Tracking of Train using Satellite Navigation

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ABSTRACT: The paper addresses the problem of assessing national railway infrastructure investment projects solved within the study. The research concentrate on evaluating the benefits associated with improving the protection and reliability of the railway system due to the realization of projects including improvements in management and safety equipment. The paper focuses on incorporating elements of satellite navigation systems in the rail traffic market. More specifically, it presents several functionalities that can either be implemented on current technological and information systems, or serve for a new digital assistive device whose system is based on the location detected through the navigation system. It can generate outputs for the driver of the engine as well as for staff of the infrastructure manager. The main aim is not to replace railway signaling systems but to raise visibility, improve employee morale and reduce the occurrence of unexpected situations. This current technology may be used to locate the exact location of the train in case any unusual activity took place.

KEYWORDS: Train tracking; transport; navigation; satellite systems; railway transport; safety.

INTRODUCTION

Nowadays, the optimum mobility of goods and people and the efficiency of the transport process, transport and logistics chain need to be ensured. A significant boost to economy is passenger and freight transport. Only a freight transport network and transport infrastructure will contribute to the growth of the national economy and economic sectors, including trade, agriculture and other manufacturing and non-productive sectors [1]. The speed and efficiency of the transportation cycle, its environmental effects and energy use significantly affect the area's sustainable development and societal growth. In recent years, however, the performance of public passenger transport in many countries has been reduced, particularly with a transitive economic situation. At the same time there is a rise in individual car transport, which is far more common among national people than mass passenger transport. The huge increase in passenger cars, however, is causing a number of negative social facts, in particular congestion and adverse environmental impacts [2].

Therefore, a range of proactive steps need to be taken now to revitalize public passenger transport, which might inspire passengers to use public transport at the cost of the commuter. It is also one of the EU transport policy's global strategic priorities, with the basic goal being to minimize pollution and modally transfer goods and people towards more environmentally sustainable modes of transport. The European Commission has therefore issued a number of strategy papers to help meet the national's goals selector [3].

Rail passenger transport has no dominant position in public transport. On behalf of suburban bus transport, but especially on individual car traffic, road transport represents the most important competition in short-distance transport. Air travel is the most important competition in long-distance travel, and is more favorable for passengers, in particular with its favorable transport costs. Rail passenger transport is thus "at risk," on the one hand especially for person motoring and, on the other, for air transport. To order to achieve the vision and execution of concrete targets for the advancement of urban passenger transport, the fundamental aim is to eradicate individual car traffic internationally, but at the cost of this, to particular, rail transport with greater provisions for cycling and walking as well as other urban passenger transport systems. In particular, however, it is important to raise the status of rail passenger transport, which must be the backbone of public transport, in short-distance transport, where it must be as competitive as possible with suburban bus transport and individual car transport, as well as with medium-distance transport and long-distance transport, where there is a need to create competitive conditions in comparison with the other.

LITERATURE REVIEW

This paper offers an overview of RUNE and provides findings from analyzes carried out on the data obtained from the experimental train test campaign. Although the testing time was short, it is necessary to collect and analyze real data for building system behavior expertise and for evaluation and tuning of algorithms. These initial results indicate success achieved in the real world and the system's ability to provide features for In-Cab Signalling and Virtual Balise. It is recognized that a reliable GNSS-based train navigation system can only be built by comprehensive field testing and validation of the system architecture and algorithms [1]. This paper introduces a new idea for an early warning system for train collisions (TCEWS), which discusses the question of train-to-train collisions. Similar to current railway network collision avoidance schemes, does the TCEWS approach allow drivers to "see".

The community leads the goal train and has up-to-date and reliable knowledge of the local traffic situation. Nevertheless, there are some variations in the TCEWS system architecture and operating principles. The main concept is to construct a network independent of current railway signaling systems, e.g. the level-2 or level-3 Chinese Train Control System. With additional sensors and prior knowledge from the electronic track map database, the Global Navigation Satellite Network can provide train state detection and collision risk assessment capabilities without relying on Automatic Train Safety or any other existing train-borne equipment [2]. The paper focuses on applying the unified standardization approach to the railway field: it reports on activities conducted to develop reference architectures for standardization of GNSS-based locator units and analyzes the resulting benefits for rail stakeholders [3]. The paper shows the effects of satellite surveying railway geometry on implementation. The investigative method outlined in the paper is split into two stages. The first step is mobile GNSS surveying and data collected from the study. The second step is to evaluate the geometry of the track using the surveying flat coordinates.

Visualization of the measured path, separation and quality evaluation of the uniform geometric elements (straight sections, arcs), identification of the polygon track (main directions and angles of intersection) are discussed and illustrated by the example of measurement within the article[4]. This article focuses on a novel on-board railway position Advanced Train Position Simulator (ATLAS) using wireless communication technologies, such as satellite navigation and location based systems. ATLAS enables multiple simulation environments to be developed which provide a versatile tool for testing and evaluating new train location services. This improvement decreases the number of tests conducted in actual scenarios and trains, minimizing new location systems' cost and development time, as well as determining the performance level for given tracks[5]. The approach is tested using both field trials and simulated results. Results show that the SLDS based integrity detection approach's false alarm rate and misdetection rate are 0 and 0.09 percent respectively, which is better than the projected train length dependent detection model and Hidden Markov Model (HMM) [6].

Map-matching techniques strive to leverage previous knowledge in road or rail networks. However, it is not easy to integrate digital map knowledge into the traditional KF setting, since this limitation leads to highly non-Gaussian posterior densities which are difficult to accurately depict using traditional techniques. Since the PF method does not pose any constraints on model non-linearity and noise distribution, the errors in velocity and heading calculation can be precisely modelled. The most important advantages of the PF method for map-matching applications are: (1) PF method offers a natural way of integrating road map knowledge into the estimation of vehicle location. (2) PF method incorporates multimodal distributions. The selected PF-based location estimators presented here are geared towards working within a smart GNSS-based localization system [7]. This paper suggests a method for defining mainline track geometry, instead various approximation methods are adopted to show different segments of the track, which allows a clearer definition of the track rather than just several consecutive points. The points-of-interest (POIs) and sidings are then added as topological railway network details.

The evaluation of the geometry and topology of the generated track map is further detailed thereafter. Finally, field data is used to produce the digital track map in real railway line and the result shows that the proposed approach can effectively classify the mainline geometry and present the topology network correctly without too much storage [8]. In the third part of the paper follows the review of objectively tested outcomes in precision and reproducibility. The GNSS raw data, collected during playback and converted to RINEX, was analyzed in terms of reproducibility to detect the causes of these divergences and compared during field measurements with the actual reported RINEX data. Such investigations indicate that there are already variances in the distance measurements between satellites and receivers from one playback run to another. Therefore the internal position algorithms of the receiver are not or are not only responsible for the variances in the position solutions.

Finally, the in phase and quadrature phase (IQ) data generated by the RF recorder unit during multiple playback runs were evaluated to determine whether the RF generator unit itself causes divergences [9]. This paper discusses research of the satellite tracking system in the context of rail transport. The test program was designed to verify the system's core functionalities and performance, as well as to verify that the system can be effectively configured and implemented to track and manage critical assets in the railway environment in real-time. The experiments were carried out to depict an operating railway under regulated conditions in a full-scale railway setting. The functionalities tested included the system's ability to communicate the location of the rail vehicles, as determined by the Global Positioning System (GPS) and inertial navigation, via terrestrial and satellite communications from a locomotive collection unit, and the system's ability to continuously update the data in real time [10].

METHODOLOGY

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KLUB

The machine operates on multiple concepts which can communicate through the radio network. In geographical coordinates the location of the train is determined using GPS or GLONASS satellite systems. Those coordinates are transformed into a track position. The system also has the complete location of the signals, point switches, stations, speed limits and other elements needed to measure the braking curve correctly.

RHINOS

The University of Pardubice has been involved with several other international organizations on the RHINOS (Railway High Integrity Navigation Overlay System) since beginning of January 2016. This is a project funded by the European Commission in the Horizon H2020 plan, aimed at identifying and improving a framework for accurate train position using the GNSS framework. The criteria is extremely high because the train's incorrect location in the high-speed rail sector may have catastrophic consequences. This device can operate with several navigation systems such as GPS, Galileo, and even EGNOS, providing even more accuracy than GPS.

ETCS LC

ETCS LC (low-cost) has also emerged to save money somewhere also called ERTMS Regional, which is based on the original ETCS system. The system should operate on the same principle as level L3, with only less or no balises. For example, these would be installed only in control points with rail branching operations. It's supposed to run at a top speed of 70 km/h on tracks.

PROPOSAL

One of the ideas is to make it easier for engine drivers to use an external system and to improve protection. The meaning lies in the fact that it includes a monitor with a digital assistant. This has means to determine location of at least one satellite positioning system from the signals. The computer memory stores an operating system to run the computer itself, and data processing and visualization application applications. The program also includes railway network interactive map data which is available for application applications. In addition, this documentation includes information for a secure and economical rail transport service, the application software which includes means for carrying out activities related to rail transport organization and management. This is focused on knowledge of the location of the system in question and details from the digital map data for secure and economic activity.

The benefits of the technology presented are:

- The efficiency and protection of rail traffic,
- Regulating the protection of transport networks and, in particular, removing the effect of human error,
- Rationalizing the costs of carrier and network manager,
- Minimizing rail crossing incidents,
- Making accessible information on the service and status of locomotives.

Display

The indicator will provide the driver with details about the direction of the locomotive displayed on the screen, so they would see how the route continues with the following curves shown. At the bottom of the screen (or elsewhere), there will be more details such as the cant of the rail track and its path over the next few kilometers, which could be useful in making the driving style more effective (for example, the driver may reduce efficiency and conserve traction energy when approaching downhill and adequate momentum). The device might itself recalculate the necessary traction power in the future and draw attention to that possibility.

In addition, it will show the locomotive class, current and maximum speeds for a given section (depending on the type of train-for example, whether it is a tilting train or contains a particular locomotive) Very useful feature is to indicate the actual kilometric location and the closest station with its distance. For example, this could be critical in handling emergencies or other unusual circumstances. Fixed-signal positions are shown in the map. The system does not reflect the cab-signaling however and therefore does not repeat the light signals. The electrical operating signals are only reflected when there is an electric locomotive.

Authentication

The application software is coupled with an authentication tool which verifies a specific driver. This security can consist of a password, a numeric code, or a visual symbol, etc. that only a single user knows about. The second choice is an external authentication system, such as a chip (RFID, NFC, etc.) or a driver's "smart bracelet," or "smart watch." In this case the digital assistant can communicate either unidirectionally or bi-directionally with such an external component (via Wi-Fi, Bluetooth, etc.). The external authentication device can be equipped with means for detecting the vital functions of the wearer and is capable of transmitting a corresponding alarm signal to the network in the event of identification of an undesired state of the wearer (e.g. an extremely elevated pulse or imminent heart attack). This signal may also be passed on to other people (such as the carrier's dispatcher or the infrastructure manager), or it may send information to the train safety network, which will have already independently analyzed it for its methodology.

Real-time activities

The system may also be paired with a current traffic and operating situation server, which provides data on current track conditions, e.g. construction works, changes or detours, exact position of temporary signals during maintenance work, occurrence of tracks without cab-signaling support etc. Furthermore, the location navigation system will provide means to monitor other trains on the same monitor through the above-mentioned data link to the current traffic and operating situation server. This can be used especially for regional tracks with direct traffic control, where there are no light signals and the motor driver.

With the application software, the operation can be greatly simplified and thus the driver's load reduced, particularly when announcing trains and train crossings. In the case of the model, when two trains pass opposite each other on the track (these tracks are often not fitted with a track signalling system), the driver is advised to stop and secure the situation. Alternatively, it could connect this device to a train safety system and issue a one-way emergency stop command. Another example of usage on tracks that are fitted with an automatic block, when the slower train runs ahead of the faster one, allowing the faster one to accelerate and brake several times.

Recording activity

The program may also track and record the driver's actions, the length of the change, their train driving results, etc. which, in conjunction with locomotive tracking, allows results records and subsequent evaluation for the needs of the carrier or infrastructure manager. If the engine data could be collected, the device would also include current consumption information, engine temperature, actual output, etc., and could pass the data to a remote server.

Also, the system can provide means to track train sets or individual wagons travel. The system will automatically generate accurate train documentation if they are provided with an identifier such as a QR code which can be checked by the computer and easily automatically registered by predefined conditions and operations. The program can track rides of sets and individual wagons in conjunction with other data sources, and it is simple to compile the entire history of vehicle use. This can be expanded by recording the faults including the option of giving the owner or operator a fault report.

CONCLUSION

The satellite navigation system is used in nearly every area. There's no reason why rail transport should not introduce it. The paper recommends its use which could lead to improved health and cost reduction. It will of course take a long time to realize all the suggested ideas, especially for the IT workers and programmers, it could be difficult. However, the suggestions above are just a suggestion of what can be done and what can help improve the health. Not only does the device save the costs of written orders, but it can also improve protection, for example by adding a requirement that the order must be checked only when the train is not in motion (with the confirmation permitted only after a certain time depending on the duration of the order). Although this time may cause a small train delay (but just a few dozen seconds), it will minimize the chance situations in which the driver acknowledges the order immediately, which means they understand it, but the order itself is read after the train has been placed into motion (e.g., to shorten the delay).

Thus, the device proposed by us will remove dangerous situations where the reading of the order during the journey draws attention from monitoring the track situation or the locomotive's operating position. And even the situations where the order applies to the next section directly after the place of delivery (the driver reads the order only while going through the place of delivery, or worse after).

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