2022-2025 fully funded PhD. sholarship in Artifical Intelligence
at INSA Rouen Normandy, France:

Improving Autonomous Vehicles perception using Transfer Learning and Vehicle-Infrastructure Cooperation strategies

Context

Connected and Autonomous Vehicles (CAVs) take advantage of the advancement of communication and sensing technologies to offer a potential sustainable alternative to current mobility services. Many ongoing projects are studying the effects of CAVs on the network, at the same time trying to identify the best strategies to develop in order to design new and dedicated traffic control strategies. The challenge here is to solve the medium-term situation where both conventional and automated traffic will share the road network.

Very first real-world deployments have been carried out experimentally and tend to confirm the expected benefits of cooperation between AVs (Stern et al., 2018), that have been previously identified in simulation (Guériau et al., 2016). These benefits however seems to require suficient penetration rates (*i.e.* high percentage of connected AVs *vs.* human-driven vehicles). Indeed, **autonomous driving algorithms**, especially when built using Artificial Intelligence techniques and **learning-based approaches**, **require** accurate and real-time perception capabilities that **rely on efficient computer vision techniques**. In the context of early-stage mixed traffic flow (*i.e.* low percentage of connected AVs *vs.* human-driven vehicles), this perception could be improved by integrating inputs from other surrounding vehicles and/or infrastructure-side sensors.

The goal of this PhD work is to jointly explore techniques akin to **transfer learning** (TL) and **multi-agent cooperation** (between vehicles and/or with the infrastructure) to assist the perception and decision stages of autonomous vehicles driving in open (but controlled) environnements. TL enable knowledge acquired by one or multiple (Taylor et al., 2019) learner (source) agents to be transferred to another or the same (target) system, helping the latter to learn a similar but different task or to adapt an existing algorithm to a similar domain. Recently, TL was shown to be particularly efficient when transferring autonomous driving tasks, between different domains (Sharma et al., 2019) and or/environnments. For instance transfer a task learnt a specific road network (ex: Paris) to a different one (ex: Tokyo) or coping with adverse weather conditions that affect vision-based perception, Blin et al. 2020).

The **deep-learning** community is being more and more aware that machine learning models are “costly to train and develop, both financially, due to the cost of hardware and electricity or cloud compute time, and environmentally, due to the carbon footprint required to fuel modern tensorprocessing hardware”[1]. This is led to the emergence of an interesting and novel research effort, called ***Green AI*** in the litterature (Schwartz et al.,2019), that aims at reducing the amount of data required for deep-learning based approaches to converge . One the the strategies, called **frugal learning**, “which has been recently gaining importance to drastically reduce computational time and energy consumed is **to exploit the availability of** different information sources”[1], or **different models, environments.**

This PhD work is part of a research project named MultiTrans, that focuses on exploring novel TL approaches for autonomous vehicles scene semantic segmentation and detection accross 3 different environments (simulation, a robotic platform and a real-world autonomous shuttle

1 https://news.mit.edu/2020/artificial-intelligence-ai-carbon-footprint-0423

test-bed). This scholarship is funded by the Agence Nationale de la Recherche (ANR) under grant reference ANR-21-CE23-0032.

Objectives

The main objective of PhD work is **to investigate and propose new perception algorithms for autonomous driving tasks that rely on transfer learning, frugal learning and cooperation mechanisms**. The roadmap of the work will target the following objectives:

1. Review and study of recent advances in the fields of transfer learning (multi-source, multi-target domain adaptation and frugal learning), multi-agent cooperation.
2. Study and proposal of learning-based cooperative strategies for autonomous vehicles.
3. Review, choice, setup and testing of both simulation (large scale microscopic simulator) and real environment (small scale: autonomous shuttles test-bed).
4. Proposition and implementation of cooperative/collaborative transfer learning-based algorithms for autonomous vehicles .
5. Evaluation of developped strategies in both environments from several perspectives: high-level such as traffic flow stability, efficienty, safety and low-level as transfer frequency, sucess rate, sensibility to context changes, etc.
6. Scientific dissemination and research outreach in the form of research papers, demonstrations, video recordings of experiments and presentations to conferences and wider audience.

Expected contributions and research outreach

The work undertaken by the candidate **should contribute** and is not limited **to**:

- a **better understanding** of issues **related to** implementing **autonomous driving** relying on **computer-vision based perception;**
- experimental **findings** (simulation and/or real test-bed) **on the benefits of communication/cooperation** to autonomous traffic;
- **insights on the use of transfer learning and cooperation (V2V/I2V) to improve** autonomous vehicle perception and decision.

Given that part of the research will be carried on the real world autonomous shuttle test-bed, it is expected that the algorithms developped will result in actual **demonstrations for research purposes** but **also used as dissemination** material (video recordings, etc.) to the public.

Keywords

Autonomous driving, perception, cooperation, transfer learning, domain adaptation, multi-agent systems, simulation.

References

- R.E. Stern, S. Cui, M.L. Delle Monache, R. Bhadani, M. Bunting, M. Churchill, N. Hamilton, H. Pohlmann, F. Wu, B. Piccoli and B. Seibold, “Dissipation of stop-and-go waves via control of autonomous vehicles: Field experiments”, Transportation Research Part C: Emerging Technologies, 2018, 89, pp.205-221.
- M. Guériau, R. Billot, N.E. El Faouzi, J. Monteil, F. Armetta, S. Hassas, “How to assess the benefits of connected vehicles? A simulation framework for the design of cooperative traffic management strategies”, Transportation research part C: emerging technologies, 2016, 67, pp. 266-279.
- R. Schwartz, J. Dodge, N. A. Smith, O. Etzioni. “Green ai.” arXiv preprint arXiv:1907.10597, 2019.
- N. Hyldmar, Y. He and A. Prorok, "A Fleet of Miniature Cars for Experiments in Cooperative Driving," 2019 International Conference on Robotics and Automation (ICRA), 2019, pp. 3238-3244.

- R. Blin, S. Ainouz, S. Canu and F. Meriaudeau, “A New Multimodal RGB and Polarimetric Image Dataset for Road Scenes Analysis”, IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops, 2020, pp. 216-217.
- A. Taylor, I. Dusparic, M. Guériau, S. Clarke, “Parallel transfer learning in multi-agent systems: What, when and how to transfer?”, International Joint Conference on Neural Networks (IJCNN), 2019, pp. 1-8.
- S. Sharma, J.E. Ball, B. Tang, D.W. Carruth, M. Doude, M.A. Islam, ”Semantic segmentation with transfer learning for off-road autonomous driving”, Sensors, 2019, 19(11), pp. 2577.

Qualification and skills

The successful candidate would:

- be completing or have completed a MSc/Master degree (or Engineering degree) in Computer Science/Computer Vision/Robotics with a specialization/interest in AI- and/or machine learning-based techniques;
- have strong English and/or French writing and oral communication skills.

Knowledge and/or experience with the following fields would be greatly appreciated:

- intelligent transportation systems, connected and automated vehicles
- techniques such as deep learning, reinforcement learning, transfer learning, multi-agent systems,
- vehicular simulation and/or robotics environments.

Supervision

Maxime Guériau (Assistant Professor), Samia Ainouz (Professor), both member of the Intelligent Transportation Systems team (STI) and Stéphane Canu (Professor) at LITIS lab (*Laboratoire d'Informatique, de Traitement de l'Information et des Systèmes*), INSA Rouen Normandy, France.

About LITIS lab and the STI team

The research conducted at LITIS lab covers 3 major fields: information access, bio-medical information processing and ambient intelligence with applications in health, automotive and smart territories. The expertise of LITIS members is recognized internationally and includes: machine learning, multi-agent systems, intelligent vehicles. The STI team (the successful candidate will be joining) is specialized in advanded driving assistance systems, computer vision, distributed and autonomous systems.

The LITIS is a laboratory (EA 4108) of University of Rouen Normandy, University of Havre Normandy and INSA Rouen Normandy. It is a member of the doctoral school MIIS and of the normand network «Digital Normandy». LITIS is a partner of the Normastic CNRS Research Federation.
Address: 685 Avenue de l'Université, 76800 Saint-Étienne-du-Rouvray.

The candidate will be allowed to access to different experimental platforms to carry out the work:

- a robotic platform featuring different robot cars equipped with state-of-the-art perception sensors;
- an autonomous shuttle test-bed with equipped infrastructure;
- an intensive computing center (CRIANN: Centre Régional Informatique et d'Applications Numériques de Normandie).

Scholarship, travel and support

This PhD scholarship is funded by the Agence Nationale de la Recherche (ANR) under grant reference ANR-21-CE23-0032, for 3 years (around 1500€ - 1800€ net/month) during which the PhD student will be registred (380€ yearly) to the doctoral school MIIS (ED 590) that offers a mandatory training program and a monitoring support throughout the PhD.

The succesful candidate will recieve support for occasional international travel (participation to conferences) and is also expected to complete is training by participating to summer schools. Occasional national travel (mainly to Nice and Paris) will be organised, enabling the candidate to visit the partners of MultiTrans project.

Dissemination and visibility of the work will be ensured by advertising it on MultiTrans website and sharing resources, open-source algorithms and findings (on a Git repository).

Application process

Candidates applications should include:

- a full resume, including a comprehensive list of publications, if any, and;
- a cover letter, and;
- contact details of up to 2 references, if available, and;
- a transcript of all MSc/Master grades;

And be sent to:

maxime.gueriau@insa-rouen.fr,
samia.ainouz@insa-rouen.fr,

By no later than May 27th 2022.