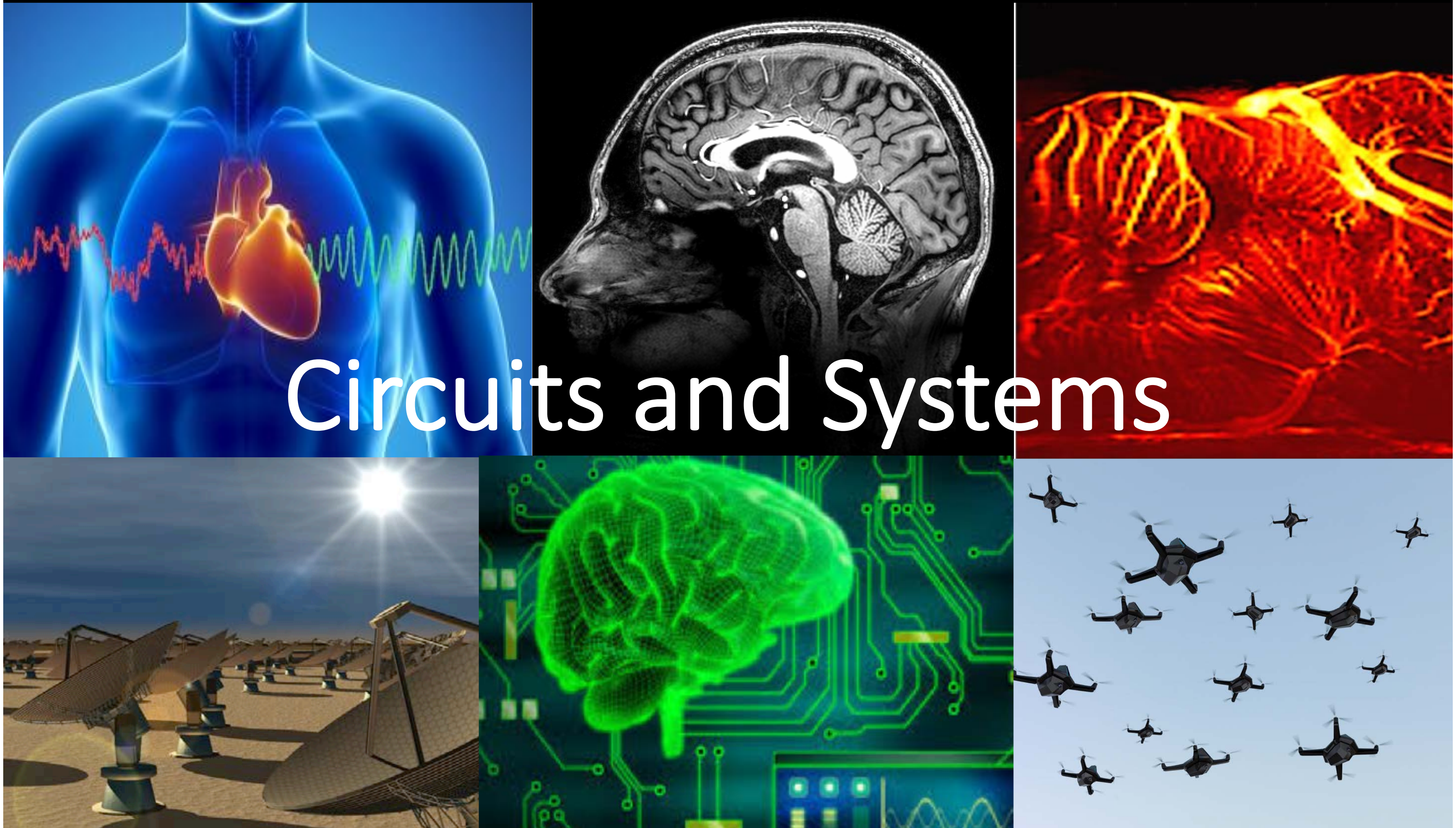
Circuits and Systems



Signal Processing and Digital VLSI Design

Circuits and Systems

Signal Processing and Digital System Design

Scientific staff members (SP part)

Profs: Alle-Jan van der Veen
Geert Leus
signal proc. for comm./array sp
Andrew Webb*: MRI (at LUMC)*
Natasja de Groot: *Cardiology (at EMC)*

Assoc. Profs:
Gerard Janssen
physical layer comm.
Richard Hendriks
audio/bio signal processing
Rob Remis
EM, remote imaging, MRI
Justin Dauwels
machine learning

Asst. Profs:
Bori Hunyadi
bio signal processing
Raj Thilak Rajan
distributed systems, space systems
Geethu Joseph
sparse signal processing











Signal processing research

Signals: speech, audio, images, biomedical, communication, sensor, ...

Models:

EM, physics	stochastic	data collections
channel descriptions	signal descriptions	data descriptions

Methods:

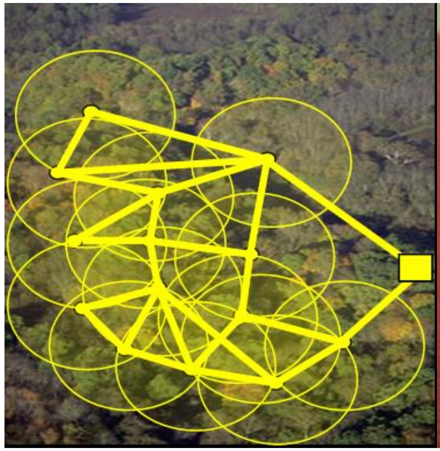
linear algebra tensors array signal proc.	estimation detection machine learning	graph signal proc. distributed proc.
compressed sensing source separation computational imaging	graphical models deep neural networks data fusion	network localization filtering on graphs distributed inference

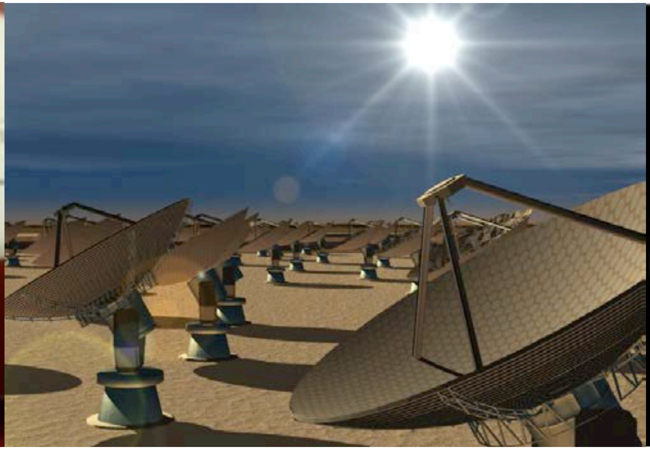
Applications:

communication sensing	biomedical	autonomous sensing systems
wireless, MIMO, 5G radar, sonar audio/acoustics radio astronomy	neuroscience, EEG cardiac, ECG MRI, ultrasound	self-driving cars drones, UAV satellite swarms sensor networks

Research highlights

- Graph Signal Processing
- 3D ultrasound using a single transducer
- Compressed spectrum sensing for cognitive radio; massive MIMO
- SP for radio astronomy
- Microphone arrays to improve speech intelligibility
- Tissue parameter retrieval in MRI (Electrical Properties Tomography): a promising enabler for thermal ablation treatment of cancer
- Neuromorphic compute platforms for low-power artificial intelligence






Signal Processing for Communications

Super-GPS

Outdoor localization with cm accuracy for autonomous highway driving

Gerard Janssen

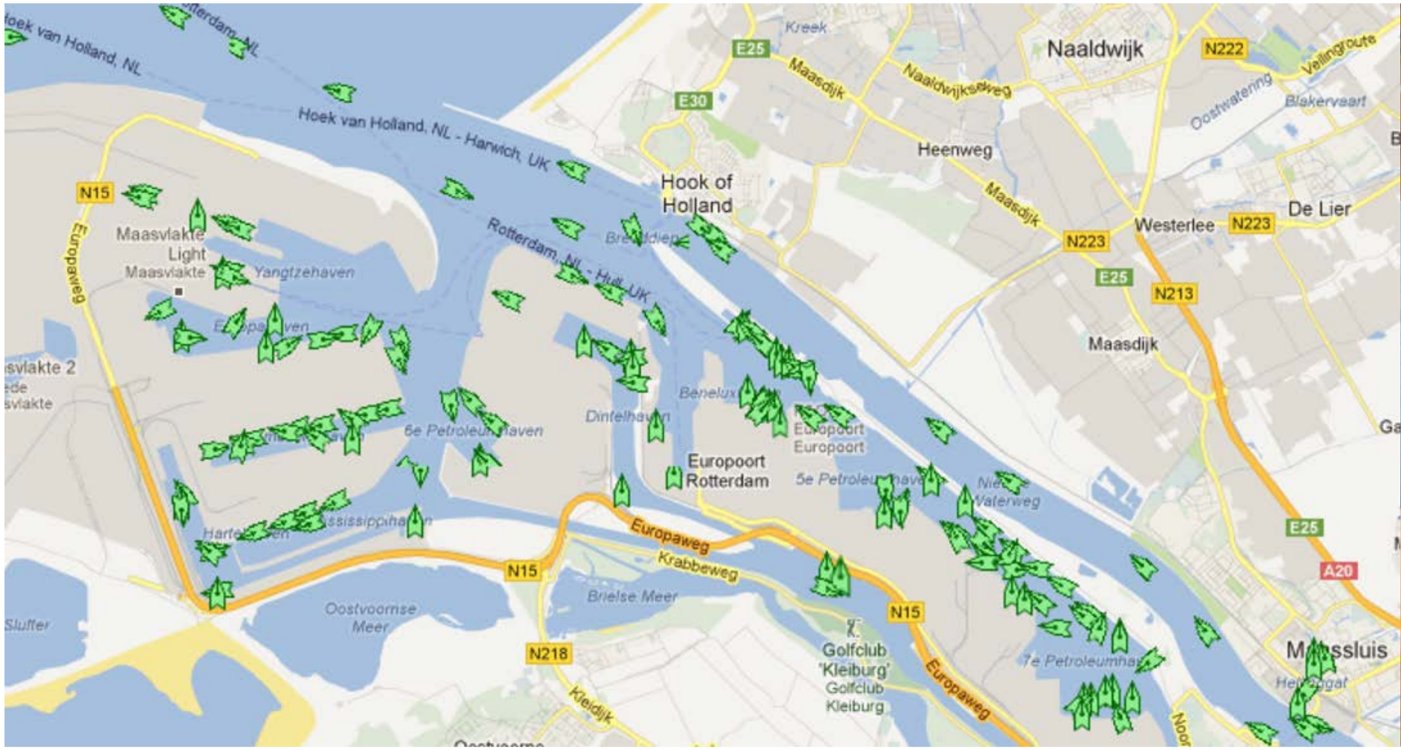
Synchronization over wireless links

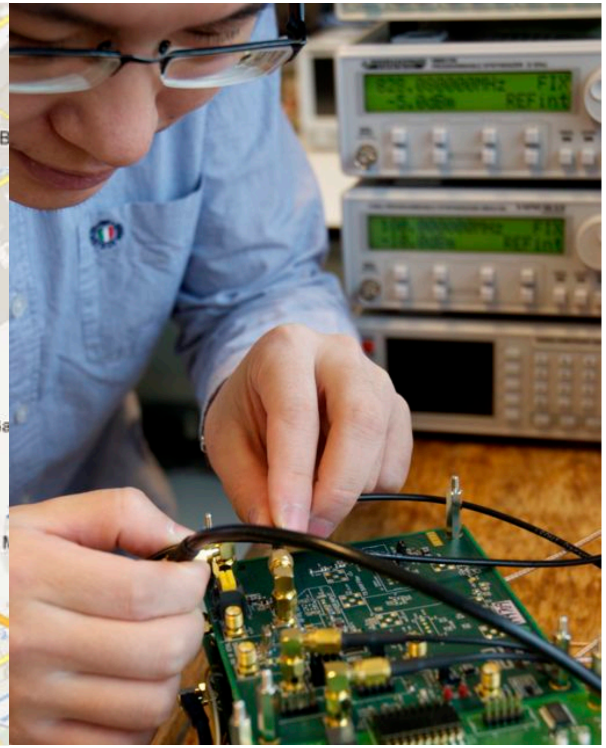
Exploiting signals of opportunity

Signal Processing for Communications

Separation of AIS ship transponder signals

AIS is a VHF communication system for ship transponders. Seen from a satellite, transponder messages overlap. The aim is to separate these using an antenna array (blind beamforming).

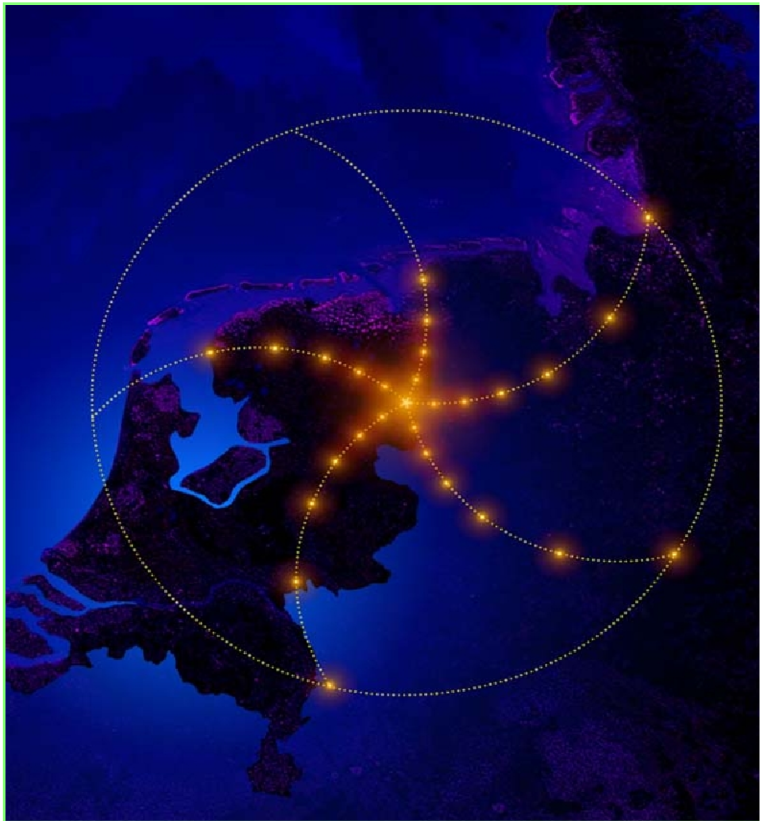




Array signal processing

Signal processing for radio astronomy

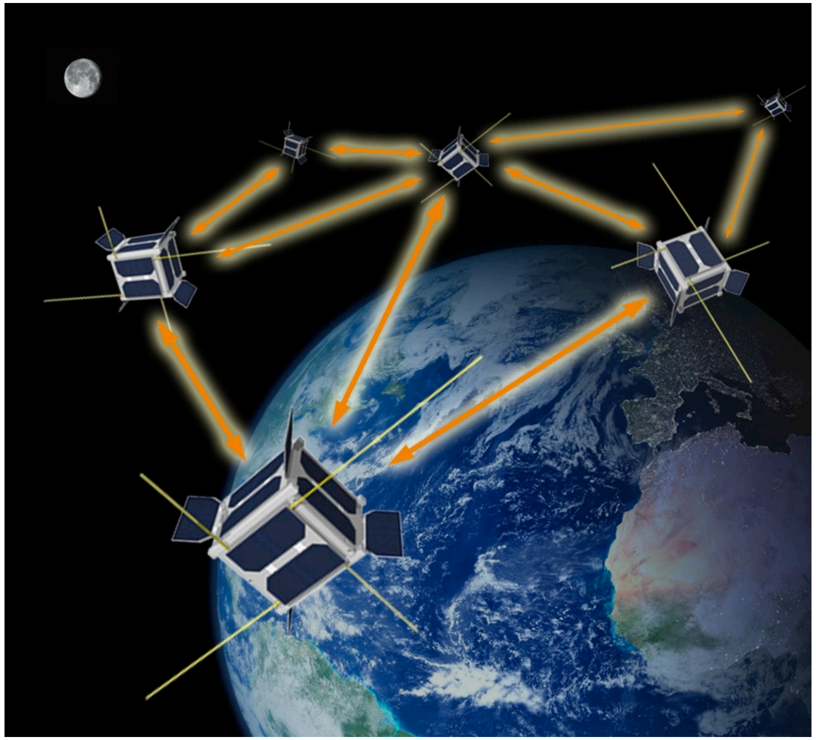
Modern radio astronomy relies on very large antenna arrays. E.g., the LOFAR telescope consists of some 50,000 antennas, distributed over 50 stations in Europe. Also classical 'dishes' will be equipped with focal plane arrays. Issues are (i) imaging, (2) calibration, (3) interference cancellation.

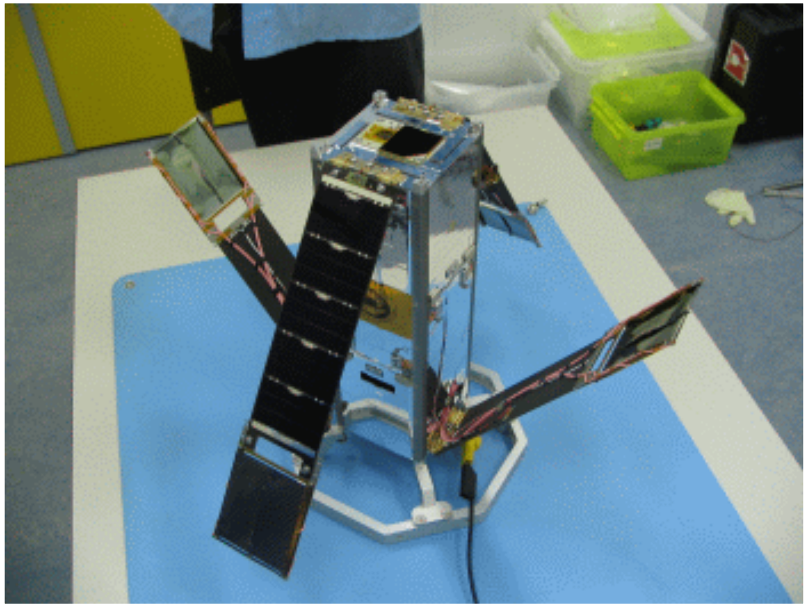


Array signal processing

Low-frequency radio telescope in space

Below 15 MHz, the ionosphere blocks EM signals from the sky. Therefore, can we design a radio telescope in space, using a swarm of inexpensive nano-satellites? Accurate localization and clock recovery is important.

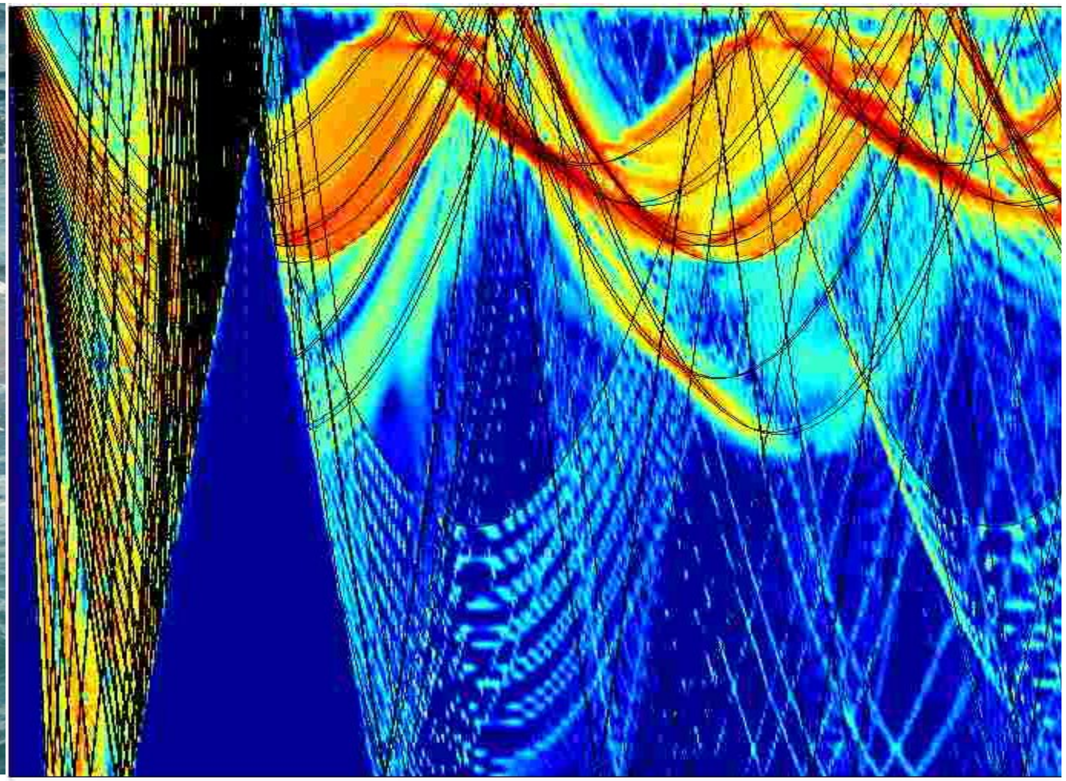




Signal processing algorithms

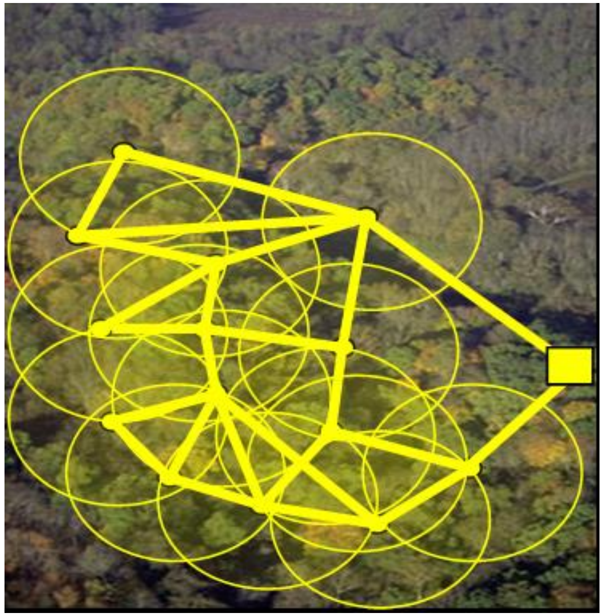
High-speed underwater acoustic communication

Communication channels are highly time-varying and rich in multipath



Signal Processing for Communications

Signal Processing for Self-Organizing Wireless Networks
Mathematical foundations to develop large self-organizing networks based on cognitive radio devices that are capable of sensing the radio spectrum and adapt accordingly. Evolved into "sparse sensing" on networks (graphs).



Geert Leus

Massive MIMO

Compressed sensing

Graph signal processing

Graph signal processing
Sampling, estimation, filtering of signals on an irregular (graph) domain

Acoustic signal processing

Intelligibility enhancement for speech communication systems
Can we do "precoding" of speech signals to enhance their intelligibility at the receiver, taking channel distortions and environmental noise into account?

Richard Hendriks

Acoustic modeling
Array signal processing
Distributed optimization

Issues:
- MIMO
- robust channel inversion

Distributed signal processing

Autonomous sensor networks

Autonomous drone navigation including localization and synchronization, using RF signals from terrestrial ground stations and collaboration with other drones.

Raj Rajan
Space and airborne systems
Space-based interferometry
Autonomous navigation
Sensor fusion

Biomedical Signal Processing

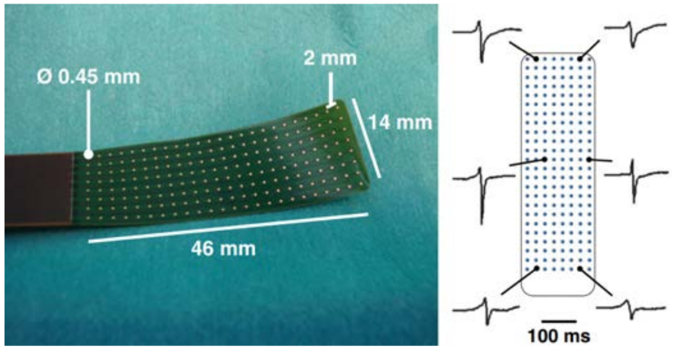
Atrial fibrillation

Detection and estimation of fibrillation based on multichannel datasets and tools from machine learning

Richard Hendriks
Borbala Hunyadi

- ECG, atrial fibrillation
- EEG, epilepsy detection

Bio signal modeling
Statistical signal processing
Mathematical techniques
Machine learning



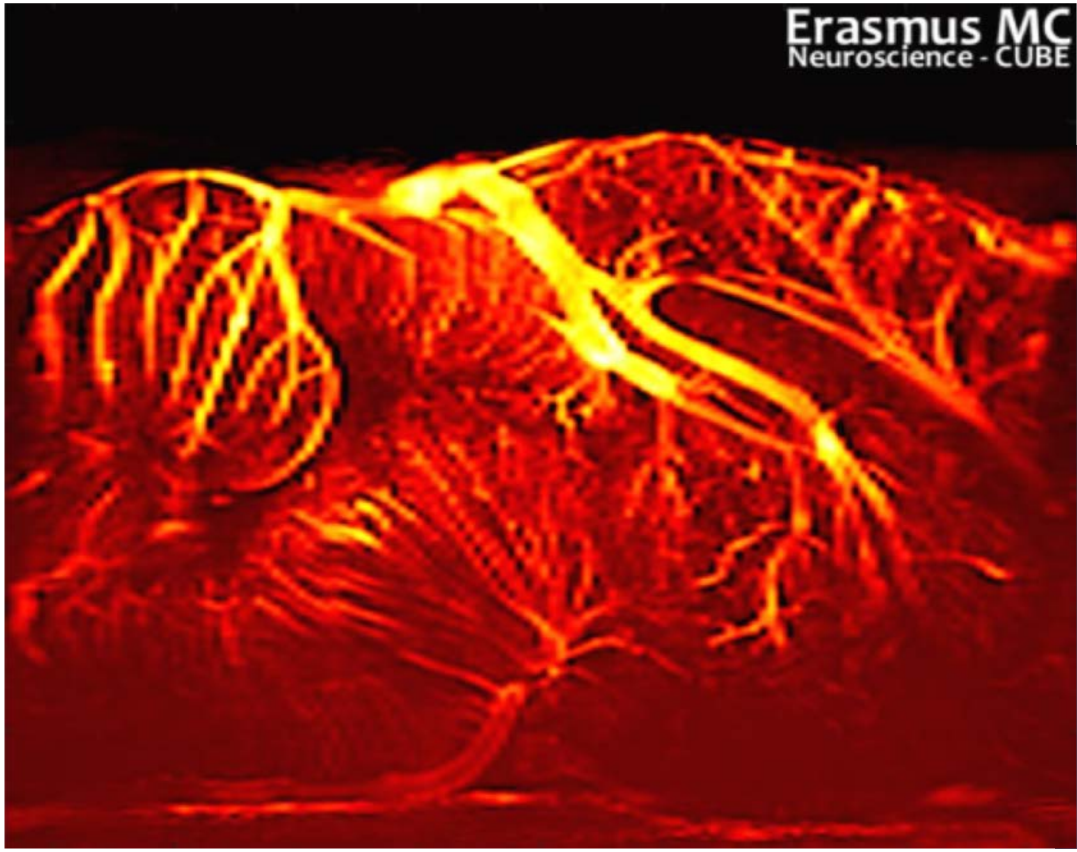
Biomedical Signal Processing

Multimodal, multiresolution brain imaging

Developing a novel brain imaging paradigm combining functional ultrasound and EEG

Bori Hunyadi, with Erasmus MC

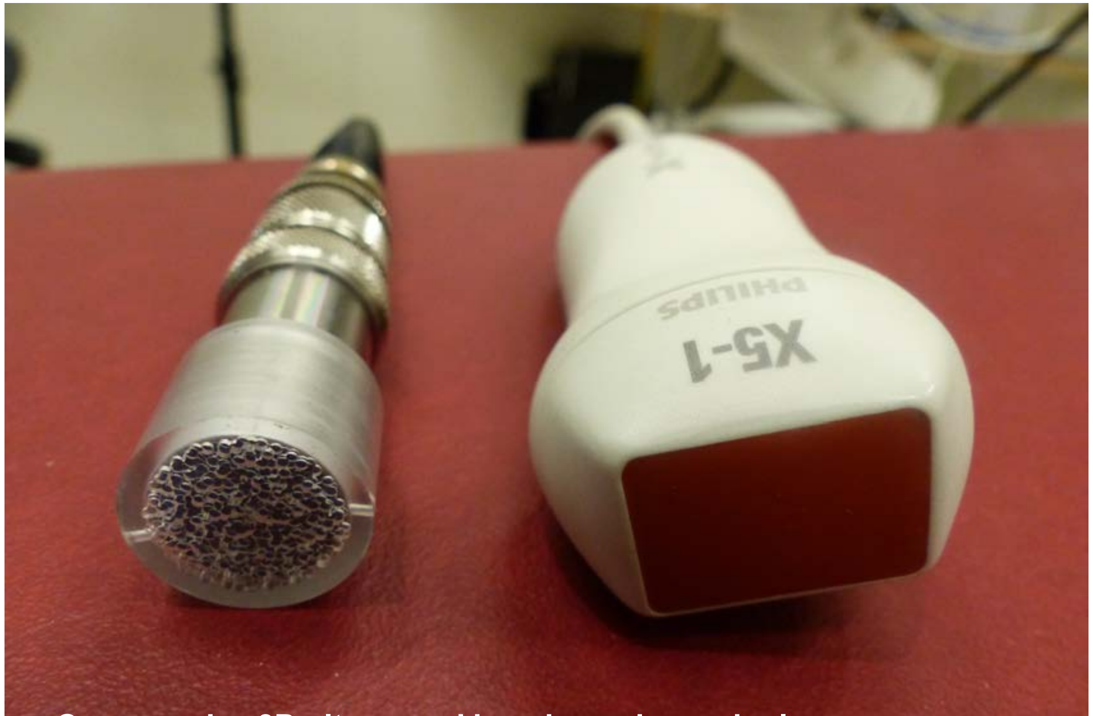
- High dimensional data
- Tensor tools



Biomedical Signal Processing

3D Ultrasound using a single transducer

Normally, 3D ultrasound requires a 2D array of transducers (10,000 elements), with complex digital acquisition. We recently showed how 3D ultrasound is possible using a single transducer and a plastic phase-shifting cap which gives a unique time-domain signal in each direction.



Compressive 3D ultrasound imaging using a single sensor
Science Advances, Volume 3, December 2017

Geert Leus, with Erasmus MC

- 3D ultrasound
- Functional ultrasound

Array signal modeling
Compressive sampling

MRI computational imaging

Reinventing MRI
Normally, MRI requires superconducting magnets (very expensive). Is it possible to make images using permanent magnets?

Rob Remis, with LUMC

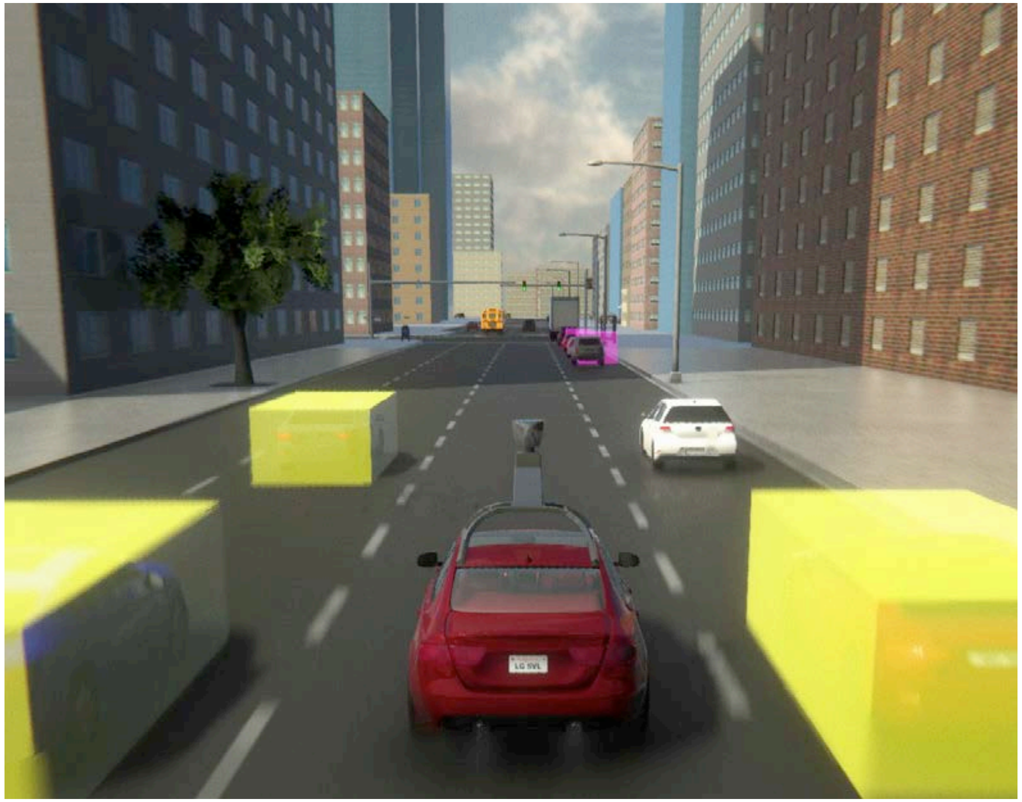
- Low-field MRI
- High-field MRI

EM field modeling
Mathematical techniques
Deconvolution algorithms

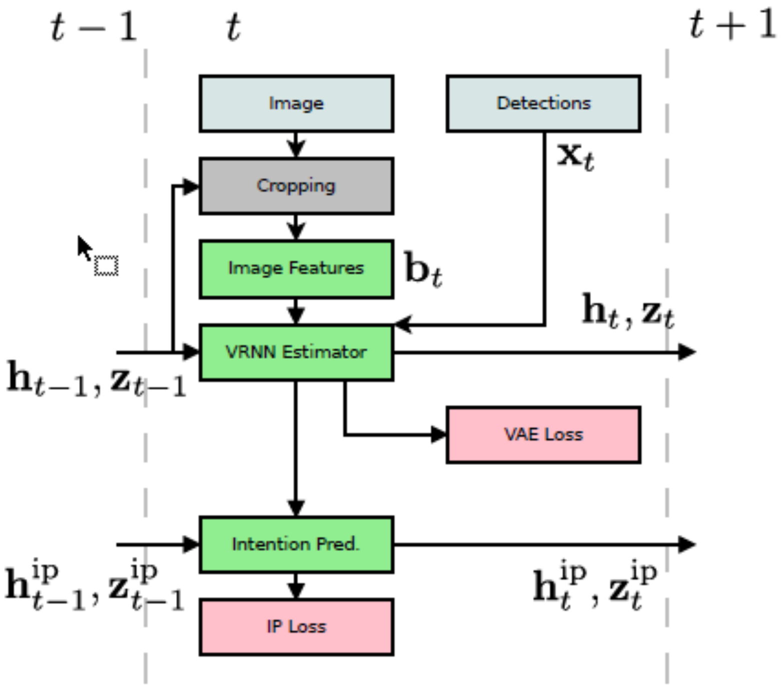
Probabilistic Machine Learning

Probabilistic graphical models and neural networks for robust real-time perception in autonomous cars

Justin Dauwels
- Graphical models
- Deep learning



Validation through simulations and field trials



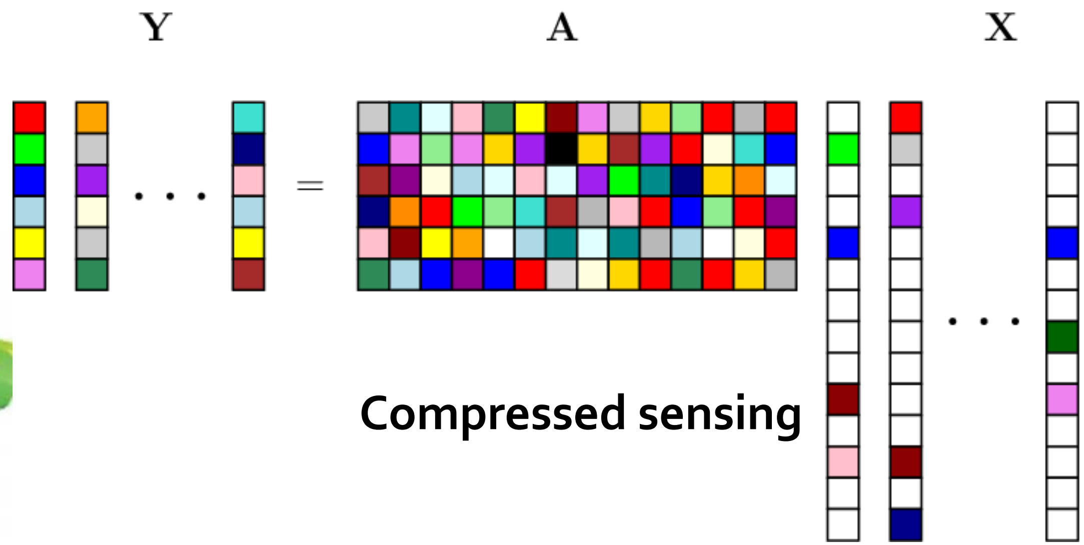
Multi-task training of neural networks

Sparsity-aware Signal Processing

Estimation, detection, and control problems related to resource-constrained stochastic networks

Geethu Joseph
- Compressed sensing
- Bayesian learning
- Reinforcement learning

Network control



Compressed sensing

Wireless communication

Circuits and Systems

Some relevant MSc courses

- EE4C03 Statistical Digital Signal Processing

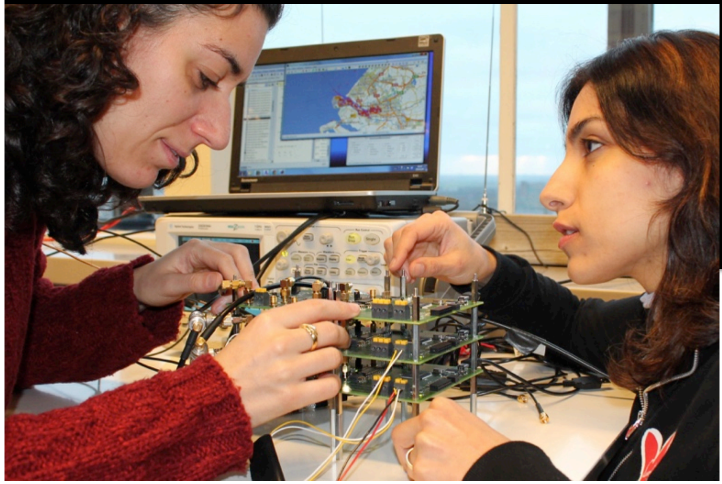
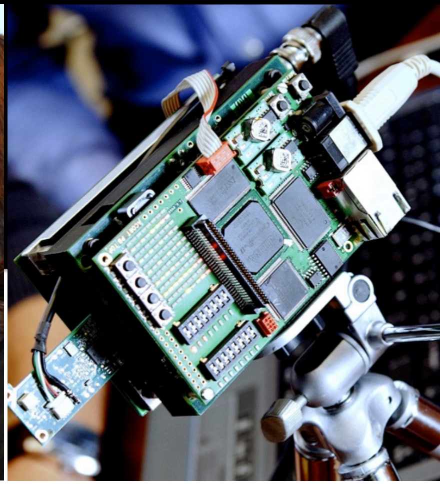
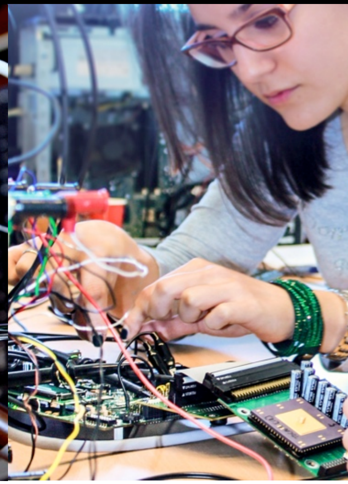
  Modeling of signals as random processes (mean, variance, pdf), and as filtered random noise. Estimation of filter parameters. Optimal prediction and filtering, adaptive filtering (LMS, RLS)

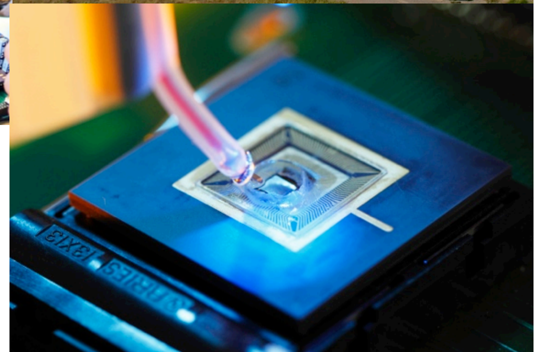
- EE4C11 Systems Engineering
- EE4C12 Machine Learning for EE
- ET 4386 Detection and Estimation

  Optimal estimation of parameters of signals in noise. Lower bounds on performance. Optimal detection of the presence of signals.

- ET 4311 Applied Optimization Methods
- EE 4685 Machine learning – a Bayesian perspective

- ET4358 Fundamentals of wireless communications
- ET4715 Array signal processing
- ET4010 Wavefield imaging
- EE4740 Data compression
- EE4750 Tensor networks



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