A laboratory treadmill for simulation of road surface induced vibrations in cycling

A4SEE Alliance for Sports Engineering Education

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Introduction

Background

Vibration dampening effects in bicycle (build) strucures as:

- performance determinating property
- potential health protecting measurement
- comfort aspect
- unique sales point

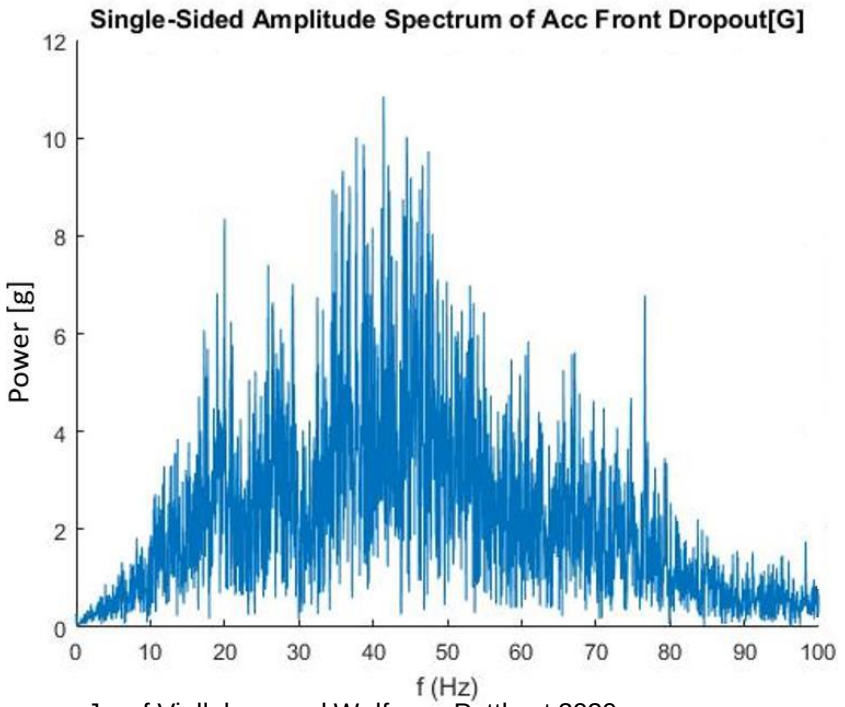
Introduction

Background

Demand on laboratory test designs for reprocucing field data.

Challenge of matching a simple up and down on a given surface with the complexity of a recorded frequency domain on eqipment attached acceleration sensors. (Josef Viellehner and Wolfgang Potthast 2020)

vs.



Josef Viellehner and Wolfgang Potthast 2020

Introduction

Background

Test designs available / established:

- trailer for field tests (Macdermid, Fink, & Stannard, 2015; Mark Oliemana, Raluca Marin-Perianua, Mihai Marin-Perianub, 2012)
- threadmill with dowels (Y. Champoux, S. Richard and J.-M. Drouet, 2007)
- stationary trainers (Petrone et al. (2015)
- shaker actuated bicycle (Lépine, Champoux, & Drouet, 2015)

Introduction

Research question

How can field recorded / riding relevant characteristics be transferred to a laboratory test and match the quality standards for test designs:

- repeatability
- reproducibility
- validity

Does it feel right? Does it feel like actual riding?

How close is the feel it to actual riding

Introduction

Research question

How does it feel like?

- fixed bikes on an actuator
- balancing
- inertia
- coasting
- steering

To what level can a required test jig be set up to provide an objective quantifying test design?

- what to measure
- with which sensors
- at what interfaces

Materials & Methods

Test rig development

Design / Engineering approach

- Planning
- Conception
- Design / Engineering
- Elaboration / Initial proof of functionality / Initial Subjective Ride and Feel tests

Materials & Methods

Planning

Finding a feasible driver set up matching the test requirements, budget and infrastructure

- energy uptake
- frequency / amplitude / stroke
- available sources / supplies
- media / energy supplies
- budget

Match the ride feel with field experience as good as possible

- unconstrained movement for rider
- field like pedalling / coasting

Materials & Methods

Actuation Requirements

Test rig actuation

Pneumatic actuators

- ≥1.500 N per platform
- up to 25 mm stroke
- up to 25 Hz

FESTO

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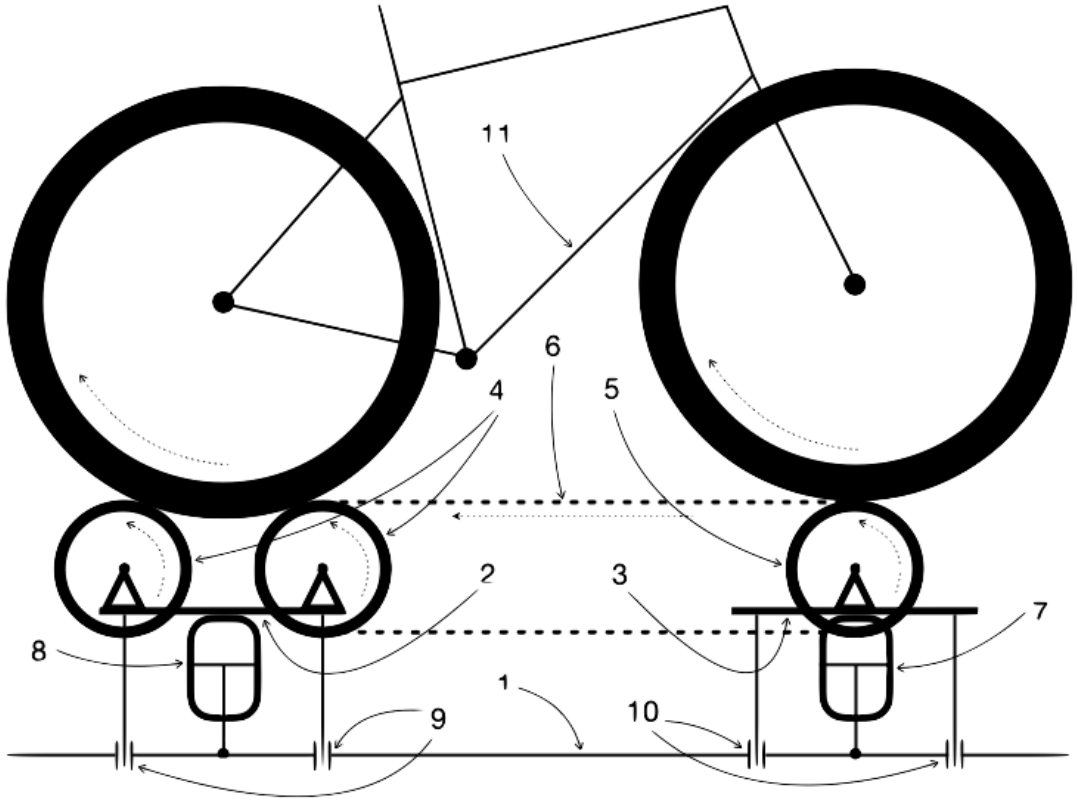
Materials & Methods

Conception

Planning / Feature List

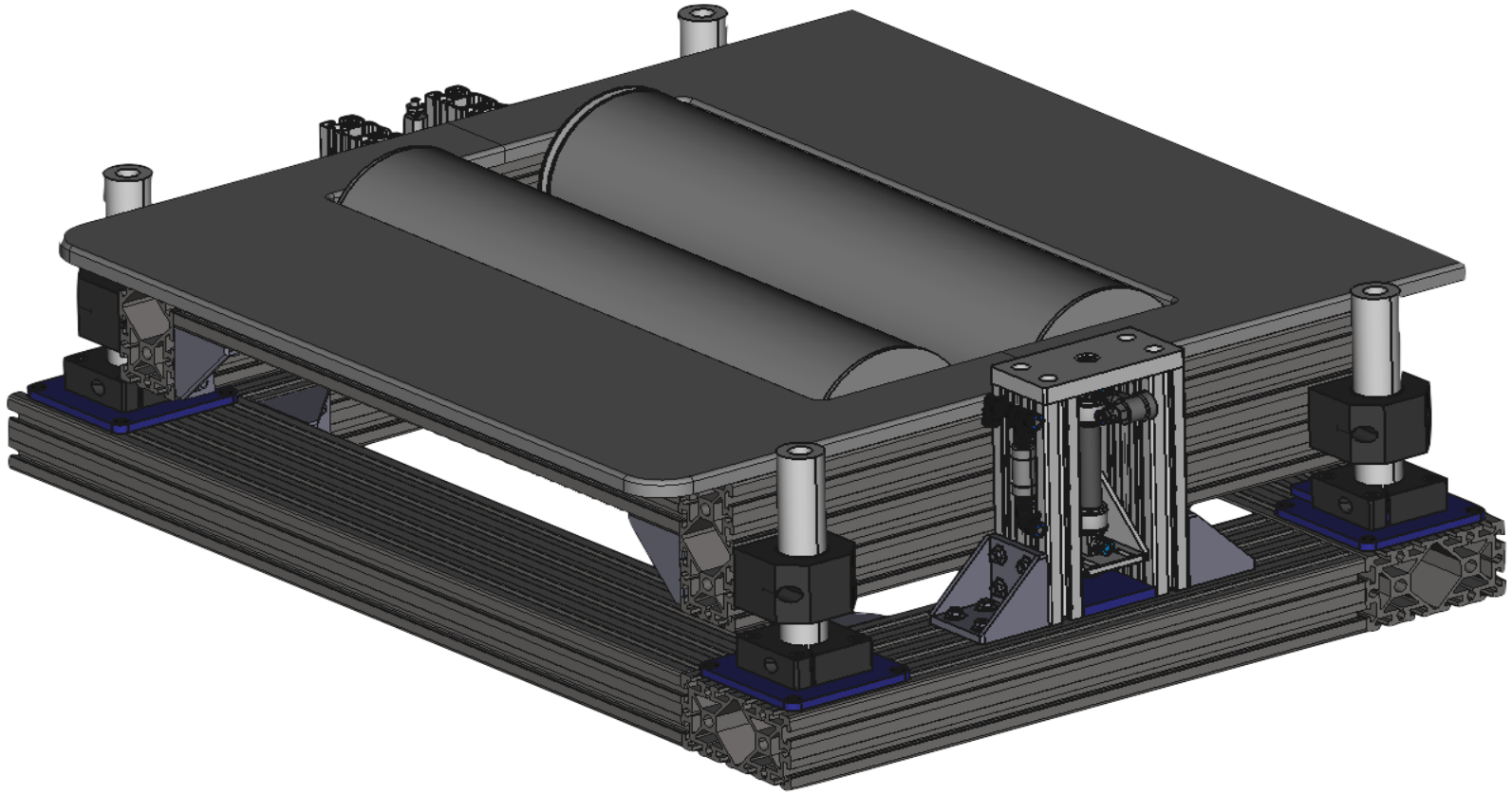
- individual support for front and rear wheel
- providing an actual ride feel
- option for and adjustable vibrational excitation
- stationary
- measurement of relevant parameters
- adjustable to different bicycles
- meeting safety requirements
- manageable by test riders after “get used to” period



Materials & Methods

Design / Engineering

2 platforms carrying a rider bicycle system (RBS). Excitation is done by 2 pneumatic drivers for each platform, adjustable in amplitude and frequency

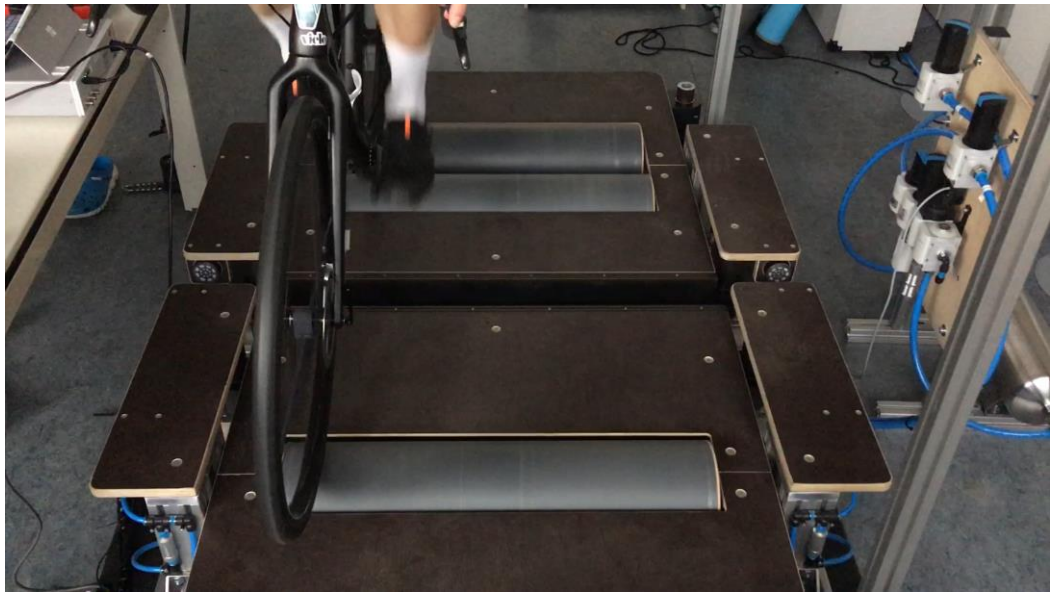


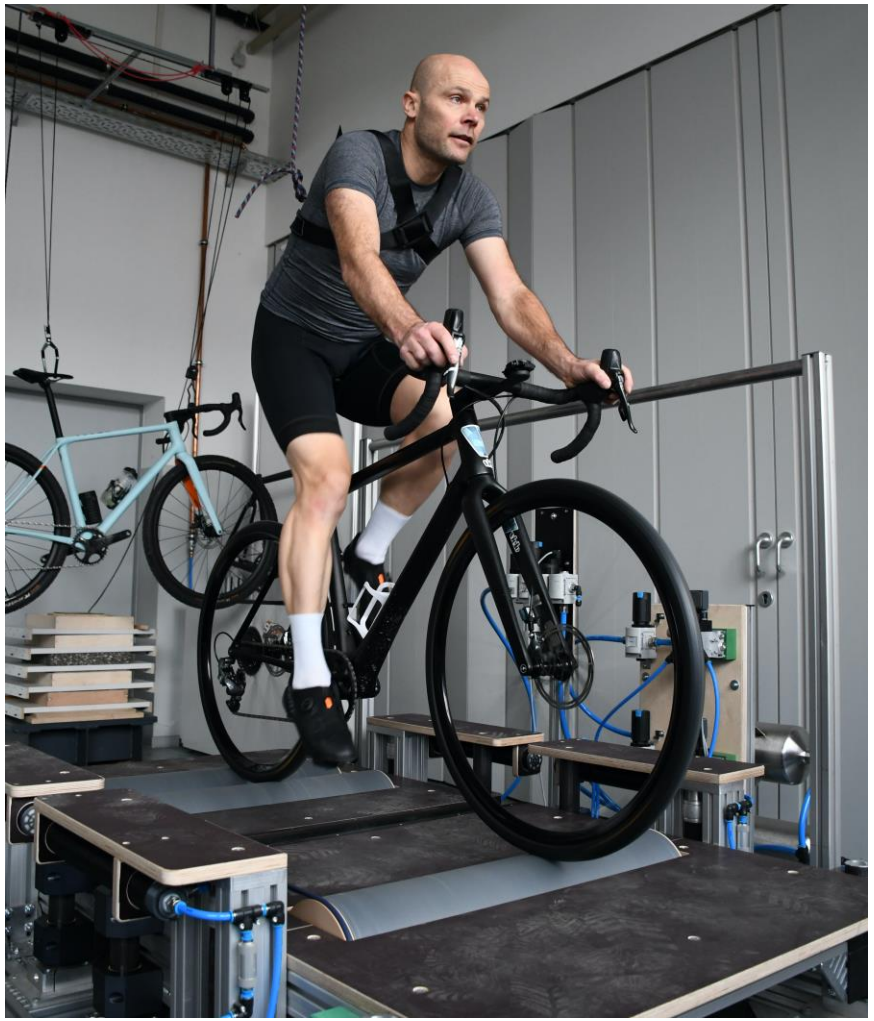
Materials & Methods

Initial Ride and Feel Tests (Subjective Evaluation)

Evaluating the ride feel first, assessing perception of:

- degree of freedom in rider movement
- coasting capabilities
- riding stability
- vibration

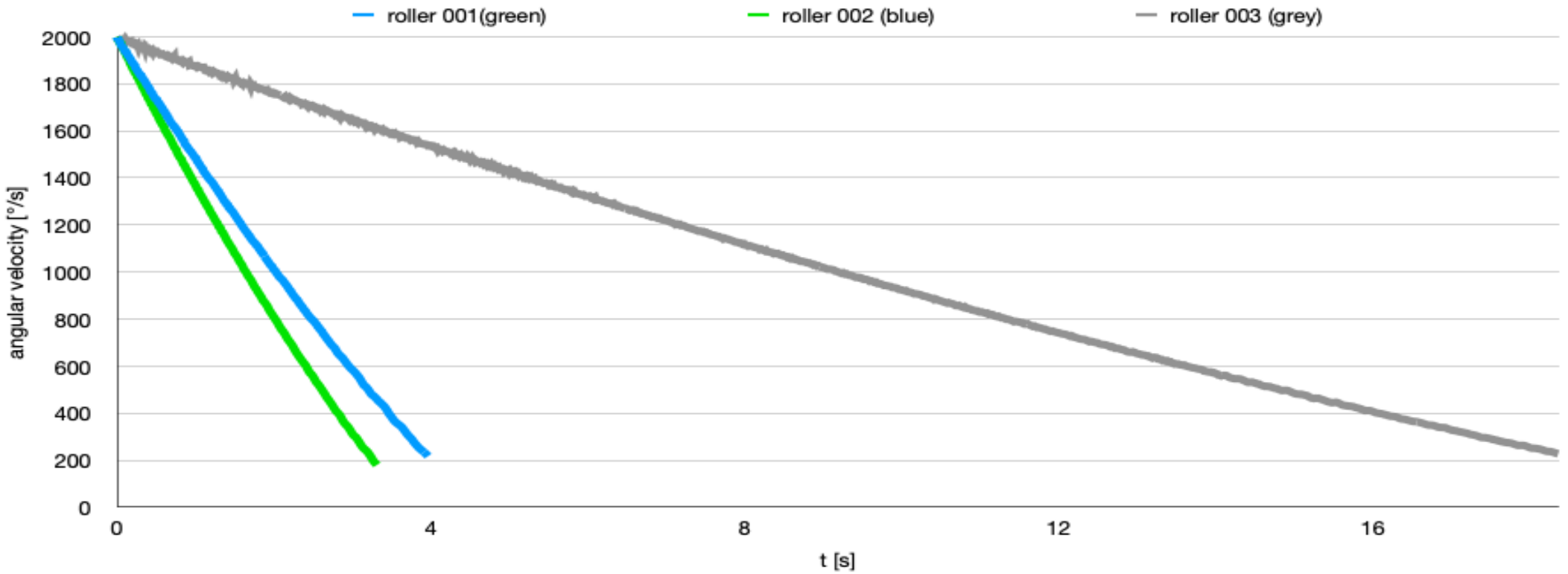




Discussion

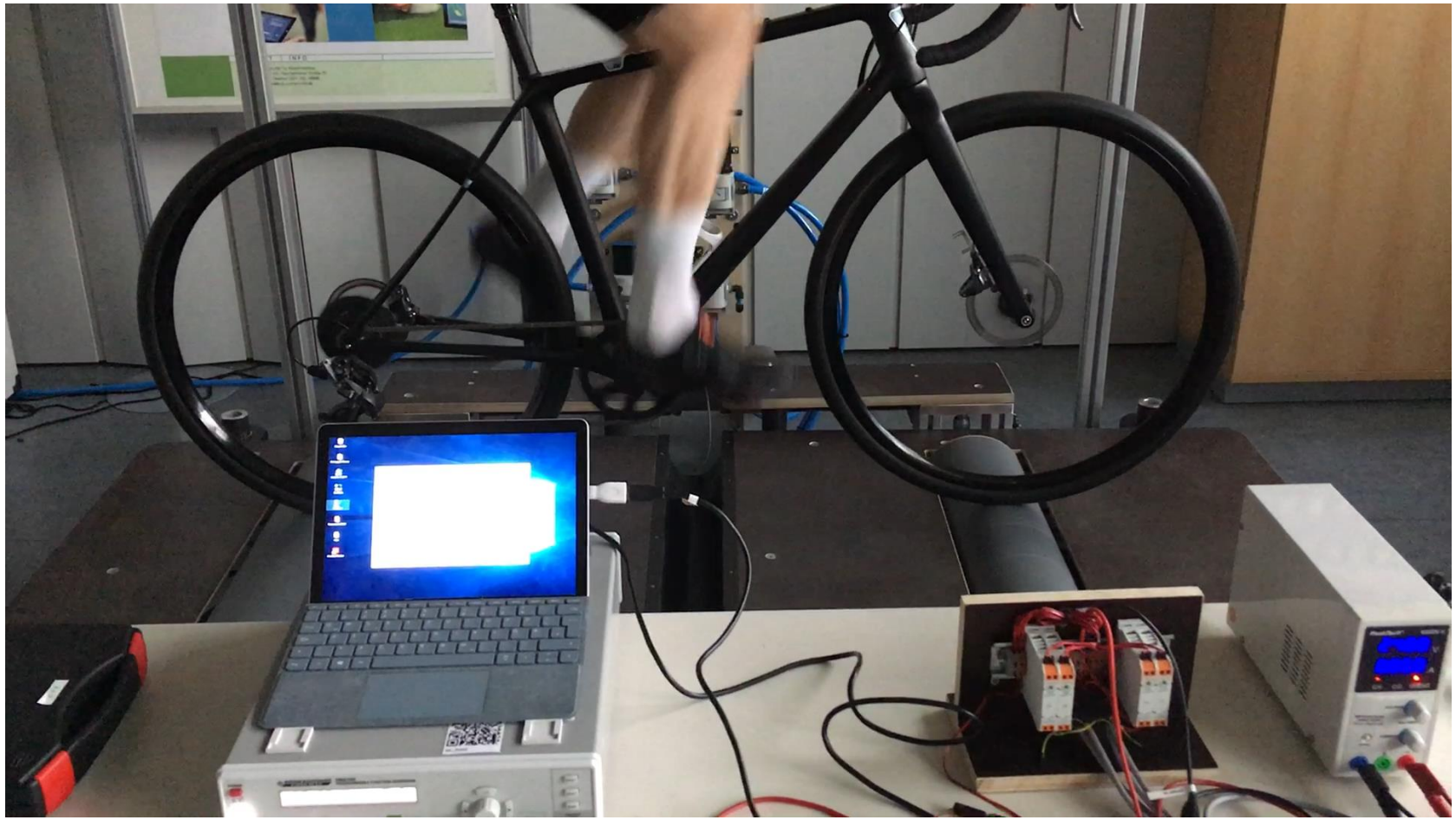
Coast out properties, riding feel / experience

Data snapshot of (proof of concept) coast out benchmark test



Discussion

Coast out properties, riding experience



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Practical applications

Bicycle / Bicycle component evaluation

Mechanic :

- efficiency in rolling
- transfer in vibration
- evaluation of vibration induced material wear

Biomechanic:

- evaluation of vibration induced rider fatigue
- biomechanical adaption of riders to vibration

Psycological:

- rider awareness, predictability, anticipation

Future outlook

Test design improvements

Development of transfer method of field measured data to test jig controls

Implementation of measurement equipment for controls (test jig related) and data collection (test related) such as 3d motion capturing

Set up of “standard” surface conditions: Tarmac, Gravel, Tiles, Cobble Stones

Usability updates (debugging): roundness of drums, electrostatic decoupling

Future outlook

Test design application

Tuned to Application / Tuned to Rider Bicycle setups

- air pressure
- tyre dimension
- frame

Tuned to customer products

- tube topology
- layup option
- material selection

Evaluation of physiological effects of vibration

… to be updated

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