Dream-like simulation abilities for automated cars

DREAMS4CARS

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Lead Editor	David Windridge, MU		
Contributors	Mauro Da Lio, UNITN		
	Riccardo Donà, UNITN		
	Alex Blenkinsop, USFD		
	Hermann Heich, HC		
	Elmar Berghöfer, DFKI		
	Andrea Saroldi, CRF		
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0.2	21 November 2018	Mauro Da Lio	Section 3.1
0.3	27 November 2018	Mauro Da Lio	Section 3.2
0.4	5 December 2018	David Windridge	Section 2.2
0.5	7 December 2018	David Windridge	(updates to/reformatting of Section 2.2)
0.6	9-11 December 2018	Mauro Da Lio	Section 1. Section 2.1. Section 3.1.3.
0.6.b	11 December 2018	Riccardo Donà	Section 3.1.3.
0.6.c	11 December 2018	Hermann Heich	Integrating contributions & formatting
0.7	11 December 2018	Andrea Saroldi	Section 3 (updates).
0.8	17 December 2018	Elmar Berghöfer	Added Section 3.3
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1.0	19 December 2018	Mauro Da Lio	General revision.
1.1	20 December 2018	Alex Blenkisop	Section 2.3
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1.3	22 December 2018	Alex Blenkinsop	Section 2.3 (improvements)
1.4	11-14 January 2019	Mauro Da Lio	Revision following WP3 workshop (Jan 7-9)
1.5	14 January 2019	David Windridge	Revision following WP3 workshop (Jan 7-9)
1.6	15 January 2019	Mauro Da Lio	Final version following internal reviewer' comments

Executive Summary

This deliverable gives the confidential final version of the Dreams4Cars runtime Agent (a public version for dissemination is given by deliverable D2.3), and complements D1.3 (System Architecture, release 2) providing details, references and methods of the implementation of the agent.

In particular, the document focuses on the runtime part of the agent (the dreaming mechanisms will be described in D3.2) and describes the multiloop agent architecture and how the individual loops contribute to achieving the cognitive abilities of the agent (learning via self-instantiated offline simulations).

There are 5 sensorimotor loops in the agent, which are realized with a modular approach using trainable, yet simple and largely verifiable, neural network building blocks embedded in traditional human-engineered container code.

The agent implements hierarchical sensorimotor control, with a physical (non-symbolic) bottommost layer and a symbolic subsumption architecture on top. Long term (strategic) goals, as well as compliance with the highway code is produced by the symbolic module. The module acts on the sub-symbolic (physical) layer by specifying desirable target areas, hence biasing low-level action selection. With this arrangement the symbolic module works via steering the behaviour of the physical layer, but the physical layer retains the final authority allowing to use only the safe tactical manoeuvres that are moment-by-moment available (it can veto incorrect high-level requests).

Reconfiguration of the agent occurs at the neural network level. Depending on which loop is involved, learning involves different agent abilities.

- The cerebellar loop learns forward/inverse models of the vehicle/environment dynamics, which is used for a) motor control, b) interoperability between different vehicles and adaptation to different environments and c) embodied simulations used for the training of the dorsal stream to learn the value of (new) short-term tactical-level manoeuvres.
- The convergence-divergence organization of the dorsal stream learns compact representations of simple events that are used to create simple episodes for developing short-term motor strategies (e.g., imagining other road users' possible behaviours and learning appropriate collision avoidance countermeasures).
- The symbolic level learns long-term strategies with high-level action selection via reinforcement learning in an episodic simulation context.

In the remaining part of the project, agent evolution will be based on learning (via wake-dream cycles) and replacing the various neural network building blocks.