

From Biosignals to Clinical Decisions - what we have done, and what must we do?

A pragmatic view on how we are missing opportunities to improve
everyone's lives.

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**The First International Conference on Integration of Digital and
AI-related Technologies – IntAI 2026**
(<https://www.dtrsociety.org/intai2026/>)

This is what I've been doing with my life.



- Nuno M. Garcia holds a PhD in Computer Science Engineering from the *Universidade da Beira Interior* (UBI, Covilhã, Portugal) (2008) and is a 5-year BSc in Mathematics / Informatics (*Hons.*) also from UBI (1999-2004). He was an entrepreneur (1988-2004), member of the Research Team at Siemens SA (2004-2007) and Nokia Siemens SA (2007-2008), and Head of Research at PLUX SA (2008-2010).
- Currently he is Full Professor at the Faculty of Sciences, University of Lisbon (FCUL) (2023-), and member of the research team of the Institute of Biophysics and Biomedical Engineering (IBEB) (2023-). He is Coordinator for the PhD course on Biomedical and Biophysical Engineering at FCUL (2024-).
- He is also President of the Administration Board of FCIências.ID (2025-2028) (www.fciencias-id.pt), an association that includes FCUL and six private companies, managing 12 research groups and laboratories at FCUL, including more than 600 researchers in more than 300 international R&D projects.
- Since 2010, he has participated as Principal Investigator, Coordinator, Local Coordinator or Researcher of several European or national Research projects.
- He was the founder and is a senior researcher of the Assisted Living Computing and Telecommunications Laboratory (ALLab, 2010), a research group within the *Instituto de Telecomunicações* at UBI.
- He was also co-founder and Chair of the Executive Council of the BSAFE LAB – Law enforcement, Justice and Public Safety Research and Technology Transfer Laboratory, a multidisciplinary research laboratory in UBI (2015-2023).
- He was the founder and coordinator of the Cisco Academy at UBI (2010-2020) and was Chair of the COST Action IC1303 AAPELE – Architectures, Algorithms and Platforms for Enhanced Living Environments (Brussels, Belgium, 2013-2017).
- He was identified as one of the world top 2% most influential researchers for the years 2019 and 2020 (Ioannidis JPA, Boyack KW, Baas J (2020)).
- He is member of ISOC and of the Non-Commercial Users Constituency, a group within GNSO in ICANN.
- His main interests include predictive algorithms for healthcare and well-being, distributed and cooperative algorithms, and the battle for a Free and Open Internet.

Predictive Algorithms for Health and Wellbeing

- The NEW Human – and the algorithms for health and wellbeing
 - or our Digital Twin
 - or my Personal Digital Life Coach
 - or the New Era of Digital Health
 - or Wearables, Algorithms and Digital Health
- and I've been working on this since 2016 (or maybe earlier)
- Nuno M. Garcia · FCUL · IBEB · FCIências.ID
 - nmgarcia@ciencias.ulisboa.pt

Yesterday ... And today

- Healthcare is mostly reactive and centred in the disease
- We need to step ahead and achieve anticipation and a healthcare continuum
- Shift the focus to the preservation of health rather and predict disease, rather than diagnosis and treatment
 - It's easier to predict and/or prevent than to diagnose and treat

Problem

we only measure when we want to diagnose

- Sparse clinical data
- Late diagnostics
- And the need to have continuous data flows
- Answer: 5P Digital Health
 - **Preventive, Personalized, Participative, Precision, Predictive.**

- A Human that is more conscious on the health processes
- Health as a personal, balanced, continuous process
- Wearables + Algorithms + Data
= 5P Digital Health
- Health management becomes anticipation
- Continuous recording: heart rate, sleep, stress, movement, voice, ...
- The body becomes the data source

Some examples

“Timed Up and Go (TUG)” test

(Sandra Reis, Virginie Felizardo)



Accumulation of specific changes over the person's life, which is associated with and/or responsible for increased susceptibility to diseases or even death.

Difficulties

Decreased ability



Adjustment to the needs

Relatives;

Health professionals;



Quality of life

Greater comfort;

Longevity of life;

Methodology

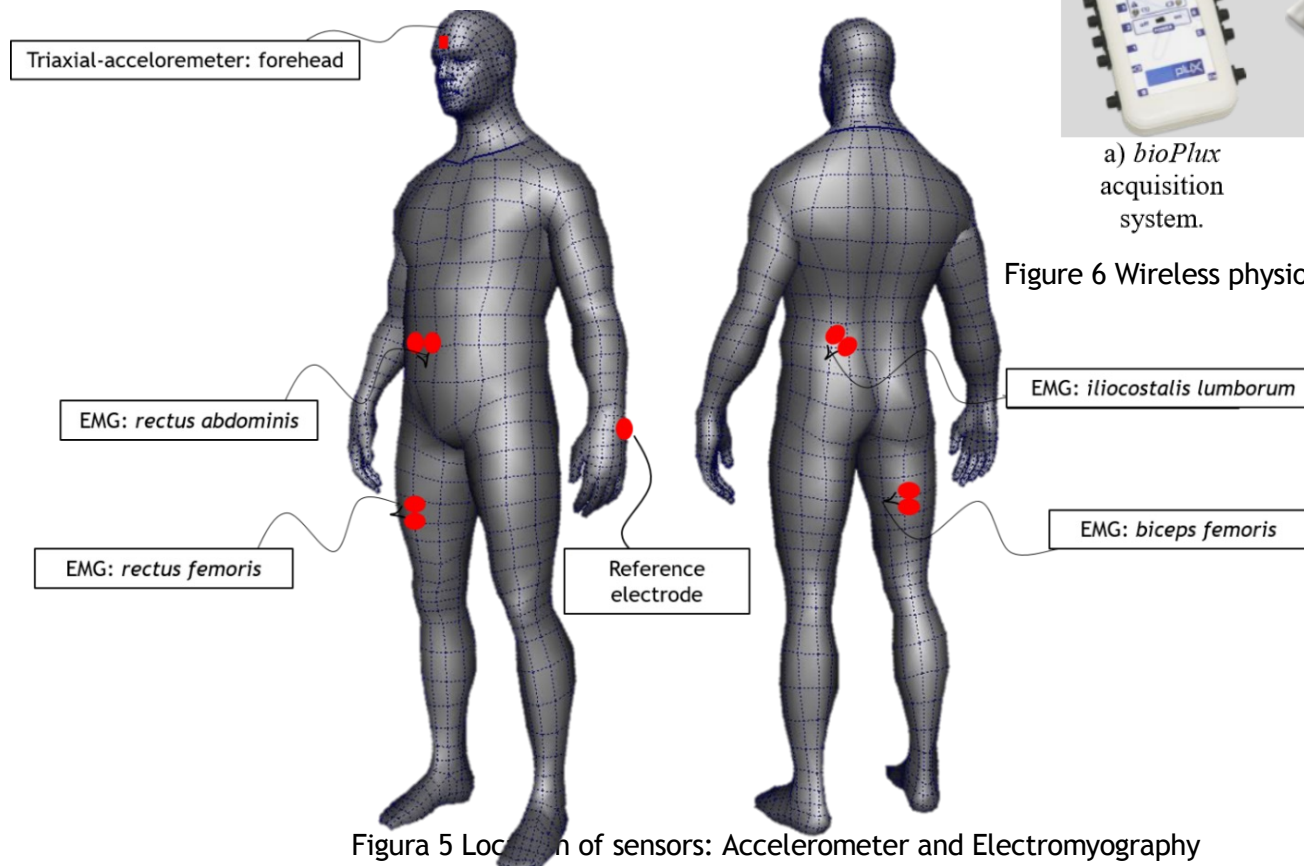


Figura 5 Location of sensors: Accelerometer and Electromyography

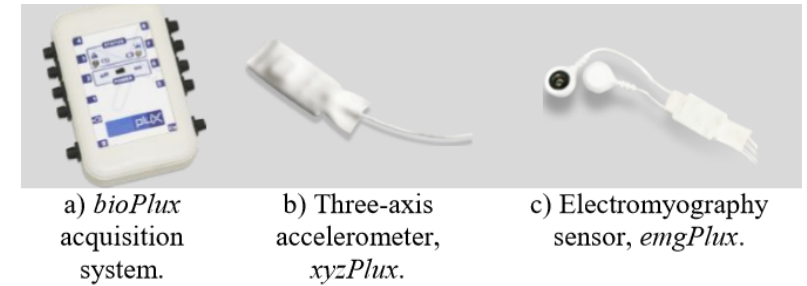


Figure 6 Wireless physiological data acquisition system bioPlux



4 EMG sensors



1 acl triaxial sensor



bioPlux

Methodology



Figure 7 Implementation of the TUG test: a) a participant sitting for start the test; b) and c) the participant in the walking phase of the TUG and d) the participant back to the starting location.

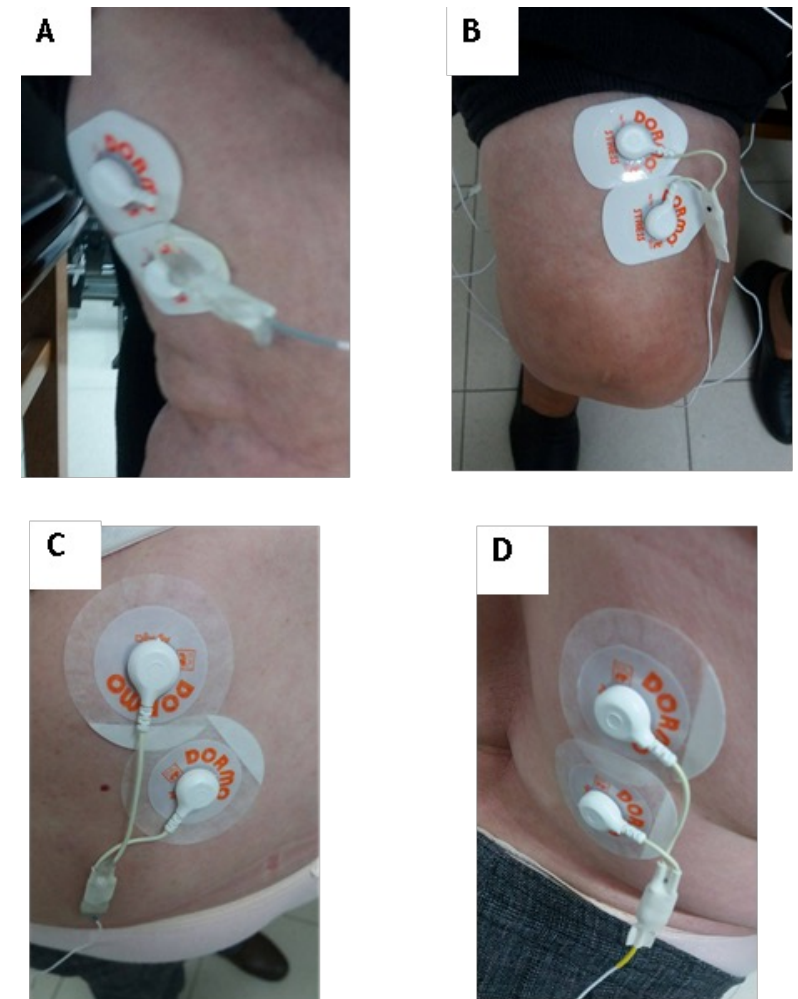


Figure 8 EMG sensors: A - Biceps Femoris B Retus Femoris C - retus abdominis D – Lumbar Iliocostalis .

Data Analysis and Processing

Triaxial-Accelerometer

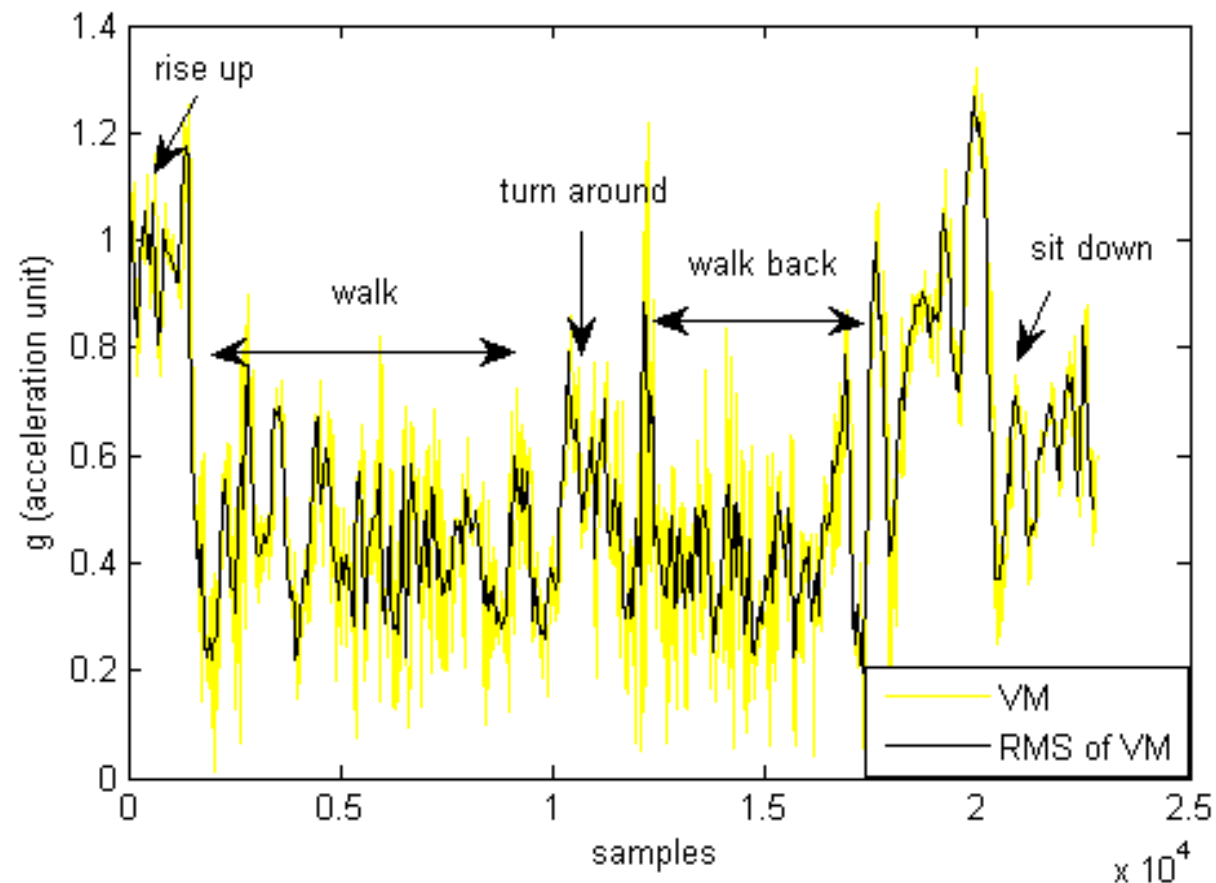


Figure 9 Participant data of Vector magnitude (yellow) and Root Mean Square of Vector magnitude (black) during TUG test.

- Current researg
 - How can we estimate the ovulation period using just a smartphone?
 - Research team:
MSc Sofia Santos, Prof.s Nuno Pombo, Nuno Garcia, Kristina Drusany Staric

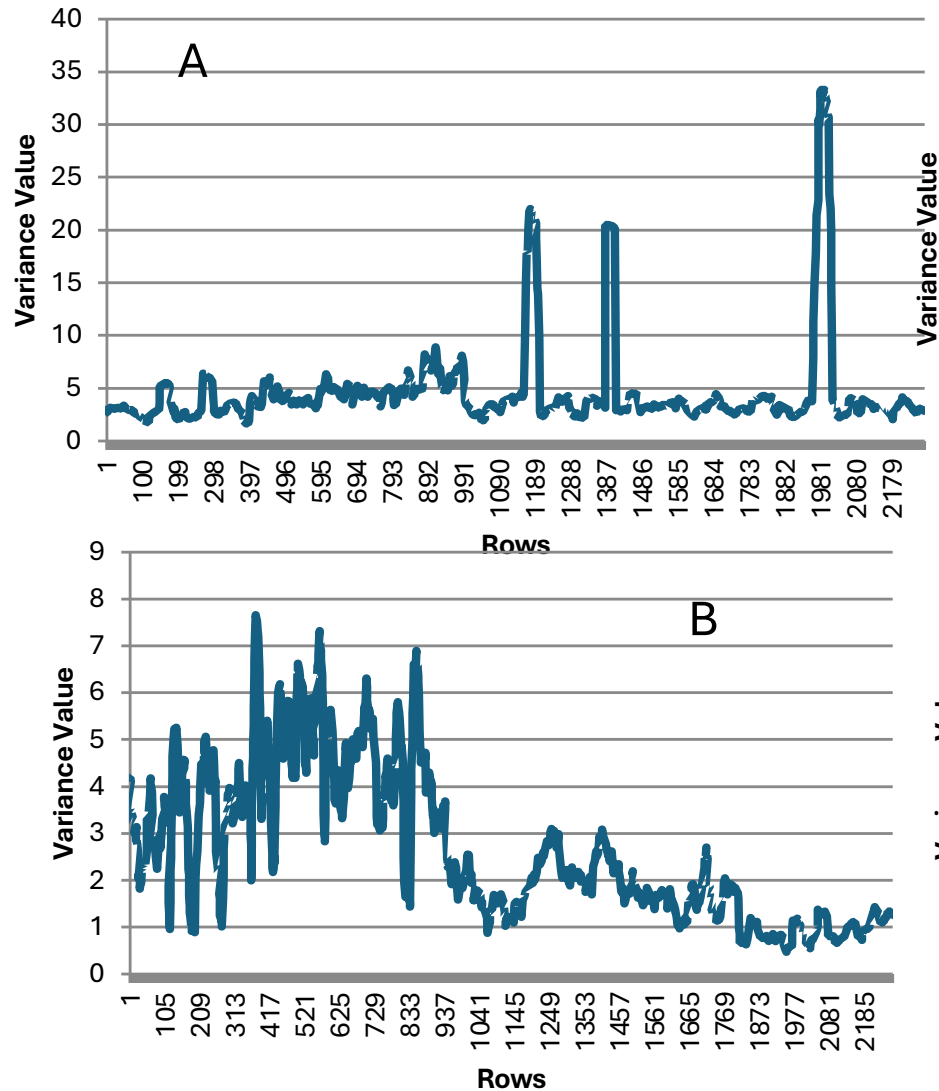
Table 7 - Results Obtained

(VFM - Variation of the frequency of menstruation days in relation to the remaining days (except days of ovulation); VFO - Variation of the frequency of Ovulation days in relation to the remaining days (except Menstruation days); VFOM - Variation in the frequency of Ovulation days in relation to Menstruation days)

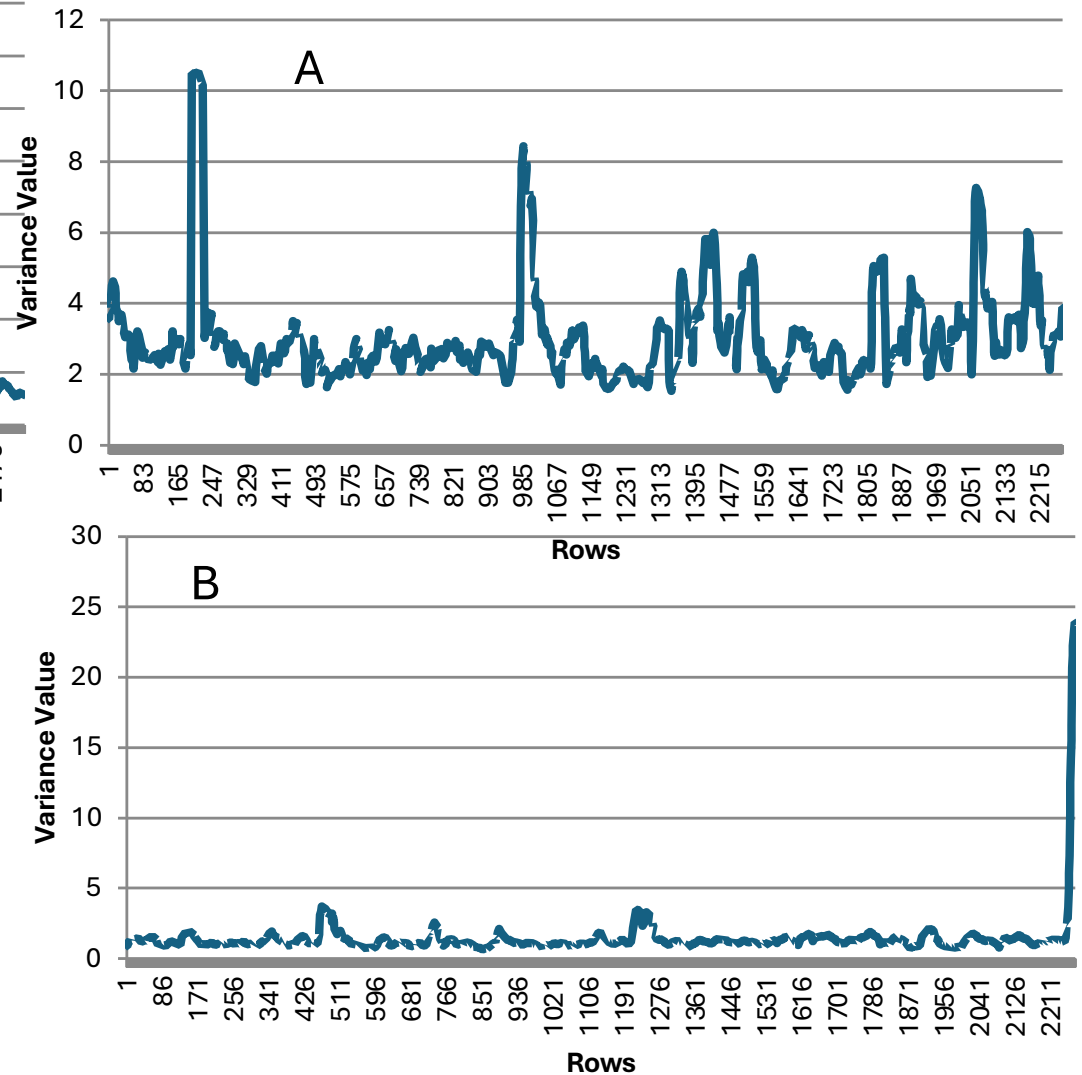
Participant	Notes	Contraceptive	Type	Regular	Menstruation F0	Ovulation F0	Nothing F0	VFM	VFO	VFOM
P2	IMC 32.3	No	--	No	199.34	215.91	195.82	1.79%	10.26%	8.31%
P4	IMC 33.9	No	--	No	171.36	206.47	182.86	-6.29%	12.91%	20.48%
P5	IMC 32.1	No	--	Yes	176.51	212.28	201.36	-12.34%	5.42%	20.26%
P6	Exercise	No	No Info	No Info	154.3	236.13	183.55	-23.37%	17.27%	33.78%
P7	IMC 24.8, Exercise	Yes	No Info	No info	213.242	192.424	190.32	12.04%	1.1%	-9.76%
P8	Exercise	Yes	Mercilon (Pill)	Yes	202.43	202.64	184.32	9,82%	9,94%	0.10%
P9	Smoke	Yes	Estinette (Pill)	Yes	184.32	192.25	166.73	10.55%	15.31%	4.30%
P10	--	Yes	Diane (Pill)	Yes	205.98	205.195	190.16	8,32%	7.31%	-0,38%
P11	Exercise, Smoke	Yes	Ring	Yes	179.96	193.15	188.69	-4.63%	2.36%	7.32%
P14	IMC 27.5, Exercise	Yes	Minigest (Pill)	Yes	186.51	215.97	192.15	-2.94%	12.39%	15.79%
P15	IMC 25.2, Exercise	No	--	No	203.895	192.08	214.27	-4.84%	-10.25%	-5.79%
P17	Smoke	Yes	No Info	No Info	217.84	196.05	224.95	-3.16%	-12.85%	-10%
P18	--	No	--	No	217.13	177.55	197.68	9.84%	-10.18%	-18.23%
P20	IMC 17, Exercise	No	--	Yes	195.75	161.76	187.04	4.67%	-13.52%	-17.36%
P21	IMC 25.4	Yes	Minigest (Pill)	Yes	181.32	187.81	177.73	2.02%	5.67%	3.58%
P23	Exercise	No	--	No	199.14	208.31	187.99	5.93%	10.8%	4.6%
P24	Exercise	Yes	Evra (Transdermal)	No	178.74	197.01	175	2.14%	12.58%	10.22%
P25	--	Yes	Minigest (Pill)	Yes	217.06	159.80	182.99	18.61%	-12.67	-26.38%

- Previous research
 - To assess metrics of self similarity on ICU patients
 - Challenge: to be able to predict the vital outcome
 - Research team:
Prof.s Miguel Castelo-Branco, Nuno Garcia, Nuno Pombo, MSc MD Márcio Rodrigues

1st 48 hours at ICU

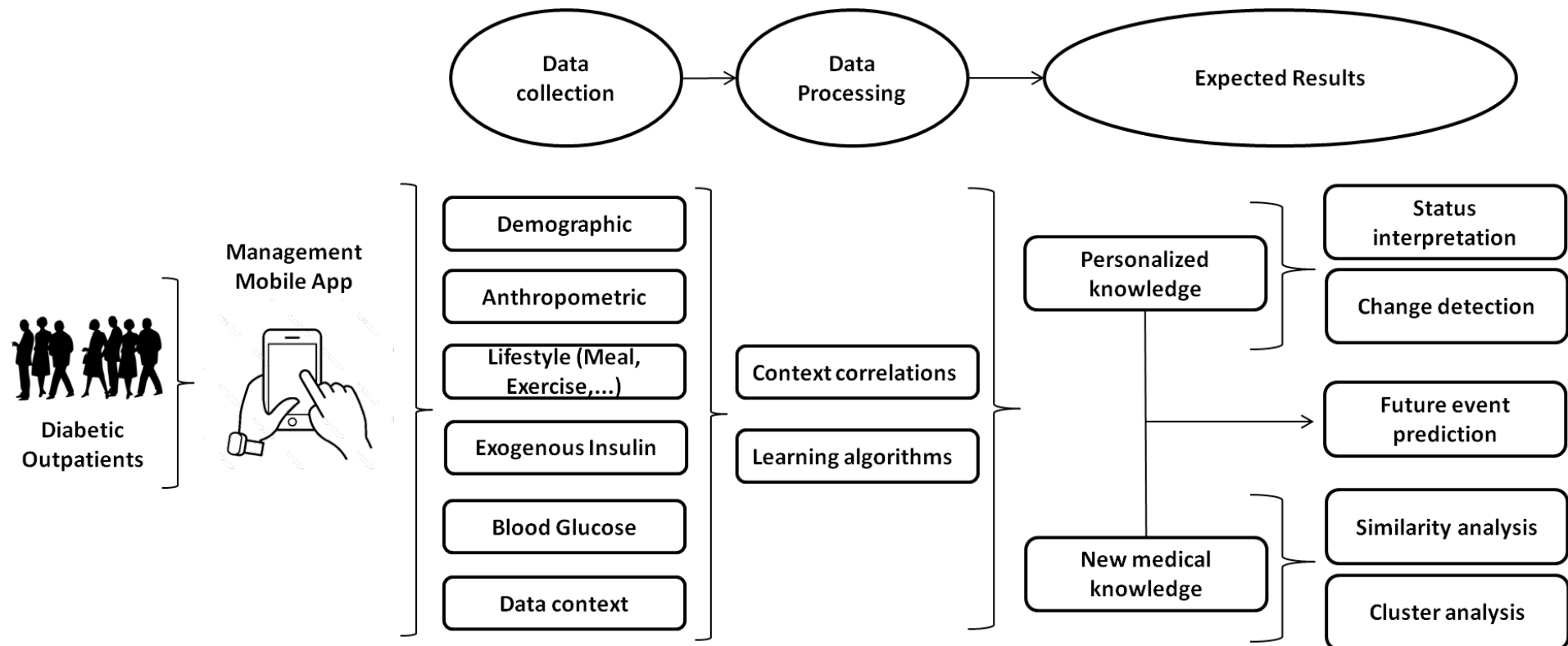


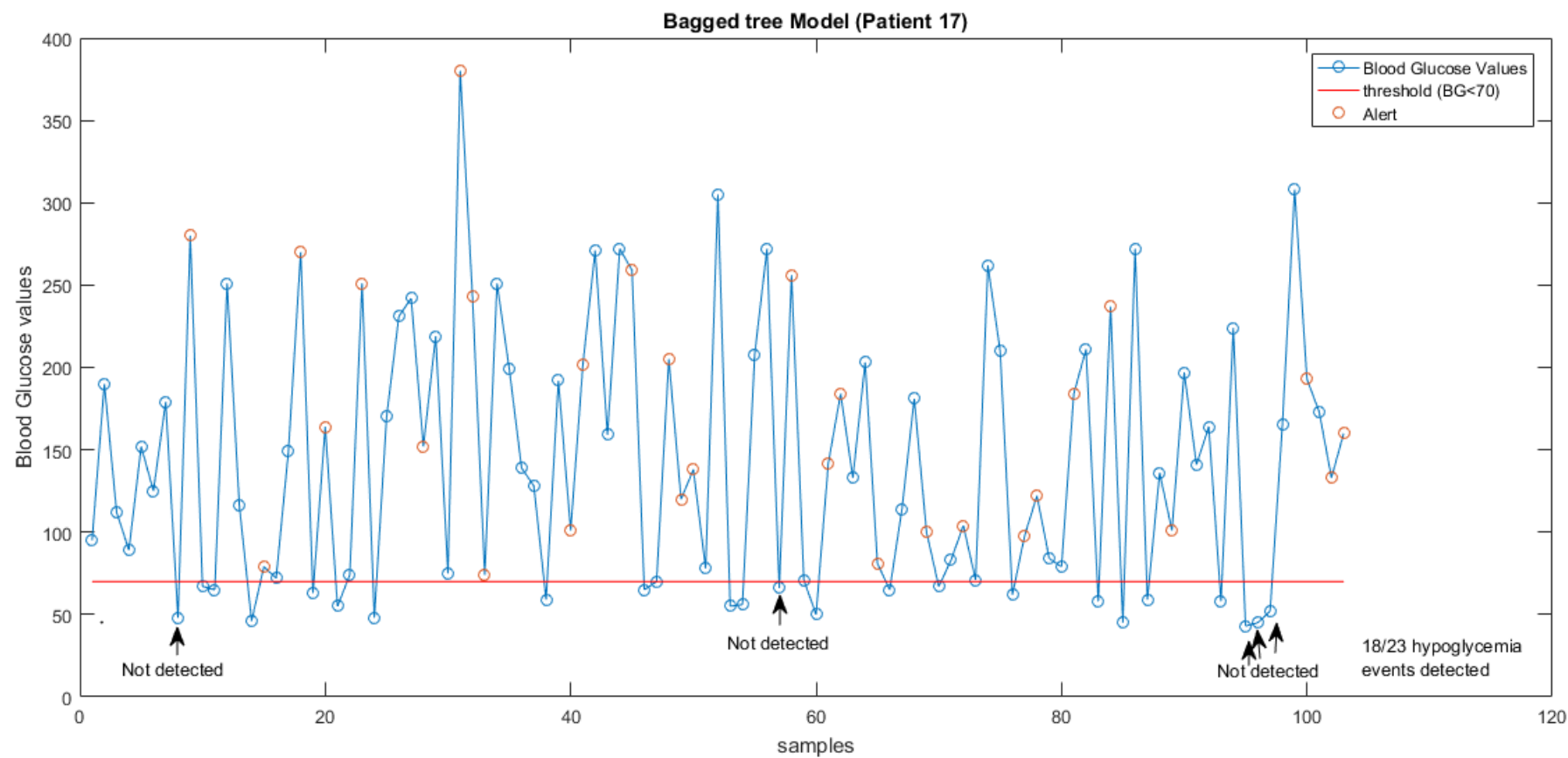
last 48 hours at ICU



- Current research
 - To predict Hypoglycemia events
 - Challenge: to be able to predict critical events in diabetic patients
 - Research team:
Prof.s Nuno Garcia, Nuno Pombo, Imen Megdiche, Sandeep, Virginie Felizardo

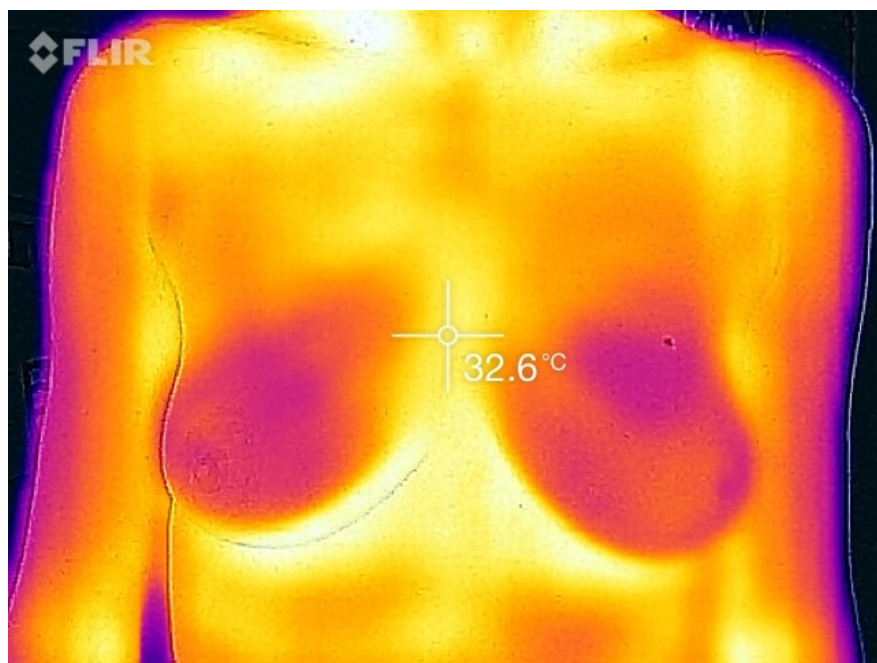
- Prediction of hypoglycemia events



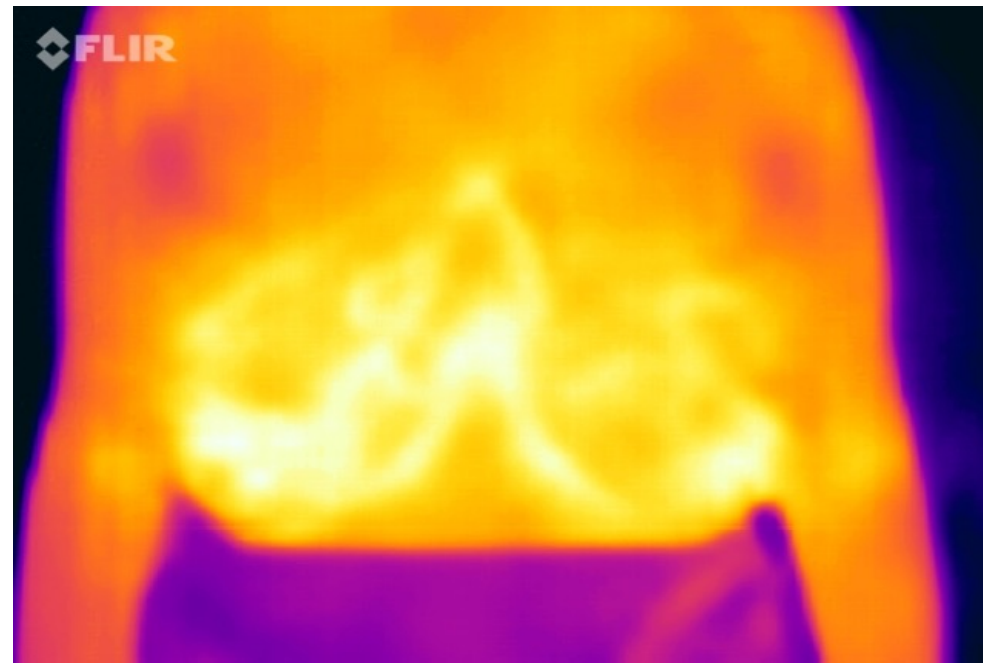


- Current research
 - Assessment of features in lactating women's breasts
 - Challenge: to overcome psychologic barriers (first time moms) by creation of a tool that gives a concrete metric
 - Research team:
Prof.s Martinez de Oliveira, Ana Gouveia, Nuno Pombo, Nuno Garcia, Nurse Marta Soares

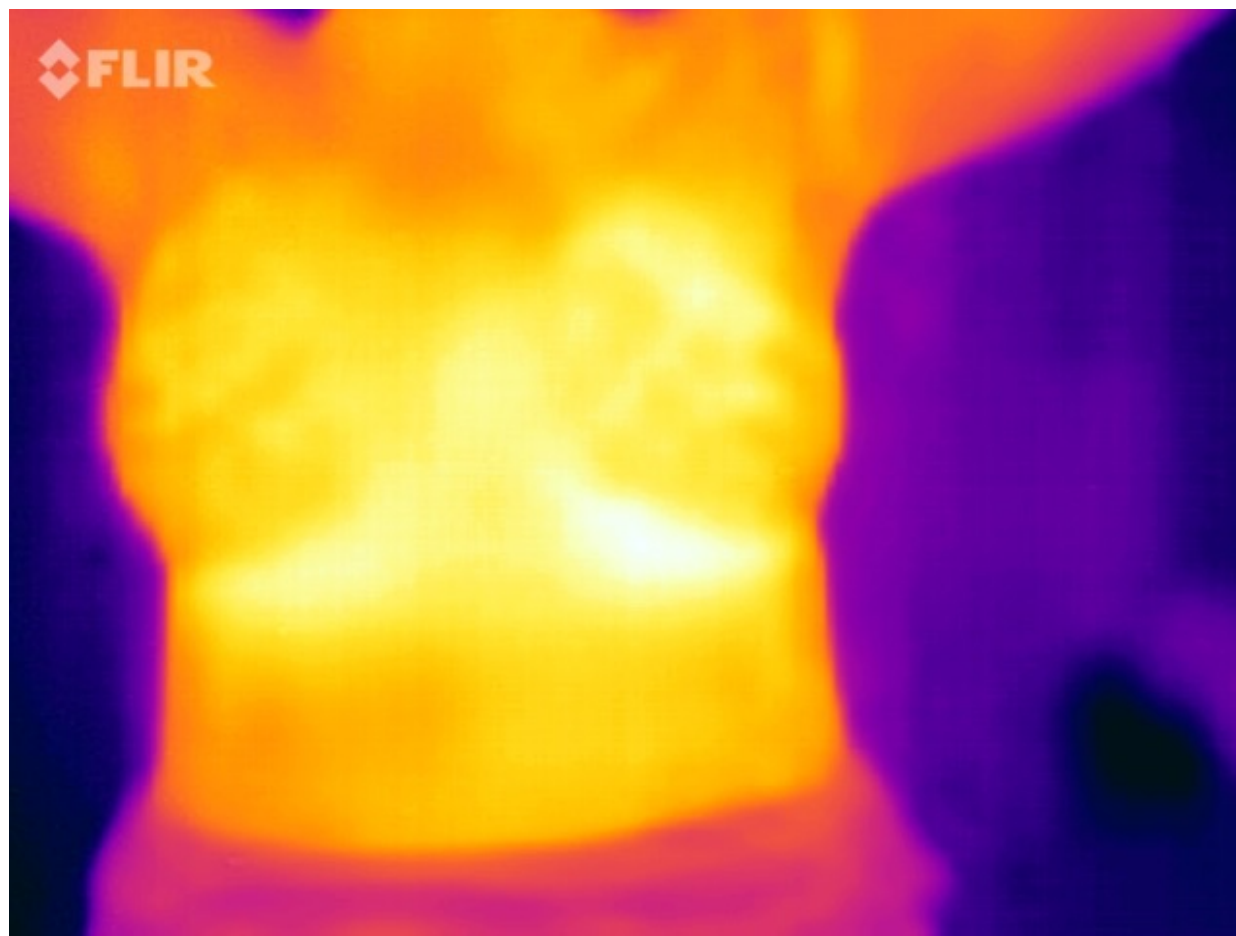
A



B

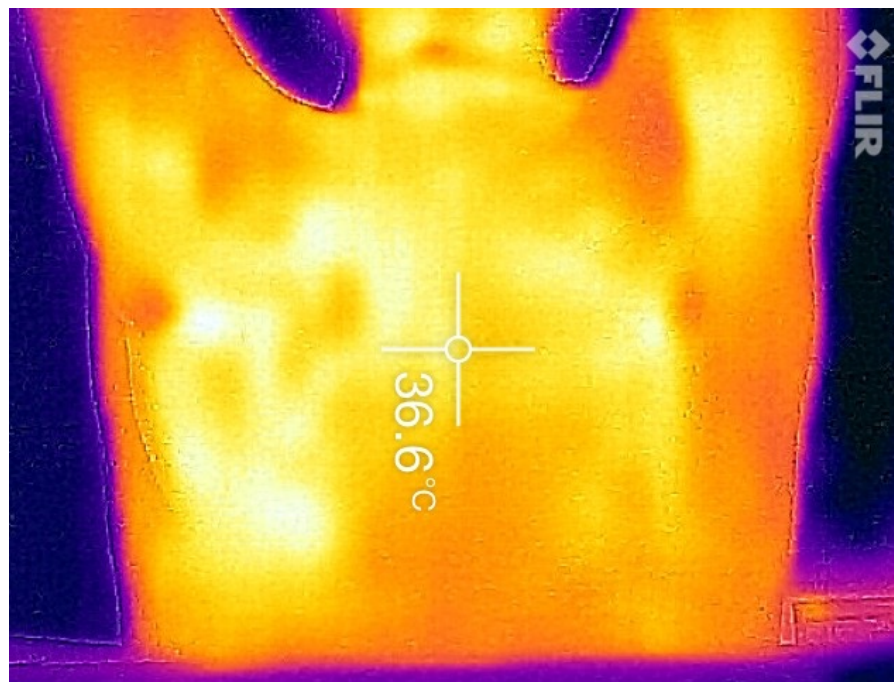


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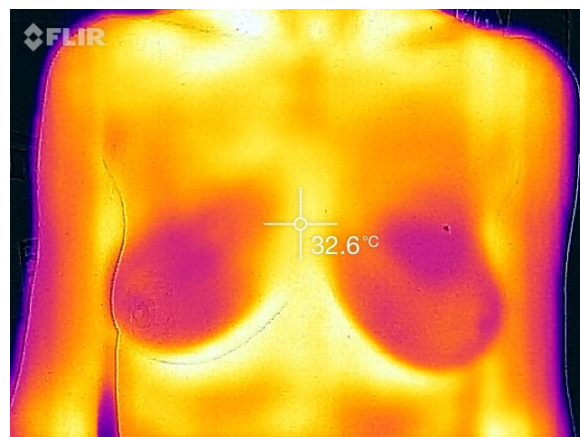


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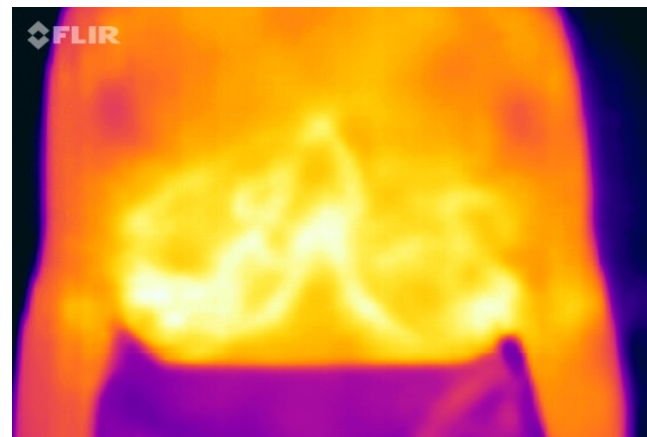
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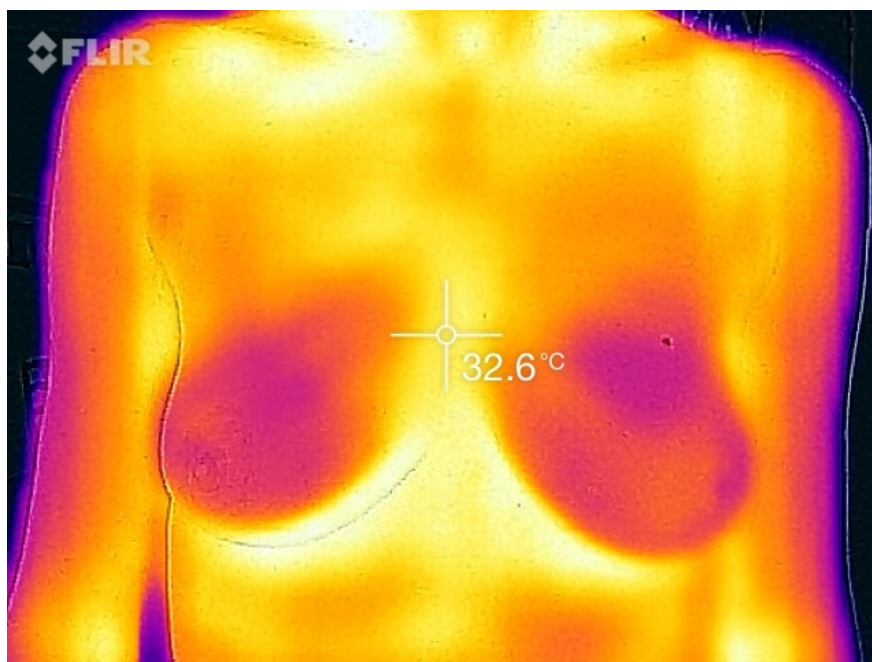
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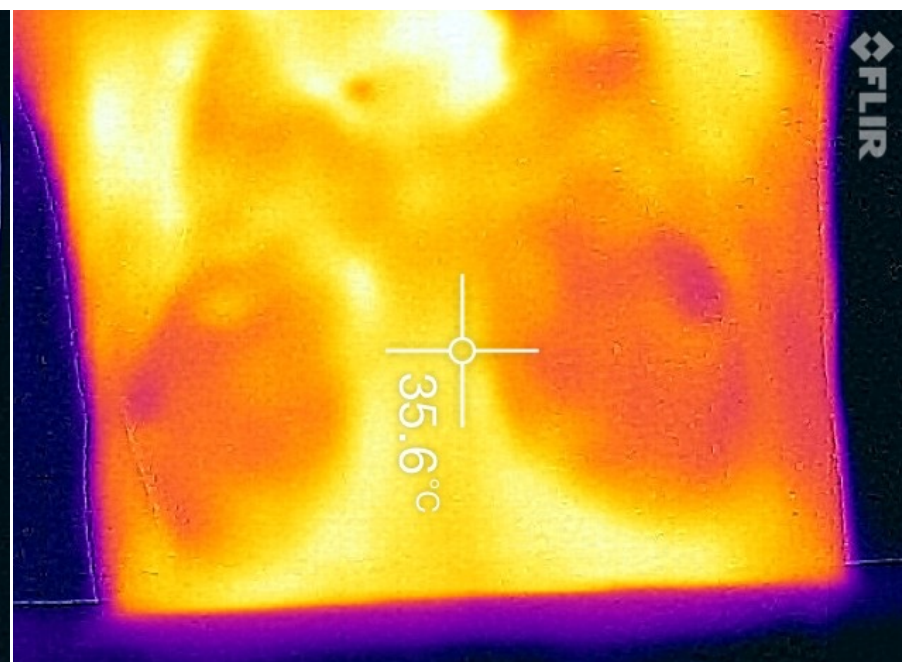
B



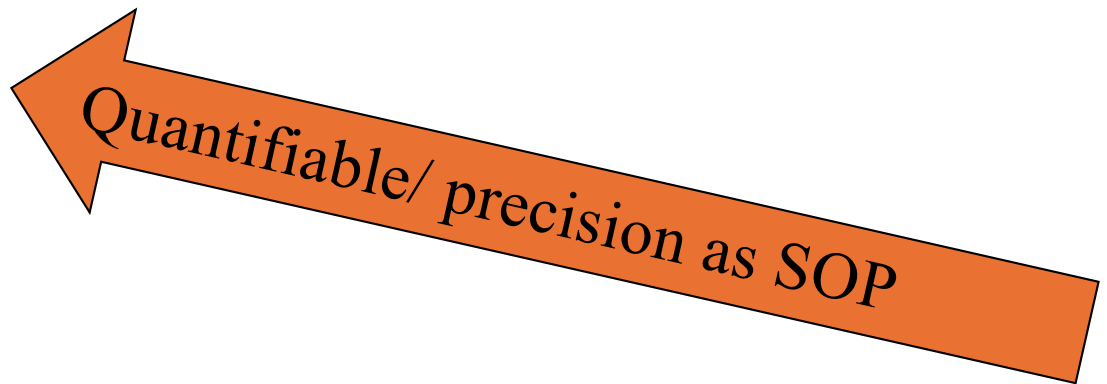
A



B



- What we do now:
 - Examin, measure and decide (and treat)
- Future:
 - Examin, measure, correlate, process, self-compare, cross-compare, test hipoteiss with digital twin, and only after, we decide



Quantifiable/ precision as SOP

*From Biosignals to Clinical Decisions –
what we have done, and what must we do?*

1st example (TUG) we can use our measurements to feed precision healthcare

2nd example (Voice) we have powerful biosignals that we don't even take the time to properly assess

3rd example (ICU) even when we measure, sometimes we don't know what to do with the measurements we have, and focus on the tree but miss the forest

4th example (diabetes) for complex problems, we need to consider complex data sources

5th example (breast) when we measure, we can find unexplainable findings.

*From Biosignals to Clinical Decisions –
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- We mostly focus on pre-XXth century concerns – to treat
 - *We need to switch focus from diagnosis to prediction*
- For the vast majority of cases, we only measure when we suspect something has gone wrong
 - *We give up too soon on handling complex problems, but these also have a solution (only may not know what it is yet)*
- We need to measure more – to be healthy has different meanings for each one of us, and at different times in our lives
 - *We need to learn to measure health, not disease*

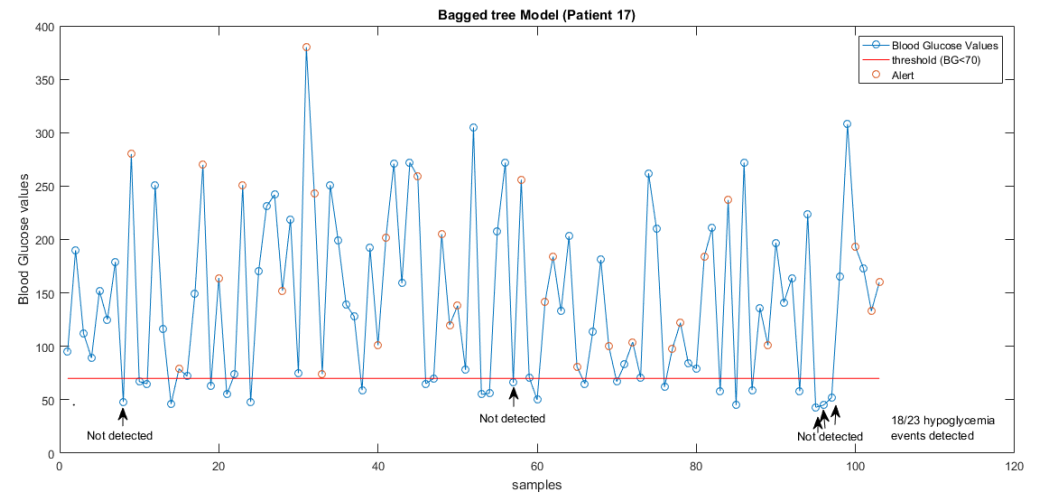
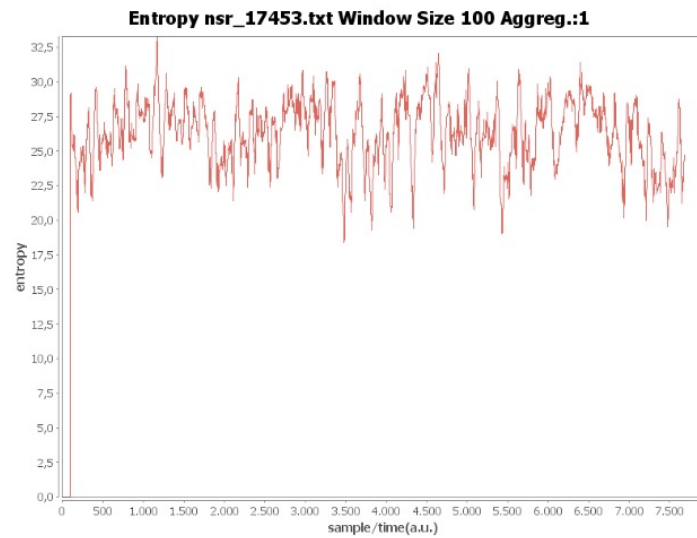
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Questions ?

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