

METHOD AND SYSTEM FOR PERFORMING A PLANNING PROCESS OF A RAILWAY SERVICE

The present invention relates to a method and a system for performing a planning process of a railway service.

A train timetable in a railway service defines the set of departure and arrival times for train lines at the stations or other relevant locations in a rail network.

The construction of a train timetable, or Train Timetabling Problem (TTP), represents only the first step of an even larger and more complex process: the yearly rail service planning.

This planning consists on the definition of the plan, and the allocation of resources to provide the annual train services, i.e., timetables, crew schedules, rolling stock, usage, etc.

Nowadays, an operator of a railway/metro line can quickly and intuitively see the current distribution of trains or vehicles over a railway track and the correspondence between the current position of each train and its expected position along the railway track according to a predetermined planned trip. This information is combined, for each train, with a reference timetable of the trip and a history of the trip representative of previous positions of the train compared with corresponding expected positions, to enable the operator to identify trends in the positioning of the train along the railway track.

The operator can therefore determine the best strategy for reducing any deviation noted in the positioning of the trains along the route with respect to the expected positions according to the planned trip.

A research from <http://ttplib.zib.de/> which explores track allocation is known. In this research, which specifically addresses the Train Timetabling Problem, an operator interface presents a tridimensional representation of a track, however, the research mainly focuses on the scheduling problem and it is only peripherally related to a tridimensional representation of data.

With respect to the above indicated tridimensional representation it is worth noting that it is only a topographical representation which uses the tridimensional view to present data regarding a timetable scheduling conflict.

According to different solutions to the Train Timetabling Problem, the train position, the trip history and the reference timetable of the trip are usually available as bi-dimensional graphs.

Figure 1 shows a first graph 1 of the bi-dimensional data available for train positions according to the prior art.

The graph 1 shows first lines 2 representative of current train positions, second lines 4 representative of expected train positions according to corresponding predetermined trips, and the first 2 and second 4 lines are arranged as a carousel.

For each train, indicated on the graph 1 with references such as G07, U14, P18, etc. both the current position and the expected position are animated and the associated first 2 and second 4 lines rotates. During normal operation the first lines 2 and the second lines 4 should align, as the train control system seeks to maintain the train position aligned with the expected position, however, perturbations such as a passenger holding a train door open and delaying the departure of the train can cause a misalignment between these two positions, this being shown in the graph 1 a circle segment 6 extending from the first line 2 to the corresponding second line 4. For example, in figure 1, the train P18 is delayed compared to the expected position 283.

Figure 2 shows a second graph 10 of the bi-dimensional data available for the trip histories and the reference timetables of trips according to the prior art.

The second graph 10 is a time/distance graph. For each train U14, G07, P18, etc., the reference timetable of a trip is indicated by a first curve 100 while the corresponding trip history is indicated by a second curve 102.

From this second graph 10 it is possible to see the trend between the reference timetable of a trip and the trip history. This graph can be animated when new trip historical data are available.

An operator can monitor the first graph 1 to visualize perturbations in the train trips and the first graph 1 clearly shows when a train has a discrepancy between its expected position and the current one. However, from the graph 1 it is not possible to detect at a glance a trend in the discrepancy.

To determine the type of perturbation occurring to a train the operator needs to switch to the second graph 10 showing the discrepancy over time. From this second graph 10 the operator can identify if the discrepancy is growing or diminishing, this allowing him to determine the appropriate action to carry out to reduce the perturbation.

There is therefore the need to simplify the analysis of the information above disclosed so as to let the operator detect intuitively and immediately disturbances to the operating trains so as to determine proper remedial actions in order to properly plan a railway service.

It is therefore an object of the present invention to provide a method and a system for performing in an easier manner a planning process of a railway service allowing an operator to detect intuitively and immediately disturbances to the operating train by overcoming the limitations of the prior art solutions.

This and other objects are fully achieved by virtue of method for performing a planning process of a railway service having the characteristics defined in independent claim 1, and by a system for performing a planning process of a railway service having the characteristics defined in claim 9.

Preferred embodiments of the invention are specified in the dependent claims, whose subject-matter is to be understood as forming an integral part of the present description.

Further characteristics and advantages of the present invention will become apparent from the following description, provided merely by way of a non-limiting example, with reference to the enclosed drawings, in which:

- Figure 1 shows a first graph of the bi-dimensional data available for the train positions according to the prior art;

- Figure 2 shows a graph of the bi-dimensional data available for the trip histories and trip reference timetables according to the prior art;

- Figure 3 shows a graph obtained according to the method according to the present invention;

- Figure 4 shows a top sectional view of a cylinder of the graph of figure 3;

- Figure 5 is a block diagram of the steps performed in a method according to the present invention, and

- Figure 6 is a schematic view of a system of the present invention.

Briefly, the method according to the present invention is based on the combination of the first graph 1 and the second graph 10 above disclosed to provide a tridimensional representation of the data.

Figure 3 shows a tridimensional graph 20 obtained according to the method of the present invention, as disclosed in detail here below, this graph 20 being obtained through the use of a supervisory system of a railway line.

The tridimensional graph 20 is displayed on a display of a remote control unit wherein an operator, placed in front of the display, can see it while performing a planning process of a railway service, said railway service including a plurality of trains moving along respective railway tracks over time.

The tridimensional space of the graph 20 can be rotated and repositioned on the display by the operator in a manner per se known, but considering the space in absolute terms, each train position is represented on a XY plane, and time is represented on a Z axis of a reference Cartesian system XYZ.

The graph 20 forms a cylinder 21 with a trip history and a reference timetable of the trip represented around the surface of the cylinder.

The reference timetable comprises data points representing important points that delineate a train mission. On the graph 20, these data points are the combination of a time instant represented on the Z axis and a position represented on the XY plane.

The position can be given as an absolute position, or a position related to a topological feature, for example a platform or a siding.

The reference timetable is constructed before being used when performing the method of the present invention, and the data points of the reference timetable are available to the supervisory system.

In a similar way a trip history comprises data that represent gathered data for a predetermined train mission. These data include time and position. The trip history is captured in real time as a train performs a mission.

In particular, the graph 20 is obtained by translating the data of the reference timetable and at least one trip history in a predetermined format representing the time and position as a point on the surface of the cylinder 21.

The Z axis represents the time, while the angle formed between a point, representing a train, on the surface of the cylinder and a point of reference on the surface of the cylinder is used for the distance of the train relative to the point of reference. Each consecutive time and position data points are connected by a line. The consequence of this translation is that the reference timetable and trip history appear as spiraling lines drawn up the side of the cylinder 21.

When a horizontal XY plane 22 intersects the cylinder 21 at a given time instant, represented by a predetermined position along the Z axis, the train positions are given. The term horizontal refers to a visualization of the cylinder 21 on the display wherein the axis of the cylinder 21 extends in a vertical direction.

A view of just the XY plane is identical to the bi-dimensional first graph 1 above disclosed.

Similarly, a sectional view parallel to the Z axis is similar to the bi-dimensional second graph 10 above disclosed.

With these views the operator can see a deviation from the carousel of train positions, and then immediately trace the history of the train trip to determine if the deviation is being corrected or if an intervention is required.

By shifting the cylinder 21 on the display along the Z axis the operator can examine at a given time the impact of any deviation happening in the past, by comparing the spiraling lines relative to the reference timetable and the trip history between the past deviation and the given time.

By shifting the cylinder 21 on the display along the Z axis the operator can also determine, from the spiraling lines relative to the reference timetable, any future evolution, and decide according to this evolution if he has to act on the railway line functioning and/or reference timetable. For example, the operator or the supervisory system can
 5 compare the last measured deviation between the trip history and the reference timetable at a given time, having the possibility of speeding up the train on an ahead portion of the railway line where the train is supposed to travel in the future.

Advantageously, the supervisory system is configured to calculate and display an estimated spiraling line corresponding to an estimated trip history from a given deviation
 10 point. The deviation point corresponds, for example, to a disturbance where a passenger delays a train on a track approaching a terminal. The operator or the system is therefore capable of comparing the estimated spiraling line corresponding to the estimated trip history with the spiraling line corresponding to the reference timetable, and to identify major disturbances of the operating train so as to use this information to determine
 15 remedial actions and to plan accordingly a railway service. The estimated trip history is determined using a predetermined statistic model of the line or historical data saved during the past functioning of the railway line.

By rotating the cylinder 21 on the display the operator can examine all the trains in the carousel.

20 The overall performance of the trains can be assessed with their trip histories and reference timetables of a trip, therefore, the operator can then determine the need for global alteration of the timetable by adding or removing trips to the supervisory system.

The cylinder 21 can be tilted on the display towards the operator to provide a train position graph which better shows the train and the relationship of its trip history to the trip
 25 reference, in particular a triangle 23 that shows if a train is in advance or delayed with respect to its reference timetable. This triangle 23, which can be seen in figure 3, is formed where for example train U14 is delayed: the triangle 23 is drawn from the actual position of the train U14 to a point on the surface of the cylinder 21 placed ahead of the train, since an angle along the circumference defined by the intersection of the plane 22
 30 and the surface of cylinder 21 represents the distance covered by the train. This corresponds to the circle segments 6 shown in figure 1.

Figure 4 shows a top sectional view of the cylinder 21.

The operator can also zoom the current view point by moving closer the cylinder 21 or pulling it away and this changes the quantity of data shown.

In the following of the description a method for performing a planning process of a railway service according to the present invention will be disclosed, with reference to figure 5 which shows a block diagram of the steps to be performed.

In a first step 200 data relative to current train positions, expected train positions, trip histories and reference timetables of trips are acquired in a manner known per se.

In a further step 202 these data are combined in a manner known per se so as to get the tridimensional graph 20 above disclosed, wherein the train positions are indicated in a planar direction XY of the cylinder 21 and the trip histories and reference timetables of trips are represented around the surface of the cylinder 21.

Finally, in a step 204 the operator performs a plurality of moving operations known per se on the cylinder 21 so as to acquire combined train-related information to be used for planning a railway service.

The tridimensional graph 20 combines the information available for live train position and trip history with the reference trip timetable, and this allows the operator of a railway/metro train line to intuitively detect disturbances to the operating trains and use this information to determine remedial actions and planning a railway service.

The current distribution of the trains can be related to the trends in train positioning coming from past data and extrapolated into the future. The past distribution of trip data can be examined to determine how it has effected the current train distribution.

Figure 6 shows a schematic view of a supervisory system for performing a planning process of a railway service according to the present invention. The system comprises a plurality of sensors 300 located along a railway track 302 and arranged to acquire data relative to current train positions and to send these data to a remote control unit 304 of said railway service. The remote control unit 304 comprises memory means 306 arranged to store predetermined expected train positions, trip histories and reference timetables of trips. The remote control unit further comprises an elaboration unit 308 arranged to combine, in a manner known per se, the data relative to current train positions, the expected train positions, the trip histories and the reference timetables of trips so as to get the tridimensional graph 20 above disclosed.

The system further comprises a display unit 310 for visualizing the graph 20.

Clearly, the principle of the invention remaining the same, the embodiments and the details of production can be varied considerably from what has been described and illustrated purely by way of non-limiting example, without departing from the scope of protection of the present invention as defined by the attached claims.

CLAIMS

1. Method for performing a planning process of a railway service comprising the steps of:

- acquiring (200), using sensors (300), train data relative to measured movement of trains
5 along a railway track (302), and reference data relative to a reference timetable of trains trips;

- generating, with an elaboration unit (308), a reference three dimensional graph (20) including a three dimensional cylinder (21) and associating a reference Cartesian system (XYZ) to the cylinder (21);

10 - calculating, with the elaboration unit (308), coordinates of history points and reference points for each train in the reference Cartesian system (XYZ) as a function respectively of said train and reference data, the coordinates of the history and reference points in a planar direction (XY) of the reference Cartesian system (XYZ) being function of a train position corresponding respectively to said train and reference data, and the coordinates
15 of the history and reference points in a vertical direction perpendicular to the planar direction (XY) being function of a time associated with said train position respectively in the train and reference data, the coordinates of each history and reference points corresponding to a point belonging to the surface of the cylinder (21);

- displaying on a display unit (310) the three dimensional graph and the history and
20 reference points;

- planning, with a control unit (304), the railway service as a function of the data displayed on the display unit (310).

2. Method according to claim 1, wherein the planning method comprises the sub-step of:

25 - performing (204) a plurality of moving operations on the cylinder (21) so as to acquire combined train-related information to be used for planning the railway service.

3. Method according to claim 2, wherein the moving operations comprise shifting the cylinder (21) along the Z axis to examine the impact of any deviation between an
30 expected train position and a current train position.

4. Method according to claim 2 or 3, wherein the moving operations comprise:

- intersect an horizontal XY plane (22) to the cylinder (21) at a predetermined position along the Z axis corresponding to a predetermined time instant so as to get trains
35 positions;

- rotating the cylinder (21) so as to examine all the trains positions which are indicated in the XY plane (22) as a carousel.

5. Method according to any of the preceding claims, wherein the train data comprise for each train, current train positions and trip history, and the reference data comprise for each train, expected train positions and reference timetables of trips.

6. Method according to any one of claims 2 to 4 and to claim 5, wherein the moving operations comprise tilting the cylinder (21) so as to provide a train position graph which shows each train and the relationship of its trip history to the reference timetable of the trip, in particular a triangle (23) that demonstrates if a train is in advance or delayed compared to its reference timetable, the triangle being generated and displayed during the displaying step, being comprised in an horizontal XY plan and having as edges one of the reference points, one of the history points and one point on a central axis of the cylinder (21).

7. Method according to any of the preceding claims, wherein during the displaying step the display unit (310) generates and displays for each train a curve linking the history points and a curve linking the reference points.

8. Method according to any of the preceding claims, wherein the planning step comprises the sub-step of:

- modifying, using the control unit (304), the planning of the railway service as a function of the position of the reference and history points in the three dimensional graph (20).

9. A system for performing a planning process of a railway service comprising:

- a plurality of sensors (300) located along a railway track (302) and arranged to acquire train data relative to measured movement of trains along the railway track (302) and reference data relative to a reference timetable of trains trips;

- a control unit (304) arranged to receive said train and reference data, said control unit (304) comprising memory means arranged to store said train and reference data, and an elaboration unit (308) arranged to:

- generate a reference three dimensional graph (20) including a cylinder (21) and associating a reference Cartesian system (XYZ) to the cylinder (21);

- calculate coordinates of history points and reference points for each train in the reference Cartesian system (XYZ) as a function respectively of said train and reference

data, the coordinates of the history and reference points in a planar direction (XY) of the reference Cartesian system (XYZ) being function of a train position corresponding respectively to said train and reference data, and the coordinates of the history and reference points in a vertical direction perpendicular to the planar direction (XY) being
5 function of a time associated with said train position respectively in the train and reference data, the coordinates of each history and reference points corresponding to a point belonging to the surface of the cylinder (21),

- a display unit (310) for visualizing said graph (20) and the history and reference points,
the control unit (304) being configured for planning the railway service as a function of the
10 data displayed on the display unit.