BENTERKI Abdelmoudjib

Curriculum Vitae

+33 769 36 67 77
abdelmoudjib.benterki@vedecom.fr
https://www.benterki.me

EDUCATION

CURRENT, FROM 2017	**Doctor of Philosophy** Electrical Engineering *Université de Paris Sud* ***PhD thesis : Estimation of road user intentions for the autonomous vehicle***
2016–2017	**Research Master 2 in Electrical Engineering, Electronics and Industrial Computing** Specialty : Human-Machine Systems Engineering *UFR Scifa, Université de Lorraine, Metz, France.* **First-class honours** ***Research internship: Contactless estimation of physiological parameters using a webcam***
2015–2016	**Research Master 2 in Automatic Control** Department of Electrical Engineering *National Polytechnic School, Algeria*
2010–2015	**Engineering Degree in Automatic Control** Department of Electrical Engineering *National Polytechnic School, Algeria*
2010	**Mathematics Baccalaureate** Bachir Biskri High school, Biskra, Algeria **First-class honours**

WORK EXPERIENCE

FROM OCTOBER 2017

VEDECOM Institute/ ESTACA Paris-Saclay/ LCOMS, Université de Lorraine
PhD Student

PhD position Funded by the VEDECOM institute in collaboration with ESTACA and the University of Lorraine as part of the Autonomous and Connected Vehicles program.

JANUARY 2020 – APRIL 2020

ESTACA Paris-Saclay
Temporary lecturer

Real time operation systems (lecture) (4^{th} year engineering students)/**32h**
Real time control (Lab work) (4^{th} year engineering students)/**32h**

FEBRUARY 2019 – APRIL 2019

ESTACA Paris-Saclay
Temporary lecturer

Real time control (Lab work) (4^{th} year engineering students)/**32h**
Algorithmics and Programming (Lab work) (2^{nd} year engineering students)/**24h**

MARS 2017 – AOUT 2017

LCOMS Laboratory, Univeristé de Lorraine-Metz
Trainee

"Research internship: Contactless estimation of physiological parameters using a webcam."

TEACHING ACTIVITIES

My teaching experience was mainly carried out at the École Supérieure des Techniques Aéronautiques et de Construction Automobile (ESTACA-Paris Saclay) as a temporary teacher. In this framework, I participated during the years 2018/2019 and 2019/2020, in a set of teaching modules of algorithmics and programming, real-time operating systems and real-time control for fourth and second year engineering students. Details of these interventions are given below.

Module	Intervention	Public	Hourly volume
Real-time operating systems	Lecture	4^{th} year engineering students	32h
Real-time control	Lab work	4^{th} year engineering students	64h
Algorithmics and Programming	Lab work	2^{nd} year engineering students	24h

Real-time operating systems

The objective of this course is to provide students with skills in using real-time operating systems (RTOS). This course is divided into four parts:

- General concepts on real-time systems, embedded systems, and real-time operating systems.
- Theoretical analysis of real-time tasks scheduling with some application exercises.
- Synchronization and concurrency of tasks.
- Inter-tasks communication.

Real-time control

The purpose of this laboratory work is to give students the knowledge of the components and the tools to create an environment for designing systems with control logic. We used the STATEFLOW tool of MathWorks to program and simulate the operation of some sequential systems. The goal is to model a system and simulate it on STATEFLOW, then to evaluate the different control strategies. We validated with some examples like an alarm system, a ventilation system, and a system of two cylinders in ABC cycle.

Algorithmics and Programming

The objective of this lab work is to provide solid experience in Oriented Object Programming. The practical sessions allow a practical programming experience in Java language on Mindstroms NXT robot platforms. The robots are made of a brick containing a microcontroller, sensors and servo motors. Each group of students is asked to program the robot to explore a labyrinth to find the treasure, save the labyrinth map and return by the shortest path.

RESEARCH ACTIVITIES

My research work is mainly in the field of artificial intelligence for different applications: Estimation of physiological parameters and autonomous vehicles. In the following paragraphs I will describe my research activities during my research internship and my PhD thesis.

Research activities during my research master

During my research master, I had the opportunity to work on the contactless estimation of physiological parameters from a webcam in the LCOMS laboratory, University of Lorraine, Metz.

I did my master's research internship in the SCAIM department of the LCOMS laboratory. During this internship, a prototype of a contactless system to measure oxygen saturation (SpO_2) was developed. The proposed system allows SpO_2 to be monitored remotely without the need to touch the patient's body. The proposed system will allow automatic remote monitoring in hospitals, at home, at work, in real time, people with chronic diseases, the elderly and people at high medical risk.

In this research work we tried to design a non-contact measurement method to measure SpO2. Using a camera and a Kinect, we recorded video streams in two formats (RGB and infrared) to extract photoplethysmographic signals (PPG). SpO2 measurements are calculated from the continuous and discrete components of the PPG signals. We have found that controlling the light source is essential for accurate tracking of SpO2 with the contactless method.

The results measured according to the proposed method were satisfactory in form but not in precision with those obtained using the SpO2 reference device. Our study could potentially offer an inexpensive solution for people who wish to monitor their SpO2 with other essential physiological parameters in normal living conditions without wearing devices. Much work remains on this subject to achieve good accuracy and to replace definitively the measuring instruments in contact with the body.

Key words: *contactless mesure, estimation of oxygen saturation, photoplethysmography, image processing, signal processing.*

Research activities during my PhD thesis

The main objective of my thesis work is to estimate road user intentions for the autonomous vehicle.

Humans are difficult to model and predict because they're irrational. In addition, no two humans are alike, which means that the possible actions are almost infinite in all scenarios. While driving, it is almost always necessary to know what the surrounding cars intend to do in order to ensure safe and optimized control of the vehicle. Let's take the example shown in Fig. 1: if the rear car in the left lane (Ego) intends to take the exit to its right, it must predict how other cars will behave in order to safely head towards the exit, if it is even possible from a safety point of view.due to human irrationality and recent successes in the field of artificial intelligence. My thesis work takes a data-driven approach to prediction.

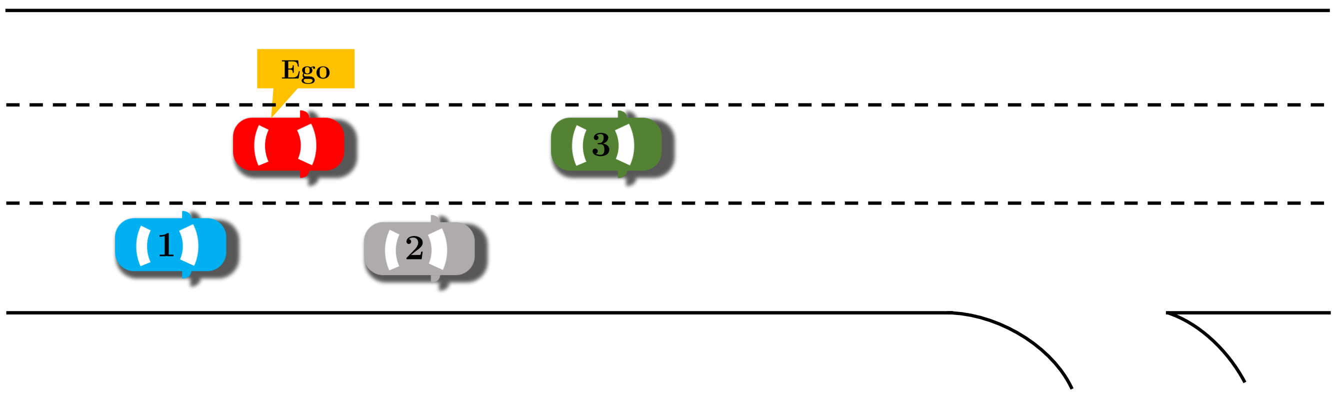

Figure 1: An example of a possible scenario on a highway.

The objective of this research is to see to what extent the intention of a human driver and the movement of the vehicle in general can be predicted using learning-based methods. In this framework, we have developed a method for trajectory prediction from an autonomous vehicle, based on artificial neural networks (ANN) and deep recurrent neural networks of the LSTM (Long Short-Term Memory) type. We propose a new hybrid model that combines maneuver classification and trajectory prediction (Fig. 2). In this work, we are interested in lane change situations on motorways.

This approach operates in two distinct steps:

- **Learning**: observe surrounding vehicles to identify and build models of typical movements. NGSIM (Next Generation Simulation) data is used to train the model.
- **Prediction** : use the learned models to predict the future state of each vehicle.

The system is divided into two main parts: manoeuvre classification and trajectory prediction. In the manoeuvre classification part, the driving manoeuvre of the target vehicle is estimated through artificial neural networks. For this purpose, an ANN is fed by the measured characteristics of the vehicle, which are expected to be available from the perception system using data from the vehicle's on-board sensors. The prediction part takes the results of the classification with the position history to predict the new position of the vehicle. Therefore, if we knew the precise manoeuvre performed by the driver, the prediction model would generate the trajectory superimposed on the manoeuvre performed.

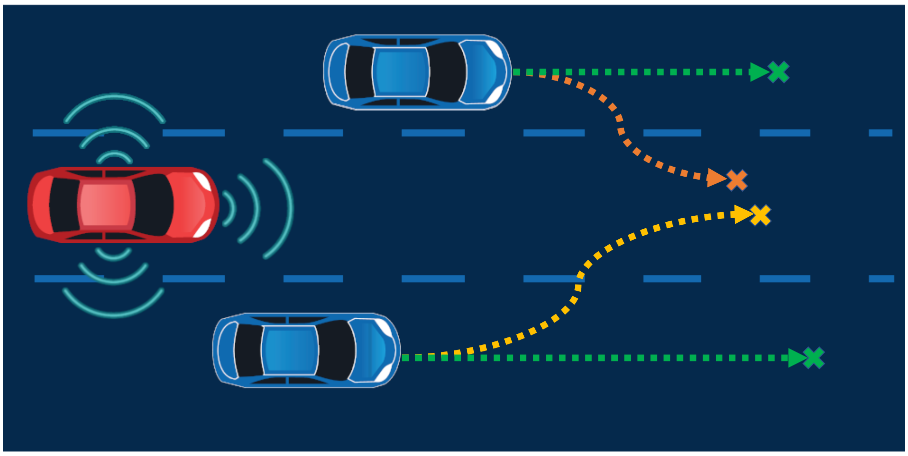

Figure 2: Representation of a driving scene: Manoeuvre classification and trajectory prediction from an autonomous vehicle.

The proposed system has been experimentally validated with real-world data. In our experiments, we used the VEDECOM demonstrator as a test vehicle. This demonstrator is an automated vehicle based on the Renault ZOE platform equipped with a long range radar (Continental ARS 408), a Lidar (Velodyne VLP-16), a GPS RTK and a Mobileye camera (Fig. 3). We collected the test drive data on the test tracks of Satory in Versailles, France. While driving, the test vehicle collects sensor measurements for lane change scenarios with an average speed of 22 m/s.

Figure 3: VEDECOM demonstrator: installed sensors and intern hardware platform.

The evaluation was conducted in two stages. First, we evaluate the classification model to test the performance of maneuver detection. Second, we evaluate the prediction model for a 5 s horizon and compare the predicted and actual trajectories. The results of the position prediction and maneuver classification tests are presented in Fig. 4. As shown in this figure, the maneuver classification model is able to accurately detect lane changes (Recall = 1) on average 2.2 s before passing the road markings. Regarding the trajectory prediction, the prediction results are very similar to the reality of the terrain. The RMS errors of the lateral and longitudinal positions are 0.30 m and 3.1 m respectively. The results of the validation demonstrate the efficiency of the proposed hybrid model. Learning using NGSIM data also proves that our model can predict the future positions of a vehicle in different driving scenarios.

Key words: *Autonomous vehicle, estimation of intentions, trajectory prediction, classification of manoeuvres, artificial intelligence.*

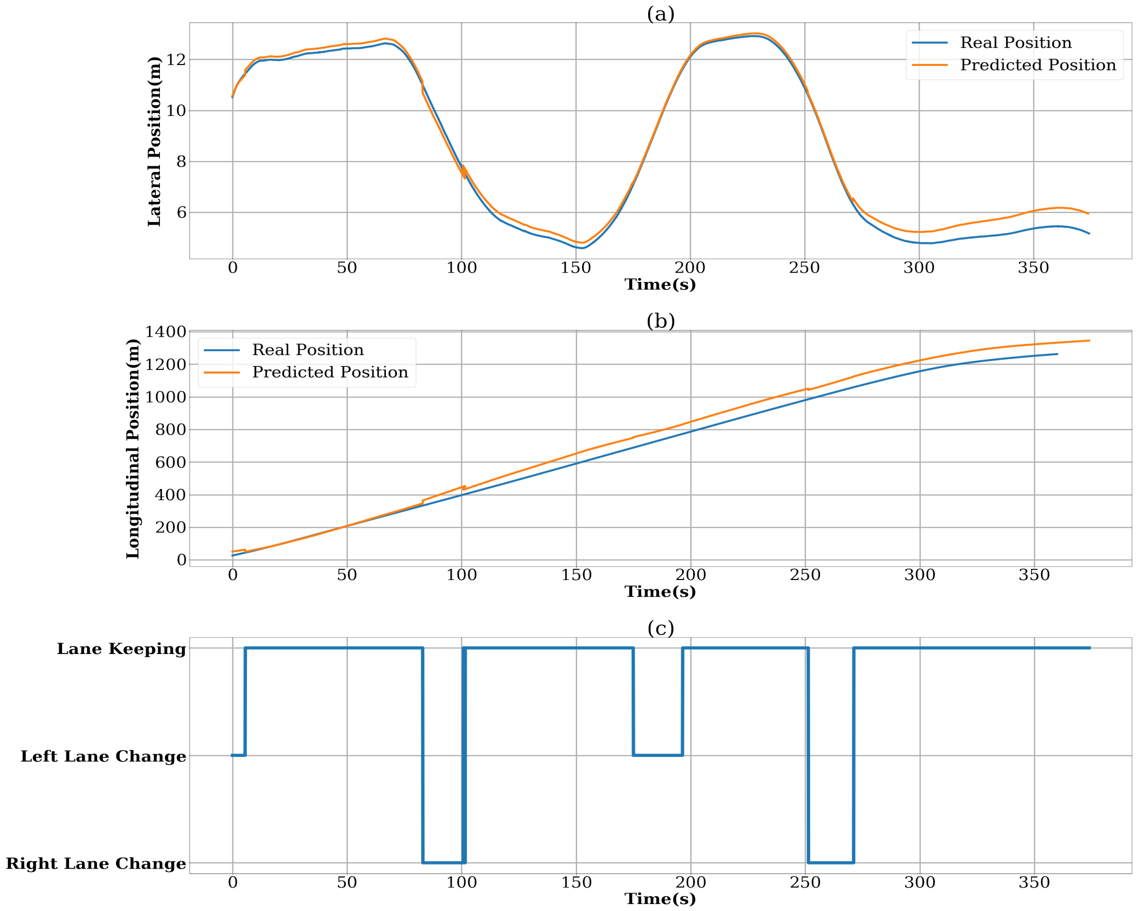

Figure 4: Trajectory prediction of VEDECOM demonstrator test: (a) and (b) represent predicted and real longitudinal and lateral trajectory respectively. (c) represents classification results.

PUBLICATIONS

International peer-reviewed journal

A. Benterki, M. Boukhnifer, V. Judalet, C. Maaoui, "Artificial Intelligence for Vehicle Behavior Anticipation: Hybrid Approach based on Maneuver Classification and Trajectory Prediction Hybrid Model".*IEEE Access Journal (IF=4.098), 8, 56992-57002.*

International peer-reviewed conferences

A. Benterki, V. Judalet, C. Maaoui, M. Boukhnifer "Long-Term Prediction Of Vehicle Trajectory Using Recurrent Neural Networks." *the 45th Annual Conference of the IEEE Industrial Electronics Society (IES) (IECON'2019), October 14-17, Lisbon, Portugal.*

A. Benterki, M. Boukhnifer, V. Judalet, C. Maaoui "Prediction of Surrounding Vehicles Lane Change Intention Using Machine Learning".*The 10th IEEE International Conference on. Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS'2019), September 18-21, Metz, France.*

A. Benterki, V. Judalet, M. Boukhnifer, C. Maaoui "Multi-Model and Learning-Based Framework for Real-Time Trajectory Prediction".*28th Mediterranean Conference on Control and Automation (MED'2020), June 16-19, Saint Raphaël, France (submitted).*

Seminars

- Presentation of research works at VEDECOM seminars with the participation of various industrial partners (PSA, Renault, Valeo and Continental).
- VEDECOM's annual scientific conferences "Smart Mobility and Intelligent Vehicle (SMIV)" (November 27, 2018, November 12, 2019).

- VEDECOM doctoral days (November 27, 2018, October 21, 2019).
- ESTACA doctoral day (June 13, 2019).

LANGUAGE SKILLS

ENGLISH	fluent (speaking, reading, writing)
FRENCH	fluent (speaking, reading, writing)
ARABIC	native language

COMPÉTENCE TECHNIQUES

Artificial Intelligence

Neural Networks (Simple, Recurrent (LSTM, GRU), Convolutional), Deep Learning, Clustering, and Data Analysis.

Autonomous Vehicles

Intention Prediction, Perception and Data Fusion, Location and Trajectory Planning.

Automatic control

advanced controls, regulation, identification and optimization.

Programming languages

Python, C, C++, C#, Java, SQL, RTMaps, Matlab and Sinmulink.

Embedded electronics

Development board (Nvidia jetson, Raspberry Pi, Arduino), image processing (OpenCV, Camera, Kinect, and infrared camera) and sensor integration and calibration.

REFERENCES

Dr. Moussa Boukhnifer

POSITION	Associate Professor HDR
EMPLOYER	Université de Lorraine
EMAIL	moussa.boukhnifer@univ-lorraine.fr
TEL	+33 (0)3.72.74.87.26

Pr. Choubeila Maaoui

POSITION	University Professor
EMPLOYER	Université de Lorraine
EMAIL	maaoui.choubeila@univ-lorraine.fr
TEL	+33 (0)3.87.54.73.02

Dr. Vincent Judalet

POSITION	Associate Professor
EMPLOYER	ESTACA Paris-Saclay, France
EMAIL	vincent.judalet@estaca.fr
TEL	+33 (0)1.76.52.12.04