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An investigation of deep imitation learning for mobile robot navigation

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Semester 6

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Plan of studies & implementation summary

Study year	Exams		Conference participations		Publications	
	Planned	Completed	Planned	Completed	Planned	Completed
I (2020/2021)	2	2	1	1		
II (2021/2022)	2	2				
III (2022/2023)			0	0	1	0
IV (2023/2024)			1	0	1	0

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Report of activity plan

Exams		Conference Participation		Publications	
Planned	**Status**	**Planned**	**Status**	**Planned**	**Status**
Machine Learning	Passed with 9/10	All Sensors 2021, Nice, France	Paper accepted and presented at All sensors 2021 conference at Nice, France. On the 20th of July, 2021.	Idea paper with the title “Combining Multiple Modalities with Perceiver in Imitation-based Urban Driving”	Published
Research methods and methodology of informatics and computer engineering	Passed with 9/10	Planned participation with a poster in conference at Druskininkai.	December 2023		
Fundamentals of informatics	Passed with 7/10				
Optimisation	Passed with 7/10				

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Workshops

Workshop	ECTS
MOKSLINIŲ REZULTATŲ PUBLIKAVIMAS PAGAL FORMALAUS VERTINIMO REIKALAVIMUS	0.1
MOKSLINĖS INFORMACIJOS IŠTEKLIAI, PAIEŠKA, IR ĮRANKIAI	0.1
MENDELEY PRAKTINIS UŽSIĖMIMAS	0.15
DeepLearn 2022 Summer School (Participated)	
Total:	0.35/3

Stages of research and dissertation preparation

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	Name of task	Duration	Notes
2.	**2.3. Empirical Research:** 1. Implementation of results of 2.2.2 and 2.2.3 to improve the state-of-the-art trajectory controller and navigation methods.	May 2022 – August 2022	Implemented conditional neural processes for conditional imitation learning based trajectory following.
	2. Performing an experimental study of the developed algorithms to analyse their effectiveness and to compare with related alternate methods.	September 2022 - February 2023	Implemented and experimented with visual place recognition trained encoder over navigation. Analysis of the proposed method was also performed on benchmarks.
	2.4. Analysis of the obtained data, summary, preparation of conclusions: 1. Summary of theoretical research. 2. Summary of empirical research. 3. Summary of results and preparation of conclusions.	March 2023 – August 2023	

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Research Object and Aim

Research object:

- Deep imitation learning methods.
- Application of deep imitation learning methods for mobile robot navigation.

Research aim:

- To develop, implement and research an autonomous navigation system for mobile robots based on imitation learning and deep neural networks

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Objectives of Research

1. To **develop and investigate** new sensorimotor reflex algorithms based on deep neural networks and various simulation learning paradigms (e.g. behaviour cloning, generative adversarial imitation learning) (e.g. trajectory following, obstacle avoidance, approach to a recognized object).
2. To **compose and implement** a new navigation system for mobile robots from the obtained sensorimotor reflexes.
3. To **compare** the obtained navigation system with alternative robot navigation algorithms.
4. To **prepare publicly available datasets** for the research of autonomous robot navigation algorithms based on the principles of deep neural networks and imitation training.

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What has been carried out so far

- Literature study from papers on imitation learning for mobile robot navigation
- Took courses:
  - Machine learning (at VU)
  - Research methodology (at VU)
  - Fundamentals of Informatics (at VU)
  - Optimisation (at VU)
  - Reinforcement learning (Online)
- Trying out Simulators (CARLA and OpenAI gym)
- Attempted to run state of the art methods in simulation
- Participation in an international conference

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What has been carried out so far

- Participation in summer school (Deep Learn 2022)
- More literature study
- Implementation of baseline and a proposed method

Research

Learning to imitate

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- In imitation learning:
  - Given: Demonstrations
  - Goal: Train a policy (model) to mimic demonstrations
- Being a form of machine learning, data is collected, models are optimized, accuracies are evaluated.

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About the problem to solve

- Learning sensorimotor skills to drive and navigate based on visual input.
- It can be done with traditional methods such as SLAM, but it would require expensive sensors and extensive programming.
- The idea of imitation learning promises to solve this problem by learning from human demonstrations.
- Yet, it remains unsolved due the unpredictability of the real world causing the problem of covariate shift.
- To compare the ability between methods Leaderboard benchmark has been established.
- Leaderboard benchmark uses CARLA simulator to seed vehicles in different parts of a map and tests the ability of reaching from point A to B, under different sets of conditions.

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Striving for weather invariance

- All end to end driving benchmarks test under varying weather conditions.
- Performance in the state of the art seem to generalise worse for previously unseen weather settings.
- Current algorithms train for different weather conditions during the imitation learning process, where it is implied but not explicit.

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Proposed method

- Currently used encoders in end to end driving architectures are imagenet pretrained resnet encoders.
- We propose, pretraining the encoder for the task of visual place recognition at first.
- Followed by carrying out imitation learning to learn the task of driving.
- This way we attempt to achieve weather invariance.

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Visual Place Recognition

- Visual place recognition is an area which deals with making recognition of places invariant to weather and lighting conditions.
- Data is collected at different times of the day, with the help of GPS coordinates in order to be able to sample closer locations and further locations as per requirement.

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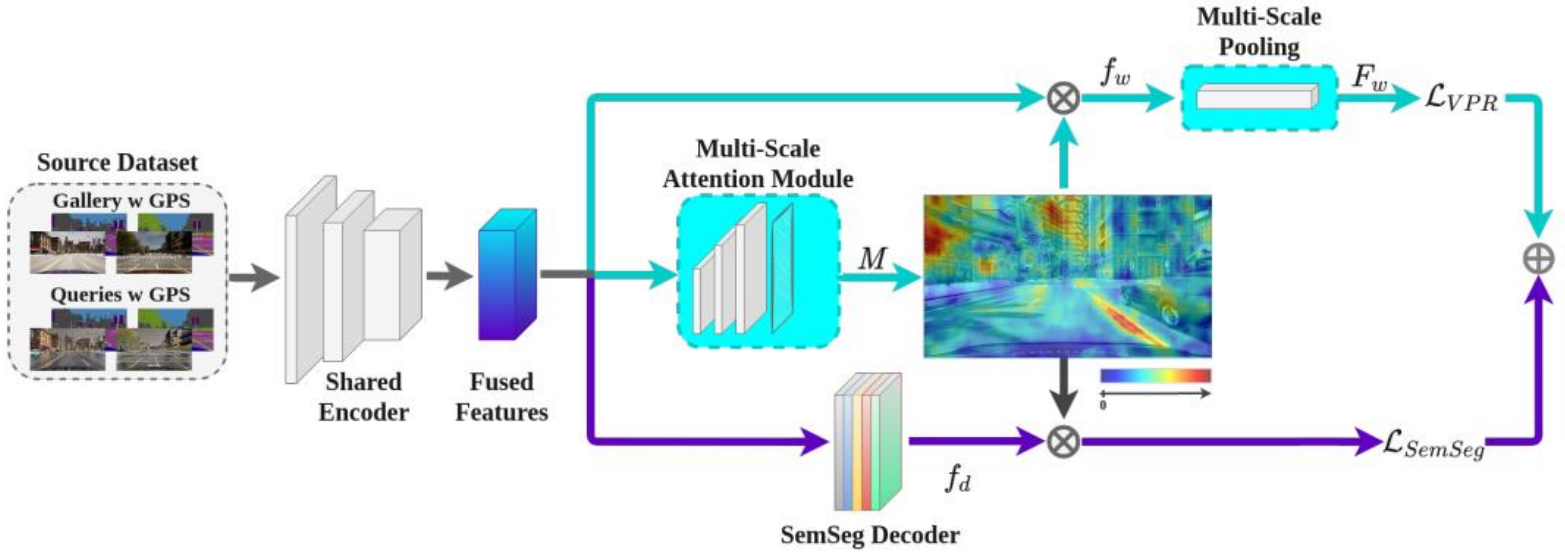
VPR Method used: SegVPR

- SegVPR learns global embeddings from visual and semantic context of data.
- It uses semantic segmentation to dynamically guide the task of recognising places.



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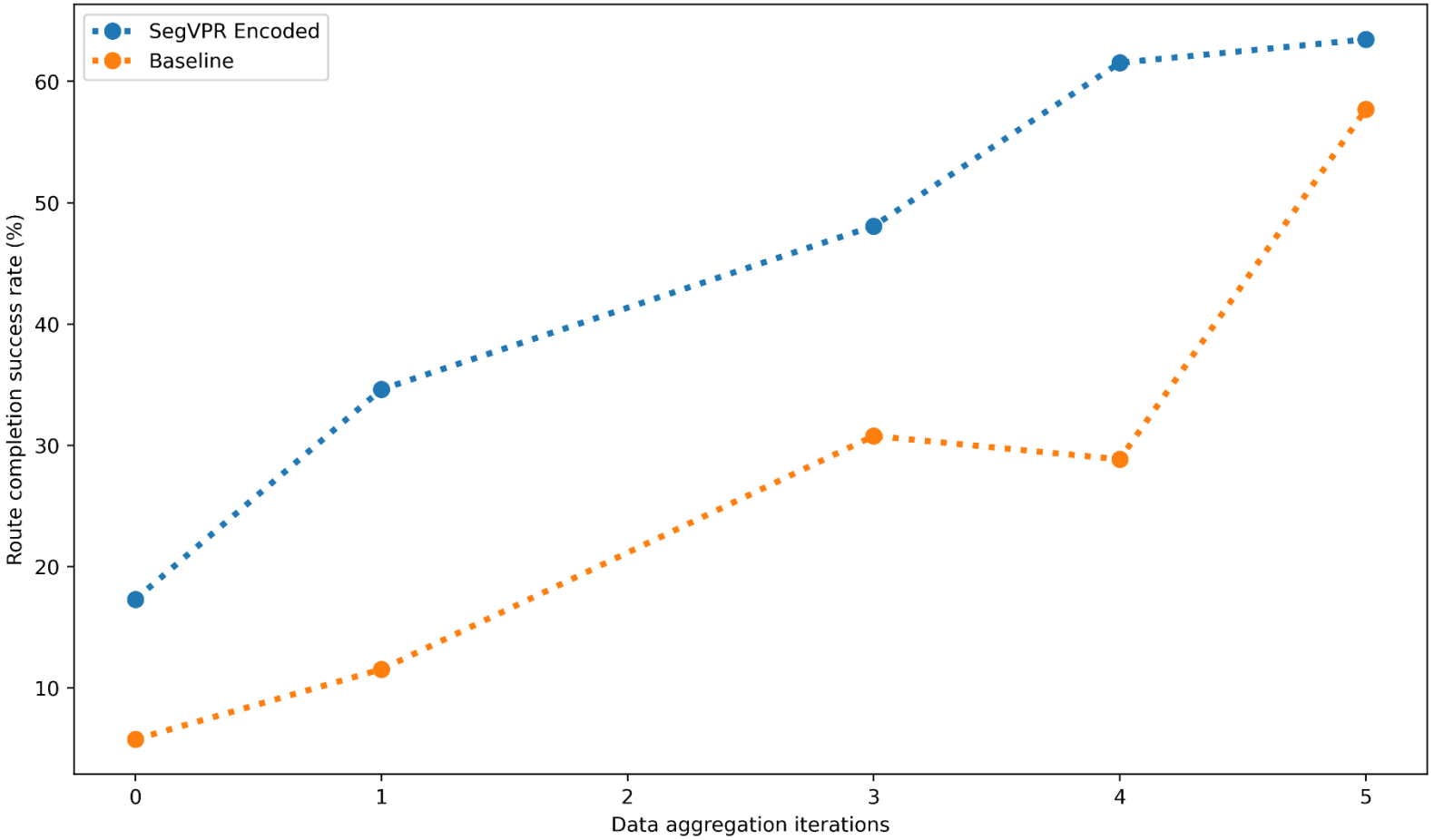
Results



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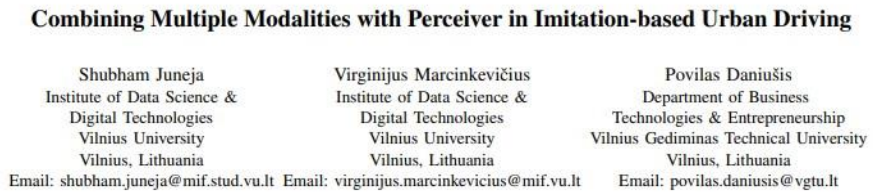
Published work

On record:

- Conference: All sensors 2021
- Participation type: Idea paper

Off record:

- Journal “Springer: Autonomous Robots”
- Impact factor: 3.6



Combining Multiple Modalities with Perceiver in Imitation-based Urban Driving

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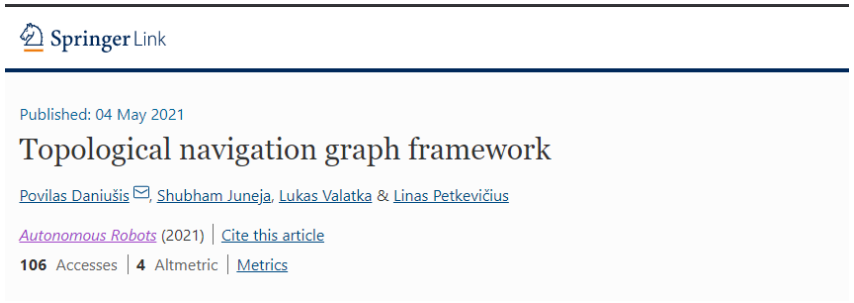

SpringerLink

Published: 04 May 2021

Topological navigation graph framework

Povilas Daniušis, Shubham Juneja, Lukas Valatka & Linas Petkevičius

Autonomous Robots (2021) | Cite this article

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Combining multiple modalities with Perceiver in IL based learning

- We present a study pointing out how end-to-end methods rely on a single modality while lacking the performance compared to traditional autonomous driving methods which take a modular approach.
- Therefore, we propose a method to enrol more than one modality in the learner.
- We propose the use of a perceiver architecture in the learner as this architecture shows capability of learning with varying number and types of modalities as input data.
- Since the published paper is a idea paper, no experiments were presented.

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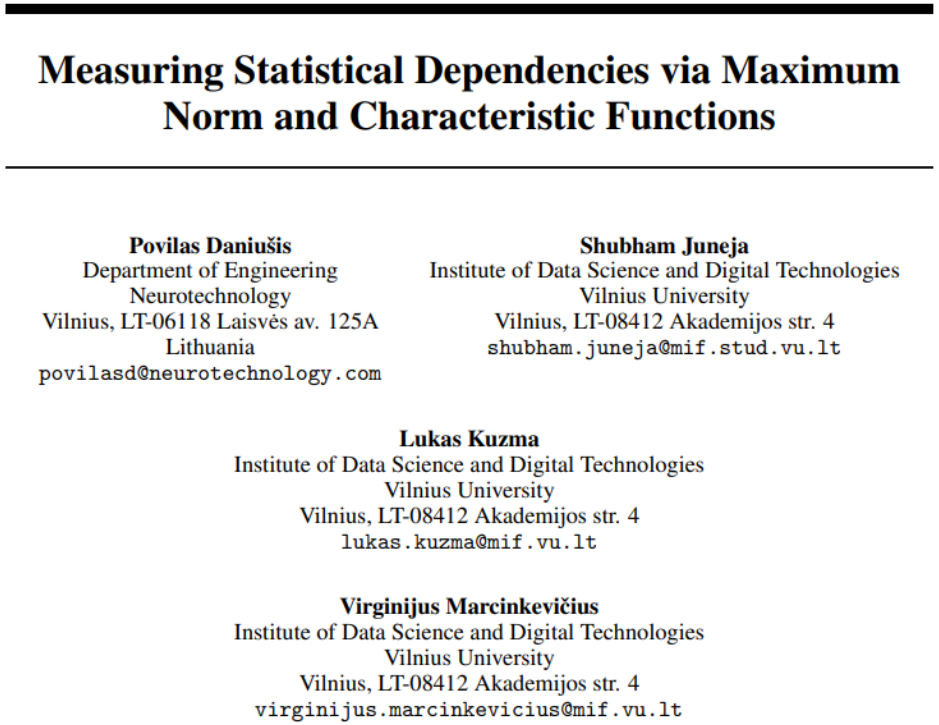
Publication work in progress:

- Under review in a journal



Measuring Statistical Dependencies via Maximum Norm and Characteristic Functions

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Work plan for semester 6

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Research:

- Completion of benchmarking and result generation.
- Publication in a journal.

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Thank you