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(54) **METHOD FOR TRANSMITTING OBSTACLE DETECTION ENHANCEMENT DATA TO A MOVING CONVEYANCE**

(57) Obstacle detection enhancement data have to be transmitted to an on-board wireless radio unit (160) of a moving conveyance (140) travelling on a predefined path (130) and embedding an obstacle detection system (170). The obstacle detection enhancement data are stored in a database (150) and include map descriptors describing knowledge of environment surrounding the predefined path (130). For determining which obstacle detection enhancement data to be transmitted toward the on-board wireless radio unit (160) in a transmission cycle, a server (120) determines a relevant map portion in the database (150) and prioritizes obstacle detection enhancement data in the determined relevant map portion by attributing a weight thereto. The weights are attributed according to distance information and/or refinement level. The server (120) retrieves from the database (150) the obstacle detection enhancement data to be transmitted in the transmission cycle, so as to fill transmission resources made available thereto, according to the weights thus attributed.

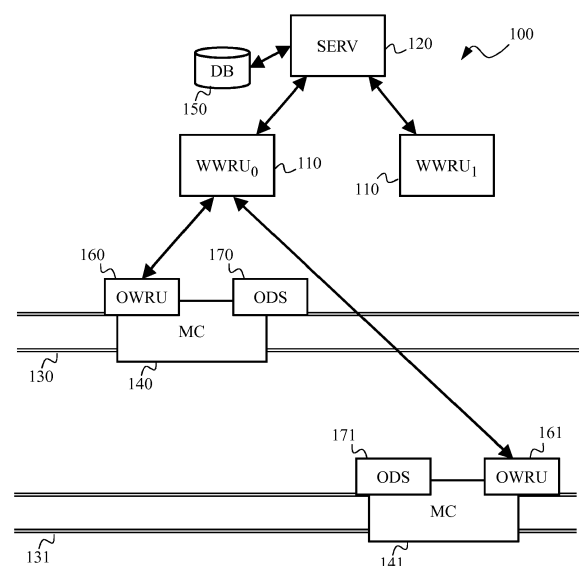


Fig. 1

Description

TECHNICAL FIELD

5 **[0001]** The present invention generally relates to adapting volume and contents of obstacle detection enhancement data to be transmitted from a server to an on-board controller in a moving conveyance according to transmission resources made available thereto and to transmitting the obstacle detection enhancement data from the server to the on-board controller in accordance.

10 RELATED ART

[0002] Moving conveyances, such as trains, can travel on predefined paths, such as railroads, without being driven by a human operator. Such moving conveyances may be automatically controlled using obstacle detection systems. The obstacle detection systems can include passive (visible and/or infrared camcorders), as well as possibly active sensors (radar, laser-scanner, sonar). The obstacle detection systems thus capture information about environment ahead of the moving conveyance so as to be able to detect presence of a potential obstacle and, if any, take appropriate countermeasures (reduce the moving conveyances' speed, even stop the moving conveyances, trigger alarm horns...). Similarly such obstacle detection systems may also be used to assist a human operator driving the moving conveyance.

15 **[0003]** In order to enhance obstacle detection for such moving conveyance travelling on predefined paths (such as railroads), a remote server may be wirelessly connected to an on-board control unit in the moving conveyance. Such a remote server can thus provide obstacle detection enhancement data previously stored in a database connected to said remote server. The obstacle detection enhancement data depend on the location of a considered moving conveyance on a predefined path, and may include descriptors of items surrounding the predefined path, descriptors of active work zones along the predefined path, or any other data that might be helpful to enable the obstacle detection system to refine obstacle detection decisions. Such obstacle detection enhancement data may be based on 3D-map information. Such a database thus stores a description of the predefined paths on which the moving conveyances are subject to travel, as well as obstacle detection enhancement data associated therewith.

20 **[0004]** Transmission resources allocation usually takes into account effective propagation conditions (presence of interferences...) from the server to the on-board control unit in the moving conveyance, but may not be large enough to be able to timely provide all available obstacle detection enhancement data.

25 **[0005]** Even though the obstacle detection is able to operate in stand-alone mode, it is particularly desirable to provide a solution in which selection of obstacle detection enhancement data transmitted from the server to the on-board control unit in the moving conveyance is optimized so as to improve obstacle detection (e.g., reducing false alarms). It is more particularly desirable to provide a solution that is simple and cost-effective.

35 SUMMARY OF THE INVENTION

[0006] To that end, the present invention concerns a method for obtaining obstacle detection enhancement data to be transmitted to an on-board wireless radio unit of a moving conveyance travelling on a predefined path, the moving conveyance embedding an obstacle detection system, the obstacle detection enhancement data being stored in a database and including map descriptors describing knowledge of environment surrounding the predefined path in association with a geographical reference, time being divided in transmission cycles, the method being performed by a server and comprising, for determining which obstacle detection enhancement data to be transmitted toward the on-board wireless radio unit in a transmission cycle C_n : obtaining information about actual speed and location of the moving conveyance on the predefined path; computing a distance d_k travelled by the moving conveyance during one transmission cycle at the actual speed of the moving conveyance; estimating location on said predefined path from which the obstacle detection system would need the obstacle detection enhancement data to be transmitted in the transmission cycle C_n , from the actual speed and location of the moving conveyance; determining a relevant map portion in the database, from the estimated location and the geographical references; prioritizing obstacle detection enhancement data in the determined relevant map portion by attributing a weight to each one of the obstacle detection enhancement data in said relevant map portion, wherein the weights are attributed according to distance separating the estimated location and the geographical reference associated with the obstacle detection enhancement data and/or refinement level of the obstacle detection enhancement data; and obtaining transmission resources made available for transmissions toward the on-board wireless radio unit during the transmission cycle C_n ; retrieving from the database the obstacle detection enhancement data to be transmitted in the transmission cycle C_n ; so as to fill said transmission resources, according to the attributed weights.

55 **[0007]** Thus, selection of obstacle detection enhancement data transmitted from the server to the on-board control unit in the moving conveyance is optimized so as to improve obstacle detection in view of transmission resources made

available to do so. False alarms avoidance by the obstacle detection is thus improved.

[0008] According to a particular embodiment, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location, the weights are attributed according to a figure of merit F1 such that

$$F1(x,y,z) = \gamma \cdot \exp(-(|x|^2+|y|^2+|z|^2))$$

wherein γ is a real constant.

[0009] Thus, obstacle detection enhancement data the closest to the moving conveyance MC 140 in absolute distance at the estimated location have higher weights.

[0010] According to a particular embodiment, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location and that x axis is directed identically as direction of the moving conveyance on the predefined path, the weights are attributed according to a figure of merit F1 such that

$$F1(x,y,z) = \beta \cdot H(x-\Delta)$$

wherein β is a real constant, wherein $H(\cdot)$ is the Heaviside step function, being equal to "1" for positive input and equal to "0" otherwise, and wherein Δ is a coordinate on x axis above which the weight becomes null.

[0011] Thus, obstacle detection enhancement data the closest to the moving conveyance MC 140 in forward distance at the estimated location have higher weights.

[0012] According to a particular embodiment, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location and that x axis is directed identically as direction of the moving conveyance on the predefined path, the weights are attributed according to a figure of merit F1 such that

$$F1(x,y,z) = \gamma \cdot H(x-BD) \cdot \exp(-(|x|^2+|y|^2+|z|^2))$$

wherein γ is a real constant and BD represents an estimated braking distance for the moving conveyance.

[0013] Thus, low priority is attributed to obstacle detection enhancement data within the estimated braking distance BD .

[0014] According to a particular embodiment, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location, that x axis is directed identically as direction of the moving conveyance on the predefined path, and that z axis is directed upwards, the weights are attributed according to a figure of merit F2 such that

$$F2(x,y,z) = 1 / |y|$$

[0015] Thus, the further the geographical reference of obstacle detection enhancement data to which the obstacle detection enhancement data refers is from the predefined path, the lower its weight.

[0016] According to a particular embodiment, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location, that x axis is directed identically as direction of the moving conveyance on the predefined path, and that z axis is directed upwards, the weights are attributed according to a figure of merit F2 such that

$$F2(x,y,z) = V_{MC} \cdot |y| / x$$

wherein V_{MC} represents the actual speed of the moving conveyance.

[0017] Thus, higher priority is attributed to items allowing enhanced protection from moving objects with low speed and/or moving objects located near the railroad.

[0018] According to a particular embodiment, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location, that x axis is directed identically as direction of the moving conveyance on the predefined path, and that z axis is directed upwards, the weights are attributed according to a figure of merit F2 such that

$$F2(x,y,z) = |y| / x$$

[0019] Thus, higher priority is attributed to items allowing enhanced protection from moving objects with low speed, and/or moving objects located near the railroad, in a simpler variant.

[0020] According to a particular embodiment, space being sampled hierarchically by using lattice structures with different granularities so as to form points in space associated with different refinement levels, obstacle detection enhancement data corresponding to points providing a lower information resolution have, according to a figure of merit F3, higher weight than obstacle detection enhancement data corresponding to points providing a better information resolution.

[0021] Thus, raw obstacle detection enhancement data are transmitted in priority.

[0022] According to a particular embodiment, refinement level is a hierarchical refinement of polytopes, and according to a figure of merit F3, the more obstacle detection enhancement data corresponding to polytope information provide refinement details, the lower the weight attributed to this obstacle detection enhancement data.

[0023] Thus, raw obstacle detection enhancement data are transmitted in priority.

[0024] According to a particular embodiment, further according to a figure of merit F4, lower weight is attributed to obstacle detection enhancement data that have already been provided to the on-board wireless radio unit and that have not changed since than to other obstacle detection enhancement data that have not yet been provided to the on-board wireless radio unit or that have changed since.

[0025] Thus, new obstacle detection enhancement data are transmitted in priority.

[0026] According to a particular embodiment, the weights are attributed to the obstacle detection enhancement data by a combination of the figures of merit F1, F2, F3 and F4. Therefore a trade-off combination of the advantages expressed above is achieved.

[0027] The present invention also concerns a method for transmitting obstacle detection enhancement data to an on-board wireless radio unit of a moving conveyance travelling on a predefined path, the method being performed by the server and comprising obtaining obstacle detection enhancement data as mentioned above, and further comprising: when the start of the transmission cycle C_n is reached, transmitting the retrieved obstacle detection enhancement data to the on-board wireless radio unit in the transmission resources made available thereto.

[0028] The present invention also concerns a server configured for obtaining obstacle detection enhancement data to be transmitted to an on-board wireless radio unit of a moving conveyance travelling on a predefined path, the moving conveyance further embedding an obstacle detection system, the obstacle detection enhancement data being stored in a database and including map descriptors describing knowledge of environment surrounding the predefined path in association with a geographical reference, time being divided in transmission cycles, wherein the server comprises, for determining which obstacle detection enhancement data to be transmitted toward the on-board wireless radio unit in a transmission cycle C_n ; means for obtaining information about actual speed and location of the moving conveyance on the predefined path; means for computing a distance d_k travelled by the moving conveyance during one transmission cycle at the actual speed of the moving conveyance; means for estimating location on said predefined path from which the obstacle detection system would need the obstacle detection enhancement data to be transmitted in the transmission cycle C_n , from the actual speed and location of the moving conveyance; means for determining a relevant map portion in the database, from the estimated location and the geographical references; means for prioritizing obstacle detection enhancement data in the determined relevant map portion by attributing a weight to each one of the obstacle detection enhancement data in said relevant map portion, wherein the weights are attributed according to distance separating the estimated location and the geographical reference associated with the obstacle detection enhancement data and/or refinement level of the obstacle detection enhancement data; means for obtaining transmission resources made available for transmissions toward the on-board wireless radio unit during the transmission cycle C_n ; and means for retrieving from the database the obstacle detection enhancement data to be transmitted in the transmission cycle C_n , so as to fill said transmission resources, according to the attributed weights.

[0029] The present invention also concerns a server configured for transmitting obstacle detection enhancement data to an on-board wireless radio unit of a moving conveyance travelling on a predefined path, wherein the server is as defined above and further comprises: when the start of the transmission cycle C_n is reached, means for transmitting the retrieved obstacle detection enhancement data to the on-board wireless radio unit in the transmission resources made available thereto.

[0030] The present invention also concerns a computer program that can be downloaded from a communication network and/or stored on a non-transitory information storage medium that comprises code instructions that can be read and executed by a processing device such as a microprocessor for causing implementation of the aforementioned methods above in any one of their embodiments. The present invention also concerns a non-transitory information storage medium, storing such a computer program.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] The characteristics of the invention will emerge more clearly from a reading of the following description of at least one example of embodiment, said description being produced with reference to the accompanying drawings, among which:

Fig. 1 schematically represents an obstacle detection enhancement system in which the present invention may be implemented;

Fig. 2 schematically represents an example of hardware architecture of a processing device of the obstacle detection enhancement system;

Fig. 3 schematically represents an algorithm for deciding which obstacle detection enhancement data to be transmitted from a server to an on-board controller in a moving conveyance according to transmission resources made available thereto and for transmitting said obstacle detection enhancement data in accordance;

Fig. 4 schematically represents an algorithm, implemented by the on-board controller in the moving conveyance for receiving and processing the obstacle detection enhancement data;

Fig. 5 schematically represents an example of obstacle detection enhancement data selection according to lateral distance from a predefined path on which the moving conveyance travels;

Fig. 6 schematically represents an example of obstacle detection enhancement data selection according to obstacle detection enhancement data granularity; and

Fig. 7 schematically represents an example of obstacle detection enhancement data selection according to definition level of obstacle detection enhancement data.

DETAILED DESCRIPTION OF AT LEAST ONE EMBODIMENT

[0032] Fig. 1 schematically represents an obstacle detection enhancement system 100 intended to provide support for improving obstacle detection during a journey of a moving conveyance MC 140 along a predefined path 130. On Fig. 1 another moving conveyance MC 141 performs a journey along another predefined path 131.

[0033] In a preferred embodiment, the moving conveyance MC 140 is a train and the predefined path 130 is railways on which the moving conveyance MC 140 travels.

[0034] The obstacle detection enhancement system 100 comprises a server SERV 120 and an on-board wireless radio unit OWRU 160 located in the moving conveyance MC 140. The on-board wireless radio unit OWRU 160 is a controller having wireless communication capabilities.

[0035] The server SERV 120 and the on-board wireless radio unit OWRU 160 wirelessly communicate with each other, potentially via wireless radio units such as wayside wireless radio units $WWRU_0$, $WWRU_1$ 110 located along the predefined path 130. The wireless radio units such as the wayside wireless radio units $WWRU_0$, $WWRU_1$ 110 are geographically installed such that wireless communication continuity can be ensured as much as possible between the server SERV 120 and the on-board wireless radio unit OWRU 160 whatever is the effective location of the moving conveyance MC 140 on the predefined path 130.

[0036] For example, the wireless radio units such as the wayside wireless radio units $WWRU_0$, $WWRU_1$ 110 are access points of a telecommunication system, for instance an LTE ("Long Term Evolution") telecommunication system or the like. For example, the server SERV 120 is connected to the wireless radio units such as the wayside wireless radio units $WWRU_0$, $WWRU_1$ 110 using copper wires or optical links.

[0037] Similarly, the moving conveyance MC 141 comprises an on-board wireless radio unit OWRU 161 wirelessly communicating with the server SERV 120.

[0038] The server SERV 120 knows, for instance by configuration, on which predefined respective path 130, 131 each moving conveyance MC 140, 141 currently travels.

[0039] The moving conveyance MC 140 embeds an obstacle detection system ODS 170. The obstacle detection system ODS 170 can include passive (visible and/or infrared camcorders), as well as possibly active sensors (radar, laser-scanner, sonar). The obstacle detection system ODS 170 thus captures information about environment ahead the moving conveyance so as to be able to detect presence of an obstacle and, if any, to take appropriate countermeasures. When the moving conveyance MC 140 is automatically driven, the obstacle detection system ODS 170 may instruct the moving conveyance MC 140 to perform emergency break in order to avoid potential collision. When the moving conveyance MC 140 is driven by a human operator, the obstacle detection system ODS 170 may provide emergency warning signals to indicate the human operator that emergency procedure shall be activated in order to avoid potential collision.

[0040] Similarly, the moving conveyance MC 141 comprises an obstacle detection system ODS 171.

[0041] In order to enhance obstacle detection performance, the obstacle detection system ODS 170 communicates with the server SERV 120 via the on-board wireless radio unit OWRU 160. The server SERV 120 thus provides obstacle detection enhancement data to the obstacle detection system ODS 170 so as to speed up obstacle detection processing

and/or to reduce ratio of false alarm occurrences. False alarms occur when the obstacle detection system ODS 170 erroneously detects collision risks ahead the corresponding moving conveyance.

[0042] For example, the obstacle detection enhancement data include descriptors of physical items (buildings, trees, crossing roads, work areas...) known to be present in the vicinity of the corresponding predefined path 130 ahead the effective location of the moving conveyance MC 140. In a particular embodiment, the obstacle detection enhancement data include 3D scene descriptors describing samples of a 3D scene of environment surrounding the corresponding predefined path 130. Such a 3D scene is for instance obtained from 3D modelling of video images captured by a camera installed on the front of a moving conveyance MC during training journeys on the corresponding predefined path 130. The samples in question can thus be polytopes extracted from the 3D modelling.

[0043] Such obstacle detection enhancement data allow the obstacle detection system ODS 170 to refine decision regarding the potential obstacle character of objects detected by the obstacle detection system ODS 170 ahead the moving conveyance MC 140.

[0044] In order to store such obstacle detection enhancement data, the obstacle detection enhancement system 100 further includes a database DB 150 used to store a description of the predefined path 130 or at least of one or more sections thereof, as well as obstacle detection enhancement data associated therewith which include surrounding environment descriptions. The obstacle detection enhancement data stored in the database DB 150 thus include map descriptors describing knowledge of environment surrounding the predefined path 130. Each surrounding environment items described in the database DB 150 is associated with a geographical reference, typically a set of 3D absolute coordinates (x,y,z).

[0045] According to one example, when the map descriptors are 3D-space points, the obstacle detection enhancement data corresponding to each 3D-space point are an association of geographical position of said 3D-space point and a bit indicating known presence or not of an object at this geographical position (building, tree...).

[0046] According to another example, when the map descriptors are descriptions of volumes such as polytopes, the geographical position of each volume is referenced by a noticeable point of the volume, such as the barycentre of the polytope, or the barycentre of a surface of the polytope, or a vertex of the polytope .

[0047] It might further be noted that the map descriptors may indicate known presence of an object at a specific geographical position or indicate a priori absence of any object at a specific geographical position.

[0048] The database DB 150 is used by the server SERV 120 to retrieve obstacle detection enhancement data per portions of the predefined path 130. Some portions of the predefined path 130 may imply more or less obstacle detection enhancement data than others. Indeed, the surrounding environment may for example be more complex to describe for some portions of the predefined path 130 than for others.

[0049] Even though the obstacle detection system ODS 170 should be able to perform obstacle detection without requiring the obstacle detection enhancement data, it is of interest to be able to transmit to the on-board wireless radio unit OWRU 160 obstacle detection enhancement data as relevant as possible among the obstacle detection enhancement data available in the database DB 150. Indeed, transmission resources made available to allow wirelessly transmitting obstacle detection enhancement data from the server SERV 120 to the on-board wireless radio unit OWRU 160 might not be large enough to transmit all obstacle detection enhancement data that might be helpful for obstacle detection where the moving conveyance MC 140 is located.

[0050] Transmission resources allocation is performed on a per-cycle basis. The transmission resources allocation may be performed by the server SERV 120 or by another equipment, which informs the server SERV 120 of the transmission resources allocation effectively performed. Time is thus divided in transmission cycles of equal duration T, one frame being transmitted from the server SERV 120 to the on-board wireless radio unit OWRU 160 at each transmission cycle. Transmission resources are then time and frequency resources within said transmission cycles.

[0051] Transmission resources effectively made available for transmissions toward the on-board wireless radio unit OWRU 160 may differ from one transmission cycle to another. Indeed, quality of wireless link between the server SERV 120 and the on-board wireless radio unit OWRU 160 may change and thus reduce or increase available bandwidth. Moreover, available bandwidth may be shared by plural concurrent transmissions, for instance when the server SERV 120 further communicates with another on-board wireless radio unit OWRU 161 present in the vicinity of the on-board wireless radio unit OWRU 160. As detailed hereafter with respect to Fig. 3, relevant obstacle detection enhancement data to be transmitted by the server SERV 120 to the on-board wireless radio unit OWRU 160 have to be adequately selected so as to match the transmission resources effectively made available for transmissions from the server SERV 120 toward the on-board wireless radio unit OWRU 160.

[0052] During a transmission cycle C_n (wherein n is a transmission cycle sequence number), the on-board wireless radio unit OWRU 160 thus receives obstacle detection enhancement data for a portion of the predefined path 130 (on the predefined path 130 or in the vicinity of the predefined path 130) on which the considered moving conveyance MC 140 travels which is at a certain distance ahead the considered moving conveyance MC 140. Processing of the obstacle detection enhancement data thus received is detailed hereafter with respect to Fig. 4.

[0053] Fig. 2 schematically represents an example of hardware architecture of a processing device 200 of the obstacle

detection enhancement system 100. The on-board wireless radio unit OWRU 160 and/or the obstacle detection system ODS 170 and/or the server SERV 120 can be built on the basis of such example of hardware architecture.

[0054] According to the shown example of hardware architecture, the processing device 200 comprises at least the following components interconnected by a communication bus 210: a processor, microprocessor, microcontroller or CPU (Central Processing Unit) 201; a RAM (Random-Access Memory) 202; a ROM (Read-Only Memory) 203; an HDD (Hard-Disk Drive) or an SD (Secure Digital) card reader 204, or any other device adapted to read information stored on non-transitory information storage medium; at least one communication interface COM 205.

[0055] When the hardware architecture concerns the server SERV 120, the at least one communication interface COM 205 enables the server SERV 120 to communicate with the wayside wireless radio units WWRU₀, WWRU₁ 110. In a variant, the at least one communication interface COM 205 enables the server SERV 120 to wirelessly communicate directly with the on-board wireless radio unit OWRU 160.

[0056] When the hardware architecture concerns the on-board wireless radio unit OWRU 160, the at least one communication interface COM 205 enables the on-board wireless radio unit OWRU 160 to wirelessly communicate with the wayside wireless radio units WWRU₀, WWRU₁ 110 and to communicate with the obstacle detection system ODS 170. In a variant, the at least one communication interface COM 205 enables the on-board wireless radio unit OWRU 160 to wirelessly communicate directly with the server SERV 120 instead of with the wayside wireless radio units WWRU₀, WWRU₁ 110.

[0057] When the hardware architecture concerns the obstacle detection system ODS 170, the communication interface COM 205 enables the obstacle detection system ODS 170 to communicate with the on-board wireless radio unit OWRU 160.

[0058] CPU 201 is capable of executing instructions loaded into RAM 202 from ROM 203 or from an external memory, such as an SD card via the SD card reader 204. After the processing device 200 has been powered on, CPU 201 is capable of reading instructions from RAM 202 and executing these instructions. The instructions form one computer program that causes CPU 201 to perform some or all of the steps of the algorithms described herein with respect to the processing device 200 in question.

[0059] Consequently, it is understood that any and all steps of the algorithm described herein may be implemented in software form by execution of a set of instructions or program by a programmable computing machine, such as a PC (Personal Computer), a DSP (Digital Signal Processor) or a microcontroller; or else implemented in hardware form by a machine or a dedicated chip or chipset, such as an FPGA (Field-Programmable Gate Array) or an ASIC (Application-Specific Integrated Circuit). In general, the server SERV 120, the on-board wireless radio unit OWRU 160 and the obstacle detection system ODS 170 comprise processing electronics circuitry adapted and configured for implementing the relevant steps as described herein with respect to the processing device 200 in question.

[0060] Fig. 3 schematically represents an algorithm for deciding which obstacle detection enhancement data to be transmitted from the server SERV 120 to the on-board wireless radio unit OWRU 160 according to the transmission resources made available thereto and for transmitting said obstacle detection enhancement data in accordance.

[0061] In a step S301, the server SERV 120 obtains information on actual speed of the moving conveyance MC 140. The information on actual speed of the moving conveyance MC 140 is provided by the on-board wireless radio unit OWRU 160.

[0062] The server SERV 120 further obtains information on actual location of the moving conveyance MC 140 on the predefined path 130 on which the moving conveyance MC 140 is travelling. The information on actual location of the moving conveyance MC 140 may be provided by the on-board wireless radio unit OWRU 160. Information on actual location of the moving conveyance MC 140 may in a variant be provided to the server SERV 120 by wayside conveyance (e.g., train) detection system.

[0063] In a step S302, the server SERV 120 determines, as function of the actual speed of the moving conveyance MC 140 what distance d_k is travelled by the at least one moving conveyance MC 140 during one transmission cycle of duration T .

[0064] In a step S303, from the actual speed and location of the moving conveyance MC 140, the server SERV 120 estimates what is the (future) location on the predefined path 130 from which the obstacle detection system ODS 170 would need the obstacle detection enhancement data to be transmitted during the transmission cycle C_n . The location estimation may take into account an estimated braking distance BD . The estimated braking distance BD depends on the actual speed of the moving conveyance MC 140 and may be obtained from a braking model as a function of the actual speed of the moving conveyance MC 140.

[0065] In a step S304, the server SERV 120 determines a relevant map portion from the location, on the predefined path 130, estimated in the step S303. The relevant map portion is the part of the map as described in the database DB 150 which is of interest for the obstacle detection system ODS 170 from said estimated location. It may include forecast information based on absolute time in view of the location, on the predefined path 130, estimated in the step S303 and at what time the moving conveyance MC 140 is expected to be at said location (forecast presence of a moving conveyance on the predefined path 130 or on an adjacent path, forecast presence of temporary works along the predefined path

130...). When considering that one feature of the obstacle detection system ODS 170 is field of view FOV (which is the maximum distance ahead the moving conveyance MC 140 in which the obstacle detection system ODS 170 is able to detect presence of physical items having dimensions greater than a predefined size), the relevant map portion is preferably the part of the map comprised between the estimated location (step 303) and a position ahead on the predefined path 130 at a distance equal to the field of view FOV plus potentially a predefined margin. The server SERV 120 may also determine the relevant map portion beyond the field of view FOV, i.e. at least one transmission cycle in advance compared with the moment the concerned obstacle detection enhancement data are effectively consumed by the obstacle detection system ODS 170.

[0066] Preferably, the server SERV 120 shifts the geographical reference of the items of the map portion in an orthonormal coordinate system which is centred on the location estimated in the step S303 and in which the first basis vector, allocated with coordinate notation x is collinear to the trajectory of the predefined path 130 at said location estimated in the step S303.

[0067] In a step S305, the server SERV 120 prioritizes obstacle detection enhancement data in the relevant map portion determined in the step S304. Prioritizing the obstacle detection enhancement data means attributing a weight to each one of the obstacle detection enhancement data in said relevant map portion. Weight can be attributed according to a figure of merit.

[0068] According to a first embodiment, the server SERV 120 attributes weights to the obstacle detection enhancement data in the relevant map portion according to distance separating the location estimated in the step S303 and the geographical reference of the items of the map portion to which the obstacle detection enhancement data refer. In this first embodiment, the figure of merit (denoted $F1$) ensures the weight decreases with absolute distance or forward distance.

[0069] The distance in question may thus be the absolute distance. In this case, considering that (x,y,z) denotes said geographical reference in the orthonormal coordinate system centred on the location estimated in the step S303, an example of figure of merit $F1$ may be defined as follows, which involves that the map items closest to the moving conveyance MC 140 (at the estimated location) have higher weights than the others:

$$F1(x,y,z) = \gamma \cdot \exp(-(|x|^2+|y|^2+|z|^2))$$

wherein γ is a real constant.

[0070] The distance in question may thus be the forward distance, which is the distance (see X_{MO} on Fig. 5) between the location estimated in the step S303 and an orthogonal projection of said geographical reference on the x axis of coordinate, which is directed identically as the direction (or speed vector) of the moving conveyance MC 140 on the predefined path 130. Another example of figure of merit $F1$ may thus be defined as follows:

$$F1(x,y,z) = \beta \cdot H(x-\Delta)$$

wherein β is a real constant, wherein $H(\cdot)$ is the Heaviside step function, being equal to "1" for positive input and equal to "0" otherwise, and wherein Δ is a coordinate on the x axis above which the weight becomes null.

[0071] A selection of information which lies only in position ahead in the direction of the x axis can be obtained by the following weighting:

$$F1(x,y,z) = \beta \cdot H(x)$$

[0072] A step-by-step decrease weight function can also be defined with the same principle as follows:

$$F1(x,y,z) = \beta_1 \cdot H(x-\Delta_1) + \beta_2 \cdot H(x-\Delta_2) + \beta_3 \cdot H(x-\Delta_3)$$

wherein $\Delta_1, \Delta_2, \Delta_3$ are distinct coordinates on the x axis above which there is a weight decrease, and wherein β_1, β_2 and β_3 are real constants.

[0073] Providing obstacle detection enhancement data for items that are located at a distance shorter than the estimated braking distance BD of the moving conveyance MC 140 might be seen as irrelevant since the moving conveyance MC 140 might not be able to avoid collision with the obstacle, but it might help anticipating a need for reducing the speed of the moving conveyance MC 140, which would limit damage in case of effective collision.

[0074] According to a second embodiment, the server SERV 120 attributes weights to the obstacle detection enhancement data in the relevant map portion according to distance separating the location estimated in the step S303 and the geographical reference of the items of the map portion to which the obstacle detection enhancement data refer, and further according to the estimated braking distance BD . In this second embodiment, the figure of merit $F1$ ensures that low priority is attributed to items within the estimated braking distance BD . An example of figure of merit $F1$ may be defined as follows:

$$F1(x,y,z) = \gamma \cdot H(x - BD) \cdot \exp(-(|x|^2 + |y|^2 + |z|^2))$$

wherein γ is a real constant.

[0075] According to a third embodiment, the server SERV 120 attributes weights to the obstacle detection enhancement data in the relevant map portion according to distance separating the location estimated in the step S303 and the geographical reference of the items of the map portion to which the obstacle detection enhancement data refer. In this third embodiment, the figure of merit (denoted $F2$) ensures the weight decreases with lateral distance. Lateral distance is represented by an angle α between the direction of the moving conveyance MC 140 and a line joining the moving conveyance MC 140 and the geographical reference in question, as shown in **Fig. 5**. The objective is to help detecting potential moving obstacle MO 500 that is moving in a direction perpendicular to the predefined path 130 with a speed V_{MO} , or located very close to the predefined path. When considering that the moving conveyance MC 140 is a train, examples are maintenance workers working near the railways or a car travelling on a crossing road. An example of figure of merit $F2$ may be defined as follows:

$$F2(x,y,z) = 1 / |y|$$

which involves that the further the geographical reference of an item of the map portion to which the obstacle detection enhancement data refer is from the predefined path, the lower its weight.

[0076] According to a fourth embodiment, the server SERV 120 attributes weights to the obstacle detection enhancement data in the relevant map portion according to a ratio between forward distance and lateral distance. Indeed, considering a moving object MO 500 (e.g., a car) moving toward the predefined path 130 (e.g., railways track), whether or not there is an effective risk of collision with the moving conveyance MC 140 (e.g., a train) depends on speed V_{MC} of the moving conveyance MC 140 and on the considered speed V_{MO} of the considered moving object MO 500, and further depending on the geographical location of the considered moving object MO 500. There is a risk of collision if the time it takes to the moving conveyance MC 140 to cover the distance X_{MO} on Fig. 5 is substantially equal to the time it takes to the moving object MO 500 to cover the distance Y_{MO} on Fig. 5. It is highly probable that the collision would occur if the following equality is met:

$$X_{MO} / Y_{MO} = V_{MC} / V_{MO}$$

[0077] Thus, by assuming that the moving object MO 500 would move on a 2D-lane (i.e., $z = 0$, since z axis is directed upwards), it is highly probable that the collision would occur when the considered speed V_{MO} of the considered moving object MO 500 meets the following relationship:

$$V_{MO} = V_{MC} \cdot Y_{MO} / X_{MO}$$

[0078] A given position with 2D coordinates (X_{MO}, Y_{MO}) is associated with a considered speed V_{MO} of an object which would be a threat of collision if it would move at the considered speed V_{MO} in the direction of the railroad with the shortest path to it. Thus, two different positions may be associated with different considered speeds V_{MO} . This allows to compare these two different positions with two different weights. The obstacle detection enhancement data corresponds to indication of geographical zones with a priori absence of objects. When a train detects an object in a position which should be empty, this object is a threat of collision only if it would move at the considered speed V_{MO} in the direction of the railroad with the shortest path to it. The item located in a given position can thus be associated with a considered speed V_{MO} of potential threat. A weight can be computed for each item as a function of the considered speed V_{MO} , for example by considering the inverse of the considered speed V_{MO} associated to the position of the item, which involves that weights are higher for items corresponding to smaller considered speeds V_{MO} .

[0079] This leads to consider that the weight should be inversely proportional to the speed V_{MO} of the considered moving object MO 500 that moves toward the predefined path 130 ahead the moving conveyance MC 140. In this fourth embodiment, the figure of merit F2 ensures that, when the obstacle detection enhancement data corresponds to indication of geographical zones with a priori absence of objects, higher priority is attributed to items allowing enhanced protection from moving objects with low speed. An example of figure of merit F2 may thus be defined as follows:

$$F2(x,y,z) = V_{MC} \cdot |y| / x$$

or simply

$$F2(x,y,z) = |y| / x$$

[0080] According to a fifth embodiment, the server SERV 120 attributes weights to the obstacle detection enhancement data in the relevant map portion according to a refinement level of the obstacle detection enhancement data in question. The refinement level is, in the fifth embodiment, space sampling granularity of the map. Space is therefore sampled, thus forming points. Several layers with respective granularities are then defined: for example, a first layer with granularity of 0.1 meter, a second layer with granularity of 0.5 meter, a third layer with granularity of 1 meter and a fourth layer with granularity of 5 meters. To be noted that the layer of order "n-1" does not contain points information already present in the layer of order "n". A two-layer example is shown in **Fig. 6**, wherein the points represented by the squares 600 are sampled according to a less accurate granularity than the points represented by the discs 601. Thus, space is sampled hierarchically by using a lattice structure. Points belonging to sub-lattices with a larger minimal distance between points would have a higher weight. Thus, the points providing a lower information resolution are prioritized with respect to points providing a better information resolution. Let's denote F3 a figure of merit modelling such a weight attribution rule.

[0081] According to a sixth embodiment, the server SERV 120 attributes weights to the obstacle detection enhancement data in the relevant map portion again according to a refinement level of the obstacle detection enhancement data in question, and the figure of merit F3 is representative thereof. The refinement level is here a hierarchical refinement of polytopes. The more the polytope information provide refinement details, the lower the weight attributed to this polytope information. Thus, each volume represented by a polytope follows a hierarchical construction such as illustrated in **Fig. 7**, wherein the vertices linking the polytope points represented by triangles 702 are associated with a high weight, the vertices linking the polytope points represented by discs 701 which provide more refined description of the polytope are associated with a medium weight, and the vertices linking the polytope points represented by squares 700 which provide even more refined description of the polytope are associated with a low weight.

[0082] According to a seventh embodiment, the server SERV 120 further attributes lower weight to obstacle detection enhancement data that have already been provided to the on-board wireless radio unit OWRU 160 and that have not changed since. Such obstacle detection enhancement data may have been provided to the on-board wireless radio unit OWRU 160 during a previous transmission cycle. Such obstacle detection enhancement data may have been provided to the on-board wireless radio unit OWRU 160 in a preloaded manner, for instance when the moving conveyance MC 140 was stationary before starting the journey on the predefined path 130 (e.g., the moving conveyance MC 140 is a train and preload is performed when the train was waiting for departure in a railway station). To do so, the server SERV 120 sets a flag associated with the obstacle detection enhancement data stored in the database DB 150 when said obstacle detection enhancement data have already been provided to the on-board wireless radio unit OWRU 160. When the obstacle detection enhancement data in question change from the previous time said obstacle detection enhancement data have been provided to the on-board wireless radio unit OWRU 160, the server SERV 120 resets the associated flag, so that the obstacle detection enhancement data that have been updated are retransmitted to the on-board wireless radio unit OWRU 160. The server SERV 120 thus attributes weight according to the status of such a flag, for instance a null weight (low priority) when the flag is set and a positive weight (higher priority) when the flag is not set. Let's denote F4 a figure of merit modelling such a weight attribution rule.

[0083] In a particular embodiment, the server SERV 120 attributes weights by applying a combination among the first to seventh embodiments described above so as to perform multi-criteria weight attribution. For example, the figure of merit F3 is combined with the figure of merit F1 so that obstacle detection enhancement data associated with geographical references up to a predefined distance ahead the moving conveyance MC 140 with low space sampling resolution are attributed high priority. Then, obstacle detection enhancement data associated with positions geographical references up to the predefined distance ahead the moving conveyance MC 140 with higher space sampling resolution come next, and so on.

[0084] Another example of combining the different figures of merit expressed above in a combined figure of merit F

is to normalise values in the range [0,1] and combine them linearly with adaptation coefficients:

$$F(x, y, z) = \alpha_1 \frac{F1(x, y, z)}{\max(F1)} + \alpha_2 \frac{F2(x, y, z)}{\max(F2)} + \alpha_3 \frac{F3(x, y, z)}{\max(F3)}$$

wherein α_1 , α_2 and α_3 are the adaptation coefficients.

[0085] Yet another example of combining the different figures of merit expressed above in a combined figure of merit F is to use the figure of merit F4 to apply a mask. The figure of merit F4 is thus used as a multiplicative factor (forcing the weight to null for obstacle detection enhancement data already provided to the on-board wireless radio unit OWRU 160). Thus, the combined figure of merit F may be based on a product, such as:

$$F(x, y, z) = F1(x, y, z) * F2(x, y, z) * F3(x, y, z) * F4(x, y, z)$$

[0086] Yet another example of combining the different figures of merit expressed above in a combined figure of merit F is to consider both lateral distance and forward distance by multiplying the figures of merit F2 and F1, and normalizing the result in the range [0,1], and further add the weight corresponding to the figure of merit F3, and then apply a mask thanks to the figure of merit F4 to ensure that non-useful retransmission is avoided, such as:

$$F(x, y, z) = F4(x, y, z) * \left(F3(x, y, z) + \frac{F2(x, y, z)}{\max(F2)} * \frac{F1(x, y, z)}{\max(F1)} \right)$$

[0087] Many other combination of the figures of merit expressed above can be derived by the one with ordinary skills in the art.

[0088] In a step S306, the server SERV 120 obtains a quantity of transmission resources available for transmitting obstacle detection enhancement data to the on-board wireless radio unit OWRU 160 during the transmission cycle C_n .

[0089] In a step S307, the server SERV 120 retrieves from the database DB 150 the obstacle detection enhancement data to be transmitted in the transmission cycle C_n . Among the obstacle detection enhancement data of the relevant map portion determined in the step S304, the server SERV 120 gathers obstacle detection enhancement data so as to fill the transmission resources according to priority attributed in the step S305. The quantity of obstacle detection enhancement data intended for the obstacle detection system ODS 170 in the transmission cycle C_n is limited to the transmission resources effectively made available to the transmissions toward the on-board wireless radio unit OWRU 160. Therefore, obstacle detection enhancement data with higher priority than others are privileged for transmission to the on-board wireless radio unit OWRU 160.

[0090] In a step S308, when the start of the transmission cycle C_n is reached, the server SERV 120 transmits the retrieved obstacle detection enhancement data to the on-board wireless radio unit OWRU 160. The obstacle detection enhancement data are then processed as detailed hereafter with respect to Fig. 4.

[0091] Fig. 4 schematically represents an algorithm for obtaining and processing the obstacle detection enhancement data. The algorithm of Fig. 4 is implemented by the on-board wireless radio unit OWRU 160.

[0092] In a step S401, the on-board wireless radio unit OWRU 160 obtains and transmits to the server SERV 120 information on actual speed of the moving conveyance MC 140. The on-board wireless radio unit OWRU 160 obtains such information for instance from a GPS (Global Positioning System) device or a speedometer installed in the concerned moving conveyance MC 140.

[0093] The on-board wireless radio unit OWRU 160 may further obtain and transmit to the server SERV 120 information on actual location of the moving conveyance MC 140 on the predefined path 130. The on-board wireless radio unit OWRU 160 may obtain such information for instance from a GPS (Global Positioning System) device installed in the concerned moving conveyance MC 140, or from cab signalling.

[0094] In a step S402, considering that the step S401 is performed during the transmission cycle C_{n-1} , the on-board wireless radio unit OWRU 160 receives in the transmission cycle C_n obstacle detection enhancement data from the server SERV 120. The obstacle detection enhancement data are transmitted in the transmission resources that have been made available to transmissions from the server SERV 120 toward the on-board wireless radio unit OWRU 160 for the transmission cycle C_n , as already addressed above.

[0095] In a step S403, the on-board wireless radio unit OWRU 160 forwards, to the obstacle detection system ODS 170 the obstacle detection enhancement data received in the step S402. The obstacle detection system ODS 170 is

thus able to enhance obstacle detection at least from the transmission cycle C_{n+1} with said obstacle detection enhancement data. Accordingly the obstacle detection system ODS 170 proceeds with enhancing obstacle detection at least from the transmission cycle C_{n+1} with said obstacle detection enhancement data.

Claims

1. A method for obtaining obstacle detection enhancement data to be transmitted to an on-board wireless radio unit (160) of a moving conveyance (140) travelling on a predefined path (130), the moving conveyance (140) embedding an obstacle detection system (170), the obstacle detection enhancement data being stored in a database (150) and including map descriptors describing knowledge of environment surrounding the predefined path (130) in association with a geographical reference, time being divided in transmission cycles, the method being performed by a server (120) and comprising, for determining which obstacle detection enhancement data to be transmitted toward the on-board wireless radio unit (160) in a transmission cycle C_n :

- obtaining (S301) information about actual speed and location of the moving conveyance (140) on the predefined path (130);
- computing (S302) a distance d_k travelled by the moving conveyance (140) during one transmission cycle at the actual speed of the moving conveyance (140);
- estimating (S303) location on said predefined path (130) from which the obstacle detection system (170) would need the obstacle detection enhancement data to be transmitted in the transmission cycle C_n , from the actual speed and location of the moving conveyance (140);
- determining (S304) a relevant map portion in the database (150), from the estimated location and the geographical references;
- prioritizing (S305) obstacle detection enhancement data in the determined relevant map portion by attributing a weight to each one of the obstacle detection enhancement data in said relevant map portion, wherein the weights are attributed according to distance separating the estimated location and the geographical reference associated with the obstacle detection enhancement data and/or refinement level of the obstacle detection enhancement data; and
- obtaining (S306) transmission resources made available for transmissions toward the on-board wireless radio unit (160) during the transmission cycle C_n ;
- retrieving (S307) from the database (150) the obstacle detection enhancement data to be transmitted in the transmission cycle C_n ; so as to fill said transmission resources, according to the attributed weights.

2. The method according to claim 1, wherein, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location, the weights are attributed according to a figure of merit F1 such that

$$F1(x,y,z) = \gamma \cdot \exp(-(|x|^2+|y|^2+|z|^2))$$

wherein γ is a real constant.

3. The method according to claim 1, wherein, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location and that x axis is directed identically as direction of the moving conveyance on the predefined path, the weights are attributed according to a figure of merit F1 such that

$$F1(x,y,z) = \beta \cdot H(x-\Delta)$$

wherein β is a real constant, wherein $H(\)$ is the Heaviside step function, being equal to "1" for positive input and equal to "0" otherwise, and wherein Δ is a coordinate on x axis above which the weight becomes null.

4. The method according to claim 1, wherein, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location and that x axis is directed identically as direction of the moving conveyance (140) on the predefined path (130), the weights are attributed according to a figure of merit F1 such that

$$F1(x,y,z) = \gamma \cdot H(x-BD) \cdot \exp(-(|x|^2+|y|^2+|z|^2))$$

wherein γ is a real constant and BD represents an estimated braking distance for the moving conveyance.

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5. The method according to claim 1, wherein, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location, that x axis is directed identically as direction of the moving conveyance (140) on the predefined path (130), and that z axis is directed upwards, the weights are attributed according to a figure of merit F2 such that

$$F2(x,y,z) = 1 / |y|$$

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6. The method according to claim 1, wherein, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location, that x axis is directed identically as direction of the moving conveyance (140) on the predefined path (130), and that z axis is directed upwards, the weights are attributed according to a figure of merit F2 such that

$$F2(x,y,z) = V_{MC} \cdot |y| / x$$

wherein V_{MC} represents the actual speed of the moving conveyance (140).

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7. The method according to claim 1, wherein, considering that "(x,y,z)" denotes said geographical reference in an orthonormal coordinate system centred on said estimated location, that x axis is directed identically as direction of the moving conveyance (140) on the predefined path (130), and that z axis is directed upwards, the weights are attributed according to a figure of merit F2 such that

$$F2(x,y,z) = |y| / x$$

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8. The method according to claim 1, wherein, space being sampled hierarchically by using lattice structures with different granularities so as to form points in space associated with different refinement levels, obstacle detection enhancement data corresponding to points providing a lower information resolution have, according to a figure of merit F3, higher weight than obstacle detection enhancement data corresponding to points providing a better information resolution.

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9. The method according to claim 1, wherein refinement level is a hierarchical refinement of polytopes, and according to a figure of merit F3, the more obstacle detection enhancement data corresponding to polytope information provide refinement details, the lower the weight attributed to this obstacle detection enhancement data.

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10. The method according to claim 1, wherein, further according to a figure of merit F4, lower weight is attributed to obstacle detection enhancement data that have already been provided to the on-board wireless radio unit (160) and that have not changed since than to other obstacle detection enhancement data that have not yet been provided to the on-board wireless radio unit (160) or that have changed since.

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11. The method according to any one of claims 2 to 4, further according to any one of claims 5 to 7, further according to claim 8 or 9, further according to claim 10, wherein the weights are attributed to the obstacle detection enhancement data by a combination of the figures of merit F1, F2, F3 and F4.

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12. A method for transmitting obstacle detection enhancement data to an on-board wireless radio unit (160) of a moving conveyance (140) travelling on a predefined path (130), the method being performed by the server (120) and comprising obtaining obstacle detection enhancement data according to any one of claims 1 to 7, and further comprising:

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when the start of the transmission cycle C_n is reached, transmitting (S308) the retrieved obstacle detection enhancement data to the on-board wireless radio unit (160) in the transmission resources made available thereto.

13. A computer program product comprising program code instructions that can be loaded in a programmable device for implementing the method according to any one of claims 1 to 11 or to claim 12, when the program code instructions are run by the programmable device.

14. A non-transitory information storage medium storing a computer program comprising program code instructions that can be loaded in a programmable device for implementing the method according to any one of claims 1 to 11 or to claim 12, when the program code instructions are read from the non-transitory information storage medium and run by the programmable device.

15. A server (120) configured for obtaining obstacle detection enhancement data to be transmitted to an on-board wireless radio unit (160) of a moving conveyance (140) travelling on a predefined path (130), the moving conveyance (140) further embedding an obstacle detection system (170), the obstacle detection enhancement data being stored in a database (150) and including map descriptors describing knowledge of environment surrounding the predefined path (130) in association with a geographical reference, time being divided in transmission cycles, wherein the server (120) comprises, for determining which obstacle detection enhancement data to be transmitted toward the on-board wireless radio unit (160) in a transmission cycle C_n :

- means for obtaining (S301) information about actual speed and location of the moving conveyance (140) on the predefined path (130);

- means for computing (S302) a distance d_k travelled by the moving conveyance (140) during one transmission cycle at the actual speed of the moving conveyance (140);

- means for estimating (S303) location on said predefined path (130) from which the obstacle detection system (170) would need the obstacle detection enhancement data to be transmitted in the transmission cycle C_n , from the actual speed and location of the moving conveyance (140);

- means for determining (S304) a relevant map portion in the database (150), from the estimated location and the geographical references;

- means for prioritizing (S305) obstacle detection enhancement data in the determined relevant map portion by attributing a weight to each one of the obstacle detection enhancement data in said relevant map portion, wherein the weights are attributed according to distance separating the estimated location and the geographical reference associated with the obstacle detection enhancement data and/or refinement level of the obstacle detection enhancement data;

- means for obtaining (S306) transmission resources made available for transmissions toward the on-board wireless radio unit (160) during the transmission cycle C_n ; and

- means for retrieving (S307) from the database (150) the obstacle detection enhancement data to be transmitted in the transmission cycle C_n ; so as to fill said transmission resources, according to the attributed weights.

16. A server (120) configured for transmitting obstacle detection enhancement data to an on-board wireless radio unit (160) of a moving conveyance (140) travelling on a predefined path (130), wherein the server (120) is according to claim 15 and further comprises:

when the start of the transmission cycle C_n is reached, means for transmitting (S308) the retrieved obstacle detection enhancement data to the on-board wireless radio unit (160) in the transmission resources made available thereto.

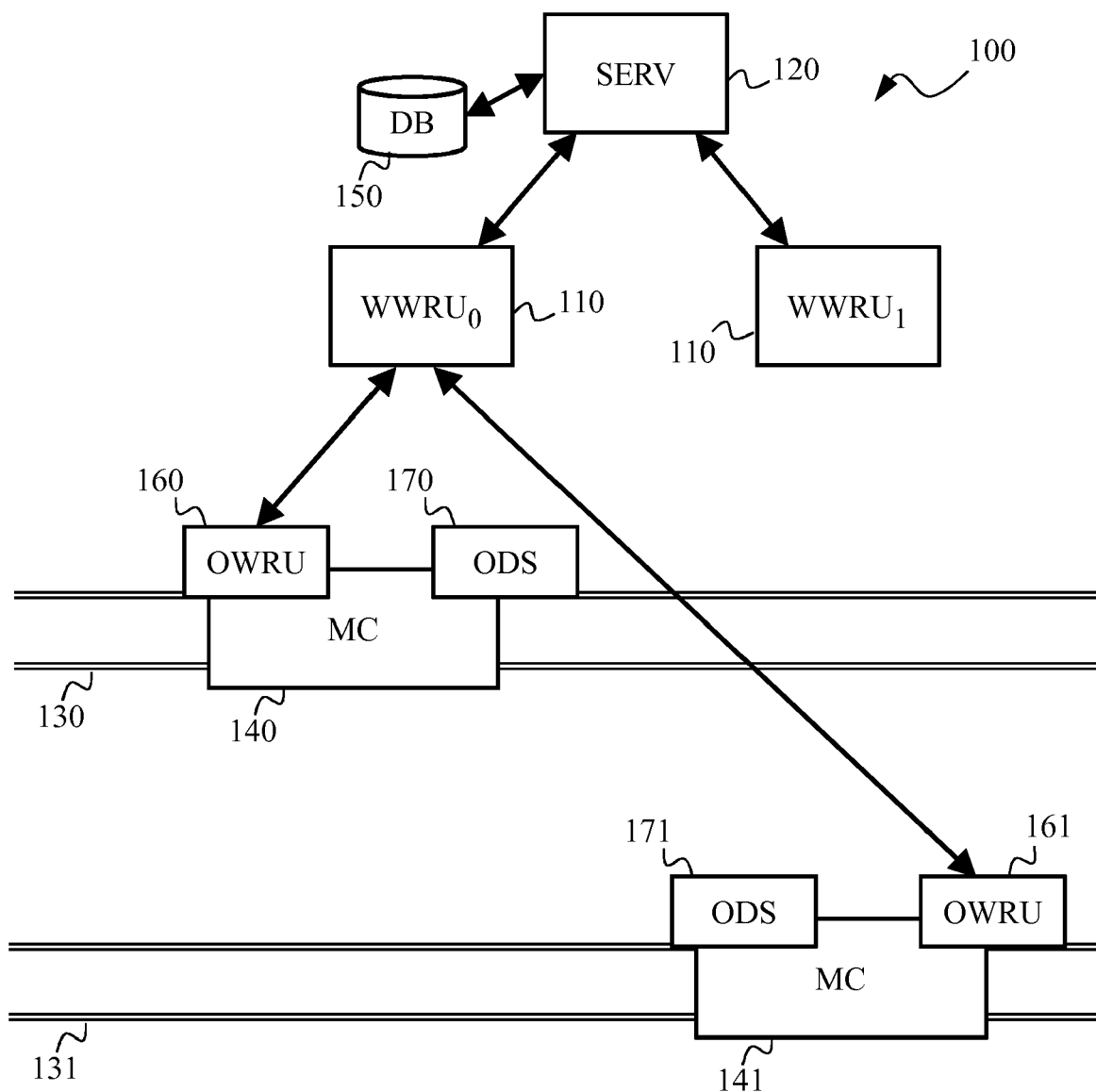
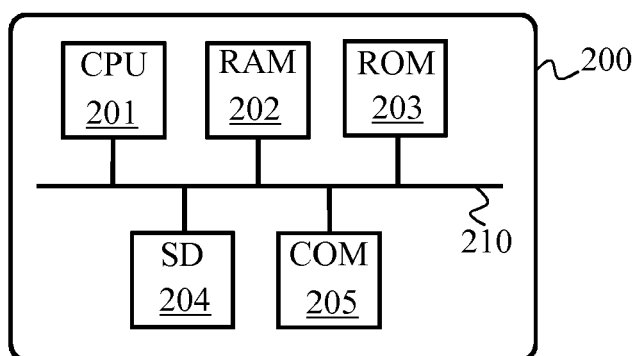


Fig. 1

Fig. 2



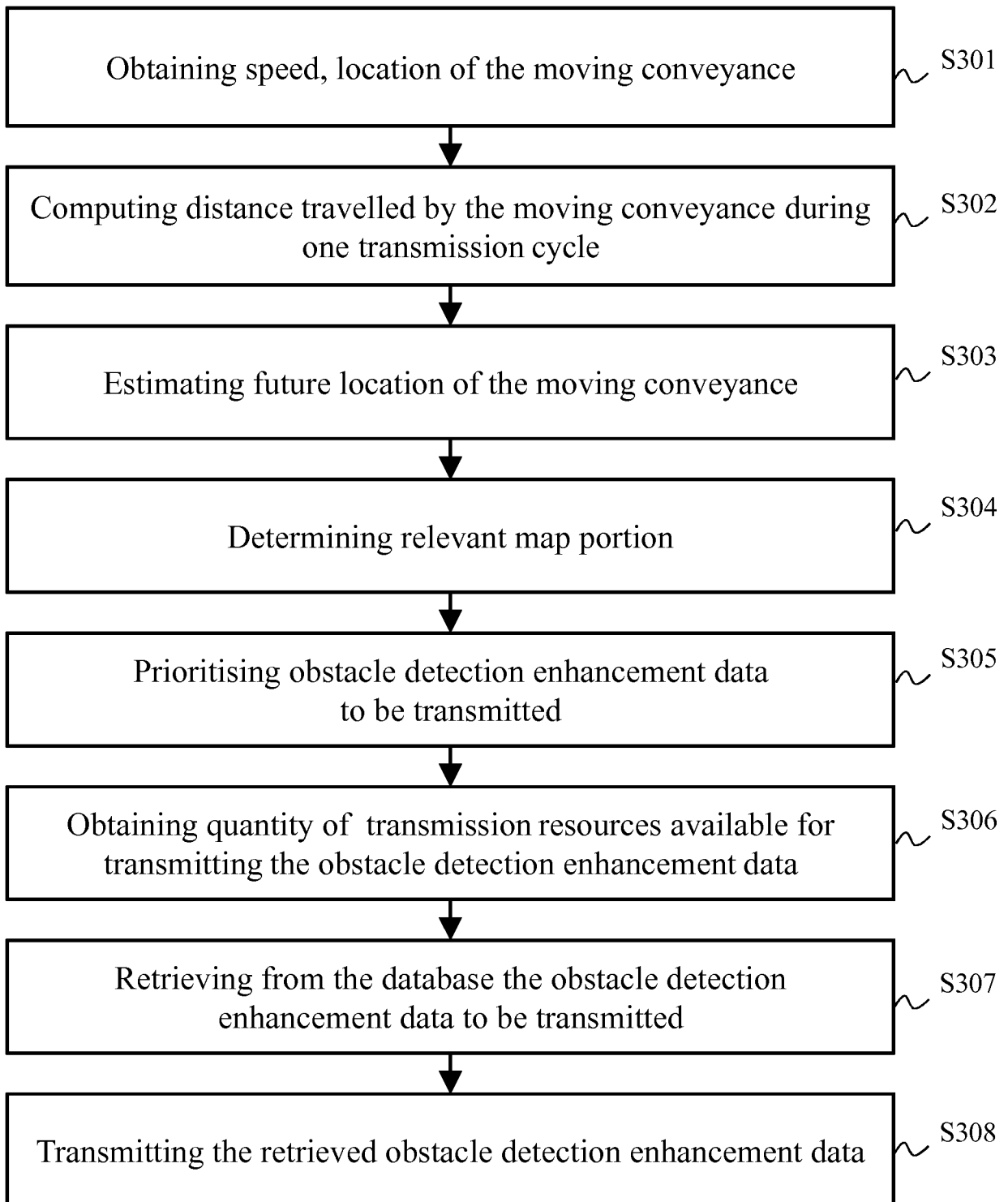


Fig. 3

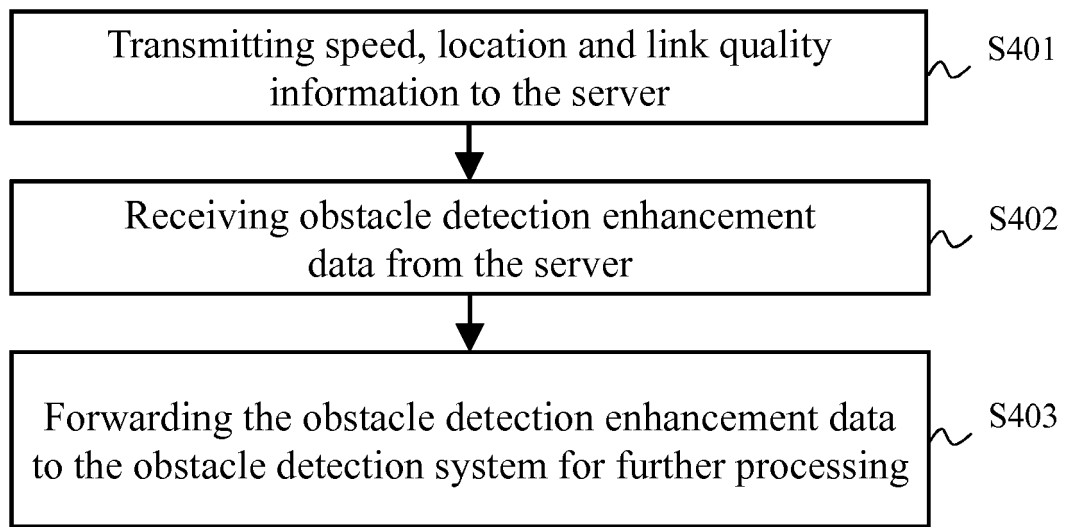


Fig. 4

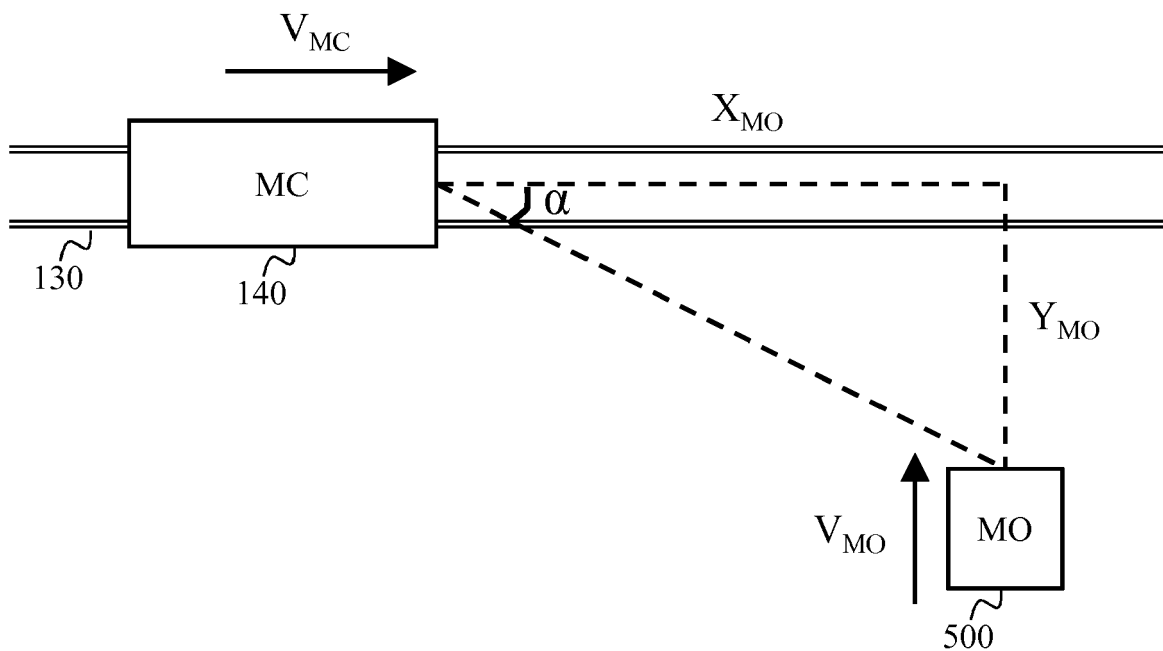


Fig. 5

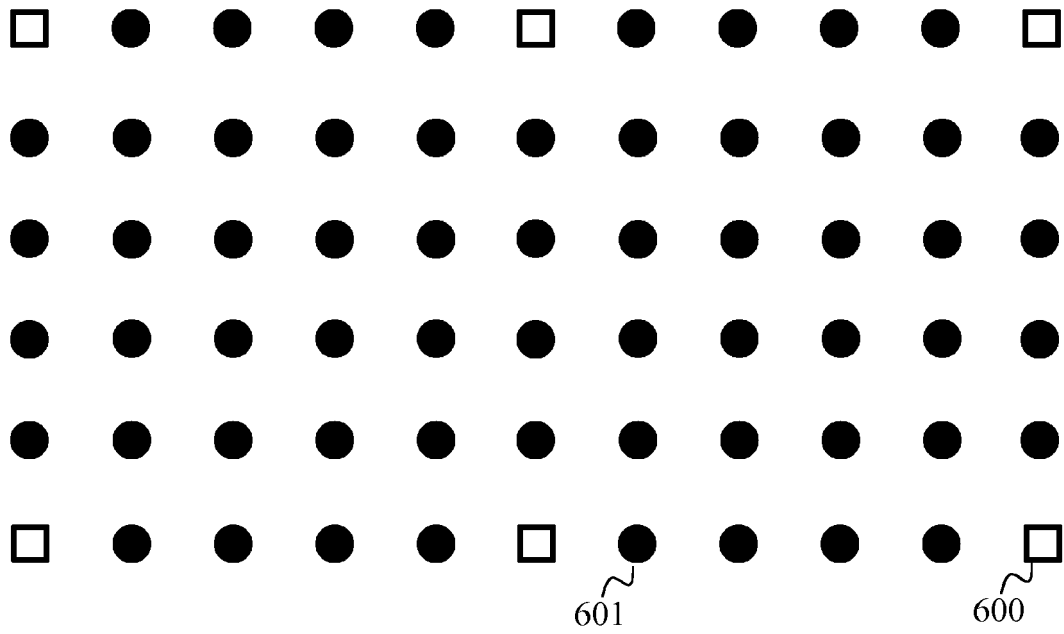


Fig. 6

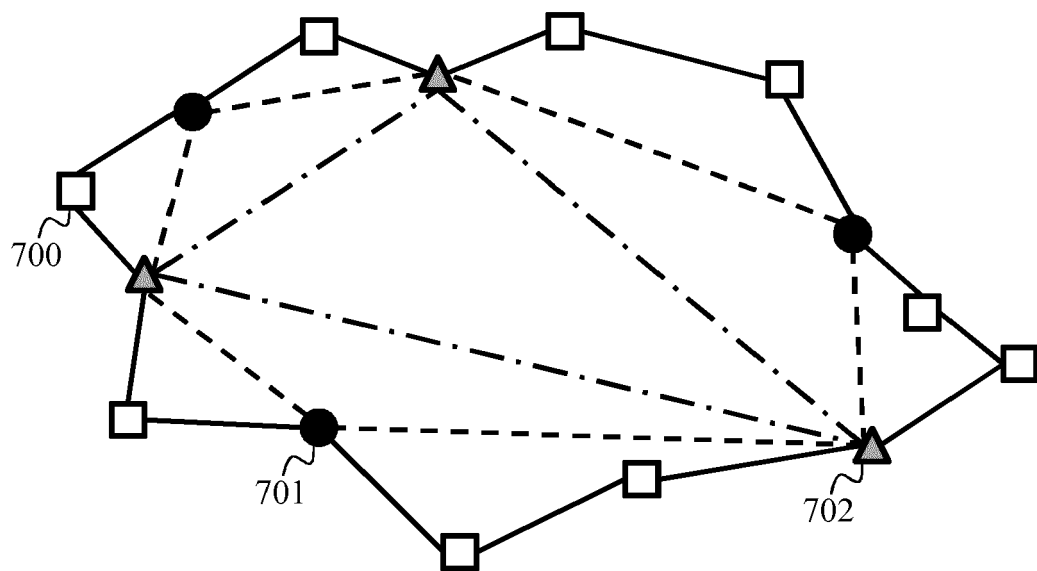


Fig. 7



EUROPEAN SEARCH REPORT

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A	EP 3 492 338 A1 (MITSUBISHI ELECTRIC R & D CENTRE EUROPE B V [NL] ET AL.) 5 June 2019 (2019-06-05) * paragraph [0028] - paragraph [0076]; figures 1a-6 *	1-16	INV. B61L23/04 B61L27/00
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			B61L
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 15 January 2020	Examiner Kassner, Holger
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 19 18 1988

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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