Department of Computing and Mathematics Computing and Digital Technology Postgraduate Programmes Terms of Reference Coversheet	
Student name:	Ante Tomicic
University I.D.:	19090041
Academic supervisor:	Dr. Ryan Cunningham
External collaborator (optional):	
Project title:	Deep Learning Solutions for Autonomous Vehicles
Degree title:	MSc Advanced Computer Science
Project unit code:	6G7Z1015
Credit rating:	60
Start date:	10.06.2020.
ToR date:	10.06.2020.
Intended submission date:	25.09.2020.
Signature and date student:	Ante Tomicic 8.06.2020.
Signature and date external collaborator (if involved):	

This sheet should be attached to the front of the completed ToR and uploaded with it to Moodle.

Does intermittent control theory have any practical impact on reinforcement learning in autonomous vehicles?

Terms of Reference (ToR)

Project description:

Progress and development in the field of autonomous vehicles presents a big challenge. It is estimated that 94% of all traffic accident is caused by humans [1]; besides accidents, problems such as traffic congestion, waste of time, caused stress, unnecessary energy consumption and CO2 pollution remain unresolved. This project aims to contribute to research in autonomous vehicles and reinforcement learning, to advance the current state of autonomous driving vehicles in society. Possible benefits are: reduction and mitigation of accidents, transporting the mobility-impaired, reduction of stress, congestion mitigation, road casualty reduction, decreased energy consumption, decreased pollution and increased productivity [1].

This project will try to successfully apply the theory of intermittent control systems (ICS) to reinforcement learning (RL) techniques. ICS is a feedback control method which provides a spectrum of possibilities between continuous control systems and discrete control systems, which allows for better control decisions, avoidance of limit cycles, etc. ICS are found deep inside the brain, within the Basal ganglia and it compliments RL within the brain [2]. Therefore, this project will investigate the potential value ICS can provide to RL, which has proven to be effective in training autonomous vehicles. Furthermore, in order to evaluate the success of the project, results will be compared to the results of common reinforcement learning algorithms such as DQN, DDQN and the Rainbow method [3]. The tested environments will include several Atari games and CARLA simulator without the implementation of visualization and recognition methods but rather simulator generated coordinates.

Project aims:

- Modification of reinforcement learning algorithms by implementing ICS theory.
- Comparison of results with already established reinforcement learning algorithms on Atari games.
- Testing in a simulated environment CARLA.

Learning outcomes:

Learning outcomes of this project are:

- Learning about a wide range of deep learning techniques, reinforcement learning algorithms, deep neural networks, control theory and autonomous vehicles.
- Learning to critically analyze the results and compare them to established reinforcement learning algorithms.
- Learning about software that is used in state of the art research and technology field of deep learning, artificial intelligence and autonomous vehicles.

Activity schedule:

Task	Start date	End Date
Initial literature review	20.05.2020.	2.06.2020.
ToR and ethics	2.06.2020.	10.06.2020.
Familiarization with RL algorithms and ICS	10.06.2020.	25.06.2020.
Implementation of ICS to RL	25.06.2020.	15.07.2020.
Comparison of results on Atari games	15.07.2020.	15.08.2020.
Familiarization with CARLA and testing	15.08.2020.	1.09.2020.
Evaluation and documentation	1.09.2020.	24.09.2020.

Evaluation plan

Evaluation plan consists of two parts:

- Part one: measure and compare quantitative metrics of ICS and RL methods against other RL algorithms and Rainbow method on some Atari games.
- Part two: measure and compare quantitative metrics of ICS and RL methods against other RL algorithms in CARLA simulator.

Quantitative metrics for part one:

- Game score – metric used for measuring performance in Atari games.
- Loss function
- Time to train to reach a specified loss

Quantitative metrics for part two:

- Loss function – which includes petrol usage, accident rate, time on journey, congestion, etc. for the CARLA simulator.
- Time to train to reach a specified loss.

References:

[1] Ekim Yurtsever, Jacob Lambert, Alexander Carballo and Kazuya Takeda:

"A Survey of Autonomous Driving: Common Practices and Emerging Technologies".

https://arxiv.org/pdf/1906.05113.pdf

[2] Kenji Doya:

"Complementary roles of basal ganglia and cerebellum in learning and motor control"

https://jsmf.org/meetings/2008/may/Doya_curr_opin_2000.pdf

[3] Matteo Hessel, Joseph Modayil, Hado van Hasselt, Tom Schaul, Georg Ostrovski, Will Dabney, Dan Horgan, Bilal Piot, Mohammad Azar and David Silver:

"Rainbow: Combining Improvements in Deep Reinforcement Learning".

https://arxiv.org/pdf/1710.02298.pdf