Adapt/:/Ve

Automated Driving Applications and Technologies for Intelligent Vehicles

Mauro Da Lio (UNITN)

Layered control architectures

for automated driving "like humans"

Technical Workshop

Athens, Greece
21-22 APRIL 2016

// Content

- Notion of '*mirroring*' the human sensorimotor control
  - Why mirroring?
  - Mirroring for low level and high level automation
- How human sensorimotor control is implemented in the brain
  - Hierarchical perception-action architectures
  - Affordance competition and action selection
- Implementing an artificial driving agent with a layered control architecture (the human way)
  - Salient examples of the artificial driver behaviours
- Conclusions

// Notion of humanlike co-driver

- A driving agent “mirroring” human sensorimotor architecture.

- M. Da Lio, F. Biral, E. Bertolazzi, M. Galvani, P. Bosetti, D. Windridge, A. Saroldi, and F. Tango, **Artificial Co-Drivers as a Universal Enabling Technology for Future Intelligent Vehicles and Transportation Systems**, **IEEE Transactions on Intelligent Transportation Systems**, vol. 16, no. 1, pp. 244–263, 2015.

// Benefits of mirroring (Yes: in the *mirror neuron* sense)

- Agent can:
  - Infer human internal states (understand human intentions) from observation of human behaviours (at low levels of automation)
  - Drive like a human and being understood by humans (at higher automation levels)

- Human-Robot interactions emerge naturally from agent architecture and are like human-human interactions.

- G. Hesslow, "**The current status of the simulation theory of cognition**," **Brain research**, vol. 1428, pp. 71–9, Jan. 2012.
- L. Cattaneo and G. Rizzolatti, "**The mirror neuron system**," **Archives of Neurology**, vol. 66, no. 5, pp. 557–560, 2009.

// Model for agent sensorimotor architecture

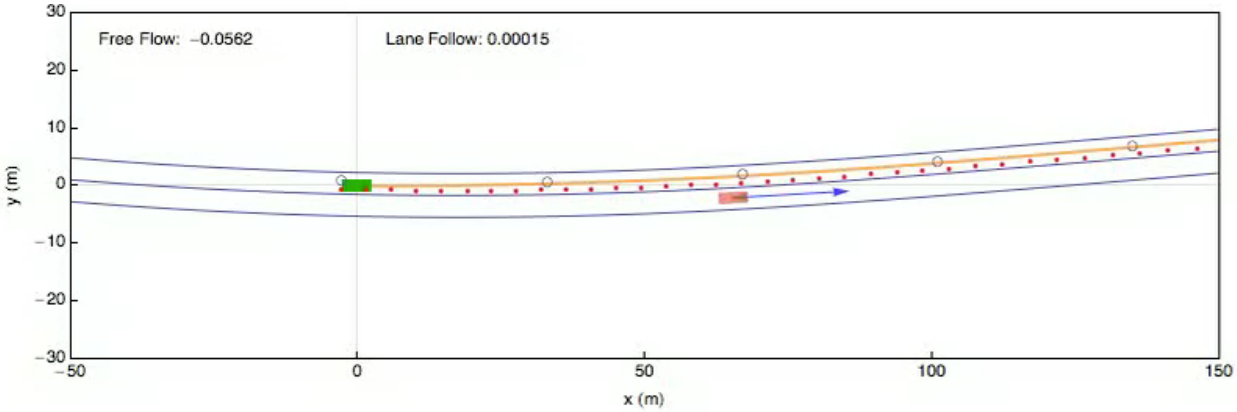
- Key concept
  - Hierarchical control architecture with
  - Simultaneous action priming
  - Selection of action

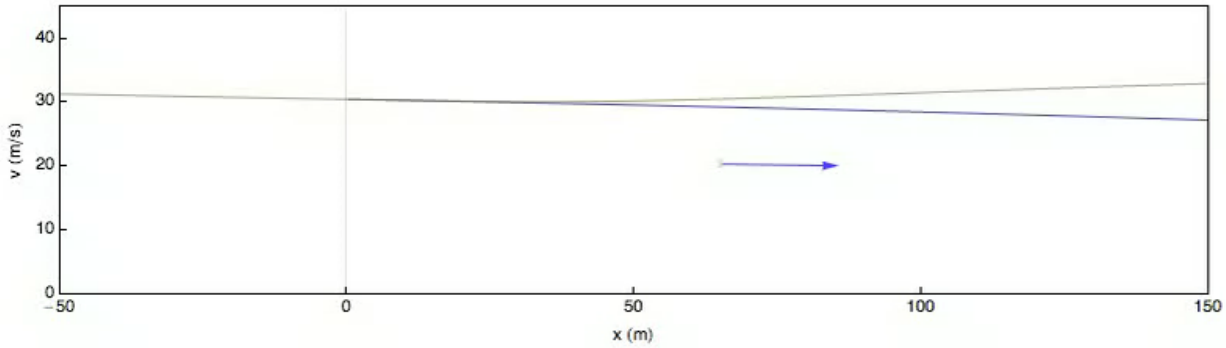
- P. Cisek, "**Cortical mechanisms of action selection: the affordance competition hypothesis**," **Philos.Trans.R.Soc.Lond B Biol Sci**, vol. 362, no. 1485, pp. 1585–1599, 2007.

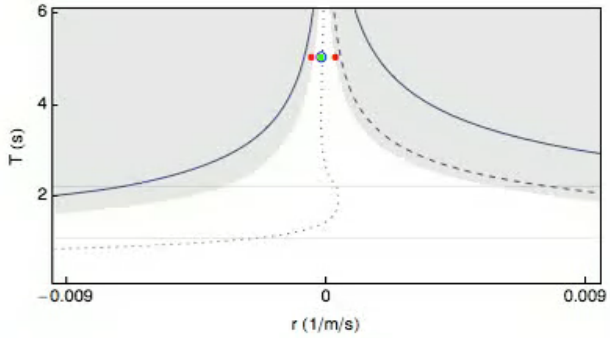
How does the co-driver really look like?

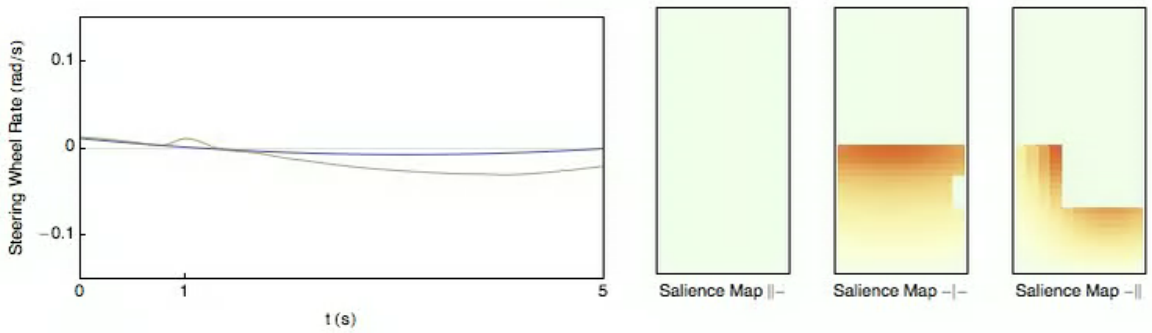
- It is a dark box (it is the same unit in the real vehicle)!

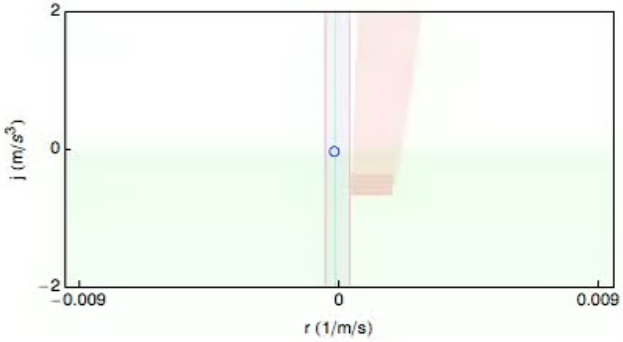
// The AdaptIVe co-driver











// Conclusions

- Automated driving is achieved via bio inspired **Layered Control, Architecture**
  - **Affordance competition**

- The **same system** produces
  - level 1 automation (by mirroring)
  - level 2-4 (shared control)
  - level 5 (mirrored by humans)

References

- M. Da Lio, F. Biral, E. Bertolazzi, M. Galvani, P. Bosetti, D. Windridge, A. Saroldi, and F. Tango, **Artificial Co-Drivers as a Universal Enabling Technology for Future Intelligent Vehicles and Transportation Systems**, **IEEE Transactions on Intelligent Transportation Systems**, vol. 16, no. 1, pp. 244–263, 2015.

- Bosetti, P., Da Lio, M., Saroldi, A. **On Curve Negotiation: From Driver Support to Automation**, (2015) **IEEE Transactions on Intelligent Transportation Systems**, 16 (4), art. no. 7045558, pp. 2082-2093.

- Da Lio, M. Biral, F., Bosetti, P., Mazzalai, A., Gurney, K., Saroldi, A., **Understanding and Modeling the Stop Behavior of Human Car Drivers**, (2016) **IEEE Transactions on Intelligent Transportation Systems**, submitted.

Co-funded by
the European Union

Adapt/:/Ve

Automated Driving Applications and
Technologies for Intelligent Vehicles

Thank you.

Mauro Da Lio
Università degli Studi di Trento
mauro.dalio@unitn.it