INTEGRATION OF AFS-FUNCTIONALITY INTO DRIVING SIMULATORS

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Abstract

Around 55,000 people are killed each year in accidents throughout the European Community. Night-time driving with conventional headlamps is particularly unsafe: only 25% of the driving is done at night but 55% of the driving fatalities occur during this period. In order to reduce these figures, new automotive lighting technologies (Advanced Front Lighting System AFS) are about to be permitted in ECE legislation. The first stage of the AFS functionality has been launched in 2003 (pre-AFS), the final stage is expected to go into effect in 2007 (full AFS).

In order to investigate the impact of these new lighting functions on road safety, a EU project (CLARESCO) has been established. These investigations will be carried out with test persons in driving simulators. Driving simulators offer a flexible way to study such functions but several constraints must be considered. First, the virtual environment must be rendered in real time including realistic lighting of the road with precise photometric data. At last, control strategies of AFS headlamp must be integrated into the driving simulation loop considering different communication protocols. This paper presents both, integration of pre- and full AFS into a driving simulator considering these constraints.

Résumé

Environ 55 000 personnes sont tuées chaque année dans des accidents de la route au sein de la communauté européenne. La conduite de nuit est particulièrement dangereuse car avec 25% du trafic seulement, 55% des accidents mortels ont lieu durant cette période. Afin de diminuer les risques d'accidents la nuit, des nouvelles technologies d'éclairage automobiles (Advanced Front Lighting System AFS) sont en cours d'homologation par les instances européennes. La première étape a été franchie en 2003 avec l'acceptation des concepts « pre-AFS ». L'étape finale est attendue pour 2007 avec l'homologation des systèmes dit « full-AFS ».

Afin d'étudier l'impacte de ces nouvelles technologies pour la sécurité routière, un projet européen 5eme PCRD a été lancé (CLARESCO). Dans ce projet, les études sont effectuées sur simulateur de conduite de part leur flexibilité. Néanmoins, certaines contraintes doivent être prises en compte de ce type d'application. Tout d'abord, l'environnement virtuel doit être affiché en temps réel et se baser sur des données photométriques de phares pour une représentation réaliste l'éclairage de la route. Ensuite, les lois d'asservissement des phares doivent être intégré dans l'environnement de simulation de conduite tout en considérant les protocoles de communication pouvant exister sur les différents simulateurs de conduite. Cette article présente l'intégration des système « pre-AFS » et « fullAFS » sur simulateur de conduite compte tenu de ces contraintes.

Introduction

Since the approval of Advanced Front Lighting Systems (so far only pre-AFS) by the European Union in 2003, these system were quickly available for a number of cars, and it is expected that their number will increase rapidly in the future. Here the question arises, what is the impact of these new technologies on road safety, and how could it be improved. To answer these questions, a project (CLARESCO) has been launched by the European Union.

To investigate this issue, large numbers of night driving data with AFS are required. These data should be collected with large number of test persons. In order to be able to compare the results with various test persons, the conditions for the test drives should be the same. However, it is virtually impossible to provide identical test conditions for a large number of test persons on public roads, especially when these investigations are to be carried out at different places. One possibility to provide identical driving conditions to all test drivers is the use of a driving simulator.

Beside this, night drive simulation can also be used in the development of automotive headlights. It offers several advantages compared to the traditional development process.
For example, virtual night drives can be accomplished during daytime. The number of actual night drives can be reduced. Virtual night drives can also be carried out with virtual head lamps, i.e. the first "test-drives" can already be accomplished in an early development stage without having an actual prototype of the headlamp.
Then, the problem arises of how AFS should be integrated into the simulator. Since these investigations should be accomplished at different places using different driving simulators, a solution is needed that can be used for all these simulators.

Advanced Front Lighting Systems

Currently, there are basically three different types of AFS-functionalities, two of them (pre-AFS) are already permitted by ECE-legislation, the third one (full AFS) is expected to get approval by 2007. The AFS-functions already allowed, are dynamic curve light (bending light) and static curve light (cornering light).

Dynamic Curve Light

The dynamic curve light is composed of a swiveling unit, and the main headlamp functions (low beam and/or high beam) which are mounted onto the swiveling unit. When driving into a curve, the headlamps are swiveled into the curve, where the extent of swiveling is calculated by an AFS-algorithm. The algorithm calculates quantities like swivelling angles (heading, pitch, roll), and intensity, and it sets the status (ON/OFF) of the headlamps by evaluating the corresponding input parameters (curve radius, speed etc.). The currently used swivelling algorithms only yield a swivelling about the axis pointing upward (heading), and always full intensity. It can be adjusted to different requirements by setting a number of parameters, and different swivelling strategies (i.e. synchronous swivelling or asynchronous swivelling). A dynamic curve light system can increase the visual range in curves up to 50% [1].

Static Curve Light

In contrast to the dynamic AFS algorithm, which controls “classical” light functions, the static algorithm is designed to manage the light status of cornering lights. Cornering lights are additional new lighting function, which are turned on for tight turns, when the swivel range of swivelling headlamps is not sufficient. They are additional headlamps that are mounted to the vehicle in that way, that they are aiming their light to the side. In a curve to the right or when turning to the right, the right headlamp is activated, in left-hand curves or when turning to the left, the left headlamp. Since tight curves are usually taken at relatively low speed, the speed range of activation is limited, typically about up to 70 km/h. The static AFS algorithm does not affect the angles of orientation of the cornering lights (i.e. no swivelling occurs), it only affects the intensity. When turning, it is relatively fast (typically in about 0.5s) dimmed up to its maximum value, after driving straight again, it is slowly (typically about 1.5s-2.5s) dimmed down again.

Full AFS Functionality

The AFS functionality to come in the future is full-AFS. At present, ECE regulations permit only two different lighting functions for car headlights during driving, low beam and high beam. The high beam would allow the driver to see sufficiently well, however, due to today’s traffic situation, most of the time the driver is restricted to low beam. The low beam, however, has only a restricted range of illumination, which is insufficient in many traffic situations, especially at higher speed. Therefore, new lighting functions are required, which on one hand enhance the driver’s vision, but on the other hand do not cause glare to the oncoming traffic.
Currently, under discussion are regulations that will permit three (or more) different light distributions, which will replace the low beam function. The high beam will be used in the conventional way.
These new lighting functions are town light, country light and motorway light. These lighting functions have light distributions especially adapted to the respective traffic situations. The town light distribution is designed for low range. The country light is similar to the current low beam, i.e. long range on the driver’s lane, and short range on the opposite side. The motorway light has a narrow light distribution with long range.

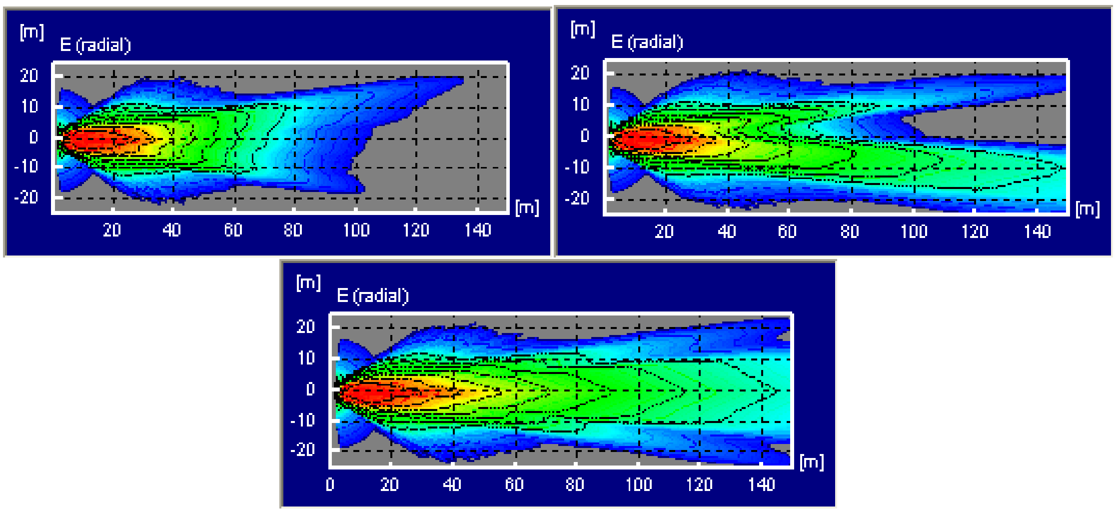

Figure 1: Distribution of town light, country light and motorway light on the road.

Also combinations of them could yield additional lighting functions (e.g. town light on the left side, plus motorway on the right side could serve as adverse weather light). Of course, when a car is equipped with this advanced lighting functions, the driver cannot be expected to switch between the various lighting functions manually. Therefore, some kind of algorithm is required that does the switching.
There are basically two ways this switching can be controlled. One would be GPS-based, i.e. the algorithm would get geographical data as input to determine the actual road situation, and activate the corresponding light function. The other way would be to determine the currently required lighting function by taking into account the current driving situation, and the driving history of the last few minutes.
Of course, the full AFS functionality can also be combined with the pre AFS functions. This means, that the new advanced light distributions can be swivelled in curves, and in tight curves additional cornering lights can be turned on.

Headlamp studies with driving simulators

RENAULT's driving simulator

In order to reduce development costs and delays of a new headlight while enhancing its quality, Renault CTS has developed a lighting simulation software [2, 3] able to render high precision visual aspects of a light beam on the road, in real-time, thanks to computer generated images. This software accepts photometrical data characterising the headlamp. Thus, a headlamp can be assessed even before having a physical prototype by clear or foggy weather at night time.

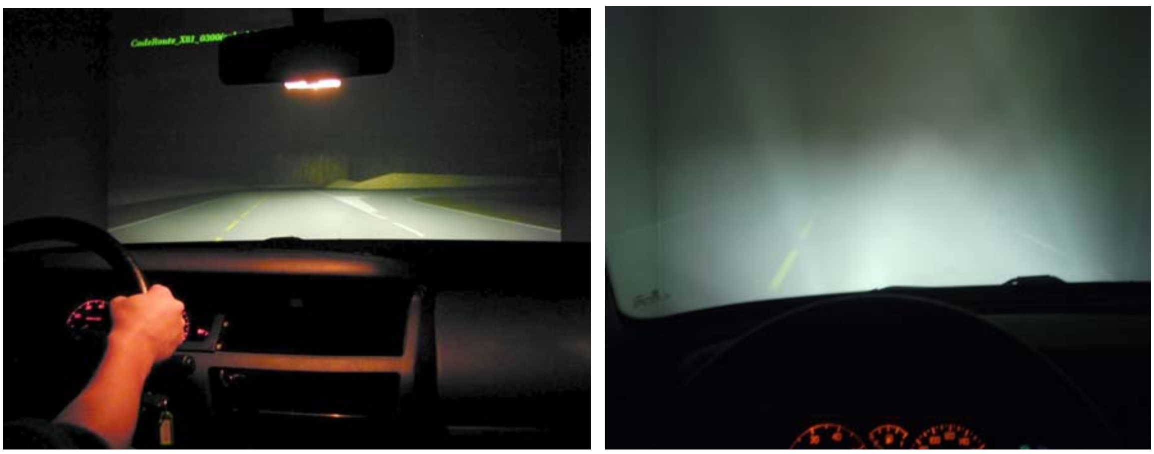

Figure 2 : Renault's driving simulator with lighting software

The Renault lighting simulation software is integrated within the SCANeR© II driving simulation software.

It is composed of two modules:

- The visualization simulation module ensures the simulation and restitution of the illumination of the road by vehicle headlamps.

- The Lighting Session Manager module is used to control the virtual night tests through network communication. According to a graphic user interface, it manages the vehicle type selection, the real time modification of vehicle headlamp position and orientation as well as several points of view.

The following scheme shows where the lighting module software is integrated within the SCANeR© II environment.

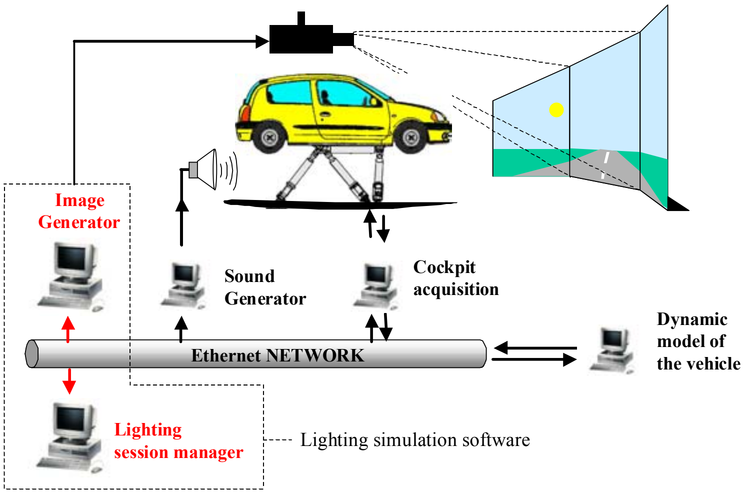

Figure 3 : SCANeR© II software architecture including the lighting simulation software

Hella's driving simulator

Hella's driving simulator is based on commercial hardware [4], and software developed at Hella [5]. The hardware consists of a smart whose cockpit has been adapted to the use as a simulator (controlled by a PC):

Figure 4 : Hella's driving simulator

Moreover, there are three headlamps and three screens that surround the front part of the smart for the visualization of the street scene.

This software was developed from the very beginning with an emphasis on night driving simulation with realistic illumination. It can not only be used together with this hardware, but can also be run as a standalone program on a PC (either an automatic drive on a fixed virtual track, or by steering via joystick or similar device), simulating its own vehicle parameters. When used together with a driving simulator, vehicle parameters are acquired from the simulator and handled by the software.

A virtual drive can be performed on a standard scene (fictitious), but it is also possible to load other scenes from a file. For example, the Hella test drive course has been surveyed, and implemented as a virtual road scene, including all the objects like buildings, trees, traffic signs and so on.

Since the equipment is also used to support the development of headlamps, features like

- measuring wall for headlamps
- distant markers
- different view points like driver's view, bird eye view

have been included.

Interfacing AFS control strategies with driving simulator

Design of an interface

In order to permit different driving simulators to access the AFS functionality without providing an individual solution for each simulator, a general interface is required.

This interface has to pass vehicle parameters like actual time, speed, current curvature, light switch position etc. from the simulator as an input to the AFS-algorithm. It should in turn return the parameters for the individual headlamp pairs like status (on/off), intensity, swivel angles. Of course, since these output parameters will modify the light distribution on the road, they have to be taken into account for rendering the light distribution into the scene. Therefore, the calculations of these quantities have to be handled in real time.

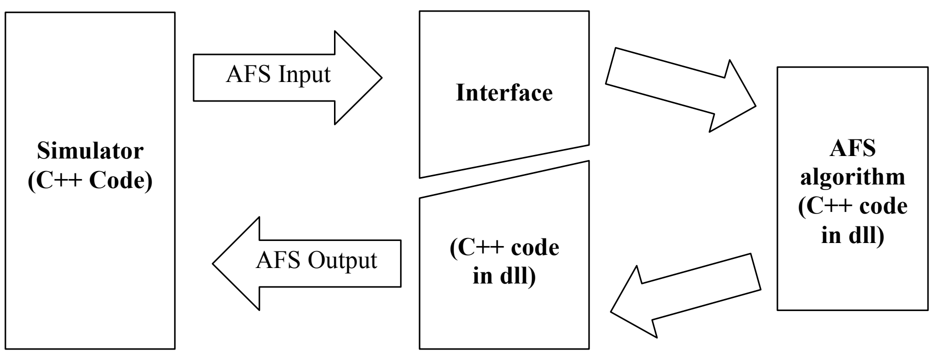

Figure 5 : Principle of interface architecture

Moreover, the algorithms contain certain parameters that can be used to tune them. It must also be possible, to set these parameters via the interface, and, the way these parameters are set should be the same for all algorithms. Especially, when additional algorithms are added in the future, the interface itself must not change. In addition, additional input parameters to the algorithm should not require modifications of the interface.

Furthermore, it should be able to handle a sufficient number of headlamp pairs. On one hand, this is necessary to make sure, that all the headlamps of a vehicle are correctly turned on/off, dimmed, and swivelled. On the other hand, it is desirable to be able to switch between different sets of headlights, to compare for example different AFS strategies, or different types of headlights (e.g. Halogen or Xenon).

Last not least, in order to protect the know how contained in the algorithms, it should ensure confidentiality. Internal structures of the algorithms should not be disclosed.

Such an interface has been realized in terms of a C++ header file, a dynamic link library, and a step file. The C++ header contains the declaration of all the interface methods that need to be accessed by the simulator, but no information concerning the inner structure of the algorithms. The dll includes both, the interface and the algorithms. The step file contains the headlamp configuration, i.e. a list of all the headlamps that will be loaded into the simulator, including information about AFS algorithms, and the corresponding parameters.

When new algorithms are developed, and need to be integrated, this will be accomplished within the dll. It does not require any modifications in the simulator environment, only the dll needs to be replaced by a new one. To use the new algorithms simply requires a corresponding entry in the step file.

For tuning an algorithm, the interface contains methods, that permit for each type algorithm loaded from the step file, to check what type of algorithm it is, what kind of parameters are available, and to modify these parameters.

Implementation on Renault's driving simulator

The **L**ighting **S**ession **M**anager (**LSM**) module of the Renault lighting software is responsible for the mounting of headlamp inside a vehicle. The positioning information is transmitted to the visual module, through network communication, in order to make the corresponding visual restitution. A user can change the headlamp position and orientation in real time through a GUI included in the lighting session manager module.

For the CLARESCO project, the interface for control strategies is carried out and run by the LSM. For each time step, output parameters of the interface are used in order to send through the network the new state for each headlamp. The modification in terms of software architecture is the addition of a *dll* loader inside the LSM and the instantiation of the corresponding C++ class. For each time step, the LSM will call the *dll*'s main method and ensure the transmission of the updated headlamp information to the visual module.

The following diagram shows the corresponding software architecture:

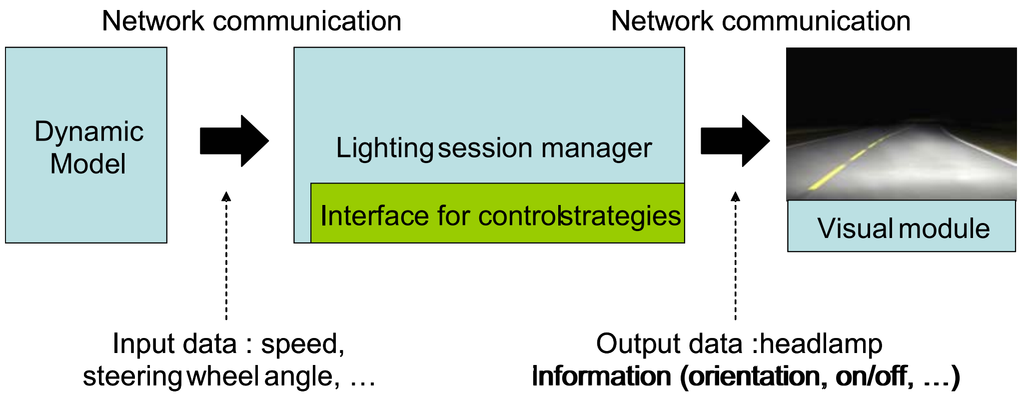

Figure 6: Basic software architecture for the integration of control strategies in Renault lighting simulation software.

The LSM integrates a graphic user interface that allows a user to modify in real time various lighting parameters. A specific graphical user interface panel has been designed in order to modify in real time control strategies parameters.

The graphic user interface expose the following information:

- A list of editable text boxes which represent the list of input parameters for an AFS control strategy.
- A list of non editable text boxes which represent the list of output parameters delivered by an AFS control strategy.

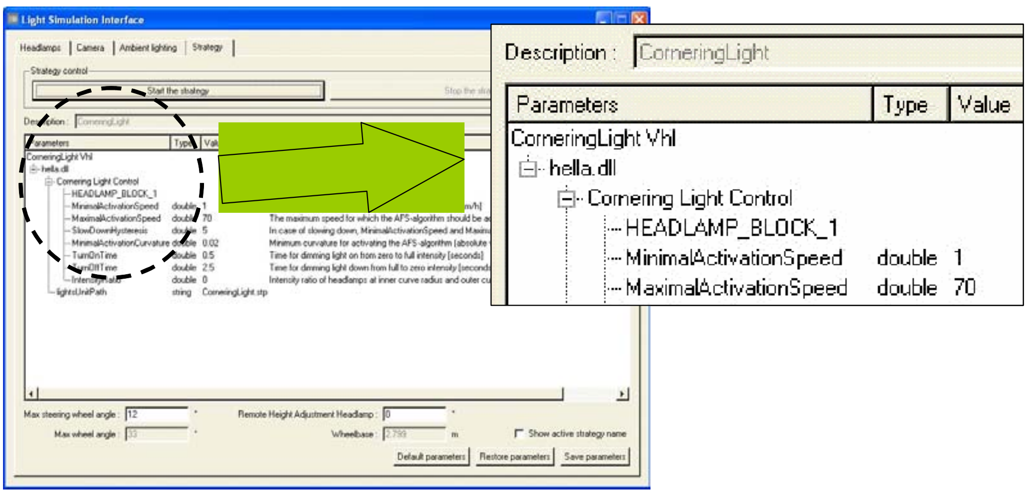

Figure 7: Graphic User Interface used to modify the strategy parameters in real time

Implementation on Hella's driving simulator

The dll is directly linked to the driving simulation software, so that the corresponding methods can be directly accessed from there.

Conclusion

Various AFS strategies have been implemented, so that they could be integrated into different driving simulators. The integration has been realized via a generic interface, that can be used on different driving simulators, as well as for different AFS types.

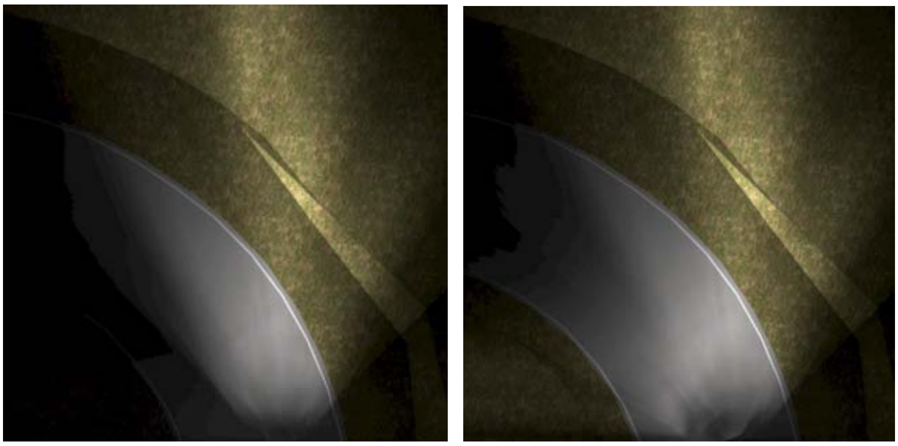

Figure 8: static bending light in action (left: not active, right: active).
Implementation on Renault's driving simulator

The simulation of AFS functionality now permits to investigate the influence of AFS on traffic safety under identical conditions for a large number of test drivers. So far, most of these investigations were carried out with real test drives [6], making it difficult to compare results taken at different places.

The investigations carried out within the framework of the CLARESCO project will soon start in different countries. Moreover, it is possible now to test virtual prototypes of both, headlamp- and AFS systems, without having an actual prototype. Therefore, problems can be seen in an early stage of the development, and shortcomings can be remedied before producing the first prototype. This reduces the number of development cycles, and thus development costs.

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