Thesis Title:
Autonomous Driving in Realistic Traffic Situations: from "Safe Driving Assist" to "Fully Autonomous Driving Co-pilot"

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Keywords: Open and dynamic environments, Uncertainty, Bayesian inference, Situation awareness, Prediction, Continuous collision risk assessment, Motion Safety, Risk-based navigation decision.

PhD thesis context

- Long-term collaboration between INRIA and Toyota Motor Europe (TME), including experimentations performed on an equipped vehicle Lexus provided by TME.
- INRIA Grenoble Rhône-Alpes, e-Motion research team led by Dr. Christian Laugier.
- Scientific domains: Robotics, Perception, Autonomous vehicles, Safe navigation in dynamic environments, Decision under uncertainty, Risk management, Embedded system.

Technical context, State of the Art and Background

Autonomous driving in realistic traffic situations remains a challenging problem for future cars. The DARPA Urban challenge in 2007 has clearly shown that such a challenge could reasonably be addressed according to the recent progresses in the fields of perception and of autonomous navigation for unmanned vehicles. Yet the safety issues and scalability problems had still to be solved. The current Google Car project tries to deal with these important issues. Recent progresses in the field of Bayesian perception, Bayesian Risk assessment, and Safe navigation in dynamic environments shall enable to potentially attain the related objectives in the coming years.

Navigating safely in a dynamic, open, and uncertain environment requires the combination of three important complementary functions:

i. A *continuous interpretation of the state of the environment* (both current state and its likely evolution).
ii. A *continuous evaluation of the collision risk* (i.e. probability of collision in the near future) according to the chosen driving decisions and to the scene characteristics and moving participants
iii. A *decision making function* taking into account the outputs of the two previous functions and involving an *on-line motion planner* having the ability to avoid the choices leading to probabilistically inevitable collisions in the near future.

Until now, this problem leading to tightly combine the three abovementioned topics has received a few significant contributions from the robotics community, in particular concerning important issues such as prediction, risk assessment, and safety.

INRIA (partly in the scope of the cooperation with Toyota) has pioneered work on these closely related topics. In particular, we have developed models aiming at improving driving safety by combining *robust perception techniques* (including efficient and robust detection and tracking algorithms using our Bayesian Occupancy Filter (BOF) approach [7]), with *cognitive functions for making predictions and for continuously evaluating the risk of collision* [1]. We have also developed models and algorithms for controlling the *intentional navigation and maneuvers* of a non-holonomic autonomous vehicle [5,6,8], for making *safe navigation decisions* based on an on-line motion planner paradigm taking into account both the risk of collision (Risk-Based Motion Planner [3]) and an evaluation of the unsafe states to be avoided using potential obstacles motions prediction (Learn and Predict paradigm [4]).
The related research work was accomplished by the INRIA e-Motion research team, and it has already led to six PhD theses [1-6] and numerous publications, for example [7-11].

PhD thesis subject

The two main goals of this PhD proposal are:

1. To develop an advanced autonomous driving controller, able to take safe driving decisions based on the Risk-based navigation and Probabilistic safety evaluation paradigms.
2. Implementing the controller on the TME-INRIA Lexus vehicle and test it under realistic driving situations, focusing in crowded urban environments with mixed traffic.

Further detail will be provided to shortlisted candidates.

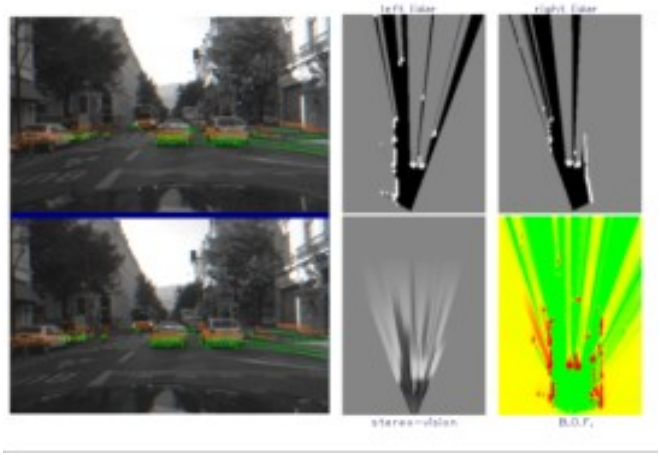
Experimental validation & TME-INRIA experimental platform
The PhD candidate will use our state-of-the-art experimental platform on the TME-INRIA equipped vehicle to conduct tests. The car is currently equipped with the following sensors: a stereo camera, two lidars, a radar, an inertial measurement unit coupled with a GPS, and an odometry measurement unit; a removable GPS RTK device mounted on the top of the vehicle might also be used for some ground truth validation. The TME-INRIA experimental platform will be modified by TME for giving access to the acceleration, braking, and steering controls.

We also plan to add a 3D laser scanner (e.g. a Velodyne) for improving the cartography, the 3D localization, and the detection and tracking embedded functions.

The experiments concerning the *Safe Navigation Assist system* (first step) will be executed on various roads (highways and other roads), using the TME-INRIA experimental platform.

The first autonomous driving experiments will be performed on some private test tracks. Autonomous Driving experiments in more realistic traffic situations will be executed in a second step in tight cooperation with TME and with the Toyota Research Center located in USA.

The acquisition of experimental data from the on-board sensors is achieved on-line by means of a dedicated middleware that runs on an on-board computer with a Graphics Processing Unit (GPU). The required data acquisition and data processing modules are developed by INRIA in the scope of both an internal INRIA development project (ArosDyn) and the INRIA-TME Research and Development agreement abovementioned. The ROS middleware has also been recently integrated on the TME-INRIA Platform.



Required competences for the PhD candidate

The ideal candidate shall possess strong analytical skills and creativity, as well as knowledge in stochastic processes, decision making, perception and robotics. She or he must have experience in software development in C++ language in Linux. The PhD candidate shall be capable of working autonomously on assigned tasks. The work will require a team work and the capability to perform experiments with an equipped experimental car. The knowledge of CUDA and Boost libraries will be appreciated. The initial experience or knowledge of the Robotics library ROS and the fluency in English will be an advantage.

Application

Please send your Curriculum Vitae, List of Publications (if applicable) and presentation letter to Dizan Vasquez: alejandro-dizan.vasquez-govea@inria.fr

Bibliography and additional information

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[10] http://emotion.inrialpes.fr/laugier

[11] http://arosdyn.gforge.inria.fr (our related recent publications)