EIT Digital – Industrial PhD position proposal

PhD thesis information

PhD Thesis – Title	**Artificial Intelligence (AI) solutions for Autonomous Driving enacted with Deep Neural Network technologies and humanlike information processing architectures.**
PhD Thesis – Short summary	The proposed PhD program will address a number of relevant research challenges for the automotive industry, with particular focus on autonomous driving, such as: - fusion of heterogeneous data coming from various on-board sensors; - mimicking loops in the brain in relation to action selection; - predicting expected driver perception; - leveraging Deep Neural Networks (DNN) and building on the NVIDIA Software Development Kit.
Rationale/challenge	To make autonomous driving possible the Automotive Industry has to work with computer science research centers to learn how to deal with real world driving situations. Today ADAS (advanced driver-assistance systems) are able to make decisions for drivers that override driver error. For instance, the Emergency Braking System and the Lane Departure Warning System are already on the market. Many technologies have been introduced onto the automobile market such as cameras, lidar, V2X, sensors and other important devices to enhance the capability of the car in "understanding" its environment. But the main challenge is to fill the gap in the capability of the autonomous vehicles to make decisions in complex and dynamic scenarios and resolve conflict situations in real time. The "new route" is to model human cognitive systems, load such information into vehicles, and to delegate an artificial intelligence (AI) to self-driving "human like" vehicles, allowing them to predict the behaviors of others around themselves.

Innovation	Deep Neural Networks (DNN) mimic the processing of information in the human brain. They are made of multiple layers in cascade (that correspond to layers of neurons in the brain). Each layer processes the information of the previous layer with simple operations (typically convolutions and de-convolutions) that resemble the transformation occurring between layers of the brain.
	While one single convolution/deconvolution step (from one layer to the next) carries out simple computations (for example edge and orientation detection) the aggregation of several layers show remarkable performance, which result in the detection of features of a higher level of complexity such as object recognition.
	Research in Deep Neural Networks has been quiescent until very recently where technology for modelling these long network chains has matured.
	Today Companies like Apple, Google and Microsoft use DNN for personal assistants like Siri, Cortana, etc.
	In the Automotive domain NVIDIA developed Graphical Processing Units for both training and online use of the DNN. They have demonstrated a Self-Driving car at CES 2017. NVIDIA provides a development tool for ADAS. http://www.nvidia.com/object/drive-automotive-technology.html
	The main use of DNN so far has been for image processing and object detection/classification (processing occurs on 2D data array that correspond to the field of view and subsequent transformations).
	However, DNN are not limited to the straight use of the network for classification and control. There are possible <u>innovative automotive applications</u> that have been overlooked: ➢ Fusion of heterogeneous data (for example self-calibrated estimation of vehicle state with transparent fusion odometer, gyro meter, GPS video and Lidar). ➢ Use of networks of deep neural networks to mimic loops in the brain (such as action selection to deal with multiple choices that exist when there are options). ➢ Use of the networks backward, to predict expected perception (which have several applications ranging to surrogate perception, e.g. imagining the road behind an obstacle in order to detect unexpected situations).
Research focus/topics	To achieve the goals of the three above described innovative automotive applications we intend to adopt a hybrid approach that combines the use of Deep Neural Network, optimal control techniques (e.g. to speed up both the DNN training) and physical models to be integrated into a hierarchical structure human brain bio-inspired. The most important ingredients to carry out the research are as follows: a) The availability of a large dataset collected from vehicle sensors guaranteed by the CRF demonstrator vehicle fitted with sensors to perceive the surrounding environment. Specific road scenarios and

	tests will be scheduled to cover a wide range of driving situations; b) Use of state of the art Deep Learning techniques and algorithms on specific hardware for training and optimal control and physical models. The Mechatronics research group has recently acquired a number of dedicated hardware (e.g. NVIDIA Jetson TK boards and DGX-1) and has 20 years of experience on vehicle dynamics and optimal control; c) simulation tools for vehicle dynamics and road scenario representation are necessary for model based design, development and validation of interpretation AI outputs. The research group has a variety of vehicle dynamics simulation software, a driving simulator and CRF may guarantee a continuous support for model validation and data interpretation.
Expected outcome	The PhD research is expected to provide artificial intelligence systems for at least one of the above cited innovative applications in the automotive domain. The AI system will be based on a hybrid structure human brain bio-inspired that combines DNNs, physical models and optimal control based solutions. Research expected results also include algorithms and numerical tools for AI system training, adaptation and performance evaluation.
Action Line	Digital Cities

Partnership

Industrial partner	Centro Ricerche Fiat S.c.p.a. (CRF)
Academic/research partner	University of Trento - UNITN (Italy)
HEI granting the title	ICT International Doctoral School – University of Trento
DTC location	Trento
PhD duration	3 years