

# BiHSP 2003/2004

Automatische Längs und Querverführung von Fahrzeugen mit Hilfe Künstlicher Neuronaler Netze

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## Project timetable:

2003-2004/ Sep-Oct, Sarajevo

Theoretical research :

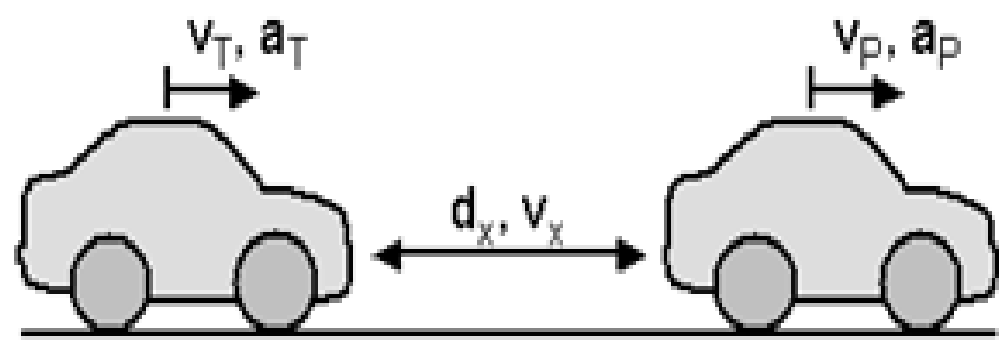
- Field: Artificial Intelligence
- Field: Control Engineering

Practical implementation :

- MATLAB- SIMULINK
- Neural Network Toolbox
- Fuzzy Logic Toolbox
- Genetic Algorithms Toolbox

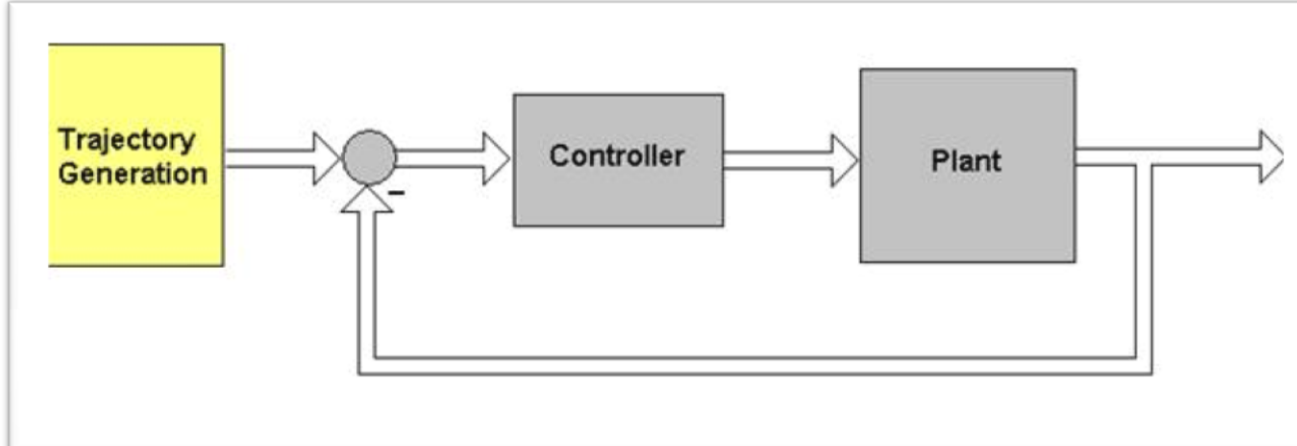
## Project description

This project presents capabilities of fuzzy logic in longitudinal vehicle guidance. Two aspects in automated driving are presented. The first is trajectory generation for longitudinal vehicle guidance, where the real driver is replaced by fuzzy inference system. The second aspect is design of fuzzy controller which can be implemented for leading ideal trajectory in longitudinal direction. Design of fuzzy system is realized in MATLAB environment where the vehicle dynamic is known. This dynamic is result of identification methods realized on the Institute of Automatic Control at the University of Erlangen-Nürnberg. Experimental results for the longitudinal vehicle guidance have been obtained by use of the Audi test vehicle equipped with sensors and control devices.



This means that in trajectory generation must be „embedded“ knowledge and experience of a driver. This system is implemented using fuzzy logic. Figure represents control scheme for tracking control.

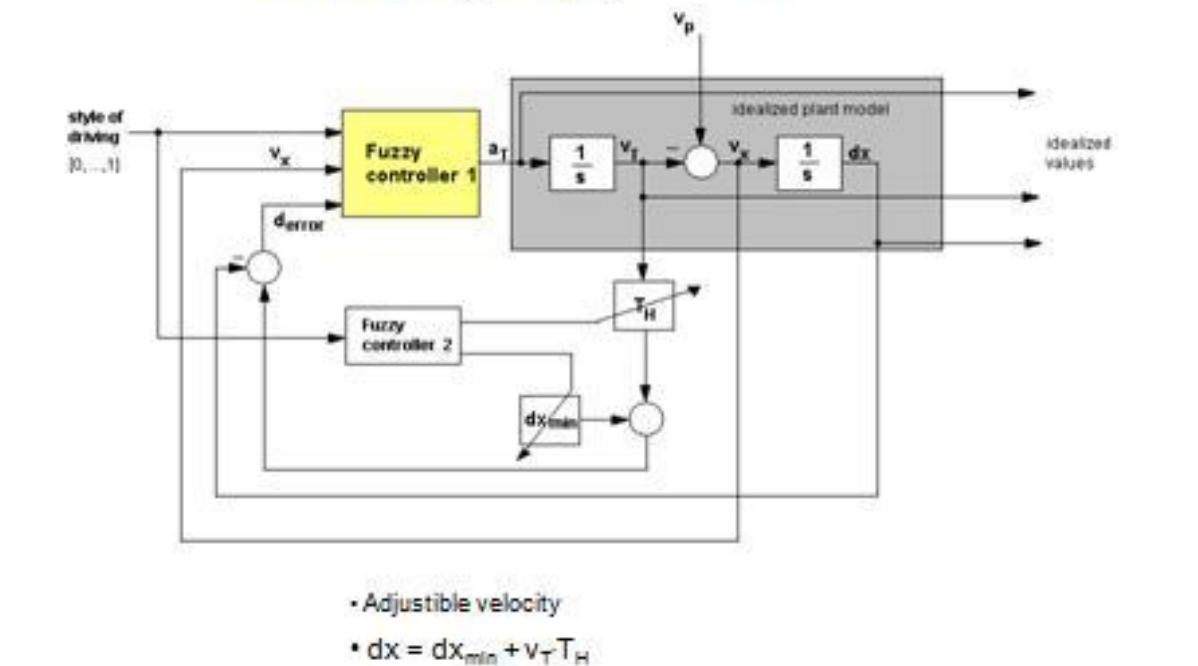
The tracking controller based on fuzzy logic (fuzzy controller) is designed to keep movement of the tracking vehicle closely as possible to generated ideal trajectory.



The block diagram of a model for the vehicle longitudinal dynamics and the relative movement in relation to a preceding vehicle is shown on Figure. A desired engine torque  $T_{ed}$  and a desired brake torque  $T_{bd}$  are adjusted with a certain time delay and with first order dynamics. The resulting torque  $T_w$  at the wheels depends on the transmission ratio of the engine torque and the brake torque. Depending on the dynamics wheel radius  $r_{dyn}$  this causes the wheel force  $F_w$ . Dividing the difference of  $F_w$  and the resistance forces by mass  $m$  of the vehicle gives acceleration  $a_t$ . The velocity  $v_t$  is obtained from  $a_t$  by integration. The relative velocity  $v_x$  is the difference between the preceding vehicle's velocity  $v_p$  and the velocity  $v_t$  of the tracking vehicle. The distance between both vehicles is then obtained by integration.

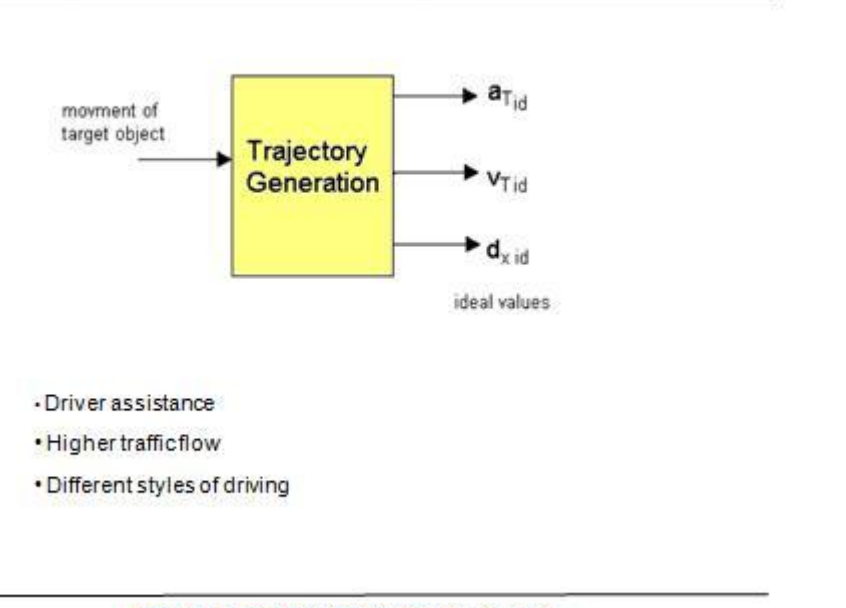
### Longitudinal Vehicle Guidance Using Fuzzy Logic

#### Model of trajectory generation



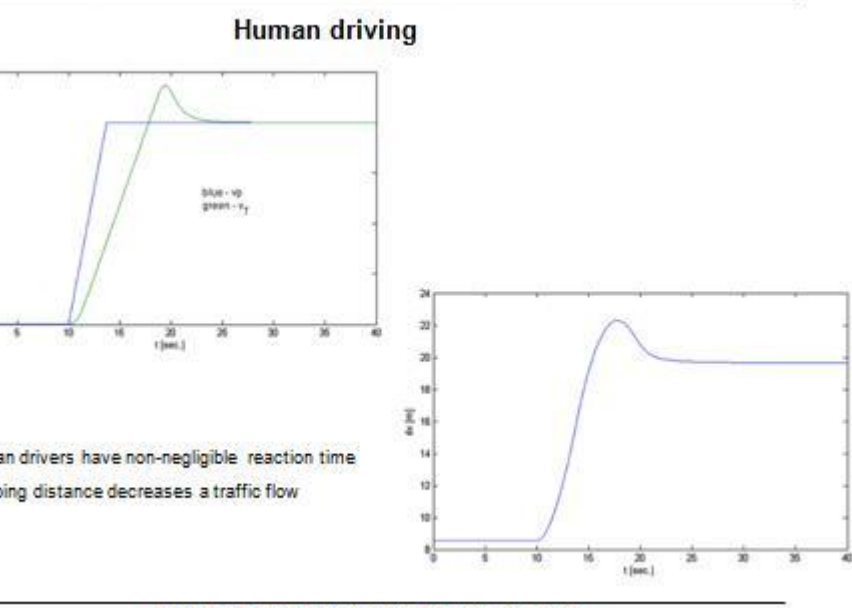
Adjustable velocity  
 $dx = dx_{min} + v_T \cdot T_{ed}$

### Longitudinal Vehicle Guidance Using Fuzzy Logic



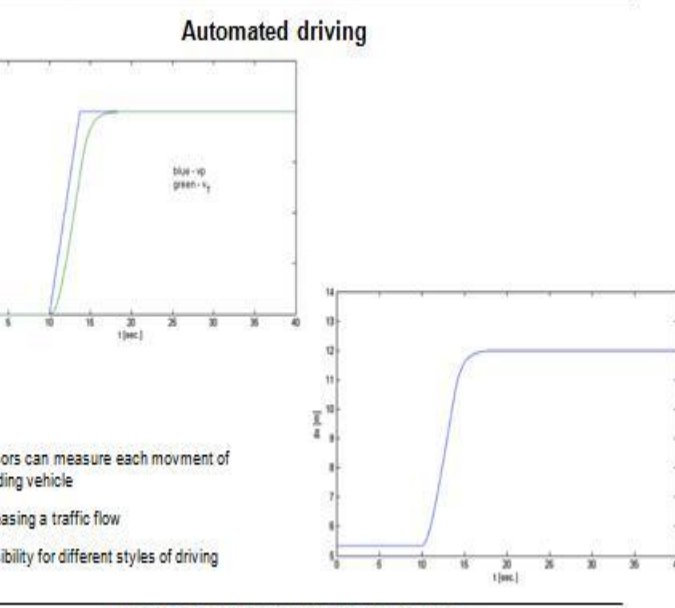
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### Longitudinal Vehicle Guidance Using Fuzzy Logic



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### Longitudinal Vehicle Guidance Using Fuzzy Logic

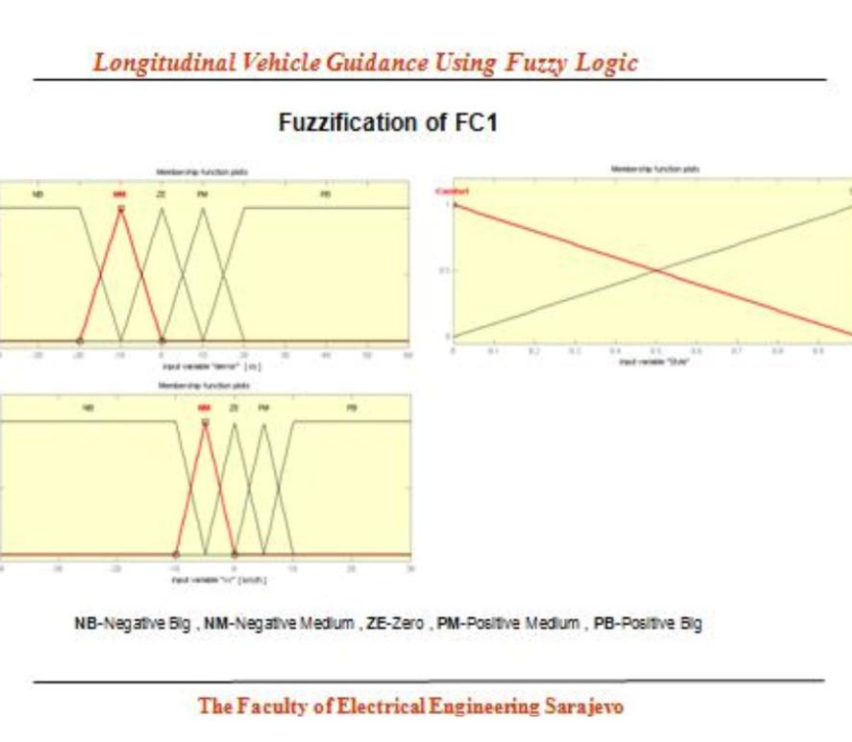


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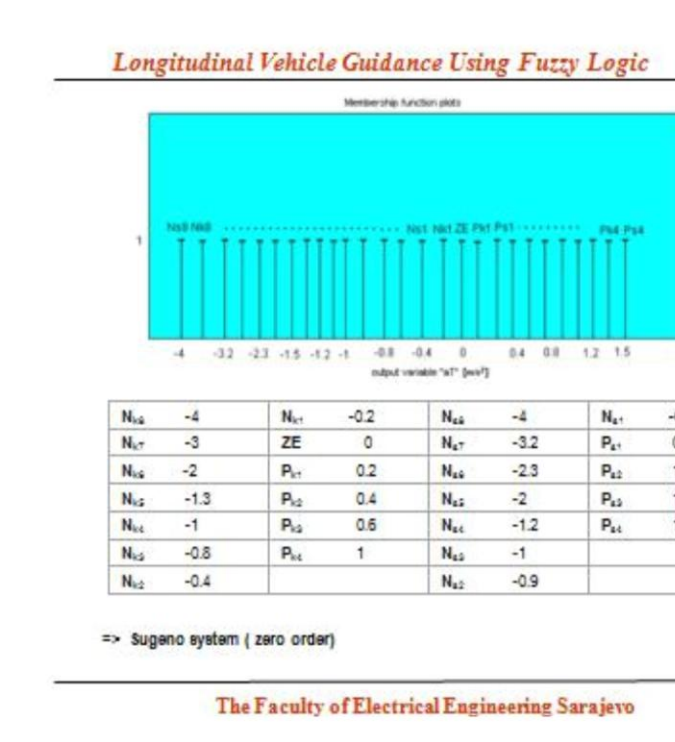
Style	$a_{max}$	$T_{ed}$	$d_{x_{min}}$
Comfortable driving: Style=0	$1.5 \text{ m/s}^2$	2 s	4 m
Sportive driving: Style=1	$1.5 \text{ m/s}^2$	2 s	3 m

Maximum deceleration  $a_{min} = -4 \text{ m/s}^2$

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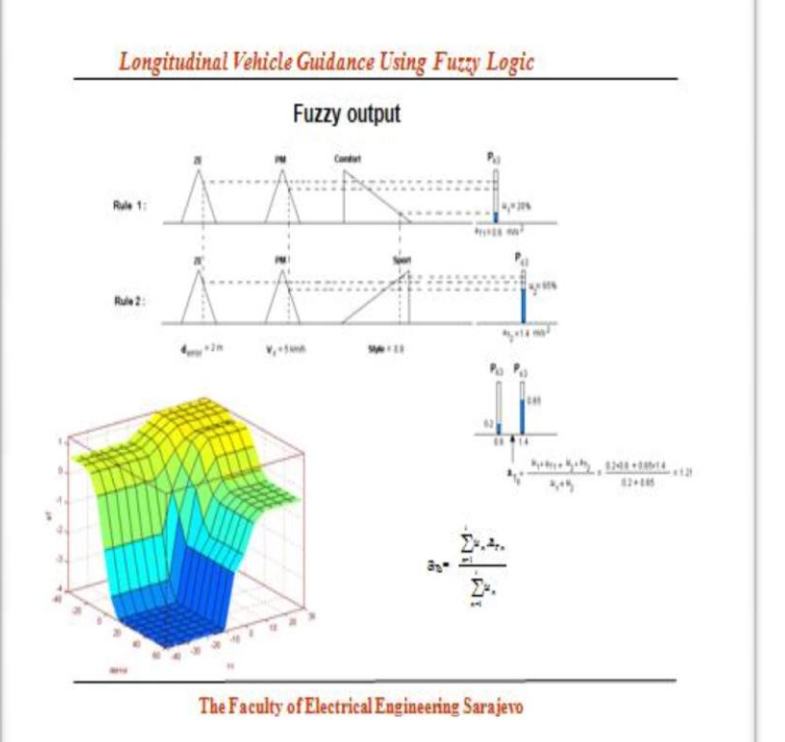
Fuzzy inference system

Rule 1: If (dew is ZE) and (v is PM) and (Style is Comfort) then (a is PB)

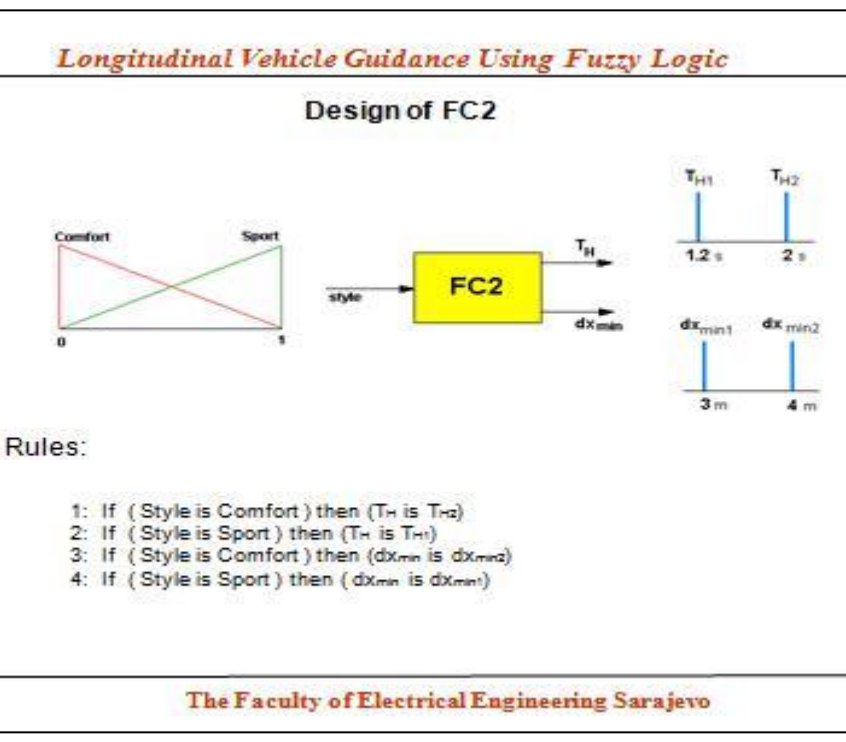
Rule 2: If (dew is ZE) and (v is PM) and (Style is Sport) then (a is PB)

Condition	ZE	PM	ZE	PM
Style	0.0	0.0	0.0	0.0
v	0.0	0.0	0.0	0.0
dew	0.0	0.0	0.0	0.0

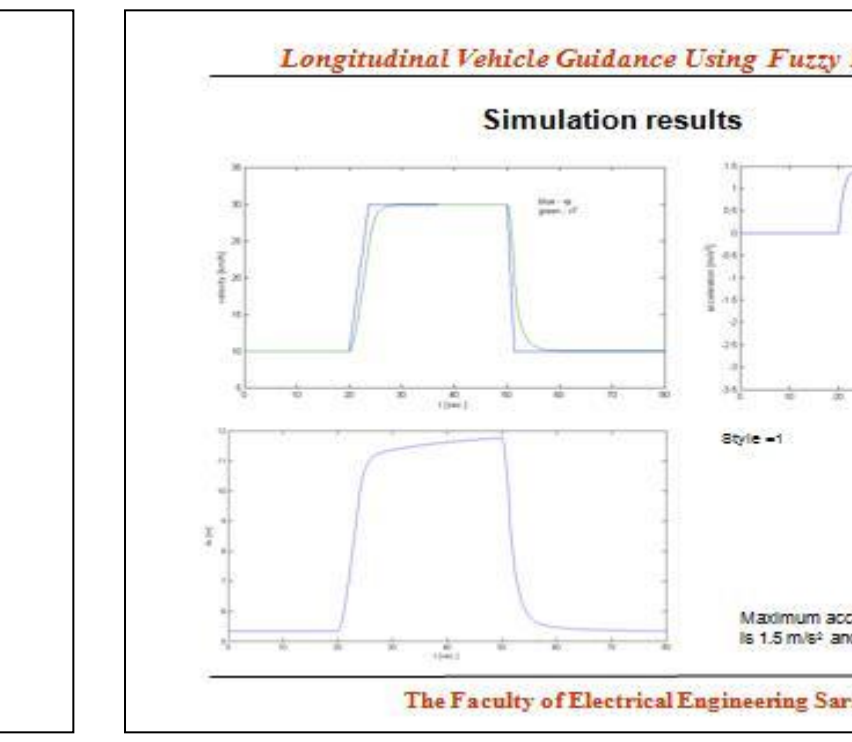
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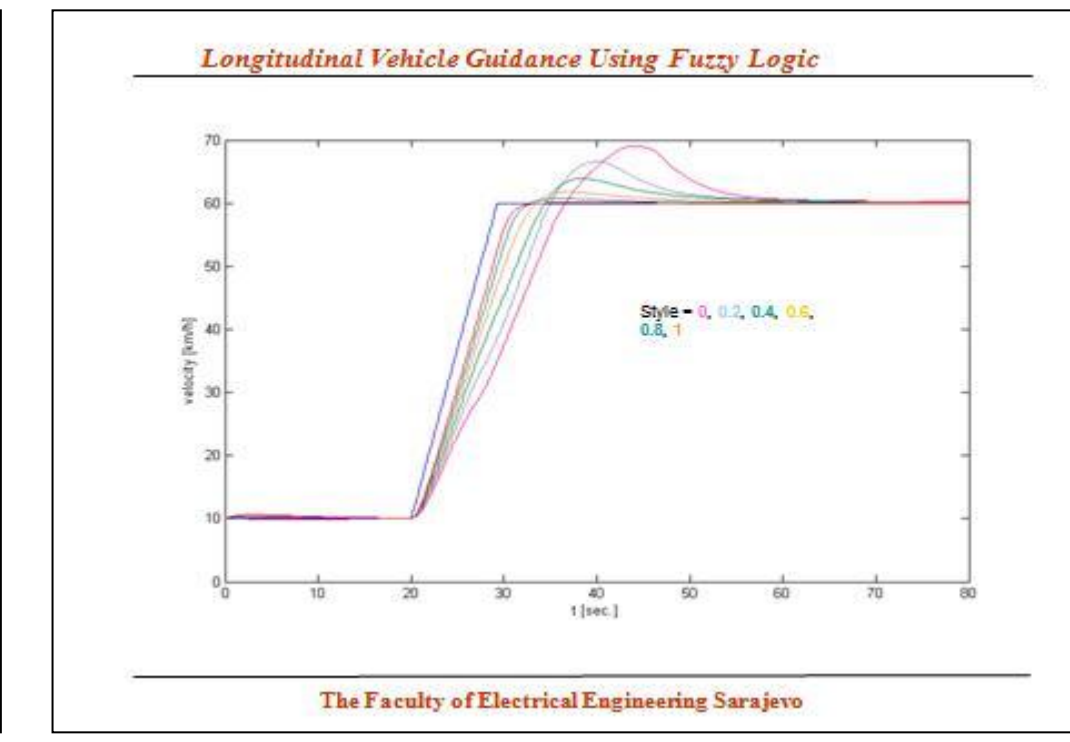
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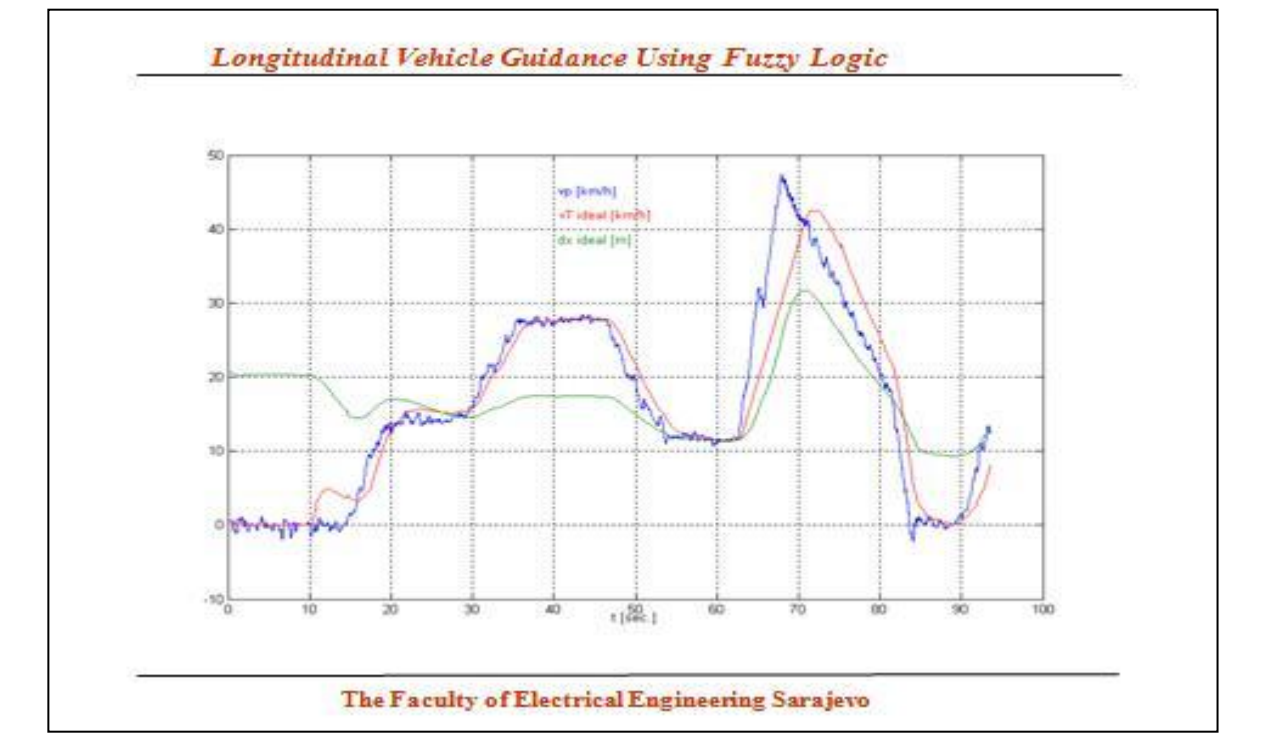
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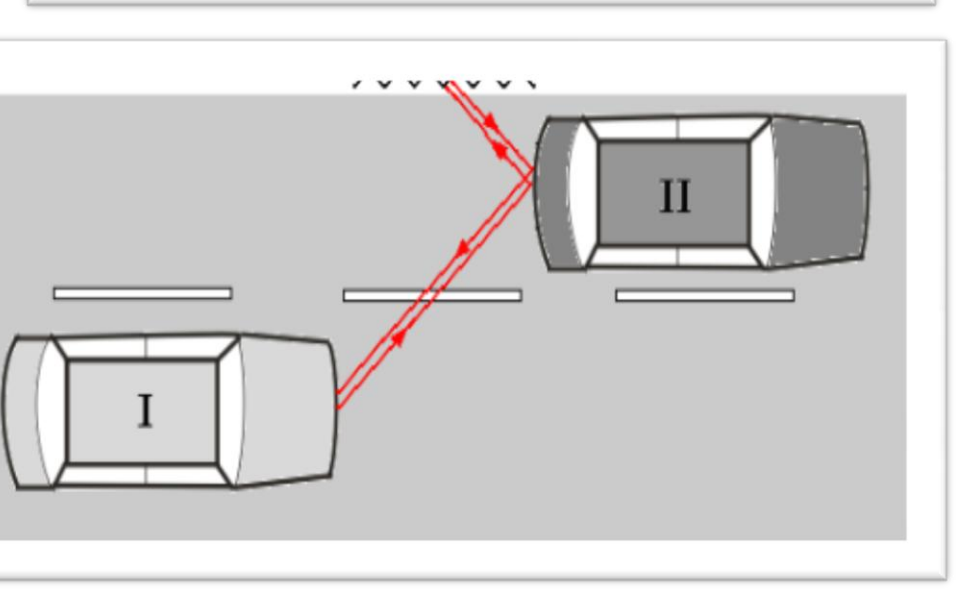
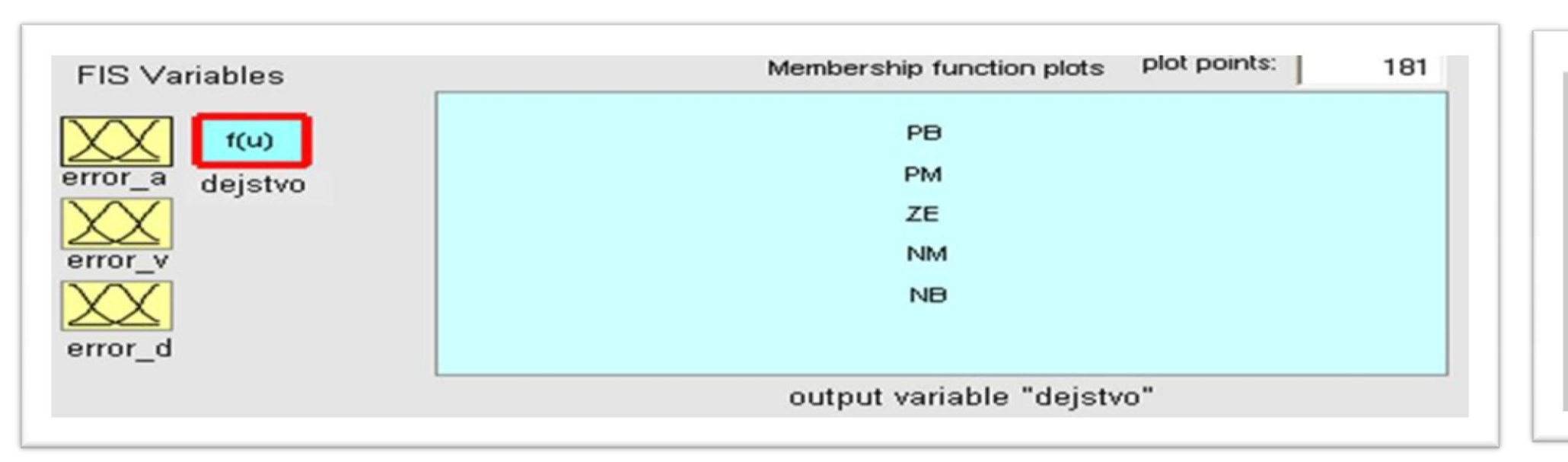
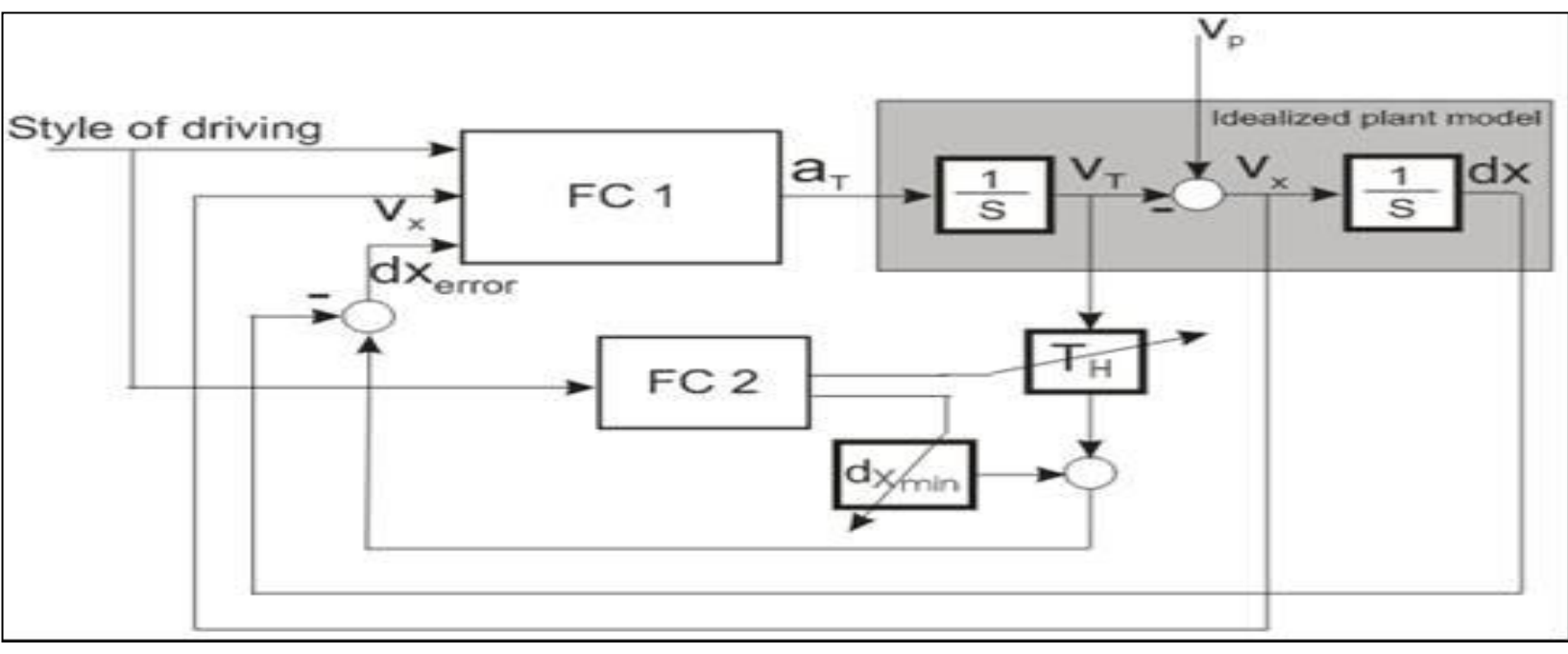
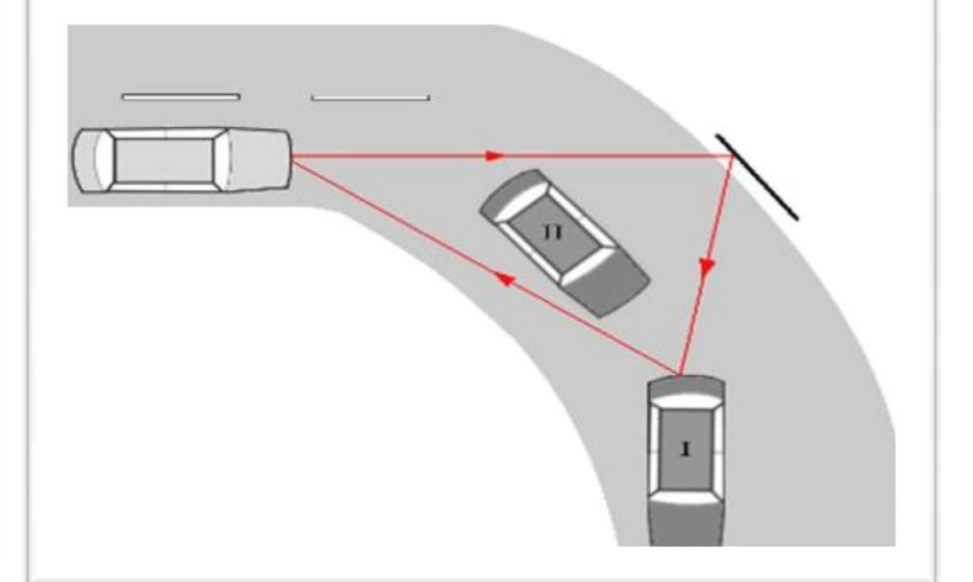
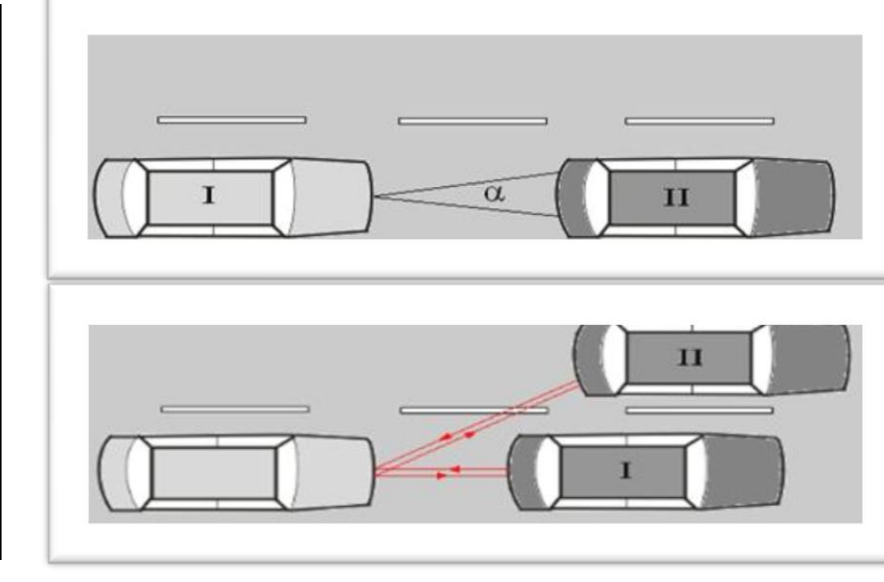
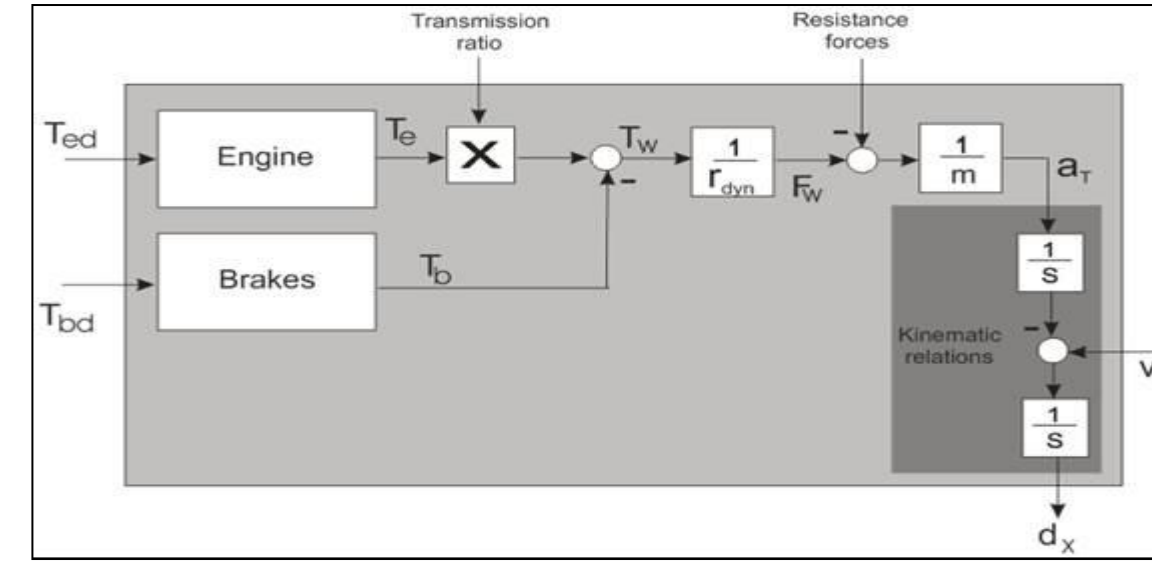


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The longitudinal vehicle guidance is based on idea of tracking control. The goal of tracking control is attempt to keep desired distance to the preceding vehicle and also leading desired velocity and acceleration. The distance  $d_x$  as well as velocity  $v_p$  and acceleration  $a_p$  are measured by radar sensor. Therefore, in a vehicle must exist a system which can give desired movement of the tracking vehicle based on behavior of the preceding vehicle (velocity  $v_p$ ). This system of trajectory generation ( $a_{Tid}$ ,  $v_{Tid}$ ,  $d_{x_{id}}$ ) needs to represent driver decision in all specific situations.



The trajectory generation is based on idealized model of the plant. This is represented by kinematic relations marked in Figure. This idealized model of longitudinal movement is independent of specific properties of the vehicle such as e.g. the time behavior of the engine or of the brakes. This approach gives a possibilities for developing system for trajectory generation only once and may then be applied to different vehicles. The tracking controller then has to be adapted to each vehicle with respect to certain dynamics.

