

Description

System and method for improving safety of a guided vehicle moving on a railway network

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Technical Field

The present invention concerns the safety of guided vehicles moving on a railway network. By “guided vehicle”, it has to be understood any rail transport means configured for moving on

10 tracks of said railway network, said guided vehicle typically running on at least one rail configured for supporting one or several wheels of said guided vehicle or using at least one rail as a guiding means for guiding the guided vehicle along a trajectory defined by said rail. Said rail transport means are for instance public transport means like subways, trains or train units, etc., as well as load transporting means such as freight trains, for which safety is a very

15 important factor. As known in the art, the railway network is made of interconnected railway tracks wherein the rails are mounted, and which usually follow the terrestrial relief, tracing railway paths sometimes upwards, sometimes downwards. The tracks of a railway network may thus present different inclinations, and knowing said inclination is important for ensuring the safety of a guided vehicle moving on said tracks. The present invention concerns in particular

20 track gradient data that define the inclination of the track (e.g. sloping upward or downward) with respect to a nominal track level (typically horizontal). Said track gradient data are of crucial importance in mechanisms that control a motion of the guided vehicle in function of a value of said track gradient data, e.g. for determining a braking force in order to match a braking curve.

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Background Art

Gradient data defines a continuous or quasi continuous slope profile for the tracks of the railway network, indicating the slope of each track or track part with respect to the nominal track level. Typically, the gradient is expressed as per mille. For instance, the value zero for a gradient

30 indicates horizontality, and a value +8 ‰, usually simply written “+8”, indicates a ratio of rise over run wherein by travelling 1000m (“the run”), the guided vehicle will gain a height of 8m (“the rise”). To ensure correct values of track gradient, tests can be performed on site in order to measure the real gradient of a railway network track. However, such tests are expensive, not always accurate enough, time consuming, and sometimes not possible because of a current

35 use of the tracks. Therefore, it does not exist a complete map of track gradient measured values for a railway network. Because of this, it is known in the art to use a conservative value of the gradient for parts of the railway network for which the “real” gradient has not been measured or

determined. The “real” gradient refers here to the gradient that would be obtained by measuring the gradient of a track on site, while said conservative value refers to a more conservative value in terms of safety than the value of the real gradient. A disadvantage of using a more conservative value for the gradient is a decrease of the exploitation performances, since for instance the authorized guided vehicle speed calculated in function of said conservative value might be lower than the speed that would have been authorized when taking into account the real value of the gradient. Other solutions are based on a use of inaccurate gradient values, wherein said inaccuracy is compensated by using a safety factor in mechanisms using one of said inaccurate gradient values for controlling a motion of the guided vehicle. Again, such solution is not optimal, since it leads to a decrease of the performance of the railway network exploitation.

Summary of Invention

An objective of the present invention is to propose a method and a system for improving the safety of a guided vehicle moving on a track whose gradient value has to be taken into account for ensuring said safety of the guided vehicle, while keeping the guided vehicle motion performant, said method and system being simple and easy to implement or install.

This objective is achieved by the measures taken in accordance with the independent claims. Further advantageous embodiments are proposed by the dependent claims.

More precisely, the present invention concerns a system for modeling a gradient of a track of a railway network, i.e. for determining a gradient profile for said track, said system comprising:

- a processing unit, e.g. a processor, configured for acquiring, for said track of the railway network, gradient values from a first source S_1 of gradient values; characterized in that
 - said processing unit is configured for acquiring, for said track of the railway network, gradient values from a second source S_2 of gradient values;
- the system, for instance its processing unit, being configured for
- splitting the railway network track in N portions $P_1, P_2, \dots, P_N$ of track, wherein each track portion P_k , for $k=1, \dots, N$, starts at a position p_k and ends at a position p'_k that is located within a directly next portion of track, called for convenience P_l , that starts at a position p_l and ends at a position p'_l . In other words, if P_k and P_l are two directly neighboring track portions, wherein P_k starts at position p_k and ends at position p'_k , and P_l starts at a position p_l and ends at position p'_l , then p_l is located between p_k and p'_k , with $k, l \in \{1, \dots, N\}$ and $k \neq l$, and N being the number of portions of track of the railway network;

- calculating for each portion P_k of track of said railway network, an average gradient value $AG_{1,k}$ obtained from the gradient values of the first source S_1 and an average gradient value $AG_{2,k}$ obtained from the gradient values of the second source S_2 ;
 - for each portion of track P_k , further comparing the average gradient value $AG_{1,k}$ to the average gradient value $AG_{2,k}$, and
 - if a difference, typically the absolute difference, between their values is smaller than a predefined reference value, then the system is configured for assigning to a sub-portion of track comprised between p_k and p_l a gradient value that is the average gradient value $AG_{1,k}$ or $AG_{2,k}$ or a mean value obtained from $AG_{1,k}$ and $AG_{2,k}$; otherwise
 - if said difference is greater than said predefined reference value, then using a third source S_3 of gradient values for calculating for said portion P_k of track an average gradient value $AG_{3,k}$, and comparing the latter to at least one of the values $AG_{1,k}$ and $AG_{2,k}$, i.e. to $AG_{1,k}$ and/or $AG_{2,k}$, i.e., in order to determine if their difference is smaller than said predefined reference value, and, in the affirmative, assigning to said sub-portion of track comprised between p_k and p_l a gradient value that is the average gradient value of said at least one of the values $AG_{1,k}$ and $AG_{2,k}$ to which $AG_{3,k}$ has been compared, or the value of $AG_{3,k}$, or a mean value obtained from their combination; in the negative, comparing $AG_{3,k}$ to the other one of the values $AG_{1,k}$ and $AG_{2,k}$, in order to determine if their difference is smaller than said predefined reference value, and, in the affirmative, assigning to said sub-portion of track comprised between p_k and p_l a gradient value that is the average gradient value of said other one of the values $AG_{1,k}$ and $AG_{2,k}$ to which $AG_{3,k}$ has been compared, or of $AG_{3,k}$, or a mean value obtained from their combination; and if both the difference between $AG_{3,k}$ and $AG_{1,k}$ and the difference between $AG_{3,k}$ and $AG_{2,k}$ are each greater than said predefined reference value, then the system is configured for generating an alert and/or using a restrictive gradient value for said sub-portion.
- 30 The present invention also concerns a method for modeling a gradient of a track of a railway network, said method comprising:
- splitting the railway network track in N portions $P_1, P_2, \dots, P_N$ of track, wherein each portion P_k of track starts at a position p_k and ends at a position p'_k that is located within a directly next portion of track P_l that starts at a position p_l and ends at a position p'_l ;
 - calculating for each portion P_k of track of said railway network, an average gradient value $AG_{1,k}$ obtained from gradient values of a first source S_1 of gradient values for tracks of the railway network, and an average gradient value $AG_{2,k}$ obtained from

gradient values of a second source S_2 of gradient values for tracks of the railway network;

- for each portion of track P_k , comparing the average gradient value $AG_{1,k}$ to the average gradient value $AG_{2,k}$, and
 - if a difference, preferentially an absolute difference, between their values is smaller than a predefined reference value, then assigning to a sub-portion of track starting at position p_k and ending at position p_l (typically, the sub-portion of track is defined as the position interval $[p_k, p_l[$ as long as P_L is not a last track portion, in which case the position interval would be defined as $[p_k, p_l]$) a gradient value that is the average gradient value $AG_{1,k}$ or $AG_{2,k}$ or a mean value obtained from $AG_{1,k}$ and $AG_{2,k}$; otherwise
 - if said difference is greater than said predefined reference value, then using a third source S_3 of gradient values for calculating for said portion P_k of track an average gradient value $AG_{3,k}$, and comparing the latter to at least one of the values $AG_{1,k}$ and $AG_{2,k}$, i.e. to $AG_{1,k}$ and/or $AG_{2,k}$, i.e., in order to determine if their difference is smaller than said predefined reference value, and, in the affirmative, assigning to said sub-portion of track comprised between p_k and p_l a gradient value that is the average gradient value of said at least one of the values $AG_{1,k}$ and $AG_{2,k}$ to which $AG_{3,k}$ has been compared, or the value of $AG_{3,k}$, or a mean value obtained from their combination; in the negative, comparing $AG_{3,k}$ to the other one of the values $AG_{1,k}$ and $AG_{2,k}$, in order to determine if their difference is smaller than said predefined reference value, and, in the affirmative, assigning to said sub-portion of track comprised between p_k and p_l a gradient value that is the average gradient value of said other one of the values $AG_{1,k}$ and $AG_{2,k}$ to which $AG_{3,k}$ has been compared, or of $AG_{3,k}$, or a mean value obtained from their combination; and if both the difference between $AG_{3,k}$ and $AG_{1,k}$ and the difference between $AG_{3,k}$ and $AG_{2,k}$ are each greater than said predefined reference value, then generating an alert and/or using a restrictive gradient value for said sub-portion.

Description of Embodiments

The present invention proposes a new way to model the gradient of tracks of a railway network, which ensures using gradient values that are safe for the control of the guided vehicle. This comes in particular from the splitting of the railway network in said portions of tracks for which at least two average gradient values, i.e. $AG_{1,k}$ and $AG_{2,k}$, are calculated. Preferentially, the length

of each portion of track is the same, i.e. each portion of track has a same length L . In particular, each portion of track overlaps a directly neighboring portion of track over a same overlapping length L' , wherein preferentially, $L'=L/2$.

5 As explained above, the present invention proposes to use multiple sources of track gradient data for determining, for each portion of track P_k , several average gradient values (e.g. $AG_{1,k}$, or $AG_{2,k}$, or $AG_{3,k}$, or a combination of at least two of the latter) that are then used to determine track gradient values for sub-portions of track so that a profile of track gradient values for the track be established, wherein said track gradient values determined for the sub-portions of the

10 track are then used for controlling a motion of the guided vehicle, notably by the system according to the invention. Preferentially, the first source S_1 , the second source S_2 , and the third source S_3 comprise, each, track gradient values coming from one of the following data sources, the data source being different for each of the first, second, and third sources S_1 , S_2 , S_3 :

- Track construction data;
- 15 - GPS data;
- Lidar data;
- Cartographic data;
- On site measurement data (e.g. using manual track auscultation or a trolley machine).

20 In other words, the first source S_1 , the second source S_2 , and the third source S_3 are three different sources of track gradient values chosen among the above-mentioned data sources. Typically, said sources use each a different method or technique for measuring or determining gradient values for the track, using for instance different devices for measuring or determining the gradient values, giving rise for instance to different errors on said measurements or

25 determinations of gradient values.

In particular, each source S_i , $i=1,\dots,3$, is configured for providing a set of position $s_{i,r}$, with $r=1,\dots,M_i$, M_i being the number of positions provided by the source S_i , wherein each position $s_{i,r}$ is a position on a track of the railway network so that, for two directly neighboring positions $s_{i,t}$

30 and $s_{i,y}$ of said set, the position interval $[s_{i,t};s_{i,y}[$ with $y\{1,\dots,M_i\}$ and $y\neq t$ corresponds to a part of the track, and according to the present invention, is associated to a gradient value $g_{i,t}$. The system according to the invention, for instance its processing unit, is notably configured for determining the average gradient value $AG_{i,k}$ of a track portion P_k extending between a position p_k and a position p'_k by implementing the following steps:

- 35 - Determining to which position interval the position p_k belongs to;
- Determining to which position interval the position p'_k belongs to;

- if p_k and p'_k belong to the same position interval, then the system, e.g. its processing unit, is configured for using the gradient value associated to said position interval as average gradient value $AG_{i,k}$ of the track portion P_k ; otherwise
- if position p_k and position p'_k belong to two different position intervals, respectively to $[s_{i,t}; s_{i,y}[$ and $[s_{i,w}; s_{i,z}[$ with $t, y, w, z \in \{1, \dots, M_i\}$ and $t \neq y \neq w \neq z$, then the system, e.g. its processing unit, is configured for calculating $AG_{i,k}$ according to:

$$AG_{i,k} = \{ (|s_{i,y} - p_k| \cdot g_{i,t}) + (|p'_k - s_{i,w}| \cdot g_{i,w}) + \text{a sum over all position intervals comprised between } s_{i,y} \text{ and } s_{i,w} - \text{called intermediate position intervals - of the length of the considered intermediate position interval times its associated gradient value} \} / (p'_k - p_k).$$

In the equation above, $|s_{i,y} - p_k|$ represents the distance (absolute distance) that separates the position $s_{i,y}$ from p_k and that is measured along the length of the portion of track P_k . The same applies mutatis mutandis to $|p'_k - s_{i,w}|$. The intermediate position intervals are defined along the length of the portion of track P_k . The length of an intermediate position interval corresponds to the distance measured along the portion of track P_k and that separates its limits or endpoints.

According to the present invention, the system is further configured for controlling a motion of the guided vehicle in function of the gradient value that has been assigned to said sub-portion. For instance, the system, notably its processing unit, is configured for controlling the speed or a braking of the guided vehicle in function of said assigned gradient value. Typically, the system according to the invention is able to automatically determine a braking curve for the guided vehicle that takes into account said assigned gradient value.

Brief Description of the Drawing

Further aspects of the present invention will be better understood through the following drawings, wherein like numbers designate like objects:

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Fig. 1 schematic illustration of a preferred embodiment according to the invention.

Fig. 2 schematic illustration of a first source of track gradient values along a path on a railway network.

Fig. 3 schematic illustration of a second source of track gradient values along a path on said railway network.

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Fig. 4 flowchart of a preferred embodiment of a method according to the invention.

Description of Examples

Figure 1 schematically shows a railway network 110 made of a plurality of interconnected tracks 111 that define different routes or paths that can be followed by a guided vehicle 120. For instance, a first route might go from a starting position A on said railway network to an ending position B, while a second route may go from said starting position A to an ending position C. During its travelling along such routes, the guided vehicle 120 may have to move on tracks that present different inclinations, i.e. gradients, with respect to the horizontal. This is better illustrated in Figure 2, wherein the different track gradients faced by the guided vehicle 120 are schematically represented for the path going from the starting position A to the ending position B. Thus, depending on its position on the railway network, the guided vehicle 120 will have to adapt its speed and/or braking force to the gradient of the track wherein it is located. In other words, the gradient value that is used by the guided vehicle for controlling its motion, for instance its speed or its braking force will have an impact on the safety of the motion of the guided vehicle, as well as on the performance of said guided vehicle.

The present invention proposes a system 100 that is able to automatically determine a gradient value for sub-portions of tracks of the railway network 110. The system 100 typically comprises a processing unit 101 and a memory 102 which might be configured for storing a map of the railway network. The system 100 according to the invention might be an on-board system, installed within the guided vehicle 120 or a central system, installed for instance in a remote control center in charge of the control of the motion of guided vehicles on said railway network 110, or might have components configured for being installed on-board the guided vehicle 120, like a braking system and/or a speed control system, and other components installed in said control center, like the processing unit 101 and the memory 102. The system 100 according to the invention might be configured for controlling a motion of the guided vehicle in function of said gradient value assigned to the sub-portion of track.

The system 100 according to the invention, for instance its processing unit 101, typically comprises instructions for automatically determining said gradient value for the sub-portions of the railway network tracks. The system 100 may automatically store the determined gradient values, for instance in a database, wherein, to each one of said sub-portions of track, a gradient value is associated. Said database might be a central database, for instance located in said remote control center, and whose data, notably any change of said data, are automatically communicated to the guided vehicle 120 by the system according to the invention, for instance to its speed control system and/or braking system. The system 100 may also store the gradient

values provided by each of the sources S_i , for instance in said database or memory 102. In particular, the gradient value assigned to a sub-portion of track might be stored by the system according to the invention in balises installed along the track, and/or in a radio block center RBC, and/or in any other system configured for sending gradient values, and therefore a track

5 gradient profile, to the guided vehicle. Such systems that are configured for sending track gradient values to the guided vehicle might be part of the system according to the invention. For instance, if a balise B is installed on one of said a sub-portions of track, called hereafter the “sub-portion B”, then the system 100 is configured for sending to said balise B at least the gradient value that has been determined for said sub-portion B of track wherein the balise B is

10 installed, and optionally the gradient values determined for a set of neighboring sub-portions located within a predefined distance from the sub-portion B comprising said balise B.

The way the system 100 is determining said gradient value for each sub-portion will be now described in connection with the method 400 according to the invention:

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At step 401, the system 100 is configured for automatically splitting the railway network 110 in N portions of tracks, denoted $P_1, \dots, P_N$, wherein each portion of track P_k overlaps at least one other portion of track that is a directly neighboring portion of track. This is better illustrated in Fig. 1, wherein P_1 overlaps with P_2 , which overlaps with P_3 . For convenience and for simplifying the

20 presentation of the invention, we will consider now the rail network 110 only made of the path going from the starting position A to the ending position B, wherein the track portions P_k are ordered from A to B according to increasing index values of k. As shown in Fig. 1, each portion P_l starts at a position p_l and ends at a position p'_l that is located within a directly next portion of track P_{l+1} that starts at a position p_{l+1} and ends at a position p'_{l+1} for $l = 1, \dots, N-1$. Thanks to the

25 splitting of the railway network according to the invention, any continuous path or route on said railway network, like the path from the starting position $A = p_1$ to the ending position $B = p'_N$ might be defined as a succession of track portions wherein each position on said route belongs at least to one track portion. For convenience, we will consider that the guided vehicle 120 has to travel from A to B.

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At step 402, the system 100 is configured for automatically calculating for each portion P_k of track of said railway network, an average gradient value $AG_{1,k}$ obtained from gradient values of a first source S_1 of gradient values, and an average gradient value $AG_{2,k}$ obtained from gradient values of a second source S_2 of gradient values for tracks of the railway network. A first source

35 of gradient values is illustrated by Figure 2, and a second source of gradient values is illustrated by Figure 3. The first source S_1 comprises for instance gradient values that have been estimated during construction of the track, while the second source S_2 comprises gradient

values coming from on-site measurements, e.g. from a LIDAR sensor, and which are for instance made every 25 cm. Each gradient value source S_i with $i=1,\dots,3$, associates to a position interval $[s_{i,t}, s_{i,y}[$ comprising one or several positions on said track, a gradient value $g_{i,t}$, so that a gradient value be associated to each position on tracks of the railway network. For convenience, the positions $s_{i,t}$ are shown according to increasing index values of t in Figure 2, which means that the position $s_{i,t+1}$ is a direct neighbor of the position $s_{i,t}$. Of course, other ways of numbering the positions $s_{i,t}$ might be used, which is why one used the term $s_{i,y}$ for representing a directly neighboring position to $s_{i,t}$. As it can be seen by comparing Figure 1 to Figure 2, the second source S_2 of gradient values is more precise than the first source S_1 of gradient values.

In the following and for convenience, we will consider that the positions $s_{i,t}$ are ordered from position A to position B, i.e. along said path from A to B, according to increasing index values of t , having for instance $s_{i,1}$ = position A and s_{i,M_i} = position B, with M_i being the number of position intervals defined by or for the gradient value source S_i , which corresponds also to the number of positions $s_{i,t}$ provided by the gradient value source S_i and to which a gradient value is associated to. For instance, if a gradient value is measured at a position $s_{i,t}$ on the railway network, then said value might be taken for all positions comprised between $s_{i,t}$ and $s_{i,t+1}$, $s_{i,t+1}$ being the next position wherein the gradient value has been measured. Of course, other ways of assigning gradient values to positions on the railway network for which no real gradient value exists or has been measured might be defined or chosen by the skilled person. At step 403, in order to calculate or determine for a portion of track P_k an average gradient value $AG_{i,k}$ from gradient values of a source S_i , the system 100 according to the invention preferentially proceeds as follows:

it first determines to which position interval each of the positions p_k and p'_k belong to, and second, if they belong to the same position interval, then it takes as average gradient value $AG_{i,k}$ for P_k the gradient value associated to said position interval to which both p_k and p'_k belong to. For instance, when considering Fig. 1 and Fig. 2, p_1 and p'_1 would both belong to the position interval $[s_{1,1}, s_{1,2}[$ and therefore, the gradient value +19 would be taken as the average gradient value for the portion P_1 . Otherwise, if the positions p_k belongs to a position interval $[s_{i,t}; s_{i,t+1}[$ that is different from the position interval $[s_{i,w}; s_{i,w+1}[$ to which p'_k belongs to (i.e. $w \neq t$), as it would be the case for p_2 and p'_2 when considering Figures 1 and 2, wherein $p_2 \in [s_{1,1}; s_{1,2}[$ and $p'_2 \in [s_{1,3}; s_{1,4}[$, then the average gradient value $AG_{i,k}$ is calculated as follows,:

$$AG_{i,k} = \{ [(s_{i,t+1} - p_k) \cdot g_{i,t}] + [(p'_k - s_{i,w}) \cdot g_{i,w}] + [\sum_{a=t+1, \dots, w-1} (s_{i,a+1} - s_{i,a}) \cdot ag_{i,a}] \} / (p'_k - p_k)$$

In the above equation, it has been considered that a frame of reference is centered on position A, the distance separating a position $s_{i,t}$ from position A increasing with increasing value of t and being measured along the track or path from A to B.

- 5 At step 404, for each track portion P_k , the system according to the invention, for instance its processing unit, is further configured for comparing the average gradient value $AG_{1,k}$ to the average gradient value $AG_{2,k}$. If a difference, for instance an absolute difference, between their values is smaller than a predefined reference value, then the system is configured for assigning to a sub-portion of track starting at position p_k and ending at position p_{k+1} a gradient value that is
10 the average gradient value $AG_{1,k}$ or $AG_{2,k}$ or a mean value obtained from $AG_{1,k}$ and $AG_{2,k}$. Said sub-portion of track might be defined as the interval $[p_k ; p_{k+1}[$.

Otherwise, if said difference is greater than said predefined reference value, the present invention proposes to use an additional source of gradient values to determine which gradient
15 values are the correct ones. In other words, the system is configured for automatically using a third source S_3 of gradient values for calculating for said portion P_k of track an additional average gradient value, that is the average gradient value $AG_{3,k}$, and then it is configured for automatically comparing $AG_{3,k}$ to at least one of the values $AG_{1,k}$ and $AG_{2,k}$. For instance, the system may start by comparing $AG_{3,k}$ to one of the average gradient values $AG_{1,k}$ or $AG_{2,k}$, if
20 they difference is smaller than said predefined value, then it can move to the next step, otherwise it compares $AG_{3,k}$ to the other one of said average gradient values, and if their difference is smaller than said predefined value, it can move to said next step, otherwise, if both the difference between $AG_{3,k}$ and $AG_{1,k}$ and the difference between $AG_{3,k}$ and $AG_{2,k}$ are greater than said predefined reference value, then the system is configured for automatically generating
25 an alert, sending for instance a signal to an operator, and/or for automatically assigning to said sub-portion of track a restrictive gradient value configured for ensuring the safety of the motion of the guided vehicle on said sub-portion of track. For instance, said restrictive gradient value can be the value of the gradient among $AG_{1,k}$, $AG_{2,k}$, and $AG_{3,k}$ that is the most restrictive, typically, the highest value among them.

30 In said next step, i.e. as soon as the system determines that the difference between $AG_{3,k}$ and one of the average gradient value $AG_{1,k}$ or $AG_{2,k}$ – called hereafter the matching average gradient value – is smaller than said predefined reference value, then it assigns to said sub-portion of track comprised between p_k and p_{k+1} a gradient value that is the average gradient
35 value of said matching average gradient value or of $AG_{3,k}$, or a mean value obtained from their combination. According to the present invention, three different sources of gradient values, namely S_1 , S_2 , and S_3 , are used, but the present concept could be extended for using more than

3 gradient value sources, in order to find the most appropriate gradient value to be associated to each sub-portion of track.

Preferentially, for the last portion of track P_N of the path from position A to position B, if a
5 difference between two of the $AG_{i,k}$ is found smaller than the predefined reference value, then the system assigns to the whole portion P_N the gradient value of one of said $AG_{i,k}$ or a gradient value obtained from their combination.

At step 405, the system according to the invention is configured for controlling a motion of the
10 guided vehicle in function of said gradient value assigned to the sub-portion of track comprised between p_k and p_{k+1} .

To conclude, the present invention proposes a new method and system for determining gradient
values that have to be associated to a track of a railway network, which are able to take into
15 consideration multiple sources of gradient values and to automatically determine, for each sub-portion of said track, the most appropriate gradient value to be associated to said sub-portion, ensuring therefore the safety of the motion of the guided vehicle on each track sub-portion.
The present method and system enable thus to easily determine or model a gradient profile for
said track by assigning to each sub-portion of said track, said gradient value. The track profile is
20 thus defined at the end by the succession of gradient values associated to the track sub-portions that compose the track, i.e. in which the track has been subdivided.

Claims

1. System (100) for modeling a gradient of a track (111) of a railway network (110), said system (100) comprising:
 - a processing unit (101) configured for acquiring, for said track (111) of the railway network (110), gradient values from a first source S_1 of gradient values for said track; characterized in that
 - said processing unit (101) is configured for acquiring, for said track (111) of the railway network (110), gradient values from a second source S_2 of gradient values for said track;
 the system being configured for
 - splitting the railway network track (111) in N portions $P_1, P_2, \dots, P_N$ of track, wherein each track portion P_k starts at a position p_k and ends at a position p'_k that is located within a directly next portion of track P_l which starts at a position p_l and ends at a position p'_l ;
 - calculating for each portion P_k of track (111) of said railway network (110), with $k=1, \dots, N$, an average gradient value $AG_{1,k}$ obtained from the gradient values of the first source S_1 and an average gradient value $AG_{2,k}$ obtained from the gradient values of the second source S_2 ;
 - for each track portion P_k further comparing the average gradient value $AG_{1,k}$ to the average gradient value $AG_{2,k}$, and
 - if a difference between their values is smaller than a predefined reference value, then the system is configured for assigning to a sub-portion of track starting at position p_k and ending at position p_l a gradient value that is the average gradient value $AG_{1,k}$ or $AG_{2,k}$ or a mean value obtained from $AG_{1,k}$ and $AG_{2,k}$; otherwise
 - if said difference is greater than said predefined reference value, then using a third source S_3 of gradient values for calculating for said track portion P_k an average gradient value $AG_{3,k}$, and comparing the latter to at least one of the values $AG_{1,k}$ and $AG_{2,k}$ in order to determine if their difference is smaller than said predefined reference value, and, in the affirmative, assigning to said sub-portion of track comprised between p_k and p_l a gradient value that is the average gradient value of said at least one of the values $AG_{1,k}$ and $AG_{2,k}$ to which $AG_{3,k}$ has been compared, or the value of $AG_{3,k}$, or a mean value obtained from their combination; in the negative, comparing $AG_{3,k}$ to the other

one of the values $AG_{1,k}$ and $AG_{2,k}$, in order to determine if their difference is smaller than said predefined reference value, and, in the affirmative, assigning to said sub-portion of track comprised between p_k and p_l a gradient value that is the average gradient value of said other one of the values $AG_{1,k}$ and $AG_{2,k}$ to which $AG_{3,k}$ has been compared, or of $AG_{3,k}$, or a mean value obtained from their combination; and if both the difference between $AG_{3,k}$ and $AG_{1,k}$, and the difference between $AG_{3,k}$ and $AG_{2,k}$ are greater than said predefined reference value, then the system (100) is configured for generating an alert and/or using a restrictive gradient value for said sub-portion.

2. System (100) according to claim 1, wherein the first source S_1 , the second source S_2 , and the third source S_3 comprise, each, track gradient values coming from one of the following data sources, the data source being different for each of the first, second, and third sources S_1 , S_2 , S_3 :
 - Track construction data;
 - GPS data;
 - Lidar data;
 - Cartographic data;
 - On-site measurement data.
3. System (100) according to claim 1 or 2, wherein the length of each portion of track (111) is the same.
4. System (100) according to one of the claims 1 to 3, wherein each portion of track (111) overlaps a directly neighboring portion of track over a same overlapping length.
5. System (100) according to claim 4, wherein the overlapping length is half the track portion length.
6. System (100) according to one of the claims 1 to 5, wherein each source S_i , $i=1, \dots, 3$, is configured for providing a set of M_i positions $s_{i,r}$ on said railway network (110), with $r=1, \dots, M_i$, wherein each position $s_{i,r}$ is a position on said track (111) of the railway network (110), wherein if $s_{i,t}$ and $s_{i,y}$ are two directly neighboring positions of said set of M_i positions, then the position interval $[s_{i,t}; s_{i,y}[$ with $y \in \{1, \dots, M_i\}$ and $y \neq t$, corresponds to a part of the track (111) and is associated to a gradient value $g_{i,t}$.

7. System (100) according to claim 6, configured for determining the average gradient value $AG_{i,k}$ of a track portion P_k extending between a position p_k and a position p'_k by implementing the following steps:

- 5 a. determining to which position interval the position p_k belongs to;
- b. determining to which position interval the position p'_k belongs to;
- c. if p_k and p'_k belong to the same position interval, then the system (100) is configured for using the gradient value associated to said position interval as average gradient value; otherwise
- 10 d. if position p_k and position p'_k belong to two different position intervals, respectively to $[s_{i,t}; s_{i,y}[$ and $[s_{i,w}; s_{i,z}[$ with $t, y, w, z \in \{1, \dots, M_i\}$, then the system (100) is configured for calculating $AG_{i,k}$ according to:

$$AG_{i,k} = \{ [| s_{i,y} - p_k | \cdot g_{i,t}] + [| p'_k - s_{i,w} | \cdot g_{i,w}] + [\text{a sum over all position intervals comprised between } s_{i,y} \text{ and } s_{i,w} - \text{called intermediate position intervals - of the}$$
- 15 length of the considered intermediate position interval times its associated gradient value]} / (p'_k - p_k)

8. System (100) according to claim 1 to 7, configured for controlling a motion of a guided vehicle (120) moving on said track (111) in function of the gradient value assigned to said sub-portion of track.

9. Method (400) for modeling a gradient of a track (111) of a railway network (110), said method (400) comprising:

- splitting (401) the railway network track (111) in N portions $P_1, P_2, \dots, P_N$ of track, wherein each portion P_k of track starts at a position p_k and ends at a position p'_k that is located within a directly next portion of track P_l that starts at a position p_l and ends at a position p'_l ;
- calculating (402) for each track portion P_k , an average gradient value $AG_{1,k}$ obtained from gradient values of a first source S_1 of gradient values for said track (111), and an average gradient value $AG_{2,k}$ obtained from gradient values of a second source S_2 of gradient values for said track (111) of the railway network (110);
- for each portion of track P_k , comparing (404) the average gradient value $AG_{1,k}$ to the average gradient value $AG_{2,k}$, and
 - if a difference between their values is smaller than a predefined reference value, then assigning to a sub-portion of said track starting at position p_k and

ending at position p_i a gradient value that is the average gradient value $AG_{1,k}$ or $AG_{2,k}$ or a mean value obtained from $AG_{1,k}$ and $AG_{2,k}$; otherwise

- if said difference is greater than said predefined reference value, then using a third source S_3 of gradient values for calculating for said track portion P_k an average gradient value $AG_{3,k}$, and comparing the latter to at least one of the values $AG_{1,k}$ and $AG_{2,k}$ in order to determine if their difference is smaller than said predefined reference value, and, in the affirmative, assigning to said sub-portion of track comprised between p_k and p_i a gradient value that is the average gradient value of said at least one of the values $AG_{1,k}$ and $AG_{2,k}$ to which $AG_{3,k}$ has been compared, or the value of $AG_{3,k}$, or a mean value obtained from their combination; in the negative, comparing $AG_{3,k}$ to the other one of the values $AG_{1,k}$ and $AG_{2,k}$ in order to determine if their difference is smaller than said predefined reference value, and, in the affirmative, assigning to said sub-portion of track a gradient value that is the average gradient value of said other one of the values $AG_{1,k}$ and $AG_{2,k}$ to which $AG_{3,k}$ has been compared, or $AG_{3,k}$, or a mean value obtained from their combination; and if both the difference between $AG_{3,k}$ and $AG_{1,k}$ and the difference between $AG_{3,k}$ and $AG_{2,k}$ are each greater than said predefined reference value, then generating an alert and/or using a restrictive gradient value for said sub-portion.

10. Method (400) according to claim 9, wherein the length of each portion of track is the same.

11. Method (400) according to claim 9 or 10, wherein each portion of track overlaps a directly neighboring portion of track over a same overlapping length.

12. Method (400) according to claim 11, wherein the overlapping length is half the track portion length.

13. Method (400) according to one of the claims 9 to 12, wherein each source S_i , $i=1, \dots, 3$, is configured for providing a set of M_i position $s_{i,r}$ on said railway network, with $r=1, \dots, M_i$, M_i being the number of positions provided by the source S_i , wherein each position $s_{i,r}$ is a position on a track of the railway network, wherein if $s_{i,t}$ and $s_{i,y}$ are two directly neighboring positions of said set of M_i positions, then the position interval $[s_{i,t}; s_{i,y}[$ with

$y\{1, \dots, M_i\}$ and $y \neq t$, corresponds to a part of the track and is associated to a gradient value $g_{i,t}$.

14. Method (400) according to claim 13, wherein the average gradient value $AG_{i,k}$ of a track portion P_k extending between a position p_k and a position p'_k is determined (403) according to the following steps:

- a. determining to which position interval the position p_k belongs to;
- b. determining to which position interval the position p'_k belong to;
- c. if p_k and p'_k belong to the same position interval, then using the gradient value associated to said position interval as average gradient value; otherwise
- d. if position p_k and position p'_k belong to two different intervals, respectively to $[s_{i,t}; s_{i,y}[$ and $[s_{i,w}; s_{i,z}[$ with $t, y, w, z \in \{1, \dots, M_i\}$, then calculating $AG_{i,k}$ according to:

$$AG_{i,k} = \{ [|s_{i,y} - p_k| \cdot g_{i,t}] + [|p'_k - s_{i,w}| \cdot g_{i,w}] + [\text{a sum, over all position intervals comprised between } s_{i,y} \text{ and } s_{i,w} - \text{called intermediate position intervals, of the length of the considered intermediate position interval times its associated gradient value}] / (p'_k - p_k) \}.$$

15. Method (400) according to one of the claims 1-14, comprising using said gradient value assigned to said sub-portion of track for controlling (405) a motion of a guided vehicle (120) on said track (111) of the railway network (110).