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Autonomous driving trains to pass in bidirectional crossing loop preventing stops

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Abstract

This study presents an intelligent approach based on software agents capable of conducting and coordination trains in stretches of single railway track, aiming to optimizing the utilization of railway and reduce environment impacts. In the Brazilian rail modal, due to the low duplication of tracks, trains that journey on single railways should accomplish required halts, in order to wait for other trains to use the crossing loop safely. The technological evolution resulted on the appearance of new railway traffic system control. However, systems that rely on software agents are not well explored yet. Therefore, this study elaborated a Intelligent System capable of simulating railway environment using agent drivers and agents with a highest level in managing the railway tracks. The behaviour of agents was based on specialized rules of conduction and his proactivity is based in obtain a sage driving with informations of position and time limit to the end of journey. The coordination between them occurs through message exchanges, always aiming to avoid halts during the journey. Results have shown an strong average reduction of 22.5% in journey time and 25.5% in fuel consumption when compared to journeys using the traditional method of conduction. The reduction, not only on the journey time, but also on the fuel consumption, entails on the decrease of CO_2 emission.

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Keywords: Artificial Intelligence; Intelligent System; Coordination; Reactive Agents; Driving of Trains.

1. Introduction

In this study, we propose the use of an intelligent system for controlling the rail modal freight trains from Brazil, which has simple lines in most of its stretch. As demand increases production, railway systems reached its exhaust linked to rail capacity [1]. This request led to some problems that have become more obvious, such as high fuel consumption; traffic congestion on the simple railways; increase travel time and appearance of judgements relating to the movement of other trains. On this context, the study offers an alternative to solve the fuel consumption problem and optimization of railways, using a reactive intelligent system capable of driving trains on a section with a crossing loop. In this context, the solution avoids the need for trains to make unnecessary stops, one of the causes of high fuel consumption [2].

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The proposed control area, the agents are inserted according to their expertise, they are: Driving Agent, License Agent and Environment Agent. Driving Agents are experts on the conductor rail. They are able to percept by the sensors and the exchange of messages with the License Agent. Regarding perceptions, Driving Agents are able to calculate many variables related to the movement of trains, such as strength calculations, the point with the acceleration of the lowest consumption, calculating stopping distance, time travel or approaching the calculation, the calculation of consumption, among others. The exchange of messages are performed to Driving Agent perception information linked to other trains on the same stretch and to obtain the license for circulation.

Regarding the management of stretching, the License Agent is specialized on the issue. It is the agent responsible for controlling a small section containing at least one passage in crossing loop, providing stretch of licenses. The License Agent detects Driving Agents next to the entrance that stretches fields. Therefore, the License Agent checks the amount of train that already have a license released in special sections and decides whether to discharge the entry of a new train on this section. This procedure follows the rules relating to the management of each train, its entry position and size. Only after checking severally, it is able to inform if crossing loop can support the amount of trains on the section.

The License Agent, control a small piece. The other agent that controls the railway is called Environmental Agent. In this study, the environmental agent executes the exchange of information on the section with the License agent. The agent's environment will not be discussed in this study because of its creation linked to the future expansion of the system. The main objective of this study will be the coordination between license and driving Agents.

2. Trains Driving and Coordination

Actually, freight trains on a railway line obey different safety standards. The standards used in Brazil follow an old system based on the Block Sections (BSs). A BS is a fixed length or variable length way one train can enter both. In this system, when a train enters the station, it closes and prevents further entry of trains. Therefore, the BS release is realized only when the train leaves the BS rest.

However, the increased demand for the use of the track, more passive permissions to a train entering a specific BS have been introduced[3],[4]. These permissions are not safe, as with the growing number and speed of trains base stations tend to become smaller. For added security, trains travelling in the same direction must keep the BS free, reducing the line capacity. This type of traffic is given the name Multi-Aspect Signalling Systems (MASS). In this standard colour lights (red, yellow and green) say the train driver if he can or can not enter a BS: A green light means that the train can enter the next BS; yellow sign indicates that the driver must enter with a lower speed; Finally, the red sign means the driver must stop the train, because after the semaphore is another train, which can cause a rear-end collision[5 6].

Other signalling systems have been used, especially in light rail systems, where a high level of security is necessary. These methods have been improved through new technologies such as global positioning satellite and wireless communications. Such technology is known under the name Communications-Based Train Control (CBTC) and uses systems such as Global Positioning Satellite (GPS) and Global Navigation Satellite Systems (GNSS)[7]. Communication using towers near the railway line was built in CBTC and led to the establishment of Positive Train Control (PTC) and Wireless Positive Train Control (WPTC)[8 9 10 11].

Although the various technologies developed have been in service, the trains still stop because of BSs (red) halt signs. The lack of a system to coordinate and provide information on the use of a synchronized base stations means that the trains are forced to stop and ensure that the Operational Control Center (OCC) check the position of other trains on the same section in the opposite direction. The OCC must allow a stopped train to travel or not after these checks have been performed. These security checks are currently performed by the OCC with the above mentioned systems, but do not manage to avoid the need to stop the trains.

In[12], the authors propose a system known under the name Advanced Automatic Train Control (AATC) to replace the current fixed automatic locking system. In the long term, it is expected that the AATC system is able not only to ensure safe operation of short progress, but also to facilitate the coordinated train control and management of energy, using an approach collaborative agent and wireless communication,[13] has developed a framework for a basic intelligent agents transport system and set up an experimental environment to investigate further.

In[14], the authors developed an intelligent agent to help train drivers. The main objective of the study was to infer rules using data from previous driving trips. In[15], Distributed Constraint Optimization (DCO) was used to achieve