(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 416 305 A1

(12) EUROPEAN PATENT APPLICATION

published in accordance with Art. 153(4) EPC

(43) Date of publication:
08.02.2012 Bulletin 2012/06

(21) Application number: **10758418.7**

(22) Date of filing: **17.03.2010**

(51) Int Cl.:
G08G 1/16 *(2006.01)* ***B60R 21/00*** *(2006.01)*
G01C 21/00 *(2006.01)* ***G08G 1/09*** *(2006.01)*

(86) International application number:
PCT/JP2010/054556

(87) International publication number:
WO 2010/113642 (07.10.2010 Gazette 2010/40)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR

(30) Priority: **01.04.2009 JP 2009088959**

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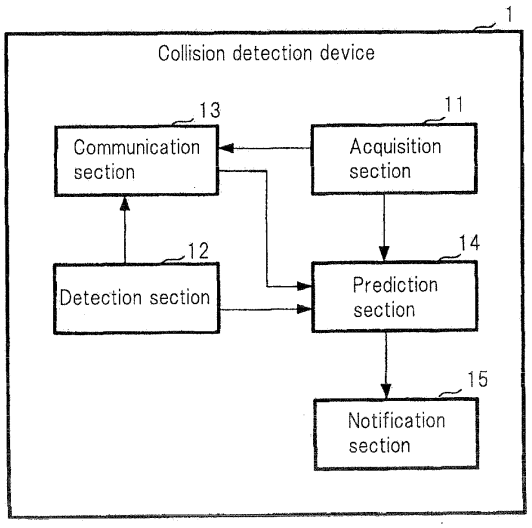
(54) COLLISION PREDICTION SYSTEM, COLLISION PREDICTION DEVICE, COLLISION DETECTION METHOD, AND PROGRAM

(57) The present invention aims at obtaining a correct collision prediction result even if a grade separated crossing cannot be recognized based on images. A collision prediction device provided in a moving object detects a mark placed on either an overpass road or on an underpass road at the grade separated crossing. Then, the collision prediction device transmits information that denotes that the mark has been detected to a collision prediction device provided in a moving object other than a concerned moving object that is provided with its collision prediction device. In addition, the collision prediction device predicts a collision depending on whether the information that denotes that the mark has been detected has been transmitted from the other collision prediction device and whether its collision prediction device has detected the mark.

Fig.4



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Description

TECHNICAL FIELD

[0001] The present invention relates to a collision prediction system, a collision prediction device, a collision detection method, and a program.

BACKGROUND ART

[0002] In recent years, vehicles that are provided with collision prediction devices that predict whether or not vehicles will collide with each other based on their position information and speed information have emerged.

[0003] If vehicles having such collision prediction devices three-dimensionally cross each other at a grade separated crossing where roads three-dimensionally cross each other, although the vehicles will not substantially collide with each other, it is likely that the devices will predict that the vehicles will collide with each other.

[0004] To prevent that, a technique that recognizes a grade separated crossing and predicts whether or not vehicles will collide with each other based on images captured by camera provided in the vehicles as information that complements position information and speed information has been contemplated (for example, refer to Patent Literatures 1 and 2).

RELATED ART LITERATURE

PATENT LITERATURE

[0005]

Patent Literature 1: JP2004-199390A, Publication
Patent Literature 2: JP2008-164506A, Publication

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0006] However, cameras have image capturing ranges. Thus, it is likely that a collision prediction device, that predicts whether the concerned vehicle that is provided with the device will collide with another vehicle based on an image that the camera provided in the concerned vehicle captures, cannot obtain a correct collision prediction result unless the concerned vehicle approaches a grade separated crossing such that the cameras can capture an image that allows the device to predict that the concerned vehicle will collide with the other vehicle.

[0007] An object of the present invention is to provide a collision prediction system, a collision prediction device, a collision detection method, and a program that can solve the above-described problem.

MEANS THAT SOLVE THE PROBLEM

[0008] To solve the above-described problem, a collision prediction system according to the present invention comprises: a collision prediction device that is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects; and a mark placed on either an overpass road or on an underpass road situated below the overpass road at a predetermined distance in front of a grade separated crossing where the overpass road and the underpass road on which said plurality of moving objects drive three-dimensionally cross each other, wherein said collision prediction device includes: detection means that detects said mark; communication means that transmits information, that denotes that said detection means has detected said mark, to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and prediction means that predicts that said concerned moving object and the moving objects other than the concerned moving object will not collide with each other, if the information that denotes that said mark has been detected has been transmitted from said collision prediction device provided in the moving object other than said concerned moving object, and if said detection means has not detected said mark or if information that denotes that said mark has been detected has not been transmitted from said collision prediction device provided in the moving object other than said concerned moving object and if said detection means has detected said mark.

[0009] To solve the above-described problem, a collision prediction system according to the present invention comprises: a collision prediction device that is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects; an overpass crossing mark that is a mark placed on an overpass road at a predetermined distance in front of a grade separated crossing where a plurality of roads on which said plurality of moving objects drive three-dimensionally cross each other; and an underpass crossing mark that is a mark placed on an underpass road situated below said overpass road at the predetermined distance in front of said grade separated crossing, wherein said collision prediction device includes: detection means that detects said mark; communication means that transmits information that denotes that the mark detected by said detection means is said overpass crossing mark or said underpass crossing mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and prediction means that predicts the collision based on the mark that the in-

formation transmitted from said collision prediction device provided in the moving object other than said concerned moving object represents and the mark detected by said detection means.

[0010] To solve the above-described problem, a collision prediction device according to the present invention is a collision prediction device that is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects, comprising: detection means that detects a mark placed on either an overpass road or on an underpass road situated below the overpass road at a predetermined distance in front of a grade separated crossing where the overpass road and the underpass road on which said plurality of moving objects drive three-dimensionally cross each other; communication means that transmits information that denotes that said detection means has detected said mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and prediction means that predicts that said concerned moving object and the moving objects other than the concerned moving object will not collide with each other, if the information, that denotes that said mark has been detected has been transmitted from said collision prediction device provided in the moving object other than said concerned moving object, and if said detection means has not detected said mark or if the information that denotes that said mark has been detected has not been transmitted from said collision prediction device provided in the moving object other than said concerned moving object and if said detection means has detected said mark.

[0011] To solve the above-described problem, a collision prediction device according to the present invention is a collision prediction device that is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects, comprising: detection means that detects an overpass crossing mark that is a mark placed on an overpass road at a predetermined distance in front of a grade separated crossing where a plurality of roads on which said plurality of moving objects drive three-dimensionally cross each other or an underpass crossing mark that is a mark placed on an underpass road situated below said overpass road at the predetermined distance in front of said grade separated crossing; communication means that transmits information that denotes that the mark detected by said detection means is said overpass crossing mark or is said underpass crossing mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and prediction means that predicts the collision based on the mark that the information transmitted from said collision prediction device provided in the moving object other than said concerned moving object represents and based on the mark detected by said detection means.

[0012] To solve the above-described problem, a collision prediction method according to the present invention is a collision prediction method that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects, comprising: detecting a mark placed on either an overpass road or on an underpass road situated below the overpass road at a predetermined distance in front of a grade separated crossing where the overpass road and the underpass road on which said plurality of moving objects drive three-dimensionally cross each other; transmitting information that denotes that said mark has been detected to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and predicting that said concerned moving object and the moving objects other than the concerned moving object will not collide with each other, if the information that denotes that said mark has been detected has been transmitted from said collision prediction device provided in the moving object other than said concerned moving object and said mark has not been detected, or if the information that denotes that said mark has been detected has not been transmitted from said collision prediction device provided in the moving object other than said concerned moving object and if said mark has been detected.

[0013] To solve the above-described problem, a collision prediction method according to the present invention is a collision prediction method that predicts whether or not a plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects, comprising: detecting an overpass crossing mark that is a mark placed on an overpass road at a predetermined distance in front of a grade separated crossing where a plurality of roads on which said plurality of moving objects drive three-dimensionally cross each other or an underpass crossing mark that is a mark placed on an underpass road situated below said overpass road at the predetermined distance in front of said grade separated crossing; transmitting information that denotes that said detected mark is said overpass crossing mark or said underpass crossing mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and predicting the collision based on the mark that the information transmitted from the moving object other than said concerned moving object represents and said detected mark.

[0014] In addition, a recording medium according to the present invention is a recording medium that records a program that causes a collision prediction device that

is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects to execute procedures, comprising: a detection procedure that detects a mark placed on either an overpass road or an underpass road situated below the overpass road at a predetermined distance in front of a grade separated crossing where the overpass road and the underpass road on which said plurality of moving objects drive three-dimensionally cross each other; a communication procedure that transmits information that denotes that said detection procedure has detected said mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and a prediction procedure that predicts that said concerned moving object and the moving objects other than the concerned moving object will not collide with each other, if the information, that denotes that said mark has been detected has been transmitted from said collision prediction device provided in the moving object other than said concerned moving object, and if said detection procedure has not detected said mark or if the information that denotes that said mark has been detected has not been transmitted from said collision prediction device provided in the moving object other than said concerned moving object and if said detection procedure has detected said mark.

[0015] In addition, a recording medium according to the present invention is a recording medium that records a program that causes a collision prediction device that is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects to execute procedures, comprising: a detection procedure that detects an overpass crossing mark that is a mark placed on an overpass road at a predetermined distance in front of a grade separated crossing where a plurality of roads on which said plurality of moving objects drive three-dimensionally cross each other or an underpass crossing mark that is a mark placed on an underpass road situated below said overpass road at the predetermined distance in front of said grade separated crossing; a communication procedure that transmits information that denotes that the mark detected by said detection procedure is said overpass crossing mark or is said underpass crossing mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and a prediction procedure that predicts the collision based on the mark that the information transmitted from said collision prediction device provided in the moving object other than said concerned moving object represents and the mark detected by said detection procedure.

EFFECT OF THE INVENTION

[0016] According to the present invention, a correct collision prediction result can be obtained on roads including grade separated crossings.

BRIEF DESCRIPTION OF DRAWINGS

[0017]

[Fig. 1] is a schematic diagram showing a first exemplary structure of a collision prediction system according to a first embodiment of the present invention.

[Fig. 2] is a schematic diagram showing a second exemplary structure of the collision prediction system according to the first embodiment of the present invention.

[Fig. 3] is a schematic diagram showing a third exemplary structure of the collision prediction system according to the first embodiment of the present invention.

[Fig. 4] is a schematic diagram showing a structure of a collision prediction device according to the first embodiment.

[Fig. 5] is a flow chart showing an operation of the collision prediction device according to the first embodiment that predicts whether or not a plurality of moving objects collide with each other.

[Fig. 6] is a schematic diagram showing a structure of a collision prediction system according to a second embodiment.

[Fig. 7] is a schematic diagram showing a driving direction of a moving object that is provided with the collision prediction device according to the second embodiment and an image capturing direction of a camera that is provided in the moving object.

[Fig. 8] is a schematic diagram showing a structure of the collision prediction device according to the second embodiment.

[Fig. 9] is a schematic diagram showing a structure of a detection section according to the second embodiment.

[Fig. 10] is a schematic diagram showing a first exemplary template of an overpass crossing mark or an underpass crossing mark that a template database stores.

[Fig. 11] is a schematic diagram showing a second exemplary template of an overpass crossing mark or an underpass crossing mark that the template database stores.

[Fig. 12] is a schematic diagram showing a structure of a prediction section according to the second embodiment.

[Fig. 13] is a flow chart showing an operation of the collision prediction device according to the second embodiment that predicts whether or not a plurality of moving objects collide with each other.

BEST MODES THAT CARRY OUT THE INVENTION

[0018] In the following, a collision prediction system (including a collision prediction device, a collision prediction method, and a program) according to an embodiment of the present invention will be described.

[0019] As shown in Fig. 1, the collision prediction system according to this embodiment is composed of a plurality of collision prediction devices 1, overpass crossing mark 21, underpass crossing mark 22, and a plurality of moving objects 31 and 32.

[0020] Overpass crossing mark 21 is placed on an overpass road of a plurality of roads that are situated at a predetermined distance in front of a grade separated crossing where a plurality of roads on which the plurality of moving objects 31 and 32 drive three-dimensionally cross each other.

[0021] Likewise, underpass crossing mark 22 is placed on an underpass road situated below the overpass road at the predetermined distance in front of the grade separated crossing.

[0022] In this case, "the predetermined distance" is a distance from overpass crossing mark 21 or underpass crossing mark 22 to the grade separated crossing where each collision prediction device 1 of moving objects 31 and 32 that cross the grade separated crossing can recognize overpass crossing mark 21 or underpass crossing mark 22 before each collision prediction device 1 predicts that moving objects 31 and 32 will collide with each other.

[0023] The forms of overpass crossing mark 21 and underpass crossing mark 22 can be arbitrary.

[0024] For example, overpass crossing mark 21 and underpass crossing mark 22 may be marks drawn, on the beds of roads.

[0025] Alternatively, overpass crossing mark 21 and underpass crossing mark 22 may be magnetic marks buried in the beds of roads using paint.

[0026] Further alternatively, as shown in Fig. 2, overpass transmission device 23 and underpass transmission device 24 may be provided on roads such that the former wirelessly transmits information that denotes that a grade separated crossing is present at the predetermined distance in front of moving object 31 or moving object 32 to moving object 31 or 32 that drives on an overpass road and the latter wirelessly transmits information that denotes that a grade separated crossing is present at the predetermined distance in front of moving object 31 or moving object 32 to moving object 31 or 32 that drives on an underpass road.

[0027] Alternatively, both overpass crossing mark 21 and underpass crossing mark 22 may be placed on roads. Further alternatively, as exemplified in Fig. 3, "mark MK" may be placed on either an overpass road situated as an upper road at the predetermined distance in front of a grade separated crossing or on a underpass road situated below the overpass road.

[0028] Collision prediction device 1 is provided in each of the plurality of moving objects 31 and 32. The number of moving objects and the number of collision prediction devices provided in each moving object can be arbitrary. Examples of "moving objects" include passenger automobiles, bicycles, robots, and users.

[0029] Collision prediction device 1 provided in moving object 31 detects overpass crossing mark 21 or underpass crossing mark 22. In addition, collision prediction device 1 transmits information, that denotes that the mark detected by itself is overpass crossing mark 21 or underpass crossing mark 22, to collision prediction device 1 provided in moving object 32. Then, collision prediction device 1 predicts whether a collision will take place based on the mark that the information transmitted from collision prediction device 1 provided in moving object 32 represents and based on the mark detected by itself.

[0030] Next, with reference to Fig. 4, the structure of collision prediction device 1 shown in Fig. 1 will be described. Since the structure of collision prediction device 1 provided in moving object 31 is the same as the structure of collision prediction device 1 provided in moving object 32, in the following, the structure of only collision prediction device 1 provided in moving object 31 will be described.

[0031] As shown in Fig. 4, collision prediction device 1 has acquisition section 11, detection section 12, communication section 13, prediction section 14, and notification section 15.

[0032] Acquisition section 11 acquires "information about its moving object" that is information with respect to its moving object (concerned moving object) 31 and outputs the information about its moving object to communication section 13 and prediction section 14.

[0033] Examples of information about its moving object include position information of the its moving object detected by a GPS function, speed information and steering angle information of the its moving object, and information detected by various types of sensors.

[0034] Detection section 12 can be generally called a detection means.

[0035] Detection section 12 is provided with a sensor that detects overpass crossing mark 21 and underpass crossing mark 22 Detection section 12 detects overpass crossing mark 21 and underpass crossing mark 22 based on information acquired by the sensor. Then, detection section 12 outputs information, that denotes the detected mark is either overpass crossing mark 21 or underpass crossing mark 22, to communication section 13.

[0036] If detection section 12 detects overpass crossing mark 21 or underpass crossing mark 22 based on the information transmitted from overpass transmission device 23 or underpass transmission device 24, the sensor is for example an electromagnetic wave receiver.

[0037] If detection section 12 detects overpass crossing mark 21 and underpass crossing mark 22 that are magnetic marks, the sensor is a magnetic sensor that detects magnetic marks.

[0038] If detection section 12 detects overpass crossing mark 21 and underpass crossing mark 22 that are

drawn on the beds of the roads, the sensor is an image sensor that detects images (for example, a camera according to a second embodiment that will be described later).

[0039] Communication section 13 can be generally called a communication means.

[0040] Communication section 13 transmits the information about its moving object that is output from acquisition section 11 and the information that denotes that the detected mark is either overpass crossing mark 21 or underpass crossing mark 22 and that is output from detection section 12 to collision prediction device 1 provided in other moving object 32 rather than its moving object 31.

[0041] In addition, communication section 13 outputs "information about other moving objects", that is transmitted from collision prediction device 1 provided in other moving object 32 and that is information with respect to other moving object 32 and outputs the information that denotes that the mark detected by collision prediction device 1 provided in other moving object 32 is overpass crossing mark 21 or underpass crossing mark 22, to prediction section 14.

[0042] Like the information about its moving object, examples of the information about other moving object include position information, speed information, and steering angle information of other moving object 32.

[0043] Prediction section 14 can be generally called a prediction means.

[0044] Prediction section 14 predicts whether or not its moving object 31 will collide with other moving object 32 based on the information about its moving object, the information about other moving object, and the detected result of overpass crossing mark 21 or underpass crossing mark 22.

[0045] According to this embodiment, if the mark that the information transmitted from collision prediction device 1 provided in moving object 32 represents is the same as the mark detected by detection section 12 and if the predicted position of moving object 31 predicted based on the information about its moving object matches the predicted position of moving object 32 predicted based on the information about other moving object, prediction section 14 predicts that there is a risk in which the plurality of moving objects 31 and 32 will collide with each other.

[0046] On the other hand, according to this embodiment, if the mark that the information transmitted from collision prediction device 1 provided in moving object 32 other than moving object 31 (concerned moving object) represents is different from the mark detected by detection section 12, prediction section 14 predicts that there is no risk in which the plurality of moving objects 31 and 32 will collide with each other.

[0047] If the information that represents the mark has not been transmitted from collision prediction device 1 provided in moving object 32 or detection section 12 of moving object 31 has not detected the mark and if the predicted position of moving object 31 predicted based on the information about its moving object matches the predicted position of moving object 32 predicted based on the information about other moving object, prediction section 14 predicts that there is a risk in which the plurality of moving objects 31 and 32 will collide with each other.

[0048] Notification section 15 notifies the driver for moving object 31 of "collision risk information" that includes information associated with a risk in which moving object 31 will collide with other moving object 32 based on the predicted result of a collision predicted by prediction section 14.

[0049] This collision risk information is an alert that notifies that it is likely that moving object 31 will collide with other moving object 32 or information that represents a predetermined evaluation index of a risk of a collision. The notification method that notification section 15 5 performs can be arbitrary. For example, notification section 15 may display the collision risk information on any display device including the monitor of a car navigation system or an instrument panel. Alternatively, notification section 15 may audibly output the collision risk information through a speaker or the like. Further alternatively, notification section 15 may notify the driver of a risk of a collision through a vibration mechanism.

[0050] Alternatively, notification section 15 may output the collision risk information to a predetermined control module that controls the driving state of the moving object (for example, the attitude, speed, and so forth of the moving object).

[0051] If the collision prediction system uses the mark MK shown in Fig. 3, communication section 13 transmits information, that denotes that detection section 12 has detected the mark MK, to collision prediction device 1 provided in other moving object 32.

[0052] In the example shown in Fig. 3, if the information that denotes that the mark MK has been detected has been transmitted from collision prediction device 1 provided in moving object 32 other than moving object 31 and if detection section 12 has not detected the mark MK or if the information that denotes that the mark MK has been detected has not been transmitted from collision prediction device 1 provided in other moving object 32 and if detection section 12 has detected the mark MK, prediction section 14 predicts that own moving object 31 will not collide with moving object 32 other than its moving object 31.

[0053] In the example shown in Fig. 3, prediction section 14 of collision prediction device 1 provided in moving object 31 may predict whether or not there is a risk in which moving object 31 will collide with moving object 32 depending on whether or not the information that denotes that the mark MK has been detected has been transmitted from other moving object 32 after detection section 12 detects the mark MK until a predetermined time period elapses. This can prevent prediction section 14 of collision prediction device 1 provided in moving object 32 from predicting that moving object 31 and moving object

32 will not collide with each other although they will collide with each other if collision prediction device 1 provided in moving object 32 detects the mark MK and transmits the information that represents the detection of the mark MK after collision prediction device 1 provided in moving object 31 detects the mark MK until the predetermined time period elapses.

[0054] Alternatively, prediction section 14 of collision prediction device 1 provided in moving object 31 may predict whether or not there is a risk in which moving object 31 and moving object 32 will collide with each other depending on whether or not detection section 12 has detected the mark MK after the information that represents the detection of the mark MK is transmitted from collision prediction device 1 provided in moving object 32 until a predetermined time elapses. This can prevent prediction section 14 of collision prediction device 1 provided in moving object 31 from predicting that moving object 31 and moving object 32 will not collide with each other although they will collide with each other if collision prediction device 1 provided in moving object 31 has detected mark MK after information that represents the detection of mark MK is transmitted from collision prediction device 1 provided in moving object 32 until a predetermined time period elapses.

[0055] In the following, the case in which moving objects 31 and 32 pass through a grade separated crossing composed of an underpass road situated on the ground and an overhead road situated above the underpass road will be described.

[0056] In the example shown in Fig. 1, overpass crossing mark 21 is painted on the bed of the overpass road at the predetermined distance in front of the grade separated crossing. In this example, detection section 12 is provided with a camera as a sensor.

[0057] Detection section 12 of collision prediction device 1 provided in moving object 31 analyzes an image captured by the camera at the predetermined distance in front of the grade separated crossing so as to detect overpass crossing mark 21. Thus, detection section 12 recognizes that moving object 31 is driving on the overpass road.

[0058] In this case, collision prediction device 1 provided in moving object 31 transmits the information that denotes that moving object 31 has detected overpass crossing mark 21 to collision prediction device 1 provided in moving object 32 that is driving on the underpass road. In addition, collision prediction device 1 provided in moving object 31 receives the information that denotes that collision prediction device 1 provided in moving object 32 has detected underpass crossing mark 22 from collision prediction device 1 provided in moving object 32. In other words, collision prediction device 1 provided in each of moving object 31 and moving object 32 transmits the information that denotes that it has detected overpass crossing mark 21 or underpass crossing mark 22 to collision prediction device 1 provided in the other moving object. Thus, both collision prediction devices 1 of moving objects 31 and 32 can accurately determine that moving objects 31 and 32 are driving on different roads at the grade separated crossing.

[0059] Next, with reference to a flow chart shown in Fig. 5, an operation of collision prediction device 1 that is provided in moving object 31 having the above-described structure and that predicts whether or not the plurality of moving objects 31 and 32 will collide with each other will be described.

[0060] First, detection section 12 detects overpass crossing mark 21 or underpass crossing mark 22 through the sensor at step 401. Then, detection section 12 outputs information that denotes whether the detected mark is overpass crossing mark 21 or underpass crossing mark 22 to communication section 13.

[0061] Next, acquisition section 11 acquires information about own moving object at step 402.

[0062] Then, communication section 13 transmits information that denotes whether the detected mark is overpass crossing mark 21 or underpass crossing mark 22 and the information about its moving object to collision prediction device 1 provided in other moving object 32 at step 403.

[0063] Then, communication section 13 receives the information about other moving object from collision prediction device 1 provided in other moving object 32 at step 404. If other moving object 32 is not present in a predetermined range based on moving object 31, collision prediction device 1 completes the process at step 405.

[0064] In contrast, if other moving object 32 is present in the predetermined range, prediction section 14 determines whether or not there is a risk in which its moving object 31 and other moving object 32 will collide with each other at step 406.

[0065] If the mark that the information transmitted from collision prediction device 1 provided in moving object 32 represents is different from the mark detected by detection section 12, prediction section 14 predicts that moving object 31 and moving object 32 will not collide with each other at step 406. In this case, collision prediction device 1 completes the process.

[0066] If the mark that the information transmitted from collision prediction device 1 provided in moving object 32 represents is the same as the mark detected by detection section 12 and the predicted position of moving object 31 predicted based on the information about its moving object matches the predicted position of moving object 32 predicted based on the information about other moving object, prediction section 14 predicts that there is a risk in which moving objects 31 and 32 will collide with each other at step 406.

[0067] If information that represents the mark has not been transmitted from collision prediction device 1 provided in moving object 32 or if detection section 12 has not detected the mark at step 406 and if the predicted position of moving object 31 predicted based on the information of its moving object matches the predicted po-

sition of moving object 32 predicted based on the information about other moving object, prediction section 14 predicts that there is a risk in which the plurality of moving objects 31 and 32 will collide with each other.

[0068] If prediction section 14 predicts that there is a risk in which moving object 31 and other moving object 32 will collide with each other, notification section 15 notifies the driver or a predetermined control module that controls the driving state of moving object 31 of the collision risk information. Thereafter, collision prediction device 1 according to the first embodiment completes the operation that predicts whether or not a plurality of moving objects will collide with each other.

[0069] As described above, according to the first embodiment, overpass crossing mark 21 that represents an overpass road at a grade separated crossing and underpass crossing mark 22 that represents an underpass road at the grade separated crossing are placed in advance. One moving object detects a mark on a road and communicates with other moving object and thereby collision prediction devices 1 provided in the plurality of moving objects share the information therebetween through communication.

[0070] Overpass crossing mark 21 and underpass crossing mark 22 according to the present invention are magnetic marks, information that denotes that overpass crossing mark 21 transmitted from overpass transmission device 23 shown in Fig. 2 is present, or information that denotes that underpass crossing mark 22 transmitted from underpass transmission device 24 is present.

[0071] Thus, according to the first embodiment, when a moving object passes through a grade separated crossing, a correct collision prediction result can be obtained. In addition, according to the first embodiment, even if a grade separated crossing cannot be recognized based on an image captured by the camera, a correct collision prediction result can be obtained.

[0072] Moreover, according to the first embodiment, overpass crossing mark 21 and underpass crossing mark 22 are placed at appropriate positions and thereby whether or not moving objects 31 and 32 will collide with each other can be predicted at an appropriate timing and with high accuracy.

(Second Embodiment)

[0073] Next, a collision prediction system according to a second embodiment will be described.

[0074] According to the second embodiment, as shown in Fig. 6, overpass crossing marks are placed at both the entrance and exit of an overpass road at a grade separated crossing. Likewise, underpass crossing marks are placed at both the entrance and exit of an underpass road at the grade separated crossing.

[0075] In the example shown in Fig. 6, moving object 31 is driving on the overpass road toward the grade separated crossing. In addition, other moving object 32 is driving on the underpass road toward the grade separated crossing.

[0076] Overpass crossing mark 211 that denotes that the grade separated crossing is present at a predetermined distance in front of moving object 31 or 32 and overpass crossing mark 212 that denotes that the grade separated crossing is present at the predetermined distance behind moving object 31 or 32 are painted on the bed of the overpass road.

[0077] Likewise, underpass crossing mark 221 that denotes that the grade separated crossing is present at the predetermined distance in front of moving object 31 or 32 and underpass crossing mark 222 that denotes that the grade separated crossing is present at the predetermined distance behind moving object 31 or 32 are painted on the bed of the underpass road.

[0078] If the collision prediction system is provided with overpass transmission devices 23 and underpass transmission devices 24, overpass transmission device 23 that transmits the information that denotes that the grade separated crossing is present at the predetermined distance in front of moving object 31 or 32 to moving object 31 or 32 that drives on the overpass road and overpass transmission device 23 that transmits information that denotes that the grade separated crossing is present at the predetermined distance behind the moving object 31 or 32 to moving object 31 or 32 that drives on the overpass road are provided on the overpass road.

[0079] Likewise, underpass transmission device 24 that transmits information that denotes that the grade separated crossing is present at the predetermined distance in front of moving object 31 or moving object 32 to moving object 31 or 32 that drives on the underpass road and underpass transmission device 24 that transmits information that denotes that the grade separated crossing is present at the predetermined distance behind moving object 31 or 32 to moving object 31 or 32 that drives on the underpass road are provided on the underpass road.

[0080] In the example shown in Fig. 3, marks MS that are different from each other may be placed on either an overpass road or an underpass road at the predetermined distance in front of and behind the grade separated crossing, respectively.

[0081] In addition, as shown in Fig. 7, moving object 31 is provided with camera 33 having a fixed image capturing direction that is the same as the driving direction of moving object 31. Camera 33 captures an image of the bed of the road in the driving direction of moving object 31.

[0082] Next, with reference to Fig. 8, the structure of collision prediction device 1 according to the second embodiment will be described.

[0083] As shown in Fig. 8, collision prediction device 1 according to the second embodiment is different from collision prediction device 1 shown in Fig. 4 in that the former has detection section 12A instead of detection section 12; and prediction section 14A instead of prediction section 14. Detection section 12A can be generally called a detection means. Likewise, prediction section

14A can be generally called a prediction means.

[0084] In the following, the structure of detection section 12A will be described in detail. As shown in Fig. 9, detection section 12A has camera 33 shown in Fig. 7 as a sensor.

[0085] In other words, detection section 12A detects overpass crossing mark 21 or underpass crossing mark 22 based on an image in which camera 33 captures the bed of the road behind moving object 31 and outputs information that denotes whether moving object 31 is driving on the overpass road at the grade separated crossing or on the underpass road at the grade separated crossing.

[0086] As shown in Fig. 9, in addition to camera 33, detection section 12A has image input section 121, bird's eye view image generation section 122, template database 123, mark identification section 124, and grade separated crossing driving information output section 125.

[0087] Image input section 121 converts an original image that camera 33 captures and outputs into a digital format image and then outputs the resultant image to bird's eye view image generation section 122.

[0088] Bird's eye view image generation section 122 converts an image of a subject (road) viewed from moving object 31 that is driving on the road into a bird's eye view image that is an elevated view image of the subject. Then, bird's eye view image generation section 122 outputs the bird's eye view to mark identification section 124. The method that converts an image captured by camera 33 into a bird's eye view image can be arbitrary as disclosed in Japan Patent Application No. 2008-271813, Specification.

[0089] Template database 123 stores image patterns of bird's eye view images of overpass crossing mark 21 and underpass crossing mark 22 as templates. Examples of templates include marks formed of repetitive patterns containing elements such as slant lines or curved lines other than segments parallel to the road as shown in Fig. 10 or Fig. 11.

[0090] Mark identification section 124 shown in Fig. 9 identifies overpass crossing mark 21 or underpass crossing mark 22 contained in bird's eye view images according to template matching using template database 123. The template matching can be an ordinary template matching method.

[0091] If mark identification section 124 identifies overpass crossing mark 21 placed on the entrance side of the grade separated crossing, mark identification section 124 notifies grade separated crossing information output section 125 that the mark has been identified.

[0092] If mark identification section 124 identifies overpass crossing mark 21 placed on the entrance side of the grade separated crossing and then overpass crossing mark 21 placed on the exit side thereof, mark identification section 124 notifies grade separated crossing information output section 125 that the marks have been identified.

[0093] If grade separated crossing information output section 125 is notified by mark identification section 124 that mark identification section 124 has identified overpass crossing mark 21 placed on the entrance side of the grade separated crossing, grade separated crossing information output section 125 outputs elevated pass driving information that denotes that moving object 31 is driving on the overpass road (elevated side) at the grade separated crossing to communication section 13 and prediction section 14A.

[0094] If grade separated crossing information output section 125 is notified by mark identification section 124 that mark identification section 124 has identified overpass crossing mark 21 placed on the exit side, grade separated crossing information output section 125 stops outputting the elevated pass driving information.

[0095] In the example shown in Fig. 3, if marks MK that are different from each other are placed on either the overpass road or the underpass road at the predetermined distance in front of and behind the grade separated crossing, detection section 12A recognizes the start or the end of driving by moving object 31 on the overpass road or underpass road on which the marks MK are placed based on the detection of the marks MK that are different from each other.

[0096] Communication section 13 according to the second embodiment transmits elevated pass driving information that is output from grade separated crossing information output section 125 to collision prediction device 1 provided in other moving object 32. In addition, communication section 13 outputs elevated pass driving information that is associated with moving object 32 and that is transmitted from collision prediction device 1 provided in other moving object 32 to prediction section 14A.

[0097] Next, with reference to Fig. 12, the structure of prediction section 14A will be described in detail. As shown in Fig. 12, prediction section 14A has other moving object position prediction section 141, own moving object position prediction section 142, analysis section 143, and collision determination section 144.

[0098] Other moving object position prediction section 141 predicts the position of other moving object 32 after the present time based on the information about other moving object transmitted from collision prediction device 1 provided in other moving object 32. In this prediction, the position of other moving object 32 that is advanced from the current position by a predicted driving distance obtained by multiplying the speed of moving object 32 at the present time by the elapsed time between the present time and a predetermined time thereafter in the driving direction of moving object 32 computed from the steering angle information of moving object 32 at the present time can be the predicted position at the predetermined time. The method that predicts the position of other moving object 32 after the present time can be arbitrary as long as the position of moving object 32 is predicted based on the information about other moving object at the present time and past time.

[0099] Own moving object position prediction section

142 predicts the position of its moving object 31 after the present time based on the information about its moving object that is output from acquisition section 11. The method that predicts the position of moving object 31 after the current time can be arbitrary as long as the position of moving object 31 is predicted based on the information about its moving object at the present time and past time.

[0100] Analysis section 143 determines whether either its moving object 31 or other moving object 32 is driving on an elevated pass based on the elevated pass driving information that is associated with moving object 31 and that is output from grade separated crossing information output section 125 and the elevated pass driving information that is associated with other moving object 32 and that is transmitted from communication section 13. If analysis section 143 determines that either moving object 31 or moving object 32 is not driving on the elevated pass, analysis section 143 notifies collision determination section 144 of this state.

[0101] Collision determination section 144 compares the predicted position of its moving object 31 predicted by own moving object position prediction section 142 with the predicted position of moving object 32 predicted by other moving object position prediction section 141.

[0102] Then, if the compared result denotes that the predicted position of moving object 31 matches the predicted position of moving object 32, when collision determination section 144 is notified by analysis section 143 of information that denotes that either moving object 31 or moving object 32 is not driving on the elevated pass, collision determination section 144 determines that there is a risk in which its moving object 31 and other moving object 32 will collide with each other.

[0103] If the elevated pass driving information has not been transmitted from collision prediction device 1 provided in moving object 32 or the elevated pass driving information has not been output from grade separated crossing information output section 125 and the predicted position of moving object 31 matches the predicted position of moving object 32, collision determination section 144 determines that there is a risk in which moving objects 31 and 32 will collide with each other.

[0104] If collision determination section 144 determines that there is a risk in which a collision will occur, collision determination section 144 notifies notification section 15 of the risk. Then, notification section 15 notifies the driver for moving object 31 of the collision risk information.

[0105] In the example shown in Fig. 3, if marks MK that are different from each other are placed on either the overpass road or underpass road at a predetermined distance in front of and behind the grade separated crossing, prediction section 14A predicts a collision based on the start or the end of driving by moving object 31 on the overpass road or underpass road on which the marks MK are placed. More specifically, prediction section 14A of collision prediction device 1 provided in moving object 31 may predict whether or not there is a risk in which moving object 31 and moving object 32 will collide with each other depending on whether or not the information that denotes that other moving object 32 has started driving on the overpass road or underpass road on which the marks MK are placed has been transmitted from other moving object 32 after detection section 12A recognizes that moving object 31 has started driving on the overpass road or underpass road on which the marks MK are placed until it recognizes that moving object 31 has stopped driving. Alternatively, prediction section 14A of collision prediction device 1 provided in moving object 31 may predict whether or not there is a risk in which moving object 31 and moving object 32 will collide with each other depending on whether or not detection section 12A recognizes that moving object 31 has started driving on the overpass road or underpass road on which the marks MK are placed after information that denotes that moving object 32 has started driving on the overpass road or underpass road on which the marks MK are placed is transmitted from collision prediction device 1 provided in moving object 32 until the information that denotes that the moving object 32 has stopped driving is transmitted.

[0106] Next, with reference to Fig. 13, the operation of collision prediction device 1 according to the second embodiment that predicts whether or not a plurality of moving objects will collide with each other will be described in detail. In the following description, it is assumed that camera 33 captures images of the bed of the road at predetermined intervals and outputs the captured images to image input section 121.

[0107] Then, as shown in Fig. 13, image input section 121 converts the images that camera 33 has captured and outputs into digital format images and then outputs the converted images to bird's eye view image generation section 122 at step 501.

[0108] Then, bird's eye view image generation section 122 converts images of the road viewed from moving object 31 that is driving on the road into bird's eye view images that are elevated view images of the road and then outputs the converted images to mark identification section 124 at step 502.

[0109] Then, mark identification section 124 identifies overpass crossing mark 21 or underpass crossing mark 22 contained in the bird's eye view images that are output from bird's eye view image generation section 122 according to the template matching based on templates stored in template database 123 at step 503.

[0110] Then, if mark identification section 124 identifies overpass crossing mark 21 placed on the entrance side of the grade separated crossing, mark identification section 124 notifies grade separated crossing information output section 125 that overpass crossing mark 21 has been identified at step 504.

[0111] Then, grade separated crossing information output section 125 outputs the elevated pass driving information that denotes that moving object 31 is driving

on the overpass road at the grade separated crossing to communication section 13 and prediction section 14A at step 505. Then, communication section 13 transmits the elevated pass driving information to collision prediction device 1 provided in other moving object 32 at step 506.

[0112] Then, other moving object position prediction section 141 predicts the position of other moving object 32 after the present time based on the information about other moving object transmitted from collision prediction device 1 provided in other moving object 32 at step 507.

[0113] Then, own moving object position prediction section 142 predicts the position of its moving object 31 after the present time based on the information about its moving object that is output from acquisition section 11 at step 508.

[0114] Then, at step 509, analysis section 143 determines whether either its moving object 31 or other moving object 32 is driving on the elevated pass based on the elevated pass driving information that is associated with its moving object 31 and that is output from grade separated crossing information output section 125 at step 505 and the elevated pass driving information that is associated with other moving object 32 and that is transmitted from communication section 13.

[0115] If analysis section 143 determines that either moving object 31 or moving object 32 is not driving on the elevated path, analysis section 143 notifies collision determination section 144 of this state.

[0116] Then, collision determination section 144 compares the predicted position of its moving object 31 predicted by its moving object position prediction section 142 with the predicted position of other moving object 32 predicted by other moving object position prediction section 141 at step 510.

[0117] If the compared result denotes that the predicted position of moving object 31 matches the predicted position of moving object 32 and collision determination section 144 is notified by analysis section 143 of information that denotes that either moving object 31 or moving object 32 is not driving on the elevated pass, collision determination section 144 determines that there is a risk in which its moving object 31 and other moving object 32 will collide with each other. If the determined result denotes that there is a risk of collision, collision determination section 144 notifies notification section 15 of the risk.

[0118] If the elevated pass driving information has not been transmitted from collision prediction device 1 provided in other moving object 32 or if the elevated pass driving information has not been output from grade separated crossing information output section 125 and if the predicted position of moving object 31 matches the predicted position of other moving object 32, collision determination section 144 determines that there is a risk in which moving objects 31 and 32 will collide with each other at step 510.

[0119] Then, notification section 15 notifies the driver for moving object 31 of the collision risk information containing information associated with a risk in which moving object 31 will collide with other moving object 32. Thereafter, collision prediction device 1 according to the second embodiment completes the series of operations that predict whether or not the plurality of moving objects 31 and 32 will collide with each other.

[0120] As described above, according to the second embodiment, an image of overpass crossing mark 21 and underpass crossing mark 22 having predetermined forms placed on the beds are captured by camera 33 and the images are analyzed and thereby can be determined whether its moving object is driving on the overpass road or underpass road. Thus, the overpass road or underpass road can be more easily detected than by using the ordinary technique that identifies a road structure based on a captured image of the grade separated crossing and determines the overpass road or underpass road based on the identified road structure.

[0121] Besides the above-described dedicated hardware that accomplishes the process of collision prediction device 1, they may be accomplished in such a manner that a program that accomplishes the functions is recorded to a recording medium that collision prediction device 1 can read, collision prediction device 1 is caused to read the program from the recording medium, and then the program is executed. Examples of the recording mediums readable by collision prediction device 1 include removable recording mediums, such as a floppy disk (registered trademark), a magneto-optical disc, a DVD, and a CD, and an HDD built in collision prediction device 1. The program recorded to the recording medium is read by for example detection section 12 and prediction section 14 with which collision prediction device 1 is provided and the same processes as those described above are performed under the control of detection section 12 and prediction section 14.

[0122] Here, detection section 12 and prediction section 14 with which collision prediction device 1 is provided operate as a computer that executes the program that is read from the recording medium.

[0123] Now, with reference to the embodiments, the present invention has been described. However, it should be understood by those skilled in the art that the structure and details of the present invention may be changed in various manners without departing from the spirit of the present invention.

[0124] The present application claims a priority based on Japan Patent Application JP 2009-088959 filed on April 1, 2009, the entire contents of which are incorporated herein by reference in its entirety.

DESCRIPTION OF REFERENCE NUMERALS

[0125]

1	Collision prediction device
11	Acquisition section
12	Detection section
121	Image input section

122	Bird's eye view image generation section
123	Template database
124	Mark identification section
125	Grade separated crossing driving information output section
13	Communication section
14	Prediction section
141	Other moving object position prediction section
142	Own moving object position prediction section
143	Analysis section
144	Collision determination section
15	Notification section
2	Information processing device
21, 211, 212	Overpass crossing mark
22, 221, 222	Underpass crossing mark
23	Overpass transmission device
24	Underpass transmission device
31, 32	Moving object
33	Camera

Claims

1. A collision prediction system, comprising:

a collision prediction device that is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects; and

a mark placed on either an overpass road or an underpass road situated below the overpass road at a predetermined distance in front of a grade separated crossing where the overpass road and the underpass road on which said plurality of moving objects run three-dimensionally cross each other,

wherein said collision prediction device includes:

detection means that detects said mark;

communication means that transmits information that denotes that said detection means has detected said mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and

prediction means that predicts that said concerned moving object and the moving objects other than the concerned moving object will not collide with each other, if the information that denotes that said mark has been detected has been transmitted from said collision prediction device provided in the moving object other than said concerned moving object, and if said detection means has not detected said mark or if information that denotes that said mark has been detected has not been transmitted from said collision prediction device provided in the moving object other than said concerned moving object and if said detection means has detected said mark.

2. The collision prediction system as set forth in claim 1, wherein said marks are placed on either said overpass road or on said underpass road at said predetermined distance in front of and behind said grade separated crossing, the marks being different from each other,

wherein said detection means recognizes the start or the end of driving by said concerned moving object on said overpass road or said underpass road on which said marks are placed based on the detection of said different marks, and

wherein said prediction means predicts that said concerned moving object and the moving object other than the concerned moving object will not collide with each other after said start of driving by said plurality of moving objects on said overpass road or on said underpass road is recognized until said end is recognized.

3. A collision prediction system, comprising:

a collision prediction device that is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects;

an overpass crossing mark that is a mark placed on an overpass road at a predetermined distance in front of a grade separated crossing where a plurality of roads on which said plurality of moving objects drive three-dimensionally cross each other; and

an underpass crossing mark that is a mark placed on an underpass road situated below said overpass road at the predetermined distance in front of said grade separated crossing,

wherein said collision prediction device includes:

detection means that detects said mark;

communication means that transmits information that denotes that the mark detected by said detection means is said overpass crossing mark or is said underpass crossing mark to the collision prediction device pro-

vided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and

prediction means that predicts the collision based on the mark that the information transmitted from said collision prediction device provided in the moving object other than said concerned moving object represents and based on the mark detected by said detection means.

4. The collision prediction system as set forth in claim 3, wherein said prediction means predicts that said concerned moving object and said moving object that is provided with said collision prediction device that has transmitted the information that represents said mark will not collide with each other if the mark that the information that was transmitted from said collision prediction device provided in the moving object other than said concerned moving object is different from the mark detected by said detection means.

5. The collision prediction system as set forth in claim 3 or 4,

wherein said roads are provided with an overpass transmission device that transmits information that denotes that said grade separated crossing is present at said predetermined distance in front of the moving object that is driving on said overpass road, and are provide with an underpass transmission device that transmits information that denotes that said grade separated crossing is present at said predetermined distance in front of the moving object that is driving on said underpass road, and

wherein said detection means detects the overpass crossing mark based on the information received from said overpass transmission device and detects the underpass crossing mark based on the information received from said underpass transmission device.

6. The collision prediction system as set forth in any one of claims 1 to 4,

wherein said marks are magnetic marks buried in beds of said roads, and

wherein said detection means uses a magnetic sensor so as to detect said marks.

7. The collision prediction system as set forth in any one of claims 1 to 4,

wherein said marks are marks drawn on beds of said roads,

wherein said detection means uses an image sensor so as to detect said marks.

8. The collision prediction system as set forth in any one of claims 3 to 5,

wherein said overpass crossing marks are placed on said overpass road at said predetermined distance in front of and behind said grade separated crossing, the overpass crossing marks being different from each other, wherein said underpass crossing marks are placed on said underpass road at said predetermined distance in front of and behind said grade separated crossing, the underpass crossing marks being different from each other,

wherein said detection means recognizes the start or the end of driving by said concerned moving object on said overpass road based on the detection of said different overpass crossing marks and recognizes the start or the end of driving by the concerned moving object based on the detection of said different underpass crossing marks, and

wherein said prediction means predicts that said concerned moving object and the moving object other than the concerned moving object will not collide with each other after said start of driving by said plurality of moving objects on said overpass road or said underpass road is recognized until said end is recognized.

9. A collision prediction device that is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects, comprising:

detection means that detects a mark placed on either an overpass road or an underpass road situated below the overpass road at a predetermined distance in front of a grade separated crossing where the overpass road and the underpass road on which said plurality of moving objects drive three-dimensionally cross each other;

communication means that transmits information that denotes that said detection means has detected said mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and

prediction means that predicts that said concerned moving object and the moving objects other than the concerned moving object will not collide with each other, if the information that denotes that said mark has been detected has been transmitted from said collision prediction device provided in the moving object other than said concerned moving object, and if said detection means has not detected said mark or if the information that denotes that said mark has been detected has not been transmitted from

said collision prediction device provided in the moving object other than said concerned moving object and if said detection means has detected said mark.

10. The collision prediction device as set forth in claim 9, wherein said detection means recognizes the start or the end of driving by said concerned moving object on said overpass road or said underpass road on which said marks are placed based on a detection of the marks that are placed on either said overpass road or on said underpass road at said predetermined distance in front of and behind said grade separated crossing, the marks being different from each other,
wherein said prediction means predicts that said concerned moving object and the moving object other than the concerned moving object will not collide with each other after the start of driving by said plurality of moving objects on said overpass road or on said underpass road on which said marks are placed is recognized until said end is recognized.

11. A collision prediction device that is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects, comprising:

detection means that detects an overpass crossing mark that is a mark placed on an overpass road at a predetermined distance in front of a grade separated crossing where a plurality of roads on which said plurality of moving objects drive three-dimensionally cross each other or on an underpass crossing mark that is a mark placed on an underpass road situated below said overpass road at the predetermined distance in front of said grade separated crossing;
communication means that transmits information that denotes that the mark detected by said detection means is said overpass crossing mark or is said underpass crossing mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and
prediction means that predicts the collision based on the mark that the information transmitted from said collision prediction device provided in the moving object other than said concerned moving object represents and based on the mark detected by said detection means.

12. The collision prediction device as set forth in claim 11,
wherein said prediction means predicts that said concerned moving object and said moving object that is provided with said collision prediction device that has transmitted the information that represents said mark will not collide with each other if the mark that the information transmitted from said collision prediction device provided in the moving object other than said concerned moving object is different from the mark detected by said detection means.

13. The collision prediction device as set forth in claim 11 or 12,
wherein said detection means detects said overpass crossing mark based on the information received from said overpass transmission device provided on said overpass road and detects the underpass crossing mark based on the information received from said underpass transmission device provided on said underpass road.

14. The collision prediction device as set forth in any one of claims 9 to 12,
wherein said detection means uses a magnetic sensor so as to detect said marks that are magnetic marks buried in beds of said roads.

15. The collision prediction device as set forth in any one of claims 9 to 12,
wherein said detection means uses an image sensor so as to detect said marks that are marks drawn on beds of said roads.

16. The collision prediction device as set forth in any one of claims 11 to 15,
wherein said detection means recognizes start or end of driving by said concerned moving object on said overpass road based on a detection of overpass crossing marks that are placed on said overpass road at said predetermined distance in front of and behind said grade separated crossing, the overpass crossing marks being different from each other and recognizes start or end of driving by the concerned moving object based on a detection of said underpass crossing marks that are placed on said underpass road at said predetermined distance in front of and behind said grade separated crossing, the underpass crossing marks being different from each other,
wherein said prediction means predicts that said concerned moving object and the moving object other than the concerned moving object will not collide with each other after said start of driving by said plurality of moving objects on said overpass road or on said underpass road is recognized until said end is recognized.

17. A collision prediction method for a collision prediction device that predicts whether or not the plurality of moving objects will collide with each other based on

position information and speed information of the plurality of moving objects, comprising:

detecting a mark placed on either an overpass road or an underpass road situated below the overpass road at a predetermined distance in front of a grade separated crossing where the overpass road and the underpass road on which said plurality of moving objects drive three-dimensionally cross each other;
transmitting information that denotes that said mark has been detected to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and
predicting that said concerned moving object and the moving objects other than the concerned moving object will not collide with each other, if the information that denotes that said mark has been detected has been transmitted from said collision prediction device provided in the moving object other than said concerned moving object, and if said mark has not been detected or if the information that denotes that said mark has been detected has not been transmitted from said collision prediction device provided in the moving object other than said concerned moving object and if said mark has been detected.

18. The collision prediction method as set forth in claim 17,
wherein detecting said mark includes recognizing start or end of driving by said concerned moving object on said overpass road or on said underpass road on which said marks are placed based on a detection of the marks that are placed on either said overpass road or on said underpass road at said predetermined distance in front of and behind said grade separated crossing, the marks being different from each other,
wherein predicting that said concerned moving object and the moving object other than the concerned moving object will not collide with each other includes predicting that said concerned moving object and the moving object other than the concerned moving object will not collide with each other after said start of driving by said plurality of moving objects on said overpass road or on said underpass road on which said marks are placed is recognized until said end is recognized.

19. A collision prediction method for a collision prediction device that predicts whether or not a plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects, comprising:

detecting an overpass crossing mark that is a mark placed on an overpass road at a predetermined distance in front of a grade separated crossing where a plurality of roads on which said plurality of moving objects drive three-dimensionally cross each other or on an underpass crossing mark that is a mark placed on an underpass road situated below said overpass road at the predetermined distance in front of said grade separated crossing;
transmitting information that denotes that said detected mark is said overpass crossing mark or said underpass crossing mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and
predicting the collision based on the mark that the information transmitted from the moving object other than said concerned moving object represents and based on said detected mark.

20. The collision prediction method as set forth in claim 19,
wherein predicting the collision based on the mark that the information transmitted from the moving object other than said concerned moving object represents and based on said detected mark including predicting that said concerned moving object and said moving object that is provided with said collision prediction device that has transmitted the information that represents said mark will not collide with each other if the mark that the information transmitted from said collision prediction device provided in the moving object other than said concerned moving object is different from said detected mark.

21. The collision prediction method as set forth in claim 19 or 20,
wherein predicting the collision based on the mark that the information transmitted from said collision prediction device provided in the moving object other than said concerned moving object represents and based on said detected mark including detecting said overpass crossing mark based on the information received from said overpass transmission device provided on said overpass road and detecting said underpass crossing mark based on the information received from said underpass transmission device provided in said underpass road.

22. The collision prediction method as set forth in any one of claims 17 to 20,
wherein detecting said marks includes using a magnetic sensor so as to detect said marks that are magnetic marks buried in beds of said roads.

23. The collision prediction method as set forth in any

one of claims 17 to 20,
wherein detecting said marks includes using an image sensor so as to detect said marks that are marks drawn on beds of said roads.

24. The collision prediction method as set forth in any one of claims 19 to 23,
wherein detecting said marks includes recognizing start or end of driving by said concerned moving object on said overpass road based on a detection of overpass crossing marks that are placed on said overpass road at said predetermined distance in front of and behind said grade separated crossing, the overpass crossing marks being different from each other, and recognizing start or end of driving by the concerned moving object based on a detection of said underpass crossing marks that are placed on said underpass road at said predetermined distance in front of and behind said grade separated crossing, the underpass crossing marks being different from each other,
wherein predicting that said concerned moving object and the moving object other than the concerned moving object will not collide with each other including predicting that said concerned moving object and the moving object other than the concerned moving object will not collide with each other after said start of driving by said plurality of moving objects on said overpass road or on said underpass road is recognized until said end is recognized.

25. A computer readable recording medium that records a program that causes a collision prediction device that is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects to execute procedures, comprising:

a detection procedure that detects a mark placed on either an overpass road or on an underpass road situated below the overpass road at a predetermined distance in front of a grade separated crossing where the overpass road and the underpass road on which said plurality of moving objects drive three-dimensionally cross each other;
a communication procedure that transmits information that denotes that said detection procedure has detected said mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects; and
a prediction procedure that predicts that said concerned moving object and the moving objects other than the concerned moving object will not collide with each other, if the information that denotes that said mark has been detected has been transmitted from said collision prediction device provided in the moving object other than said concerned moving object, and if said detection procedure has not detected said mark or if the information that denotes that said mark has been detected has not been transmitted from said collision prediction device provided in the moving object other than said concerned moving object and if said detection procedure has detected said mark.

26. The recording medium as set forth in claim 25,
wherein said detection procedure recognizes start or end of driving by said concerned moving object on said overpass road or on said underpass road on which said marks are placed based on a detection of the marks that are placed on either said overpass road or on said underpass road at said predetermined distance in front of and behind said grade separated crossing, the marks being different from each other,
wherein said prediction procedure predicts that said concerned moving object and the moving object other than the concerned moving object will not collide with each other after said start of driving by said plurality of moving objects on said overpass road or on said underpass road on which said marks are placed is recognized until said end is recognized.

27. A computer readable recording medium that records a program that causes a collision prediction device that is provided in each of a plurality of moving objects and that predicts whether or not the plurality of moving objects will collide with each other based on position information and speed information of the plurality of moving objects to execute procedures, comprising:

a detection procedure that detects an overpass crossing mark that is a mark placed on an overpass road at a predetermined distance in front of a grade separated crossing where a plurality of roads on which said plurality of moving objects drive three-dimensionally cross each other or an underpass crossing mark that is a mark placed on an underpass road situated below said overpass road at the predetermined distance in front of said grade separated crossing;
a communication procedure that transmits information that denotes that the mark detected by said detection procedure is said overpass crossing mark or is said underpass crossing mark to the collision prediction device provided in the moving object other than the concerned moving object that is provided with the collision prediction device of said plurality of moving objects;

and

a prediction procedure that predicts the collision based on the mark that the information transmitted from said collision prediction device provided in the moving object other than said concerned moving object represents and based on the mark detected by said detection procedure.

28. The recording medium as set forth in claim 27, wherein said prediction procedure predicts that said concerned moving object and said moving object that is provided with said collision prediction device that has transmitted the information that represents said mark will not collide with each other if the mark that the information transmitted from said collision prediction device provided in the moving object other than said concerned moving object is different from the mark detected by said detection procedure.

29. The recording medium as set forth in claim 27 or 28, wherein said detection procedure detects said overpass crossing mark based on the information received from said overpass transmission device provided on said overpass road and detects said underpass crossing mark based on the information received from said underpass transmission device provided on said underpass road.

30. The recording medium as set forth in any one of claims 25 to28, wherein said detection procedure uses a magnetic sensor so as to detect said marks that are magnetic marks buried in beds of said roads.

31. The recording medium as set forth in any one of claims 25 to 28, wherein said detection procedure uses an image sensor so as to detect said marks that are marks drawn on beds of said roads.

32. The recording medium as set forth in any one of claims 27 to 31, wherein said detection procedure recognizes start or end of driving by said concerned moving object on said overpass road based on a detection of overpass crossing marks that are placed on said overpass road at said predetermined distance in front of and behind said grade separated crossing, the overpass crossing marks being different from each other and recognizes start or end of driving by the concerned moving object based on a detection of underpass crossing marks that are placed on said underpass road at said predetermined distance in front of and behind said grade separated crossing, the underpass crossing marks being different from each other,

wherein said prediction procedure predicts that said concerned moving object and the moving object other than the concerned moving object will not collide with each other after said start of driving by said plurality of moving objects on said overpass road or on said underpass road is recognized until said end is recognized.

Fig.1

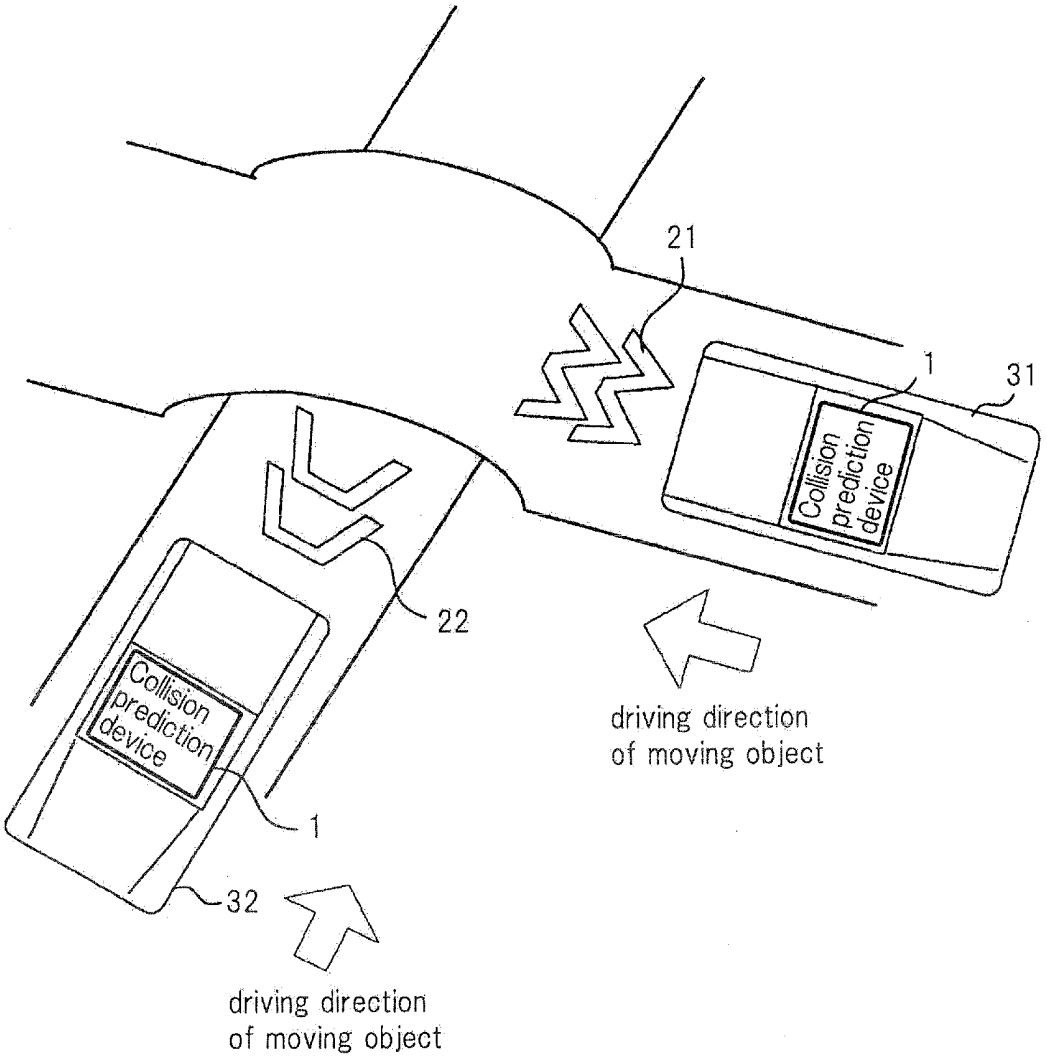

21
1
31
Collision prediction device
22
Collision prediction device
1
32
driving direction of moving object
driving direction of moving object

Fig.2

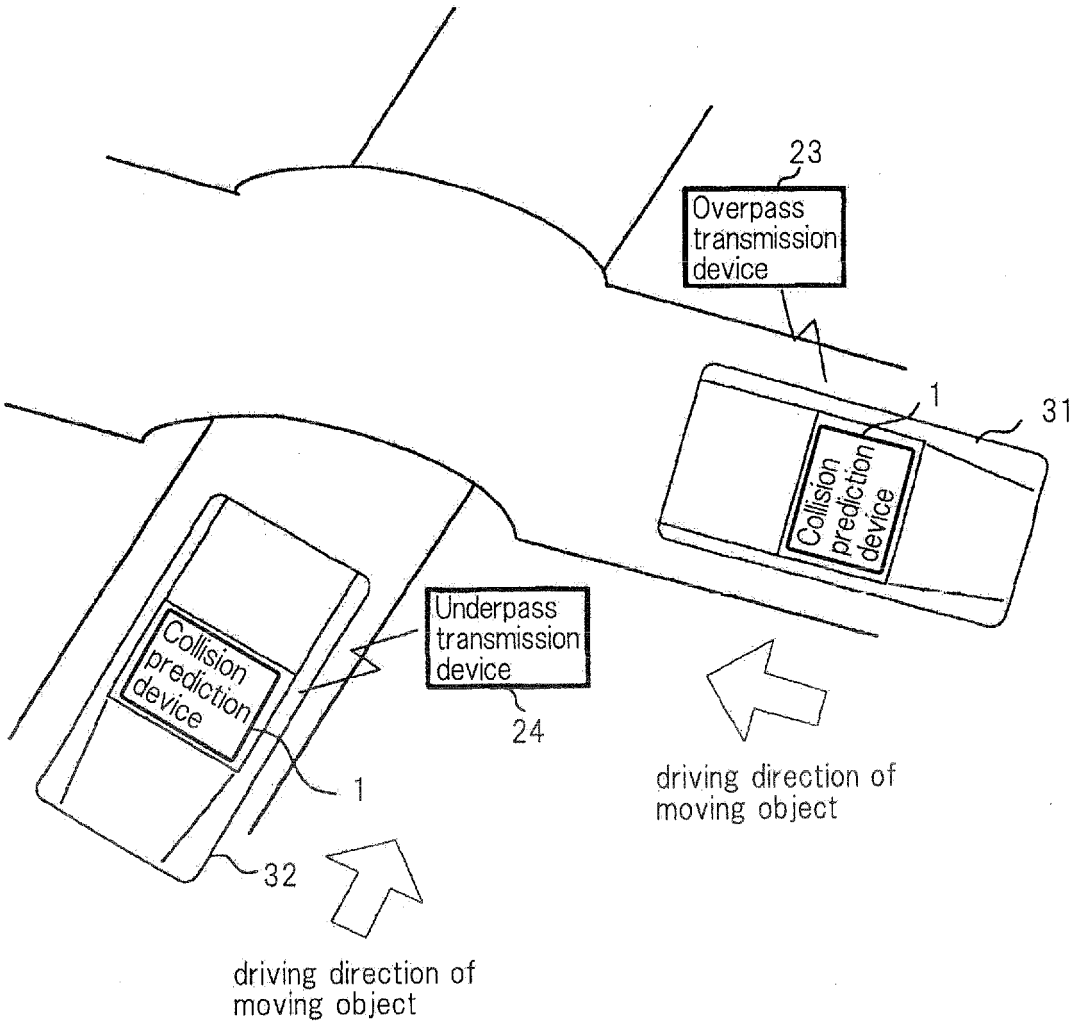

23
Overpass transmission device
1
31
Collision prediction device
Underpass transmission device
24
Collision prediction device
1
32
driving direction of moving object
driving direction of moving object

Fig.3

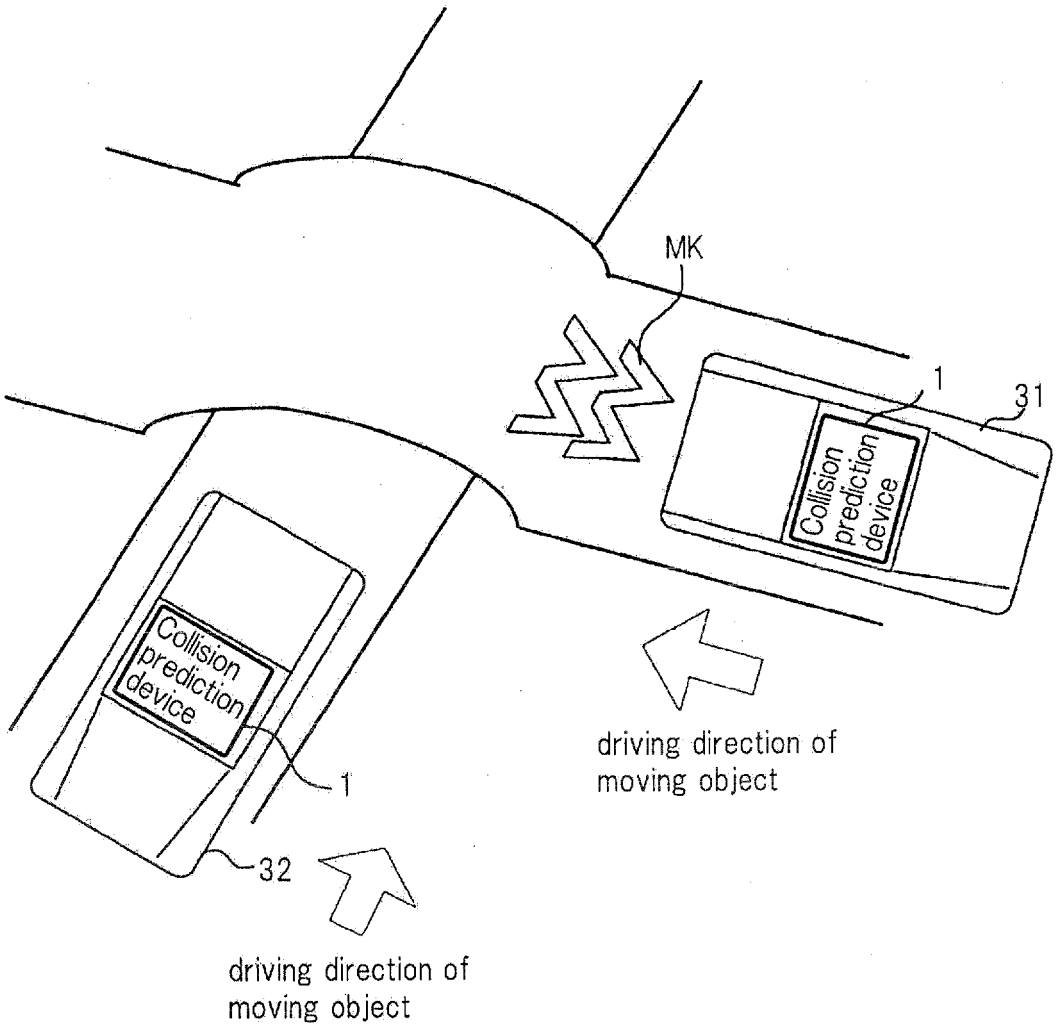

MK
1
31
Collision prediction device
Collision prediction device
1
32
driving direction of moving object
driving direction of moving object

Fig.4

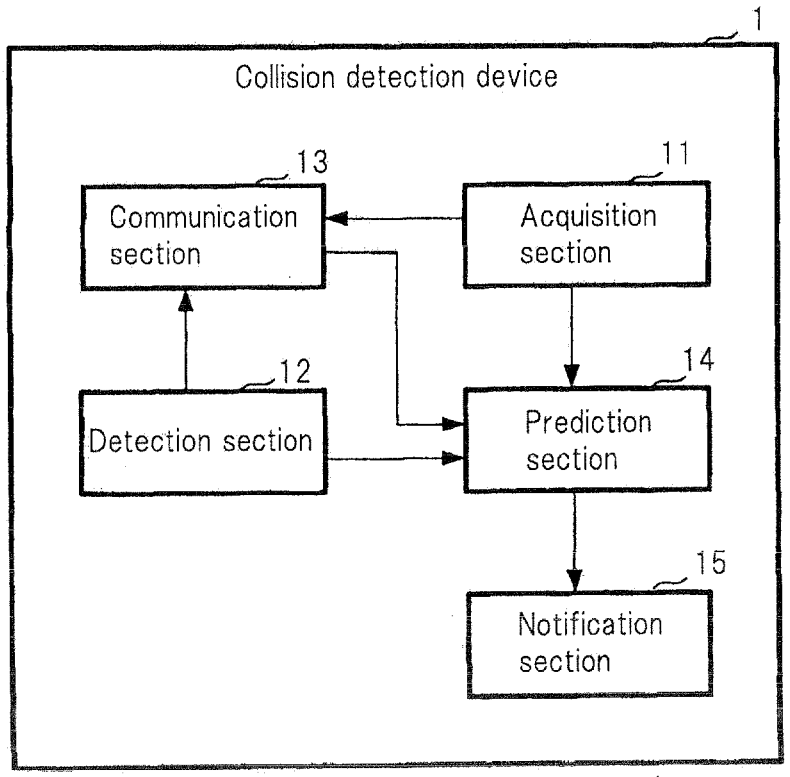

1
Collision detection device
13
Communication section
11
Acquisition section
12
Detection section
14
Prediction section
15
Notification section

Fig.5

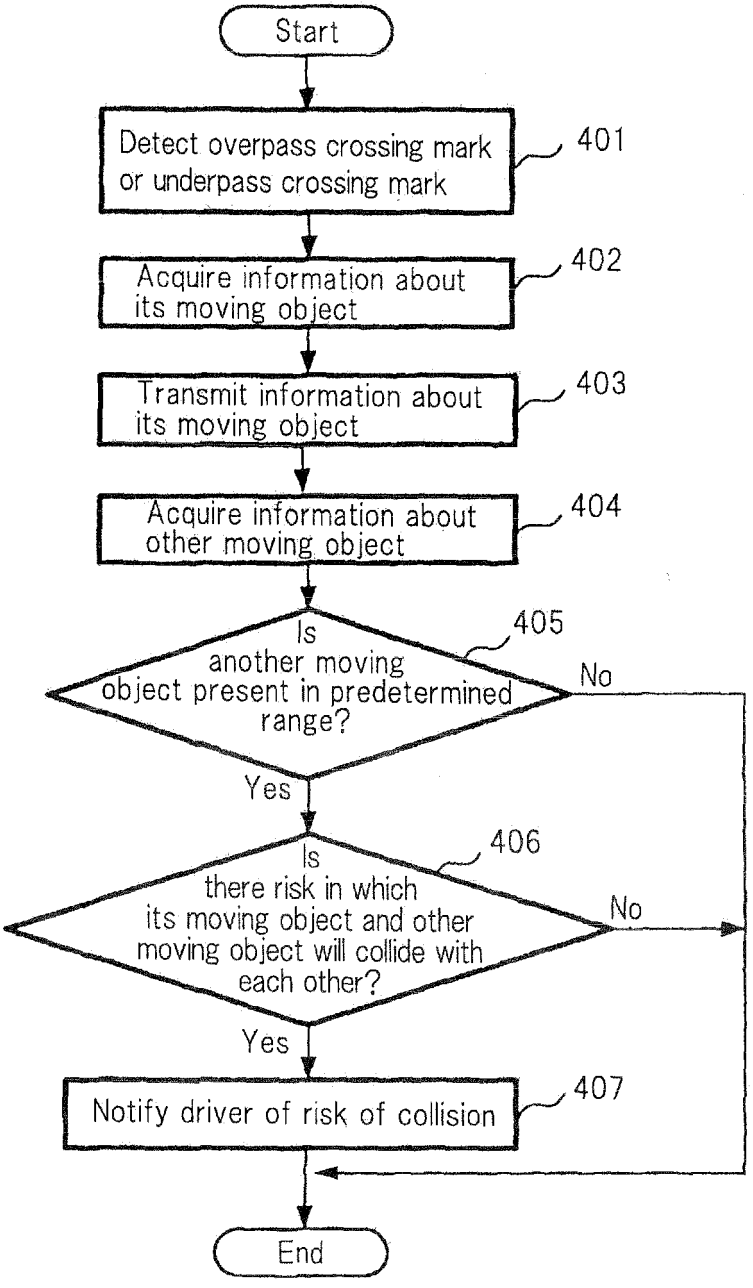

Start
Detect overpass crossing mark or underpass crossing mark
401
Acquire information about its moving object
402
Transmit information about its moving object
403
Acquire information about other moving object
404
Is another moving object present in predetermined range?
405
No
Yes
Is there risk in which its moving object and other moving object will collide with each other?
406
No
Yes
Notify driver of risk of collision
407
End

Fig.6

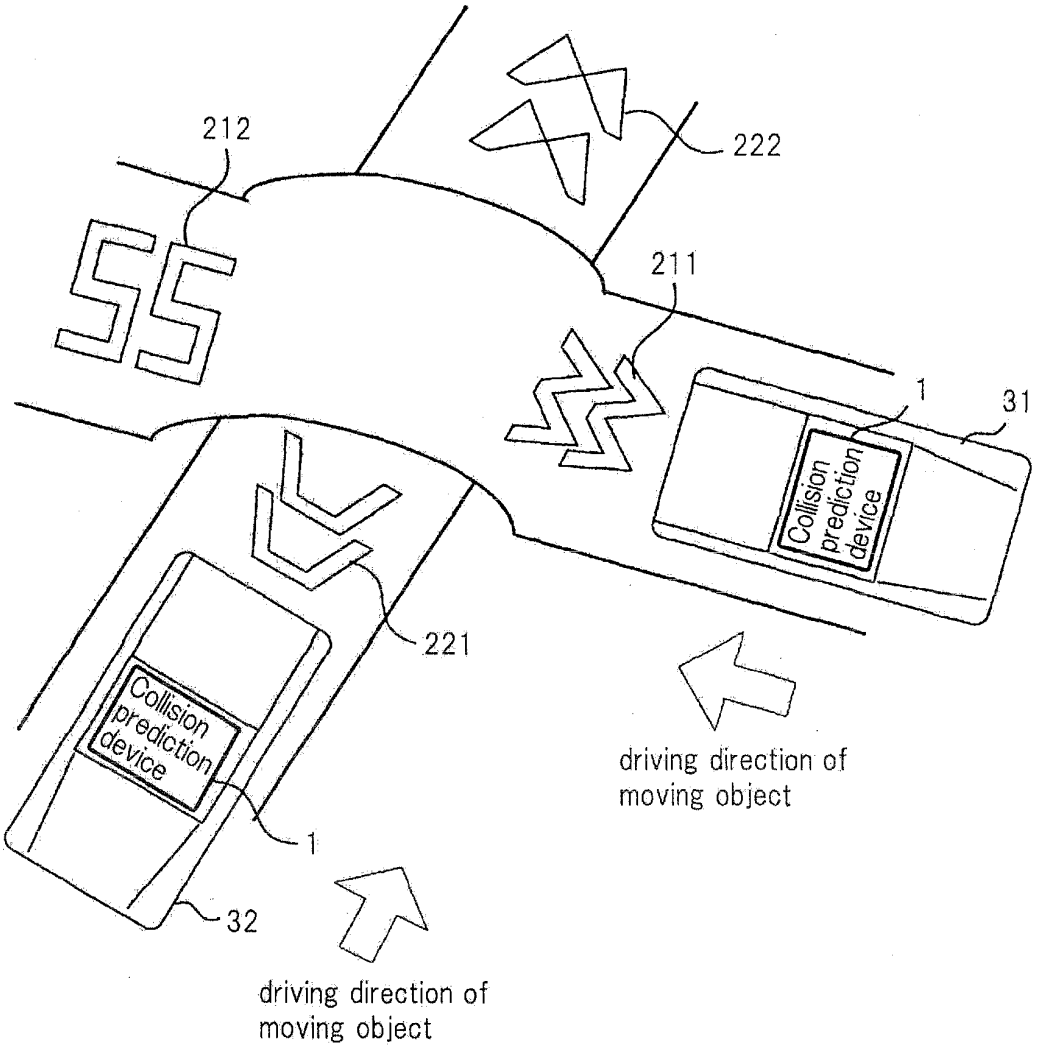

212
222
211
1
31
Collision prediction device
221
Collision prediction device
1
32
driving direction of moving object
driving direction of moving object

Fig.7

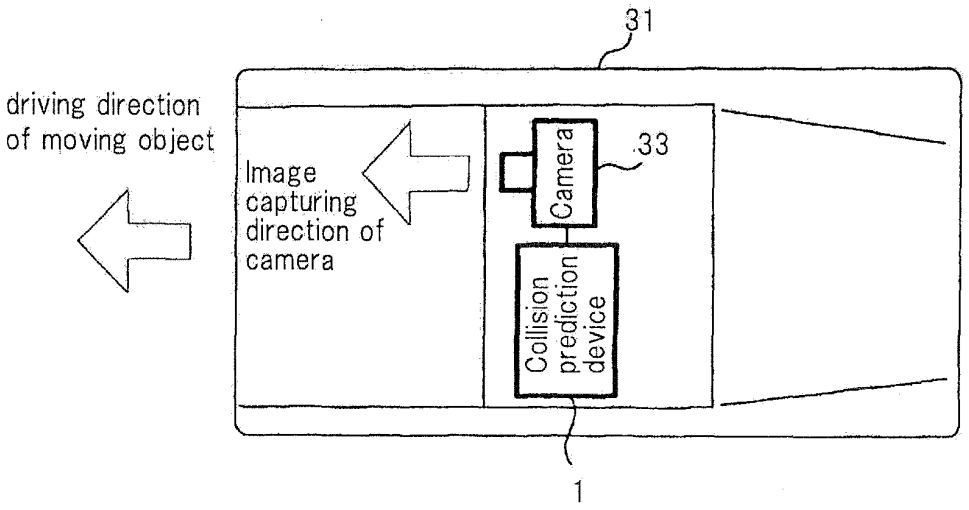

31
driving direction of moving object
Image capturing direction of camera
Camera
33
Collision prediction device
1

Fig.8

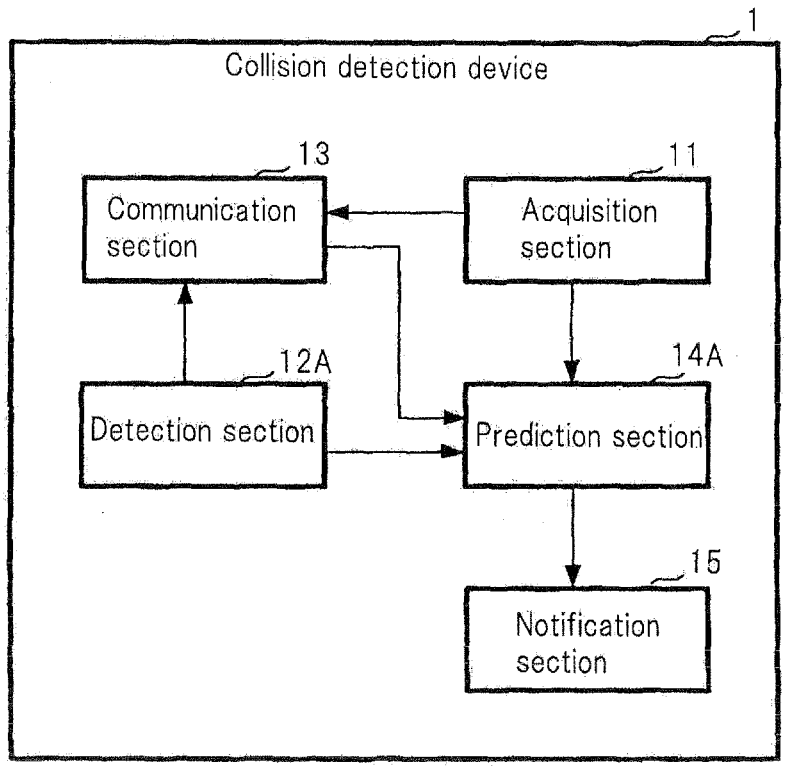

1
Collision detection device
13
Communication section
11
Acquisition section
12A
Detection section
14A
Prediction section
15
Notification section

Fig.9

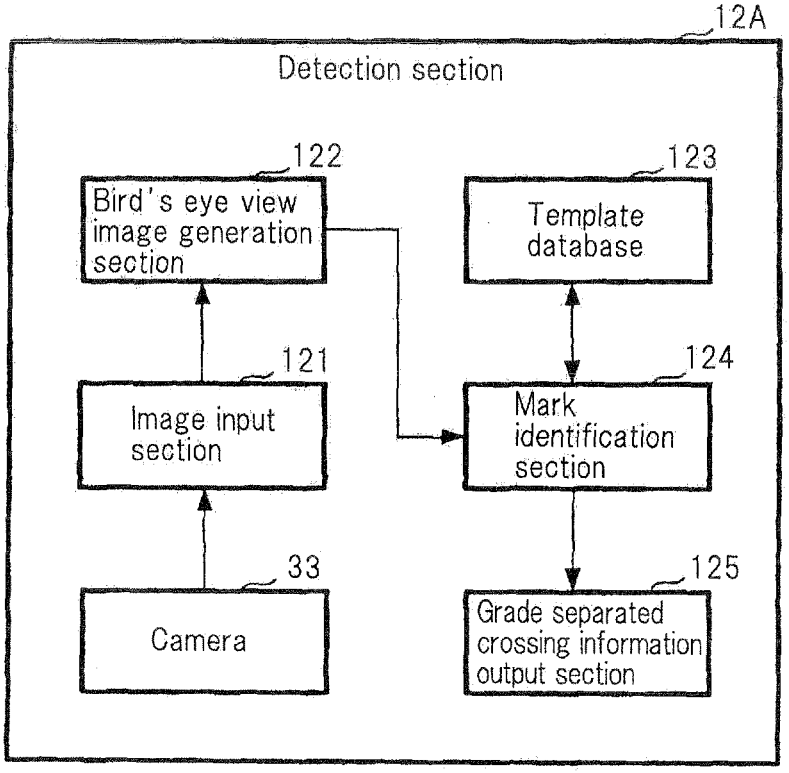

12A
Detection section
122
Bird's eye view image generation section
123
Template database
121
Image input section
124
Mark identification section
33
Camera
125
Grade separated crossing information output section

Fig. 10

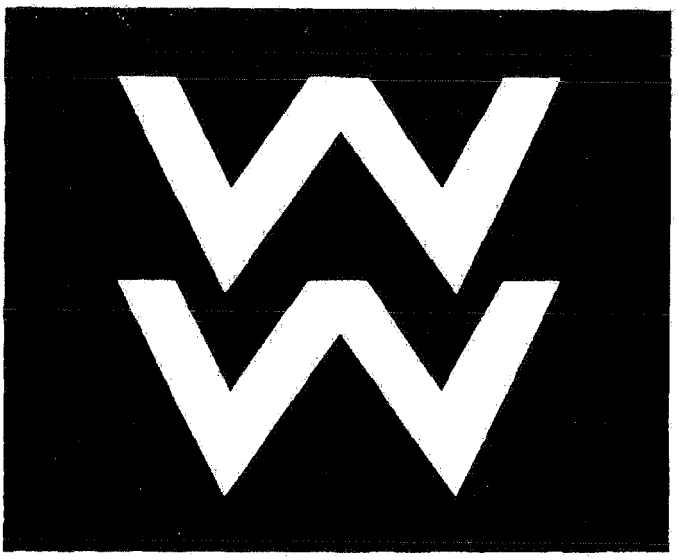


Fig. 11

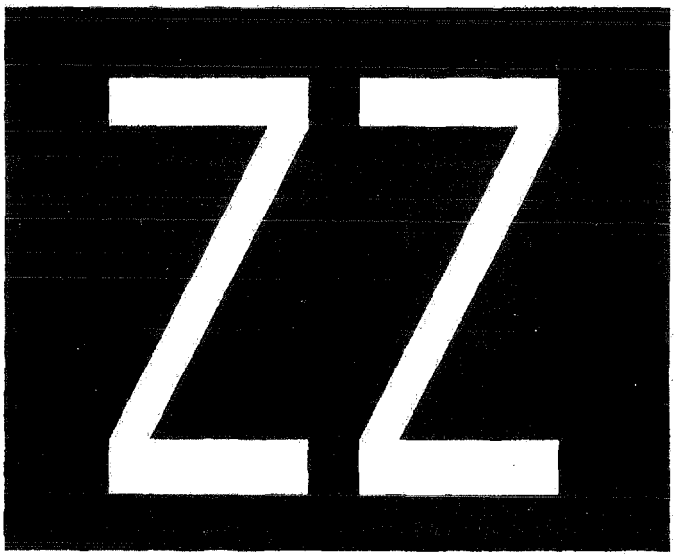


Fig.12

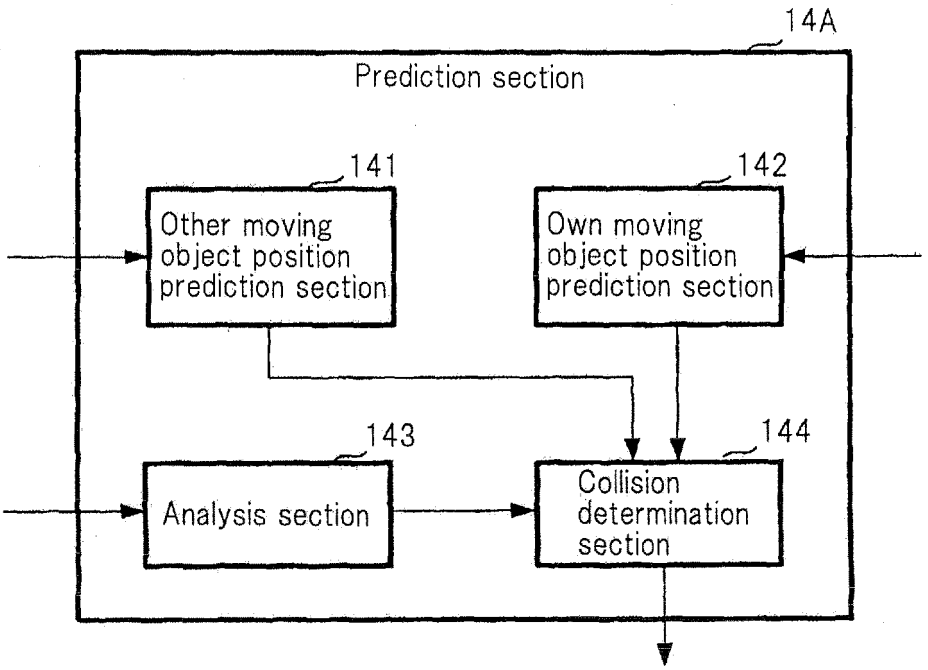
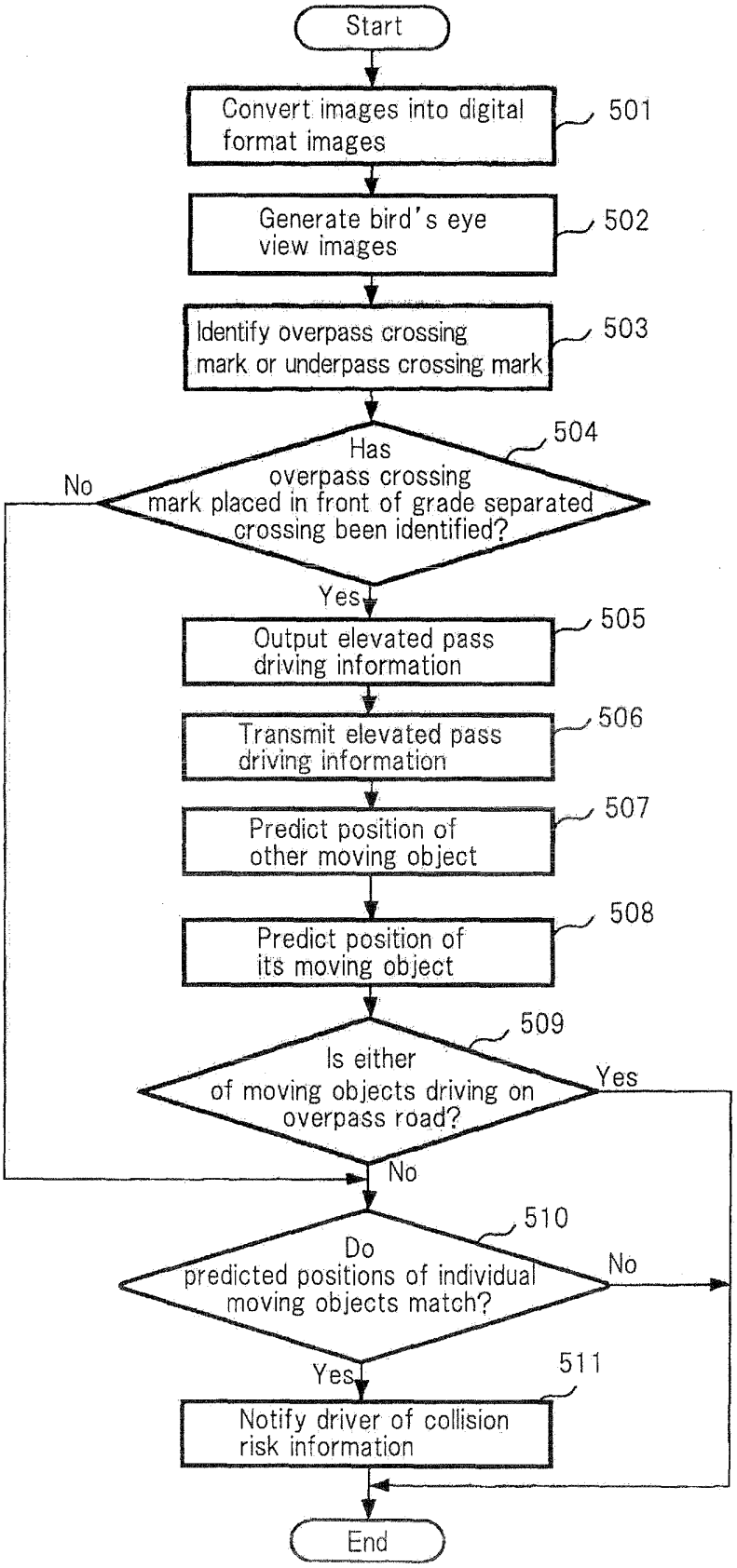

14A
Prediction section
141
Other moving object position prediction section
142
Own moving object position prediction section
143
Analysis section
144
Collision determination section

Fig.13


Start
Convert images into digital format images
501
Generate bird's eye view images
502
Identify overpass crossing mark or underpass crossing mark
503
Has overpass crossing mark placed in front of grade separated crossing been identified?
504
No
Yes
Output elevated pass driving information
505
Transmit elevated pass driving information
506
Predict position of other moving object
507
Predict position of its moving object
508
Is either of moving objects driving on overpass road?
509
Yes
No
Do predicted positions of individual moving objects match?
510
No
Yes
Notify driver of collision risk information
511
End

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/054556

A. CLASSIFICATION OF SUBJECT MATTER
G08G1/16(2006.01)i, *B60R21/00*(2006.01)i, *G01C21/00*(2006.01)i, *G08G1/09*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G08G1/16, B60R21/00, G01C21/00, G08G1/09

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010
Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2009-9219 A (Denso Corp.), 15 January 2009 (15.01.2009), paragraphs [0036], [0037], [0040], [0041], [0046], [0048], [0049], [0055], [0057] to [0063], [0070], [0071]; fig. 2, 3 (Family: none)	1-32
Y	JP 2008-165393 A (Toyota Motor Corp.), 17 July 2008 (17.07.2008), paragraph [0017] & US 2009/0322502 A & EP 2097884 A & WO 2008/081323 A2 & CN 101542554 A	1-32
Y	JP 11-110700 A (Toyota Motor Corp.), 23 April 1999 (23.04.1999), paragraphs [0021] to [0025], [0030]; fig. 1 & US 6292109 B1	2,8,10,16, 18,24,26,32

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 May, 2010 (27.05.10)	08 June, 2010 (08.06.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/054556

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-164441 A (Denso Corp.), 28 June 2007 (28.06.2007), paragraphs [0021], [0022], [0027], [0041]; fig. 1, 2 (Family: none)	7,15,23,31
A	JP 2005-10938 A (Mazda Motor Corp.), 13 January 2005 (13.01.2005), paragraphs [0064], [0065] (Family: none)	1-32

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2004199390 A **[0005]**
- JP 2008164506 A **[0005]**
- JP 2008271813 A **[0088]**
- JP 2009088959 A **[0124]**