DOCTORATE PROGRAM IN ELECTRONIC ENGINEERING

DOCTORAL TRAINING SEMINARS: RESEARCH PROJECTS IN THE DEPARTMENT OF ELECTRONIC ENGINEERING

Noninvasive instrumentation to monitor and evaluate trends in the cardiovascular system

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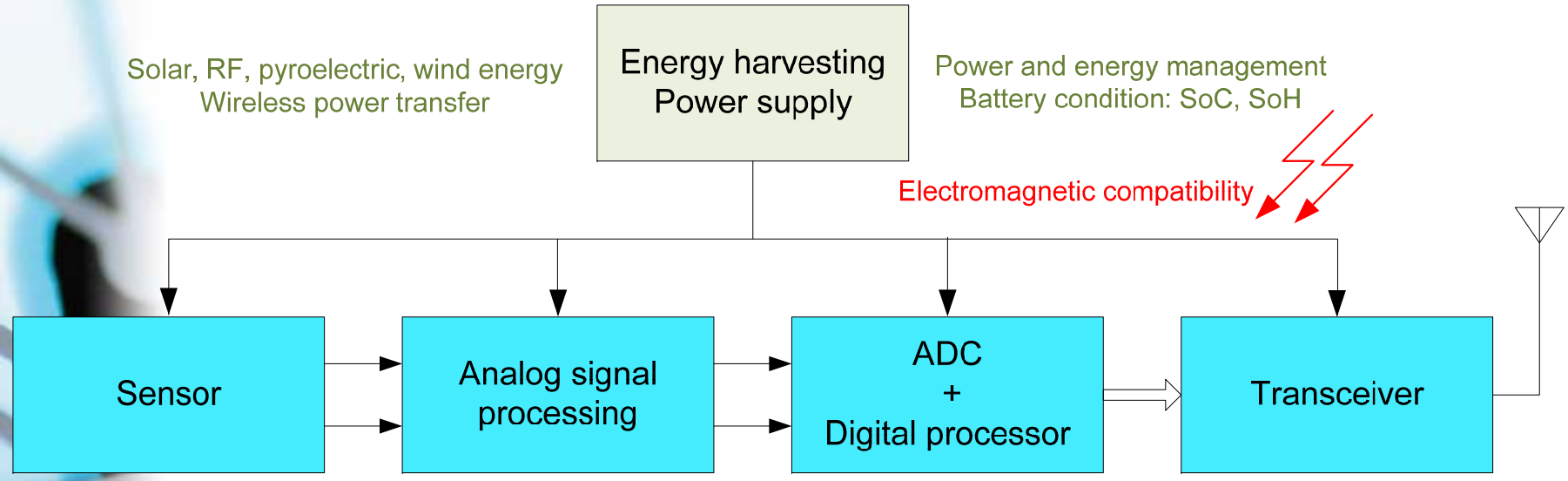
PROGRAMA DE DOCTORAT EN ENGINYERIA ELECTRÒNICA

Jornades formatives 2014: Projectes de recerca al Departament d'Enginyeria Electrònica

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH
Departament d'Enginyeria Electrònica

ISI Research areas

Instrumentation, Sensors and Interfaces Group



Noninvasive instrumentation to monitor and evaluate trends in the cardiovascular system TEC2009-1302

Contents

1. Introduction: Health care costs: future of medical devices

2. Our research in monitoring physiological signals in non-clinical environments

1. Health care costs

1. High-income countries
    1. Increasing percentage of GNP: **sustainability**?
2. Less-developed countries

    Current technology: almost **unaffordable**

Health care costs: economic

- Many medical devices are expensive as compared to commonplace electronic gadgets
  1. Reliance on the latest technology advances
     - Result from research **not oriented to mass market**
  2. Focus on life-threatening scenarios
     - Clinical oriented: stringent **functional** and **safety** requirements

➢ But a large demand (and expense) arise from long-term conditions, permanent disability and ageing

Future health-care market

1. More emphasis on **prevention**
    1. Physical activity programs
    2. Fast check-ups of large groups
2. Telemedicine and **home health care**
3. **Pharmacies** as alternative to primary health-care centers
4. **m-Health**

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1. Health care costs: future of medical devices
2. **Our research in monitoring physiological signals in non-clinical environments**

2. Monitoring physiological signals in **non-clinical** environments

1. Basic design requirements
    1. Simple to use: no training required; no skills
    2. Comfortable: no body attachments, fast
    3. Reliable: feedback to user
    4. Affordable
2. Approach

Novel **patient interfaces**

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Patient interfaces and signals

- Hands, feet
  - Handle bar, steering wheel, touch electrodes…
  - Platform, body weighing scale
- Chair, bed

Signals:

➢ ECG, IPG, BCG

✓ Joint signal analysis: BP, arterial elasticity…

✓ Mild hemodynamic maneuvers

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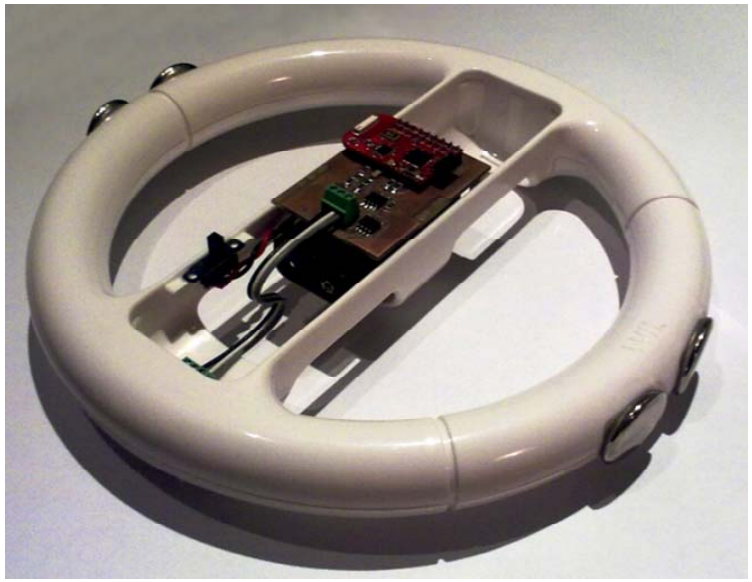
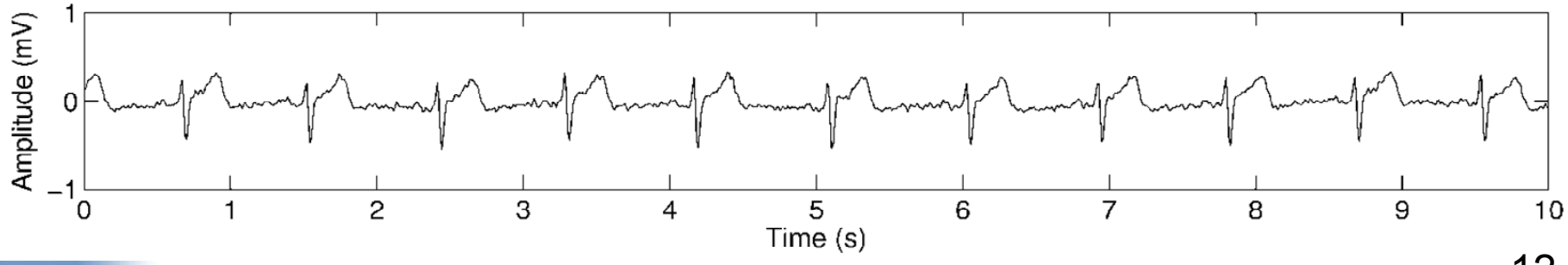
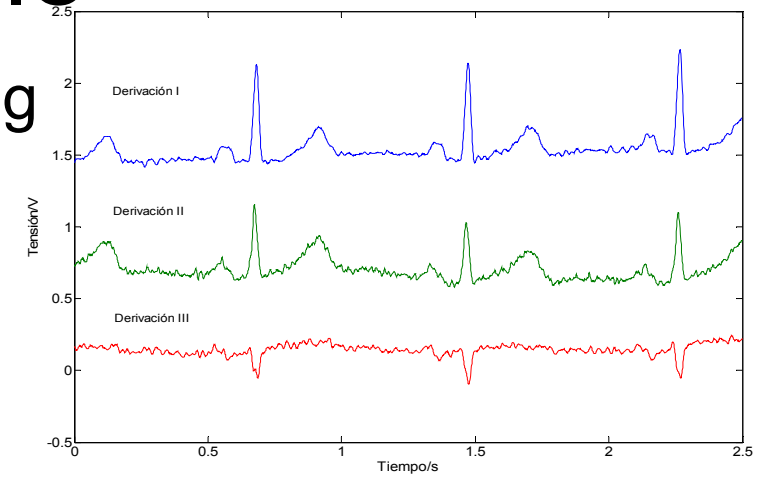
Wheel-ECG



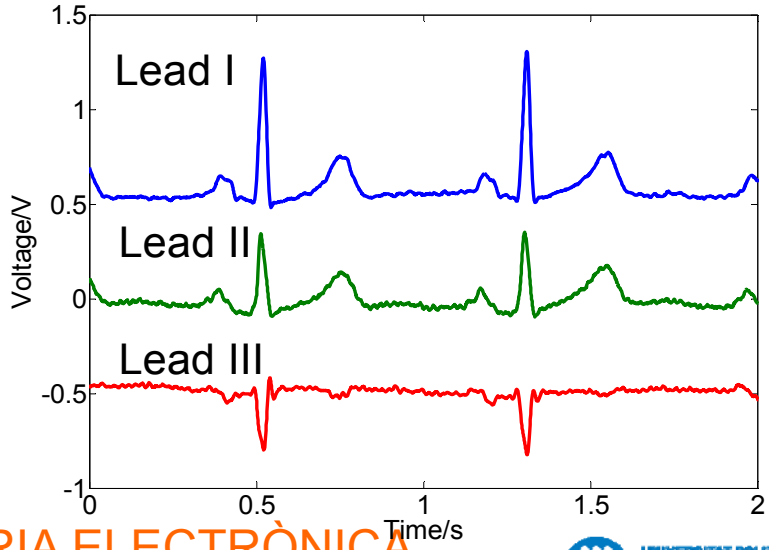


Six std. ECG leads from bathroom scale

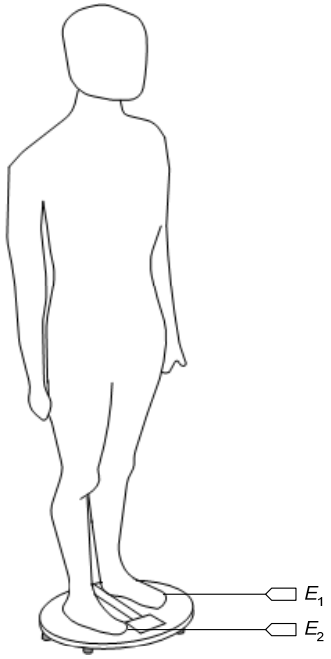
Standing

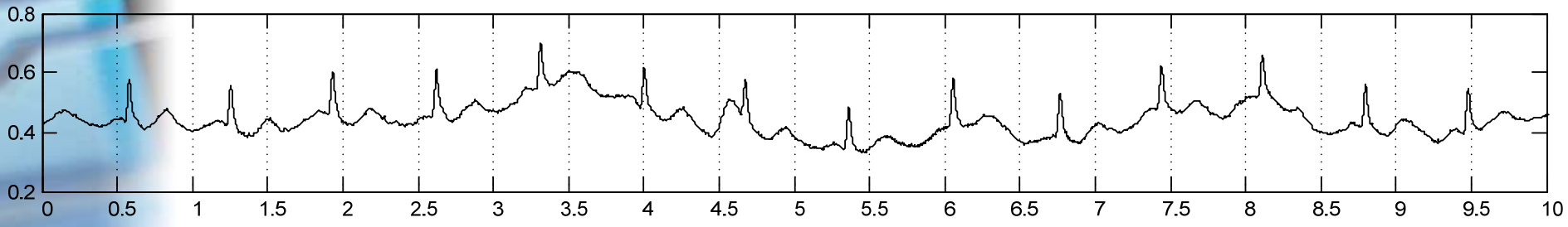


Seated

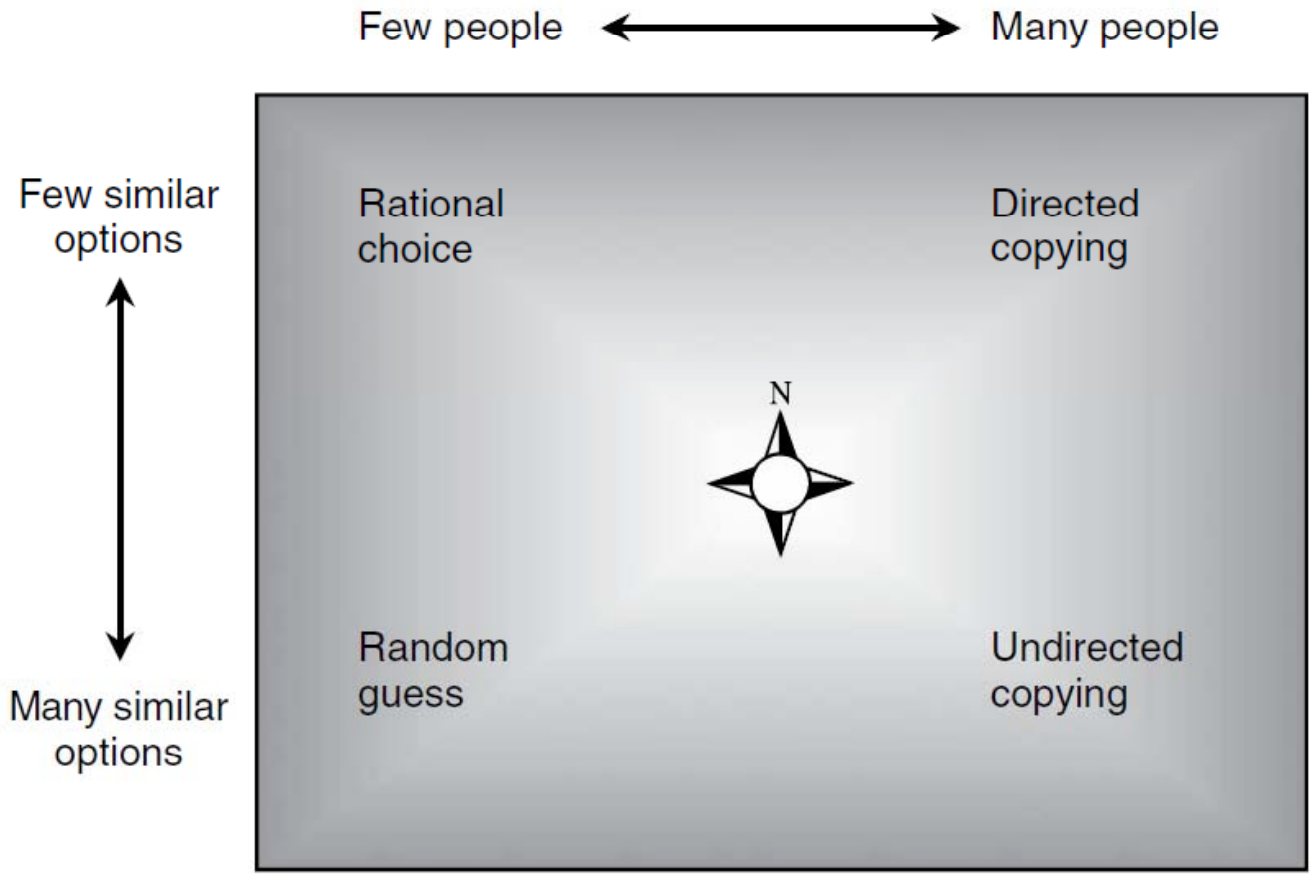


ECG in a platform





Revisiting old ECG circuits Driven-Right-Leg Circuits?



(2011) A. Bentley, M. Earls, J. O'Brien "I'll have what she's having" MIT Press

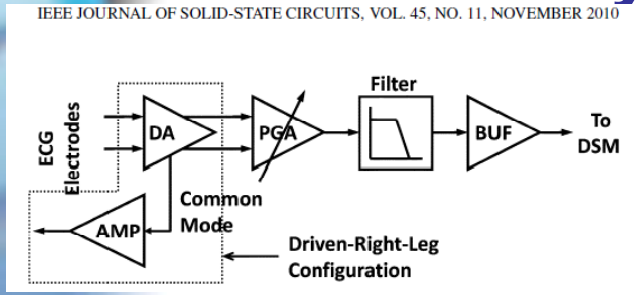
The Driven-Right-Leg (DRL) Circuit …

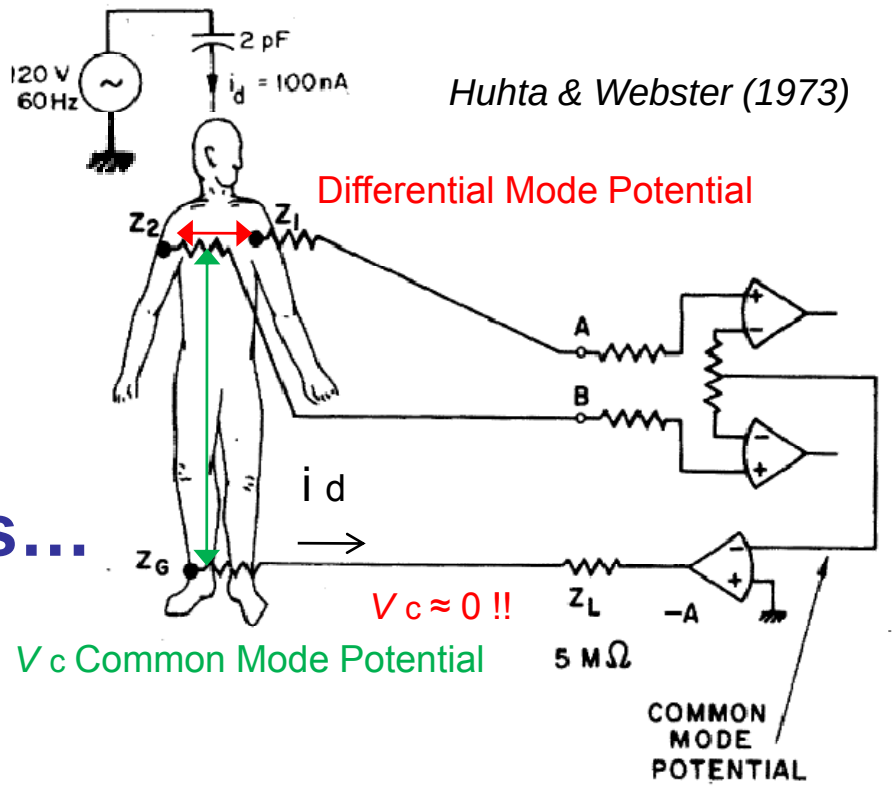
In the 70's …

Power line interference reduction in ECG recordings

Grounded Patients …

And still nowadays…





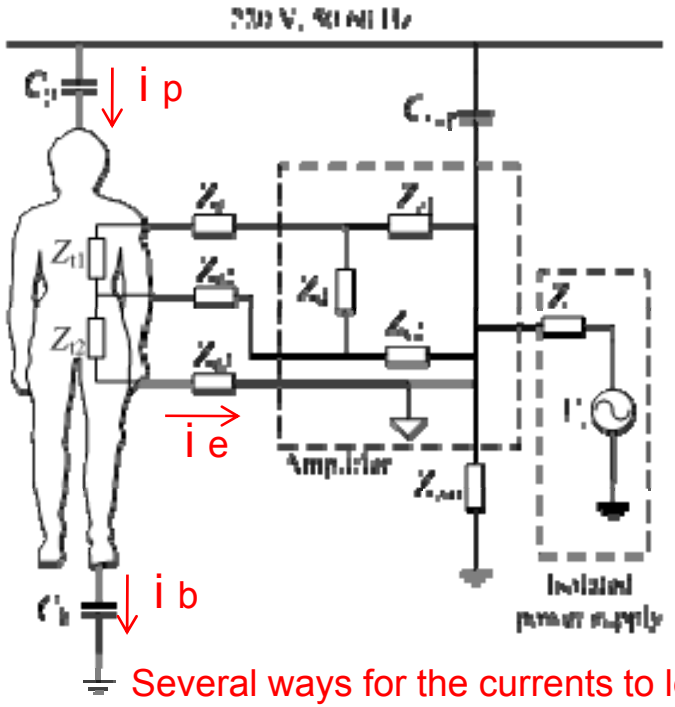
Mainly only one point (right leg) for the current leaving the body….

The Driven-Right-Leg (DRL) Circuit …

But nowadays….

Power line interference reduction in ECG recordings

Patients are not grounded anymore !!!
(Medical Grade Isolation)



Several ways for the currents to leave the body….

If you connect a DRL circuit you can change the whole current distribution (and maybe increase differential mode interference !!!)

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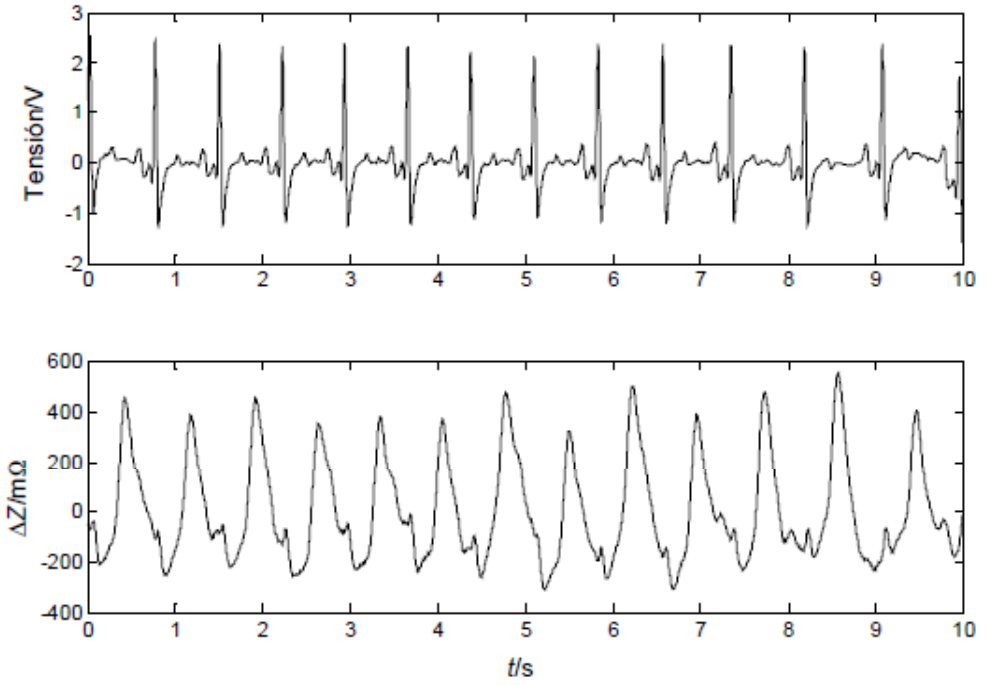
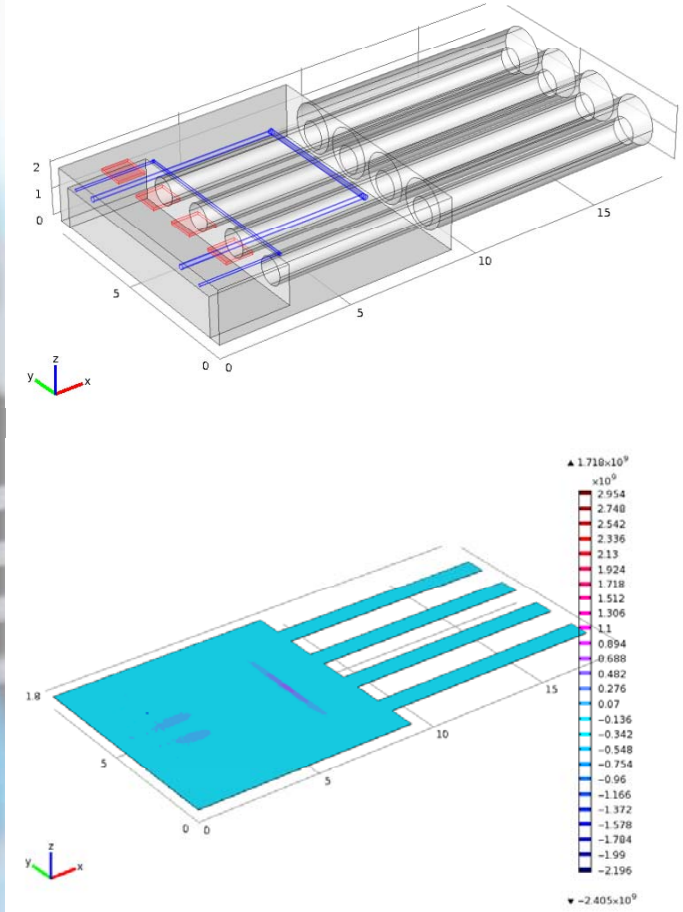
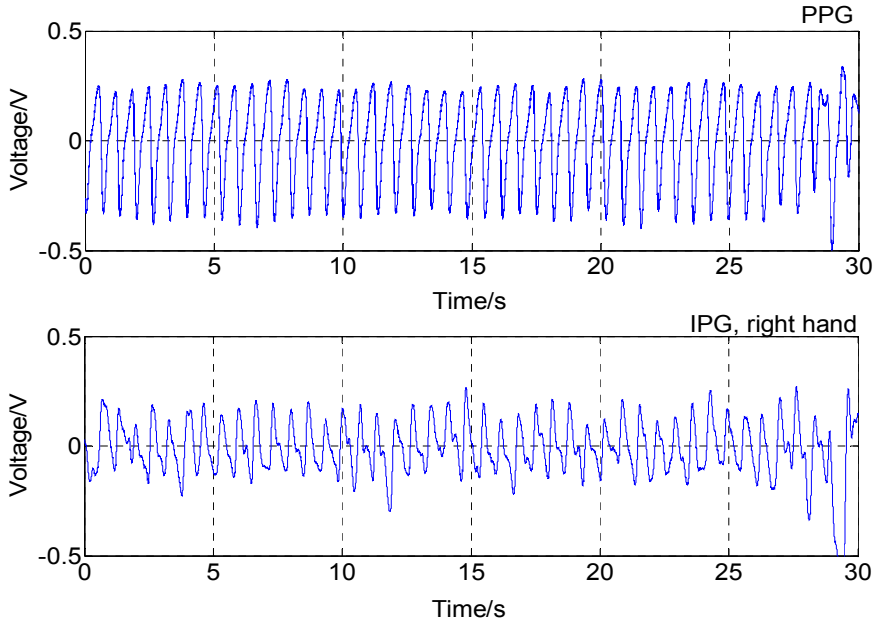
Heart rate in a platform (IPG)

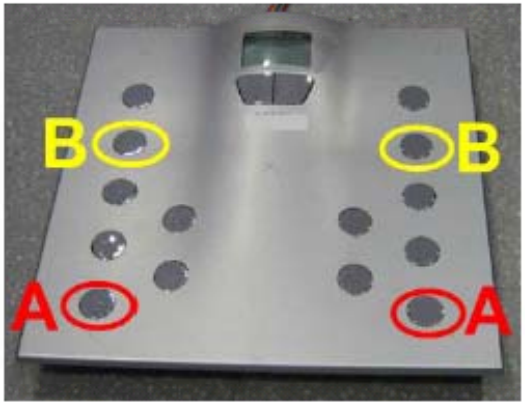


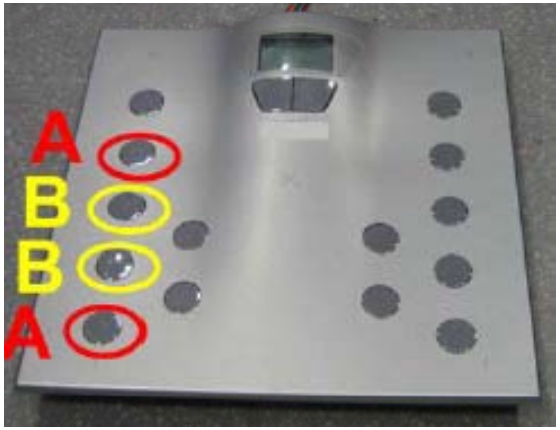
Heart rate in a hand (IPG)

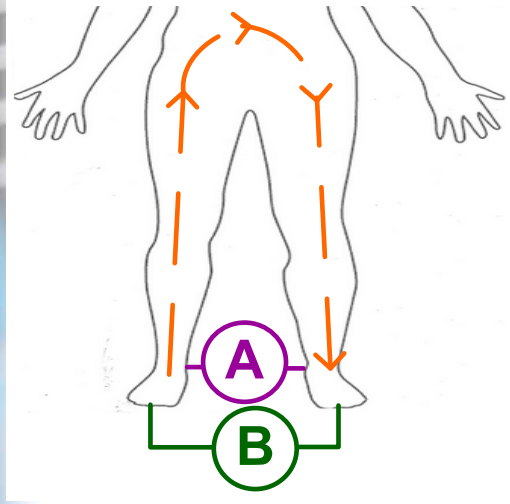


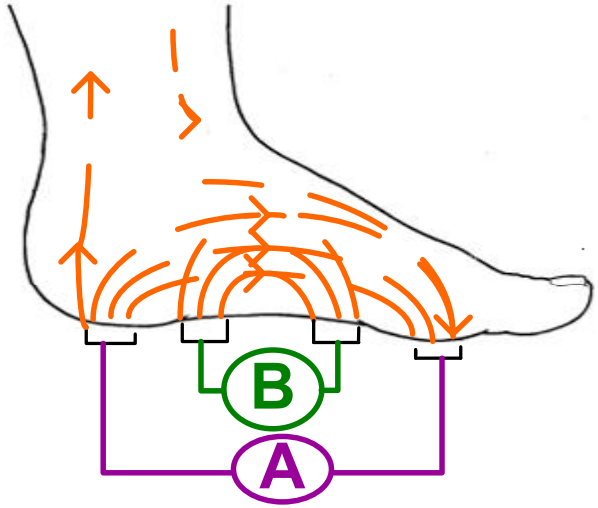


Pulse wave from the IPG









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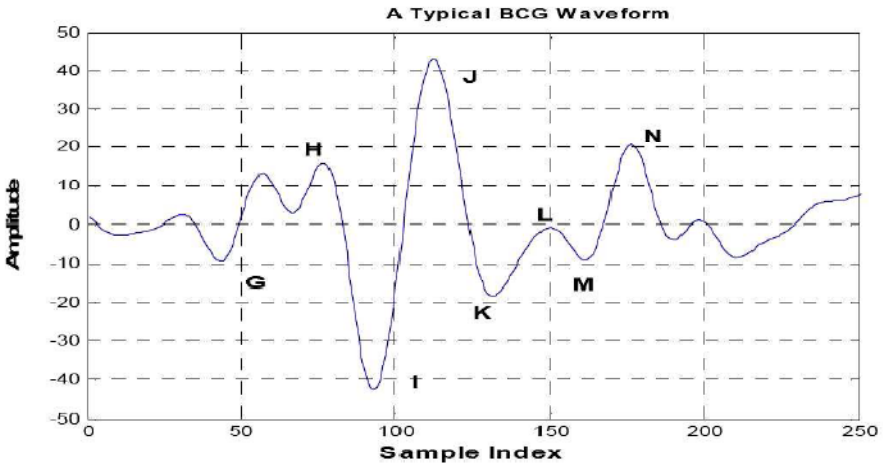
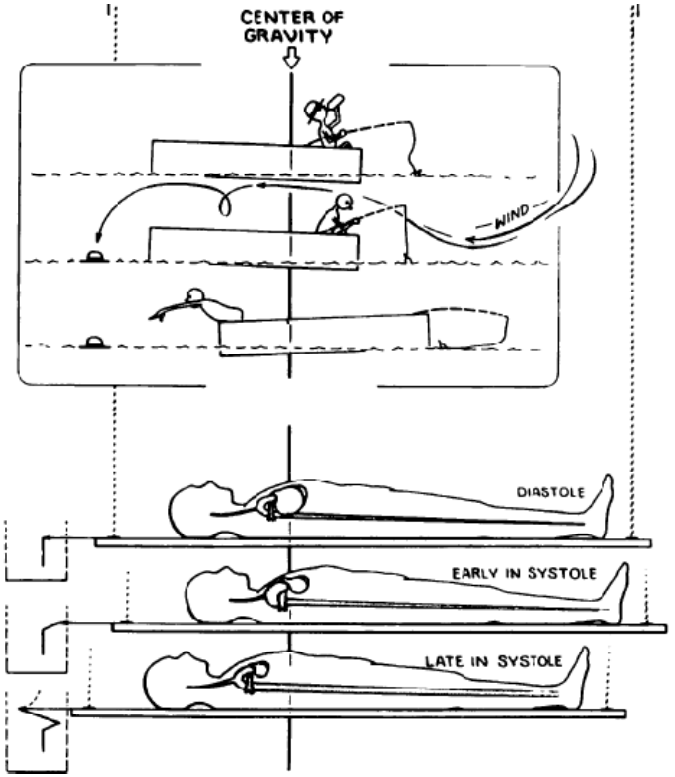
Heart's mechanical activity (BCG)

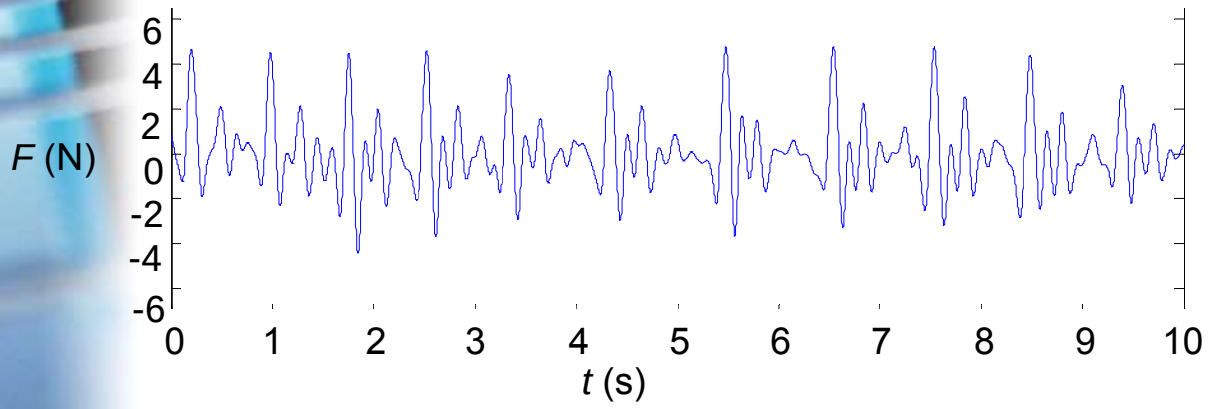


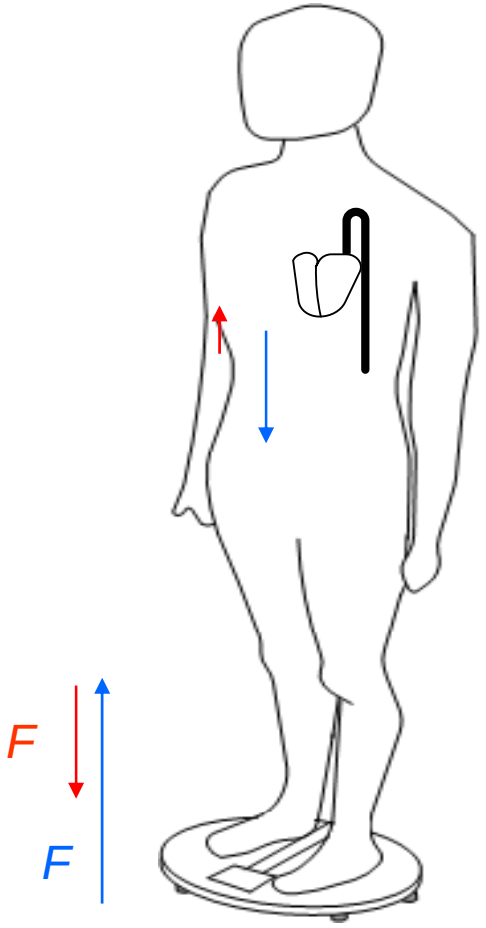
Acceleration head-feet BCG



(Noordergraaf 1961)

BCG from a bathroom scale





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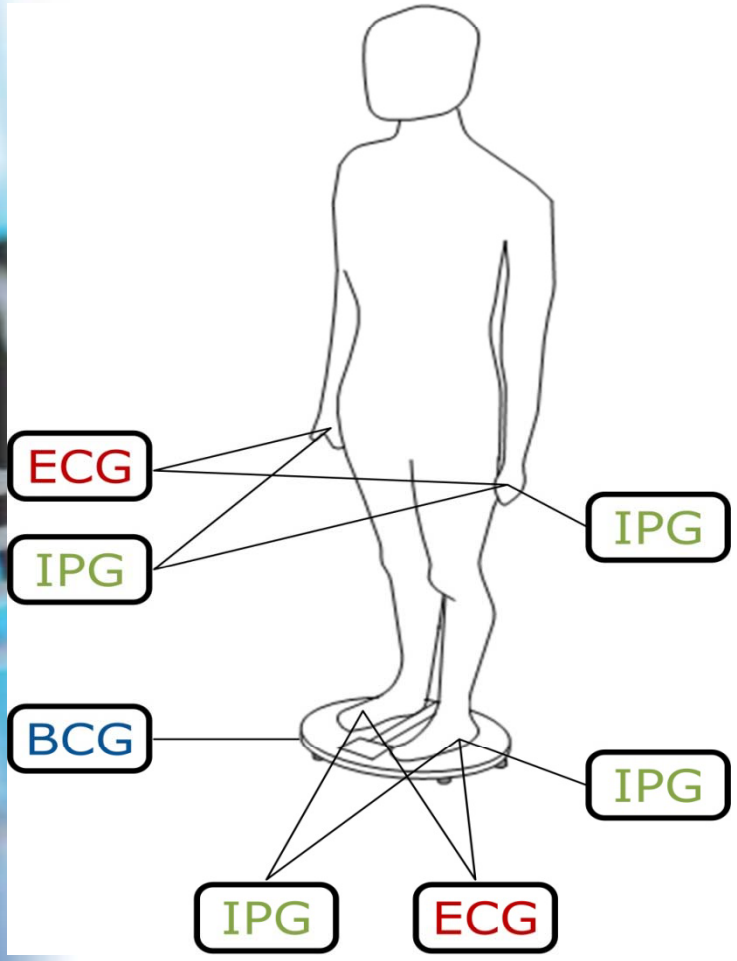
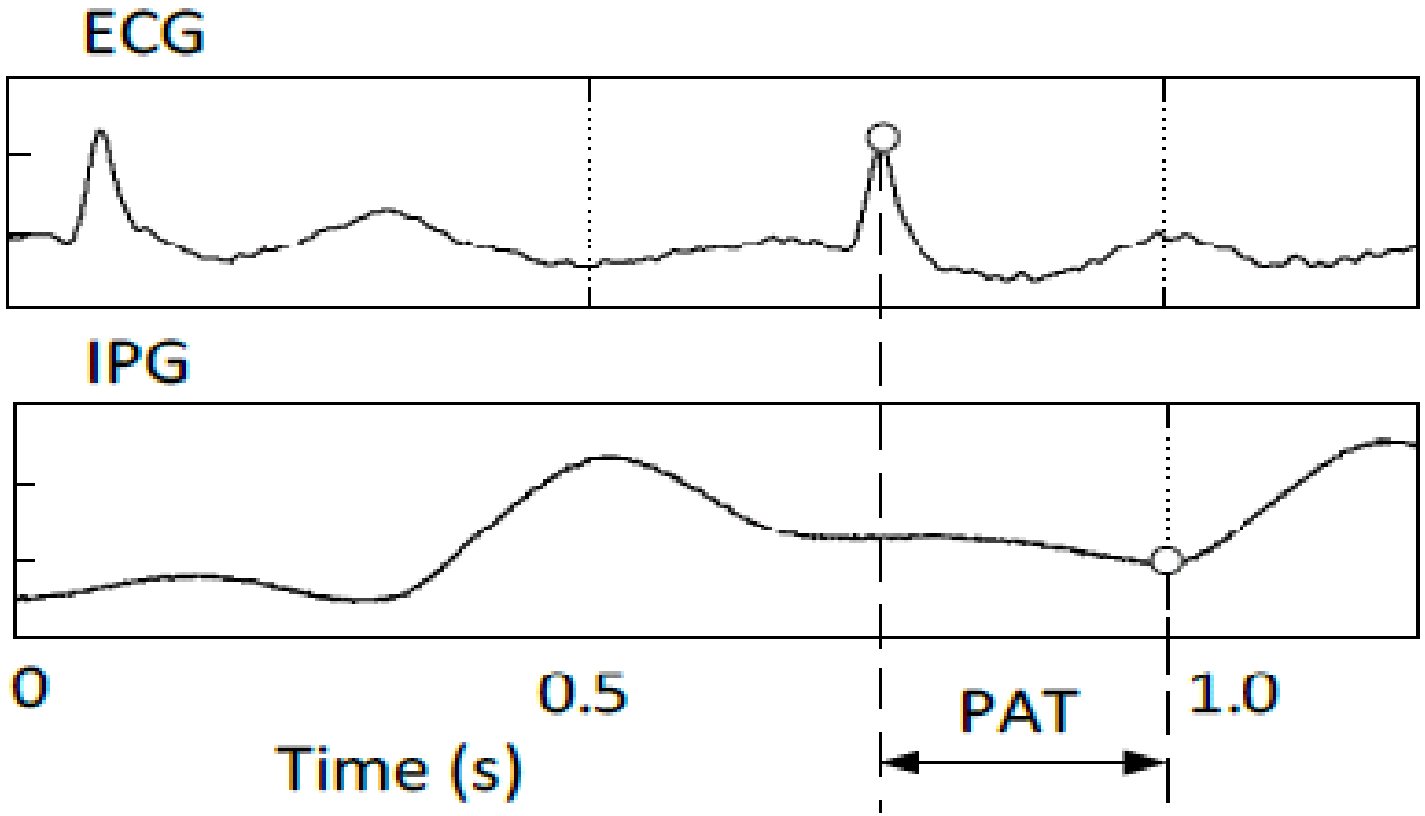
Combined systems

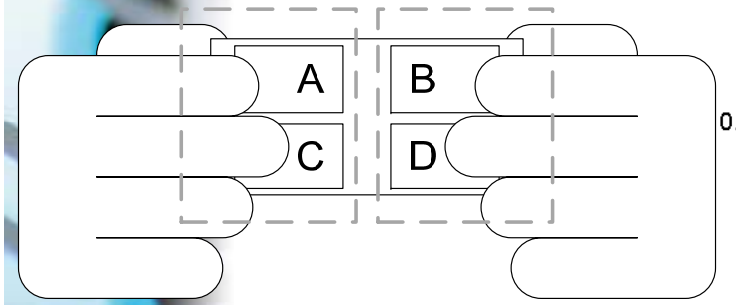


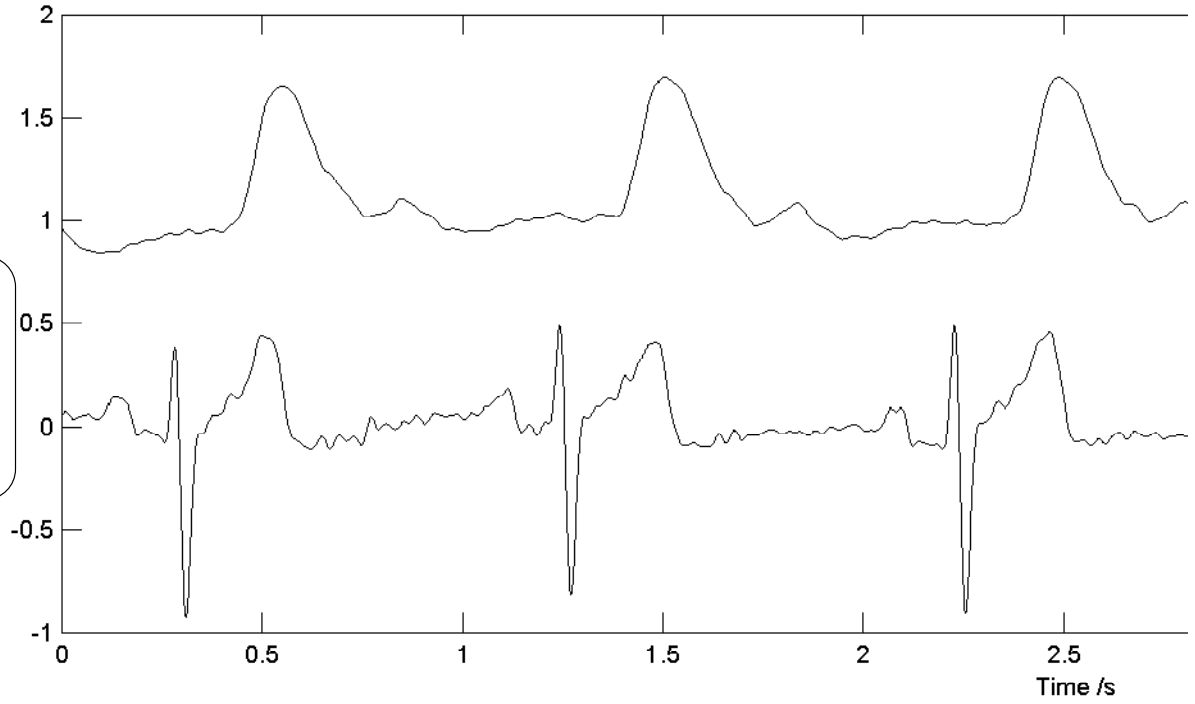
- Handheld device
- Bathroom scale
- Bathroom scale with handheld bar

ECG between feet + IPG in a foot

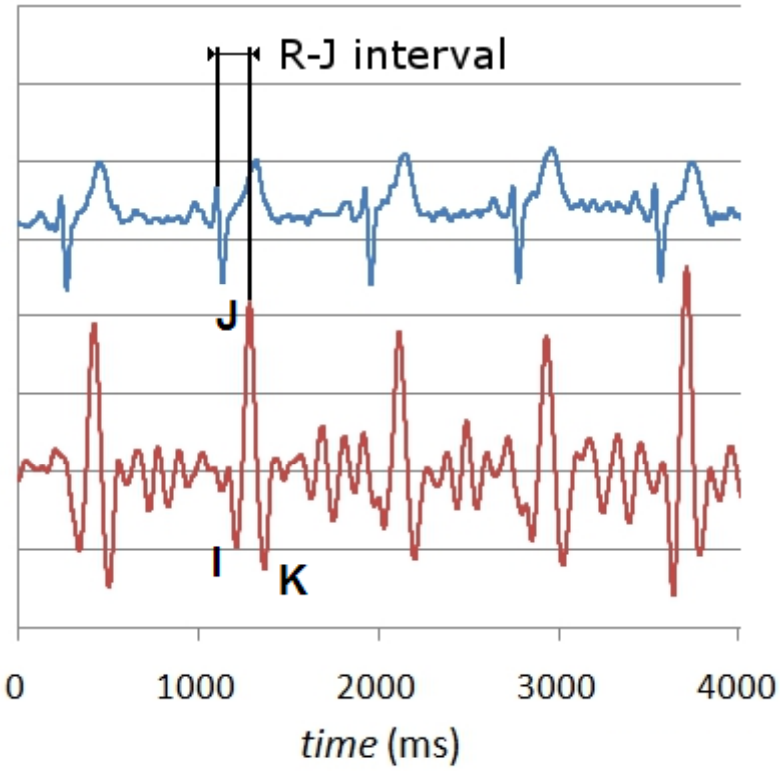


ECG + IPG between hands





Time intervals using BCG



Up to now, mainly R –J interval and

Valsalva Maneuver

R-J → SBP *(Shin et al. 2009)*

R-J → PEP *(Etemadi et al. 2009)*

Related but not the same…

?

Our Proposal

Further investigation on BCG Time intervals:

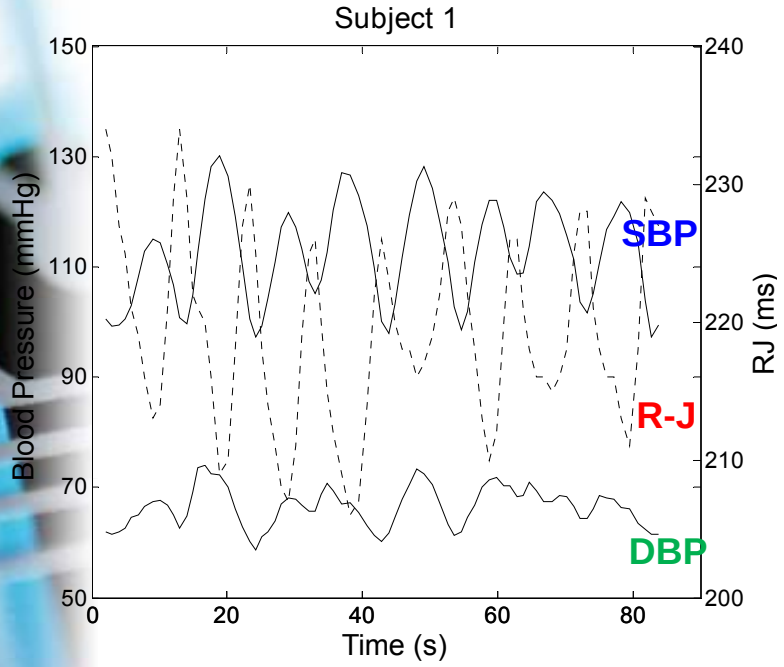
- Alternative maneuver: Paced respiration 0.1 Hz (faster, easy to implement)

- ECG, BCG (weighting scale) recordings plus beat-to-beat pressure wave.

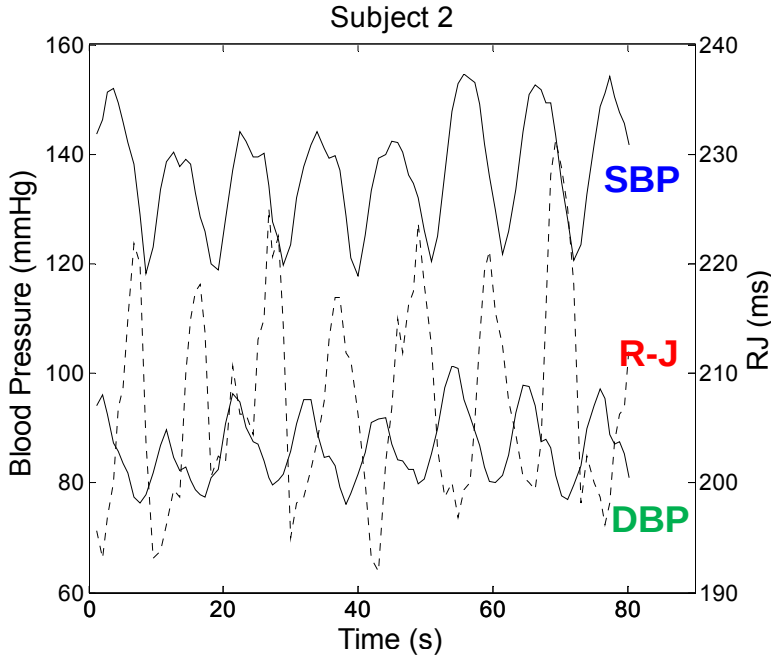
Two subjects

Subject	*Age*	*Height*	*Weight*
S1	47 years	173 cm	75 kg
S2	28 years	189 cm	72 kg

Results (I)

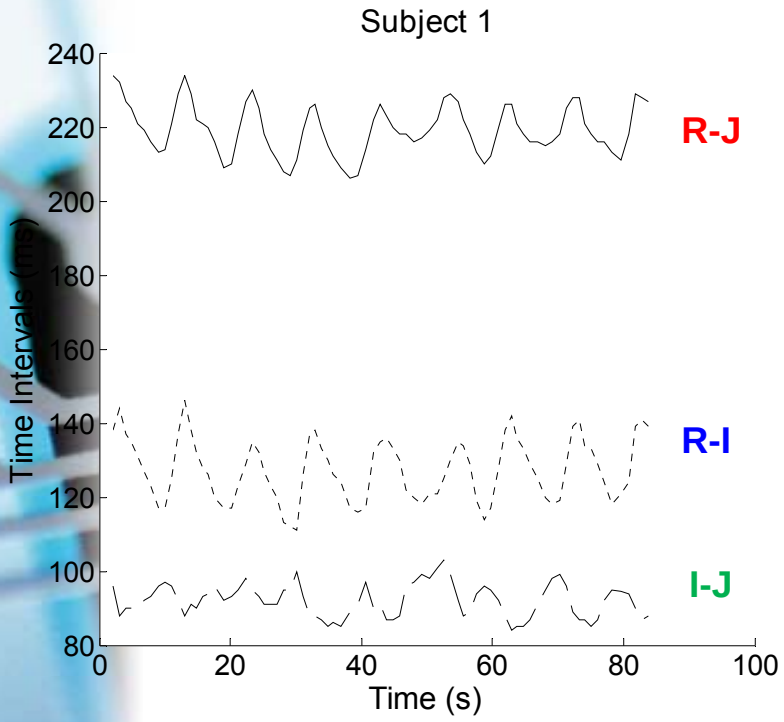


R-J inverse to SBP

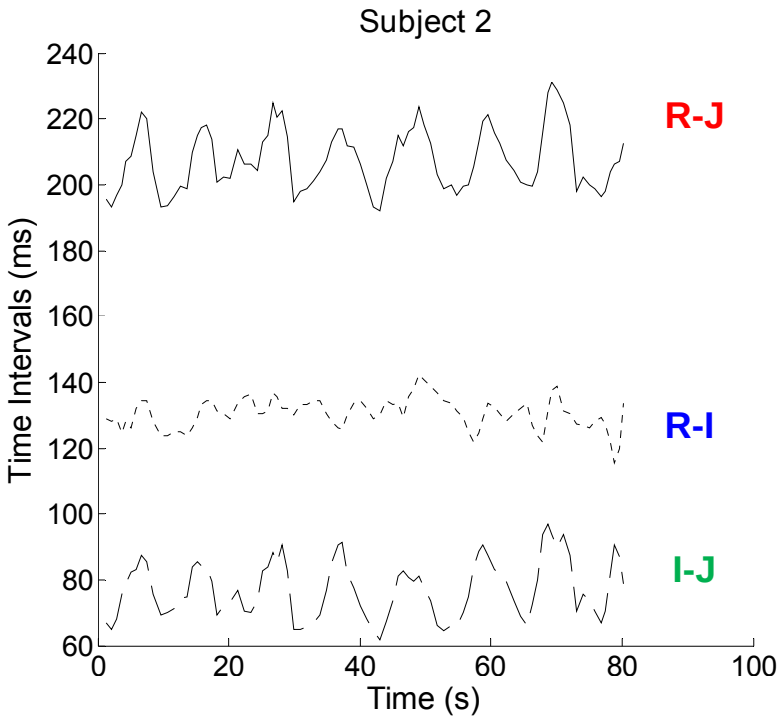


R-J inverse to DBP

Results (II)



R-J mainly R-I



R-J mainly I-J

M-Health Smart scales

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