Bringing Healthcare to Home:

Wearables and Large-area Sensors

2022-06-13 | Ashok Sridhar, PhD | Business Development

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An Introduction to Holst Centre

Holst Centre

- ✓ Started in 2006 on initiation from Philips Research, named after Gilles Holst, first director of Philips Research
- ✓ Located at the High Tech Campus in the heart of Brainport area, home of Dutch high tech industry
- ✓ Aimed at fostering and orchestrating innovation with and between companies

Holst Centre Fundamentals

- Managed and run by 2 reputed R&D institutes: TNO and imec
  - TNO: biggest Dutch R&D organisation focused on applied research aimed at improving societal welfare coupled to economic growth
  - Imec: famous Belgian R&D institute aimed at advancing chip technology

TNO innovation for life

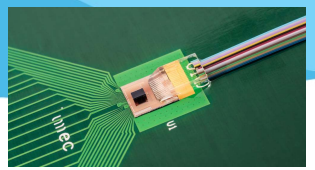
- Thin film and flexible electronics
- Energy storage

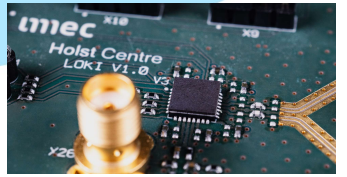
- Health care technology
- Integrated photonics

imec

- Low-power wireless communication
- Edge AI

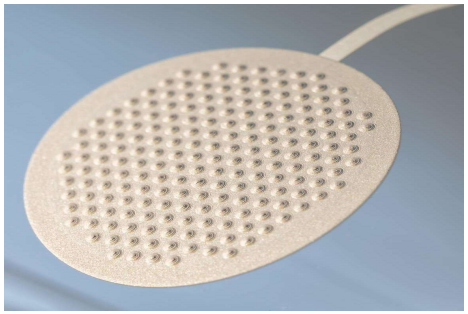
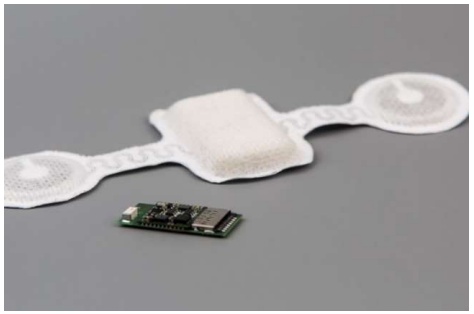
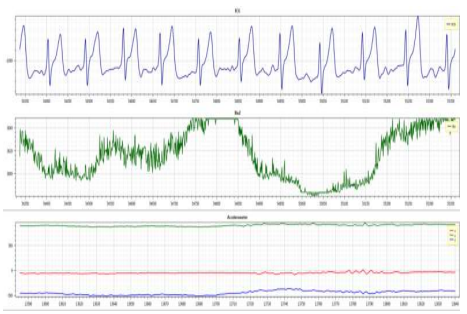




R&D Orchestrator

- One-stop shop approach
- From application requirements to full system design and material + equipment development
- Organizing and executing complex and disruptive innovations with and along the value chain

Technology	Components	Systems	Applications & Data analytics
			
Materials, equipment, processes => pilot line	Electrodes, sensors, electronic components	Health patch, IoT devices, optical switch	(Clinical) trials, data analysis, algorithms

Business Models

1. **Shared innovation**

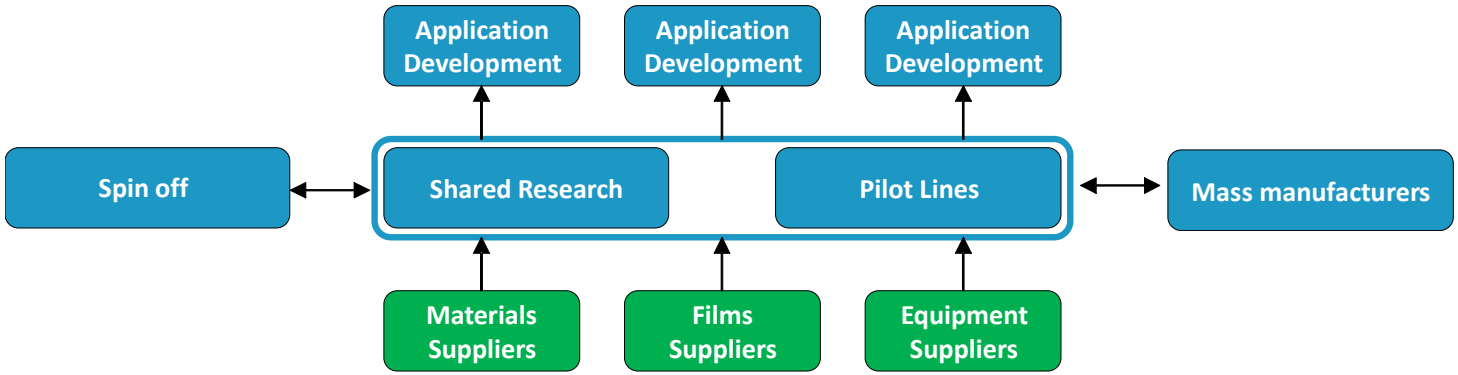
   Results and technology roadmap shared between program partners non-exclusively

2. **Dedicated projects**

   With one partner or with a closed consortium

3. **Technology transfer (licenses, spin-offs)**

   From existing background know-how



HealthTech @ Holst Centre:
Enabling Remote Patient Monitoring

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Wearable Devices

Large Area Sensors

Smart Clothing

- Generic **technology platforms** tailored to specific **applications**
- **Technology platforms**: integration of **sensors**, **materials**, flexible **printed electronics**
- Continuously being expanded via **new sensors and read-outs**

Remote Patient Monitoring:
Why is it relevant?

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People at the core, technology is the enabler!

- Leverage advancements in digital health to shift the focus away from ‘treating patients’ towards ‘ensuring the well-being of human beings’
- Unburdening the healthcare system by moving away from care at hospitals to “Care at Home”
- Highly personalized and not a one-type-fits-all approach
- Healthcare providers evaluated by “health and well-being of populace” and not by “services rendered”

Key Enabling Technology:
Printed and Thin-film Electronics

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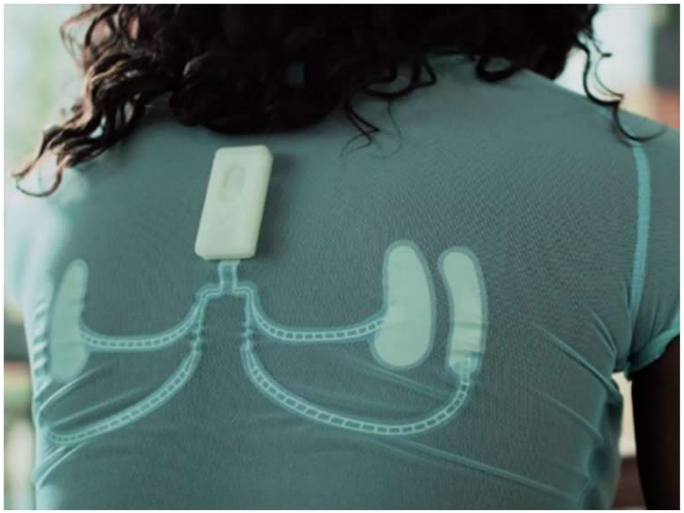
Flexible

Stretchable

Washable



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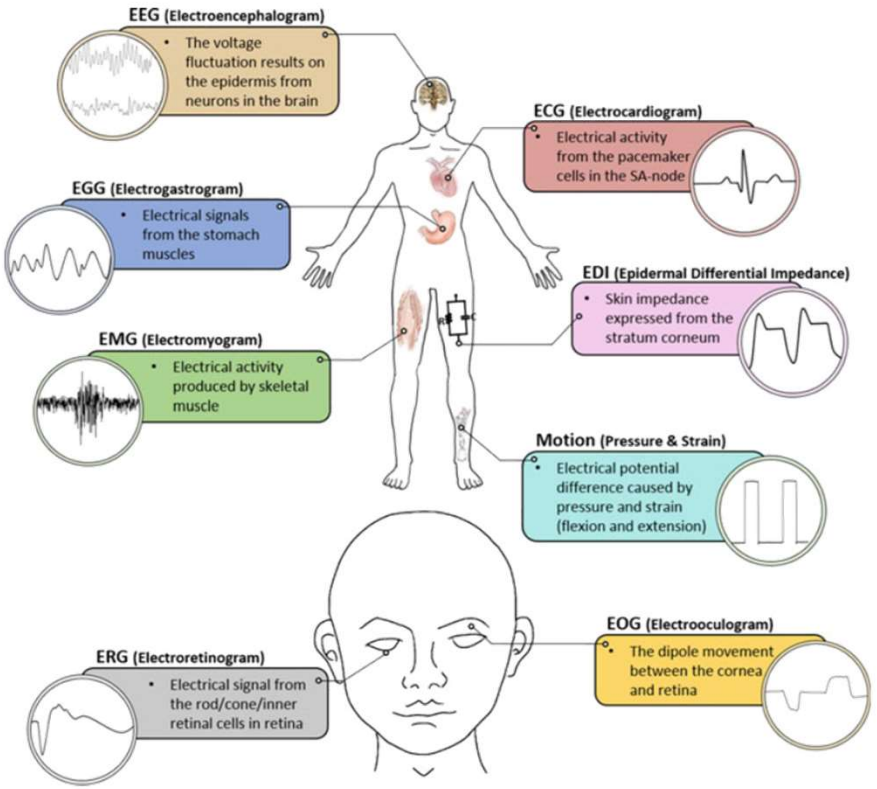
Bringing Healthcare to Home: Wearables

Parameters for Next-Gen Wearables

- Electrical
  - **Biopotentials** (ECG, EEG, EHG, …), hydration
- Thermal
  - Thermography, thermal transport, hydration
- Fluidic
  - Sweat (loss and chemistry), **blood flow**
- Mechanical
  - Strain, **motion**, modulus, **pressure**
- Optical
  - UVA/UVB, **oximetry, PPG, vein mapping**
- Mechano-acoustic
  - Cardiac auscultation, **ultrasound**



Wearable Health Patch Platform

Wearable Health Patch Platform

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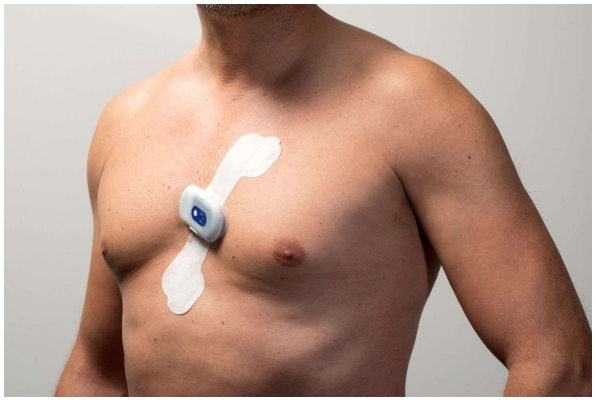
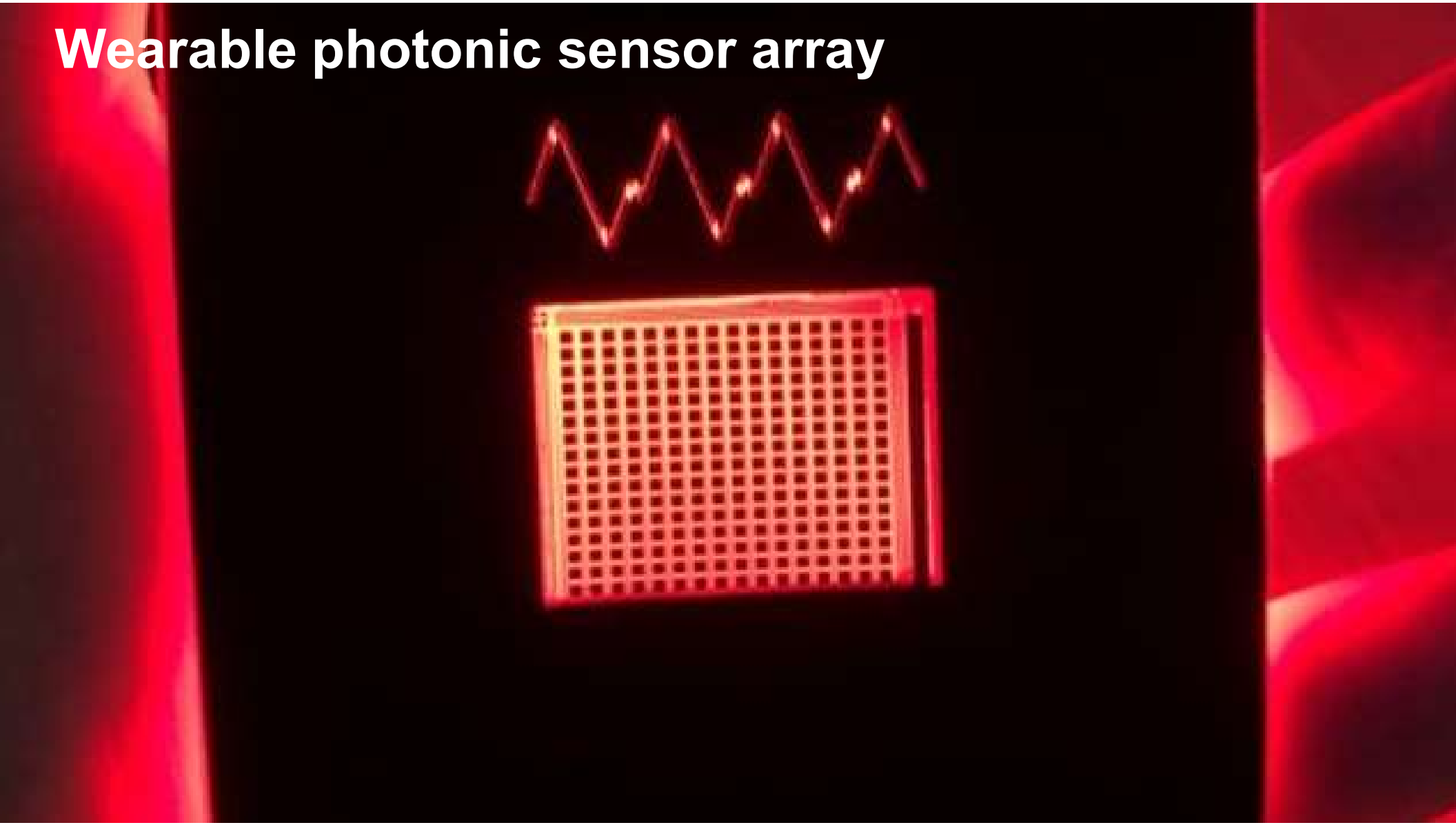
- ECG
- BIO-IMPEDANCE
- ACCELEROMETER
- POSTURE
- TEMPERATURE
- SPO_2
- DRY ELECTRODES
- CORE BODY TEMPERATURE
- ON-BOARD DATA STORAGE
- BLUETOOTH
- WATER PROOFING
- FALL DETECTION ALGORITHM
- LONG-TERM WEAR

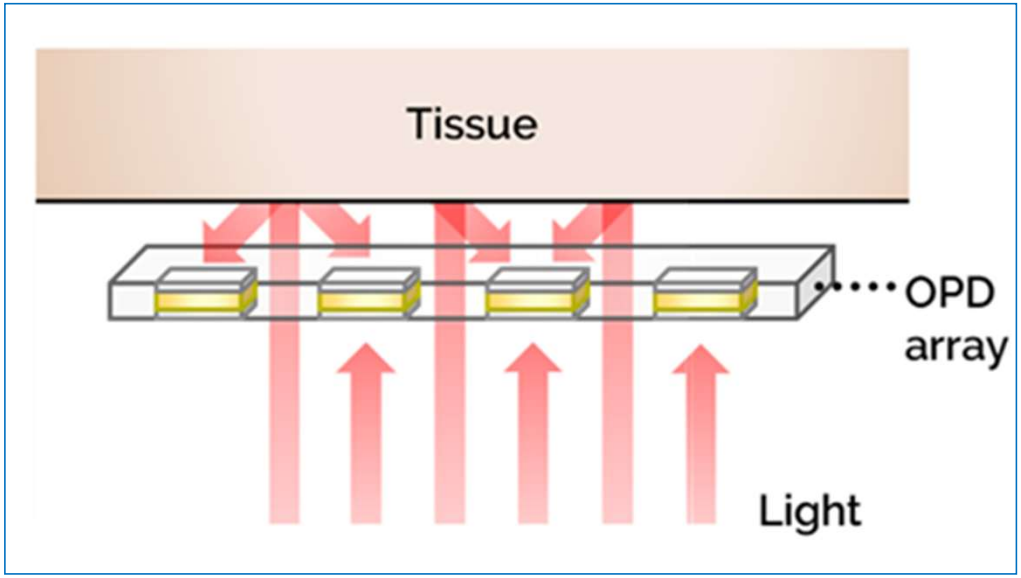
SENSOR AVAILABLE
HW / SW
IN DEVELOPMENT



Wearable photonic sensor array



Wearable Photonic Sensor Array



- Flexible photodiode arrays with integrated illumination
- High quality signals in reflection at all locations on the body
- Signal quality and biomarker mapping over area & in time

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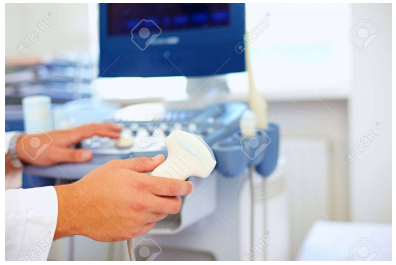
Bringing Healthcare to Home: Large-area Sensors

Large-area Ultrasound Devices

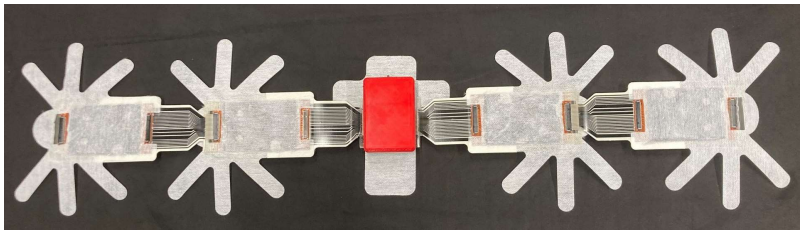
Ultrasound is the fastest growing medical imaging technique

- Early detection and prevention of medical conditions
- Safe and low-cost technology for health monitoring
- A wearable, large-area form factor brings this versatile technology to home, without the need for a skilled practitioner

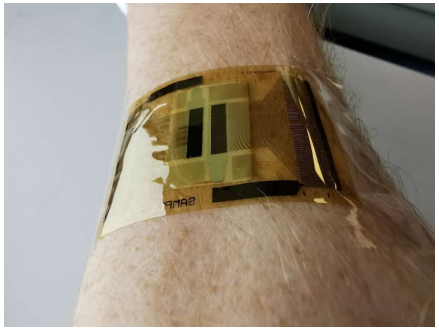


From handheld

to patch (small)

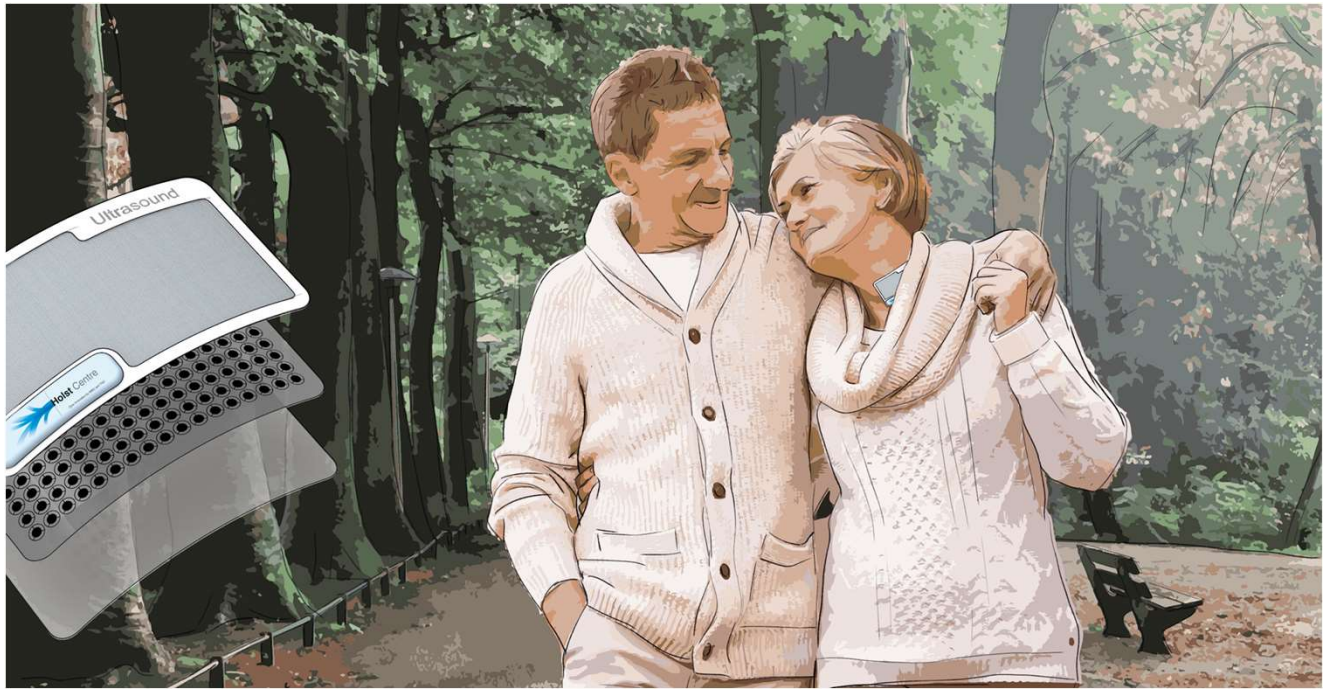


to modular patch (tiling of small, rigid CMUT chips)



and truly large-area & flexible

Large-area Ultrasound Devices



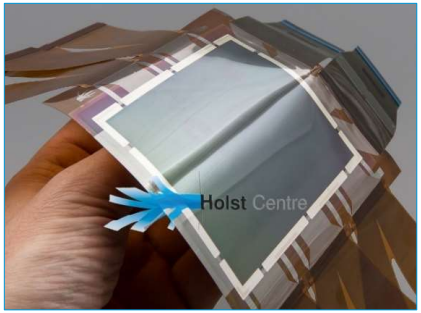
Applications:

- Blood pressure
- Cardiac output
- Vena cava
- Pregnancy monitoring
- …

Large-area Flexible X-Ray Detectors

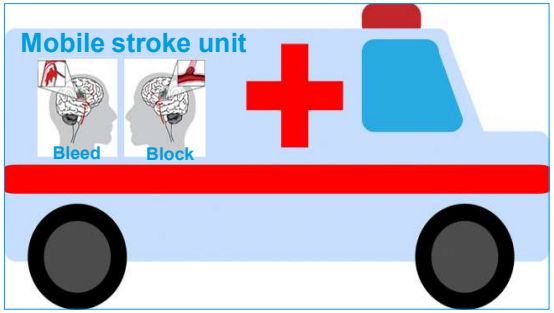
Same performance on plastic substrates that:

are light-weight



can have a curved form factor

can be used for mobile applications



Large-area Flexible X-Ray Detectors

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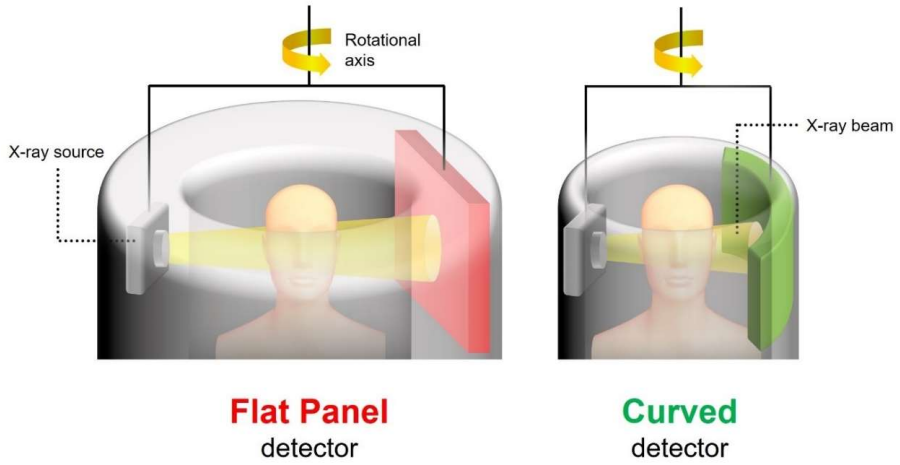
Cone beam computed tomography

- Curved detector enables compact systems: up to 50% footprint detection
- Smaller size enables point-of-care and mobile applications



Large-area Sensors for Object Integration

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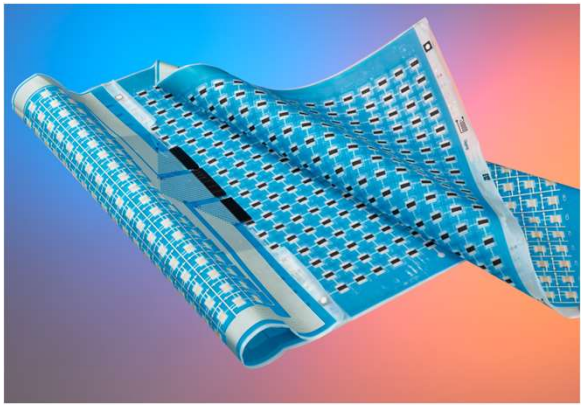
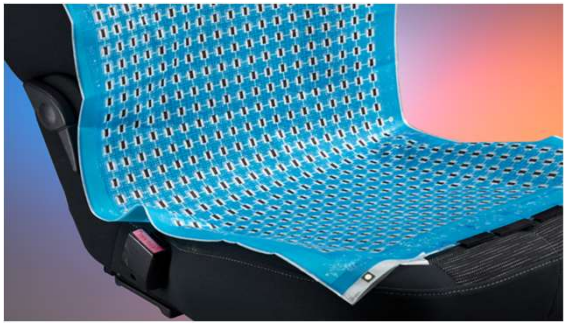
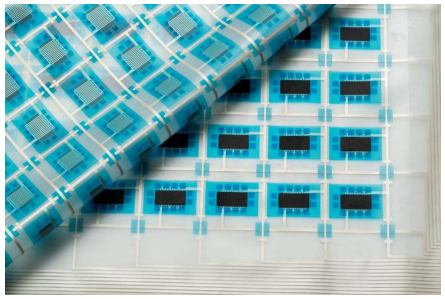
Non-contact sensing

- Large-area sensing devices that are seamlessly integrated in everyday objects such as mattress and chair => it “disappers” into these objects.
- Completely non-intrusive => the user does not need to take any proactive action to wear / enable / replace / recharge the device.
- Can be tailor-made for the application: sensitivity, size of the measurement area, geometry of the object in which it is integrated, etc.
- Multiple sensing functionalities can be integrated in a single sensing surface, enabling multi-modality.

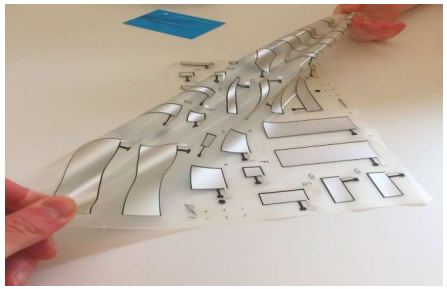




Applications

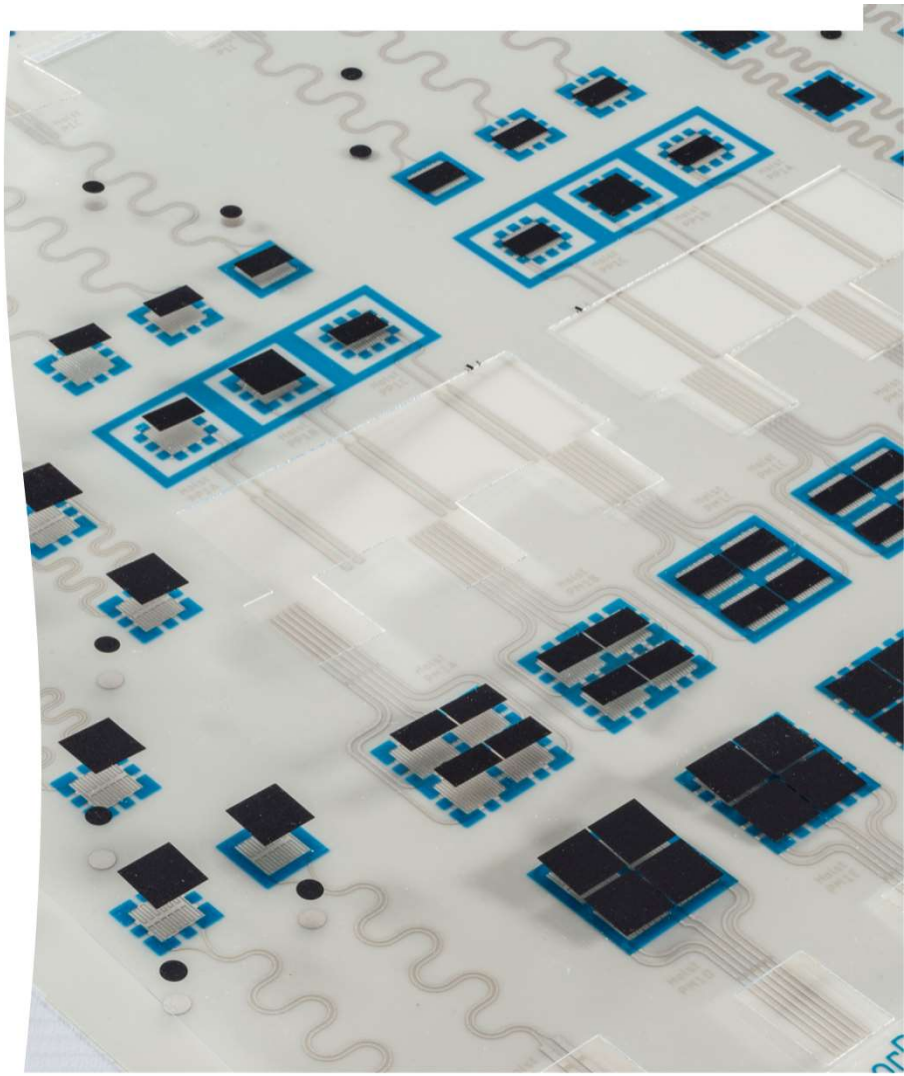


Pressure sensor
Posture, Micro-movements



Piezoelectric sensor
Heart rate, HRV,
Respiration patterns

- Infant monitoring
- Elderly monitoring
- Decubitus monitoring
- Sleep apnea / sleep quality monitoring
- Driver monitoring
- …



Multi-modal sensor
Combining pressure and piezoelectric sensors

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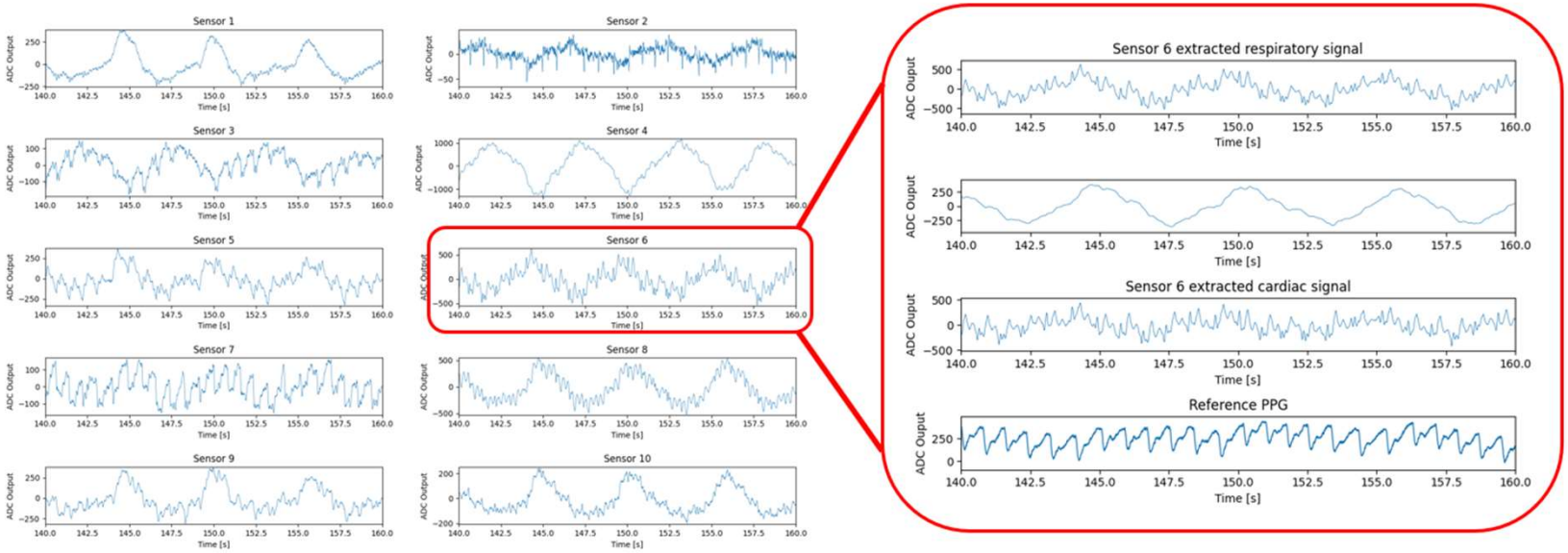

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Health Patch Build-up

Readout electronics in casing

Top cover

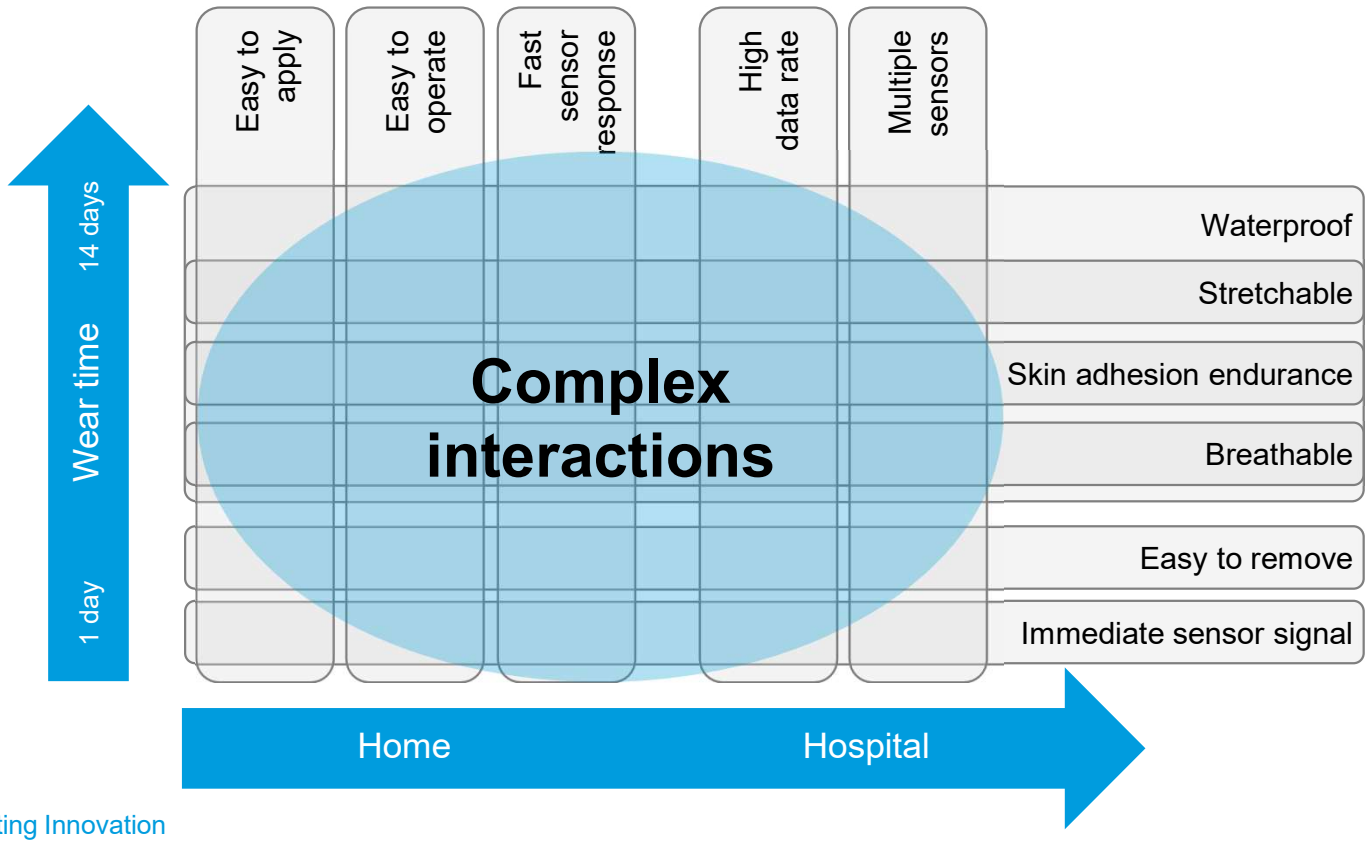
Stretchable and flexible substrate

Printed circuitry

Electrodes

Skin-adhesive

Functionality Matrix



Wearable large area ultrasound: modular transducers, stretchable circuitry

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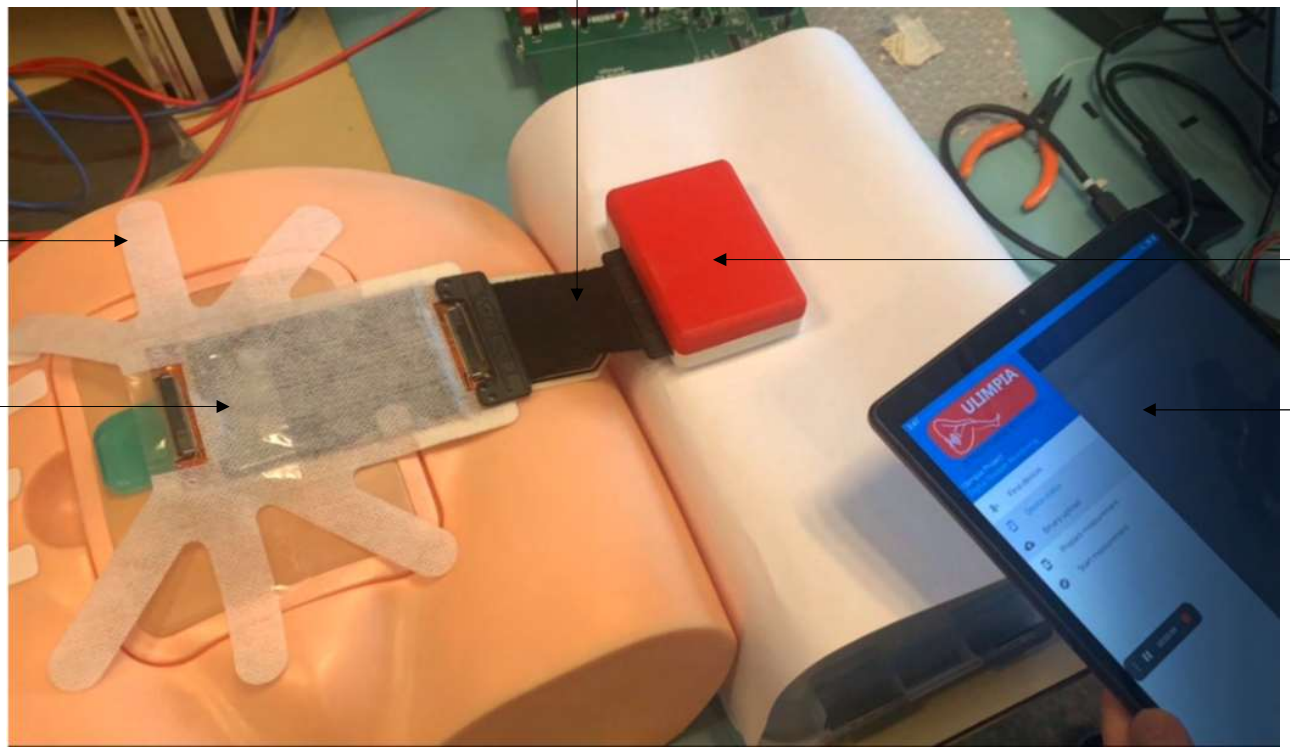
Flexible printed connector

Bladder phantom

Modular board with Ultrasound transducer (CMUT) + FPGA + local voltage regulators

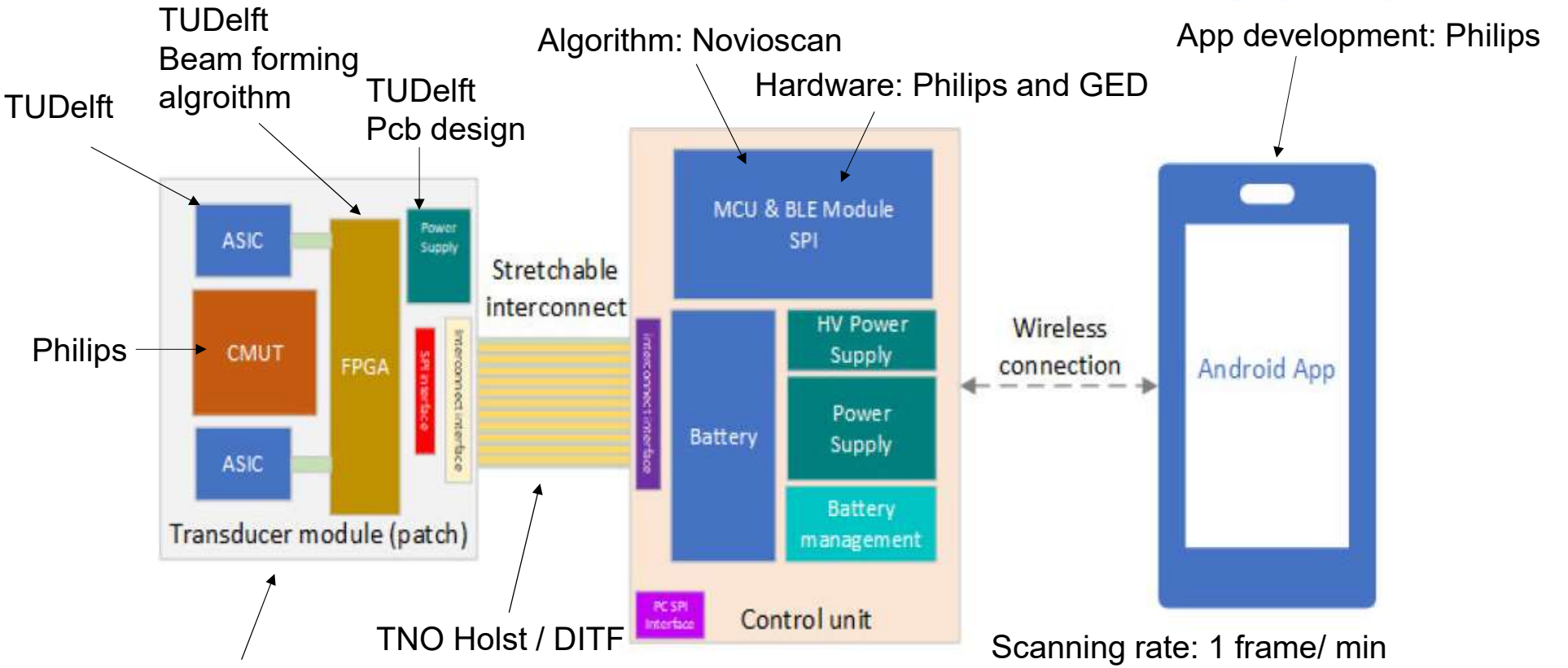


Controller & battery

App connected via bluetooth

Project ULIMPIA, PENTA endorsed by EUREKA, PENTA cluster number E!9911

Wearable large area ultrasound: schematics



Wearable photonics sensor array: clinical relevance of several read-outs

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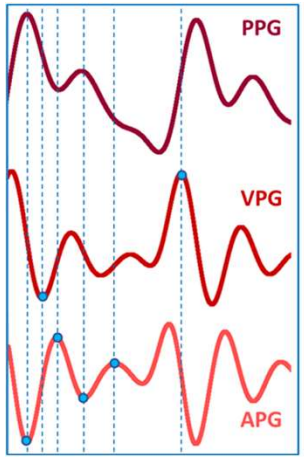
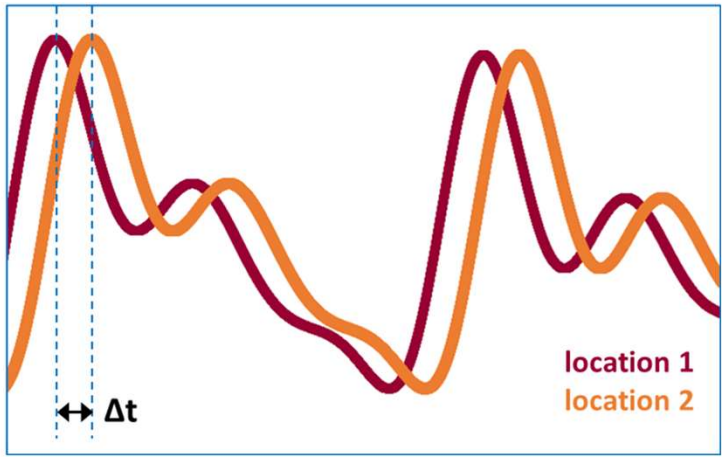
Clinically-relevant parameters:

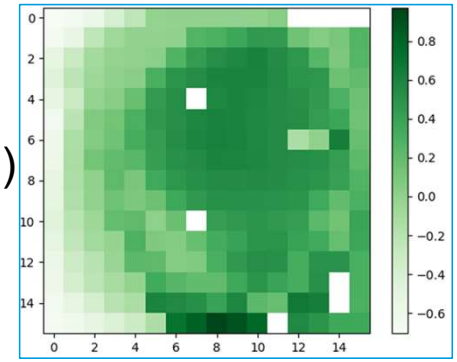
- Heart rate
- Respiration
- Blood oxygen saturation
- Tissue oxygen saturation
- Perfusion
- Blood pressure
- ...





Read-outs in 2D & time:

- Photoplethysmogram (PPG)
- Pulse wave velocity (PWV)



Wearable photonics sensor array

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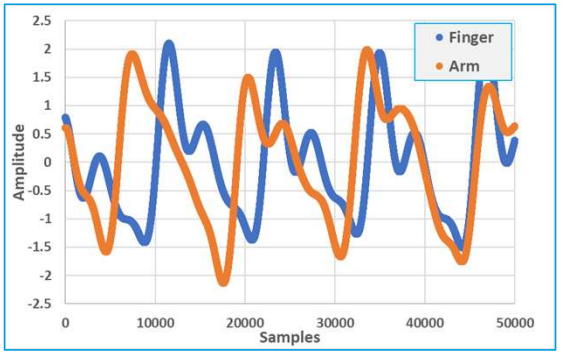

Summary:

- Wearable and conformable photonic sensor arrays
- Good PPG measurements in VIS and NIR on any body location
- Continuous measurements in 2D and time

Next steps:

- Clinical studies on relevant target group
- Large-area mapping of relevant biomarkers
- Array designs for specific clinical applications