Autonomous navigation of a platform with UVc-light

to prevent crop infestation by powdery mildew

1st AXEMA-EurAgEng Conference

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Background

- PhD-student, started in January 2016
- Research at Octinion
  - R&D-company
  - Automation in agrofood applications
- Member of *Motion Estimation, Control and Optimization* (MECO)– group of KU Leuven
- Supported by *Vlaams Agentschap Innoveren en Ondernemen* (VLAIO)

MECO RESEARCH TEAM
MOTION ESTIMATION, CONTROL & OPTIMIZATION

AGENTSCHAP INNOVEREN & ONDERNEMEN
Vlaanderen is ondernemen

Introduction

- Strawberry industry: yearround cultivation system

Introduction

- Constant Menace: Powdery Mildew

Introduction

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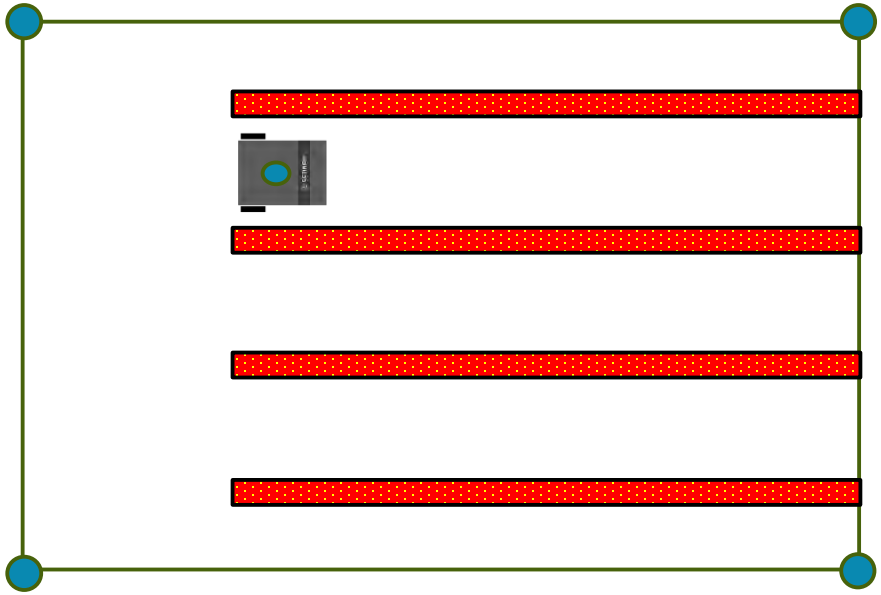
- Illumination with UVc light (Investigated by *Research Centre Hoogstraten*)
  - Treatment every 48 hours
  - Suppression of 70 – 90 %
  - Harvested strawberries completely unaffected

- **Problem:** Treatment takes a lot of time
  - Big labour cost

- **Goal:** Automate the process

Introduction

- Requirements for navigating:
  - 3-5 cm precision
  - constant velocity
- Positioning technology: accurate GPS => no option
  - Indoor positioning with Ultra Wideband



Introduction

- Dribble

Introduction

- Sneak peek

Content of presentation

- Modeling the platform
- Positioning the platform
- Controlling the platform
- Trajectory issues
- Results and discussion

Modeling the platform

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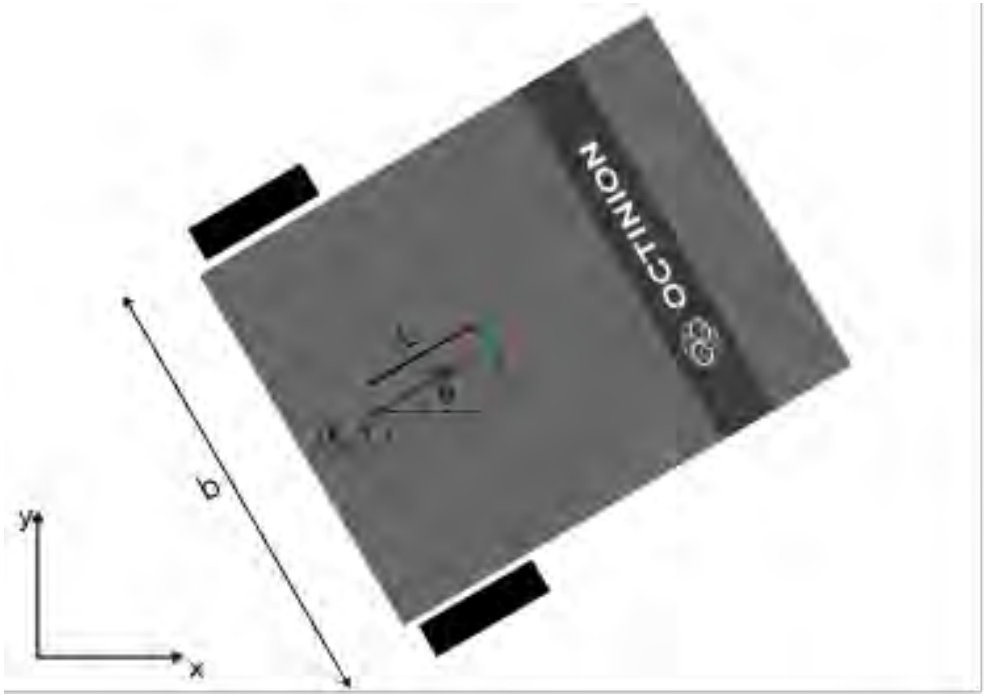
Kinematic model

- Equations:

$$\begin{cases} \dot{X}_c = v_x \cdot \cos(\theta) \\ \dot{Y}_c = v_x \cdot \sin(\theta) \\ \dot{\theta} = \omega_z \\ v_x = \dfrac{v_l + v_r}{2} \\ \omega_z = \dfrac{v_r - v_l}{b} \end{cases}$$



- 2nd order behavior of motor drives included

Positioning the platform

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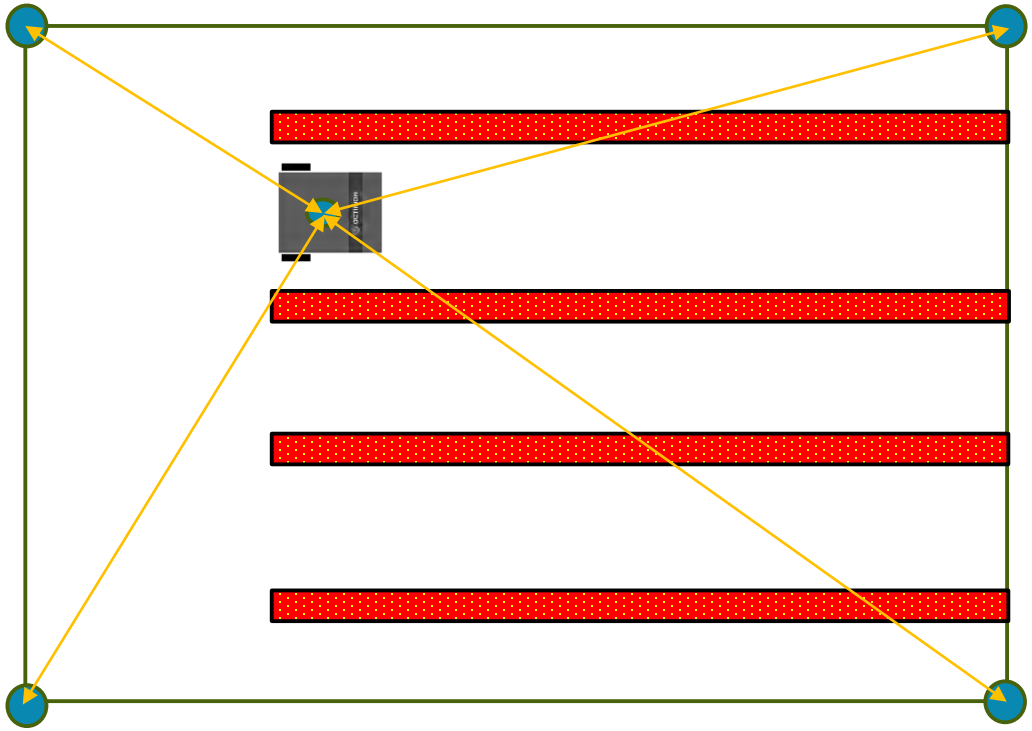
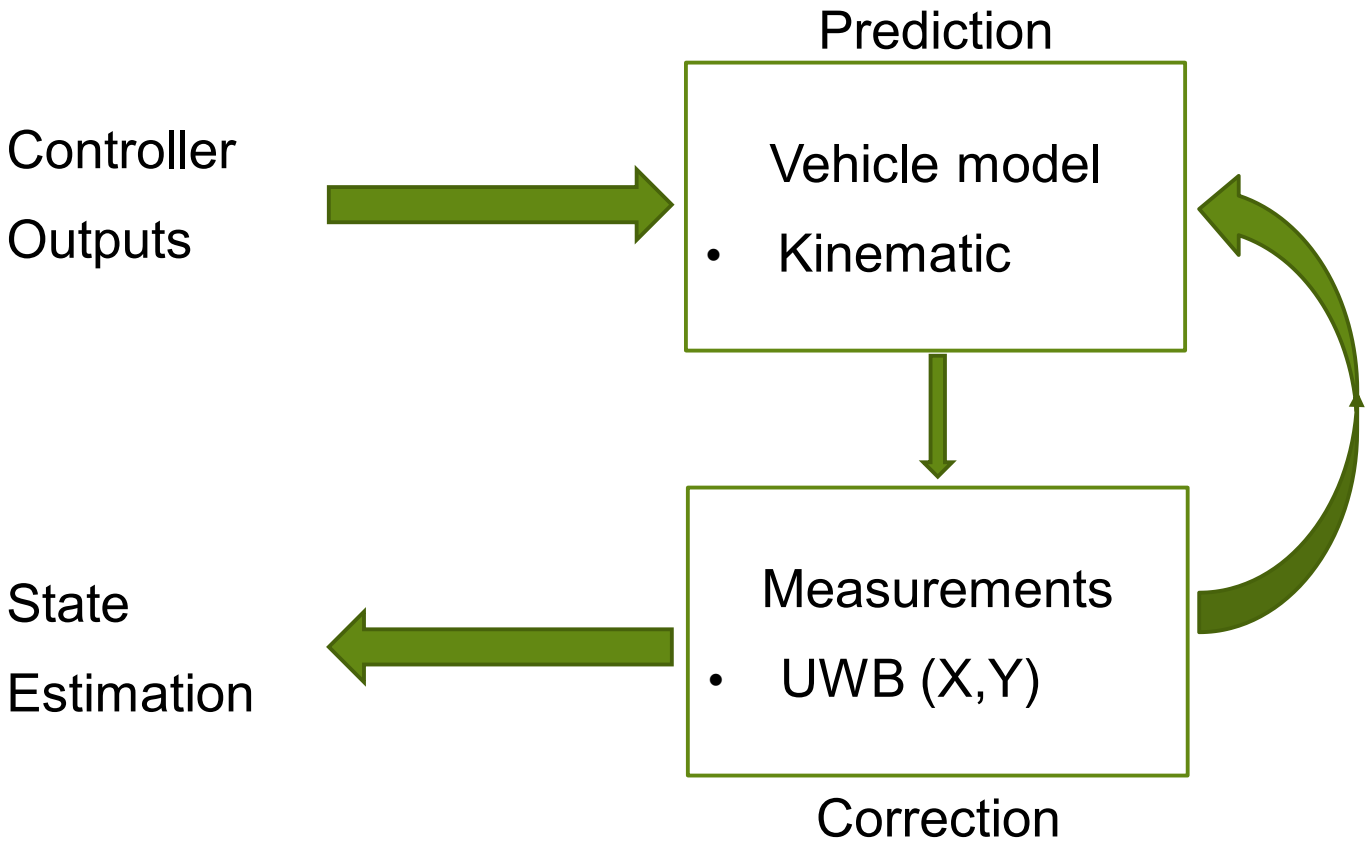
Ultra Wideband

- Least-squares solution of distances



State Estimation: Extended Kalman Filter



Controlling the platform

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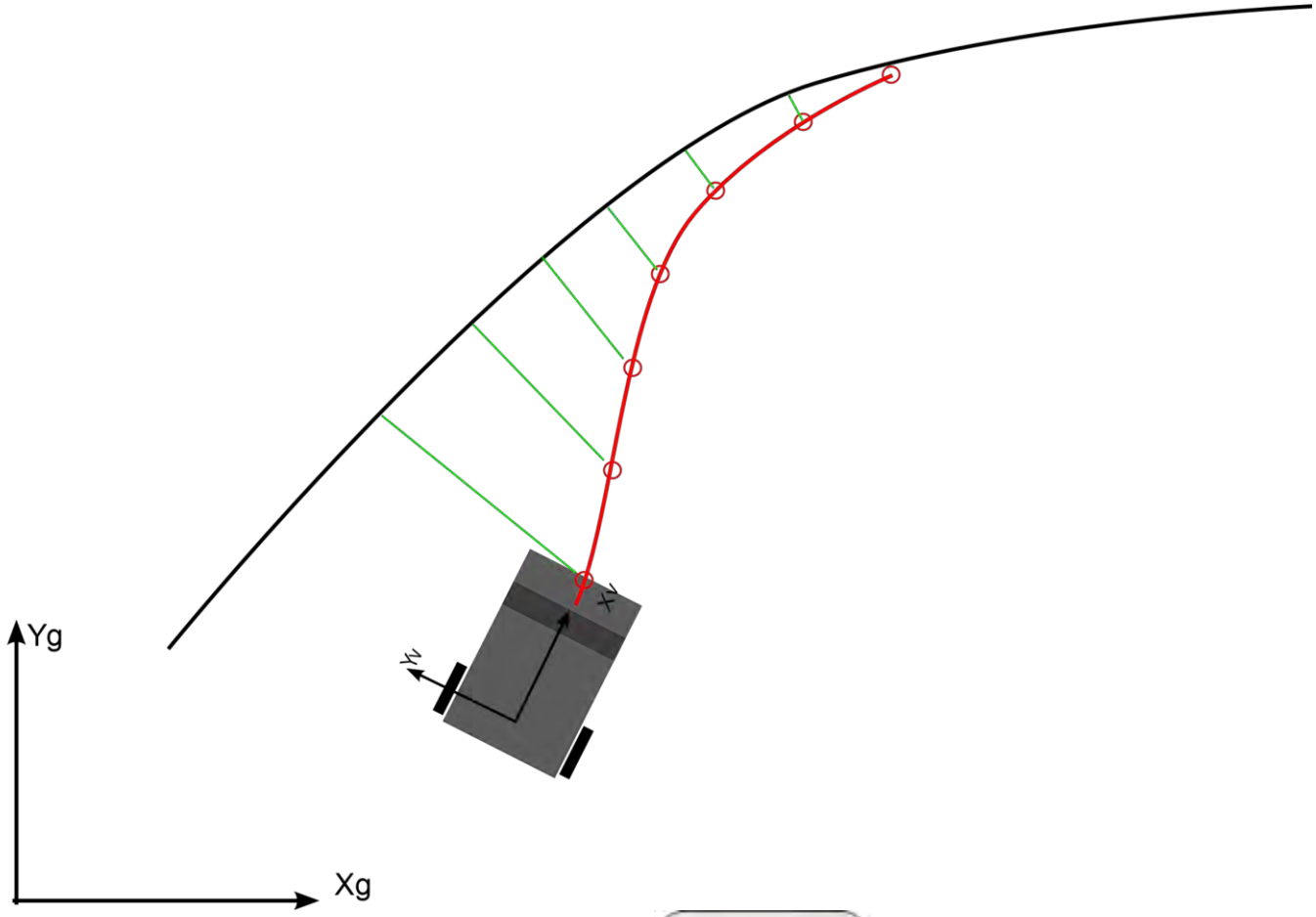
Model Predictive Control

On every time step *k*:

Optimization

Minimize:	**Deviation** from reference of *k+1* to *N*
Variables:	**State** x[-] from *k+1* to *N*
	Inputs from *k+1* to *N*
Constraints:	Dynamic model of vehicle
	Min/Max values on actuator inputs
	Min/Max values on states

Model Predictive Control



- Implemented with ACADO

Trajectory issues

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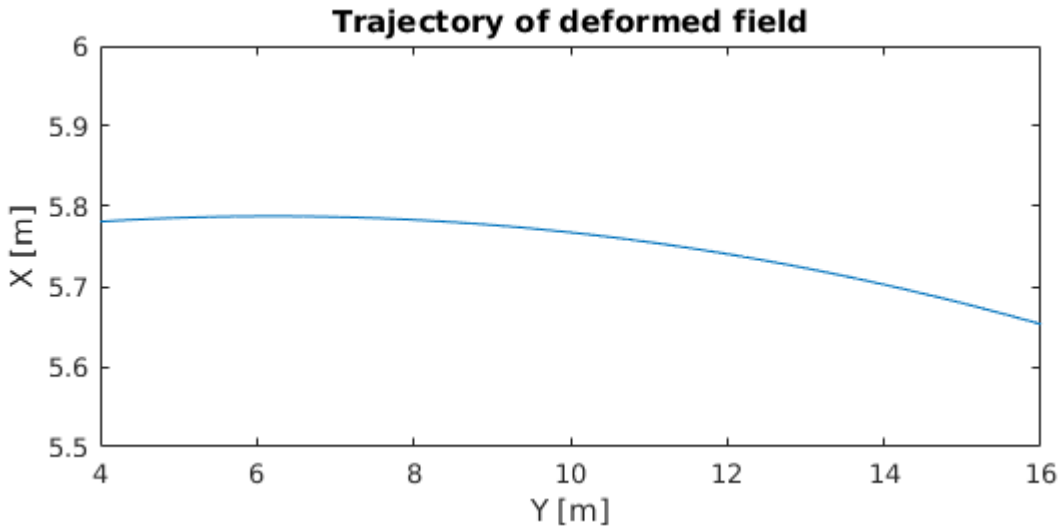
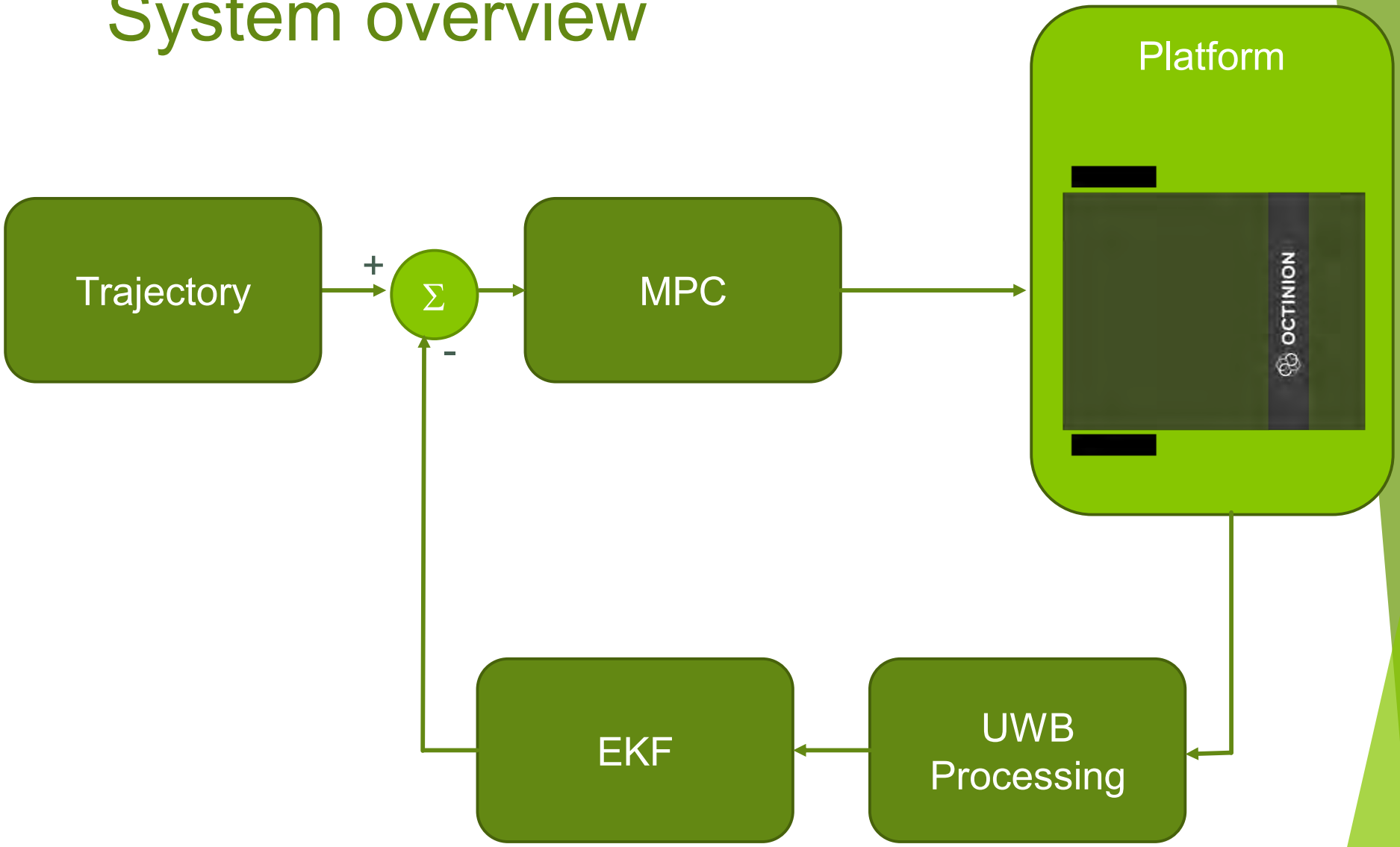
Trajectory issues

- First tests => good accuracy results
  - But: platform was clearly driving a curve
  - Offsets of UWB system
- Curved trajectory as reference



System overview



Results and discussion

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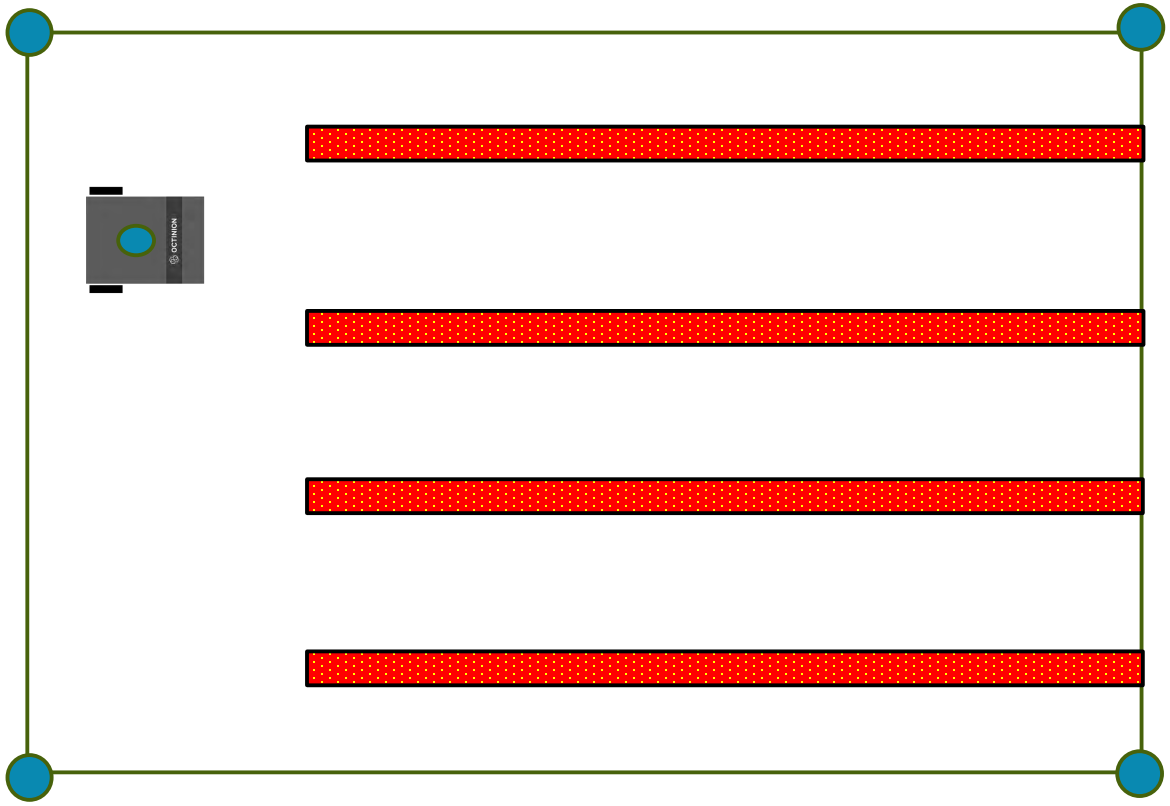
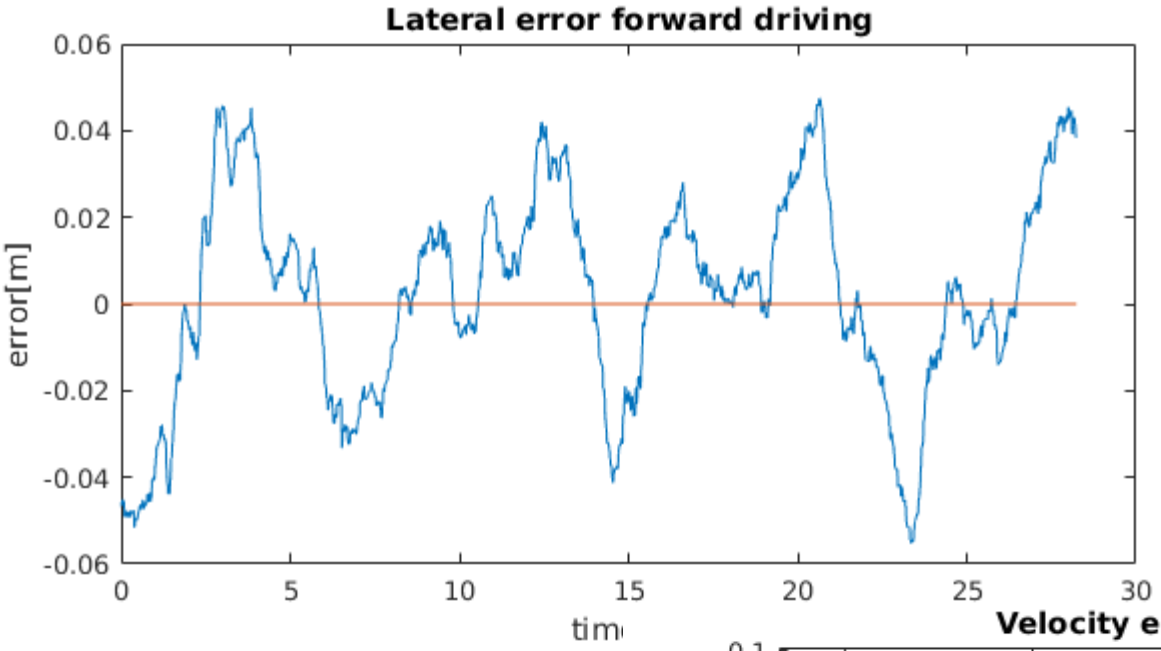
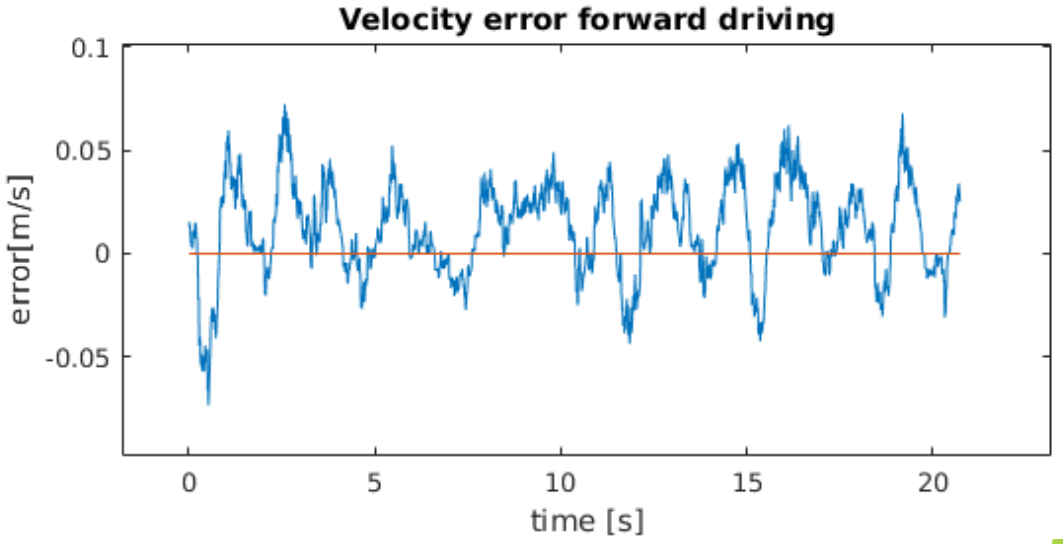
Autonomous driving

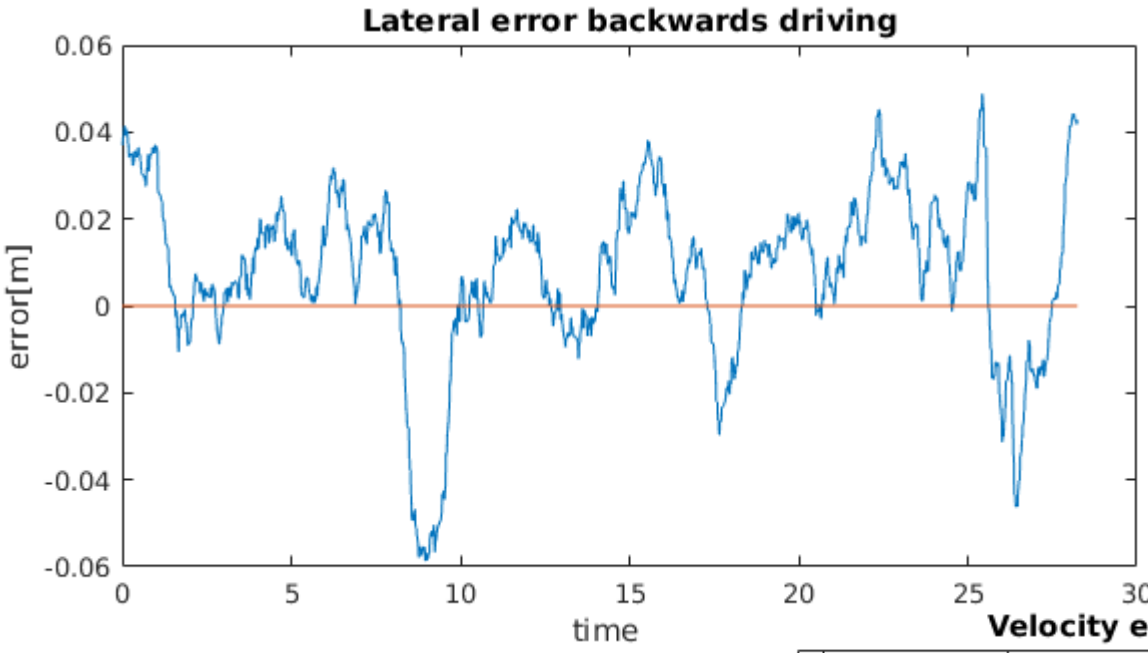


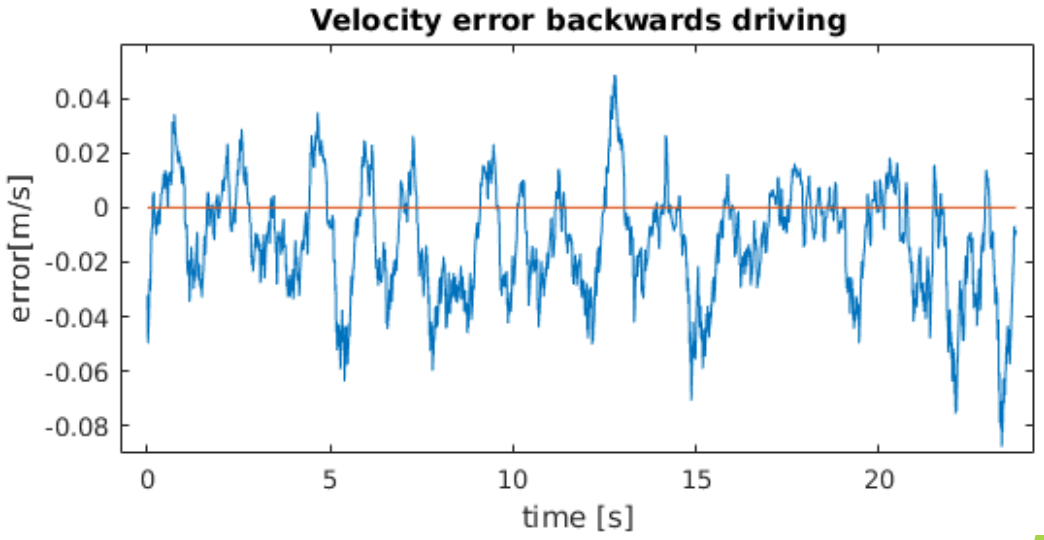
Forward driving





Backwards driving





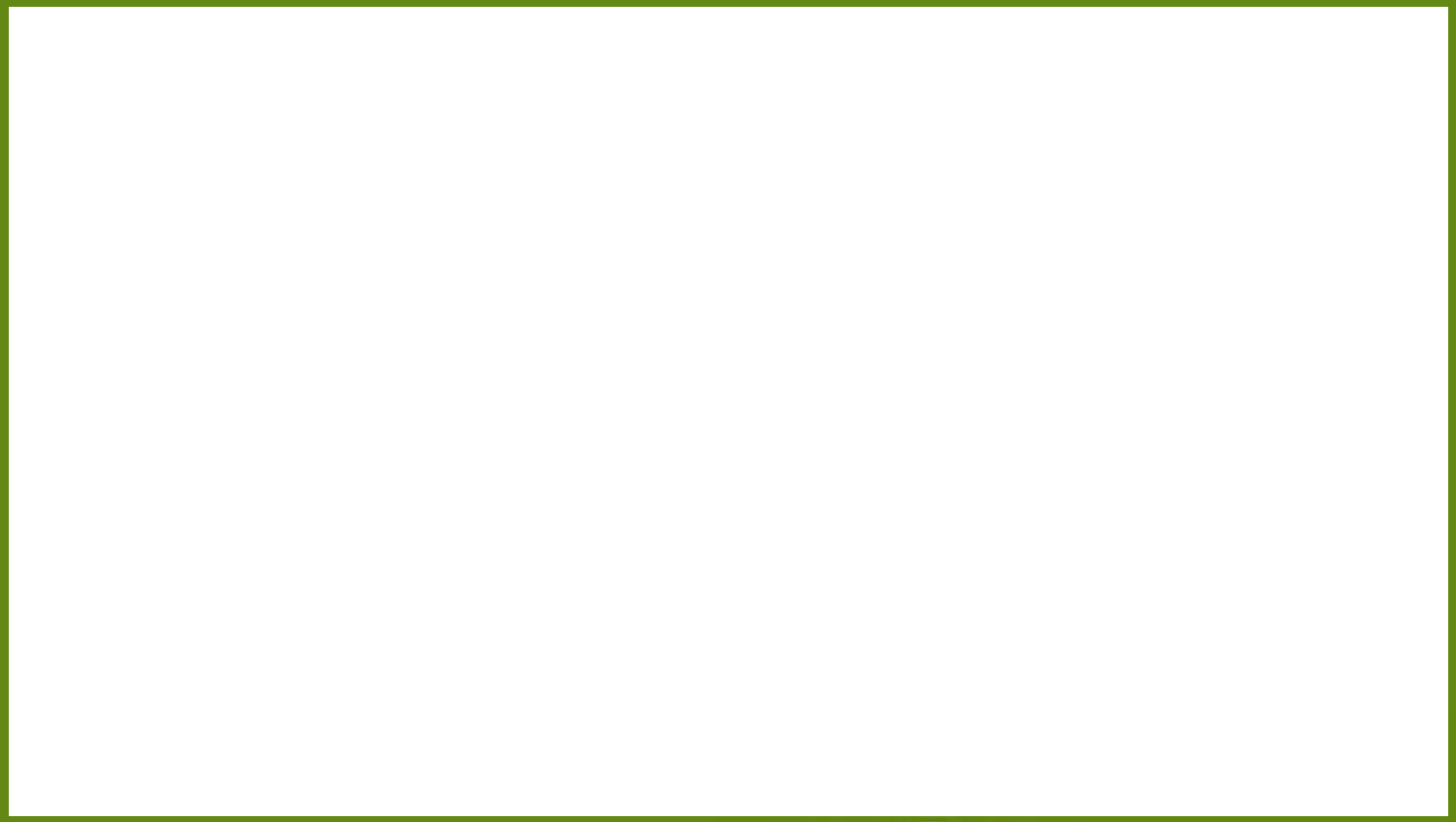
Discussion

- Requirements:
  - 3-5 cm accuracy ✓
  - Constant velocity ✓
- Remarks:
  - Curved trajectory => not sustainable
    - Eliminating UWB-offsets
  - UWB-system: prone to influences of objects in LOS
    - Adding local sensors

Conclusion

- Autonomous platform
  - Positioning: UWB + EKF
  - Control: MPC
  - Remarks on reference trajectory
- Tested + validated in realistic environment

Thank you for your attention. Questions?



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