Future Health

Decision Support for Professionals, Patients & Policy

Bart De Moor

ESAT-SCD-SISTA, ESAT-PSI, CUO, ITEC

ibbt
connect.innovate.create

IBBT

- IBBT = Interdisciplinary Institute for Broadband Technology
- 1 out of 4 strategic research centers (SOC) in Flanders

technology driven

society driven

research driven

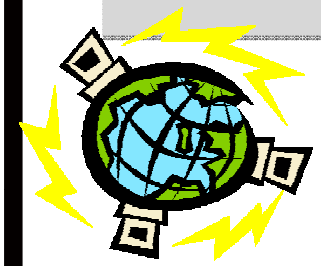
demand driven

- Virtual: expertise of university research groups
- Link between research and industry

  → Innovative ICT services and applications in close collaboration with government and industry

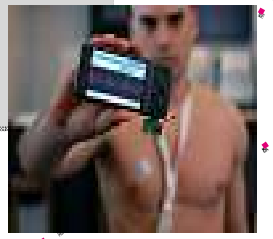
IBBT Structure: 5 research departments

Future Internet



Security

Future Health



Digital Society

Future Media

Associated research groups

- bioinformatics & machine learning
- biomedical data processing
- digital signal processing for audio & telecom

SISTA

- Fac. Engineering Dept. ESAT - K.U.Leuven

- bioinformatics & computer science
- education
- linguistics
- statistics

itec
Interdisciplinary Research on Technology, Education & Communication

- K.U.Leuven campus Kortrijk

- user experience research

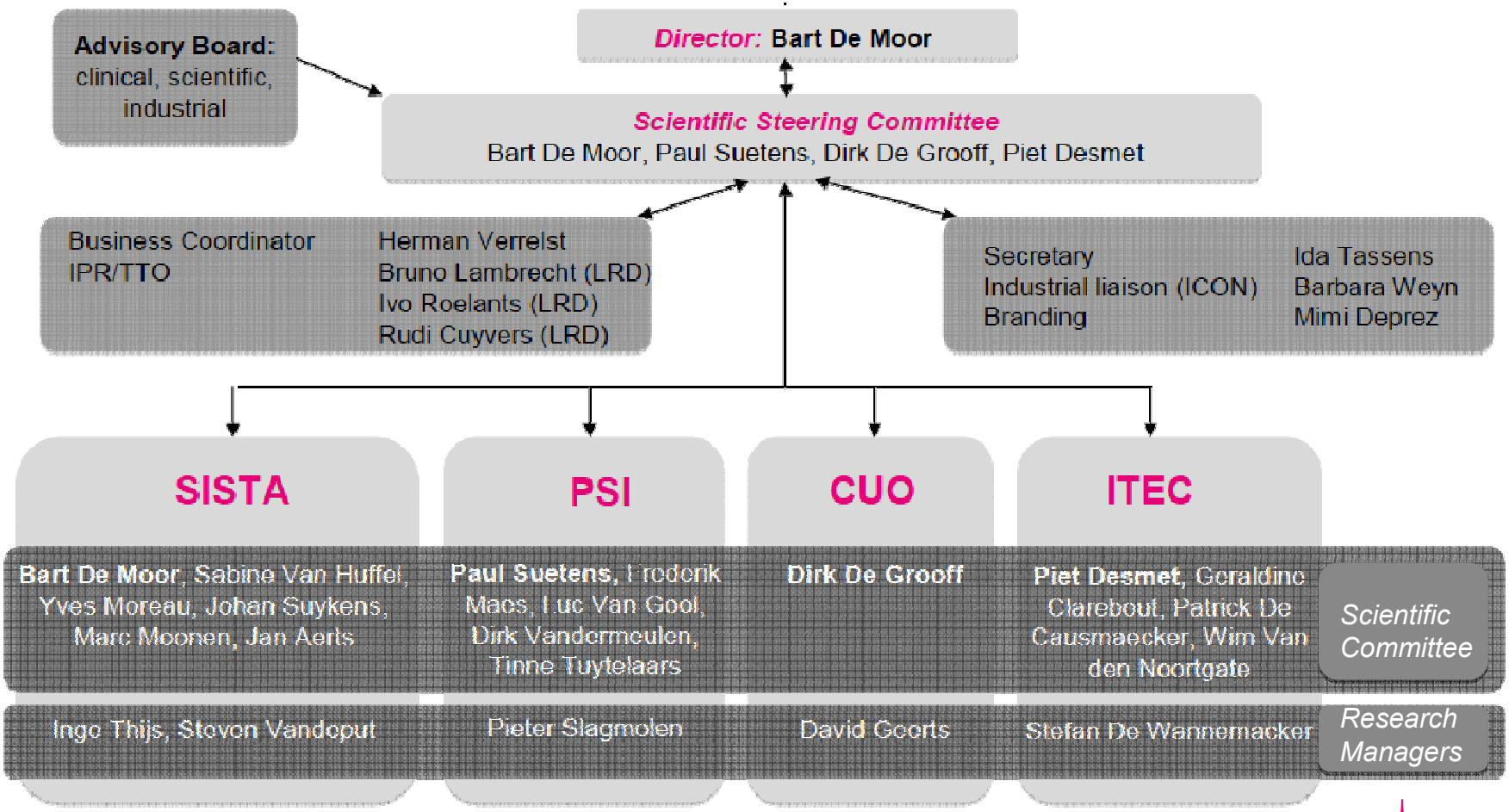
CUO

- Fac. Social Sciences K.U.Leuven

PSI

- medical imaging
- Fac. Engineering Dept. ESAT K.U.Leuven

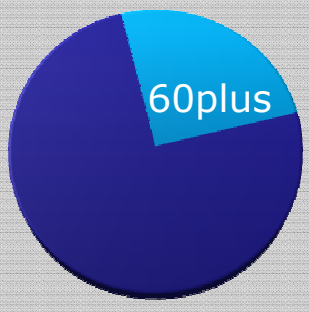
Structure department



Societal trends

Ageing

Flanders 2012



age related & chronic diseases rise

→ **challenge:** reconcile **quality** with **costs**

Patient empowerment → P4 Medicine

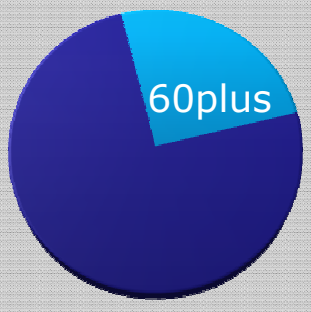
- Personalized
- Preventive
- Predictive
- Participatory

→ **challenge: patient-centric & personalized** health care

Societal trends

Ageing

Flanders 2012



age related & chronic diseases rise

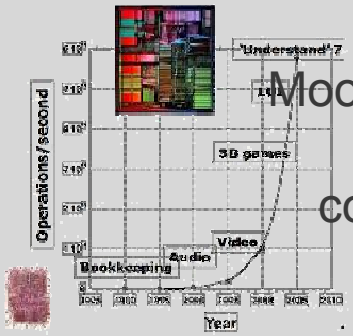
→ **challenge:** reconcile **quality** with **costs**

Patient empowerment → P4 Medicine

- Personalized: right treatment for right patient at right time
- Preventive: avoid high costs in curation
- Predictive: determine risk profiles and predict progression and outcome
- Participatory: patient is central and active shareholder in health care

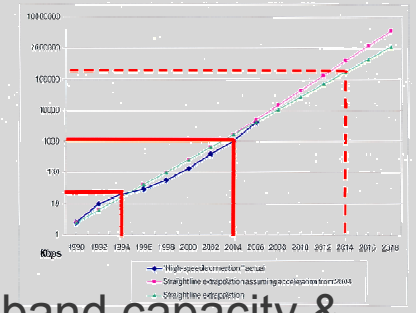
Technological trends

IT + internet performance & pervasiveness



Moore's Law
↓
computing power

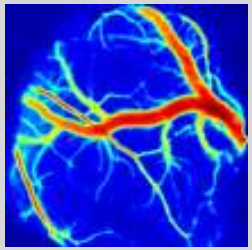
supercomputing



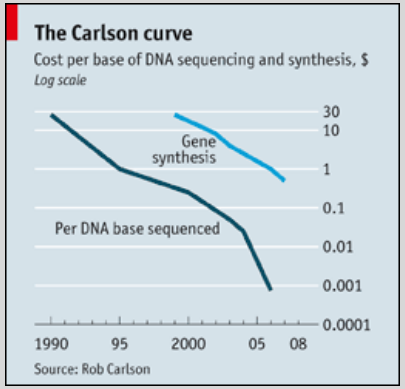
broadband capacity & pervasiveness
→ data access / sharing

Monitoring & smart systems

- Variety of imaging modalities
- Increasing resolution
- Multichannel, Mobile & Real-Time

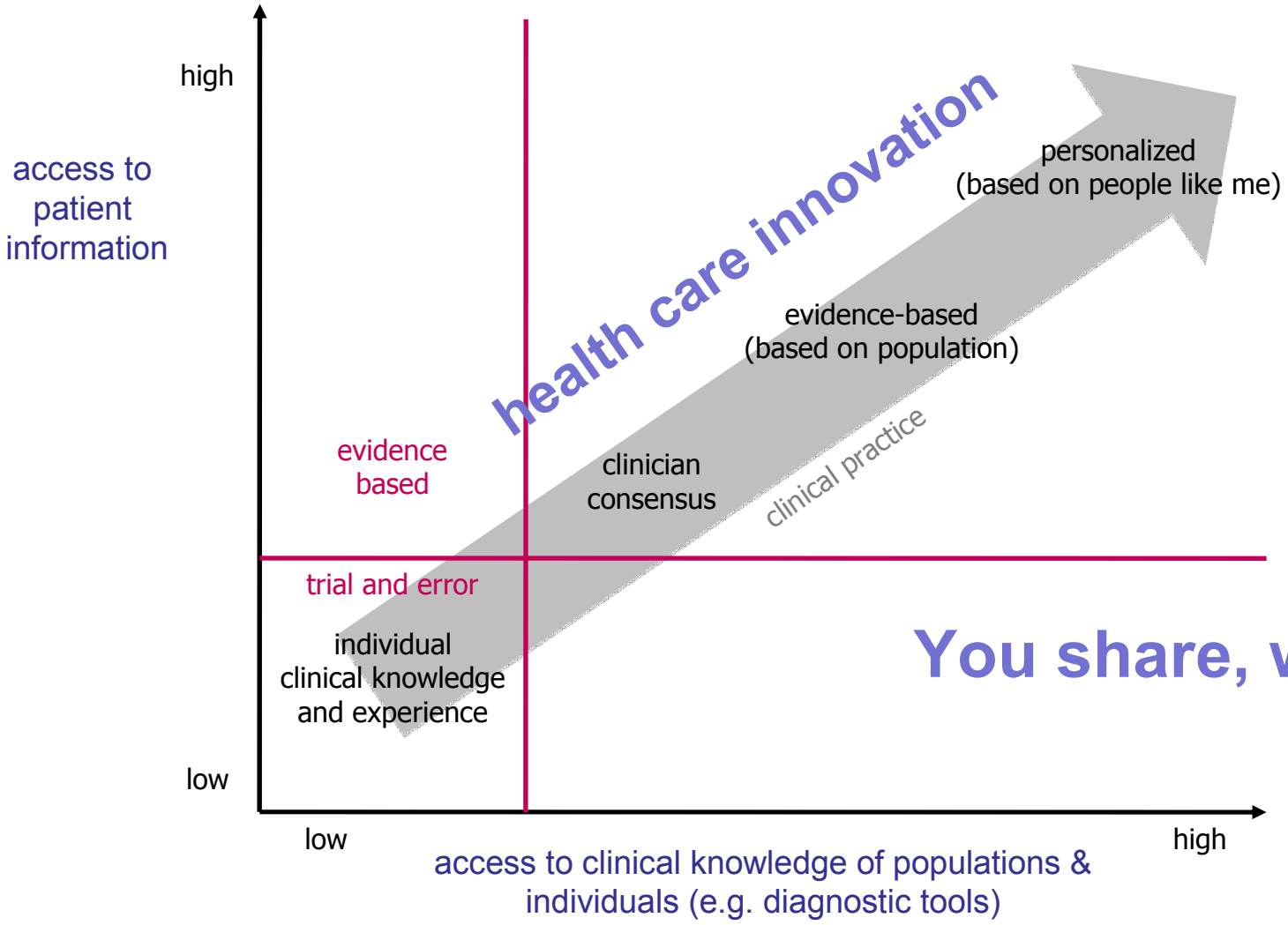


Biomedical technologies



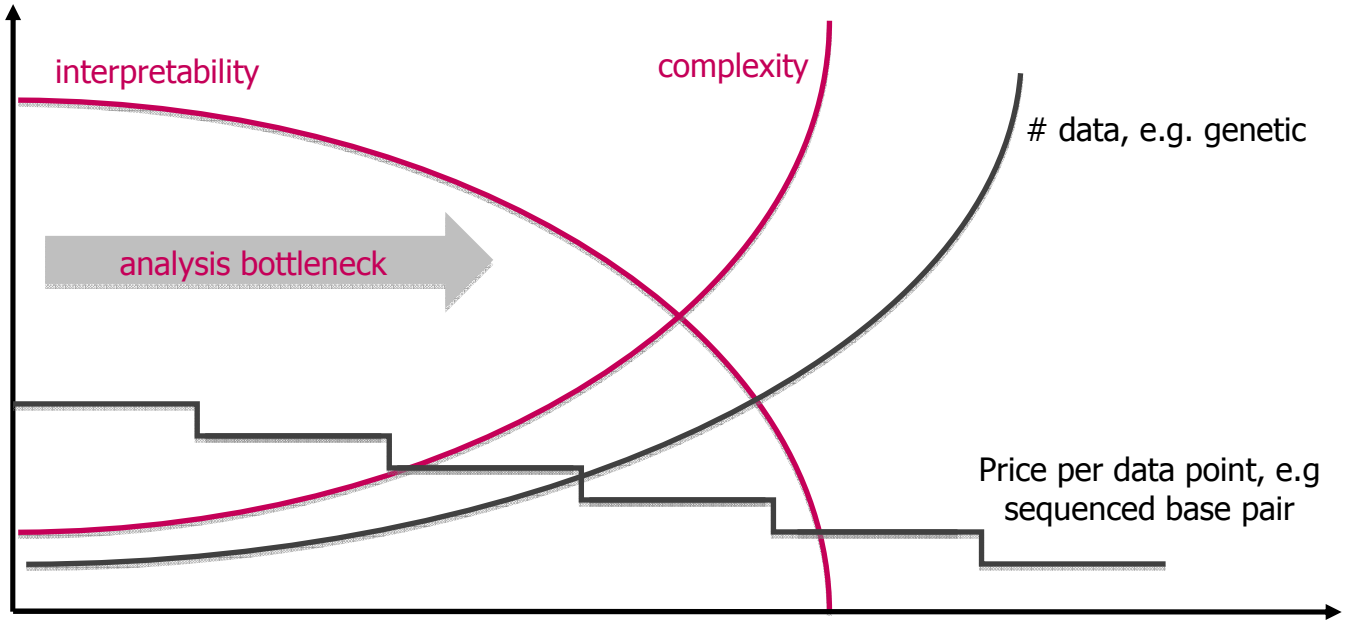
Carlson's law →
$1000 personal genome

Towards evidence-based and personalized medicine



You share, we care!

Challenge: data tsunami



IT to the rescue!

IT, mathematical engineering and software design

→ **fully exploit the opportunities** created by advancing technologies

IBBT Future Health Department: Health Decision Support

data: clinical, biomedical, imaging, omics, health insurance data, medical knowledge …

- **Professional** — **exploit data for more effective medicine**
- **Patient** — **patient-centred care for empowered patients**
- **Policy** — **smart & data-driven health care system policies**

- IT & software design
- data processing & mining
- data integration & visualization
- user experience & e-learning

to **extract appropriate information**

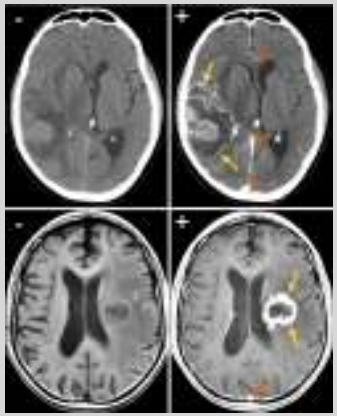
to **transfer this information** to the user:
professional, patient and policy maker

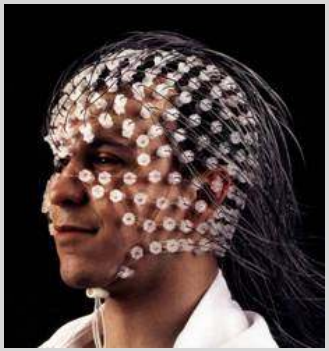
decision support to enable better health care

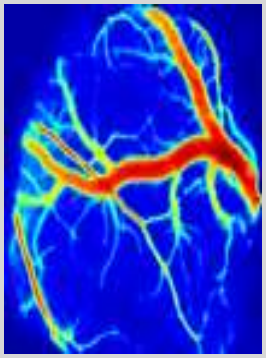
Research Focus

Professional / Clinical Decision Support

- interpretation of wide range of data & heterogeneous data fusion
- demand-driven, user-centred, with future vision





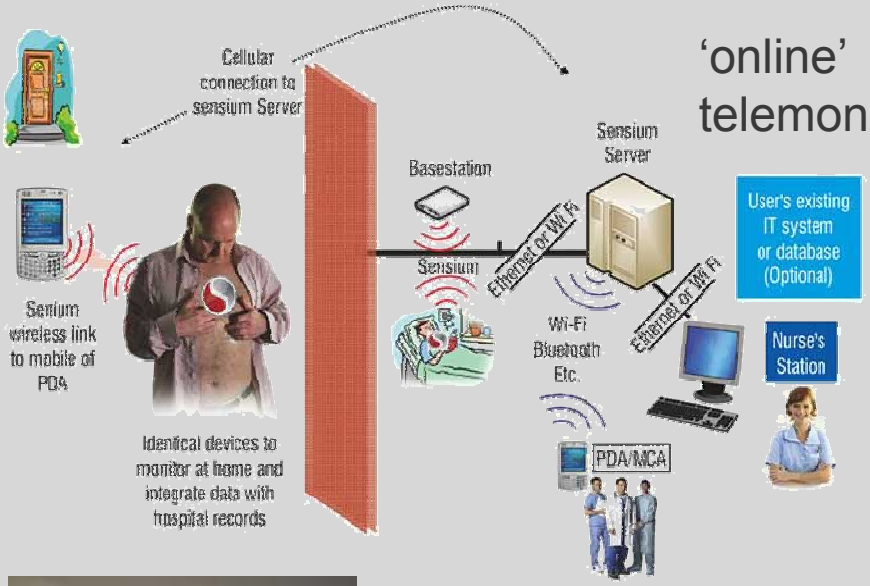

Patient DS

Policy DS

Research Focus

Clinical DS

Patient Decision Support



'online' telemonitoring

'patient empowerment': e.g. disease management for patients with chronic diseases using new media

Policy DS

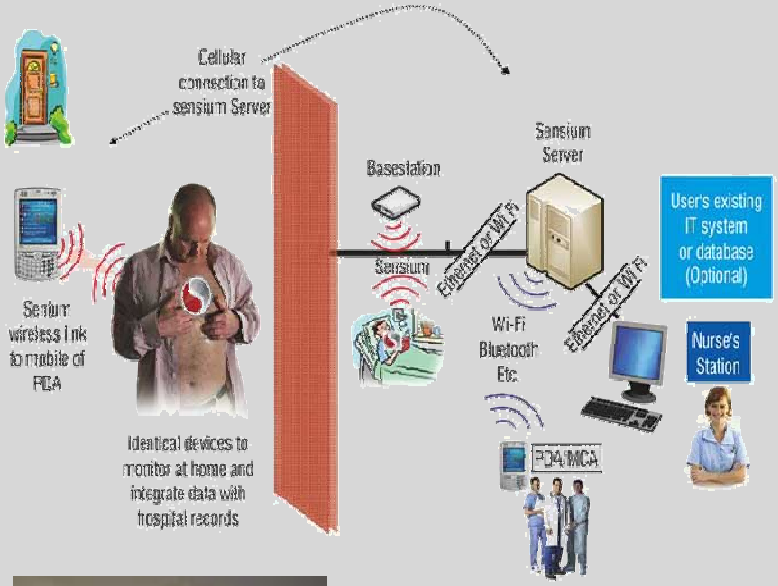
- data mining to identify best practices, …

- hospital logistics

Research Focus

Clinical DS

Patient Decision Support



'online' telemonitoring

'patient empowerment':
e.g. disease management for patients with chronic diseases using new media

Policy DS

Research Focus

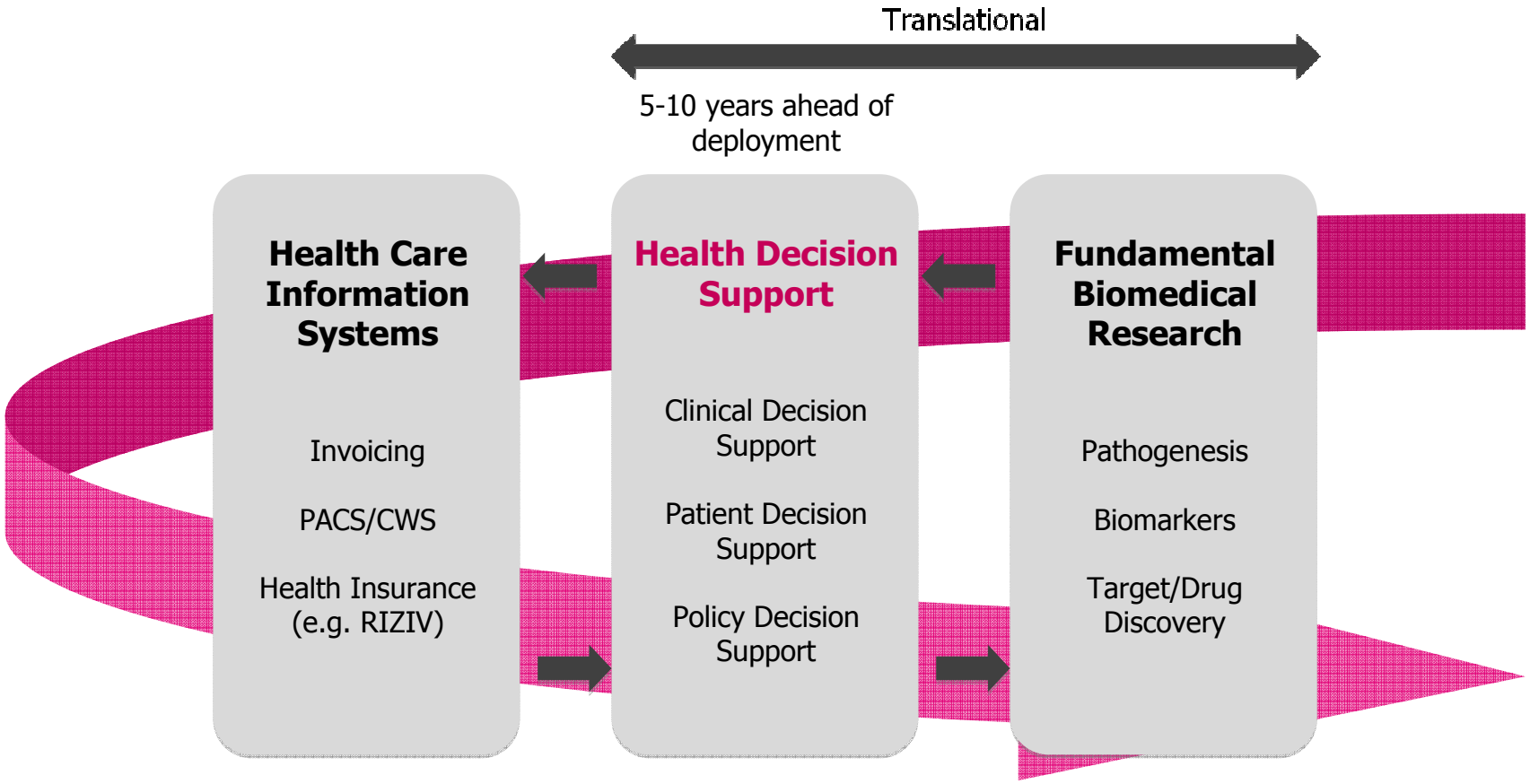
Clinical DS

Patient DS

Policy DS

- data mining
  - trend detection
  - clustering
  - outlier detection
- to identify policy best practices, for hospital management, …
- nationaal kanker Registere, RIZIV-INAMI, Mutualities…

Future Health: Positioning



Research focus: track record

Cartagenia

data handling & mining
for clinical genetics

silicos

in silico
drug
discovery

icoMetrix
Quantifying Your Images

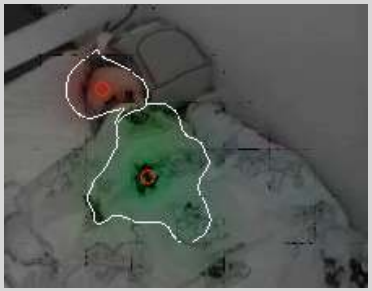
image quantification

PYXIMA
SOCIAL INTEREST SOFTWARE SERVICES

social interest software

medicim
MEDICAL IMAGE COMPUTING

medical image computing



home monitoring for
epilepsy detection

televic
education

(e-)learning solutions

VISION++
Experts in Computer Vision

vision software & hardware

Theraplay: ergotherapeutic game

Research focus: track record

- 17 PI, 25 postdocs, 88 PhD students
- ~ 270 publications /year
- ~ € 5 million external financing /year
- ~ 15 PhDs /year
- ~ 40 patents
- 5 spin-offs launched since 2005

Interaction with stakeholders is essential for innovation in health care

research
universities & research centres
strategic research centers: imec, VIB, VITO
…

health care stakeholders
patients
hospitals
doctors
health insurance
health care policy
…

technology providers
& core facilities
industry
supercomputing
medical imaging center
usability lab
sequencing (Genomics Core)
…

Cases

- IOTA: International Ovarian Tumour Analysis Group
- Endeavour: disease gene prioritization
- Epilepsy detection
- Tumor classification via MRS
- Semi-Automatic Blood Glucose Control in the ICU

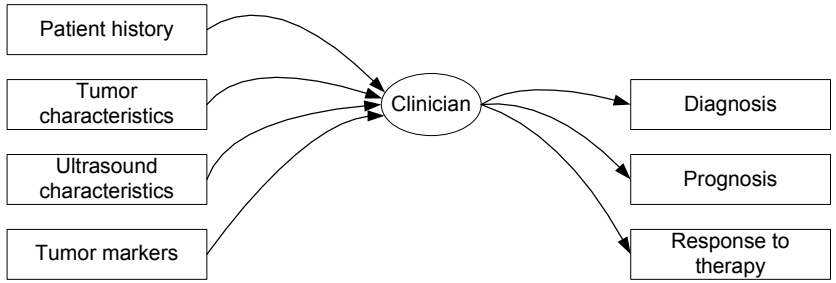
Cases

Case: IOTA - International Ovarian Tumour Analysis Group

→ Making it easier to diagnose ovarian cancer

Clinicians have to make many decisions concerning the therapy of their patients e.g.:

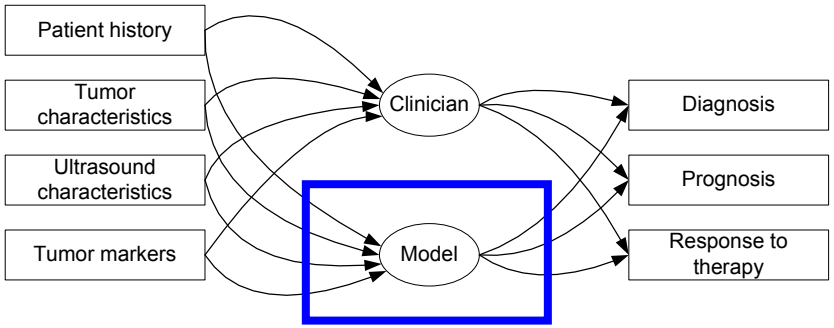
Diagnosis
Prognosis
Therapy response



- Based on **expertise**
- But often the clinician has
  - Patient Data
    - Patient history
    - Tumor characteristics
    - Ultrasound characteristics
    - Tumor markers

Case: IOTA - International Ovarian Tumour Analysis Group

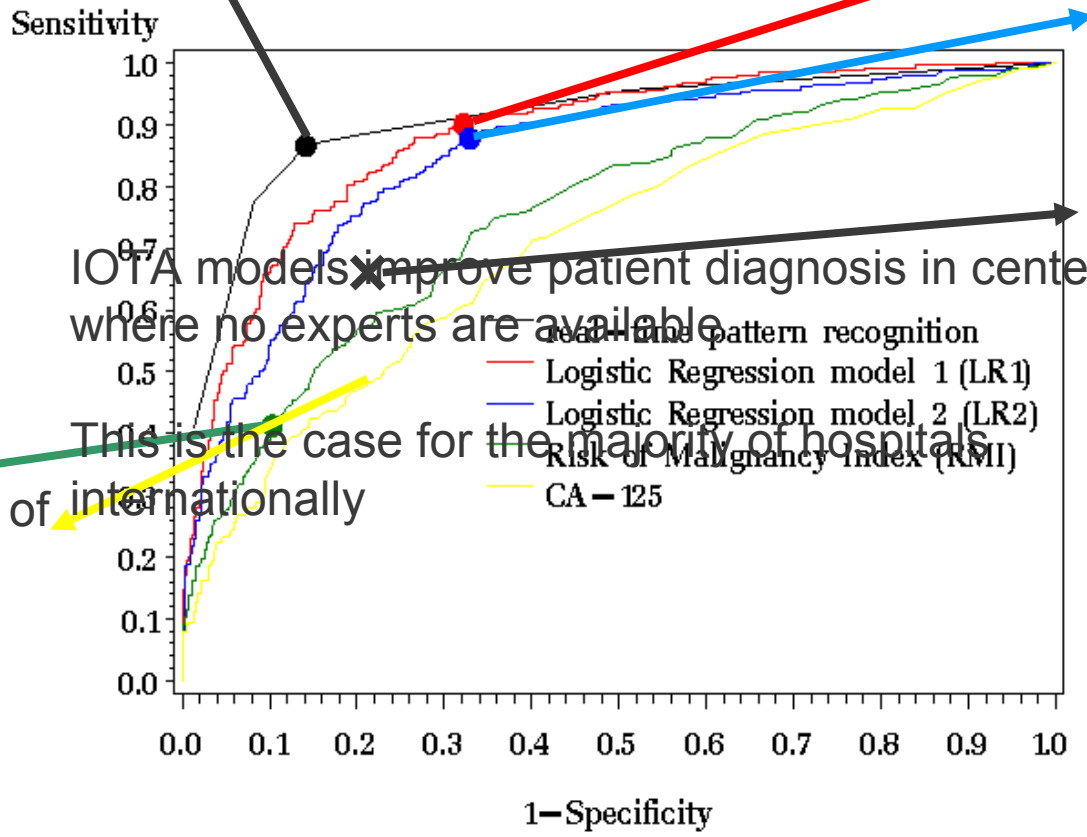
- Solution:
  - Clinical decision support modeling
  - Building a mathematical model on the data
  - Use this model to predict patient outcome
    - Diagnosis
    - Prognosis
    - Therapy response



Case: IOTA - International Ovarian Tumour Analysis Group

Performance of an expert

Performance of IOTA models



Performance of non-experts

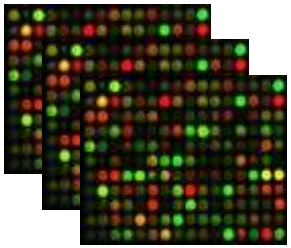
IOTA models improve patient diagnosis in centers where no experts are available

This is the case for the majority of hospitals internationally

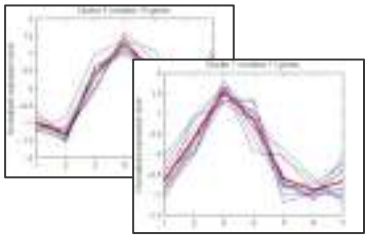
Performance of old models

Case: Endeavour - disease gene prioritization

High-throughput genomics



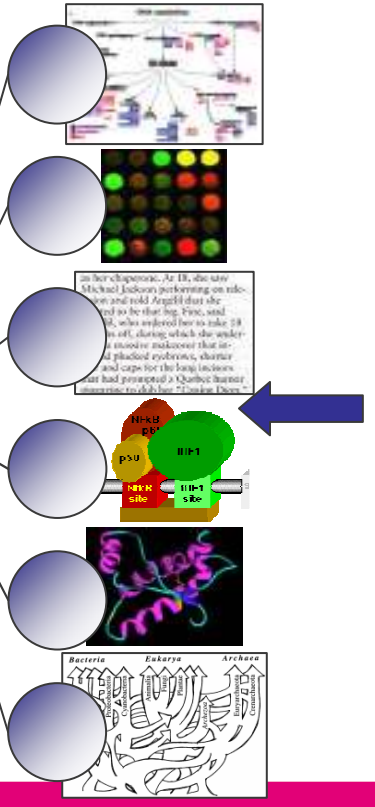
Data analysis



Candidate genes

Name	Ensembl
TTR	ENSG00000118271
PAH	ENSG00000171759
G6PC	ENSG00000131482
IGF1	ENSG00000017427
ALB	ENSG00000163631
CRP	ENSG00000132693
HABP2	ENSG00000148702
IF	ENSG00000138799
FST	ENSG00000134363
ARAF1	ENSG00000078061
HMGA2	ENSG00000149948
C9	ENSG00000113600
PCBP2	ENSG00000111406
HOXB6	ENSG00000108511
RERE	ENSG00000142599
HOXA11	ENSG00000005073
CLIC1	ENSG00000096238
ERCC3	ENSG00000163161
ERCC3	ENSG00000163161
TLL2	ENSG00000095587
SYT4	ENSG00000132872
SYT4	ENSG00000132872
PIK4CB	ENSG00000143393
PKD2	ENSG00000118762
	ENSG00000081026
ANKRD3	ENSG00000183421
F13A1	ENSG00000124491
BPAG1	ENSG00000151914
KCNN3	ENSG00000143603
GRIN2A|GRIN2B	ENSG00000150086
SIM1	ENSG00000112246
	ENSG00000174891
	ENSG00000089195
C14orf10	ENSG00000092020
STX8	ENSG00000170310
	ENSG00000107671
MSH5	ENSG00000096474
CRH	ENSG00000147571
MID1	ENSG00000101871
	ENSG00000184508
	ENSG00000113460
TGFB3	ENSG00000
C1QR1	ENS
N	ENS
PDG	ENS
PD	
NR	
NFYA	
	ENSG 06537
MMP3|MMP1	ENSG00000149968

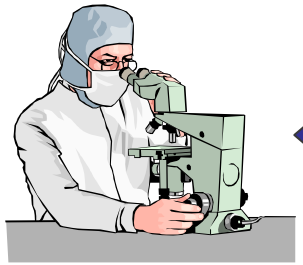
Information sources



Candidate prioritization

Rank	En	Ex	Ip	Ke	GO	Te Avg	Pval
1	TTR	G6PC	PAH	G6PC	IGF1	TTR	TTR
2	IGF1	TTR	IGF1	PAH	PAH	IGF1	PAH
3	CRP	ALB	TTR	RERE	G6PC	CRP	G6PC
4	HOXB6	HABP2	ALB	ERCC3	TTR	HOXB6	IGF1
5	ALB	PAH	HDC	ERCC3		ALB	
6	NR4A2	IF	TLL2	ANKRD3		HMGA2	
7	PAH		C1QR1	ARAF1	HDC	NR4A2	HABP2
8	HOXA11	IGF1	G6PC	PKD2	F13A1	PAH	IF
9	NFYA	CRP	HABP2	MTMR1	KCNN3	HOXA11	C13orf7	FST
10	C9	ARAF1	IF	HDC	CLIC1	NFYA	TTR	ARAF1

Validation



ESAT/SCD

KATHOLIEKE UNIVERSITEIT LEUVEN

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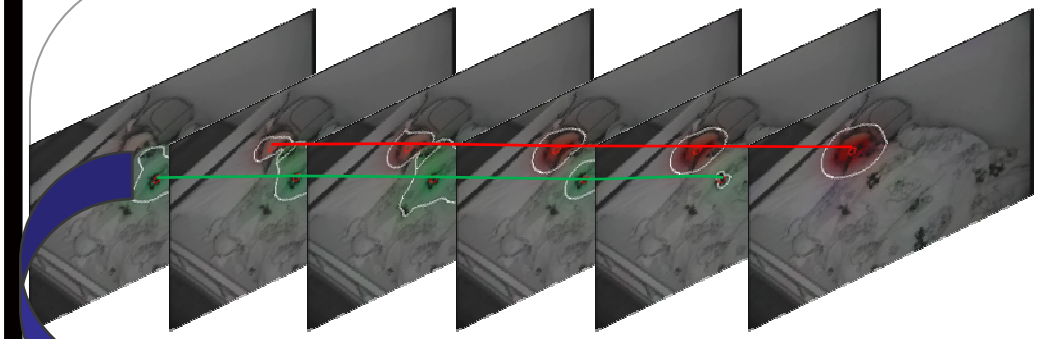
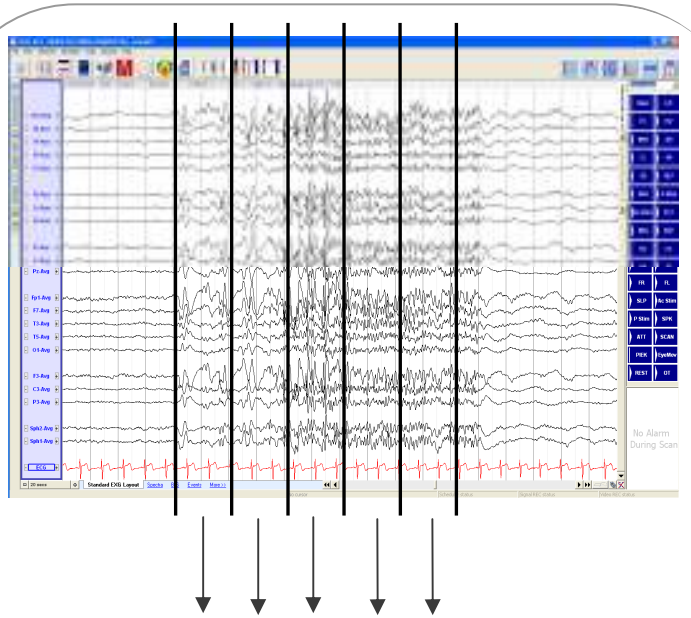
Case: Epilepsy detection



Motion tracks

Extract features based on the motion tracks



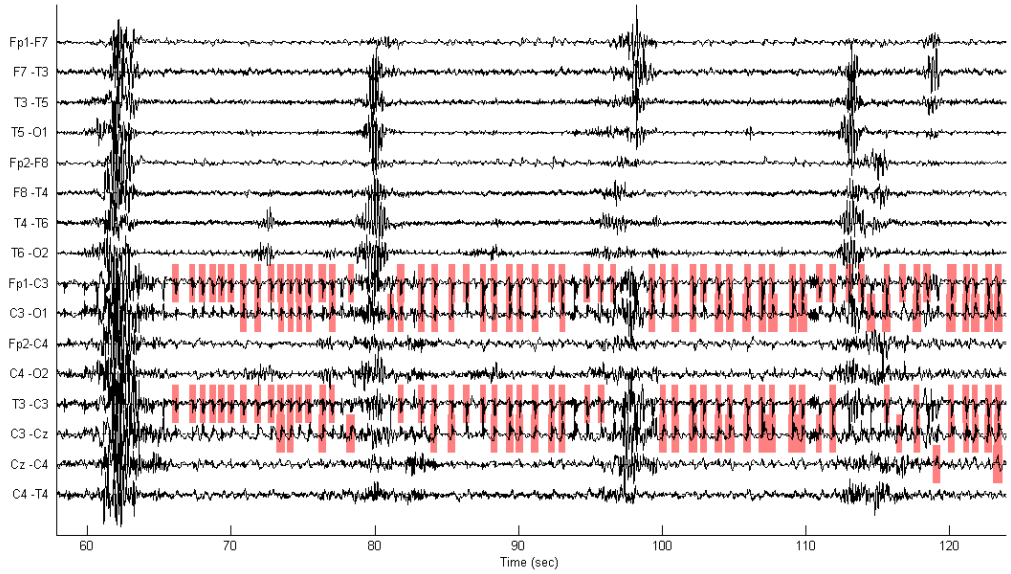
Extract time and frequency domain **features**

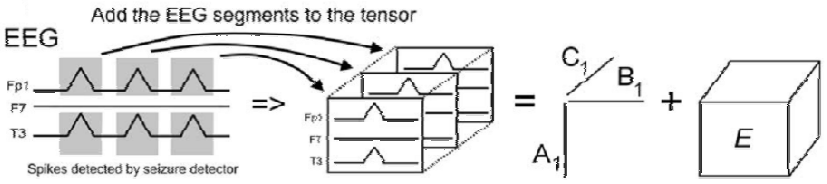
Video-EEG monitoring

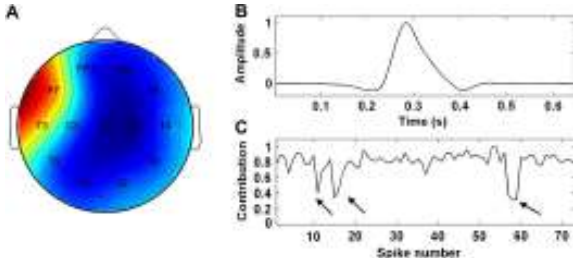
ESAT/SCD

Discriminate between **normal** and **epileptic** events

Seizure localization

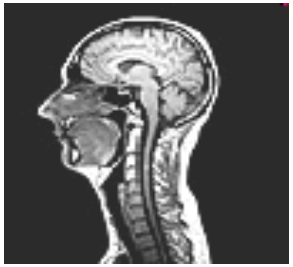






Parafac component corresponding to seizure

Case: Tumor classification via MRS

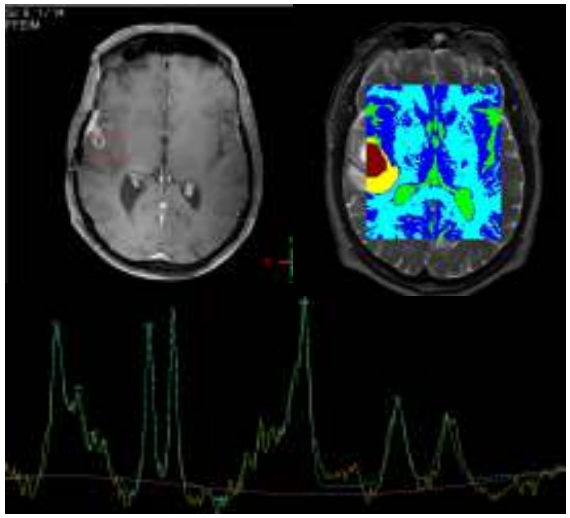


Nuclear magnetic resonance imaging (NMR):

- "water images"
- concentraion of protons → anatomical details

Magnetic resonance spectroscopic imaging:

- Quantitative metabolite maps

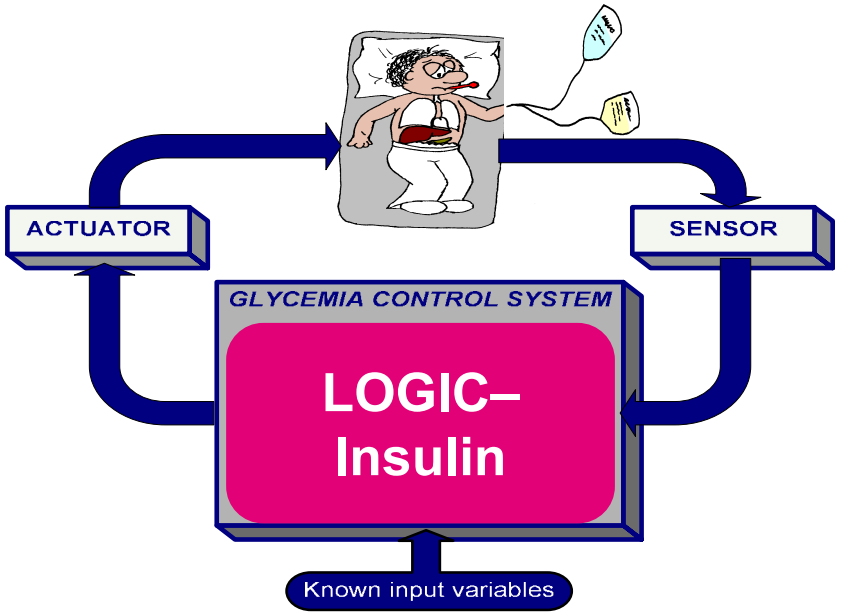


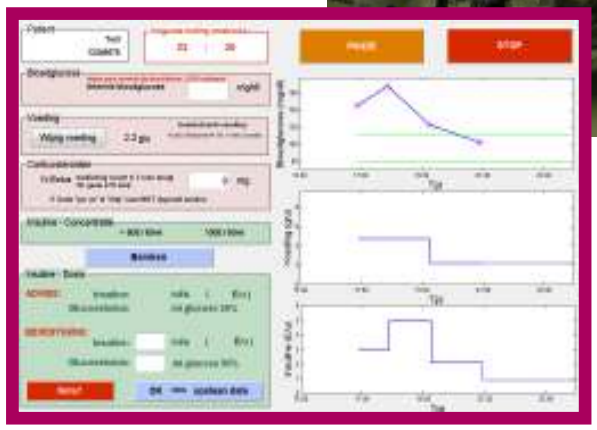
Key challenges:

- Accurate and fast quantitaion
- Artifact removal
- Automated classification

Case: Semi-Automatic Blood Glucose Control in the ICU

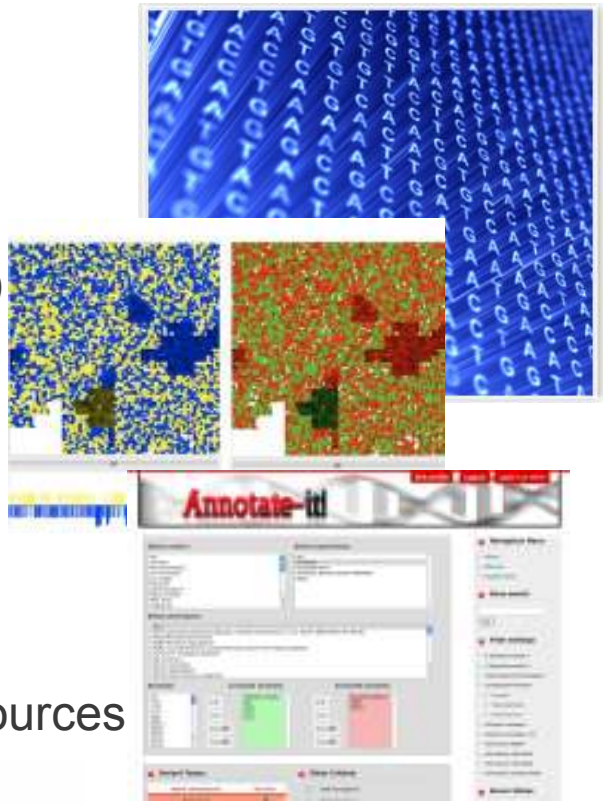
- Intensive Care Unit: critically ill patients - High insulin resistance leads to hyperglycemia in the ICU → need for Tight Glycaemic Control (TGC) = 80-110 mg/dl
- LOGIC-Insulin: algorithm and graphical user interface for normalizing blood glucose in critically ill patients in the ICU





Clinical genomics

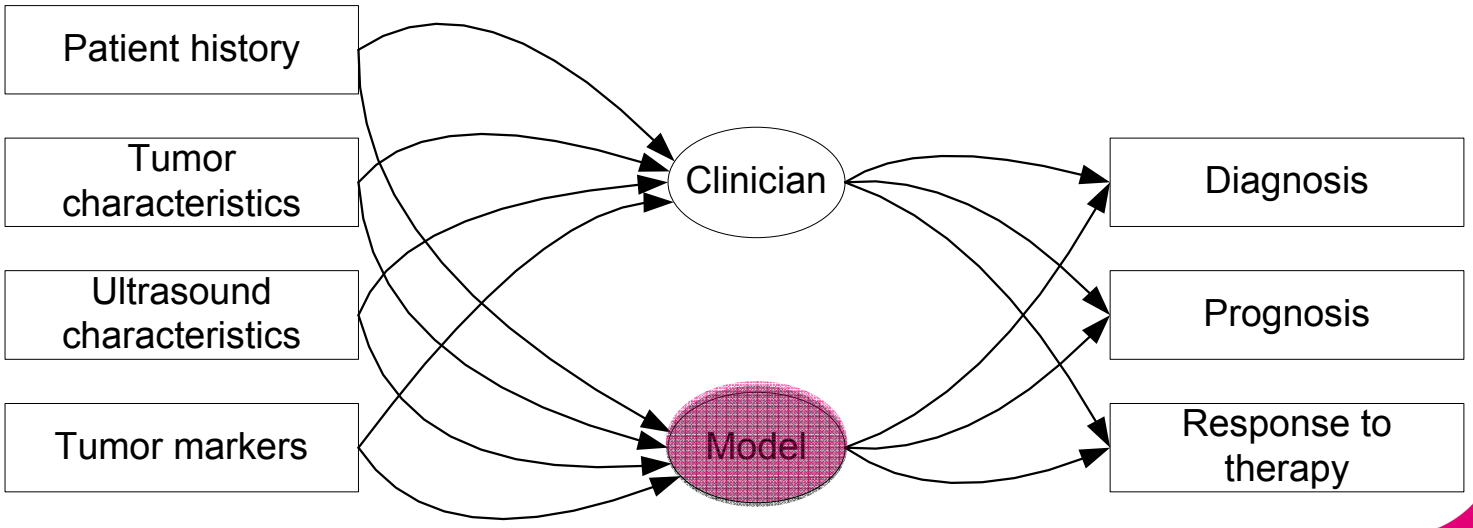
- next-generation sequencing: $1000 human genome will revolutionize clinical diagnostics
  - genetic disorders
  - risk analysis
  - interaction with drugs (pharmacogenomics)
- but: huge amounts of data
- clinician → extract relevant information in a timely manner!
  - construct clinical data pipelines
  - data mining & integration with other data sources
  - visualization



Cartagenia

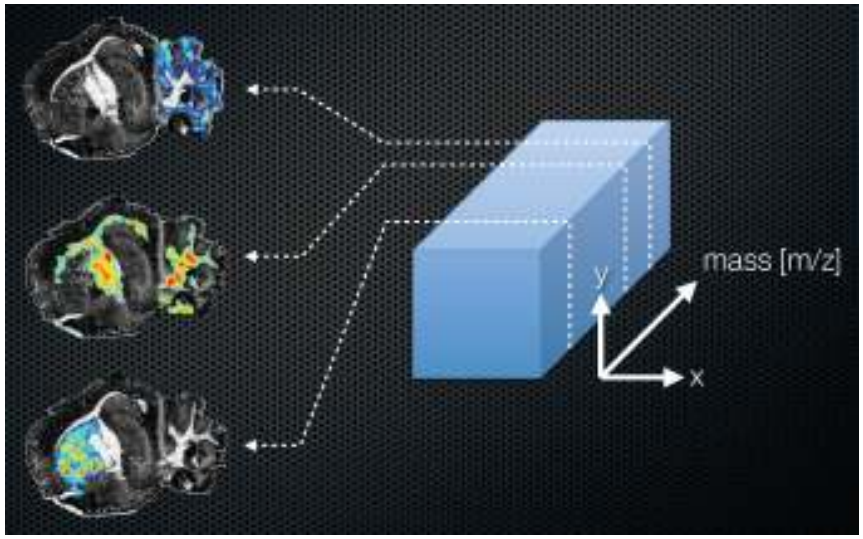
Heterogeneous data integration for predictive modeling & biomarker discovery

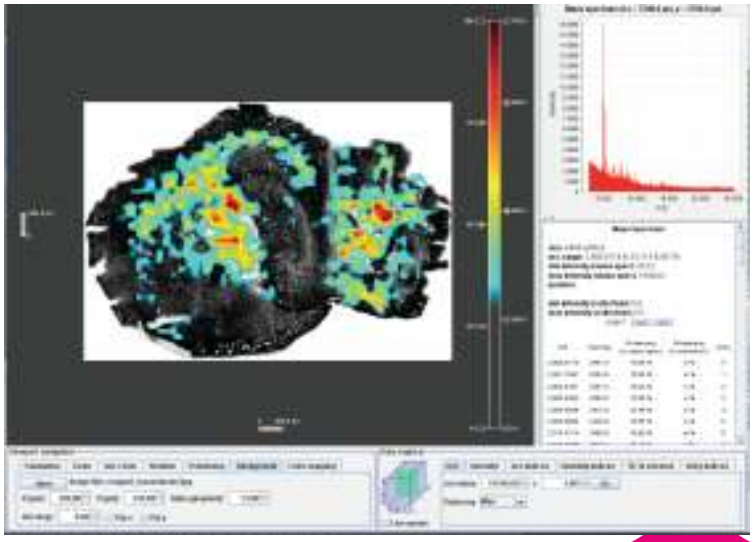
- Example: IOTA = International Ovarian Tumour Analysis Group → making it easier to diagnose ovarian cancer
  - help clinicians take decisions on diagnosis, prognosis and therapy response
  - make use of patient data ánd population information (patient biobank & database, literature …)



Biomarker discovery through Mass Spectral Imaging

- combines proteomic and metabolomic information with spatial distribution
  - localize biomarkers in tissue
  - discover new targets for drug delivery
  - unravel mechanisms underlying disease





Semi-Automatic Blood Glucose Control in the ICU

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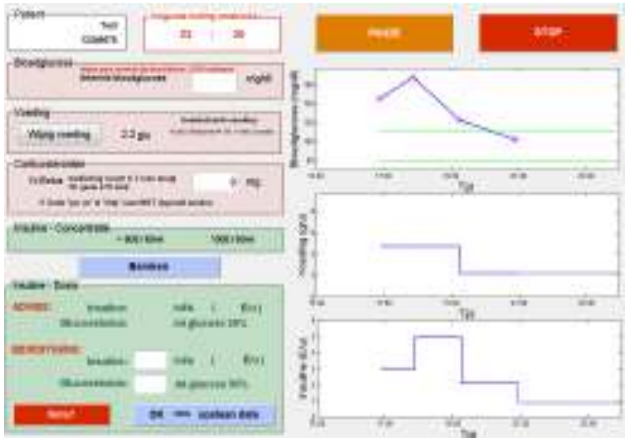
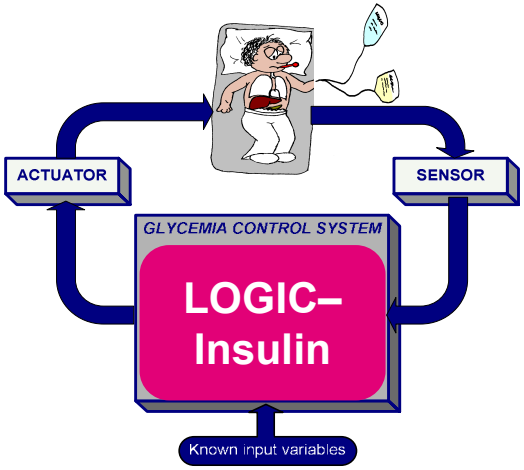
  - algorithm and graphical user for normalizing blood glucose in critically ill patients in the ICU





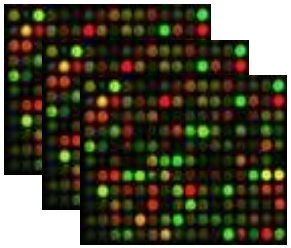
Text & Data Mining

- Exploit information in text files – unstructured information
  - disease related gene analysis in biomedical literature
  - medical report annotation – e.g. use medical history to predict adverse drug effects

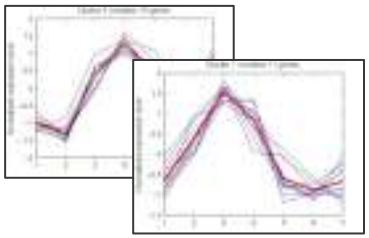
- Data mining of health care system data (RIZIV, mutualities …)
  - trend detection
  - clustering
  - outlier detection

Disease gene discovery by genomic data fusion: Endeavour

High-throughput genomics



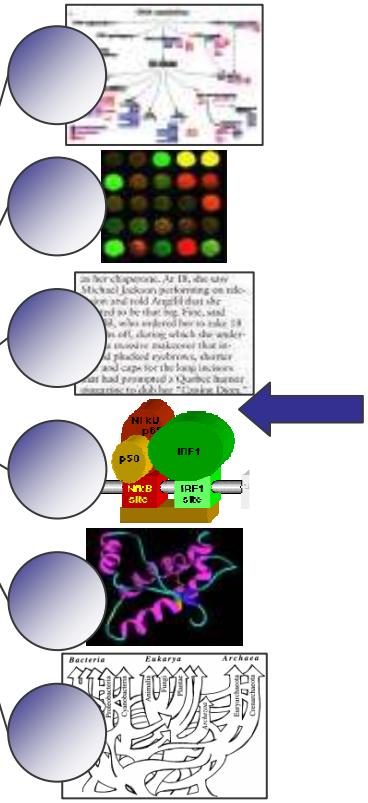
Data analysis



Candidate genes

Name	Ensembl
TTR	ENSG00000118271
PAH	ENSG00000171759
G6PC	ENSG00000131482
IGF1	ENSG00000017427
ALB	ENSG00000163631
CRP	ENSG00000132693
HABP2	ENSG00000148702
IF	ENSG00000138799
FST	ENSG00000134363
ARAF1	ENSG00000078061
HMGA2	ENSG00000149948
C9	ENSG00000113600
PCBP2	ENSG00000111406
HOXB6	ENSG00000108511
RERE	ENSG00000142599
HOXA11	ENSG00000005073
CLIC1	ENSG00000096238
ERCC3	ENSG00000163161
ERCC3	ENSG00000163161
TLL2	ENSG00000095587
SYT4	ENSG00000132872
SYT4	ENSG00000132872
PIK4CB	ENSG00000143393
PKD2	ENSG00000118762
	ENSG00000081026
ANKRD3	ENSG00000183421
F13A1	ENSG00000124491
BPAG1	ENSG00000151914
KCNN3	ENSG00000143603
GRIN2A|GRIN2B	ENSG00000150086
SIM1	ENSG00000112246
	ENSG00000174891
	ENSG00000089195
C14orf10	ENSG00000092020
STX8	ENSG00000170310
	ENSG00000107671
MSH5	ENSG00000096474
CRH	ENSG00000147571
MID1	ENSG00000101871
	ENSG00000184508
	ENSG00000113460
TGFB3	ENSG00000
C1QR1	ENS
N	ENS
PDG	ENS
PD	
NR	
NFYA	
	ENSG 06537
MMP3|MMP1	ENSG00000149968

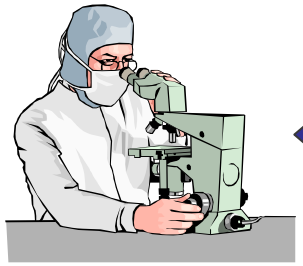
Information sources



Candidate prioritization

Rank	En	Ex	Ip	Ke	GO	Te Avg	Pval
1	TTR	G6PC	PAH	G6PC	IGF1	TTR		TTR
2	IGF1	TTR	IGF1	PAH	PAH	IGF1		PAH
3	CRP	ALB	TTR	RERE	G6PC	CRP		G6PC
4	HOXB6	HABP2	ALB	ERCC3	TTR	HOXB6		IGF1
5	ALB	PAH	HDC	ERCC3		ALB		
6	NR4A2	IF	TLL2	ANKRD3		HMGA2		CRP
7	PAH		C1QR1	ARAF1	HDC	NR4A2		HABP2
8	HOXA11	IGF1	G6PC	PKD2	F13A1	PAH		IF
9	NFYA	CRP	HABP2	MTMR1	KCNN3	HOXA11	C13orf7	FST
10	C9	ARAF1	IF	HDC	CLIC1	NFYA	TTR	ARAF1

Validation



Aerts et al., Nature Biotechnology, 2006

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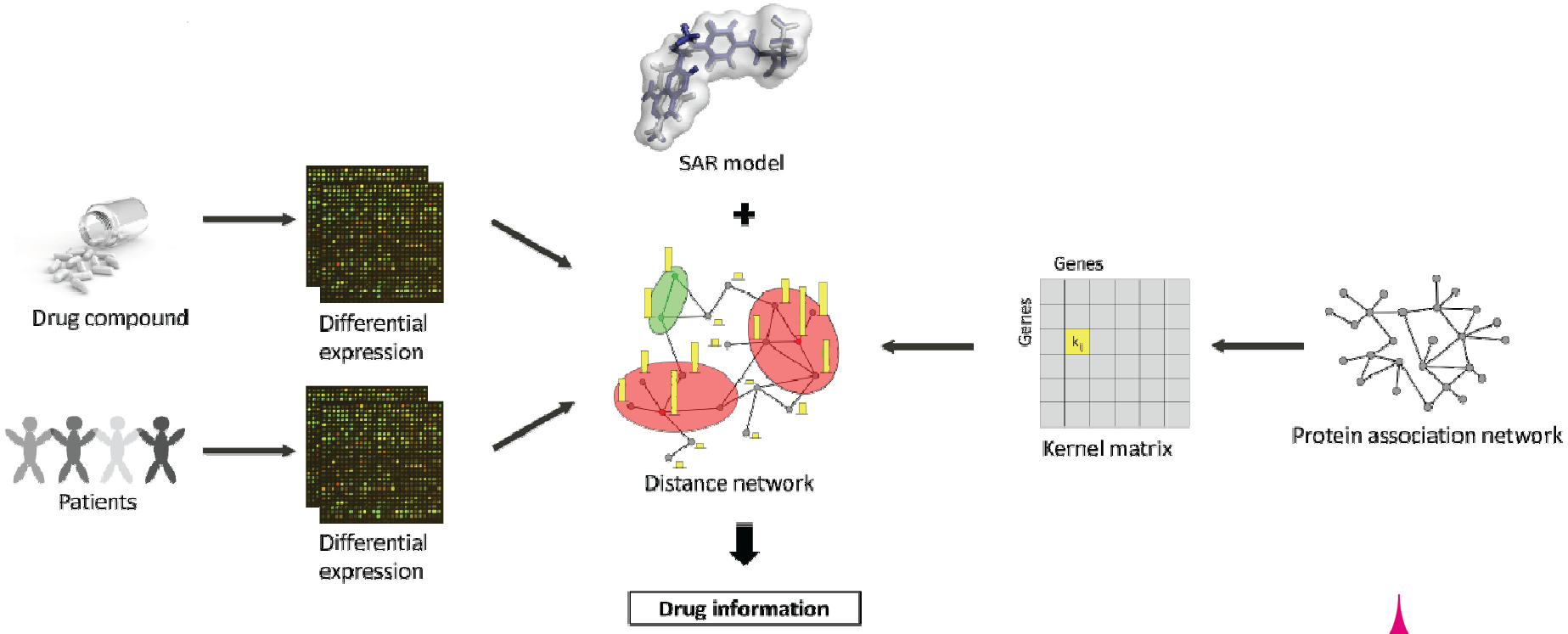
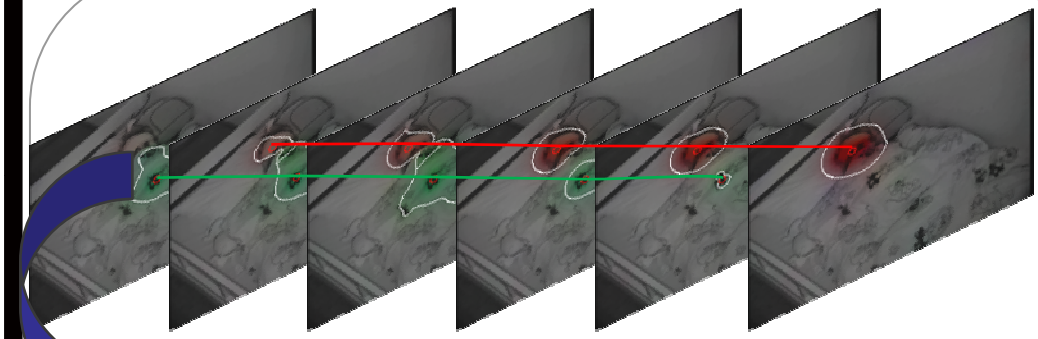
Network biology for drug profiling

- identify mode of action of drugs, adverse effects etc. through a network analysis of drug responses

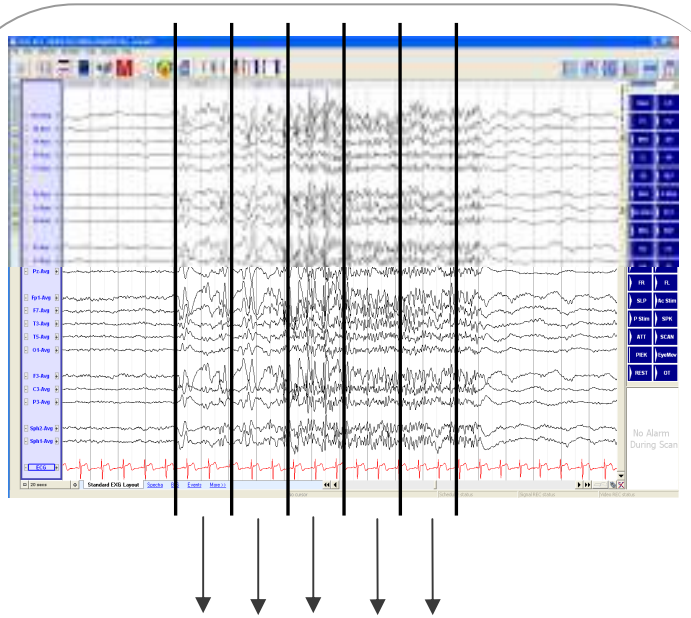


Epilepsy detection



Motion tracks

Extract features based on the motion tracks

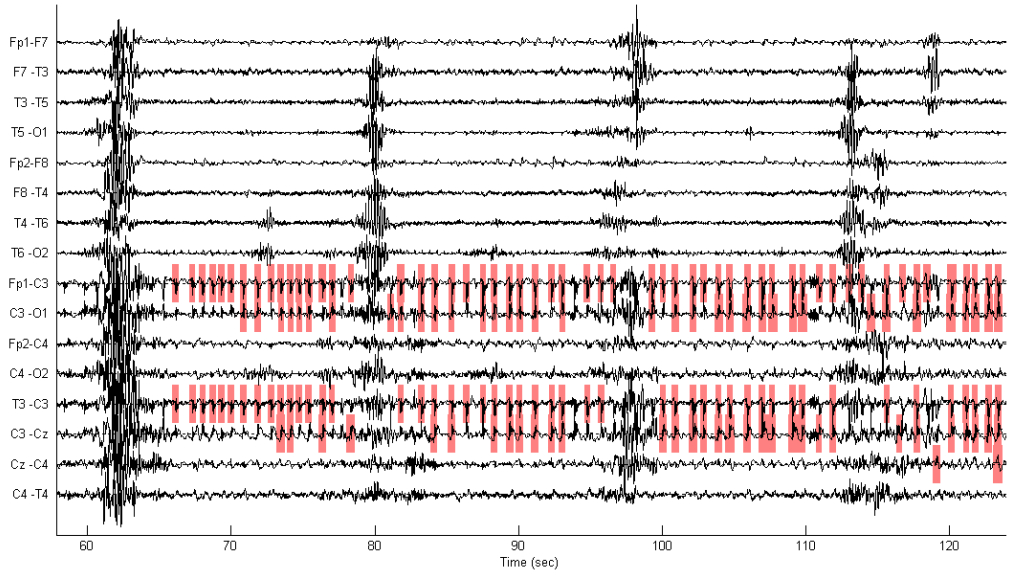


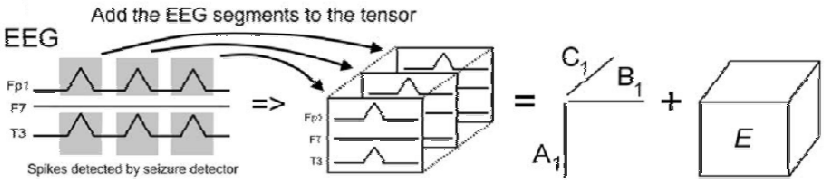
Extract time and frequency domain **features**

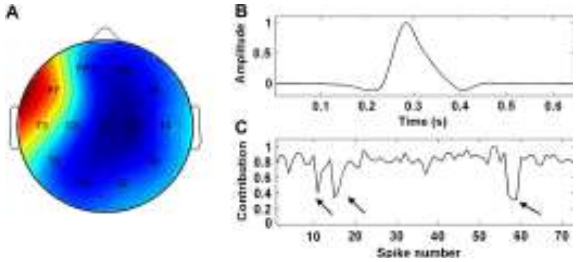
Video-EEG monitoring

Discriminate between **normal** and **epileptic** events

Seizure localization

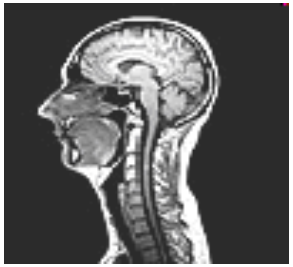






Parafac component corresponding to seizure

Tumor classification via MRS

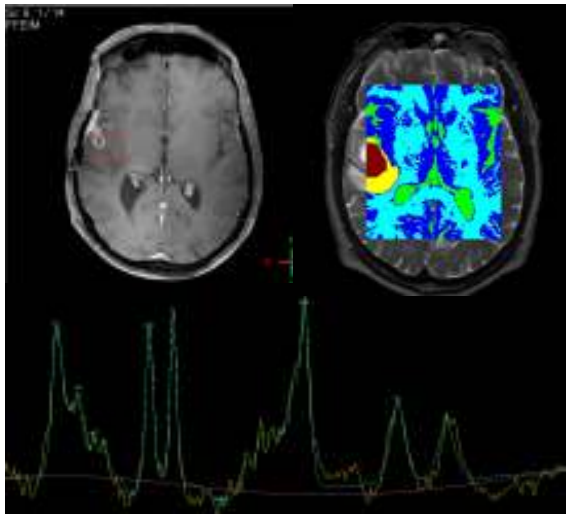


Nuclear magnetic resonance imaging (NMR):

- “water images”
- concentraion of protons → anatomical details

Magnetic resonance spectroscopic imaging:

- Quantitative metabolite maps

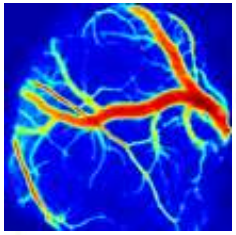


Key challenges:

- Accurate and fast quantitaion
- Artifact removal
- Automated classification

Conclusion

Trends



improve health care quality and cost effectiveness

Decision Support for Professionals, Patients & Policy

- **Clinical** — exploit data for more effective medicine
- **Patient** — patient-centred care for empowered patients
- **Policy** — smart & data-driven health care system policies

- Dialogue
- Demand-driven
- User-centred
- Future vision

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