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DEVELOPMENT OF THE CONTRIBUTION

A 3D virtual universe based simulation platform: Application to intelligent video surveillance of level crossings

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Abstract

This paper proposes a simulation platform dedicated to test and validate methodologies that can be able to bring potential solutions for level crossings safety in terms of infrastructure organization and intelligent video surveillance. The development of this platform is in its beginning and the main objectives are precise 3D virtual universe modeling and visualization, video sensors positioning, scenarios simulation and user interaction. The first results in terms of 3D virtual universe modeling/visualization and scenarios simulation are presented in the framework of the PANsafer project (Towards a safer level crossing), supported by the French National Research Agency.

Introduction

Level crossings are identified as a weak point in road and railway infrastructures. Many projects have been dedicated to improve level crossings safety by providing recommendations and evaluation of technological solutions [4,5,8]. One of the interesting solutions is to use intelligent video surveillance systems aiming to detect and track objects of interest (pedestrians, vehicles, etc.) in order to recognize dangerous situations [3,6]. Simulation tools is used for several applications (for example: virtual robot simulation [1], vehicle simulation [2] or driver training [7], 3D city models [9], etc) but we find no many applications oriented safety in the literature. Developing such systems is confronted to some constraints related to the infrastructure. Indeed, to achieve experimental tests, the possibilities to install equipments are limited and require a hard organization to avoid

disturbances in railway and road traffic. Furthermore, experiments need specific installation procedures that guarantee people and infrastructure safety.

Considering these difficulties, the aim of this paper is to propose a simulation platform that brings help to evaluate potential methodologies in terms of sensor positioning and simulation of critical scenarios in virtual 3D environments. The platform will also serve as a tool to achieve preliminary tests of the events detection based algorithms by generating video images from simulated cameras. This work is a part of the PANsafer project (Towards a safer level crossing), supported by the French National Research Agency.

Simulation platform objective

The objective of the simulation platform is to give a tool allowing testing and evaluating rapidly and with facilities potential experimental methodologies. The entire task is realized in a virtual environment that describes precisely a level crossing environment, which is modeled using real data collected from different sources like GIS and topographical data, and photography.

This objective is declined through four principal tasks: virtual universe construction, video sensors positioning in the virtual universe, edition of scenarios and simulation of critical scenarios.

3D modeling of virtual universe

The simulation validity is based essentially on the precision of the 3D model of the environment. In the proposed application, the precision is interpreted into two essential points: the geometric precision of the digital model and the realism of the generated images. The first point imposes to use a 3D digital model with a precise geometry, i.e., very close to the reality. To answer the second point, a graphic engine with advanced rendering features is needed. In the following, the technological choices to answer these two constraints are described.

To construct a universe with correct geometry, one needs to use topological data (cf Fig. 1 – part 1). Indeed, the traditional task of graphic designers is not enough precise to obtain a sufficient precision for the geometry of the universe. To reach the needed geometric precision, automatic methods are first used to construct the universe. These methods are based on numerical terrain models and other geographical information. Naturally, at this step of construction, the universe has no texture mapping. In a second step, graphic designers use photos taken directly in the real level crossing (for example for building's sides), and apply them on each virtual object to improve the realism of the universe.

Producing a realistic and an attractive universe is a hard task. But this task becomes more complex when the considered application requires rendering the universe in real time. Indeed, as it will be shown later, the proposed simulator has in charge simulating virtual video sensors. A graphic engine enough effective is then needed to generate realistic images with lighting shadows, etc. Furthermore, the simulator considers stereo video sensors. This characteristic adds more complexity since the graphic engine must be able to generate two images or more in one rendering loop.

Video sensors positioning

The safety and organizational constraints imposed by SNCF (French National Railway Company) around railway environments lead to many difficulties to achieve the equipments deployment task. In addition to these constraints, one must think about how to implement supports to fix and adjust geometrically the video sensors that have to monitor the level crossing environment. The constraints, difficulties and the long time consuming make the determination of the ideal position of the sensors almost impossible in a real level crossing environment. To overcome all of these difficulties, one needs to simulate potential configurations and test them in order to reach the relevant one.

With the proposed simulation platform, one can place directly virtual supports and virtual cameras within the virtual universe. The platform offers the necessary interfaces for locating with precision the equipments (cf Fig. 1 - part 2), while taking into account the ground constraints as well as the means of precise setting of the cameras in terms of intrinsic and extrinsic parameters (resolution, field of view, focal length, orientation, etc.). Once the virtual sensors are positioned, the user can get render images comparable to the real images acquired with real video sensors in the same conditions. He can then refine the settings in the virtual universe in order to validate the ideal configuration, which will be implemented on the real level crossing environment.

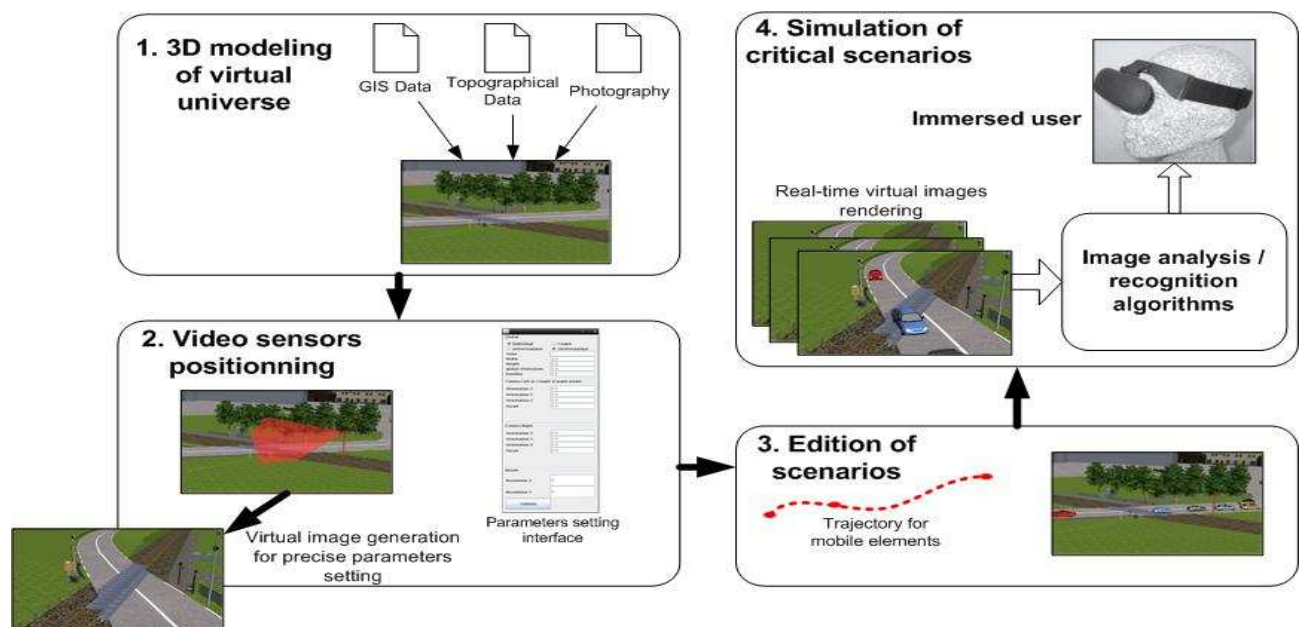


Fig. 1: Simulation platform functionalities

Edition of scenarios

The objective of the proposed simulation platform is also to generate critical scenarios (even those that cannot be obtained in real level crossing environments) for observation analysis and algorithmic based processing via images given by the virtual cameras (cf Fig. 1 - part 3). This is useful to achieve preliminary tests and evaluation

of the proposed algorithms. To generate the scenarios, the platform manages dynamic objects and their environment (vehicles, trains, pedestrians, etc.). The scenarios management module allows to edit animations for all mobile objects, with predefined trajectories and speeds, and to replay them according to the needs. Different scenarios can be created and tested with a range of algorithms.

Simulation of critical scenarios

The simulation part of the platform (cf Fig. 1 part 4) is organized around two real-time 3D graphic engines (cf Fig. 2). The first one concerns the generation of the virtual images from the virtual sensors. The second 3D graphic engine displays virtual images representing the universe for visualization. These two graphic engines share the virtual universe on which the virtual cameras are positioned. Furthermore, a module manages the dynamic aspect of the universe by playing the object's animations according to the desired scenarios.

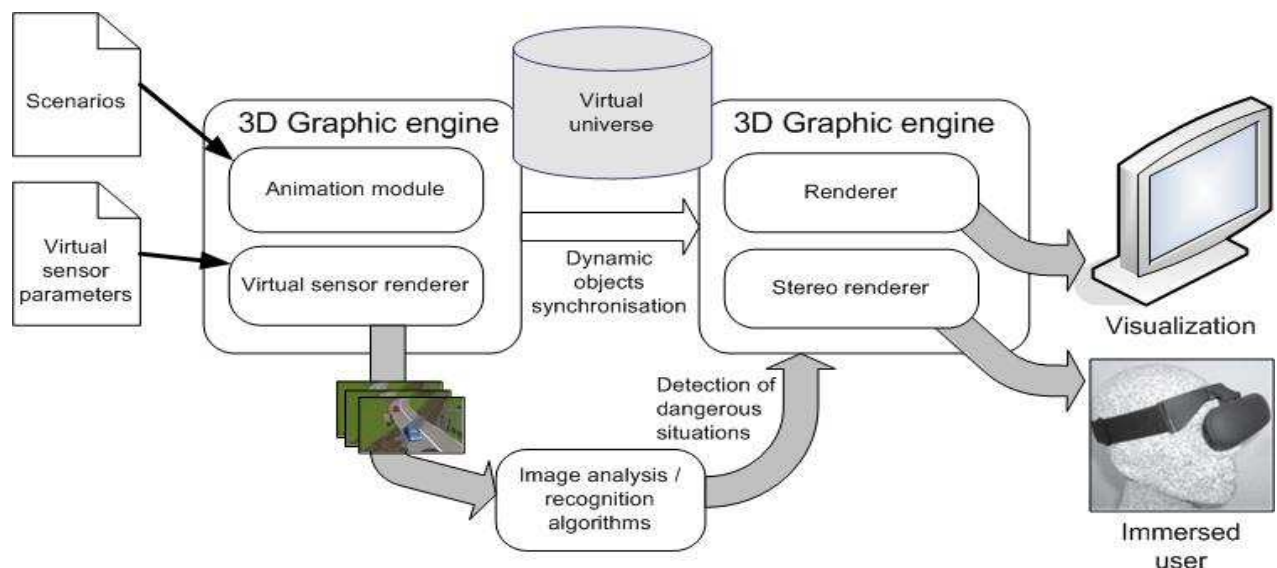


Fig. 2: Simulator global architecture

As the objectives of these two graphic engines are different, the renderer of each of them can have different functions. For example, the graphic engine dedicated to the image processing algorithms supply must generate precise shadows. On the other hand, for the universe visualization, precise shadows are not necessary, but the management of the immersion of the user in the universe is very important.

The goal of the first graphic engine is thus the generation of images to be analyzed. This first engine needs render features allowing the images to be as well realistic as possible. This engine could work in two ways: first the generated images could be transferred directly to the image analysis algorithms or stored in order to compose video sequences that will be processed later. For the first way, the engine needs to have a high seep frame rate. As shadows could be interpreted wrongly by analysis algorithms, it's very important that the image generation process provides very precise shadows in terms of geometry and color.

The second graphic engine is in charge to visualize the universe and to display the information provided by the image analysis algorithms. To make possible the user immersion in the virtual universe, a stereoscopic immersion helmet is used. This peripheral requires the generation of stereo images and the management of the inertial motion tracker allowing interaction with the user.

Simulation results

In the framework of the PANsafer Project, the universe 3D modeling focuses on potential dangerous level crossings with different configurations (lack of visibility, corner exit, dense road traffic, typology of level crossings, etc.). An example of modeled level crossings (from real data) is illustrated in Fig. 3.



Fig. 3: Example of modeled level crossings

Several scenarios are envisaged in the project. To show the interest of the simulation platform, two scenarios are considered in this paper. In the first one (cf. Fig. 4), a two-wheeled vehicle moves towards a level crossing with a speed of 70 km/h (Fig. 4-left). The traffic light indicates the arrival of a train and the barriers start lowering. The two-wheeled vehicle decides to slalom between the barriers (Fig. 4-middle). Then, he loses the grip of his vehicle and falls on the railway, while the train is approaching closely the level crossing (Fig. 4-right). In the second scenario, a car moves towards a level crossing (Fig. 5-left). Engaged to cross the level crossing behind a line of vehicles, the car moves with stop&go maneuvers, while the barriers start lowering indicating the arrival of a train (Fig. 5-middle). The car is then blocked on the railway without any possibility to leave the lane (Fig. 5-right).



Fig. 4 : Scenario with a two-wheeled vehicle that falls on the level crossing



Fig. 5 : Scenario with a car blocked on the level crossing behind a line of vehicles

Conclusion

A simulation platform to test and evaluate methodologies for level crossings safety is presented. This platform offers functionalities such as 3D virtual universe modeling, video sensors positioning, edition and simulation of scenarios. Current works are dedicated to integrate in the platform image processing algorithms to analyze virtual images generated from simulated cameras in order to evaluate their performances. The objective is also to analyze the interaction between level crossing safety solutions and the user throughout his immersion in the virtual universe.

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