

# A psychophysiology-based driver model for the design of driving assistance systems

**Franck MARS**

PsyCoTec team

**Philippe CHEVREL**

Control team

Institut de Recherche en Communications  
et Cybernétique de Nantes

*Neuroergonomics 2016  
Paris, October 6<sup>th</sup>, 2016*

# The problem

## Lane departure crashes may be due to several causes:

- steering errors
- driver distraction

## Countermeasures: advanced driving assistance systems (ADAS)

- lane departure warning systems
- lane keeping systems
- driver state monitoring

## For all types of ADAS:

- a key problem: to predict the driver behaviour
- our approach: to incorporate a driver model in the design process

**Step 1:**  
**Building a visuomotor model  
of steering control**

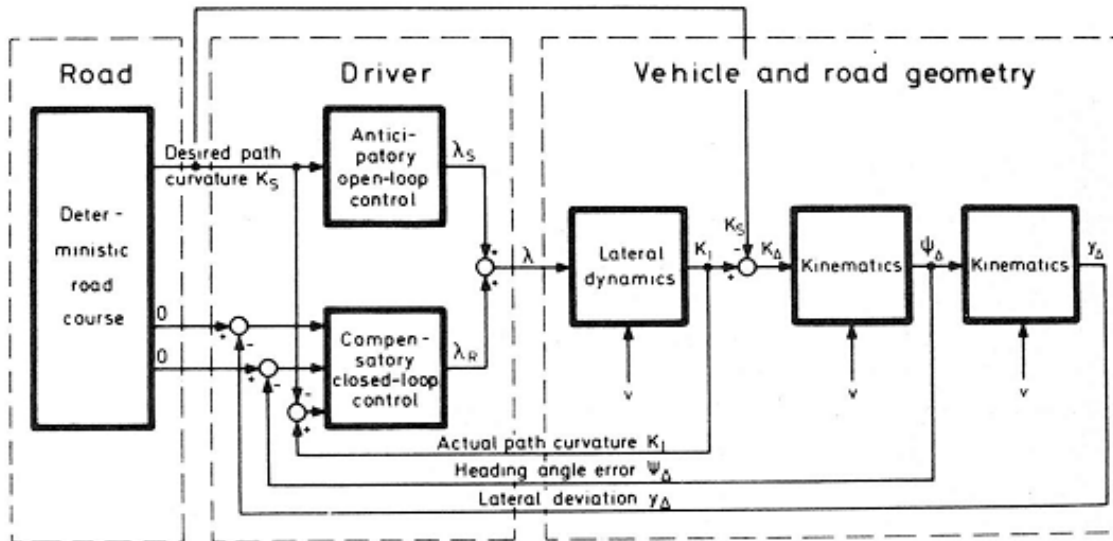
# What we need

## A model of steering control

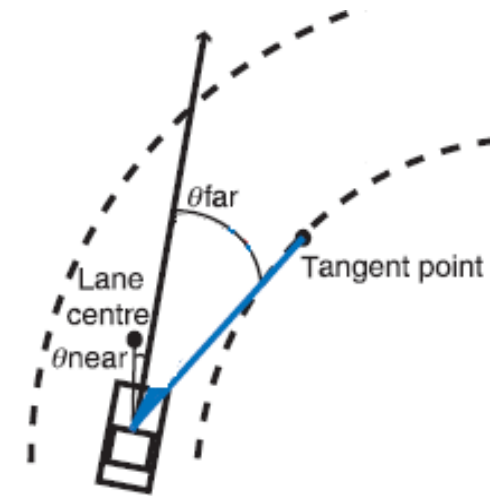


- A model that processes information from the visual scene
- A motor system that converts steering intention into actions

# Two-levels visual control of steering



*Donges (1978), Human Factors*



*Salvucci & Gray (2004), Perception*

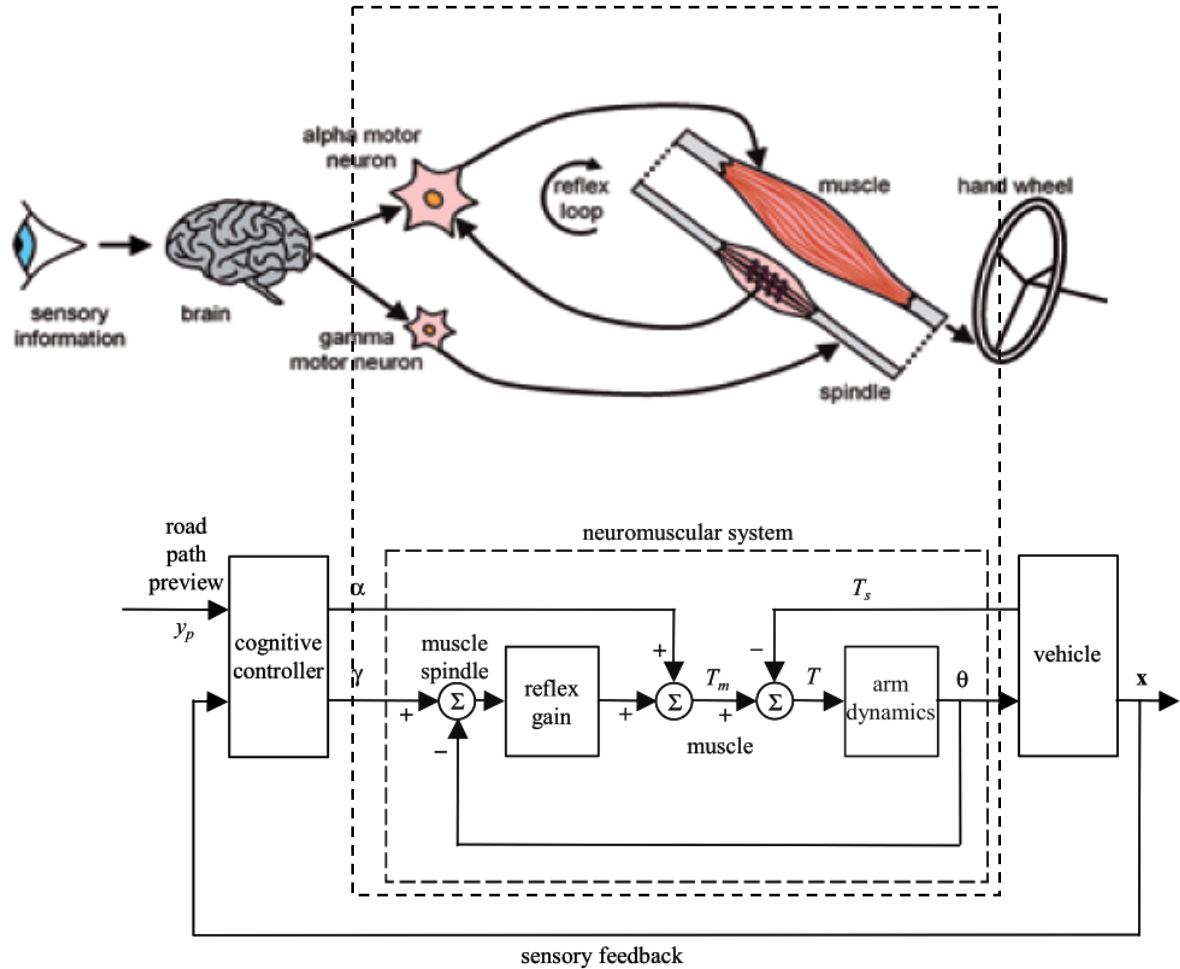
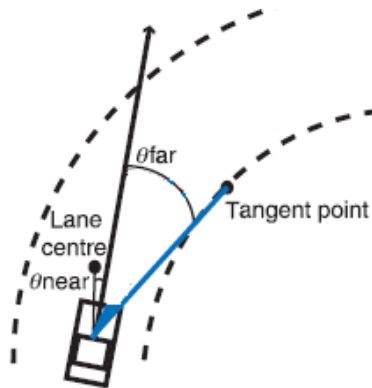
## Anticipatory control

- anticipation of changes in road curvature
- fed by far visual information:  $\theta_{far}$  (tangent point)

## Compensatory control

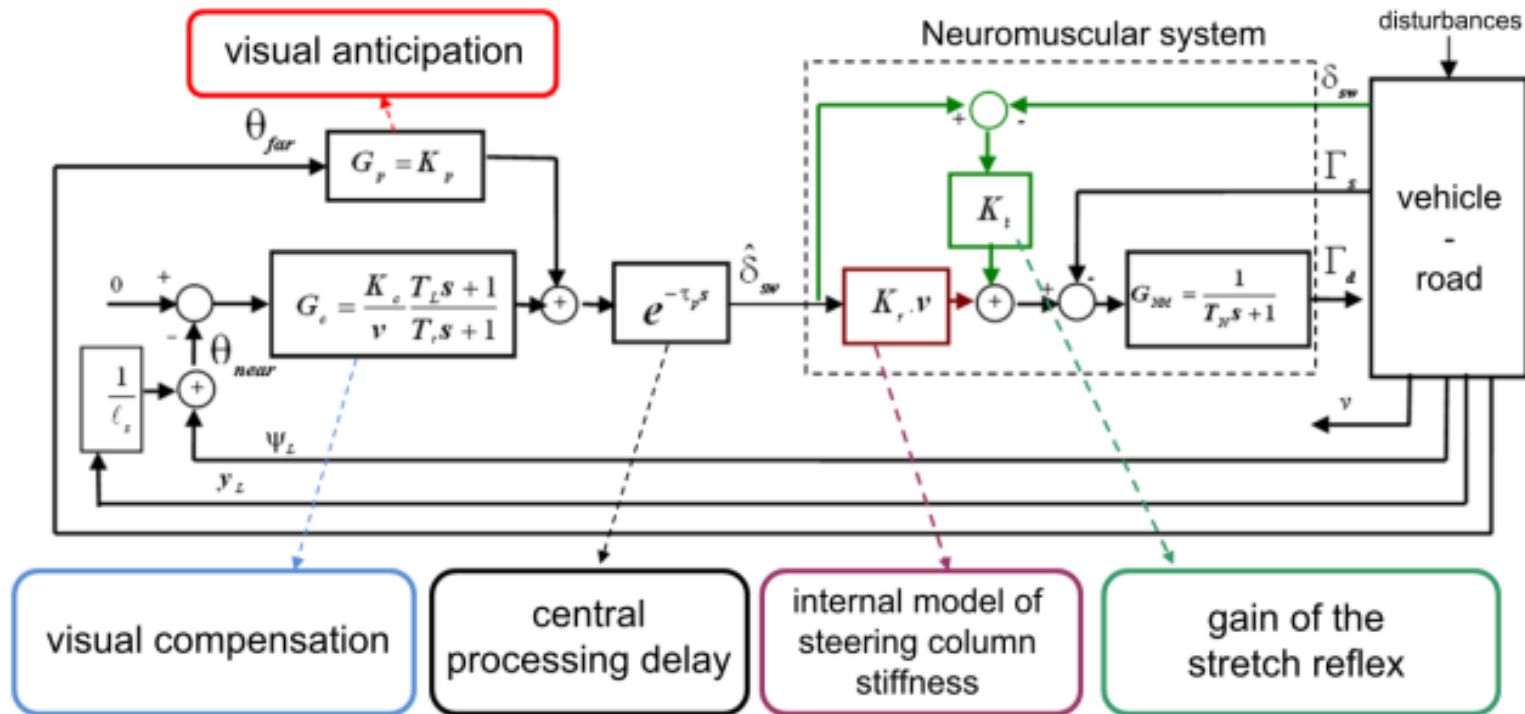
- on-line correction of lateral position errors
- fed by near visual information:  $\theta_{near}$  (lane center)

# Adding a motor system



*Hoult & Cole (2008), Vehicle Systems Dynamics*

# Our driver model



Saleh et al. (2011) IFAC World ; Mars et al (2011), HFES

## A cybernetic model:

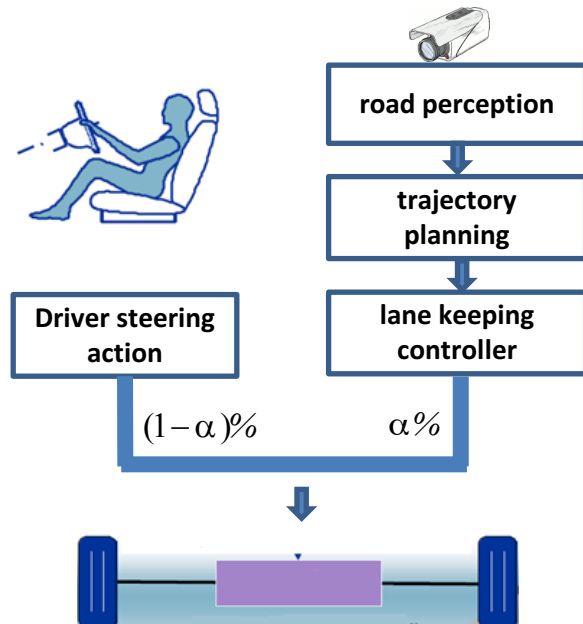
- designed as a function of current knowledge on perceptual and motor processes
- that can be identified in various driving situations

## Step 2:

# Application to haptic shared control

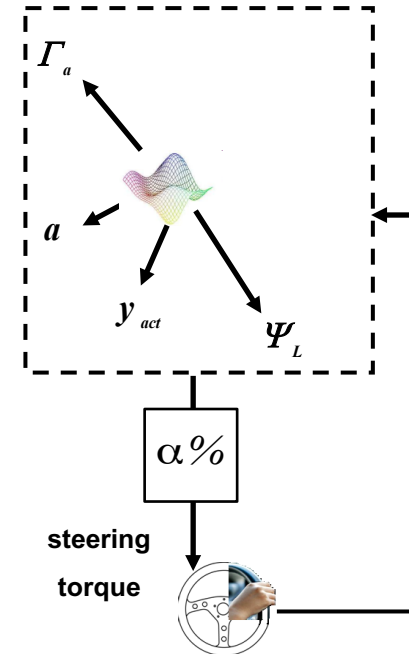


# Shared control without a driver model



## Haptic shared control:

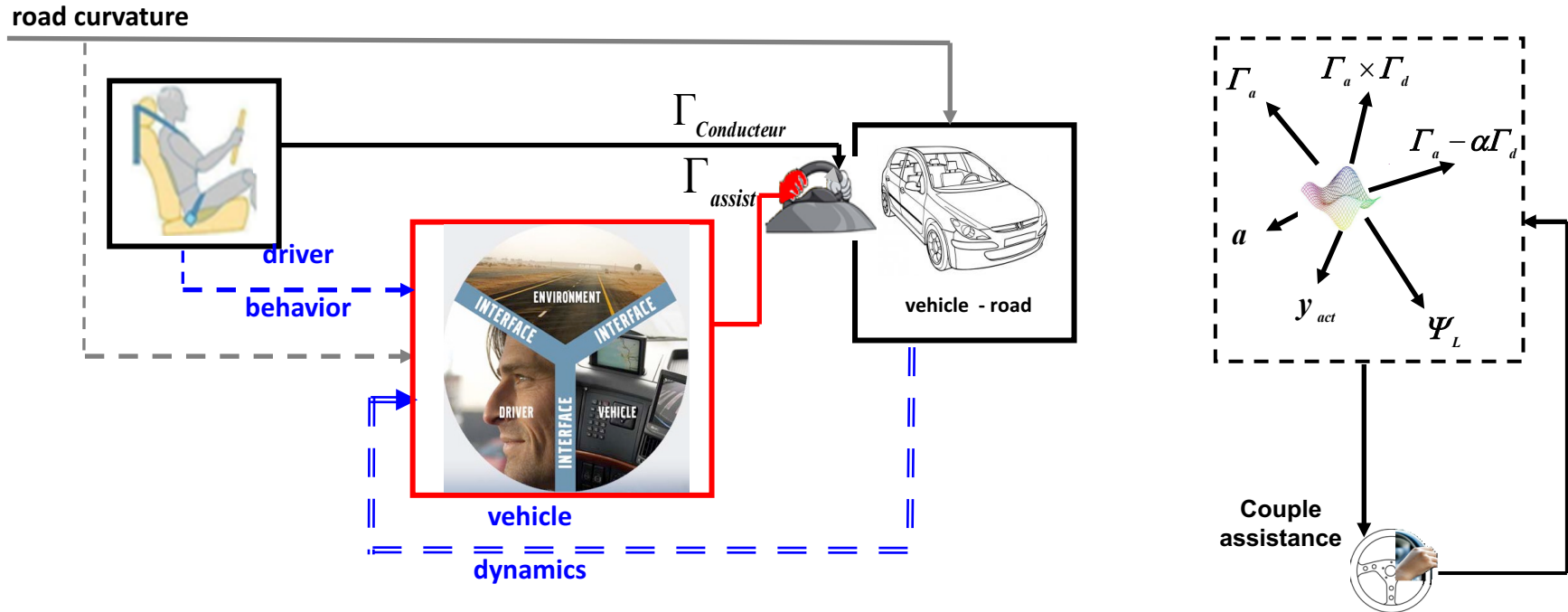
continuous and simultaneous action of the driver and an automaton on the steering wheel



## Without a driver model:

- the controller optimizes performance and safety criteria
- no prediction of the driver behavior

# Shared control with a driver model



**With a driver model, the control law also optimizes cooperation criteria**

- shared control is smoother
- improved agreement between the driver and the automation

## Step 3:

# Application to distraction state estimation

# A steering model for distraction



## Different types of distraction influence steering in different ways

- cognitive distraction
- visual distraction
- motor distraction
- visuomotor distraction

## Can a visuomotor model help detect and discriminate distraction episodes?

### Discriminating distraction types by means of on-line parameter identification

- the visual anticipation gain decreases only for high visual distraction
- motor distraction influences neuromuscular dynamics only
- visual distraction propagates to the motor system parameters

# Want more details?

## When the driver model drives



### Contact information

[franck.mars@irccyn.ec-nantes.fr](mailto:franck.mars@irccyn.ec-nantes.fr)

## Presentation of the model

- Mars, F., Saleh, L., Chevrel, P., Claveau, F., & Lafay, J.F. (2011). Modeling the visual and motor control of steering with an eye to shared-control automation. *Proceedings of the Human Factors and Ergonomics Society 55th Annual Meeting*, pp. 1422-1426
- Saleh, L., Chevrel, P., Mars, F., Lafay, J.F., & Claveau, F. (2011). Human-like cybernetic driver model for lane keeping. *Proceedings of the 18th IFAC World Congress*, pp. 4368-4373

## Application to haptic shared control

- Saleh, L., Chevrel, P., Claveau, F., Lafay, J.F. & Mars, F. (2013). Shared steering control between a driver and an automation: Stability in presence of driver model uncertainty. *IEEE Transactions on Intelligent Transportation Systems*, 14(2), 974-983

## Application to driver distraction

- Ameyoe, A., Chevrel, P., Le Carpentier, E., Mars, F. & Illy, H. (2015). Identification of a Linear Parameter Varying Driver Model for the Detection of Distraction. *IFAC-PapersOnLine*, 48(26), pp. 37-42
- Ameyoe, A., Mars, F., Chevrel, P., Le Carpentier, E. & Illy, H. (2015). Estimation of driver distraction using the prediction error of a cybernetic driver model. *Proceedings of the Driving Simulation Conference Europe 2015*, pp. 13-18