Transferability and Data-Efficient Learning for Perimeter Control in Urban Traffic Networks

This internship will be supervised by:

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Context

Perimeter Control (PC) is a well-established strategy for managing traffic in urban networks under oversaturated conditions, regulating vehicle flows into and out of a Protected Network (PN) using the Macroscopic Fundamental Diagram (MFD). Many existing studies implement efficient control strategies, but these are typically optimized for specific regions and conditions (Zhou, 2024). While deep reinforcement learning (DRL) has demonstrated its efficiency in managing traffic signals and optimizing perimeter control strategies, these data-driven approaches can face significant challenges in real-life applications. These challenges include dealing with unexpected perturbations, such as accidents or sudden traffic increases, and ensuring robustness when deployed in unseen regions where the model has not been trained (Hu & Ma, 2024).

This internship will not focus on optimizing new PC strategies but on the transferability of existing strategies across different urban areas. The core question is: How can we effectively learn from data in one region and successfully apply those learned strategies to another region with different traffic conditions, including disturbances such as accidents or surges in traffic?

Objectives and Activities

The primary objective of this internship is to explore recent deep learning transfer techniques such as transfer learning, few-shot learning, and knowledge distillation to enable efficient transfer of knowledge across different regions with minimal data and retraining (Zhang et al., 2024).

The main steps are:

- **State-of-the-Art Review** The first stage will involve reviewing relevant literature on transfer learning, few-shot learning, and knowledge distillation. Additionally, the intern will become familiar with existing DRL-based perimeter control strategies, which will serve as the foundation for the subsequent work.
- **Implementation, Testing, and Evaluation** In the second stage, selected transfer techniques will be implemented into an existing perimeter control strategy. The model will be trained in one region and then tested

in another, evaluating its performance under different conditions, including various traffic perturbations.

- **Valorization** Finally, the results from the testing and evaluation stage will be documented, with a focus on exploring opportunities for publication in relevant academic journals or conferences.

Materials

- **SUMO**: A microscopic traffic simulation tool for testing existing perimeter control strategies.
- **TraCI**: the Python interface is necessary to dynamically update the state of SUMO's objects.
- **Python, PyTorch**: Programming languages and libraries for implementing deep learning models and transfer learning techniques.

Candidate Profile

The ideal candidate should preferably have:

- Experience with Deep Learning and familiarity with concepts like reinforcement learning, transfer learning, few-shot learning, knowledge distillation, and data-efficient learning.
- Proficiency in Python programming and experience with deep learning libraries such as TensorFlow or PyTorch.
- Interest in urban mobility and traffic control systems.

Internship location

ENTPE (Graduate School of Civil, Environmental and Urban Engineering), Vaulx-en-Velin, France

Application Process

To apply, please send your ZIP folder named `[MobilityTransferability_NameSurname]` to `rim.slamasalmi@entpe.fr` and `pierre-antoine.laharotte@univ-eiffel.fr`.
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This folder should contain your **CV**, **academic transcripts** from high school (post-baccalaureate) to the most recent year of your master's program, and any **certifications in deep learning** if you have any.

References

Hu, Z., & Ma, W. (2024). guided deep reinforcement learning for coordinated ramp metering and perimeter control in large scale networks. *Transportation research part C: emerging technologies*, *159*, 104461.

Zhang, D., Yan, H., Chen, Y., Li, D., & Hao, C. (2024). Cross-domain few-shot learning based on feature adaptive distillation. *Neural Computing and Applications*, *36*(8), 4451–4465.

Zhou, D. (2024). Deep reinforcement learning approaches to perimeter metering control problems.