

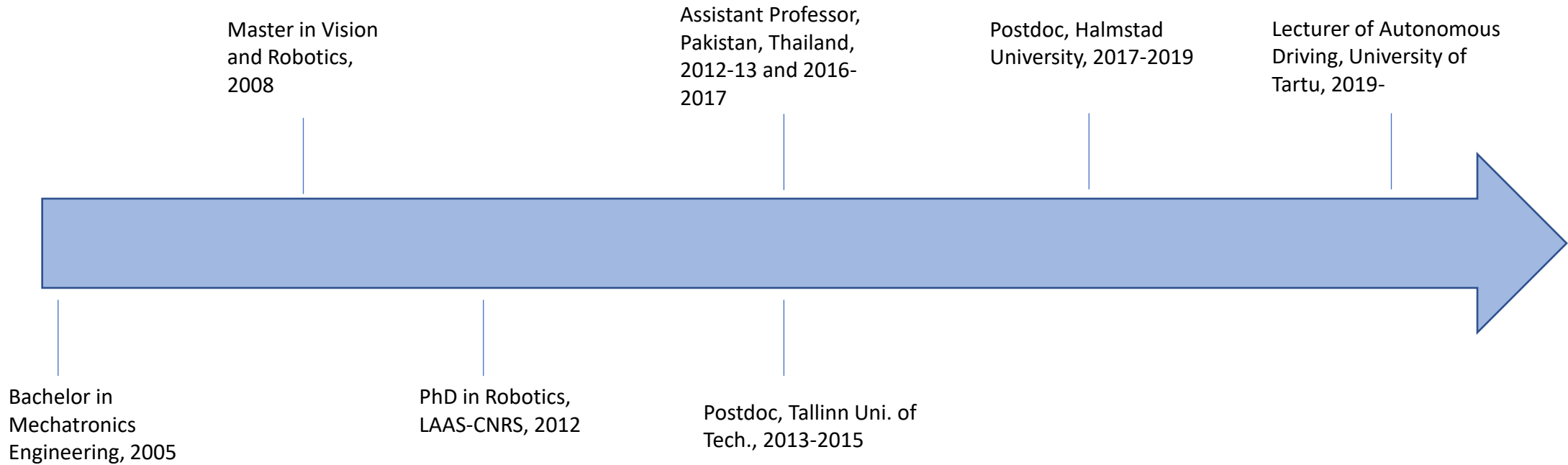
# Autonomous driving

## Behaviour modeling and motion prediction

Naveed Muhammad,  
Lecturer of Autonomous Driving,  
Institute of Computer Science



# A bit about myself



# Autonomous Driving

- The ability of a vehicle to operate without the intervention of a human operator



Autonomous Driving Lab,  
<https://www.cs.ut.ee/en/autonomous-driving-lab>

# Autonomous Driving

- The ability of a vehicle to operate without the intervention of a human operator
- Why bother?
  - Safer roads – reduction in accidents caused by human error
  - Mobility for all
  - Ease and comfort
  - Freeing up time
  - More efficient transportation



Autonomous Driving Lab,  
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# Autonomous driving is a diverse field

<b>Human driver</b>	<b>Autonomous Vehicle</b>
Be able to see	
Know where you are	
When to accelerate, slowdown etc.	
Know where you want to go and how	
Have an idea about the area you are in	
Know how others (on the road) behave	
Be able to interact with others	

# Autonomous driving is a diverse field

<b>Human driver</b>	<b>Autonomous Vehicle</b>
Be able to see	Exteroceptive perception
Know where you are	Localization
When to accelerate, slowdown etc.	Control
Know where you want to go and how	Planning
Have an idea about the area you are in	Mapping
Know how others (on the road) behave	Behaviour prediction
Be able to interact with others	Human-vehicle interaction

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# Agent behaviour modeling and prediction

As humans, we instinctively use our understanding of other road users' behaviour for the purposes of:

- Enhanced efficiency
- Safety of the traffic



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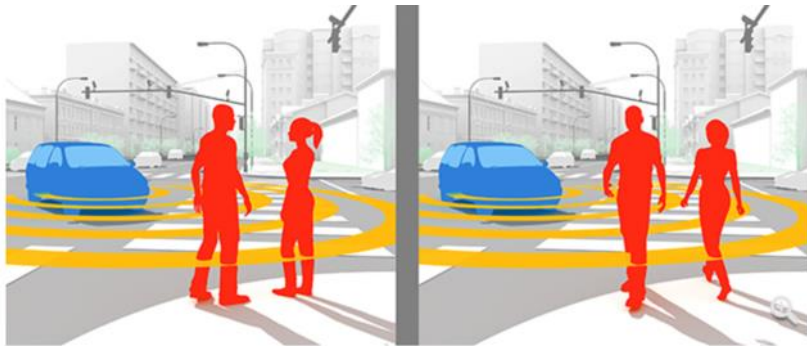
But it's not trivial at all for autonomous vehicles!

# Agent behaviour modeling and prediction

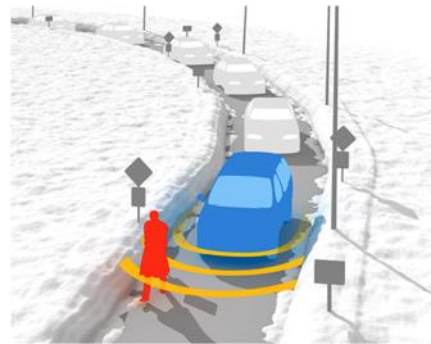
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But it's not trivial at all for autonomous vehicles!



Source: [1]



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Source [2]

[1] Rodney Brooks, "The Big Problem with Self-Driving Cars Is People", IEEE Spectrum, 2017.

[2] Naveed Muhammad, Björn Åstrand, "Predicting Agent Behaviour and State for Applications in a Roundabout-Scenario Autonomous Driving", Sensors, 19(19), 2019.

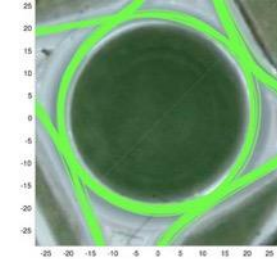
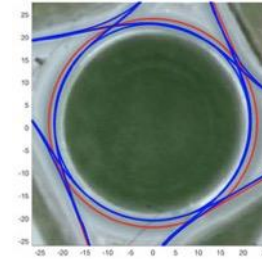
# Agent behaviour modeling and prediction

Behaviour modeling and motion prediction at a roundabout

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## Behaviour modeling and motion prediction at a roundabout

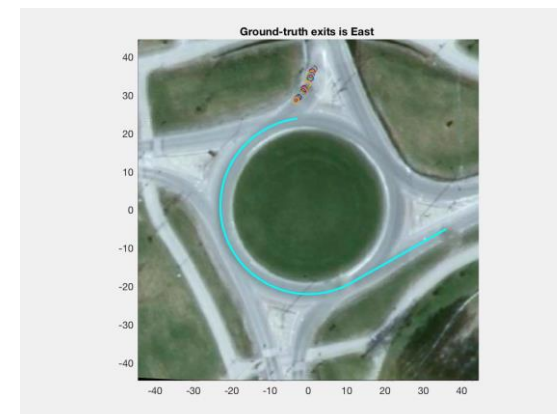
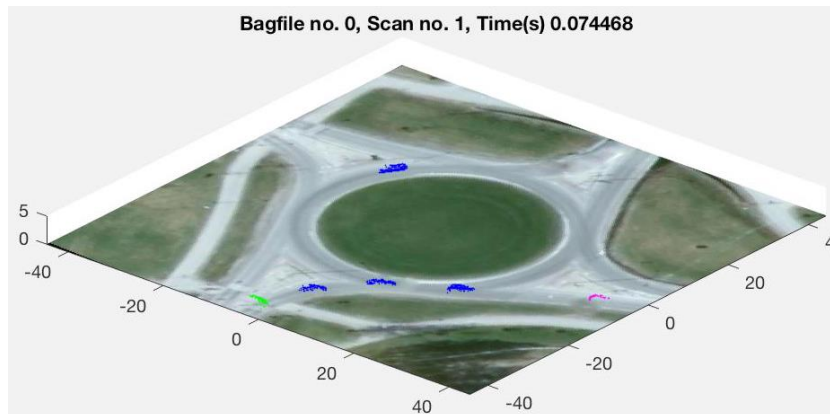
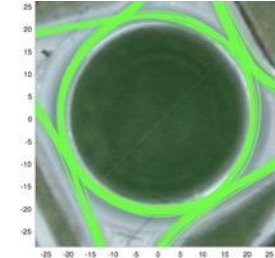
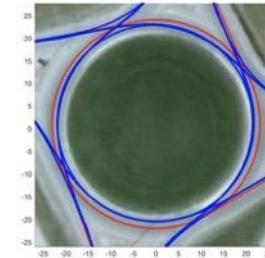
- Using
  - road geometry, extracted from satellite image
  - real-world trajectories of agents, extracted from perception data



# Agent behaviour modeling and prediction

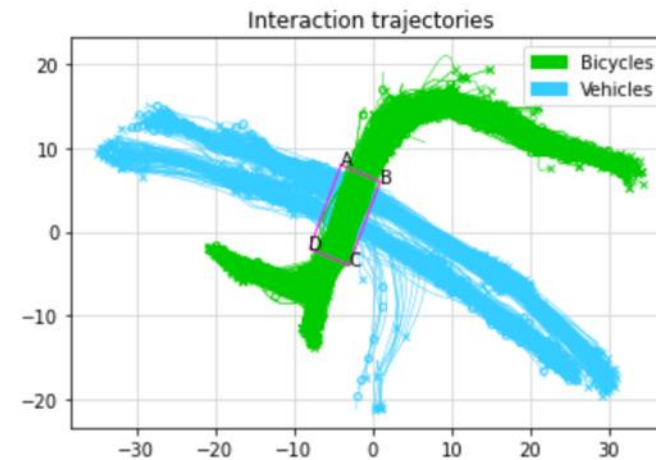
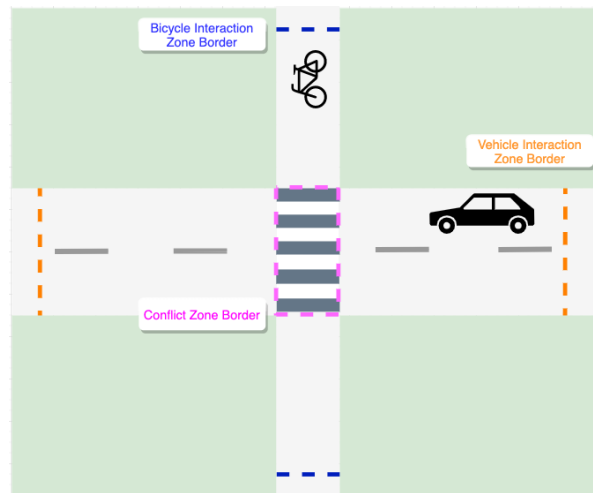
## Behaviour modeling and motion prediction at a roundabout

- Using
  - road geometry, extracted from satellite image
  - real-world trajectories of agents, extracted from perception data
- Employing
  - filtering techniques
  - machine learning methods including decision trees



# Agent behaviour modeling and prediction

Driver yielding decision towards bicycles, at unsignalised intersections

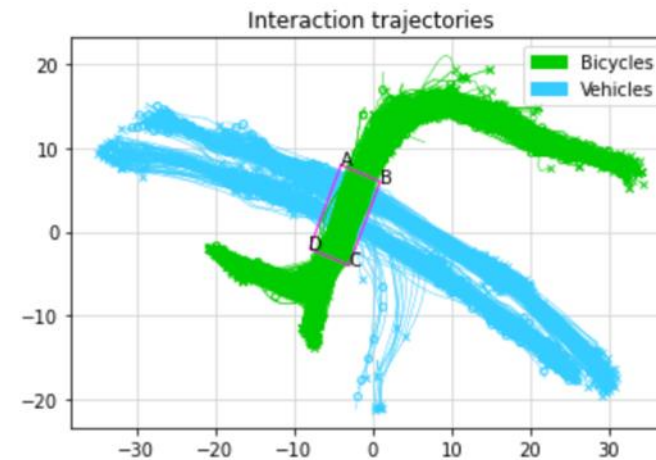
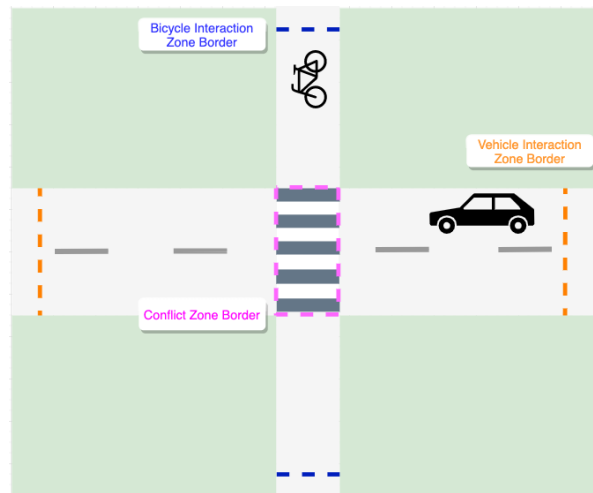


Work by Laura Liis Metsvaht

"Modelling Interactions Between Traffic and Crosswalk Agents at Unsignalized Crossings", Master Thesis, University of Tartu, Estonia, 2021.

# Agent behaviour modeling and prediction

## Driver yielding decision towards bicycles, at unsignalised intersections



- Most significant features were found to be:
  - bicycle distance from the conflict zone when vehicle enters the interaction zone
  - vehicle mean speed inside interaction zone
  - minimum speed inside interaction zone
  - minimum speed distance

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# Agent behaviour modeling and prediction

- Current work
  - Vehicle motion prediction at roundabouts and unsignalized intersections, using in-situ sensors
  - Pedestrian motion prediction at crosswalks
  - Anomaly detection – for example:
    - Pedestrians along the streets
    - Pedestrians standing by the crosswalks
    - Pedestrians crossing using non-designated areas
  - Incorporating the prediction functionalities into our vehicle





# Take-home message

- Agent behaviour prediction has been an active area of research
  - but the scale, and the level of complexity, at which it needs to be addressed (in autonomous driving) is challenging

# Take-home message

- Agent behaviour prediction has been an active area of research
  - but the scale, and the level of complexity, at which it needs to be addressed (in autonomous driving) is challenging
- Application areas in addition to autonomous driving
  - Delivery robots
  - Automated forklifts in factories and warehouses, vehicles at ports and mines etc.
  - Urban planning

Thanks. Questions?



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