embodiment, this information is transmitted to the remote prediction means 24 by the vehicle 12 via a central control station, or by any other suitable means. In the case of the second embodiment, this information is
25 transmitted locally in the vehicle 12.

The method then comprises a prediction step wherein the prediction means 24 predicts the risk of a collision between the public transport vehicle 12 and a mobile object 18 as a function of data collected during the detection step 22, as well as position and speed information of the vehicle 12.

30 Knowing the speeds, positions and trajectories of the vehicle 12 and the mobile object 18, the prediction means 24 may estimate whether there is a risk of collision.

In the case where there is a risk of collision, the method comprises a preparation step to prepare a command by the prediction means 24 for the anti-collision measure-implementation means 32, and to transmit this command to the anti-collision measure-
35 implementation means 32.

It should be noted that such a command is also sent when a fixed obstacle is detected on the track by the second detection means 33.

The method then comprises an anti-collision measure-implementation step through the anti-collision measure-implementation means 32 arranged on board the vehicle, as a function of the command supplied by the prediction means 24.

The measure is chosen from among sending a warning signal to the driver and/or automatic braking of the vehicle 12, wherein the braking intensity depends on the distance between the vehicle 12 and the intersection 14. In particular, if the vehicle 12 is relatively far from the intersection 14, braking will be moderate. On the other hand, if the vehicle 12 is close to the intersection 14, emergency braking is triggered.

It is clear that the invention greatly reduces the risk of collision and derailment of the vehicle 12, or, in the most adverse cases, may reduce the severity of a collision.

In addition, thanks to the invention, the vehicle 12 does not need to reduce its speed when approaching an intersection 14 when no object 18 is detected. The invention therefore makes it possible to increase the speed of the vehicle 12 at the intersection 14.

It should be noted that the invention is not limited to the embodiments described above.

For example, as a variant of the first embodiment, it is possible to provide a transmission of the command via direct transmission means to the vehicle 12, which does not include beacons.

CLAIMS

1. A collision prevention device (20) for an urban public transport vehicle (12), in particular a tram, intended to run on a track (10), **characterized in that** the prevention
5 device (20) comprises:

- first means (22) for detecting a mobile object (18) and for estimating the behavior of this mobile object (18), wherein the first detection means (22) are configured to be arranged near the track (10),
- means (24) for predicting the risk of a collision between the public transport
10 vehicle (12) and a detected mobile object (18), as a function of data collected by the first detection means (22),
- anti-collision measure-implementation means (32) which are designed to be arranged on board the vehicle (12), and activated according to a command provided by the prediction means (24),

15 wherein the first detection means (22) are able to estimate the speed and a trajectory of the mobile object (18), and

wherein the anti-collision measure-implementation means (32) are able to control at least one among a warning signal to a driver of the vehicle (12) and/or braking whose intensity depends on the position and/or the speed of the vehicle (12).

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2. The collision prevention device (20) according to claim 1, wherein the first detection means (22) are able to estimate a volume, a shape and a type of the mobile object (18).

25 3. The collision prevention device (20) according to any one of the claims 1 to 2, comprising information exchange means (26) on the ground to exchange information with the vehicle (12).

30 4. The collision prevention device (20) according to claim 3, wherein the information exchange means (26) comprise a plurality of beacons (28) intended to be arranged along the track (10), and a receiver module (30) configured to be arranged on board the vehicle (12), wherein the receiver module (30) is able to receive information transmitted by a nearby beacon (28).

5. The collision prevention device (20) according to claim 3, wherein the information exchange means (26) comprise a direct transmission module (34) configured to be arranged near the track (10), and a receiver module (36) configured to be arranged on board the vehicle (12).

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6. The collision prevention device (20) according to any one of claims 3 to 5, wherein the prediction means (24) are configured to be arranged on board the vehicle (12), and wherein the information transmitted by the information exchange means (26) comprises the data collected by the first detection means (22).

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7. The collision prevention device (20) according to any one of the claims 3 to 5, wherein the prediction means (24) are configured to be arranged near the track (10), and wherein the information transmitted by the information exchange means (26) comprises the command to the anti-collision measure-implementation means (32).

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8. The collision prevention device (20) according to any one of the preceding claims, comprising second detection means (33) for detecting fixed objects on the track (10), wherein the prediction means (24) are able to provide a command as a function of data collected by the second detection means (33).

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9. A collision prevention method for an urban public transport vehicle (12), in particular a tram, intended to run on a track (10), **characterized in that** it is implemented by means of the collision prevention device (20) according to any one of the preceding claims, and in that it comprises:

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- a detection step wherein the first detection means (22) arranged near the track (10) detect a mobile object (18) and estimate the behavior of this mobile object (18),
- a prediction step wherein the prediction means (24) predict the risk of a collision between the public transport vehicle (12) and a detected mobile object (18), as a function of data collected during the detection step (22),
- an anti-collision measure-implementation step, wherein the measure-implementation means (32) arranged on board the vehicle (12) implement an anti-collision measure as a function of a command provided by the prediction means (24).

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