

# Approaches to integrated medical technology development

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# Background

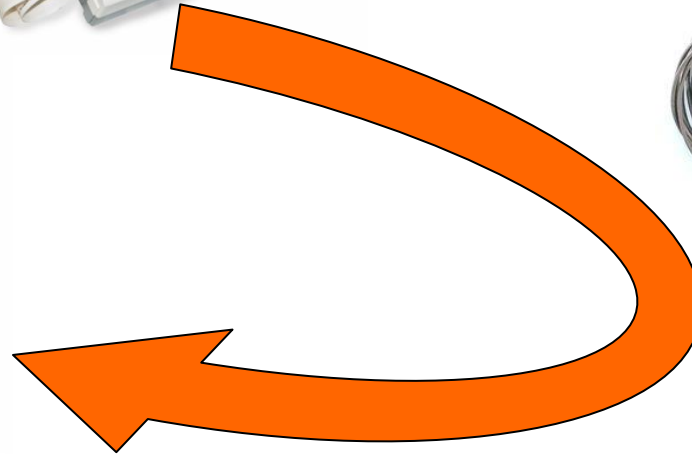


[HP1]



[HP2]

[HP5]



[HP4]



[HP3]

- Status quo
  - Clinical examinations are the backbone of today's medical supply
  - A single diagnostics can require multiple steps

# Background

- Current limitations
  - High costs (equipment and staff)
  - Availability of (qualified) staff is a bottle neck
  - Troublesome to patients (scheduling difficult, examination situation is stress to patients)
  - Personal desire for „continuous“ healthcare
- Current observation: shift from a row of single (complex) examinations to a continuous approach (domestic, ambulatory) → **integrated medical technology**
- Close relation to the field of ambient assisted living

## Topic

# Approaches to integrated medical technology

[HP6]



[HP7]

# Contents

- From clinical to domestic technologies
- From univariate to multivariate
- From intuitive to inductive
- From reactive to predictive
- Valuation – projects, current state and prognosis
- Summary

# From clinical to domestic technologies

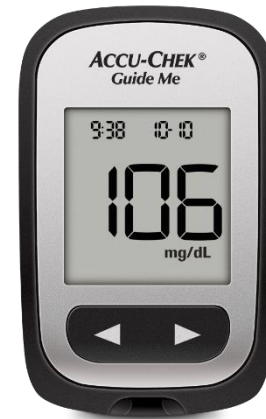
# From clinical to domestic technologies - concept

- Today's medical technology is optimized for clinical use (expensive, experts required, eventually invasive)
- Current approach requires novel technologies for physiological measurements
  - Affordable (large scale usage)
  - Easy to use
  - Harmless to the patient (non-invasive or imperceptible)
- Technological approaches
  - „Established“ technologies used at home
  - Wearables
  - Non-contact technologies
  - Implants



# From clinical to domestic technologies - realizations

- „Established“ technologies used at home
  - Content: measurement of easy-to-get „standard“ parameters
  - Wireless connection and system integration
  - Various platforms to integrate information
  - Many „big players“
  - Detailed information via continua (Personal connected health alliance, <http://www.pchalliance.org/>)



[HP8]



# From clinical to domestic technologies - realizations

- Wearables and ambulatory hardware
  - Various techniques available
  - Conventional parameters (most often heart rate, respiration, motion) (see e.g. [Wang2017])
  - Large impact via wellness and fitness applications



[Wiklund2007]

[HP9]

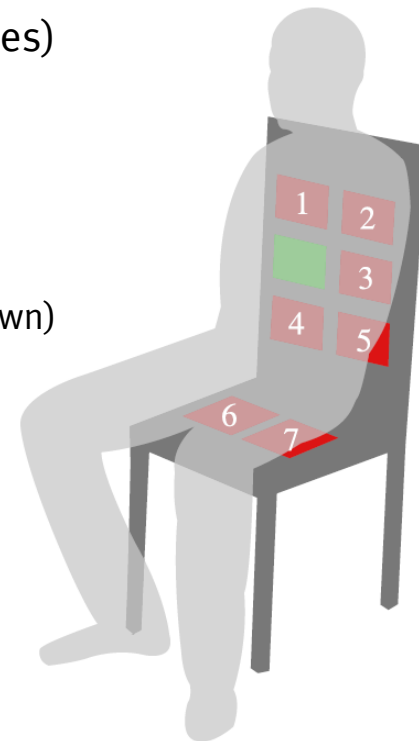
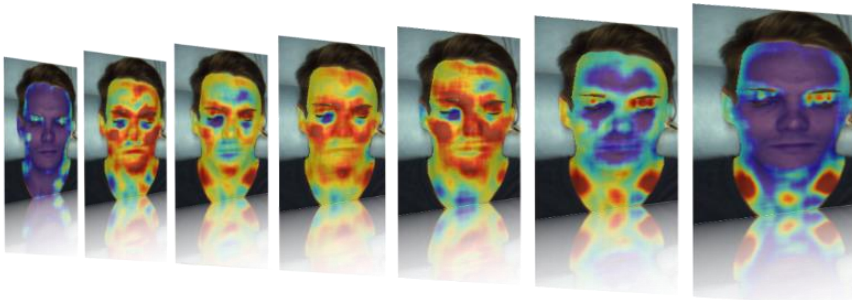


ASUS Vivo watch for ECG, PPG and thus blood pressure estimation (2018)



# From clinical to domestic technologies - realizations

- Integrated techniques (see lecture on contactless techniques)
  - Various techniques available
  - Innovative parameters available
  - Not-yet established
- Implants
  - Today: used implants have extended capabilities (benefit shown)
  - Complex measures available
  - Also critical aspects, e.g. in combination with smartphones [Treskes2016]
  - Miniaturization features further spread

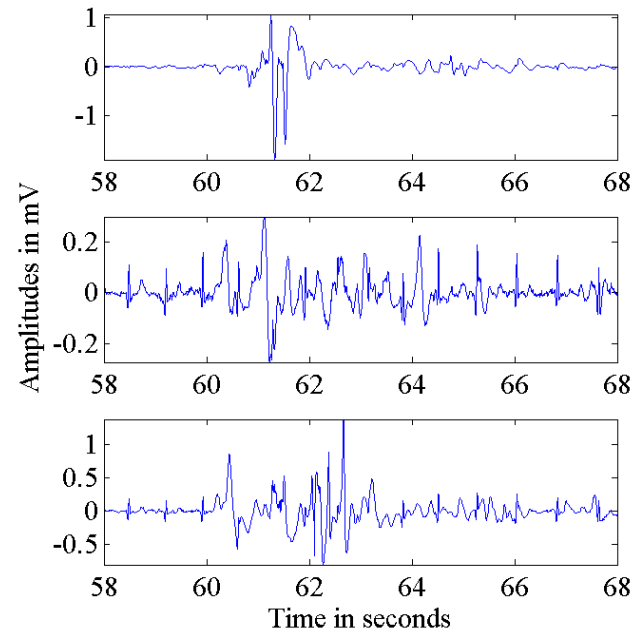
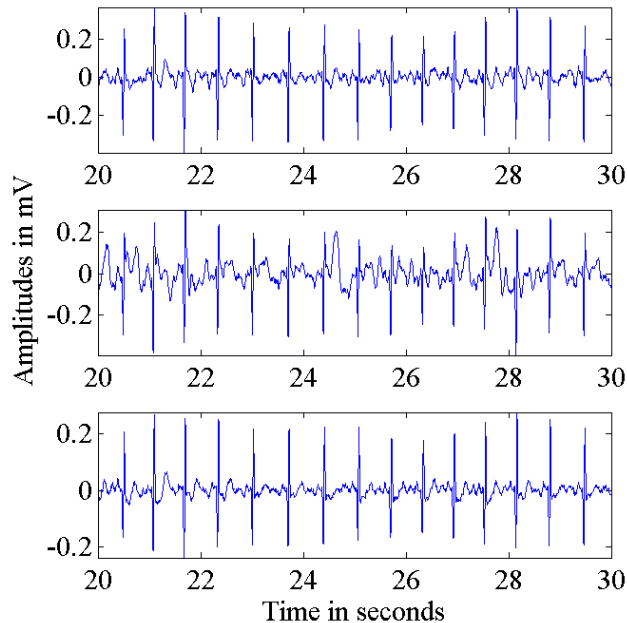


[Wedekind2018]

# From univariate to multivariate

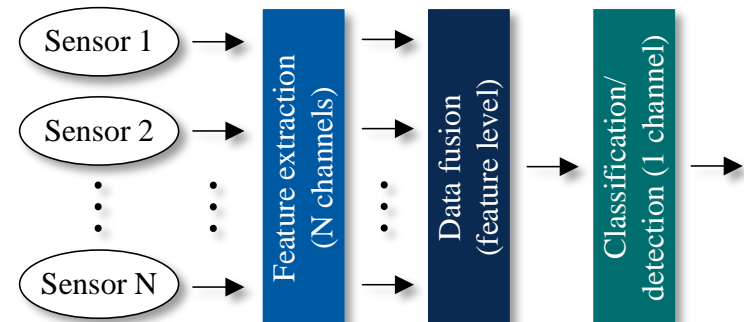
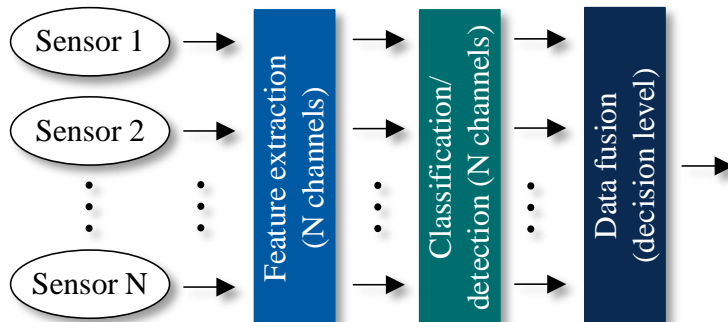
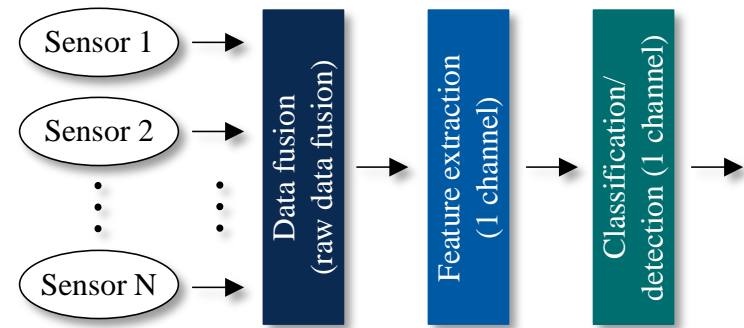
# From univariate to multivariate - concept

- In today's clinical practice examinations are carried out under defined and well controlled conditions → high quality of data
- In most cases: domestic technologies provide **less informative** and **highly distorted** measurements



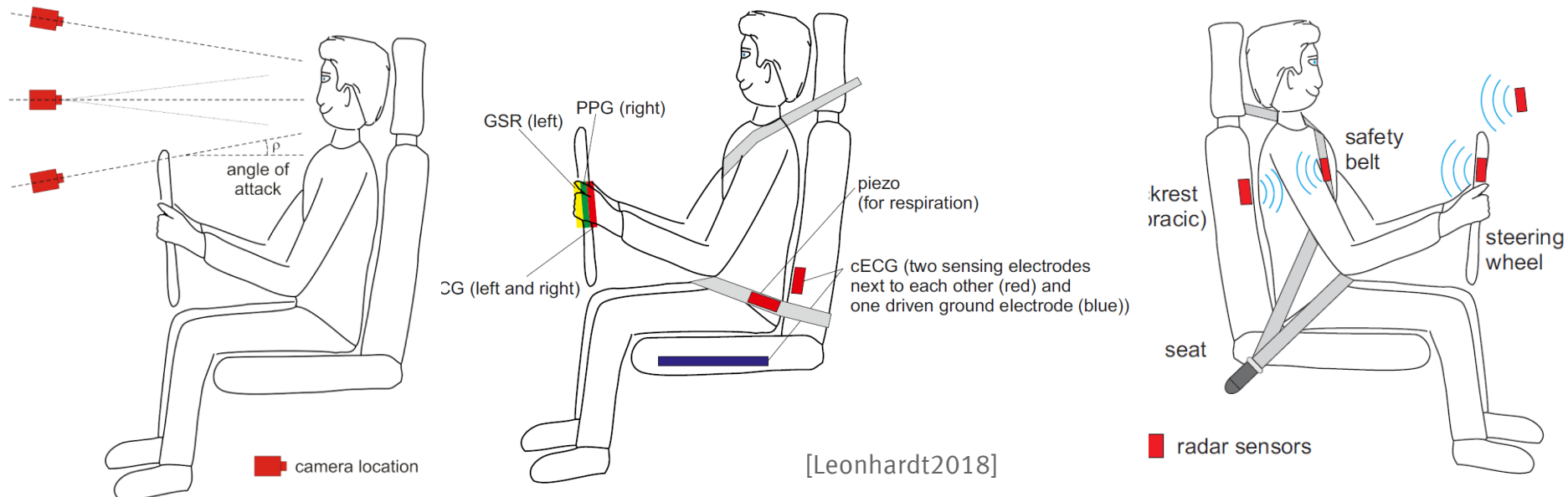
# From univariate to multivariate - concept

- Multivariate approaches can (partially) compensate for such disadvantage
- Sensor data fusion provides a framework
- Potential benefits
  - Make analysis more robust
  - Create a more comprehensive view (by considering different parameters from different modalities)
  - Derive additional parameters by combination of modalities



# From univariate to multivariate - realizations

- Example: driver's state monitoring
  - Make measurement more robust by redundant measurement systems
  - Combine complementary information and estimate additional parameters
  - Add Information of variable origin (not necessarily physiological measurements)



# From intuitive to inductive

# From intuitive to inductive – concept

- In today's clinical practice: very specific diagnostics → „intuitive“ measurement technologies are employed (e.g.: if you are interested in the ejection fraction, use a catheter and measure it)
- Though data fusion, discrepancy between available data and desired information in the integrated approach
- Shift towards „inductive“ procedures: “coarse” long term multivariate data and sophisticated processing methods are used to assess not measurable quantities



# From intuitive to inductive – concept

- Examples of inductive diagnostic approaches

Disease / task	Gold standard	Inductive approach (examples!)
Sleep disorders /sleep staging	Polysomnography (EEG, EOG, EMG, ...)	Sleep staging based on movement or heart rate (e.g. [Aktaruzzaman2015, Beattie2017])
Heart failure / determination or control of ejection fraction	Invasive, ultrasound	Photoplethysmographic morphology analysis [Elgendi2018]
Alzheimer / assessment of progression	Cognitive tests, imaging, laboratory	Daily life movement pattern analysis [Kirste2014]



# From reactive to predictive

# From reactive to predictive - concept

- Today's medical supplies are mostly reactive, i.e. actions take place upon decompensation or acute events
- Integrated medical technologies tries to avoid such situations → prediction and proactive action instead of reaction
- Basis: sophisticated algorithms, mostly machine learning based on multivariate data



# From reactive to predictive - realization

- Approaches for predictive medicine (note that most concepts today have been applied clinically because of the availability of data)

Goal	Used data	Reference
Prediction of sepsis	Biosignals, biomarker	[Calvert2016], [Nemati2018]
Risk of cardiovascular events	Biosignals, biomarker, demographic data, clinical data	[Weng2017]
Risk of readmission	Biosignals, biomarker	[Calvert2017]
Prediction of ventricular arrhythmia	Bioisgnals	[Lee2016]
<b>Prediction decompensation in heart failure</b>	<b>Biosignals</b>	<b>[Strehlik2018] *, [Aydemir2018]**</b>

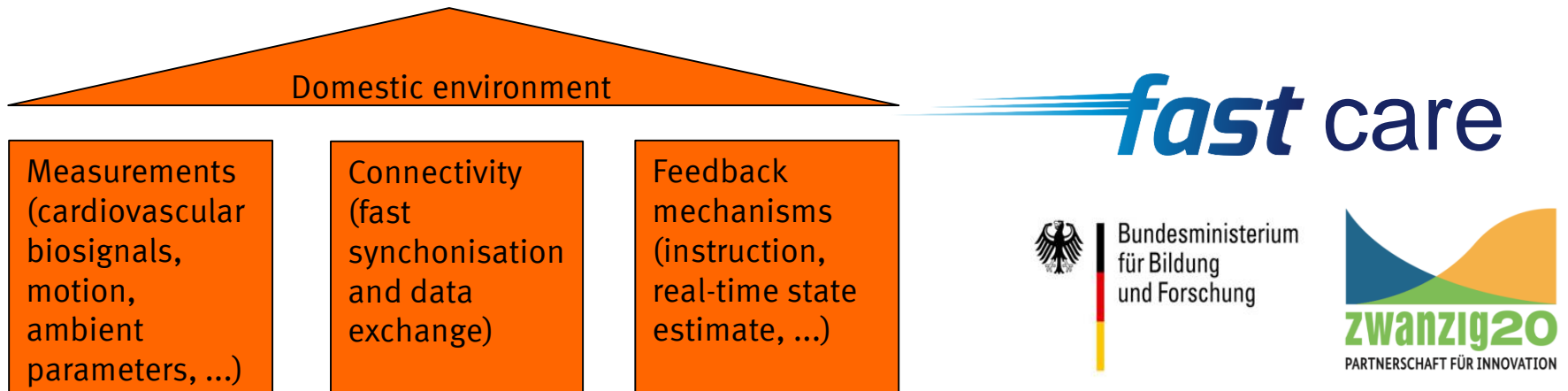
\* Continuous Wearable Monitoring Analytics Predict Heart Failure Decompensation: the Link-Hf Multi-Center Study

\*\* Ballistocardiography for Ambulatory Detection and Prediction of Heart Failure Decompensation

# Valuation – projects, current state and prognosis

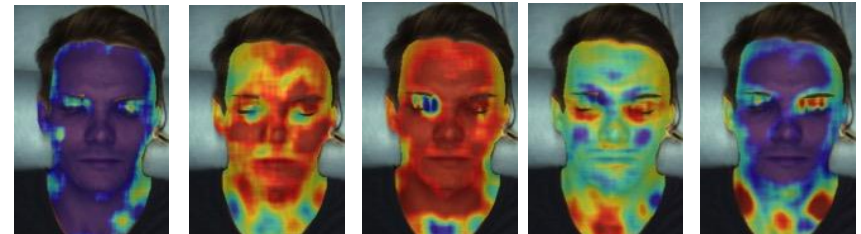
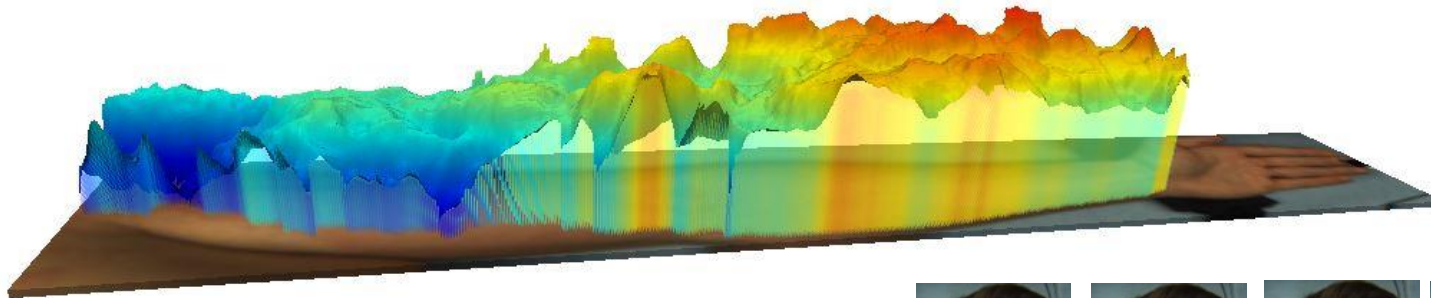
# Valuation - projects

- Today huge interest in novel approaches of medical care (and ambient assisted living)
- Exemplary project: FAST Care (Fast Sensor and actuators Technology)
  - Aim: setting up a domestic environment for integrated medical care
  - Partners: 8 partners (universities, industry)
  - Approach: multivariate monitoring
  - Population: elderly (unspecific, various diseases)
  - Evaluation: technically (test with volunteers under laboratory conditions)



# Valuation - projects

- Exemplary project: Domestic Health Station
  - Aim: optimize therapy based on frequent measurements at home
  - Partners: TU Dresden (IBMT, University hospital), industry
  - Approach: camera-based monitoring multiple times per day (conventional and novel parameters)
  - Population: hypertension/heart failure patients (living at home, receiving medication)
  - Evaluation: medical study



# Valuation - current state

- Many more projects, not only focusing on elderly and ill: e.g. prenatal care, prevention programs, ...; see e.g. <http://www.aal-europe.eu/our-projects/>
- Limitations
  - Many activities, but mostly research projects
  - (Commercial) exploitation often difficult
  - “Medical” validation and proof of benefit missing
  - Many projects are not realistic: Focus on single aspect and assuming laboratory condition, but reality means multimorbidity and extensive disturbances → here the network approach comes in
    - Avoid misinterpretation
    - Added value from interdependencies
  - Moreover, many aspects “not entirely” new, but were not successful previously

# Valuation - prognosis

[HP10]



Casio BP-100 for ECG, PPG and thus blood pressure estimation (1993)

Can an integrated approach  
now be successful?

[HP9]

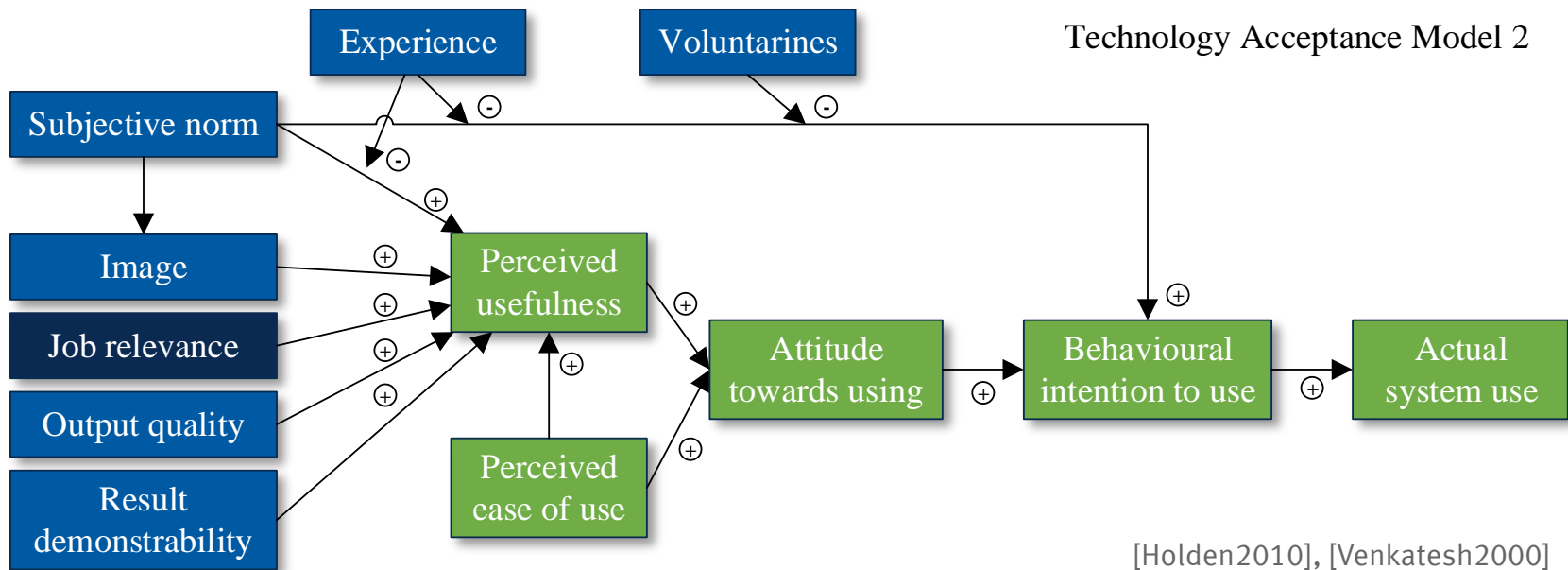


ASUS Vivo watch for ECG, PPG and thus blood pressure estimation (2018)



# Valuation - prognosis

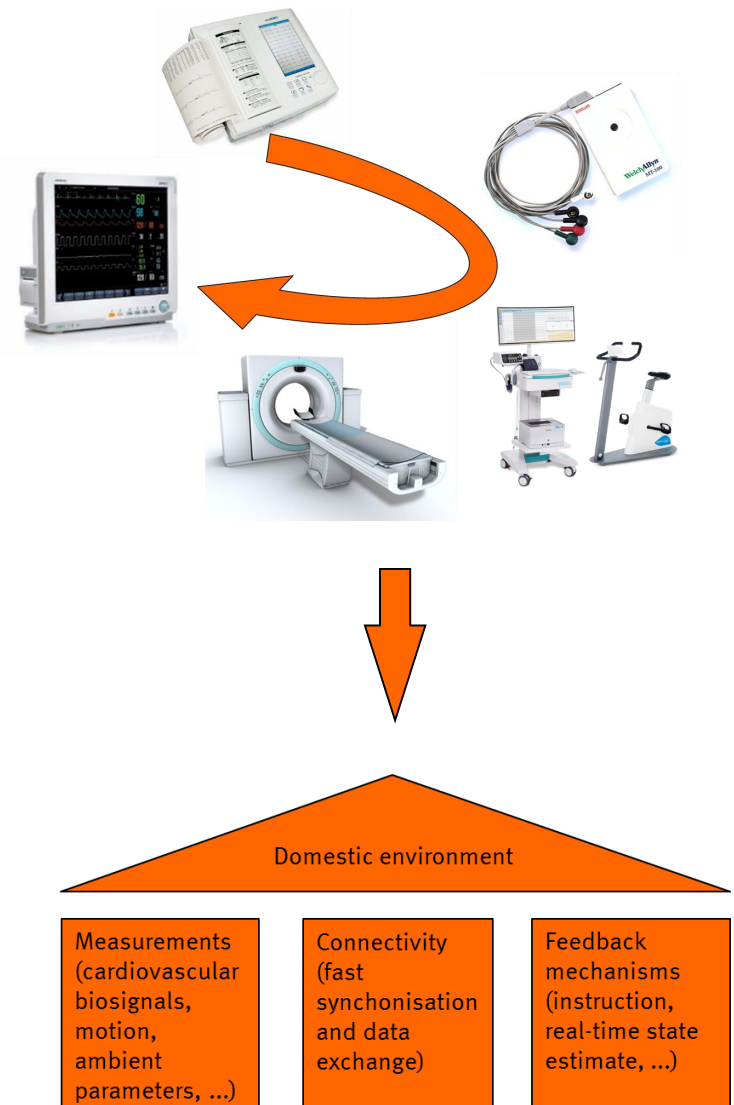
- ... i believe: yes
- „When will a technology be successful?“ → Technology Acceptance Model

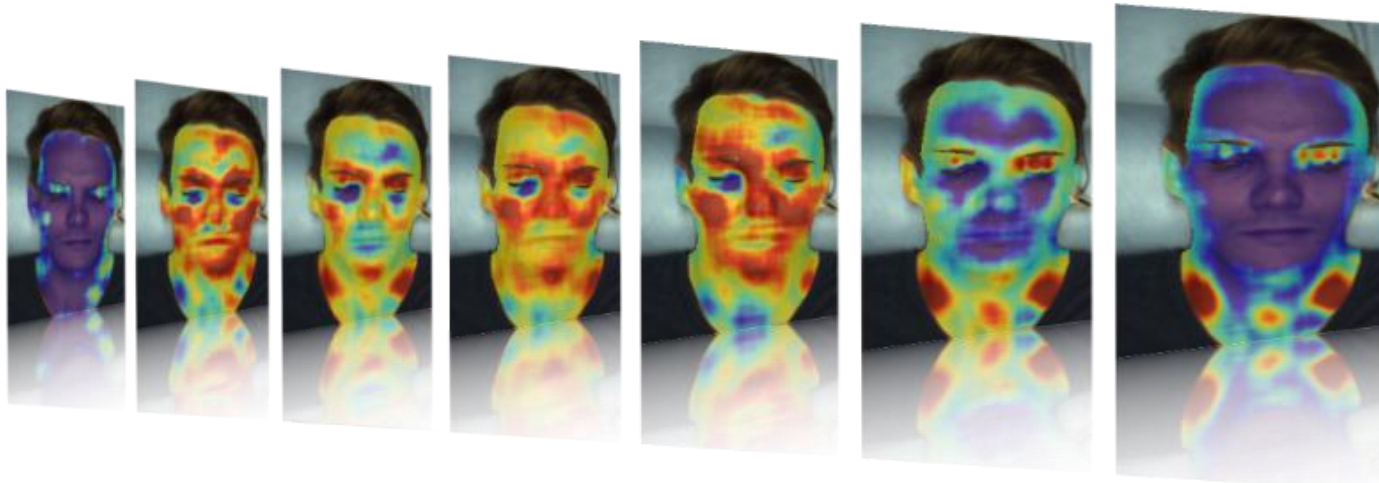


# Summary

# Summary

- Shift towards a novel medical approach: from single examination to integrated medical technology
- Data preprocessing is much more important
- Multivariate approaches are necessary
- The network approach has a big potential
  - It might avoid misinterpretation
  - It can add valuable information
- The circumstances might account for a spread of the integrated medical technology





Thank you for your interest

# Literature

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