DHBW ENGINEERING Stuttgart

eSleek20

CONCEPT REVIEW _VDC


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WHAT IS _VDC?

WHAT IS _VDC?

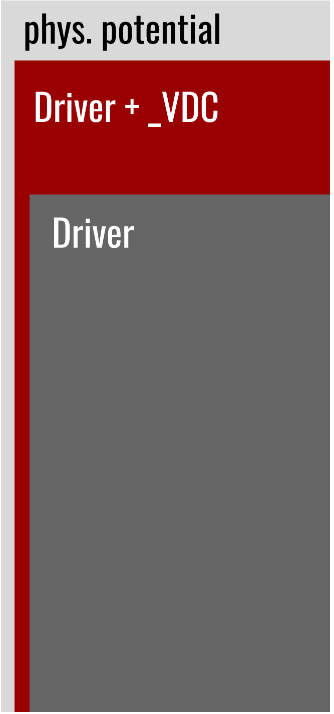
Vehicle Dynamics Control

Sensors

Vehicle Information

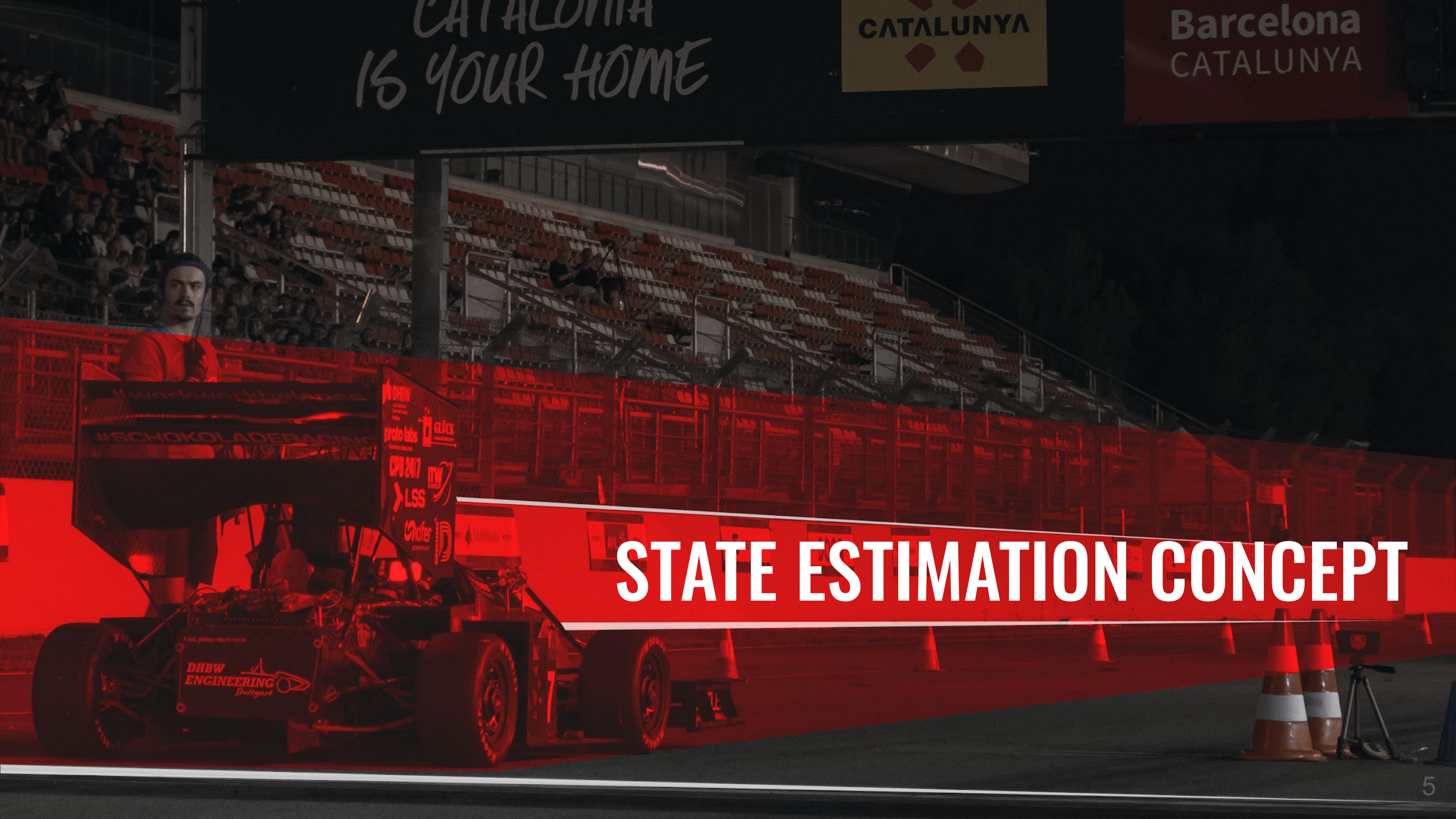
Motor request

WHAT IS _VDC?



The VDC is a tool that helps the driver to exploit the maximum physical potential of the vehicle.

- cf. Kirill, 2017



STATE ESTIMATION CONCEPT

STATE ESTIMATION CONCEPT

Sensor data:
- SFII
- IMU
- GPS
- Wheel speed
- ...

→

State Estimation and Sensor Fusion with Extended Kalman Filter (EKF)

→

Estimated state:
- Position: x, y
- Velocities: v_x, v_y
- Heading/yaw: psi
- Yaw rate: dPsi
- Vehicle slip: beta

→ VDC

→ DV Control

STATE ESTIMATION CONCEPT

Improvements over eSleek 19:

- Addition of position estimation
- Better estimation of lateral velocity
- Possibly: better velocity estimation using wheel speed sensors
  - SF-II can be removed

STATE ESTIMATION CONCEPT

Why this concept?

- EKF has proven itself in previous seasons and is state-of-the-art
- New and stricter requirements because of DV
  - Reduce effort and increase quality by using same model with different parametrization

REALISATION

REALISATION

- Close collaboration with VDC and Driverless team to define interfaces
- Find appropriate models to use in EKF
    - Start simple, make more detailed if necessary
- Simulate before pre-season testing, possibly using vehicle simulation
- Characterize sensor noise for EKF
- Parametrize for EV and DV

RISKS AND COUNTERMEASURES

RISKS AND COUNTERMEASURES

Risk	Countermeasure
Sensor failures/outliers	Redundant sensors to guarantee observability Outlier detection using max. change rate Drift detection using EKF bank
Inaccurate estimations	Compare different models using simulation to find best one

FUNCTIONALITY TEST

FUNCTIONALITY TEST

Unit testing of state estimation module using vehicle simulation

1. Connect state estimation inputs with vehicle simulation outputs
2. Run different scenarios using real driver inputs from testing
3. Compare actual value from simulation with estimated value
4. Adapt model, if needed

HOW DOES IT MAKE THE eSleek20 better?

HOW DOES IT MAKE THE eSleek20 BETTER?

VDC and driverless controller require an

- *accurate* and
- *reliable*

estimation of vehicle state

→ foundation for optimal decision-making in performance-critical software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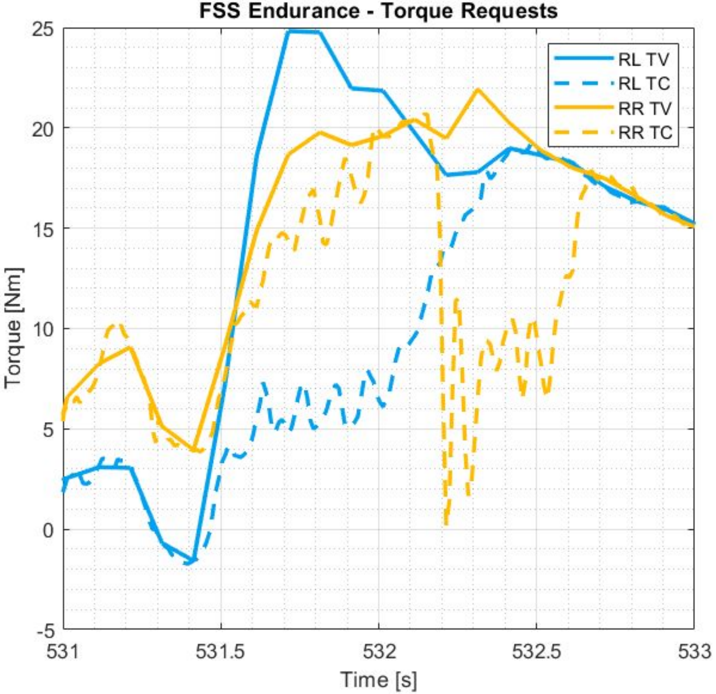
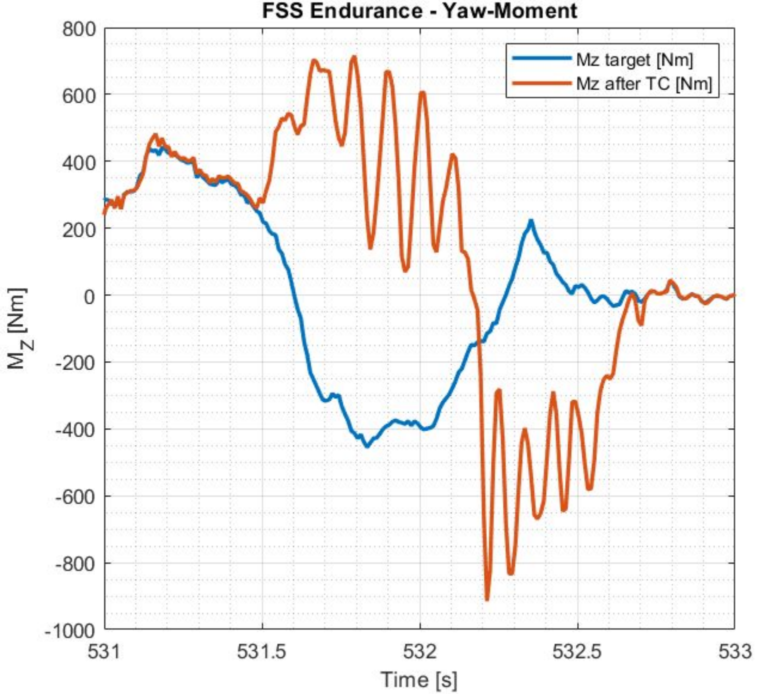
TV CONCEPT

TV CONCEPT


FSS Endurance - Torque Requests
RL TV
RL TC
RR TV
RR TC
Torque [Nm]
Time [s]
25
20
15
10
5
0
-5
531
531.5
532
532.5
533


FSS Endurance - Yaw-Moment
Mz target [Nm]
Mz after TC [Nm]
M_Z [Nm]
Time [s]
800
600
400
200
0
-200
-400
-600
-800
-1000
531
531.5
532
532.5
533

TV CONCEPT

- Problem of eSleek18 TV: Requests unrealistic torques
  → Limited by TC, wrong M_Z
  → Develop quadratic optimizer (QP) with physical knowledge for eSleek19

- Problem of eSleek19 TV: Calculation of target yaw moment is not based on a physical model and adapted to old optimizer (Simplex)
  → QP can not use full vehicle potential
  → Develop new model for target yaw rate calculation for eSleek20

TV CONCEPT

- Requirements for new model
  - Controllability
  - Stability
  - Repeatability
  - Predictability
- Use vehicle simulation for first evaluation of concepts based on requirements and performance
- Fine-tune concepts during pre-season testing

RISKS AND COUNTERMEASURES

RISKS AND COUNTERMEASURES

Risk	Countermeasure
Still no better performance than with Simplex	No breaking changes, possibility to switch between different optimizers and target yaw rate generation methods is kept

OTHER CONCEPTS

ERROR HANDLING CONCEPT

Error detection	Error handling	Error visualization
• Sensor outlier detection • Bank of Kalman Filters for sensor drift detection	• Can an alternative sensor be used? • Does the car have to stop?	• Error code(s) on dashboard • Lookup table to quickly investigate possible causes for failures

TC MODERNIZATION CONCEPT

- Use newly developed tire model and calculate wheel load using strain gauges, wheel acceleration sensors, spring travel sensors
  → More accurate potential estimation
- Examine and improve TC in corner entry with potential estimation (Pre season testing)
- Apply TC for new Powertrain

QUALITY CONCEPT

- Write unit tests for submodules
  - Possibility to implement submodules and check functionality
- Create documentation

HOW DOES IT MAKE THE eSleek20 faster?

HOW DOES IT MAKE THE eSleek20 BETTER?

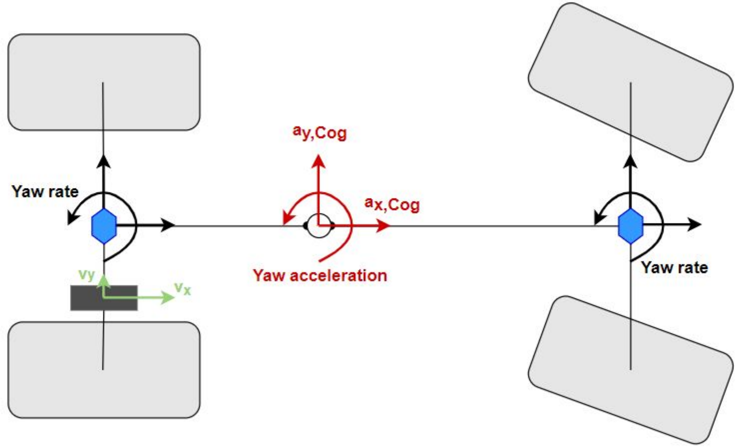
- Better exploitation of the physical vehicle potential
  - Better longitudinal acceleration
  - Better cornering ability (especially during braking)
- Less usage of erroneous sensor data
- Simpler and quicker error investigation → Minimize downtime
- Documentation helps new team members

VIELEN DANK FÜR EURE AUFMERKSAMKEIT!

AVAILABLE SENSOR

Kistler Correvit SF-II - 250Hz

Jacobs Design 3Force - 500Hz



IPEspeed GPS - 20Hz

Wheel Speeds - 1000Hz

STATE ESTIMATION