Investigating two-wheeler balance using experimental bicycles and simulators

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Content

- Overview of the project
- Aim of the project
- Experimental setups
- Conclusion
- Impact to society

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Overview of the project

Working packages

WP1 (Rider training)

- New or optimization of existing training techniques

Investigate impact of learning effect on given riding tasks & possibility of transferring skills from different activities into riding

WP2 (Active safety systems)

- Automatic braking
- Steering assist

Investigate rider powered two wheeler interaction (ptw)

WP3 (Protective equipment)

- Helmets & ppe’s

Injury/ impact biomechanics

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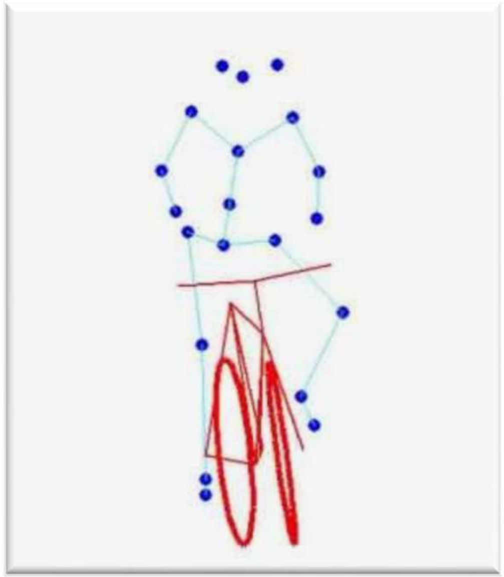
Aim of WP2

Investigate ptw interaction

MOTOR-IST

1. Construct motorcycle & bike simulator :

- *Realistic visual environment & motion (if needed)*
- *Realistic steering feel*
- *Monitor states and rider control input*



2. Instrumented bicycles

- *Monitor states & rider control input*
- *Perturbation mechanisms*

3. Perform rider in the loop testing

- *Analyze human control input & machine states*
- *Analyze human motion ''Biomechanics''*

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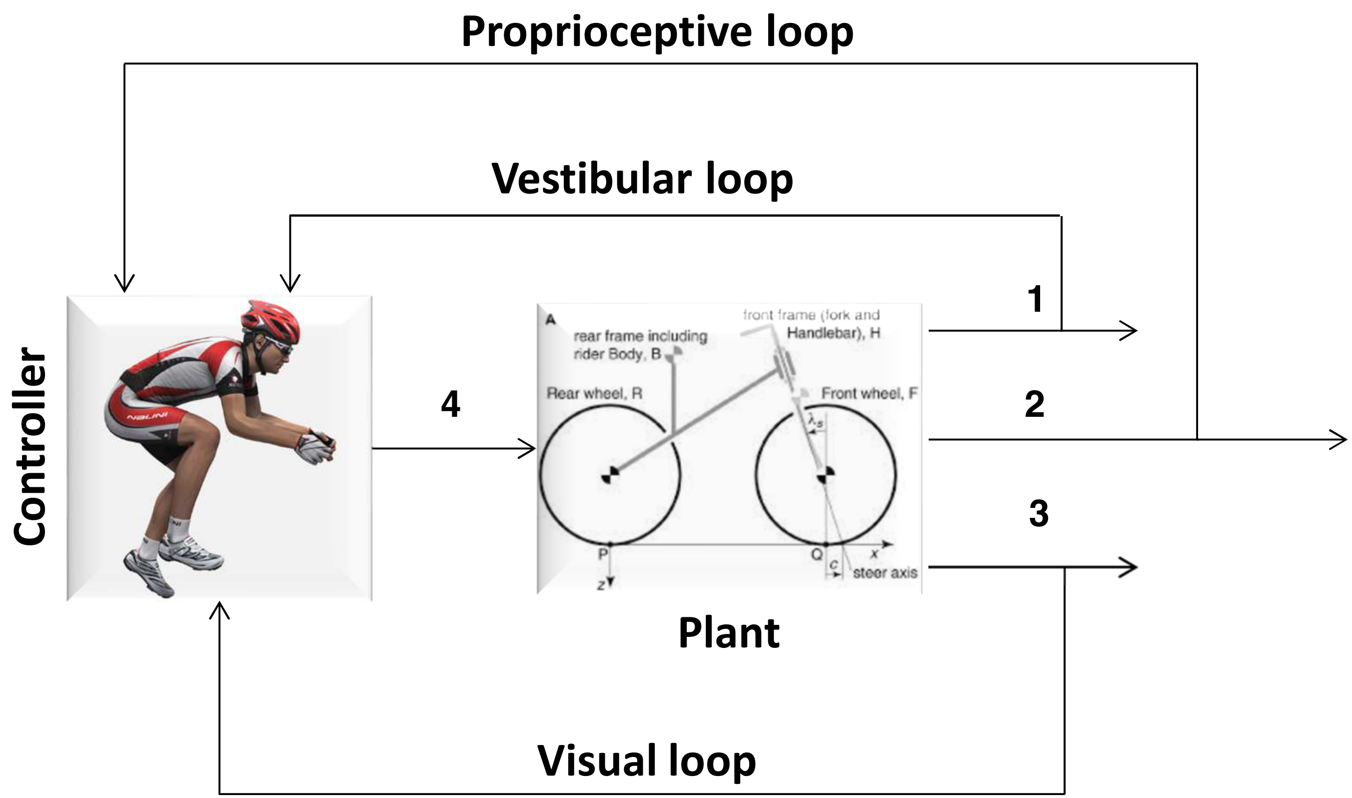
J.Moore,Human control of a bicycle, Davis Mechanical - Aerospace Engineering Univ.California

Aim of WP2
Theoretical model



1. Roll accelertion 2. Steering angle 3.Roll angle 4. Steering torque

Aim of WP2

Research questions

Analysis of rider behavior:

- *1. Assuming that the rider is acting as an optimizer what is the rider optimizing to balance when a lateral perturbation occurs? Andy Ruina*

  "Expressed from optimal control theory Q,R weight factors"

- *2. Which of the sensory system feedback and in what degree is used in order to obtain state information?*

  "Expressed from the feedback gains "$K\varphi p$, $K\varphi d$, $K\delta i$, $K\delta d$"

- *3. What is the response of the neuromuscular system in terms of "stiffness" when a torque perturbation occurs?*

  "Expressed from damping coefficient"

AL Schwab et. al . Journal of Multi-body Dynamics, IMech, August 2013

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1^{st} Fixed base bicycle simulator

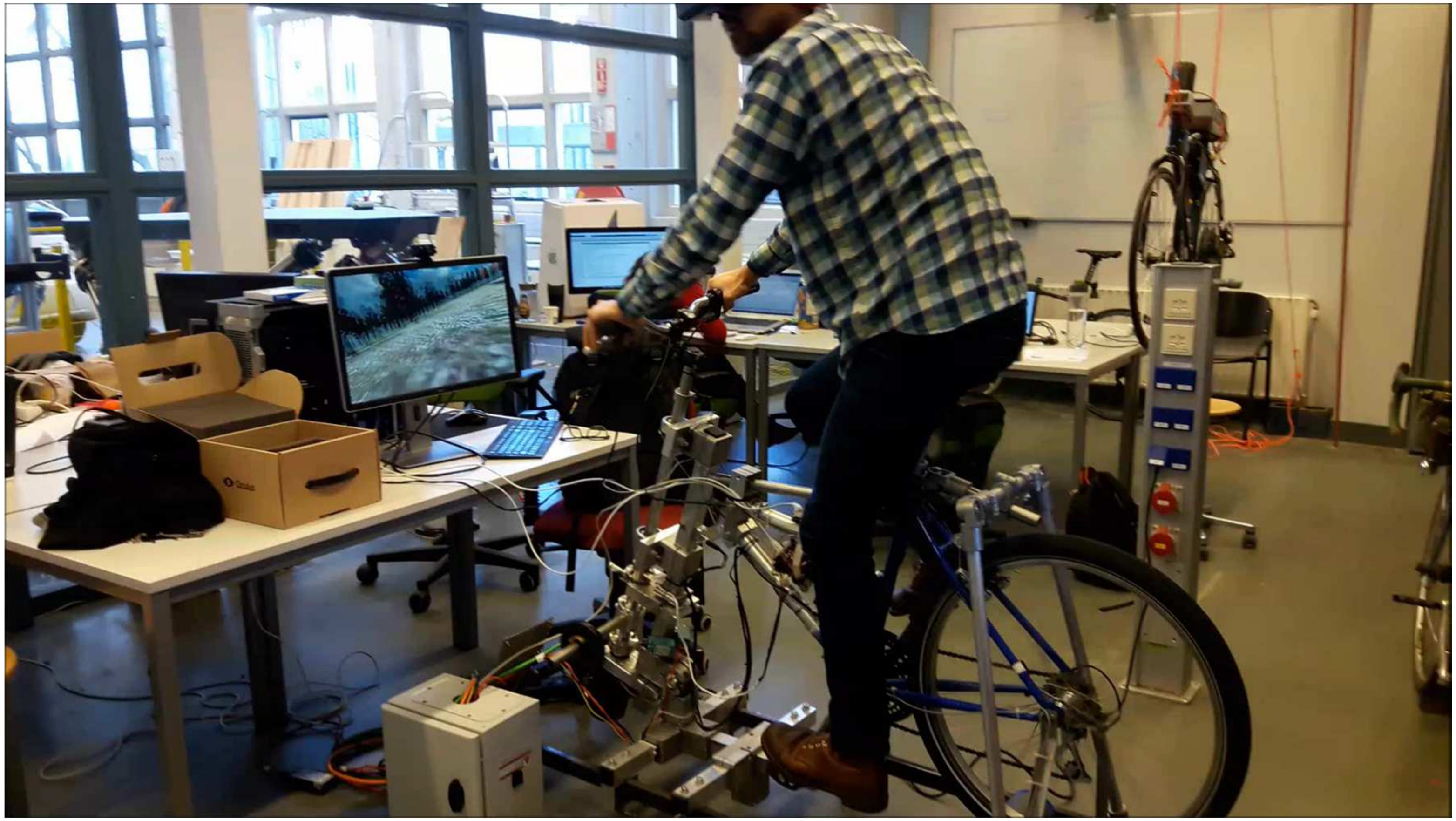
Objective

"Perform rider control identification experiments in a virtual environment"

- Direct measurement of steering torque
- Realistic steering feedback
- Real time computation of dynamic equations
- Adjustable fitting for every rider

1^{st} Fixed base bicycle simulator

Video



2nd Steer by wire bike

Objective

''Perform rider control identification experiments in real conditions while exciting bicycle rider system''

State and rider input:

Roll rate – **IMU**
Forward speed – **GTS**
Pedal cadence **- GTS**
Steer torque – **RTS**
Steer & fork rate – **AME**

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2nd Steer by wire bike

Headtube assembly

MOTOR-IST

T-sensor
Range ± 25 Nm
Resolution ±4 µNm

Abs.Encoder
Resolution±0,043 deg/rev

Motor+G.head
Stall torque 7,5 Nm
Max.torque 11,3Nm

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2^{nd} Steer by wire bike

Perturbation mechanisms

AL Schwab et. al . Journal of Multi-body Dynamics, IMech, August 2013

3rd Bicycle mock up

Objective

"Identification of riders mechanical impedance and resonance"

13 Wheatstone bridges

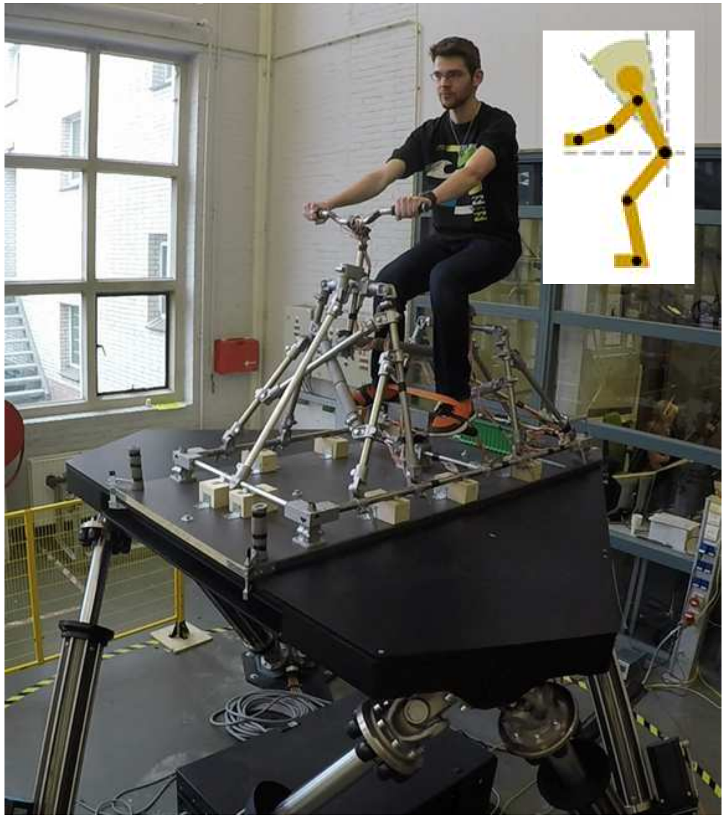
- 3 bridges per handlebar side
- 2 bridges per footpegs
- 3 bridges at seat posttube

2 IMU

- 1 Chest of the rider
- 1 Hexapod

****Geometry of the frame:***

- Stack to handlebars=78 cm
- Reach to handlebars=68 cm



** The shape of the impedance curve is influence mainly by rider posture and G loading*

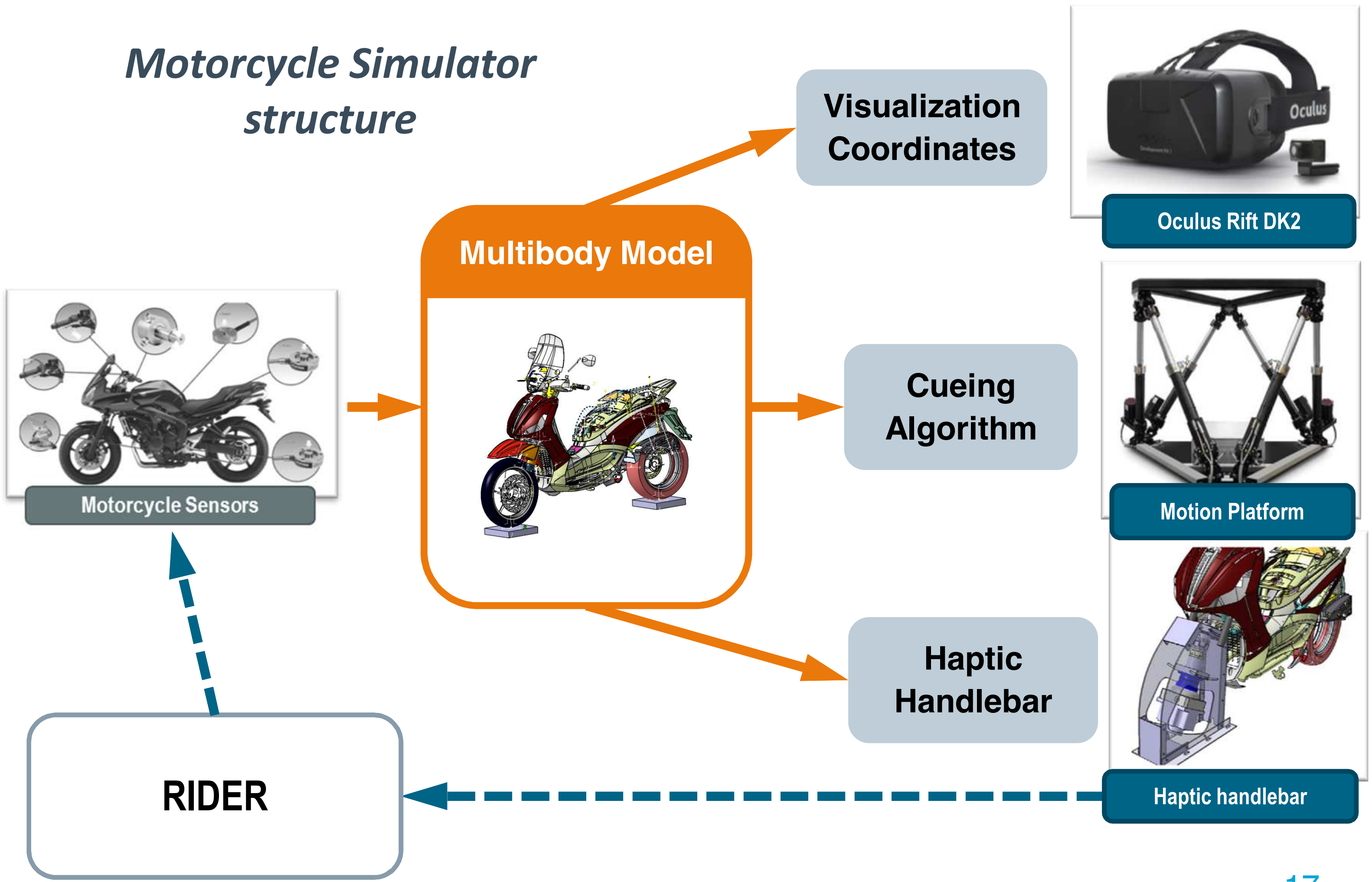
3rd Bicycle mock up

Video

4th Motorcycle simulator

Objective

"Perform rider control identification experiments in a virtual environment"



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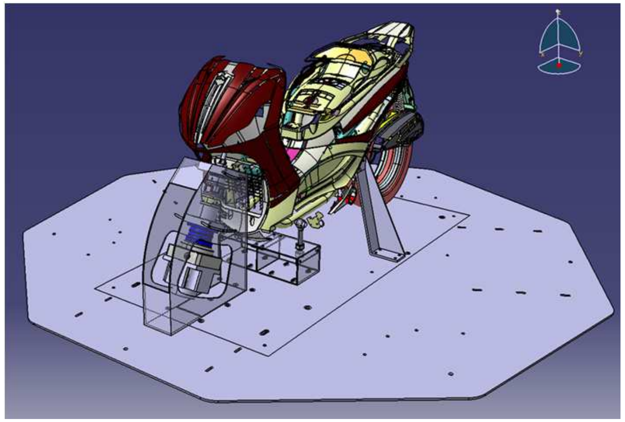
4th Motorcycle simulator

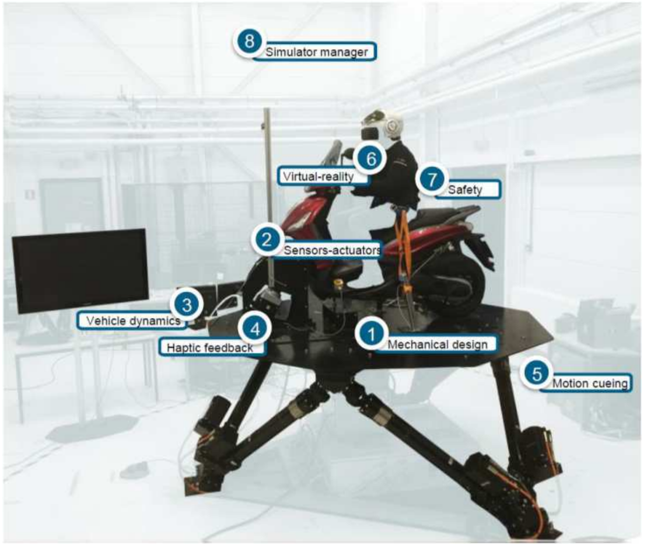
Simulator structure

Design is divided in two different setups:

- ***Static simulator***
  The scooter is fixed to a static plate on which also the steering motor is fixed. This setup allows easier system settings working from the ground.



- ***Dynamic simulator***
  In the dynamic configuration the static plate is lifted and mounted on top of the motion base. For this configuration an additional lateral support will sustain lateral movement of the scooter.



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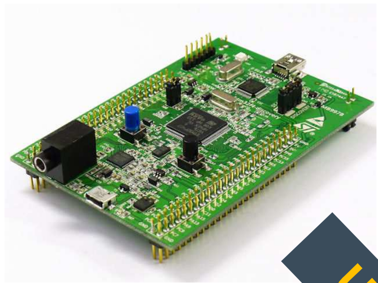
4th Motorcycle simulator

Sensors

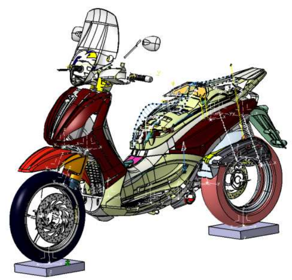
Different sensors have been mounted on the scooter in order to read the input given by the simulator rider

Motorcycle Sensors



UDP

Multibody Model



- Front brake encoder
- Rear brake encoder
- Throttle encoder
- Steering encoder
- Torque sensor
- IMU

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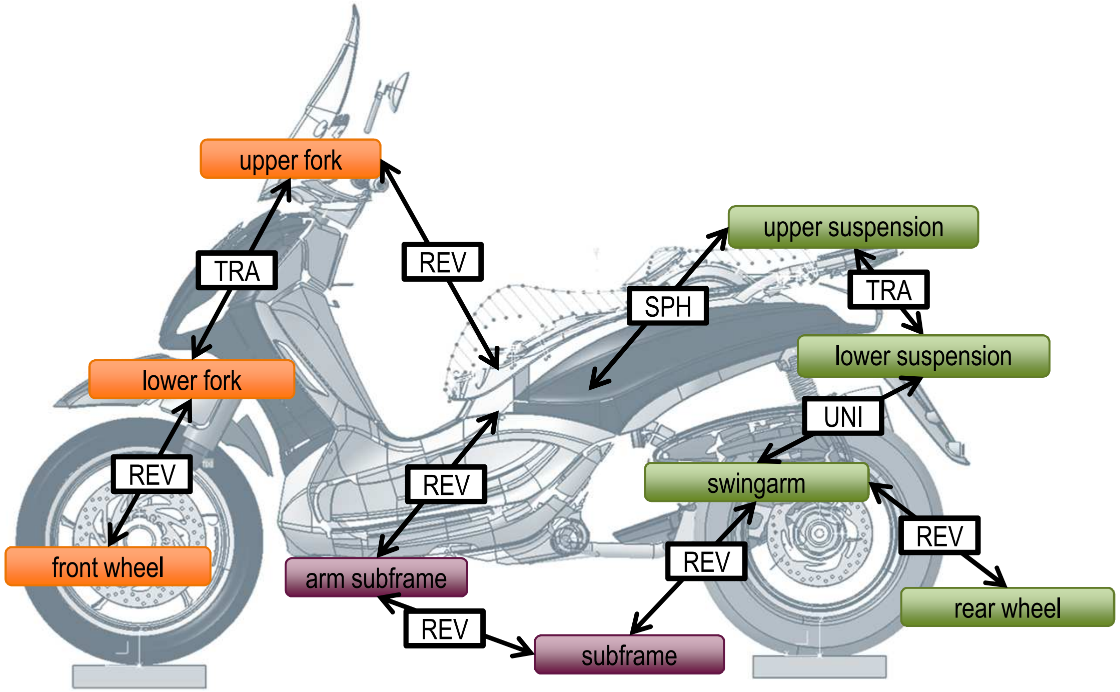
4th Motorcycle simulator

Description of the model

- High-fidelity model in **LMS Virtual.Lab Motion**
- Model realized in collaboration with the manufacturer
- Rigid bodies connected with ideal joints
- Nonlinear stiffness and damping curves
- Estimated tires parameters
- 17 bodies
- 18 joints

➢ **13 DOF**



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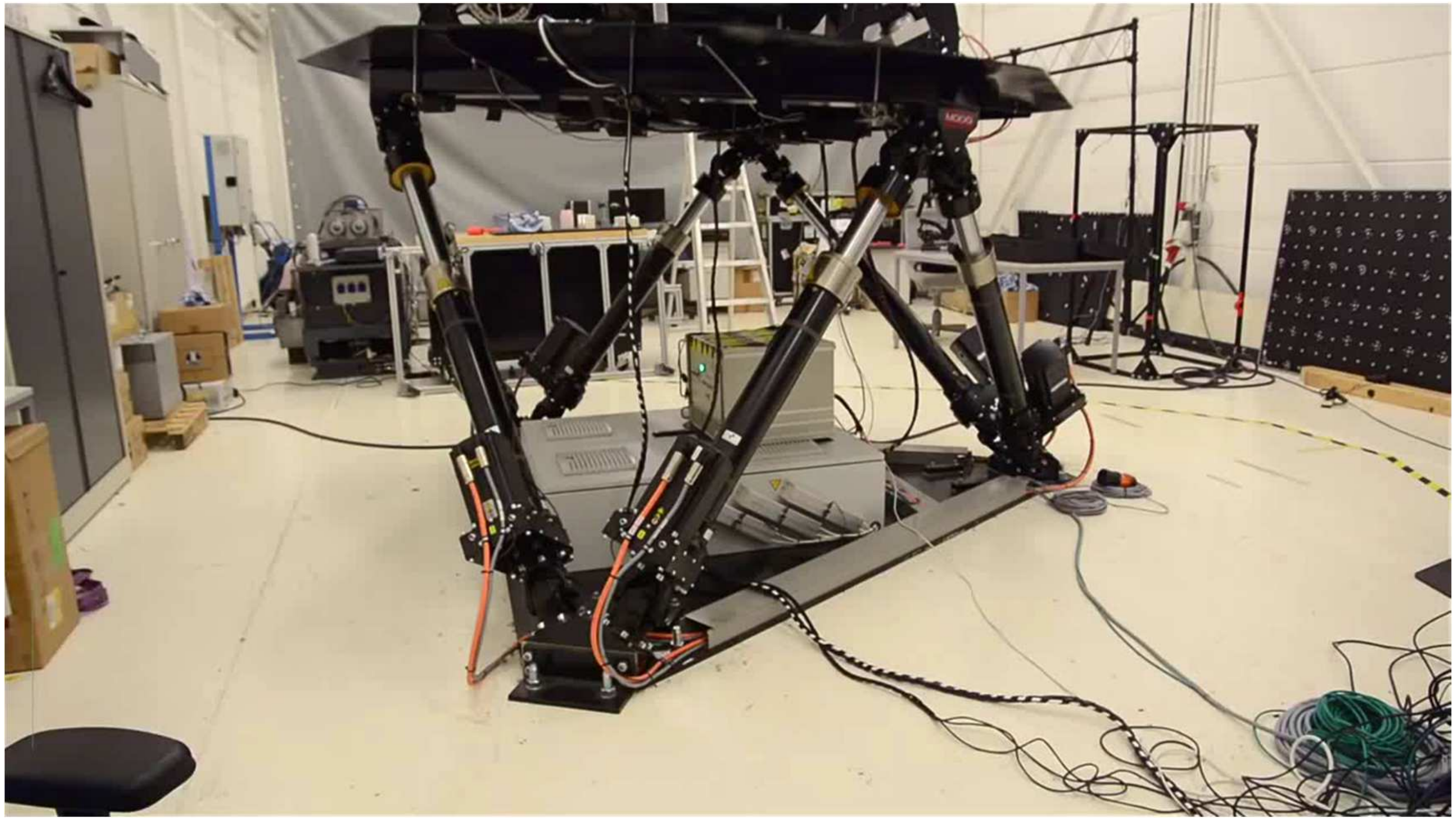
4th Motorcycle simulator

Video



Engineers responsible for the project are :

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Conclusion

Results & future work

- **Fixed base bicycle simulator**

1. *Rider can balance and manoeuvre ✓
2. Compare rider response between different situations with data obtained from naturalistic studies, or instrumented bicycle studies

- **Steer by wire bicycle**

1. Complete testing of peripherals ✓
2. Evaluate system performance (Siltesting)

- **Bicycle mock up**

1. Testing & calibrations of sensors completed✓
2. Evaluate excitation magnitudes & frequencies based on rider comfort

- **Motorcycle simulator**
- Validate acceleration/deceleration & braking behaviour✓
- Evaluating different motion cueing algorithms

*Screen vs oculus showed that with oculus the perception of roll is two strong participants had the behaviour to roll off the fixed bike frame

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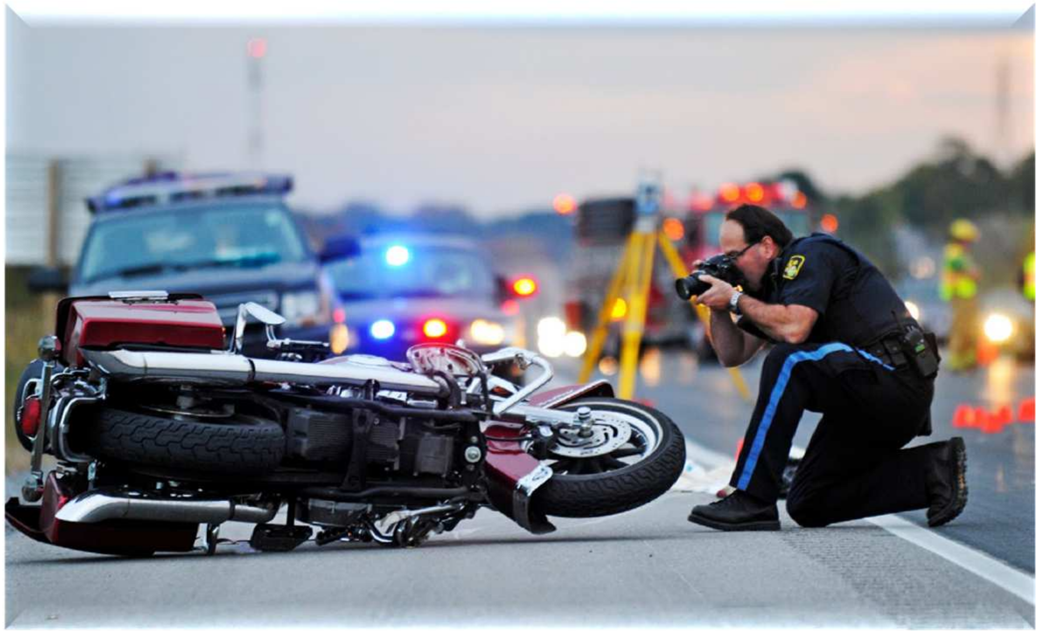
Safety aspects
Final goal

- **What the impact of this technology to our society?**

- Improving training techniques
- Creating active safety systems **"steering assistance"**
- Improving human machine collaboration **"Handling qualities"**

"Contributing to Safer Motorcycle Mobility"



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Thank you for your attention!!!

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