ASIC USE CASE & RELATED WORK VIRTUAL PHYSIOLOGICAL HUMAN (VPH)

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HEAD OF HIGH PRODUCTIVITY DATA PROCESSING & CROSS-SECTIONAL TEAM DEEP LEARNING
18TH FEBRUARY SMITH ASIC AG2 WORKSHOP, RWTH UNIVERSITY CLINIC AACHEN, GERMANY

SMITH Smart Medical Information Technology for Healthcare
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES
DEEP Projects
RDA RESEARCH DATA ALLIANCE
UNIVERSITY OF ICELAND
SCHOOL OF ENGINEERING AND NATURAL SCIENCES
FACULTY OF INDUSTRIAL ENGINEERING, MECHANICAL ENGINEERING AND COMPUTER SCIENCE
JÜLICH Forschungszentrum
JÜLICH SUPERCOMPUTING CENTRE

JUELICH SUPERCOMPUTING CENTRE (JSC) OF FZJ

Simulation & Data Labs (SDL) using High Performance Computing (HPC)

Research Group High Productivity Data Processing

Research Groups

Communities (e.g. remote sensing & health)

RDA RESEARCH DATA ALLIANCE

Smart Data Innovation Lab

SMITH Smart Medical Information Technology for Healthcare

DEEP-EST EU PROJECT

Domain-specific SDLs

Simulation Labs

Cross-Sectional Team Deep Learning

Cross-Sectional Teams

Data Life Cycle Labs

Exascale co-Design

PADC

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JÜLICH Forschungszentrum | JÜLICH SUPERCOMPUTING CENTRE

ON4OFF

Landsvirkjun National Power Company of Iceland

SOCCERWATCH BETA

Modular Supercomputer JURECA

Facilities

Modular Supercomputer JUWELS

Industry Relations Team

ASIC USE CASE – OVERVIEW

- SMITH ASIC Use Case
  - ASIC: Algorithmic Surveillance of Intensive Care Unit (ICU) Patients & Focus on Acute Respiratory Distress Syndrome (ARDS)
  - University Clinic Aachen (UKA): Machine Learning for patient stratification & virtual ICU patient & risk patterns
  - FZJ: Parallel & Scalable Machine Learning & Statistical Modelling via HPC
  - Bayer AG: clinical trial optimization in prevention studies & virtual ICU patients & organ models

UKA-Schuppert	FZJ-Riedel	Bayer-Lippert	UKA-Haferkamp
Phänotypen Identifikation und Integration in PheP VP Identifikation und Integration in das ASIC Expertensystem (WP 5/6/8)	Phänotypen und VP Identifikation und Modellreduktion (WP 5/8)	VP Identifizierung, Erstellung des VP Modells und Validierung Patienten Subgruppen-Stratifizierung (WP 6, 8)	DIZ-Datenverfügbarkeit Anbindung Forschungsdatenbank

[1] SMITH Project Web Page

[2] SMITH Methods Journal

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ASIC USE CASE – MECHANISTIC MODELING & ML

SMITH Smart Medical Information Technology for Healthcare

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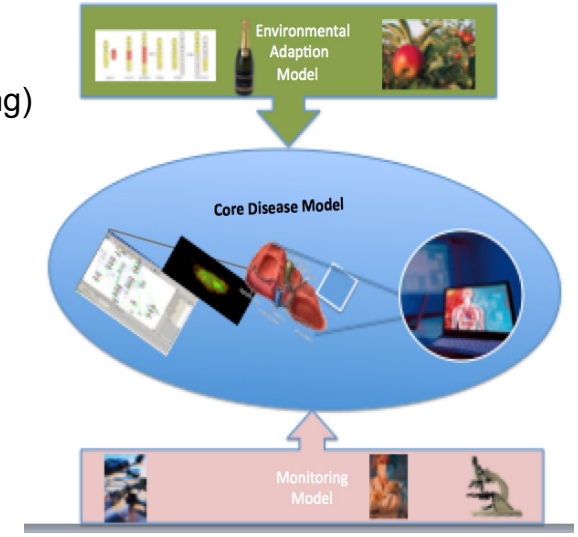
MEDIZIN INFORMATIK INITIATIVE

UNIKLINIK RWTH AACHEN | ukb universitäts klinikum bonn | UKD Universitätsklinikum Düsseldorf | Universitätsklinikum Essen

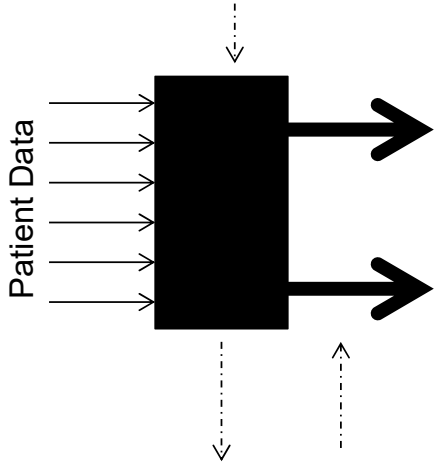
Patient + state paramters:
individualisation (Machine Learning)

generic model (mechanistic)



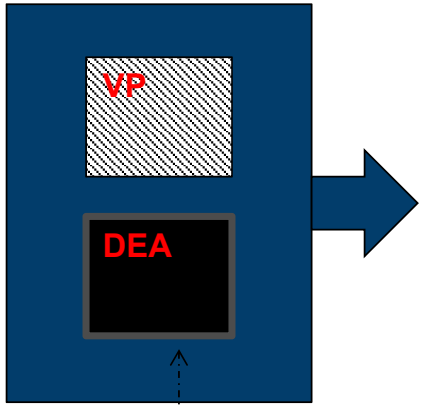
adaption of generic model to available data (Machine Learning)

Unsupervised Patient Stratification
- Dynamic clustering
- Critical state detection



Patient subgroups & classifiers

Predictive modelling Machine for Algorithmic Surveillance of ICU Patients



Machine Learning, Patient association, Subgroup specific prediction

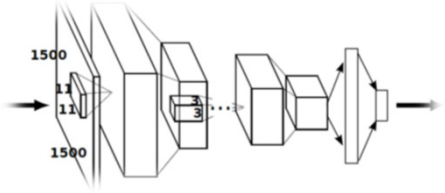
Prognosis for Individual patient

UNCERTAINTY QUANTIFICATION & DEEP LEARNING

Smart Medical Information Technology for Healthcare

- MCMC with VP models
  - 1 run for a patient ~ 2 sec (1 core)
  - 10^6 runs required for MCMC
  - 1 patient ~ 1000 core-h
  - Good news: 100% parallel → nice scalability and useful for booster
  - More data is helpful for more concrete feature selection w.r.t. ARDS
- Compute-intensive part of the Virtual patient model will be mapped onto a deep-learning (DL) network
  - DL-network has is numerically hard to train, but fast to simulate
  - Mapping strategy has been evaluated and applied at partner Bayer
  - Requires HPC (scanning of the full parameter space)

- **Markov Chains Monte Carlo (MCMC) with Virtual Patient models**
- **In clinical practise not feasible with today's computer technology => model reduction is necessary**
- **Virtual Patient (VP) model mapped into a deep learning network**



RELATED WORK VIRTUAL PHYSIOLOGICAL HUMAN

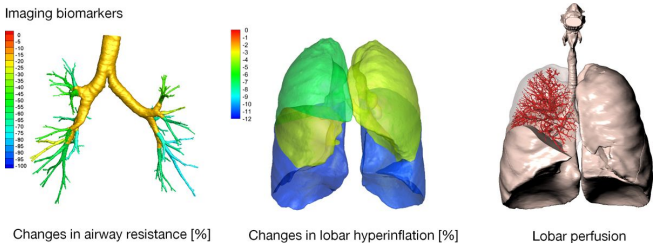
- Virtual Physiological Human (VPH) Institute
  - The Physiome project started in 1997 with the aim of developing a framework for modeling the entire human body
  - E.g. VPH models are the organ systems that have the best biophysical characterisation: the cardiovascular and respiratory system, and the neuromotor and musculoskeletal system, etc.
  - VPH had a long tradition in EC projects (FP6, FP7, …)
  - Sustainable Belgium non-profit organization as VPH – Institute

[6] Physiome Web Page

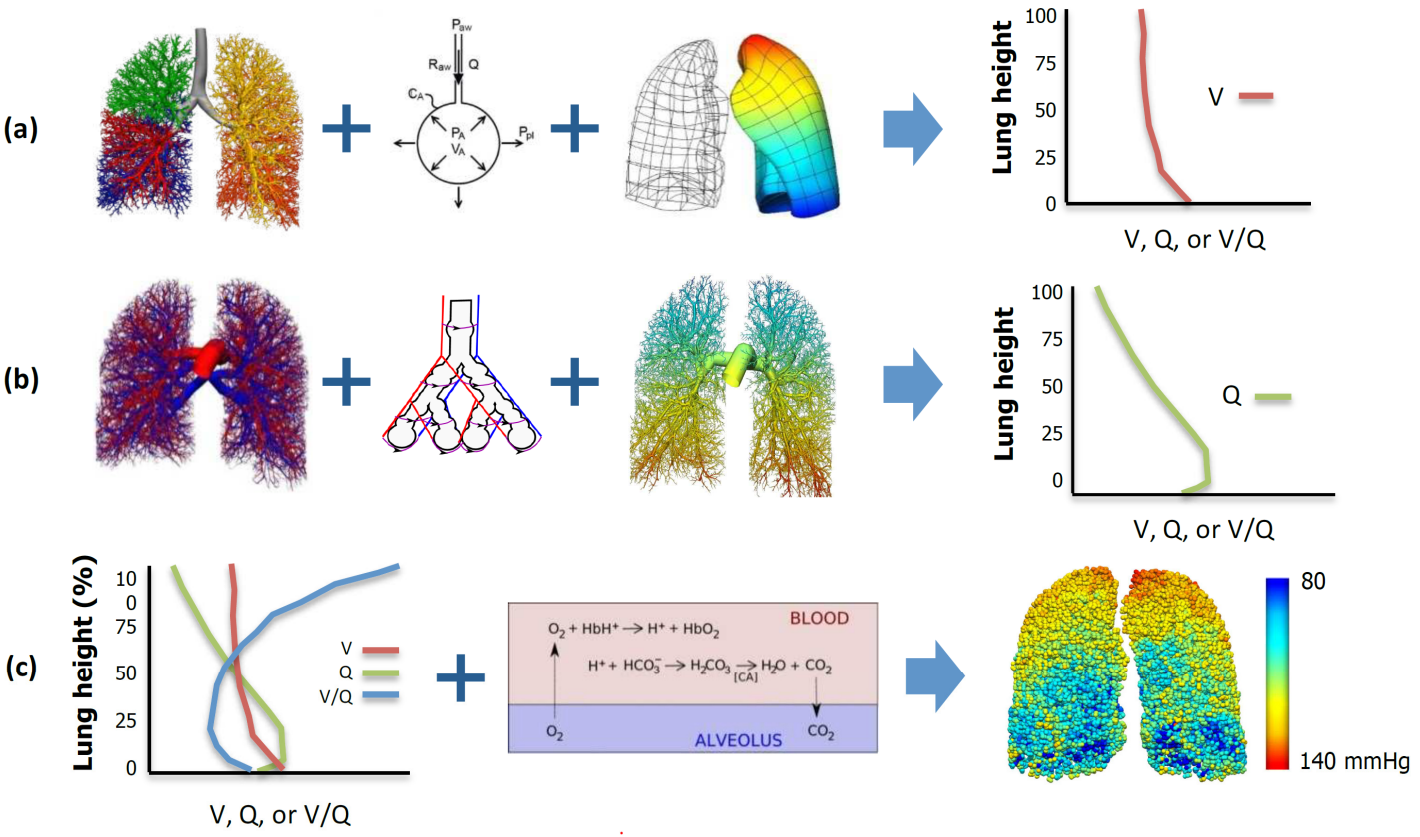
[3] VPH-Institute Web Page

[7] Kelly Suzanne Burrowes et al., 'Computational modeling of the obstructive lung diseases asthma and COPD', 2014

- Several articles point to work in context to lungs
  - E.g. a project on modelling respiratory biomechanics for the diagnosis and treatment of COPD and asthma



RELATED WORK VIRTUAL PHYSIOLOGICAL HUMAN



[8] M. Viceconti, P. Hunter, 'The Virtual Physiological Human: Ten Years After', 2016

POTENTIAL COLLABORATION & PREVIOUS WORK

SMITH
Smart Medical Information Technology for Healthcare

- Collaboration with Prof. Peter Coveney
  - Prof. Coveney is one of the drivers of VPH using HPC
  - Published together in XSEDE, PRACE, DEISA, e.g. brain blood flow models (HemeLB code) ~2010

[4] M. Riedel, P. Coveney et al., 'Exploring the Potential of Using Multiple e-Science Infrastructures with Emerging Open Standards-Based E-Health Research Tools', 2010

  - Later working together in European Data Infrastructure EUDAT

[5] M.Riedel, P. Coveney et al., 'A Data Infrastructure Reference Model with Applications: Towards Realization of a ScienceTube Vision with a Data Replication Service', 2013

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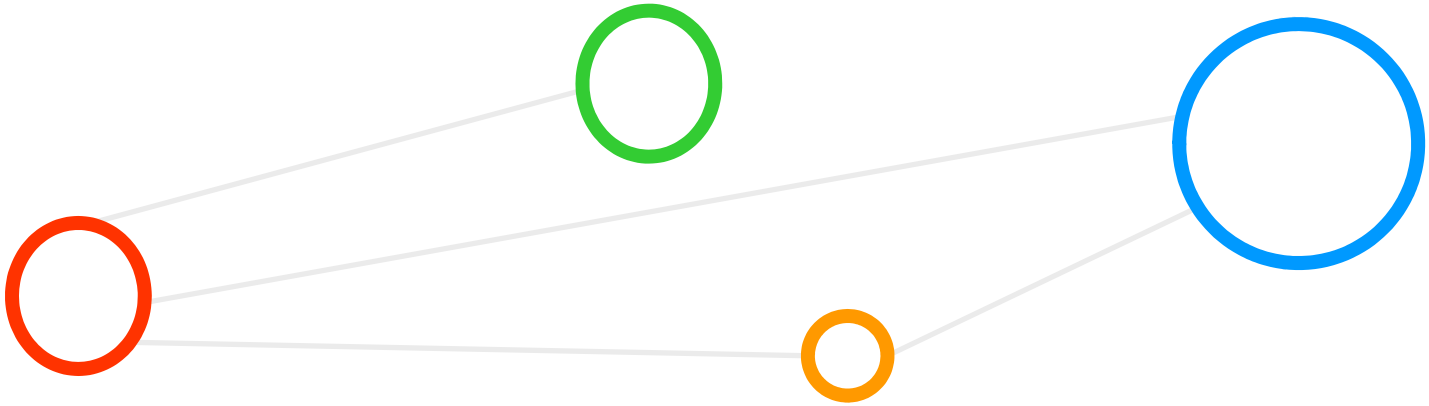

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- [3] Virtual Physiological Human (VPH) – Institute,
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- [5] Riedel, M., Wittenburg, P., Reetz, J., van de Sanden, M., Rybicki, J., von St. Vieth, B., Fiameni, G., Mariani, G., Michelini, A., Cacciari, C., Elbers, W., Broeder, D., Verkerk, R., Erastova, E., Lautenschlaeger, M., Budig, R., Thielmann, H., Coveney, P., Zasada, S., Haidar, A., Buechner, O., Manzano, C., Memon, A.S., Memon, M.S., Helin, H., Suhonen, J., Lecarpentier, D., Koski, K., Lippert, T.: A Data Infrastructure Reference Model with Applications: Towards Realization of a ScienceTube Vision with a Data Replication Service, Springer Journal of Internet Services and Applications, Vol 4 (1), 2013, DOI: https://doi.org/10.1186/1869-0238-4-1

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- **[7] Kelly Suzanne Burrowes, Tom Doel, Chris Brightling, ,'Computational modeling of the obstructive lung diseases asthma and COPD', 2014,**
  Online: https://doi.org/10.1186/1479-5876-12-S2-S5
- **[8] Marco Viceconti, Peter Hunter, 'The Virtual Physiological Human: Ten Years After', Annual Review of Biomedical Engineering, Vol 18, 2016**
  Online: https://doi.org/10.1146/annurev-bioeng-110915-114742

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Previous & current members of the High Productivity Data Processing Research Group

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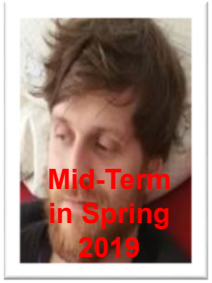

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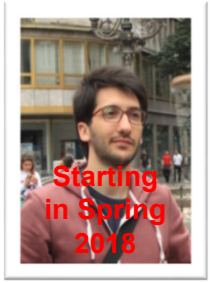

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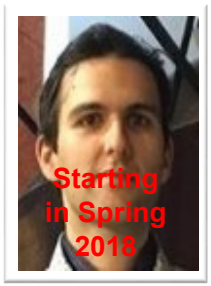

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Talk shortly available under www.morrisriedel.de