

Biosignal acquisition

4. lecture

Dr. Miklos Kozlovszky
kozlovszky.miklos@nik.uni-obuda.hu

Origin of biosignal (types)

- Organism's body parameters

- Internal

- Physiological (physical, chemical, etc.) parameters
 - Measured internally (invasive)
 - Fluid (Blood) samples, etc.
 - Measured externally (non invasive)
 - Blood pressure, pulse, ECG, EEG, EMG, etc.

- External

- Skin temperature, color, etc.
 - Humidity
 - Temperature
 - Pose, acceleration, velocity, etc., movement
 - ...





Why only DAQ?

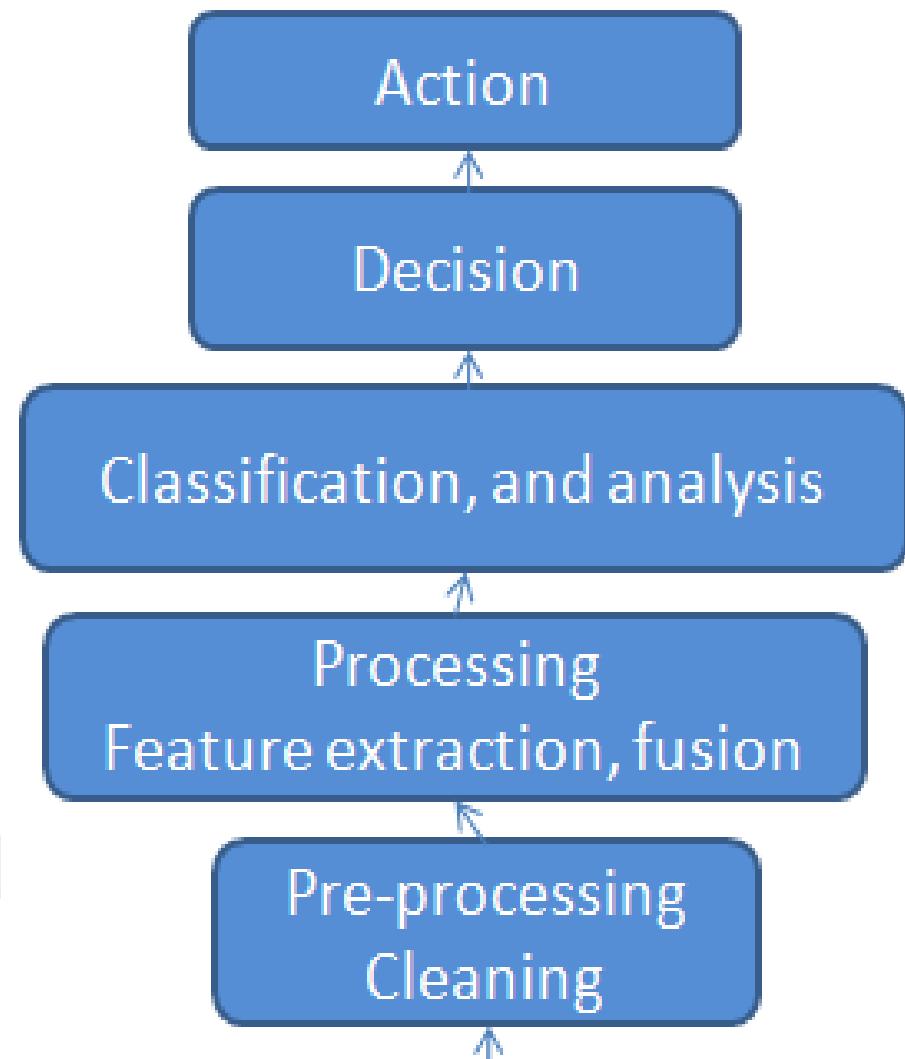
- Why just DAQ?
- Control?
- Distributed Control?
- Supervisory Control?

Sensor data handling

- **Data Acquisition (DAQ)**
 - Single/multiple sensors
- **Data management**
 - Processing/filtering
- **Store and retrieve**
- **Vizualisation**
- **Data sharing**



What if setup is unknown?





Measured biosignals

- Measurement results:
 - Actual temperature of the human individual is 39° C
 - Accelerometer has reported a 1 g movement.
 - Patient does not moved since 6 hours.
 - Patient's hand moved 1 cm
 - Patient's hand oscillate 1 cm with an average amplitude X

Are these values bad or good? How accurate?

Until this, this is pure science...

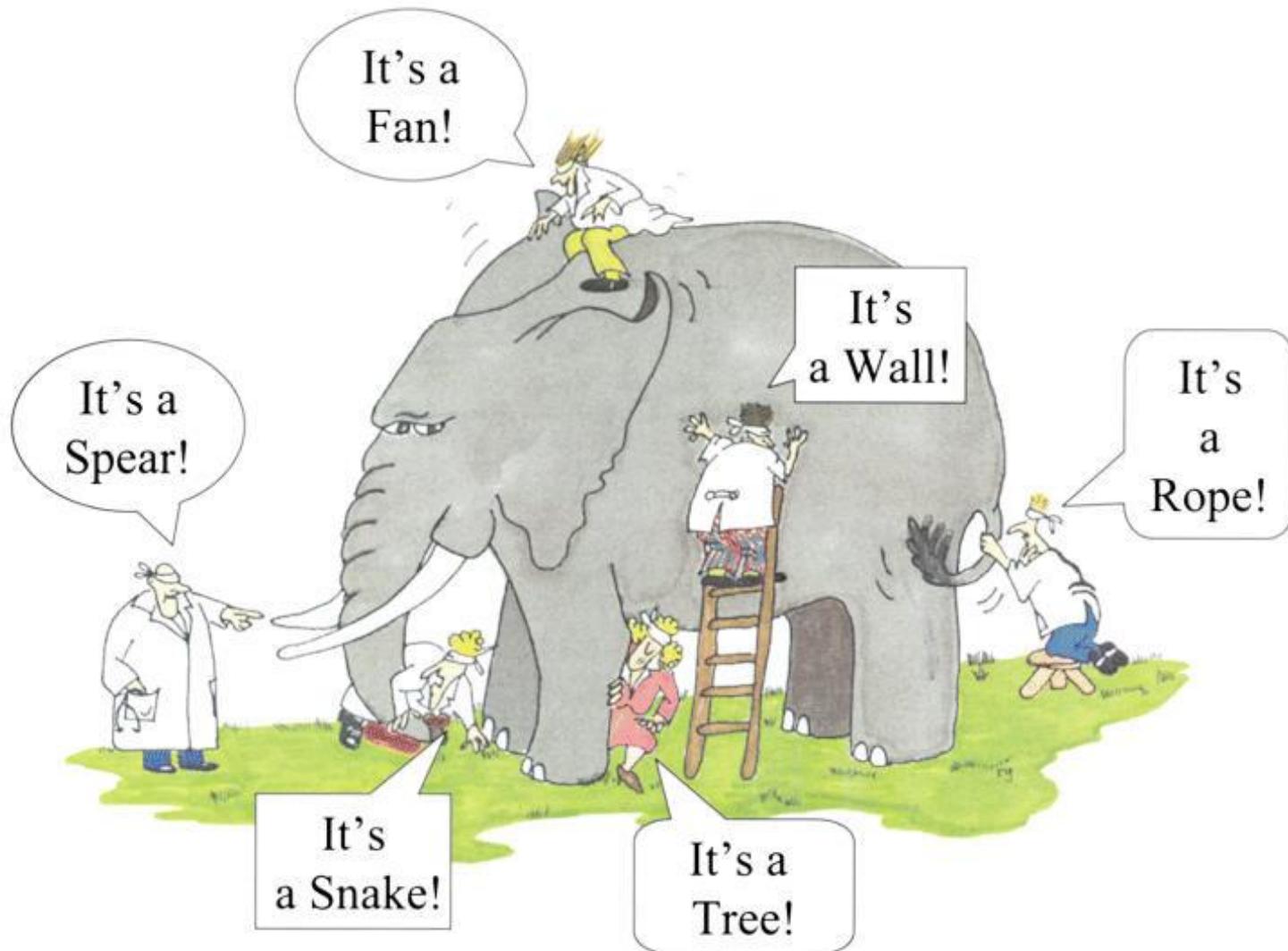
Measured biosignals (contd.)

- Measurement result:
 - Patient do not move since 6 hours
 - Patient with serious hypertension problems has normal values during weekends.

Pure scientific work (as usual):

- Plan the measurement
- Do the measurements in a known setup/environment
- Pre-process (clean, filter,etc.) measured data
- Process measured data
- Evaluate measured data
- Make decisions

A very old story...





Small things vs. big picture





Error of the measured biosignals

Every measurement contains errors!

- Error comes from:
 - Sensing error
 - A→D conversion (quantification)
 - Sampling issues (Nyquist–Shannon sampling theorem)
 - ...
 - Measurement setup
 - Measurement device related problems
 - AAMI - American Association for the Advancement of Medical Instrumentation, BHS-British Hypertension Society (A class 40%: 5Hgmm)
- Remote measurement can contain invisible parameters too. (because we do not know how the measurement was realized)

Error detection and correction

- Calculate/estimate the parameters of the error
 - Short term and long term errors of the time series
- Use additional (alternative) measurements to receive more information
 - More alternative sensors, increased number of measurement, environment exploration, etc.

But this cause more work and problems!

Single vs. multi sensor measurement issues

From the multiple sensors: receive different results

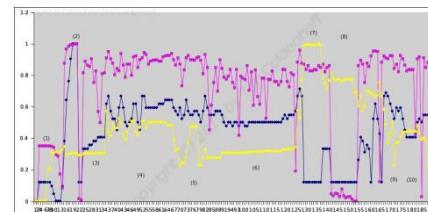
Q: Which measurement results is (more) true?

Should we take:

-average?

-weighted average?

-...?



From this point, this is more sexy pure science with math...

Can be a hard task.



Engineering challenges with large scale biosignal DAQ systems

- Generic challenges
 - P1: Large number of DAQ client nodes
 - P2: Large number of sensors (different sensors types)
 - P3: High data rate
- Communication performance problem → P1*P2*P3
- Software constraints
 - Real-time DAQ + Pre-processing + Processing + Vizualisation (different ranges)
 - Complex decisions
 - Online data management (sharing + archiving)

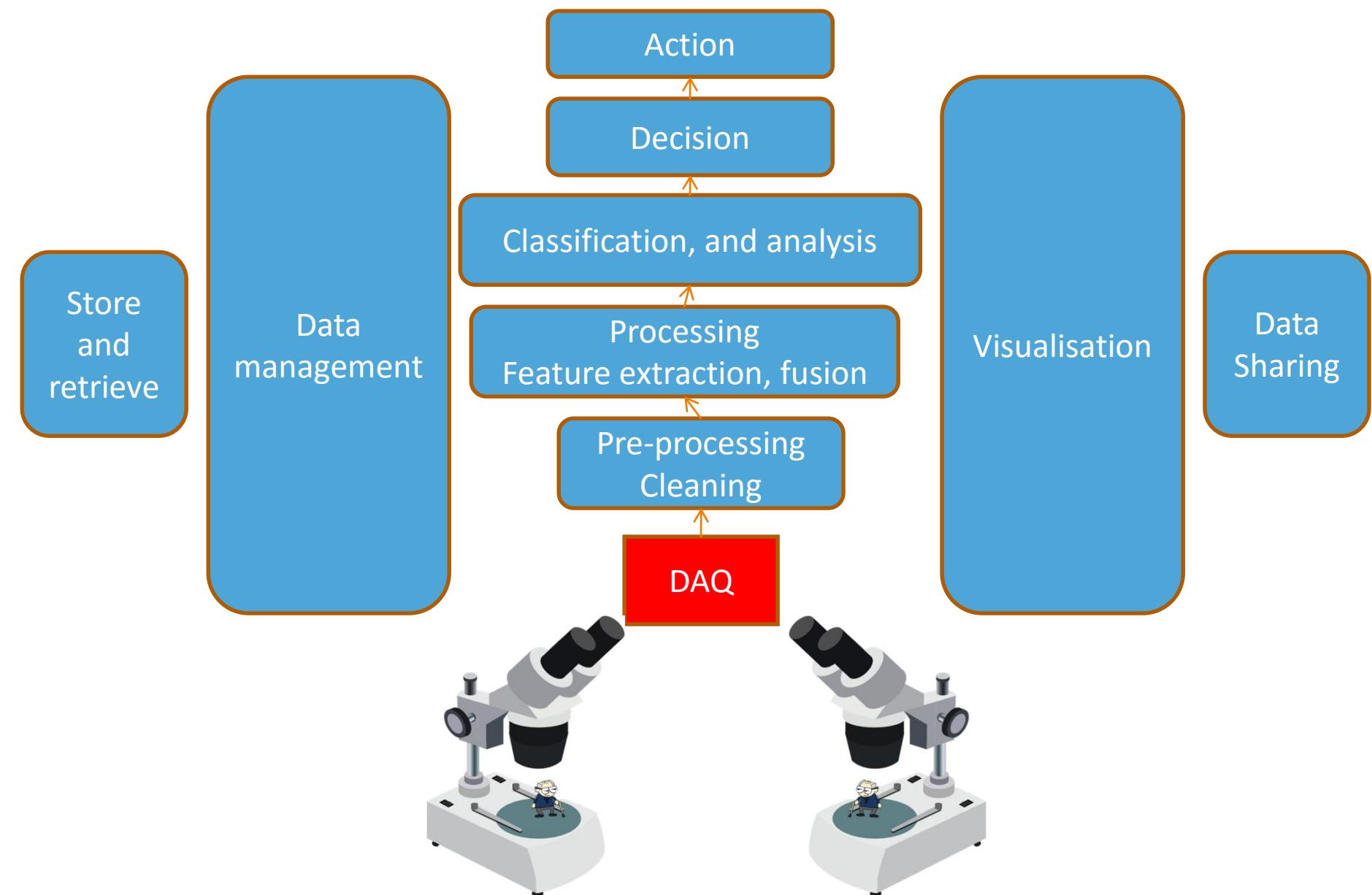


Engineering challenges with large scale biosignal DAQ systems

- Hardware constraints:
 - Energy consumption
 - Communication ranges , data multiplexing issues /in time, frequency, etc. domains/
 - Security
 - Reliability
 - Usability (size, GUI, etc.)



(Bio)signal handling process





Remote biosignal acquisition

Sensors

In sport and everyday life

Sport activity monitoring

- Nike/Nike+

<https://www.youtube.com/watch?v=NqBHQ-8Bs9Q>

Year 2000, PAN communication

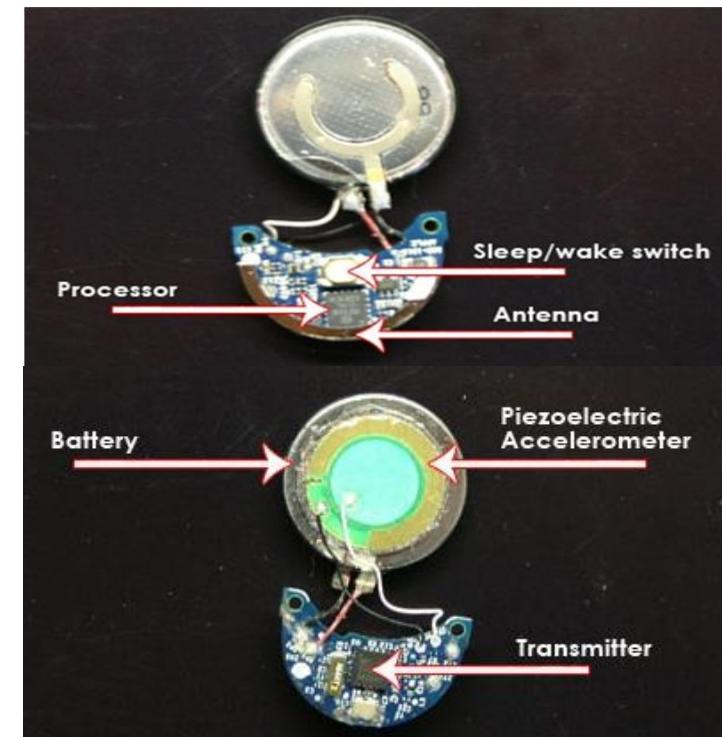


Watches

Polar:

<https://www.youtube.com/watch?v=EGcgtqm7CV0>

Suunto, Garmin, ...





Sport activity/performance monitoring



Wearable Sensor belts
embedded in clothes
Examples:



Model type	Manufacturer	Sensor type	Connection type
HxM	ZephyrTechnology Ltd.	Pulse monitor	Wireless (BTv2)
Bioharness	Zephyr Technology Ltd.	DAQ harness: pulse,posture,R-R,Heart rate	Wireless (BTv2)
H6/H7	Polar Inc.	Heart rate sensor	Wireless (BTv4)

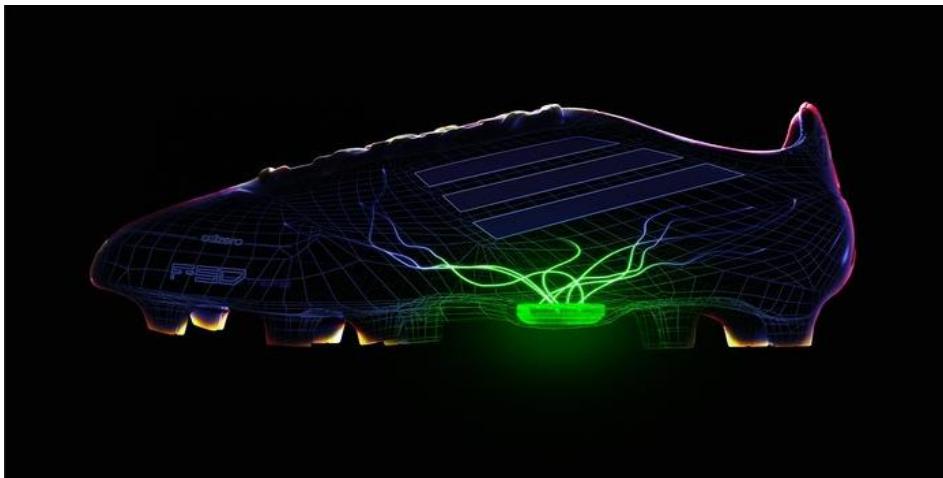


Sport performance monitoring

- Adidas / Adidas Adizero f50 (miCoach SPEED_CELL)

For Pros: <https://www.youtube.com/watch?v=-32FanFg-uE>

Speed, step count, acceleration, step length, turning speed, sprint counting, ...



- Swimmerx (stroke counting, pulse, distance, speed,...)

<https://www.youtube.com/watch?v=dA12gew3FWs>

Sport skill/performance monitoring

- Adidas / Adidas MyCoach smart Ball

<https://www.youtube.com/watch?v=YwWrrlJg0XQ>



- Smart rackets

- Badminton (6DOF IMU)

<http://www.youtube.com/watch?v=NBPynWCp9po>

- Tennis

<https://www.youtube.com/watch?v=upHOTFAhF50>

Smart bicycle (sensors: GPS, power, speed, cadence, biosignals) <https://www.youtube.com/watch?v=T4tGQggQ3Ww>

Environment monitoring

- Live Image/action cameras

<https://www.youtube.com/watch?v=IkeFA1LbZH0>



- Radiation meters

- Light condition meters

- IR / normal visible light (Lux)
 - UV A/UV C <400 nm



<https://www.youtube.com/watch?v= CaZygjRq98>

Environment monitoring

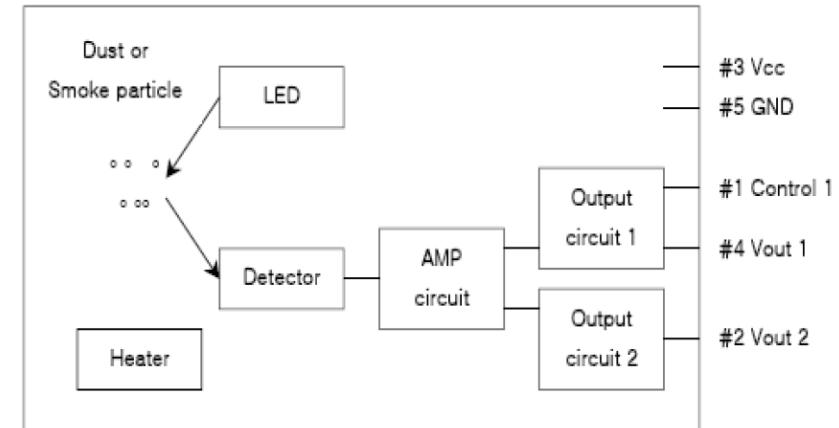


- Air quality/condition meters

- Temperature/humidity

- DUST, pollution

- Volatile Organic Compounds (VOCs)



Substance Group	Example	Sources
Alcohols	alcohol, mineral spirits	cleaning supplies
Aldehydes	formaldehyde	building materials
Ketones	butanone	Paints
Esters	methyl acetate	Glues
Terpenes	pinene	Glues
Aromatics	xylol	paints and glues
Alkanes	heptane	human breath

Location monitoring

- GPS
- Bluetooth based systems
- WiFi based systems
- Cell based systems (GSM/2G/3G/4G/5G)
- IMU

Life activity monitoring

- FitBit



<https://www.youtube.com/watch?v=6e9zBlyLk3s>

Sleep tracking, step counting, sport activity,...

- Helo - Health and Lifestyle Oracle (Toshiba) scam valószínüleg:
- <https://youtu.be/Si39nFbk0Ks>

Heart rate, ECG, blood pressure, step counting, panic button, breath rate, calories...



HEALTH WEARABLE COMPARISON

Health & Fitness Features	SAMSUNG GEAR S2	APPLE WATCH	FITBIT SURGE	MICROSOFT BAND	GARMIN FORERUNNER	FITBIT BLAZE	Wor(l)d HELO
Heart Rate	♥	♥	♥	♥	♥	♥	♥
Steps	♥	♥	♥	♥	♥	♥	♥
Calories	♥	♥	♥	♥	♥	♥	♥
Distance Covered	♥	♥	♥	♥	♥	♥	♥
Sleep			♥	♥	♥	♥	♥
Compatible w/ iPhone/Android			♥	♥	♥	♥	♥
ECG / EKG							♥
Blood Pressure							♥
Blood Temperature							♥
Blood Oxygen							♥
Breath Rate							♥
Mood/Emotion							♥
Fatigue							♥
Remote Monitoring/Vital Signs							♥
Germanium Plates							♥
Panic Button							♥
Blood Sugar (Forthcoming)							♥
Business Opportunity							♥
COST	\$249	\$350	\$330	\$250	\$330	\$170	\$320



Life activity monitoring (medical grade)

- Empatica - e.g.: epilepsy monitoring
 - <https://youtu.be/jyrDV1rPqb4>
 - <https://www.empatica.com/>



Remote biosignal acquisition

Sensors

in Elderly Care



Starting point



- Thomas A.: 62 years, height 1.80 m, weight: 120 kg (obese). Skin: clear, no icterus, no cyanosis. Normal circulation, normal breathing, good hearing, good vision. RR 170/90 Hgmm, pulse regular. Liver size normal, no oedema, feet pulse ok on both sides.
- John B. : 62 years, height 1.57 m, weight 72.8 kg. No icterus, no cyanosis. Skin clear, normal circulation, normal hearing, good vision. RR 160/80 Hgmm, pulse regular, liver size normal, no oedema, feet pulse ok on both sides.
 - Both of them are afraid of future...

Parallel lives

- Thomas
 - Stays at home
 - Watches TV, goes fishing
 - Surfs on the internet
 - Eating → Diabetes



John

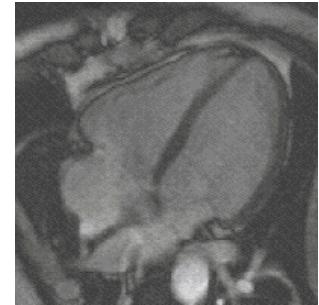
- Goes back to work
- Doing sports
- Wants to prove he is OK
- Stress → Hypertony



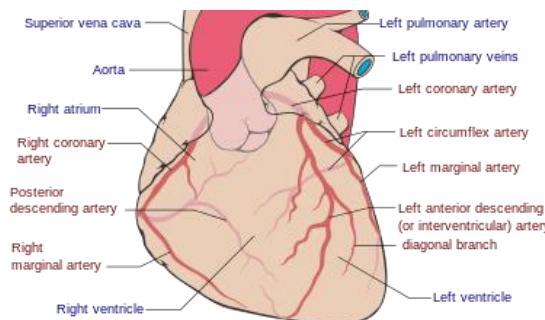
Health IT in the lives of the elderly

- **Thomas**
 - Remote patient monitoring
 - Diabetes monitoring
 - Medication monitoring
- **John**
 - Remote patient monitoring
 - Hypertony monitoring
 - Medication monitoring
 - Sport activity monitoring

Blood pressure



- The force created as the heart pumps blood and moves through the blood vessels.
- Two numbers are recorded when checking B/P
- Systolic pressure-force of blood in the vessels when the heart pumps
- Diastolic pressure-force of the blood in the vessels in between beats

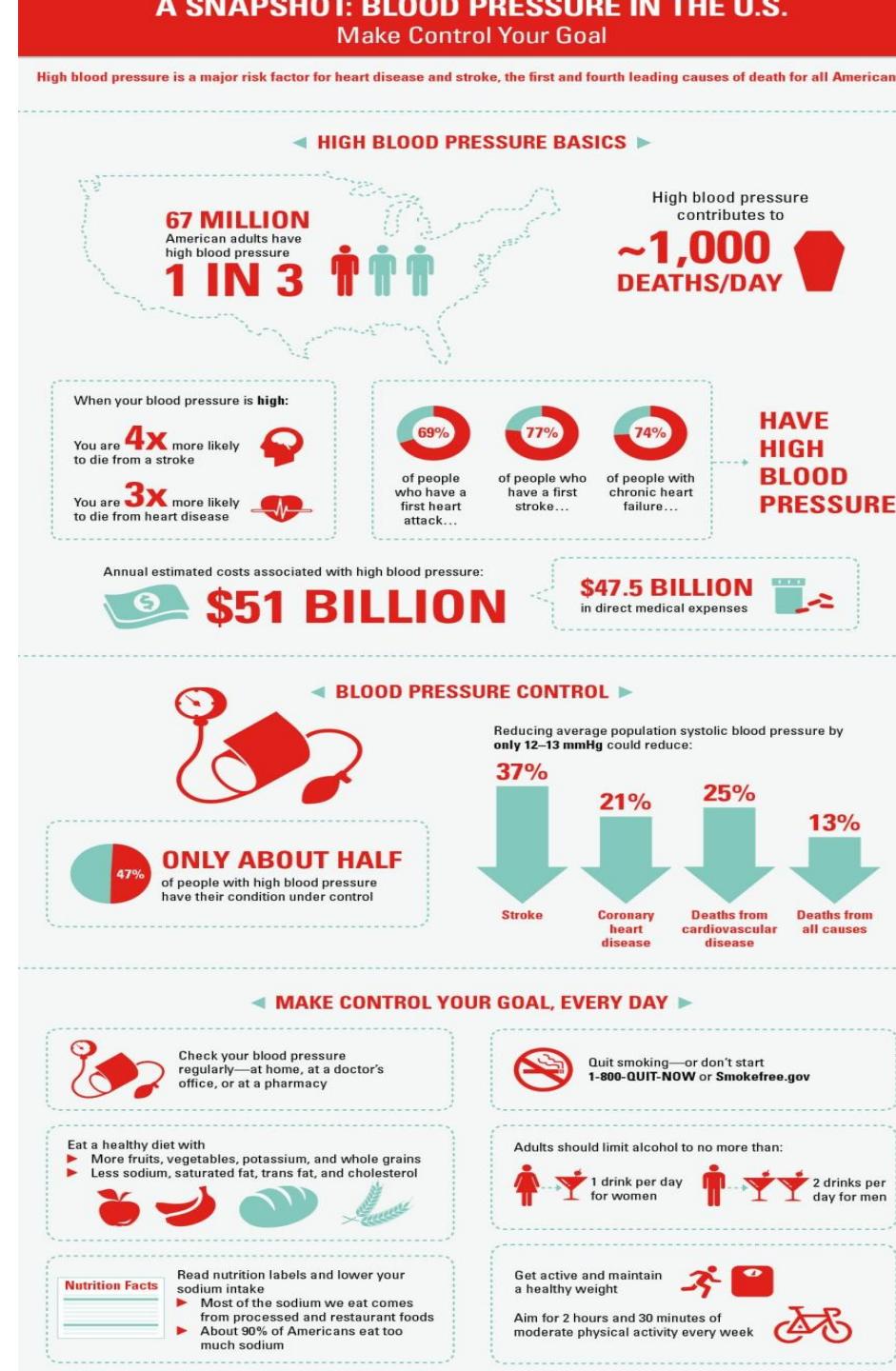




Biotech Lab

Hypertension

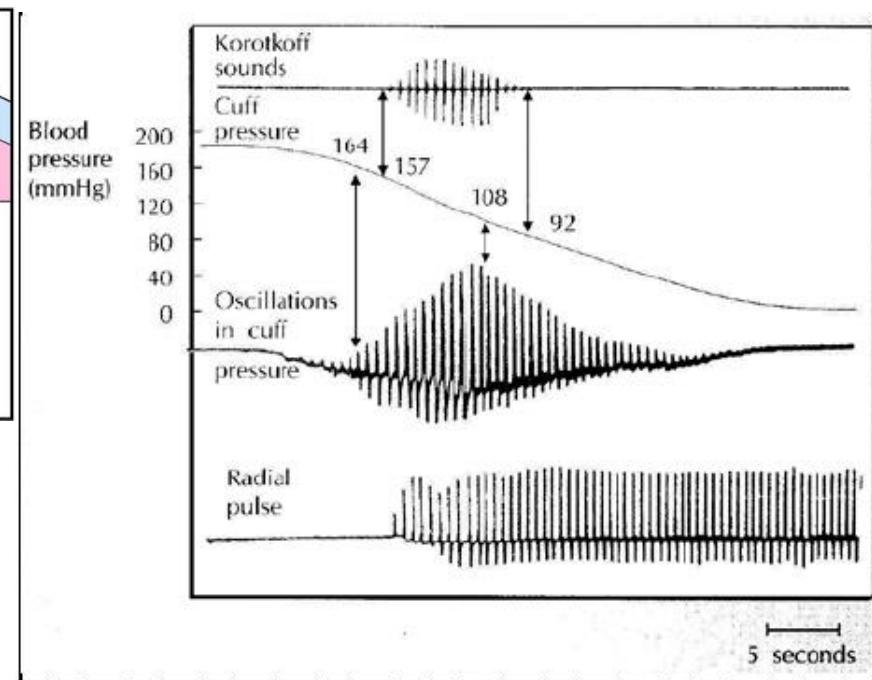
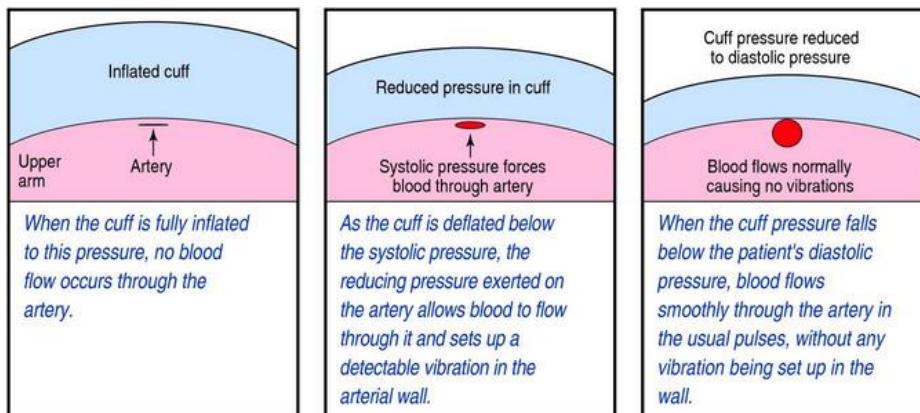
- High blood pressure (HBP)
- does not cause symptoms.
- Silent killer works on long term.
- Normal range 130/85
- High B/P = 140/90 and higher.
- The higher your B/P , the higher the problem.



Blood pressure monitoring

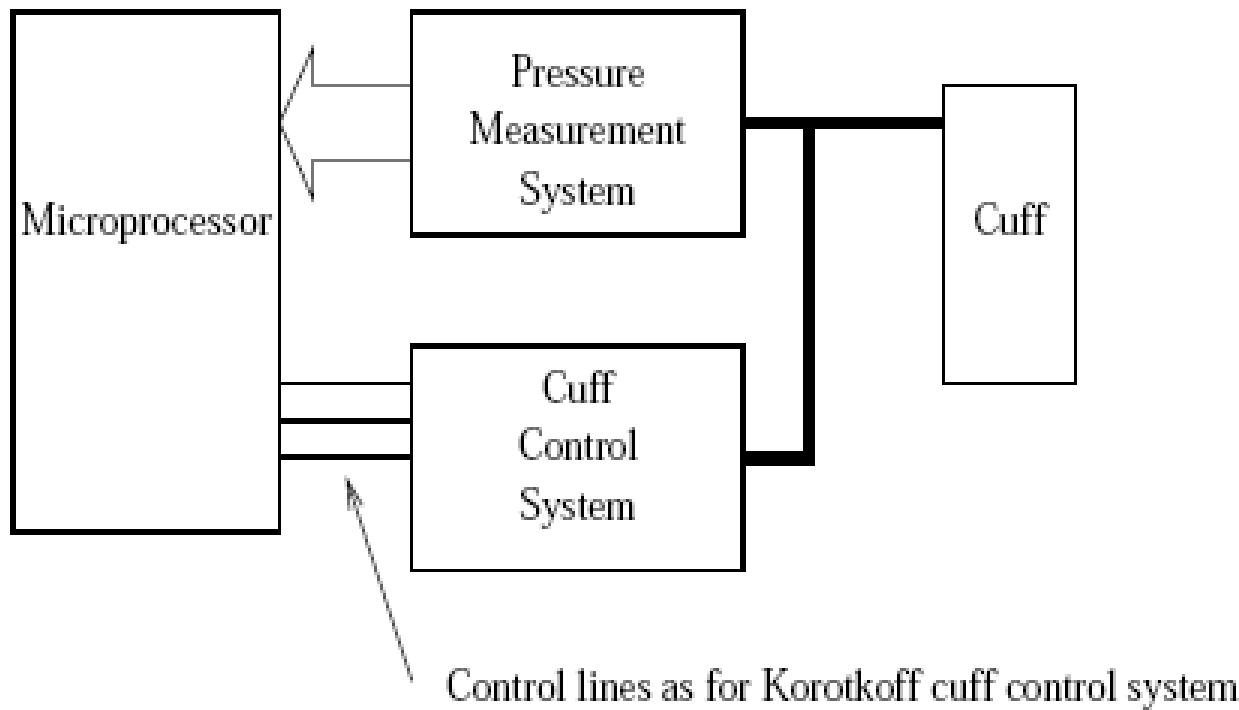
(for John)

- Auscultation (listening)
 - Korotkoff sounds
 - Cons: short sampling time, measurement errors, subjective
- Oscillometry method (Marey)
 - All automatic device using this
 - Cons: arteries changing with age, but parameters not

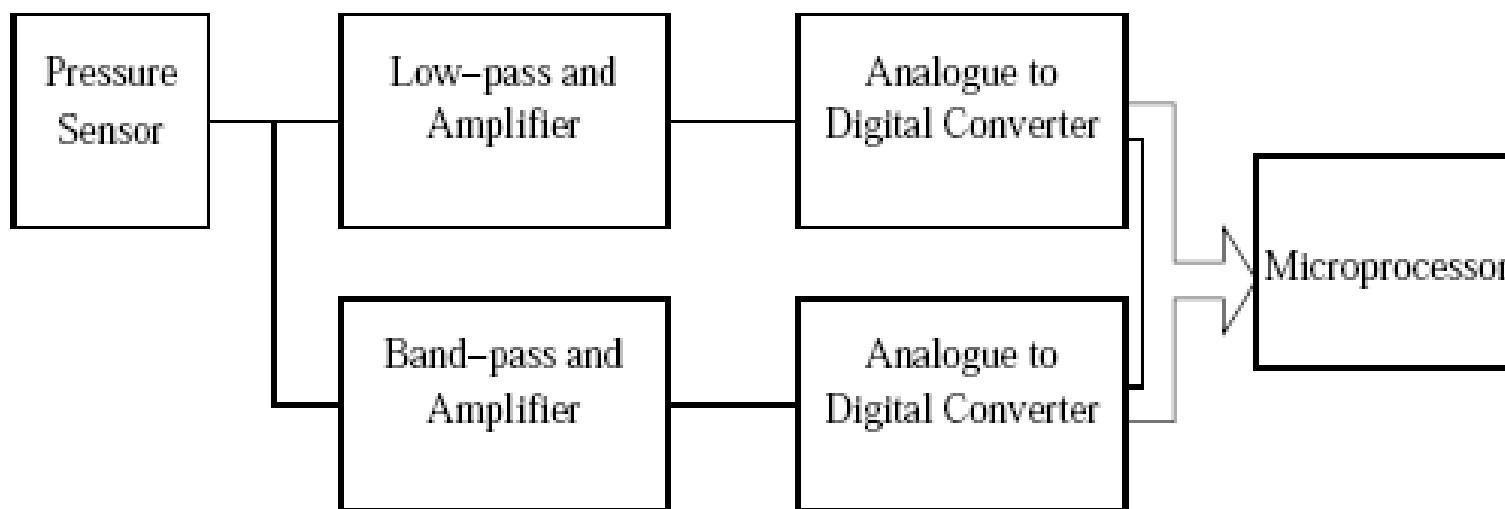


- Tonometry method
- PPG-based measurement

Blood pressure measurement using (oscillometry)



Blood pressure measurement block diagram (oscillometry)



Blood pressure in practice

- Arm
- Wrist
- Fingertip



BPM is more inclined to be inaccurate measured at wrist and at fingertip because the blood vessels are more away from the heart than the upper arm BPM.

Blood pressure chart

Blood Pressure Condition	Systolic / Diastolic pressure (mm Hg)
Hypertension stage 4	210 / 120
Hypertension stage 3	180 / 110
Hypertension stage 2	160 / 100
Hypertension stage 1	140 / 90
High normal blood pressure	130 / 85
Normal blood pressure	120 / 80
Low normal blood pressure	110 / 75
Borderline Hypotension	90 / 60
Serious Hypotension	60 / 40
Very Serious Hypotension	50 / 33



Bood pressure chart by age

Age	Min	Normal	Max
1 to 12 months	75 / 50	90 / 60	100 / 75
	1 to 5 years	80 / 55	95 / 65
	6 to 13 years	90 / 60	105 / 70
	14 to 19 years	105 / 73	117 / 77
	20 to 24 years	108 / 75	120 / 79
	25 to 29 years	109 / 76	121 / 80
	30 to 34 years	110 / 77	122 / 81
	35 to 39 years	111 / 78	123 / 82
	40 to 44 years	112 / 79	125 / 83
	45 to 49 years	115 / 80	127 / 84
	50 to 54 years	116 / 81	129 / 85
	55 to 59 years	118 / 82	131 / 86
	60 to 64 years	121 / 83	134 / 87

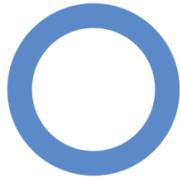
Blood pressure biases!

- Body position
 - Legs crossed: + 8 Hgmm. Sitting: +5 Hgmm (in comp. to lying.)
- Measurement technology
- Time of day
- Emotional situation
- Physical activity
- Arm / Armband size ratio (80%!)



Measurement of blood parameters

- Blood glucose level measurement/monitoring
- Cholesterol level monitoring (Cholesterol enables animal cells to dispense with a cell wall)
 - LDL “bad” cholesterol level
 - Carries cholesterol around in the blood
 - Forms plaque in the arteries
 - Increases risk of heart disease
 - HDL “good” cholesterol level
 - Carries cholesterol to liver and out of body
 - Helps avoid plaque and heart disease
 - VLDL cholesterol level
- Triglycerides level (main constituents of body fat in humans)
- Lactat monitoring



- Diabetes (mellitus)
- Group of metabolic disorders
- This makes it difficult for the body to convert the food into energy → cells cannot survive.

Insulin is hormone that regulates the blood sugar and is produced by the Pancreas.

Frederick Banting, Charles Best, John James McLeod (Nobel price 1923 in medical field)



DIABETES

DIABETES IS
ON THE RISE



422 MILLION
adults have diabetes

THAT'S 1 PERSON IN 11



Main types of diabetes



TYPE 1 DIABETES

Body does not produce enough insulin



TYPE 2 DIABETES

Body produces insulin but can't use it well

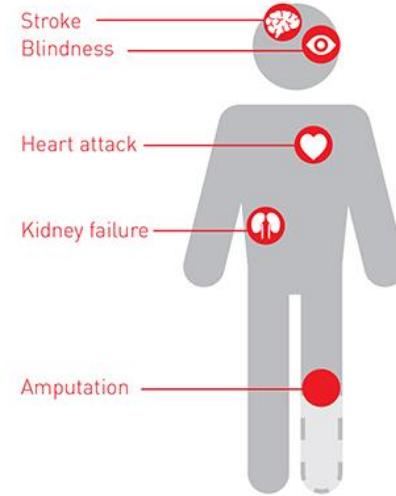


GESTATIONAL DIABETES

A temporary condition in pregnancy

Consequences

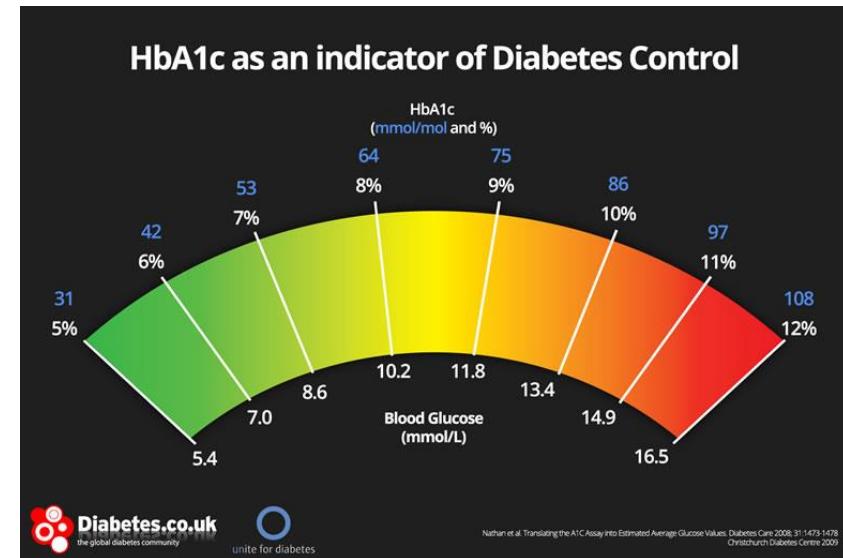
Diabetes can lead to complications in many parts of the body and increase the risk of dying prematurely.



Blood Glucose level

- Blood glucose level is ever changing during time
- Transport of the monosaccharide glucose to all cells is a key function of the blood circulation.

- In humans,
 - the normal level of blood glucose is about 4-6 mmol/l before eating, after eating is about 5-9 mmol/l
 - In case of diabetes the range is bigger
- Other possible diabetes indicators:
 - HbA1c: glycated haemoglobin. It develops when haemoglobin, a protein within red blood cells that carries oxygen throughout the body, joins with glucose in the blood, becoming 'glycated'.
(week-month range indication)



Blood Glucose Measurement



- Simply, easy to use
- Small meters
- Reliable results (with smaller samples)
- Options for alternate (to finger poke) site testing
- Enhanced electronic functions to record, share, and analyze data

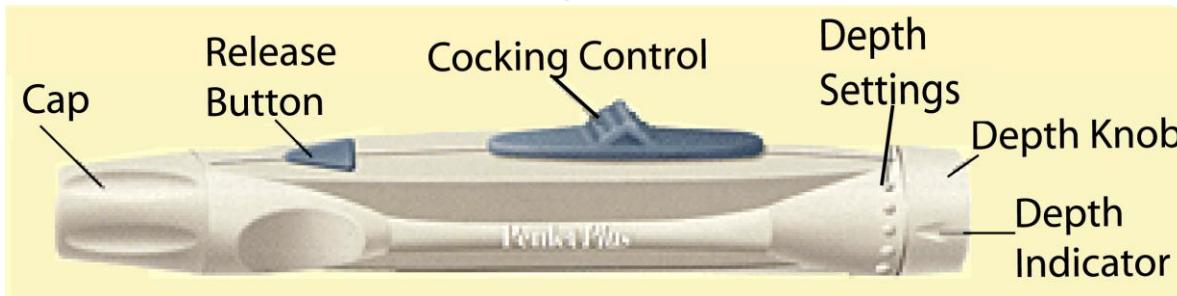
Limitation – don't know blood glucose between checks

Lancing Devices

Lancets/Needles



Pen-type Lancing Devices

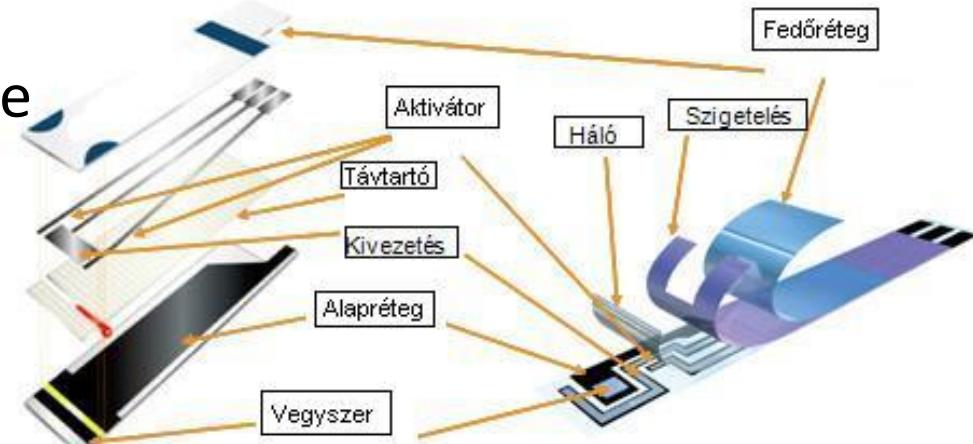


MultiClix



Glucose measurement device

- Glucose measurement device
 - Small, easy to use
- Test stripe
 - Photometric
 - Color compairing (Ames Inc. Bayer)
 - Amperometric (older)
 - an electrical current flows from the ferrocyanide to the glucose meter, which uses the strength of this current to measure the amount of glucose in the blood.
- Pre-calibrated values



<http://www.youtube.com/watch?v=oyVre1FnG54>

Diabetes monitoring examples

Model type	Manufacturer	Connection type
Accu-check Active	Roche Ltd.	Wired, via Smartpix™/USB Wireless infrared (via ir2voice™)
Mygluecohealth	Mygluecohealth Ltd.	Wireless, BTv2
Dcont Personal Optimum	77 Elektronika Ltd.	Wireless, infrared (via ir2voice™)
Dcont Partner	77Elektronika Ltd	Wireless, infrared (via ir2voice™)
Breeze II.	Bayer AG.	Wired, via USB

Problems

- Chemical reagents has expiry date
- Automatic reading problems
- Result reproducibility, result validation

Monitoring of other blood parameters

- Cholesterol
 - A fatty substance found only in animal foods, it is also made by our bodies.
 - Small amounts are needed by the body for essential functions.
 - LDL “bad” cholesterol level
 - Carries cholesterol around in the blood, forms plaque in the arteries
 - Increases risk of heart disease
 - HDL “good” cholesterol level
 - Carries cholesterol to liver and out of body
 - Helps avoid plaque and heart disease
 - VLDL cholesterol level
- Triglycerides level (main constituents of body fat in humans)
- Lactat level (Lactic acid → cells lack sufficient oxygen ineffective metabo
- Similar measurement devices as blood glucose
 - Similar technology : checking color changes
 - Different test stripes (for each parameter), similar lancet





Continuous Glucose Monitoring (CGM)

How it works:

- A tiny glucose-sensing device called a "sensor" is inserted just under the skin
- The sensor measures glucose in the tissue and sends the information to a pager-sized device
- The system automatically records an average glucose value every 1-5 minutes for up to 3, 5, or 7 days (or more)
- Finger stick pokes and regular meter needed to calibrate
- Alarms signal when glucose is out of target range

Limited, but increasing use; emerging technology

Continuous glucose monitoring (cGM)

- Combined with insulin „pump”
- Artificial pancreas
- Automatic algorithms
- Insulin and/or carbohydrate intake

Abbot Freestyle Libre

<https://youtu.be/LFYyimOBomU>

MEDTRONIC

<https://www.youtube.com/watch?v=ASQo9bIPch4>

Roche evesense:

<https://www.youtube.com/watch?v=GbKXOgBbz6Q>

Dexcom G6

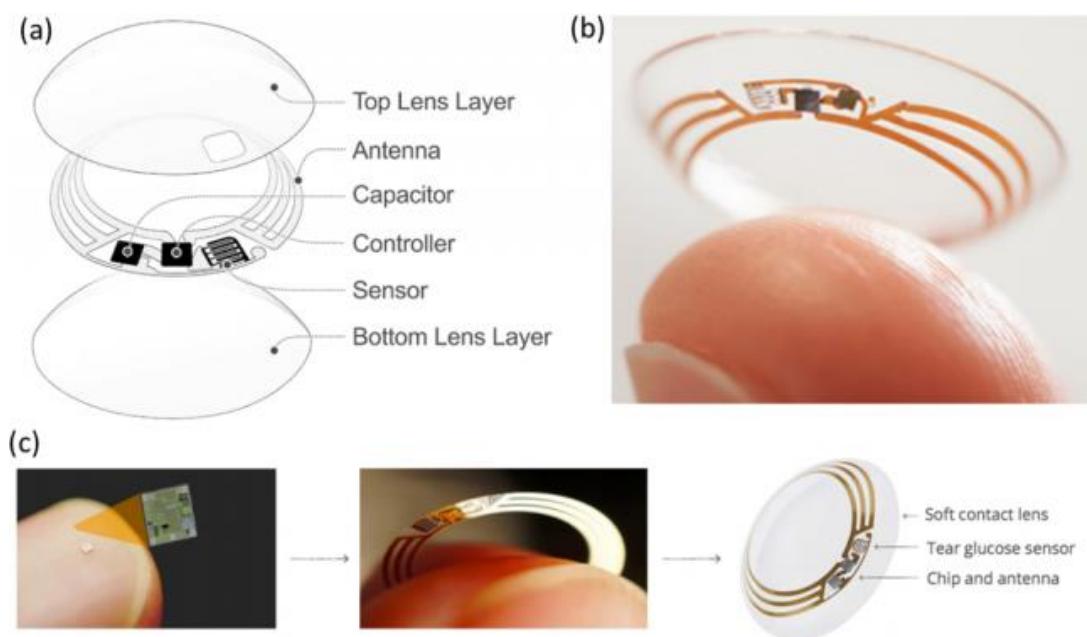
77 electronika: <https://e77.hu/termeket/cgms/glucomendayszenzor>

Marev: Medtrum TouchCare: <https://merv.hu/medtrum-touchcare->



More advanced glucose level monitoring

- Novartis+Google
 - N/A yet





Insulin intake – future

- Nasal spray
- Orally (tablet, capsule, liquid forms)
- Inhalation

Medication

- „huge business”
- Wide market with vulnerable people (children, elderly)
- Elderly take more medicine
- Pill dispensers
 - Electronic/mechanic

„Evolution”

Mechanic/Manual
Cheap, no alert



Alert only



~40 USD

complexity

~100 USD

Mechanic-electronic



No Monthly Fe

Fully automated

Fully automated and
remote controlled

Fully automated



~60 USD



~300-1000 USD

Parallel lives



- Thomas
 - weight gain (120→130 kg)
 - Diabetes+Hypertony
 - Doctor prescribes „telemonitoring”
 - Stays at home, watches TV
 - Mixes up day and night

- John
 - Gets and survives first heart infarct
 - Gets and survives first stroke
 - Movement and speech problems remain
 - Joins rehabilitation programme
 - Family factor
 - Home care service
 - AAL



Panic alert systems

Home monitoring – Ambient Assisted Living



Cons: Who will push the button?

<https://www.youtube.com/watch?v=Jhm5up5NQwk>

Talking to „Big brother”
(distance → ← quiet)

In old days: only landline (POTS)
User → ← Dispatcher central
GrandMom resistant
Watch-like



Panic alert systems

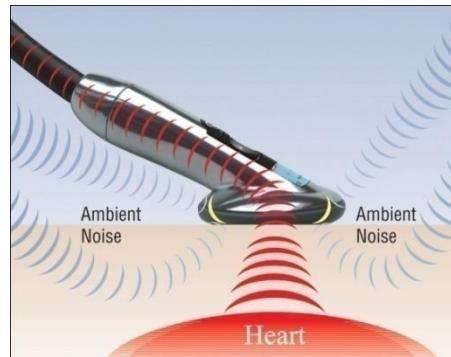
Alternativ solutions



- Panic buttons / wearables
 - Small, waterproof, rugged, wearable, frequent recharge needed
- Normal GSM Mobiles
 - SOS Telefon, MohaNet, DrMedNet, No localization
- Smart Phones
 - Many pros: more information where and what happened (GPS & Timestamp)
 - Cons:
 - problem with elderly people (hand skin → touch screen)
 - Water resistance?

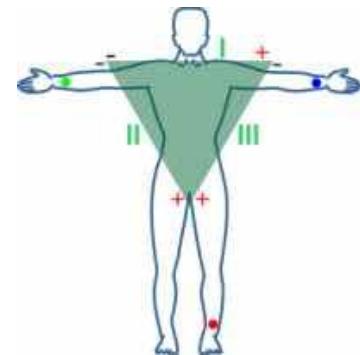
Digital stethoscope

- Littmann 3M 31xx,32xx, ...
- Bluetooth connection
- Record, replay
- Noise filtering + 24x signal amplification
- Sound visualization

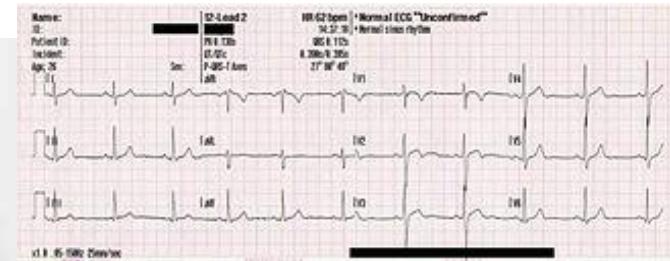
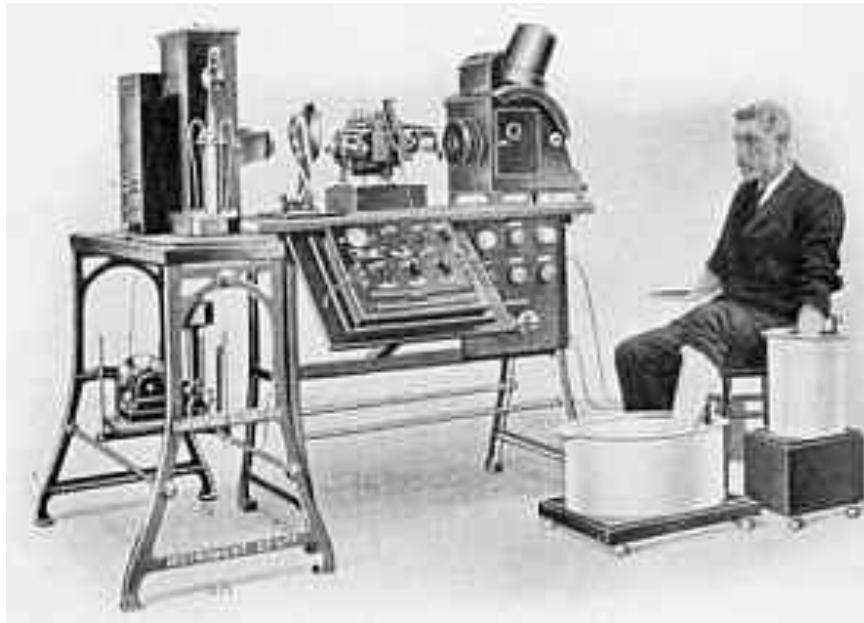




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Cardiac monitoring ECG Then and now



~1900, Willem Einthoven : ECG for diagnosis

ECG nowdays:

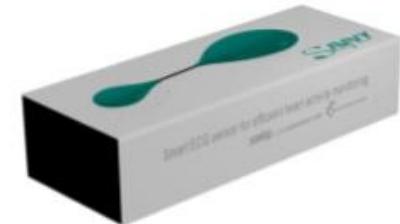
66*59*17mm, 50 g, 1-2-3-5 Channel

150-300-600 Hz

8-130 min, or non-stop Holter monitoring

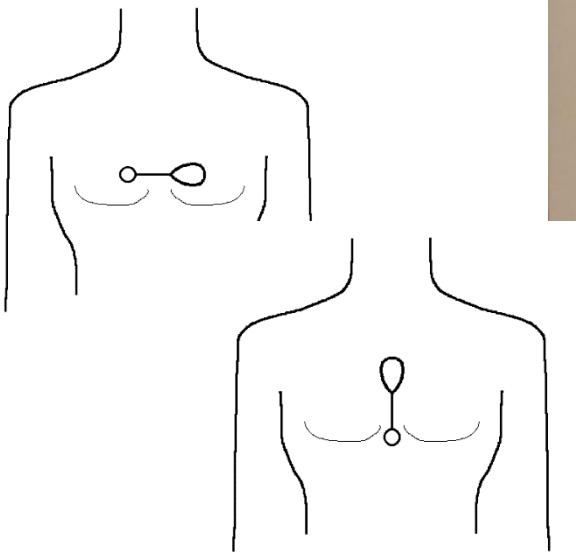
Cardiac monitoring / ECG examples

Model type	Sensor type	Connection type
Cardioblue (Medical grade)	Mobile ECG, 5 channels , 600Hz, 1-2 days, holter like	Wireless (BTv2)
Savvy (medical grade)	Mobile ECG, single channel, 1 week, holter like	Wireless (BTv4)
Quardio (Consumer electronic grade)	Mobile ECG , GSR, temperature, pulse, breathing activity, 1 day	Wireless (BTv4)



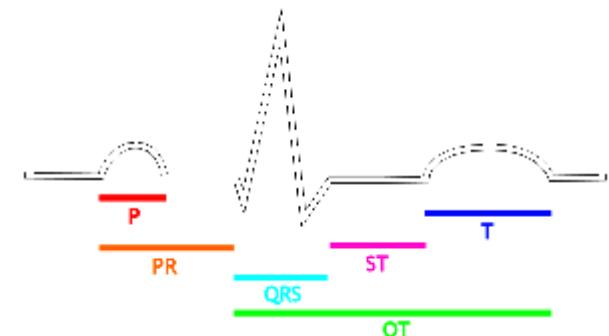
ECG monitors

- Medical device
 - CardioBlue (event monitor)
 - Wiwe
 - Savvy



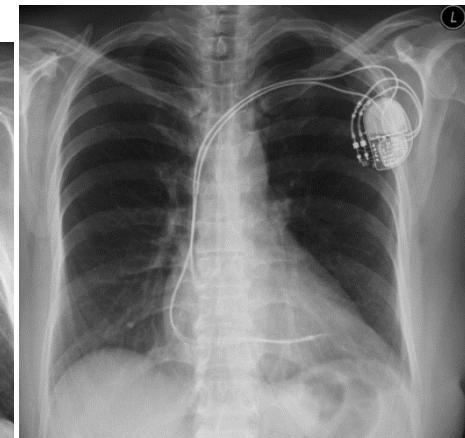
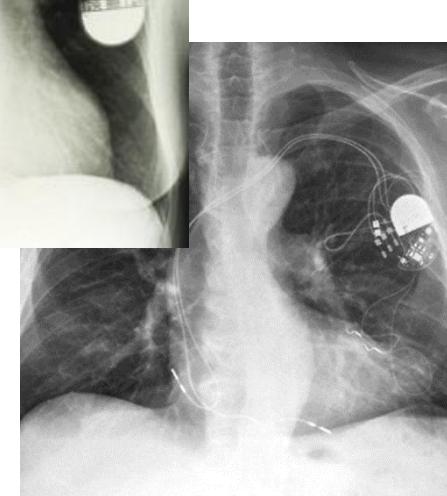
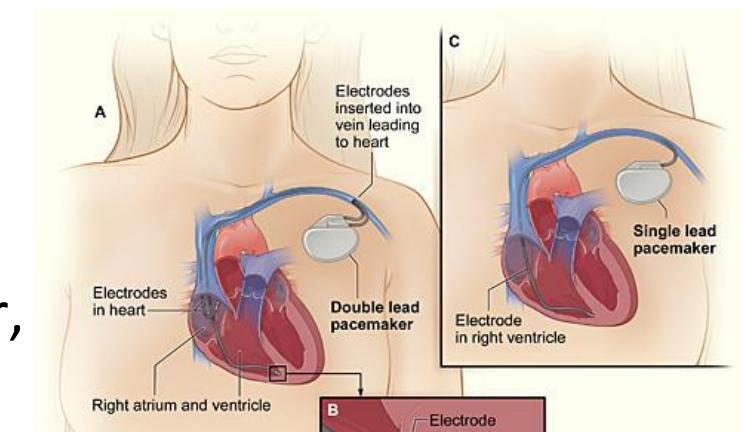
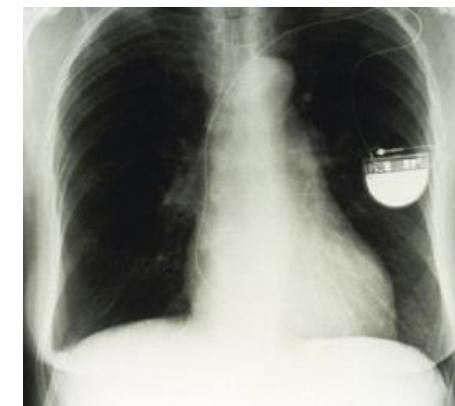
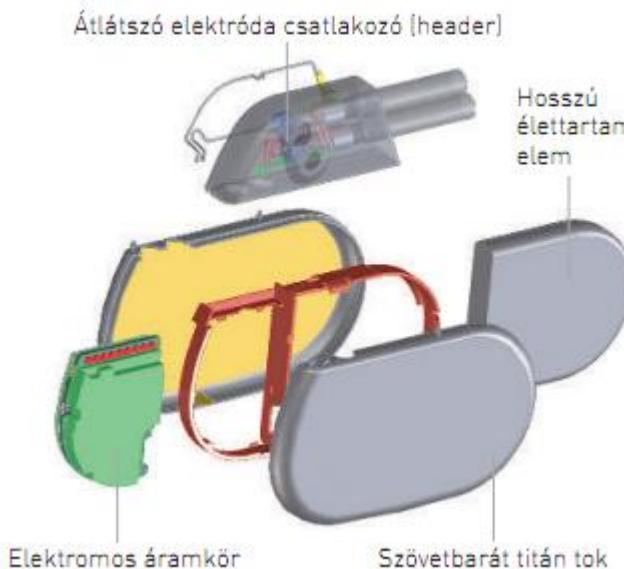
Medical measurement protocol targeting (serious) cardiac events

- ECG Measurement with duration: 1 hour/day/week/month
- Continuous pulse measurement
 - Monitoring:
 - S-T elevation: How much elevation (+/-) S-T has (<2mm)
 - Q-R-S length (0,12-0,15ms) + heart rate monitoring (120-130)
 - R-R homogeneity: $\Delta R-R$ deviation from average calculated
 - Q-T length: elongation is measured
- Pulse frequency variability
- Calorie/ Metabolic equivalent (MET) calculation



Pacemaker

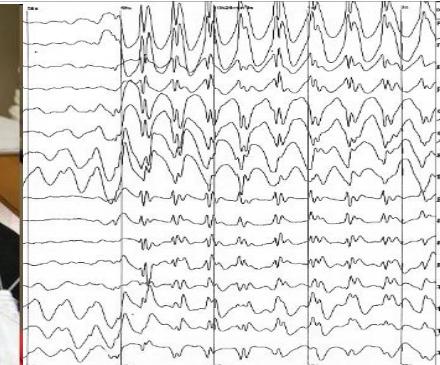
- Building blocks:
 - battery,
 - Microcontroller + signal generator,
 - wire + sensor → elektrode(s)



EEG - ElektroEncephaloGraphy

- Recording the brain activities
- Rarely used for patients at home
- With Emotiv holter like EEG monitoring

14+2 Electrodes, Gyroscope, WiFi, battery powered 6-8 hours

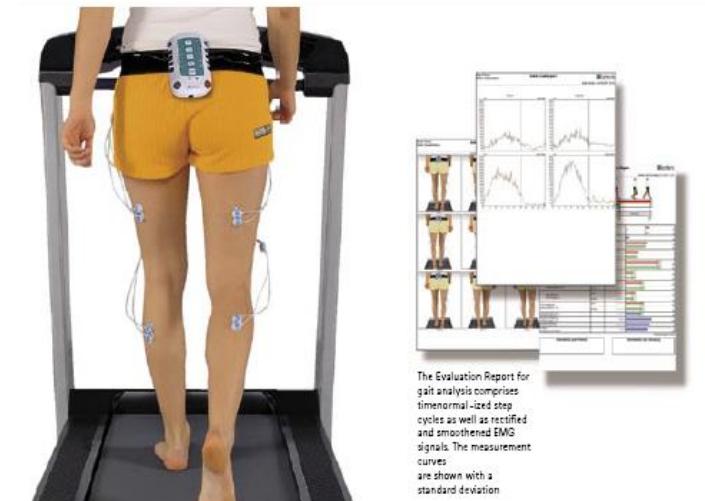
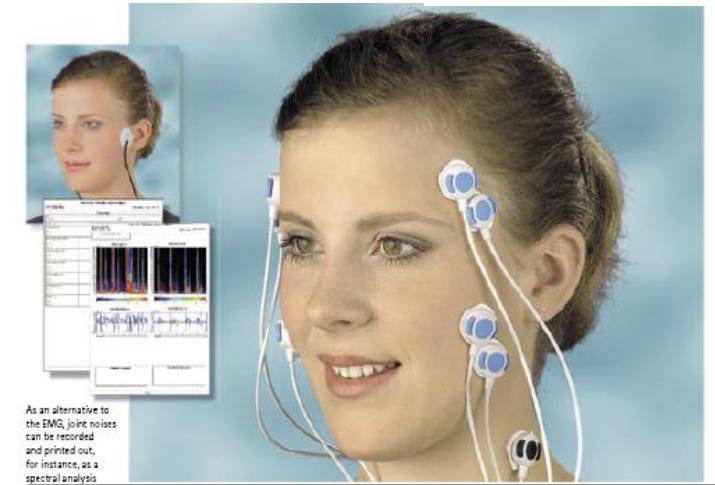


Electromyography - EMG

Evaluating and recording the electrical activity produced by skeletal muscles

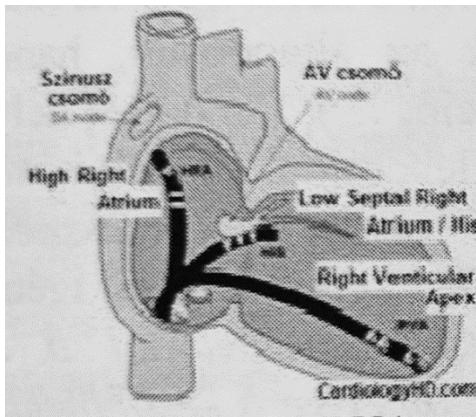


- Can be
 - non-invasive
 - Invasive (Intramuscular EMG)

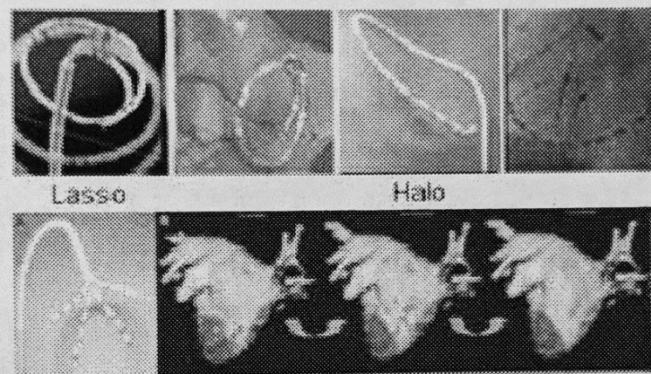


Diagnostics catheters

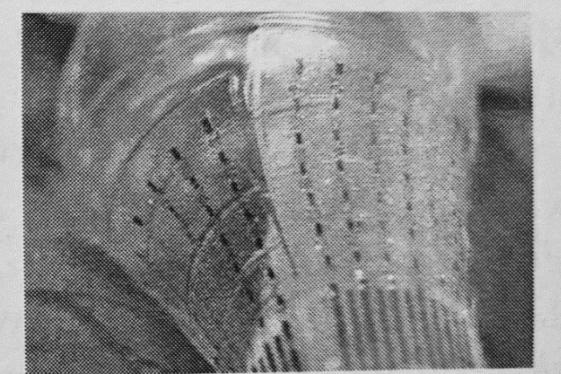
- Special catheters
- Parallel measurements at many points
- X-ray and Ultrasound supported guiding



a) HRA, HIS, RVA



b) Lasso, Halo, Pentarray



c) Ballon

ECoG/ECG =ElektroCOrticoGraphy

- Invasive measurement
- Microelektrodes in the brain tissue
- Good resolution (spatial and temporal)

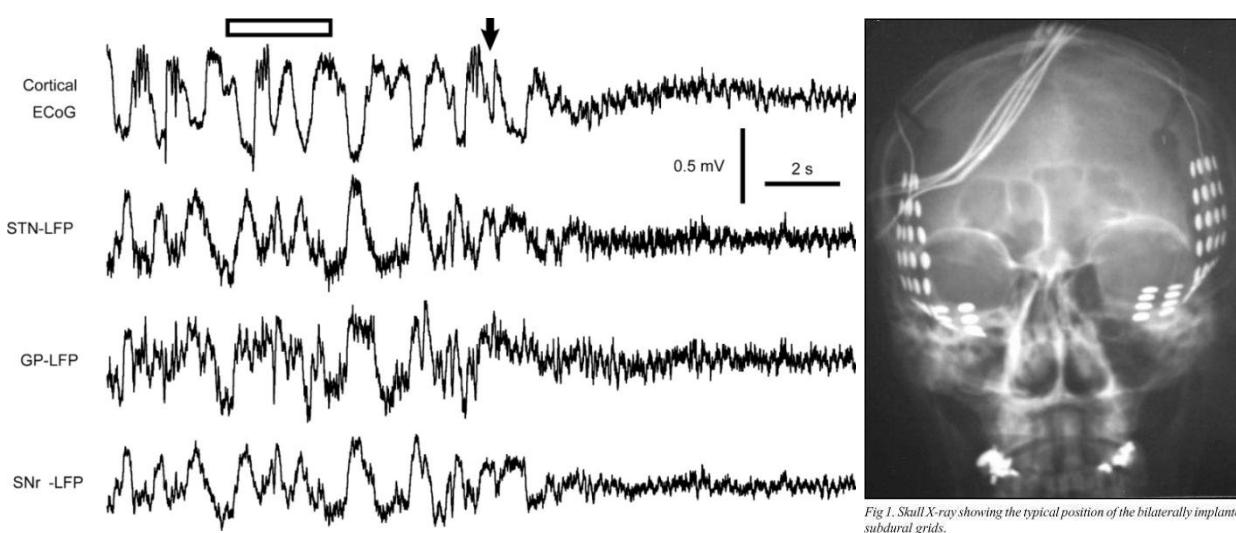
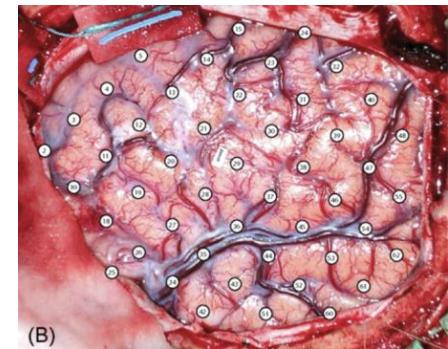
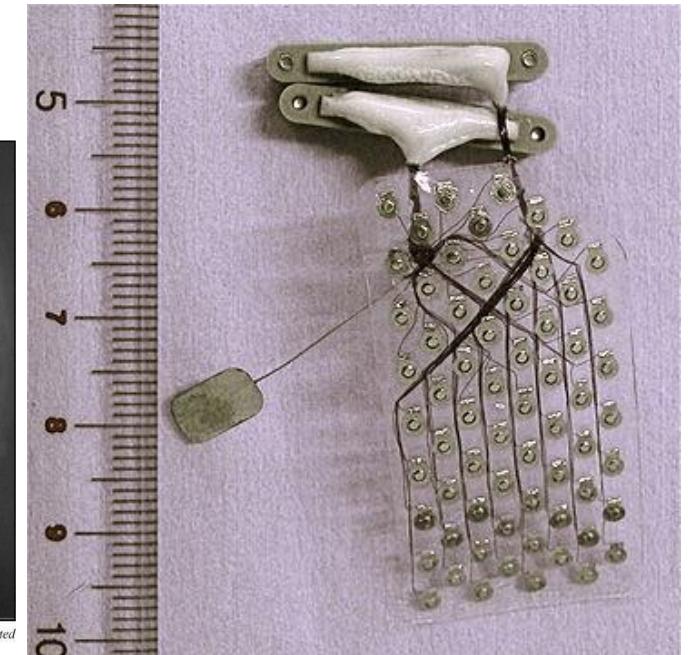


Fig 1. Skull X-ray showing the typical position of the bilaterally implanted subdural grids.



Alternative: Neuralink

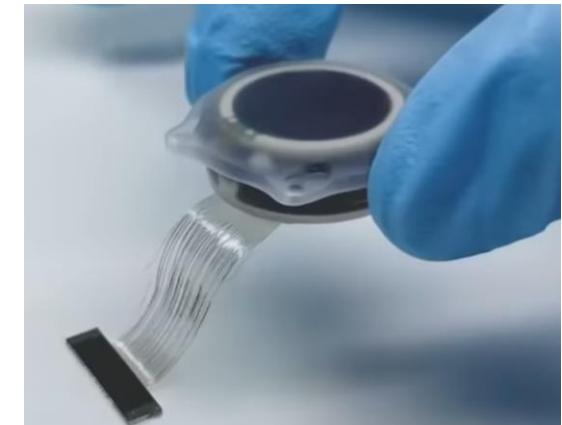
Implantable brain–computer interface (BCI)

application-specific integrated circuit

1,536-channel recording system

256 amplifiers capable of being individually programmed

- <https://neuralink.com/>
 - <https://www.youtube.com/watch?v=tN1IVwTHCMw>



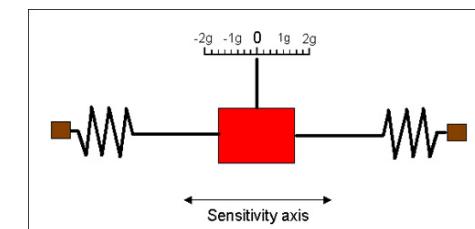
Sleep monitoring

- Same sensor set can be used as for daily usage
 - ECG, SPo₂, movement detection, skin temperature
- Additional sensors:
 - In-built microphone
 - Snoring detection
 - Breath counting
 - Apnoe detection
 - Environment monitoring (room temperature, humidity)
 - Survey about patient perception
 - How was the sleep period?



Fall monitoring

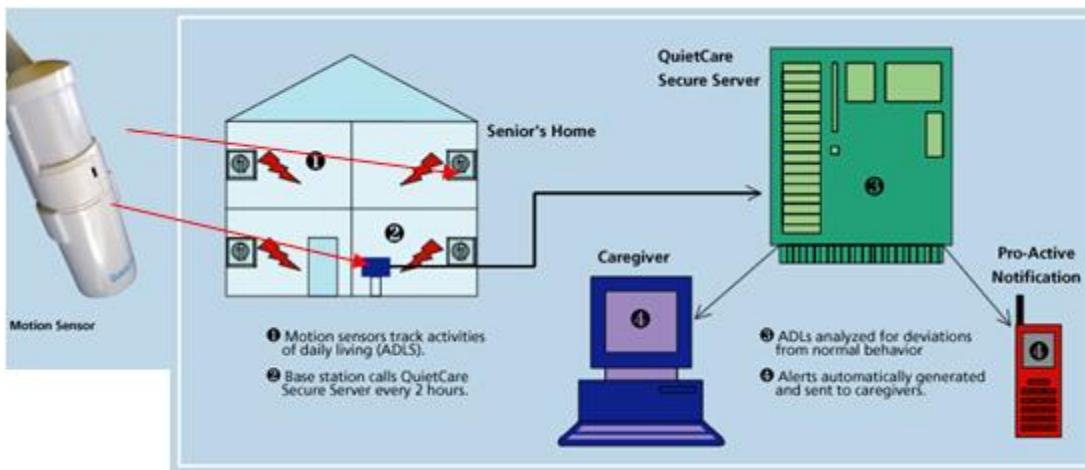
- Mostly wearables
 - Using IMUs
- Acceleration
- Usually combined with:
 - Location
 - Speed
- Also useful for motor/bicycle riders



Life habit & style monitoring

- Quantity sensors
 - „Smart rooms“ → GE Healthcare: Quiet Care system
 - Lifesignal monitoring (Chimney – smoke signal)
- Movement pattern analysis:

<https://www.youtube.com/watch?v=mC03aOIJzU>



Pulsoxymetry

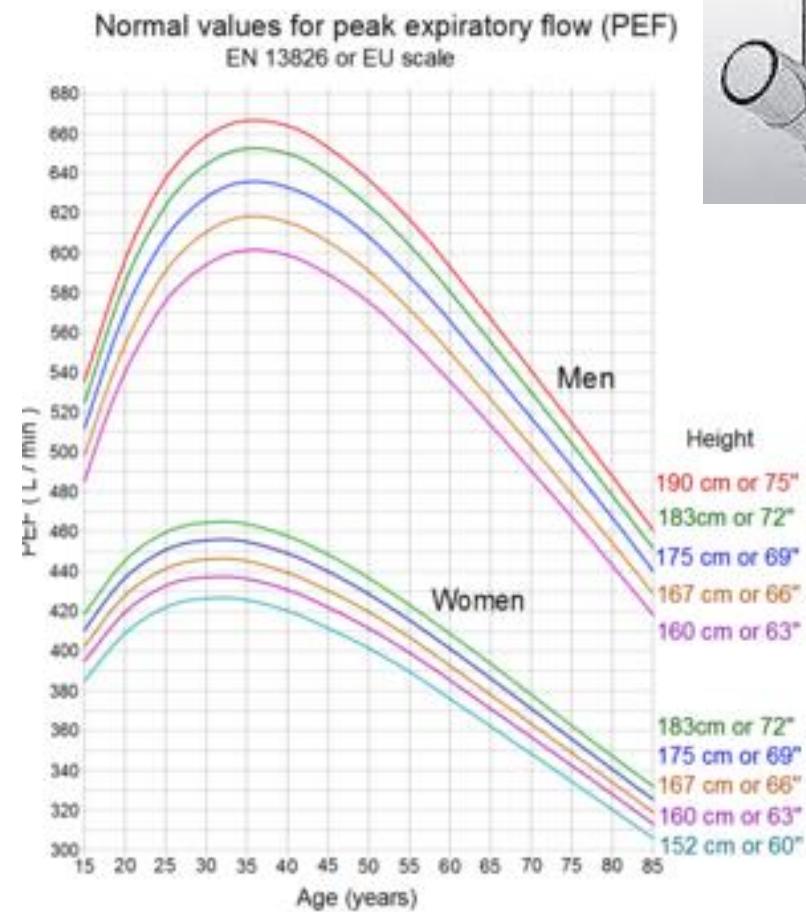
- Infrared light , absorption
- SpO₂ + pulse

- Problems:
 - Signal recognition
 - Problems with limited circulation (Schock, Hypothermie)
 - CO/CO₂ recognition
 - Painted, covered nails



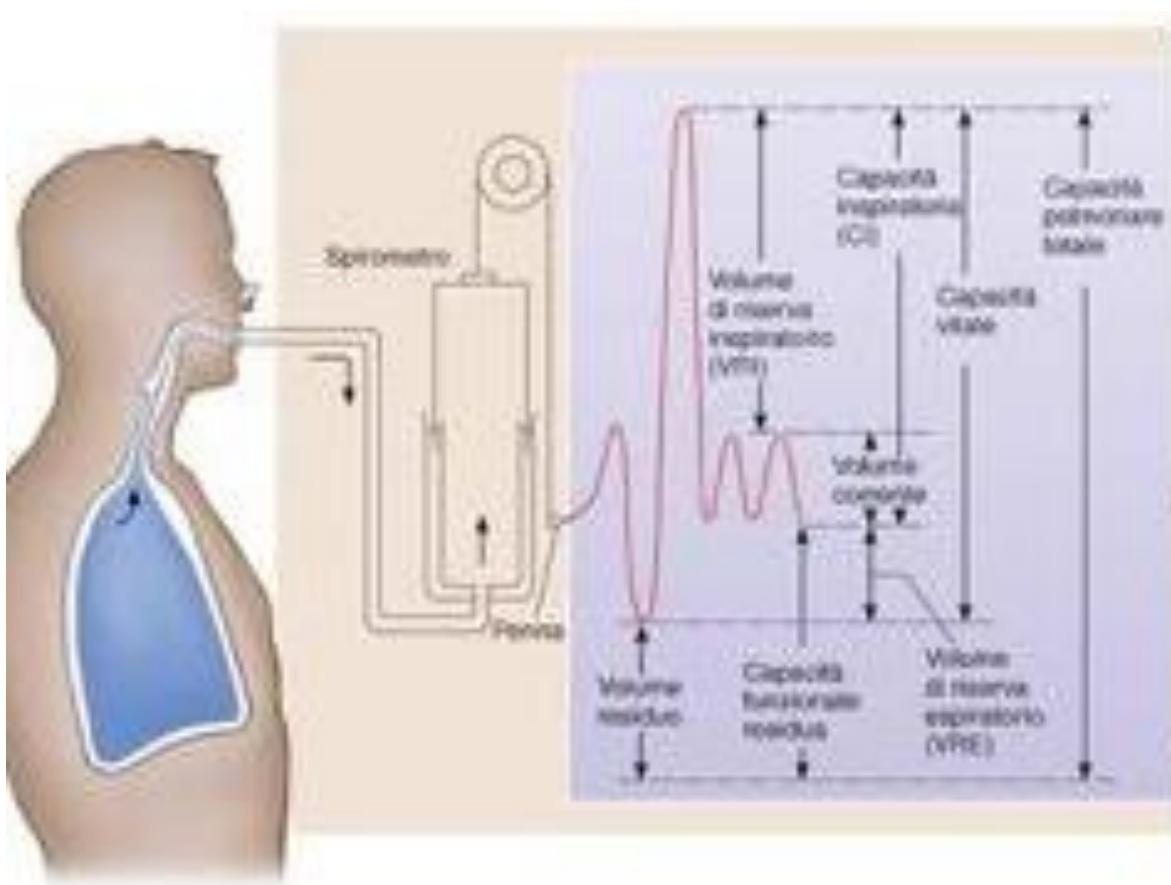
PEAK flow meter

- Exhale peak flow
- Measures max air flow velocity
- With internal tube and a propeller
- Lung function analyse
- Indication for Asthma
 - Medication setup
 - Trend analysis



Spirometer

- Lung vital capacity measurement



Body Composition Monitors

Body Weight Scales

- Simple scales
- Body Composition Monitors
 - Methods
 - Optical / Anthropometric /X-ray based
 - **BIA (Body Impedance)**
 - Setup
 - Between
 - Fingers
 - Hands
 - Legs
 - Hands-Legs
 - Measurement
 - Resistance
 - Errors: conductivity/amount of water in the body, ...



Thank you for your attention...

Questions?

kozlovszky.miklos@nik.uni-obuda.hu

Questions

- Are you, or any of your family members using health monitoring device(s)/service(s)?
 - If yes: What? When/how often?
 - What parameters can be monitored by the device(s)?
 - Where is the data stored?
- Are you planning to use any monitoring device(s) or service(s) in the future?
 - For who? (grandparents, kids, family members)
 - What and how?

Questions (contd.)

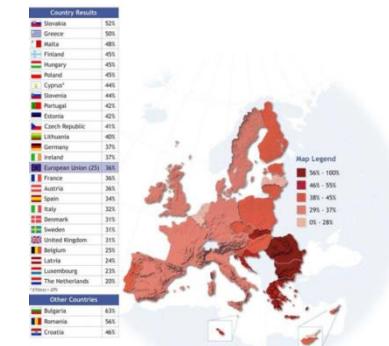
- Let's assume you have a DAQ system:
 - What parameters will you store about any sensor?
 - How would you store threshold parameters of sensor values?
 - How would you store patient related threshold parameters?
 - E.g.: Male/female, age, tissue implantation, heart surgery, diabetes



Monitoring human individuals remotely

Generic motivations

- Economical and social problems
 - Large rural areas, non-accessible areas
 - Aging population, longer life expectancy
 - Healthy long living (prevention)
 - Costly health problems: diabetes, cardio vascular diseases, neurodegenerative disease issues: Alzheimer, Parkinson's, etc.
 - Sparse/Limited resources: nurses/doctors, beds at hospital, equipments (devices), with reliable connectivity



Remote patient monitoring

Motivations for an Engineer

- Multimodal sensor monitoring
- Many different
 - Data type
 - Value unit
 - Scale
- Adaptable, personalisable, generic data visualization
- State of the Art
 - Vendor specific monitoring solutions: MyHealthPoint, Accu Check 360...
 - Fitness focused solutions: MyFitnessCompanion,...
 - Care focused solutions: iCare,...
 - Generic medical data management solutions: HealthVault,..



Monitoring scenarios

- Cardio vascular disease monitoring
 - Cardiac event/disease monitoring
 - Hypertension monitoring
 - Monitoring blood pressure
- Diabetes monitoring (I/II)
 - Blood glucose level + medication
- Obesity/bulemy monitoring
 - Movement monitoring (Activity), Triglyceride +medication
- Sleep disorder monitoring
- Domestic assistance: Panic/Emergency situations



Sensor set

- COTS (Commercial off-the-shelf) sensors
- Sensor drivers at client side is written carefully
 - Huge work: incompatible, proprietary solutions
 - Sensors are protected by law (no reverse engineering ☹)





Generic remote patient monitoring system architecture

