Fuzzy logic based decision-making for urban platooning on urban roundabout scenarios

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Framework and motivation

- The work is framed in a bigger use case where a human driven vehicle is supposed to pick and relocate Autonomous vehicles in an urban environment.

- Urban environments have several conflicto points. One being the roundabouts.

- Asumptions:
  - Follower vehicles have no problems with positioning.
  - There is no communication delay nor error.
  - Information from other vehicles is received from communication without error.

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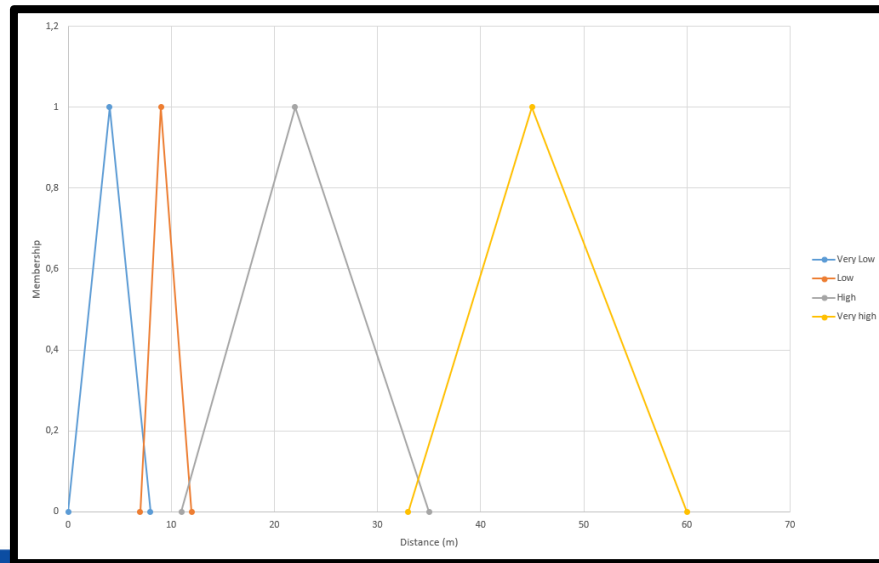# Algorithm description: Decision

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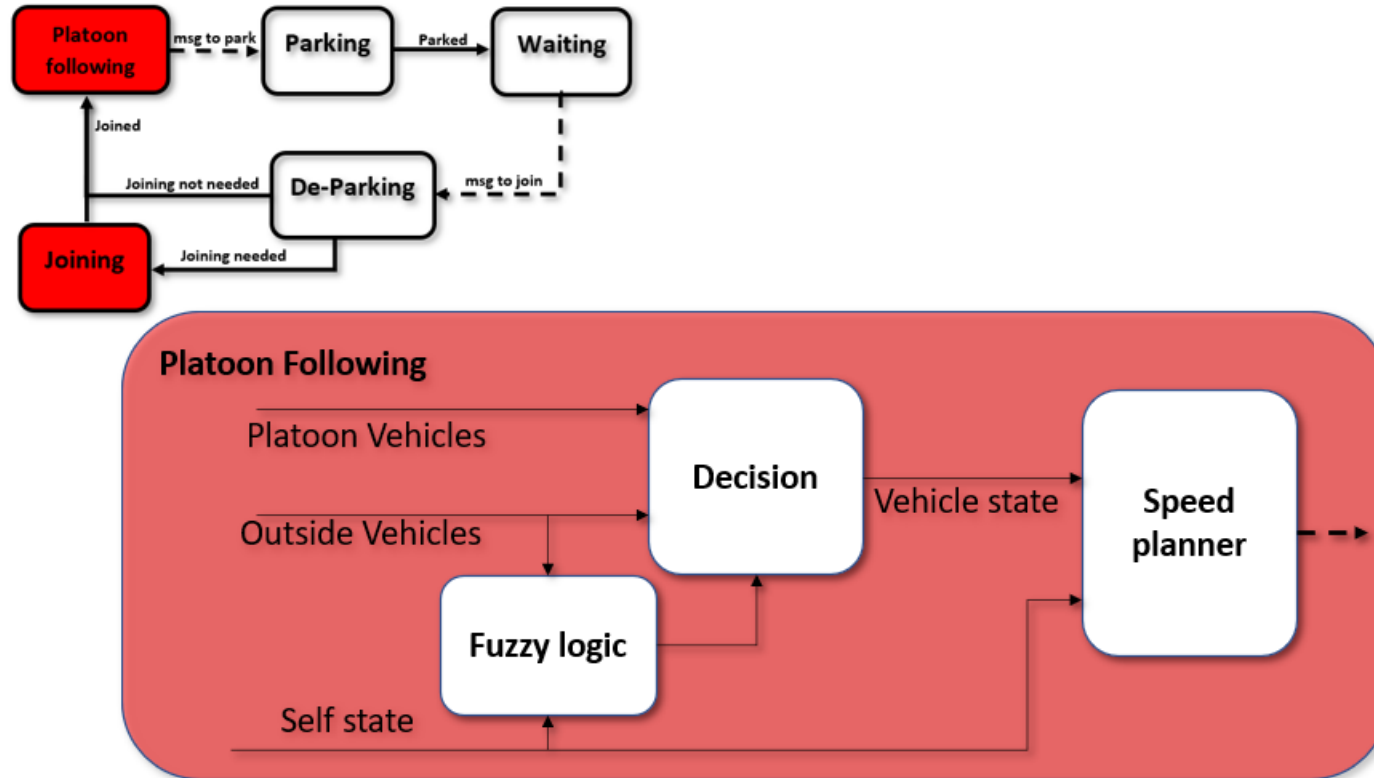
Algorithm description: Decision

Distance	Begin	Top	End
VC	0	4	8
C	7	9	13
FA	13	22	35
VFA	33	100	200

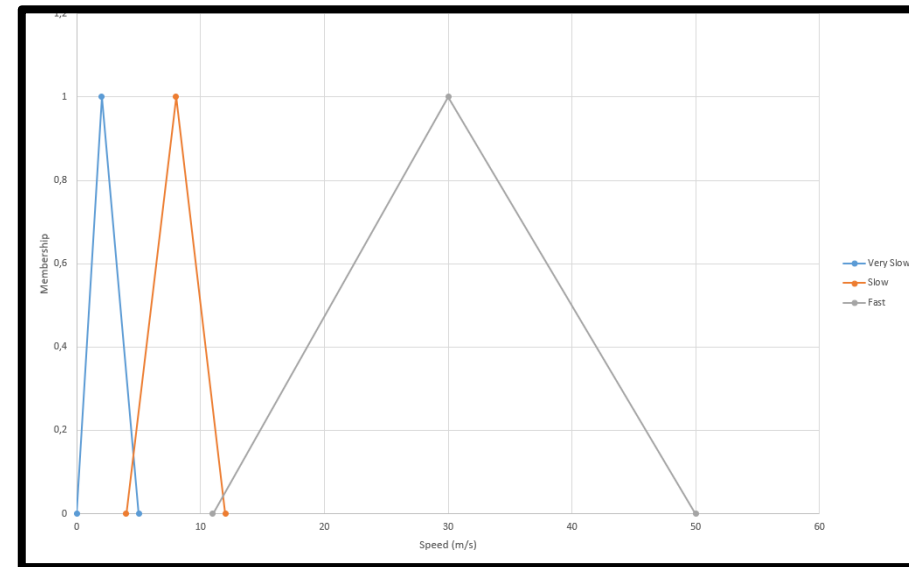| Speed	Begin	Top	End
L	0	2	5
M	4	8	12
H	11	30	50

Triangular membership functions: computationally less expensive than other alternatives:

- **Distance** (m):
  - VC (Very Close), C (Close), FA (Far Away), VFA (Very Far Away)
- **Speed** (m/s):
  - L (Low), M (Medium), H (High)

Distance Membership functions

Speed Membership functions

Algorithm description: Decision

Distance	VC		
Oposed / Controlled	S	M	F
S	FOV	FOV	FOV
M	FOV	FOV	FOV
F	FOV	FOV	FOV

Distance	C		
Oposed / Controlled	S	M	F
S	FOV	FOV	SIP
M	FOV	FOV	SIP
F	SIP	SIP	SIP

Distance	FA		
Oposed / Controlled	S	M	F
S	SIP	SIP	SIP
M	SIP	SIP	SIP
F	SIP	SIP	SIP

Distance	VFA		
Oposed / Controlled	S	M	F
S	SIP	SIP	SIP
M	SIP	SIP	SIP
F	SIP	SIP	SIP

Fuzzy rules

FOV: Follow Other Vehicle

SIP: Stay In Platoon

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Algorithm description: Control

For the platoon control we have used an MPC based controller for the speed planning and a PID for the speed following:

$$\dot{x}_{rleader} = v_{leader} - v$$
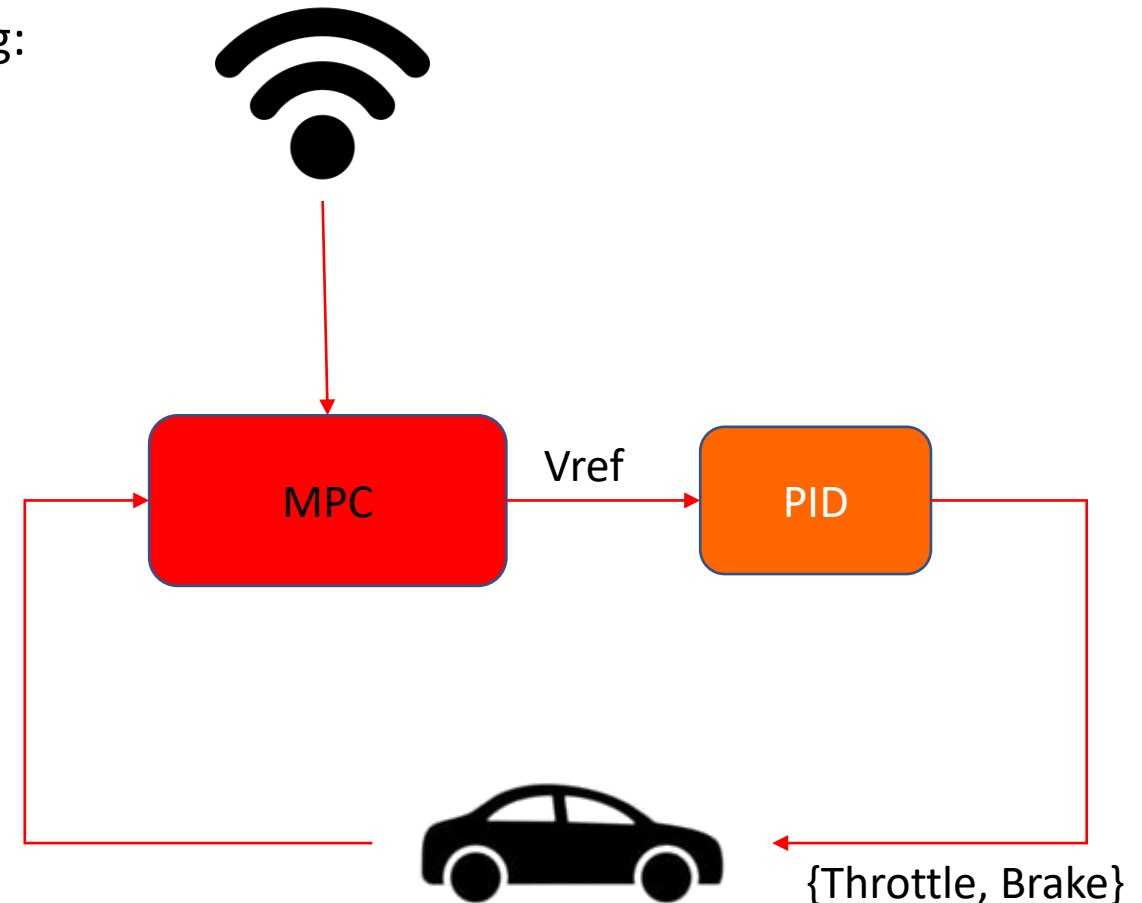$$\dot{x}_{rfront} = v_{front} - v$$
$$v^{+} minJ(x_{rleader}, x_{rfront}, v)$$
$$s.t$$
$$v \in (0, v_{max})$$
$$x_{rleader} > x_{rleadermin}$$
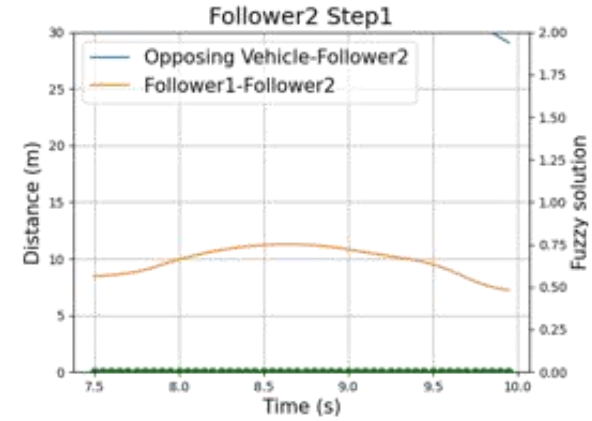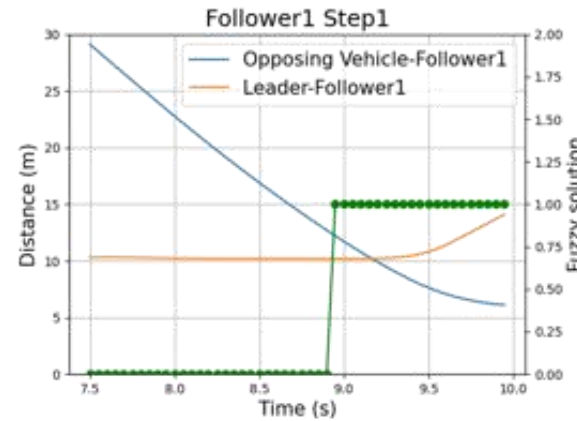$$x_{rfront} > x_{rfrontmin}$$

MPC

Vref

PID

{Throttle, Brake}

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Simulation results

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Simulation results

- **Step1**: The platoon arrives to the roundabout and it splits between the leader and the first follower.

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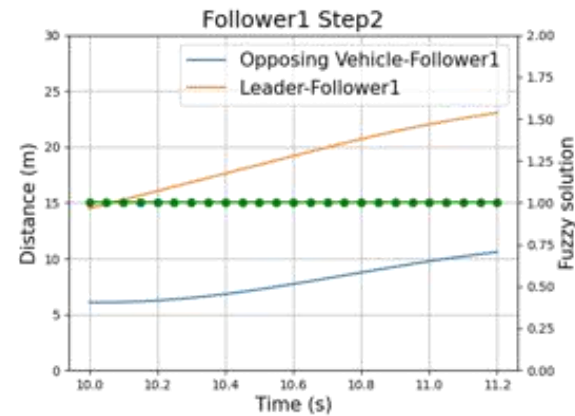
Simulation results

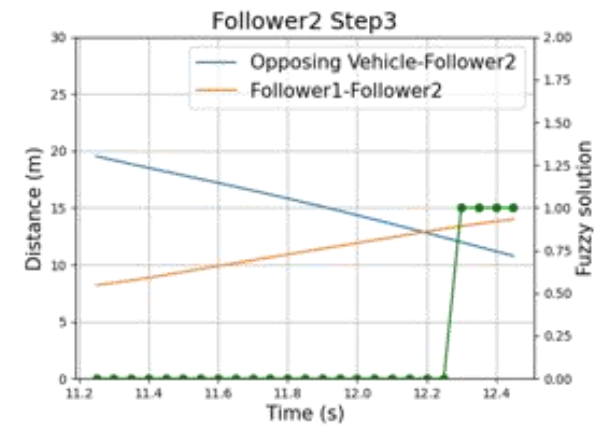- **Step2**: The Follower1 follows the vehicle inside the roundabout.

Step 2

Follower1 Step2
— Opposing Vehicle-Follower1
— Leader-Follower1

Follower2 Step2
— Opposing Vehicle-Follower2
— Follower1-Follower2

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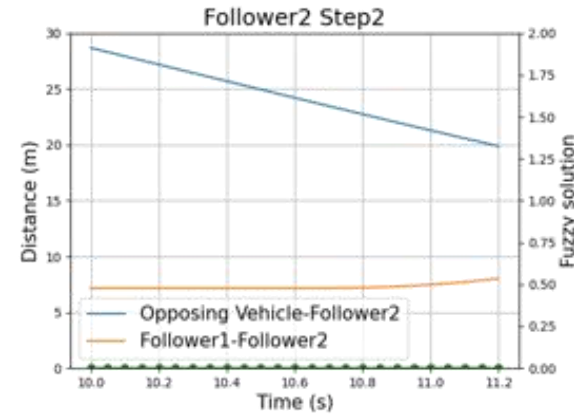
Simulation results

- **Step3**: The platoon is split between the two followers.
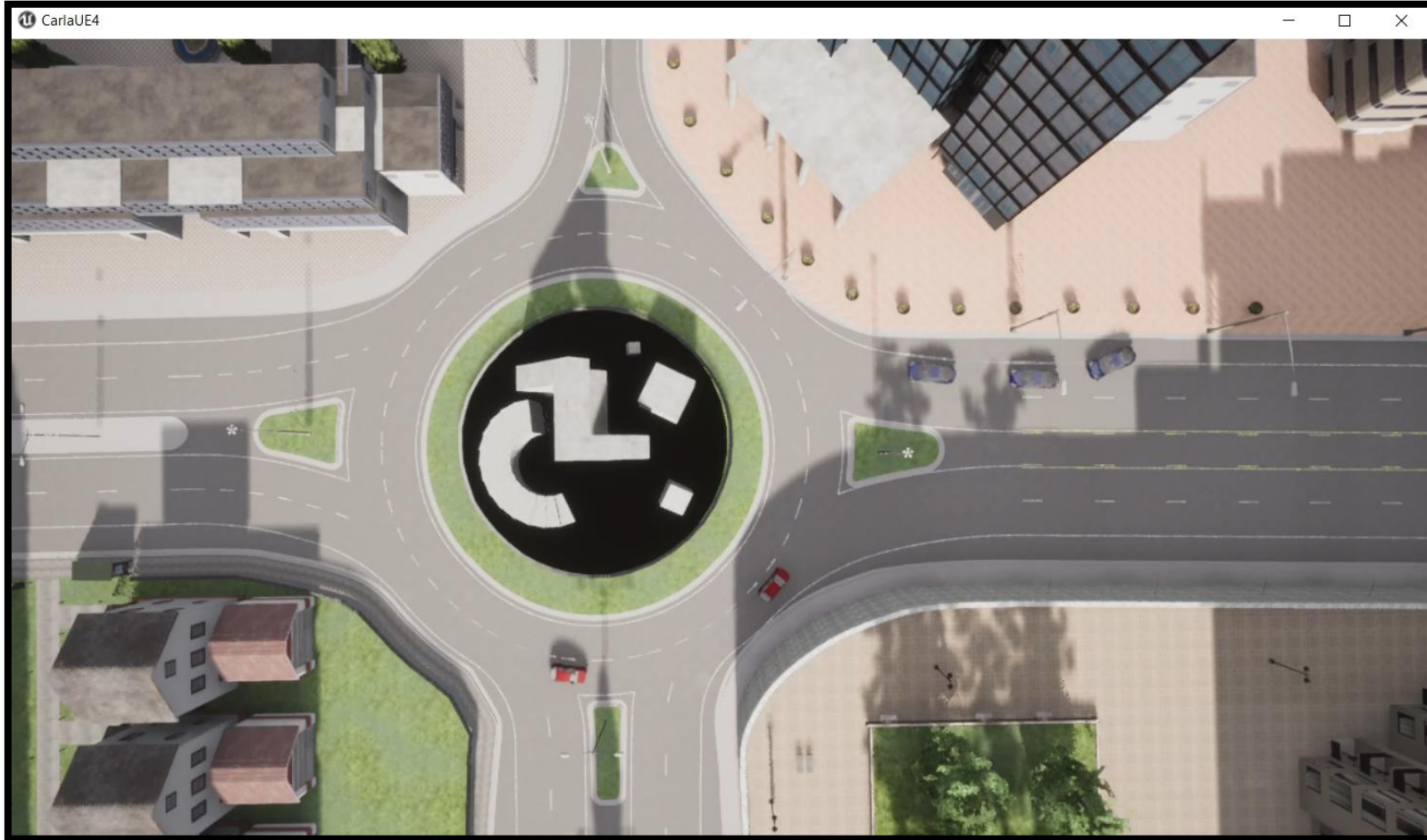
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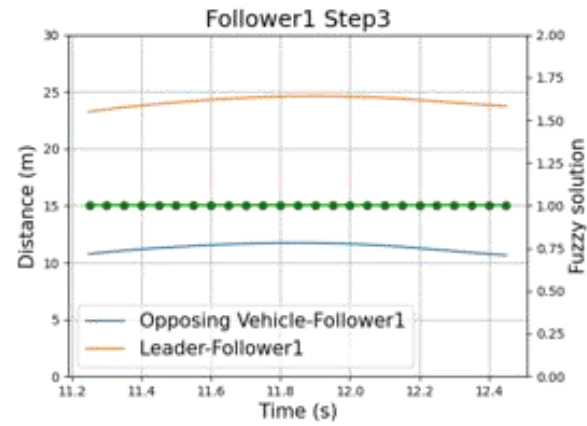
Simulation results

- **Step4**: The follower2 follows the second vehicle inside the roundabout. Both vehicles get off the roundabout and catch up to the leader.
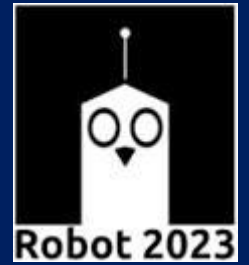
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Simulation results

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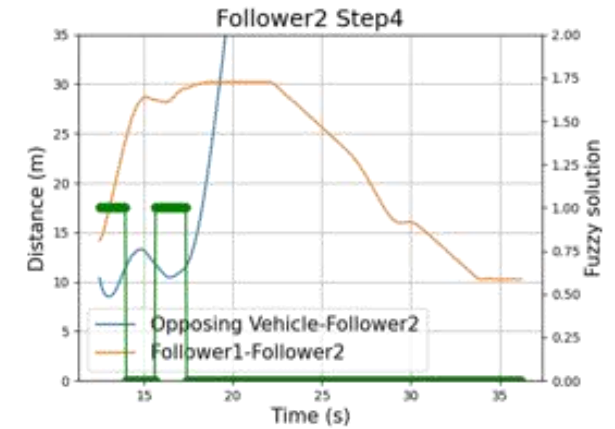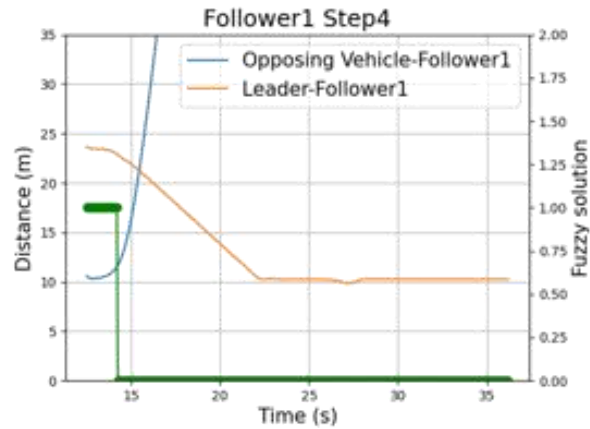
Future work

- Comparison with other solutions.

- Use of motion prediction algorithms for smoother behaviour.

- Integration of a more complex Speed planner.

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Any questions?

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Thank you for your attention!

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