Multi-Agent Control of A fleet of Cybercars

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Who I am
Who I am

- second year Ph.D candidate
Who I am

• second year Ph.D candidate

• member of Hybrid and Distributed Systems and Control group
Who I am

- second year Ph.D candidate
- member of Hybrid and Distributed Systems and Control group
- work with Ton van den Boom and Bart De Schutter
Do you drive car?
- accidents
• accidents
• congestion
- accidents
- congestion
- energy consumption
• accidents
• congestion
• energy consumption
• pollution
Public transport systems

- considered suitable solutions to those problems
Public transport systems

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- e.g., buses, trams, subways, etc
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- widely used and continuously improved
Public transport systems

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- e.g., buses, trams, subways, etc
- widely used and continuously improved
- * predefined schedules and routes
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In terms of personal mobility, private cars still win!!
Public transport systems

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- e.g., buses, trams, subways, etc
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In terms of personal mobility, private cars still win!!

Problems are still unsolved!!
New approach for personal mobility
New approach for personal mobility

Cybercars

- automated road vehicles
New approach for personal mobility

Cybercars

- automated road vehicles
- provide on-demand and door-to-door service
New approach for personal mobility

Cybercars

- automated road vehicles
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- mostly small-sized
New approach for personal mobility

Cybercars

- automated road vehicles
- provide on-demand and door-to-door service
- mostly small-sized
- energy efficient
Cybercars

*pictures from www.cybercars.org*
Cybernetic transportation system (CTS)

- promising solution to urban transportation challenges
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- promising solution to urban transportation challenges
- formed by a fleet of cyberears
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- high flexibility and reactivity
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- emerged in Europe and first used at Schipol airport
Cybernetic transportation system (CTS)

- promising solution to urban transportation challenges
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- projects including **CyberCars**, **CyberMove** and **CyberCars-2, CityMobil**
Opportunity and Challenge
Opportunity and Challenge

Opportunity

automated driving technology has been well developed
Opportunity and Challenge

**Opportunity**
automated driving technology has been well developed

**Challenge**
lack of efficient cooperation strategy
Cooperation of cybercars
Cooperation of cybercars

Cooperation

- necessary for optimal performance of CTS
Cooperation of cybercars

Cooperation

- necessary for optimal performance of CTS

variety

- collision avoidance
- platoon merge and split
- dynamic routing
Cooperation of cybercars
Cooperation of cybercars

Multi-agent system
Cooperation of cybercars

Multi-agent system

- moving decision-making agents
Cooperation of cybercars

Multi-agent system

- moving decision-making agents
- extensive on-board processing and communication capabilities
Cooperation of cybercars

Multi-agent system

- moving decision-making agents
- extensive on-board processing and communication capabilities
- abundant information of environment
Cooperation of cybercars

Multi-agent system

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Abstract object of our research !!
Fleet control problem of cybercars
Fleet control problem of cybercars

Existing research
Fleet control problem of cybercars

Existing research

- from conceptual point of view
Fleet control problem of cybercars

Existing research

- from conceptual point of view
- conceptual description of control system architecture and functions
Fleet control problem of cybercars

**Existing research**

- from conceptual point of view
- conceptual description of control system architecture and functions

**Our research**
Fleet control problem of cybercars

Existing research

- from conceptual point of view
- conceptual description of control system architecture and functions

Our research

- explore specific case, i.e., dynamic routing problem
Problem description
Problem description

Set up
Problem description

Set up

- dedicated roads network
Problem description

Set up

- dedicated roads network
- cybercars are free to make its desired route choices
Problem description

Set up

- dedicated roads network
- cybercars are free to make its desired route choices
- traffic densities in all roads decide velocities
Problem description

Set up

- dedicated roads network
- cybercars are free to make its desired route choices
- traffic densities in all roads decide velocities
- energy consumption depend on velocities and variation of velocities
Problem description
Problem description

Modeling
Problem description

Modeling

- discrete-time
Problem description

Modeling

- discrete-time
- discrete-event
Problem description

Modeling

- discrete-time
- discrete-event

Objectives
Problem description

**Modeling**
- discrete-time
- discrete-event

**Objectives**
- minimizing total time spent (TTS)
Problem description

Modeling

- discrete-time
- discrete-event

Objectives

- minimizing total time spent (TTS)
- minimizing total energy consumption (TEC)
Model predictive control (MPC)

*figure from Ph.D thesis of L.D. Baskar*
Centralized MPC

*figure from Journal paper of J.M. Maestre
Distributed MPC

*figure from Journal paper of J.M. Maestre*
Research guide
### Research guide

**Modeling**

- discrete-time modeling & discrete-event modeling
Research guide

Modeling
- discrete-time modeling & discrete-event modeling

Centralized control
- desired solution of distributed control
Research guide

Modeling
- discrete-time modeling & discrete-event modeling

Centralized control
- desired solution of distributed control

Distributed Control
- decomposing the problem
Research guide

Modeling
- discrete-time modeling & discrete-event modeling

Centralized control
- desired solution of distributed control

Distributed Control
- decomposing the problem
- extending existing distributed control methods
## Research guide

### Modeling
- discrete-time modeling & discrete-event modeling

### Centralized control
- desired solution of distributed control

### Distributed Control
- decomposing the problem
- extending existing distributed control methods
- developing new distributed control methods
Review
Review

- motivation
Review

- motivation
- specific research problem
Review

- motivation
- specific research problem
- potential control scheme
Review

- motivation
- specific research problem
- potential control scheme
- research guide
Thank You!