INTERNATIONAL SEMINAR

REPOSI 2015

Milan, Italy

24-25 September

TARGETING THE BURDEN OF POLYPHARMACY IN THE ELDERLY

Information and communication technologies to improve prescription appropriateness and therapy adherence in the multimorbid elderly

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Vision of care

Sensing (clinical exams)

Reasoning

Action (prescription)

Vision of care

Sensing (clinical exams)

Reasoning

Action (prescription)

Multimorbidity problems

Uijen AA1, van de Lisdonk EH. **Multimorbidity in primary care: prevalence and trend over the last 20 years**. Eur J Gen Pract. 2008; 14 Suppl 1:28-32.

Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study

Karen Barnett, Stewart W Mercer, Michael Norbury, Graham Watt, Sally Wyke, Bruce Guthrie

2012 – The Lancet

Optimal care is defined for single disease**. Failure to consider multiple conditions** (InterCheck by Mario Negri is aimed to fill this gap at least in Italy).

Multiple specialists are required. **Need for coordination arises.**

Many visits by GP and specialists are required to the patients. **This provokes often delay of important appointments.**

Many different types of physiological samples are required. **Make sampling easier.**

Most disease care happens at home and is unsupervised by professionals. **Need for better education arises**.

ICT can help!

New guidelines required for multimorbidity

Guidelines should have the following properties:

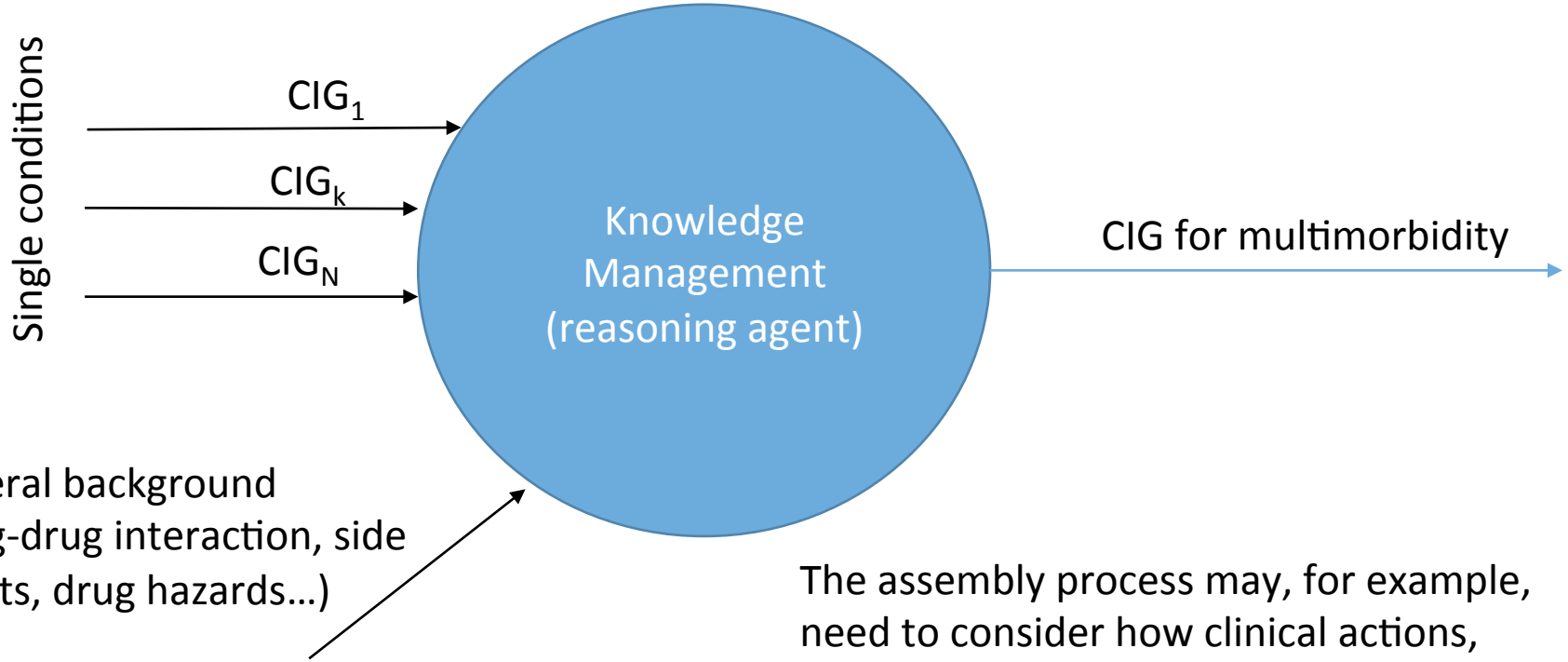
- Be tailored to the conditions that an individual patient has
- Clearly identify recommendations which are synergistic, potentially interacting in a problematic way, or contradictory
- Identify drug-disease and drug-drug interactions with good evidence of harm
- Take account of limited life expectancy if present
- Identify which recommended treatments have the greatest potential benefit in particular patients, to allow clinicians and patients to choose the most effective but appropriately parsimonious treatment regimen

Shift from paper based to electronic guidelines

Creation of guidelines for multimorbidity patients

Knowledge management => Computer Interpretable Guidelines (CIG) for multimorbidity

A CIG is a declarative specification of tasks and their (inter)relationships organised in a hierarchy of plans and their components.



The assembly process may, for example, need to consider how clinical actions, medications, time periods, etc. should be added, removed or modified to avoid or mitigate possible hazards.

Deals with complexity

How to create these guidelines?

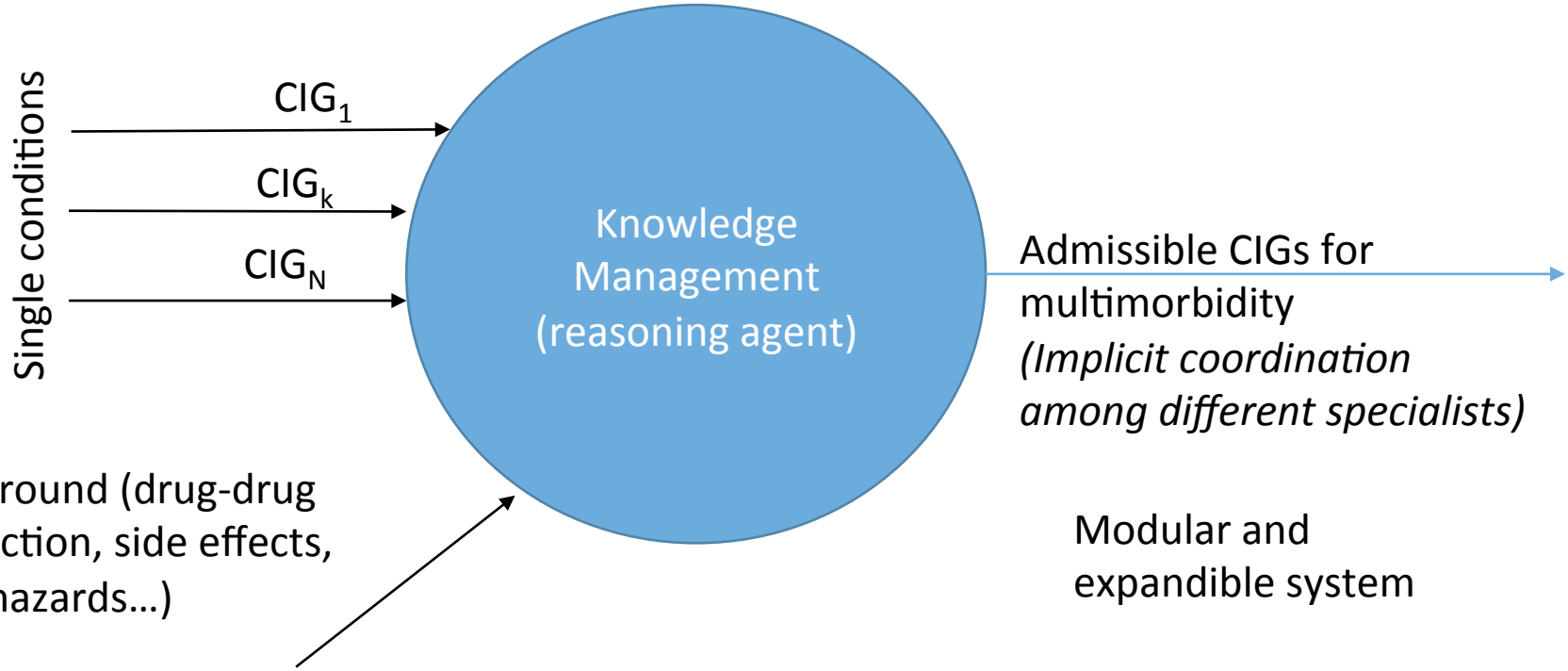
Ontologies are used to represent specific background:

SNOMED-CT (Clinicial CIGs and vocabulary): http://www.ihtsdo.org/
OpenEHR (electronic records): http://www.openehr.org/home
HL7 (clinical digital standards): http://www.hl7.org/

and more general background:

OBO foundry (biomedical domain): http://www.obofoundry.org/
BioPortal (biomedical domain): http://bioportal.bioontology.org/

Specific languages to represent otologies have been developed: RDF, OWL (based on XML).
Queries and reasoning (**logic inference = rationale agent**) can be supported by specific applications: Arden Syntax, Glif, PROforma, STRIP.



An example of an RDF description

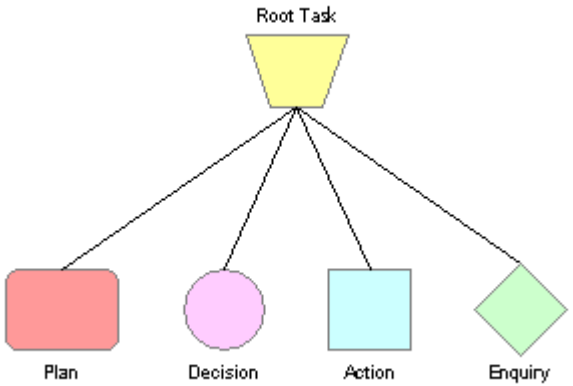
Cat is a sub-class of class: Animal.

```
<rdf:Description rdf:ID="Animal">
<rdf:type rdf:resource="http://www.w3.org/2000/01/rdf-
schema#Class"/>
</rdf:Description>

<rdf:Description rdf:ID="cat">
<rdf:type rdf:resource="http://www.w3.org/2000/01/rdf-
schema#Class"/>
<rdfs:subClassOf rdf:resource="#Animal"/>
</rdf:Description>
```

Interfaces to write XML with graphical / text interfaces are provided by software aimed to create ontologies.

An example of CIG

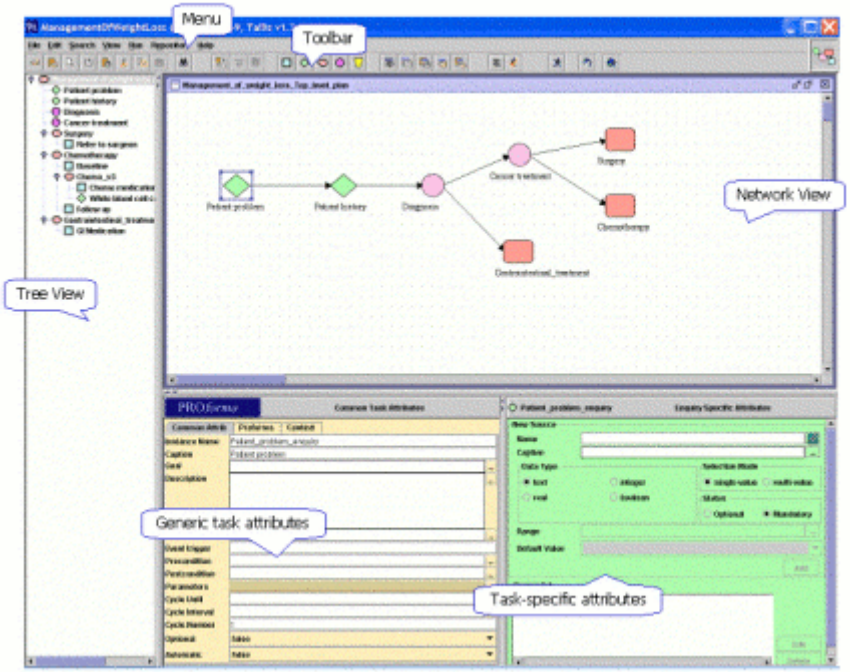


PROForma language:

- Arezzo (1996) -> InferMed Ltd.
- Tallis -- (2000) http://www.cossac.org/tallis

Spin-off from Oxford University, starting since 1992, based on Java language)

Four classes, each with their own attributes: *Plans*, *Actions*, *Decisions* and *Enquiries*. Classes are combined in a directed graph.



Guidelines, support for management and decision applied to clinics for: *HIV treatment (RETROGRAM), Renal Anaemia (ORAMA), Clinical trial (MACRO), Cancer pain control (ARNO),…*
and applied to research for: *Genetic risk management, asthma management, lympholastic leukaemia…*

How reliable can be the system?

Can the system act intelligently? Can it solve *any* problem that a doctor would solve by thinking and reasoning? (this is the basic question of Artificial Intelligence)

There is some special quality of the human mind that is necessary for thinking and yet cannot be duplicated by a machine (Dreyfus, Turing…). This has to do with unconscious, intuition, not symbolic processing, …

These observations have obscured AI for decades.

Expert systems in the 80s promised to substitute many profession but…. Failed. Expert systems should rather be seen as decision support systems.

However, Internet has changed the way in which Expert systems can work.
Continuous Learning has change the way in which Expert systems are thought.

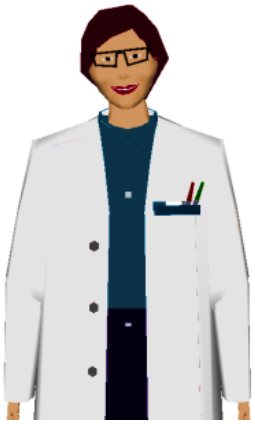
Systems have the potentiality of continuously been tuned: they **have the potentiality to produce new CIGs and better CIGs found collectively by doctors from many countries**.

Critical issues:

- Power of CIGs
- Usability of instruments (time to use / advantage)

Vision of care

Sensing (clinical exams)



Reasoning

Action (prescription)

Heart rate for fitness

Heart rate monitor through a strap band with a wrist receiver

www.polar.com

In early plastic straps, water or liquid was required to get good performance. Later units have used conductive smart fabric with built-in microprocessors that analyze the ECG signal to determine heart rate.

Heart electrical signal is acquired through conductive material, amplified, digitized and, more recently, transmitted wireless to the display unit.

Strapless heart rate monitors were later developed taking advantage of sweating to increase conductance (e.g. handlebar in cyclettes and running bikes).

Fitness ECG without requiring specific objects

Samsung Gear Fit - 2015

Electro-conductive pads.

Here we see a fundamental shift:

From sensors that have to be attached to the body to sensors that are attached to objects.

From devices, to wearable devices to smart objects.

http://www.technogym.com/

A different measuring principle: otpical plethysmography

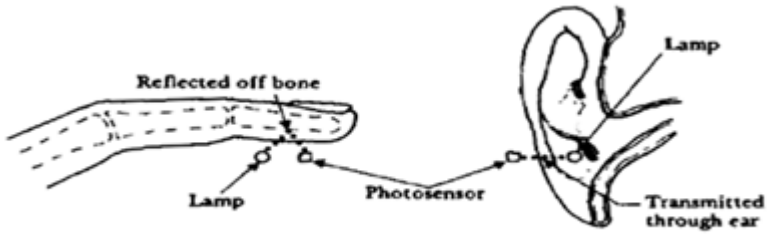
It measures the change in volume blood indirectly by measuring reflected or transmitted light.

Light absorption is regulated by the volume of blood that is decided by the rate of heart pulses. Since light is absorbed by blood, the signal pulses are equivalent to the heart beat pulses.

There are two types of photoplethysmography:

Transmission: Light emitted from the light emitting device is transmitted through any vascular region of the body like earlobe and received by the detector.

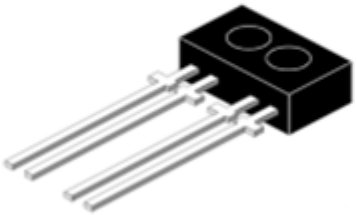
Reflection: Light emitted from the light emitting device **is reflected by the regions**.



Optical based heart rate measurement with commodity hardware

Basic components are:

- LED
- Photodiode



Wrist sensor

Clip

http://www.elprocus.com/heartbeat-sensor-working-application/

Even without specific hardware

Apps that can be used with the camera integrated for instance inside a smart phone.

https://www.runtastic.com - 4.4 Stars from people using this software.

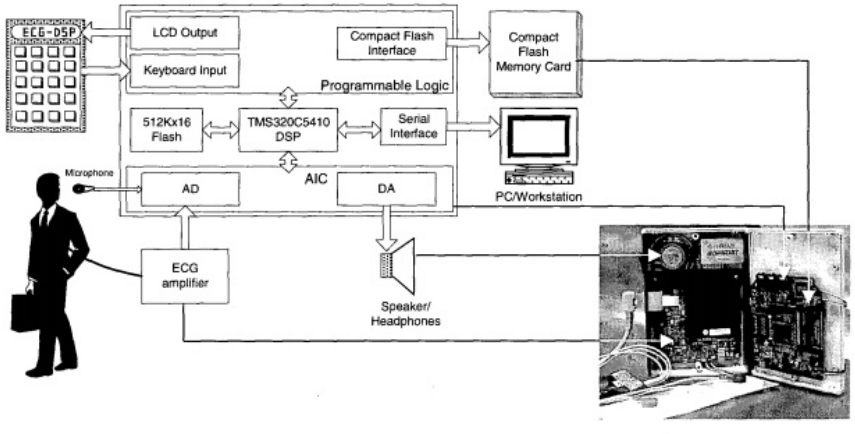
EASY TO USE

- * Place and lightly hold your (index) finger against the back camera lens and flashlight
- * Do not press too hard, otherwise blood circulation will be altered and the results could be affected
- * When using a smartphone or tablet without a LED flashlight, be sure to take the measurement in a well-lit area (bright daylight works best)
- * Remain calm and try not to move too much during the measurement, as this can compromise measurement accuracy
- * Do not measure with cold fingers when the blood circulation is poor.

WARNING: This is not a medical product.

Note: more recently the same principle is under investigation with eyes.
http://www.google.com/patents/US6477394

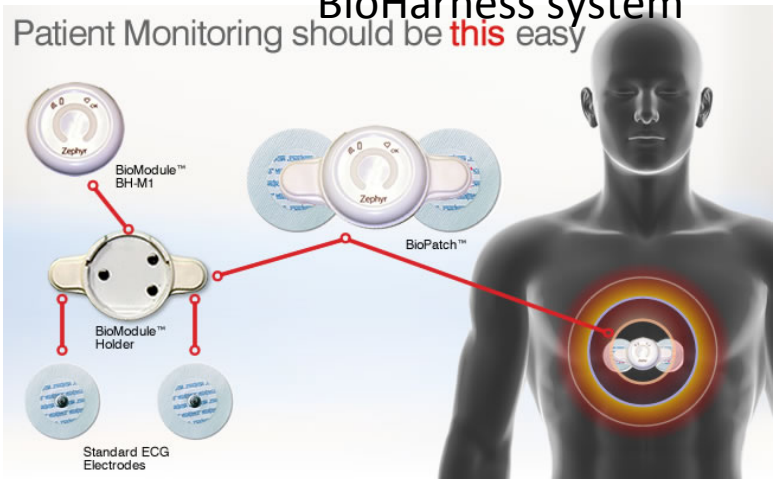
Heart Rate clinical measurement



Martin et al., 2000

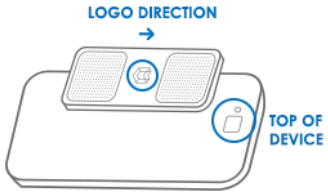
Still measuring heart beat

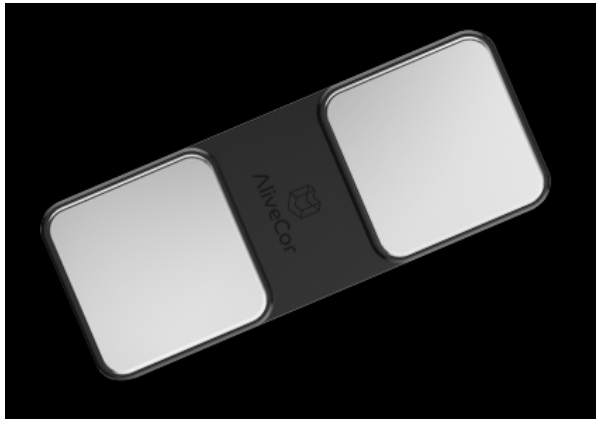
BioHarness system



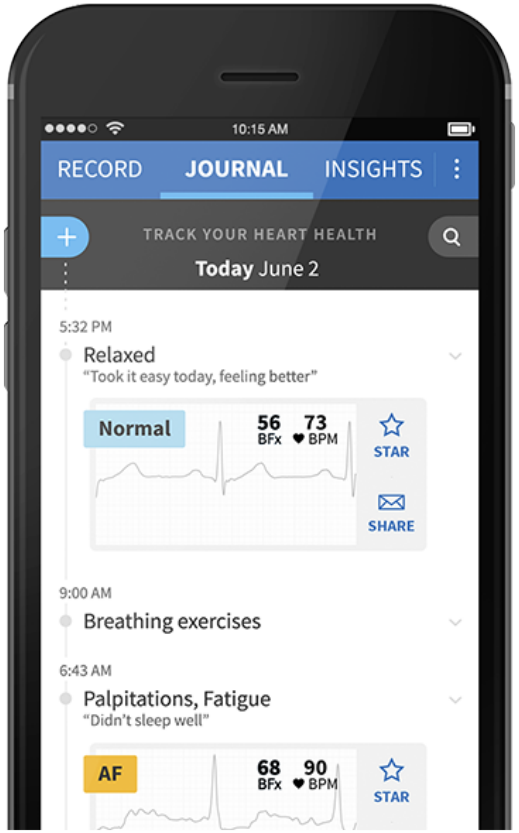
http://zephyranywhere.com/products/biopatch/
FDA approved

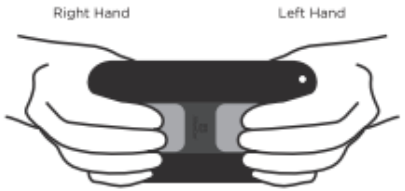
I-Phone and tablet based ECG measurement





http://www.alivecor.com/





POSITION YOUR FINGERS

Place two or more fingers (it doesn't matter which fingers) from each hand on the electrodes for 30 seconds. While recording, try to relax your arms and hold still.

TIP: Each time you record, your left hand should touch the electrode above the word "AliveCor" and your right hand should touch the electrode below the word "AliveCor."

Small device attached to the back of the smart-phone or tablet.

FDA-cleared also as Atrial Fibrillation Detector.

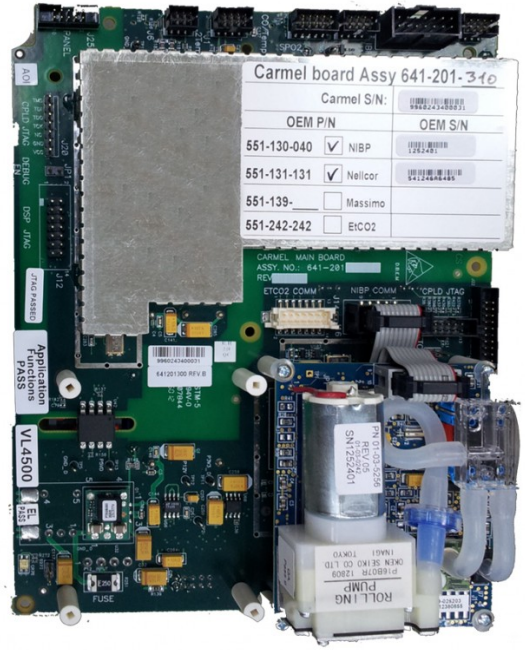
Clinical evidence of reliability

Int J Cardiol. 2013 Apr 30;165(1):193-4. doi: 10.1016/j.ijcard.2013.01.220. Epub 2013 Mar 7.
iPhone ECG application for community screening to detect silent atrial fibrillation: a novel technology to prevent stroke.
Lau JK, Lowres N, Neubeck L, Brieger DB, Sy RW, Galloway CD, Albert DE, Freedman SB.

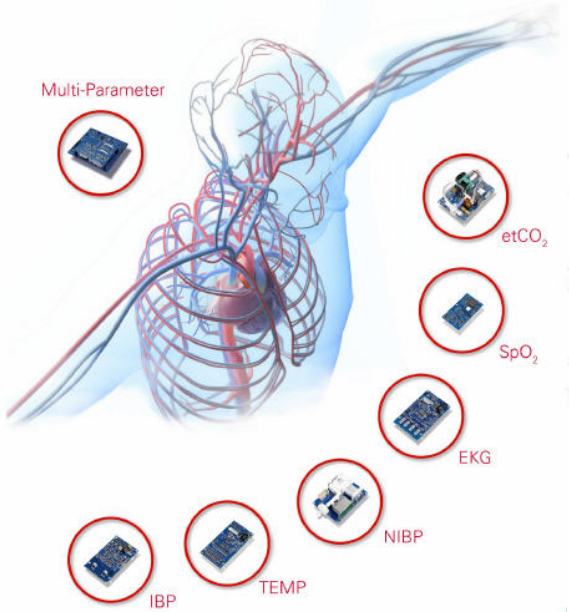
J Cardiovasc Electrophysiol. 2013 Apr;24(4):480-3. doi: 10.1111/jce.12097. Epub 2013 Feb 19.
Ubiquitous wireless ECG recording: a powerful tool physicians should embrace.
Saxon LA.

Abstract
"….. As patient advocates, physicians and particularly cardiac electrophysiologists should embrace the future and promise of wireless ECG recording, a technology solution that can truly scale across the global population."

OEM Modules (original Equipment Manufacturers)

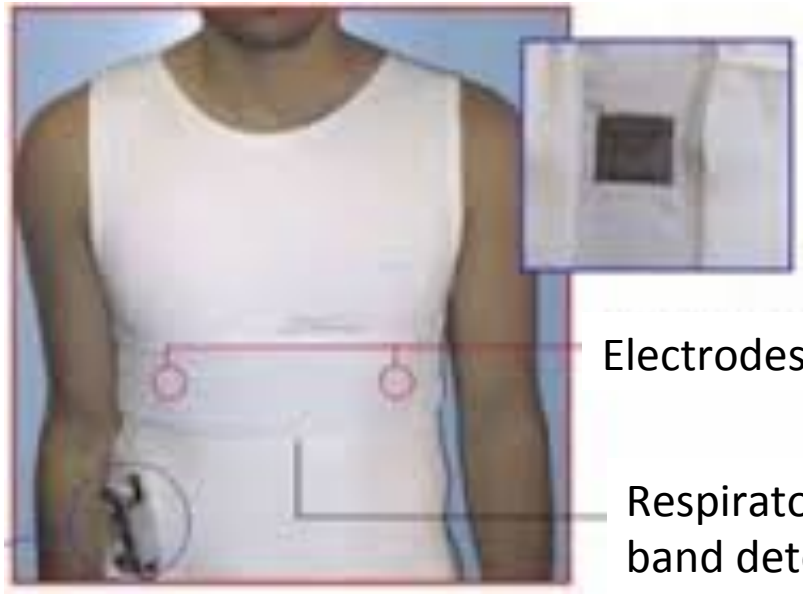


http://mennenmedical.com/products/oem



http://www.medlab.eu/

Multiple electrodes ECG



Electrodes positioned

Respiratory
band detector

M. Di Rienzo group @ Fondazione ProJuventute – Milan

Smartex company

http://www.smartex.it/

The ECG and respiratory signal are obtained by means of sensors made of yarns that are fully integrated into the textile structure that compose the garment.

Other sensors (glucose meters)

Accucheck
Transfer data to smart phone (30 Euros)

Version «nano» (20 euros)

Measuring through a conductive strip

Data transmission

Data integrity and safety is an issue. Secure transmission protocols (e.g.Https)

It is not only a matter of stealing data, but altering them.

https:

Port 443

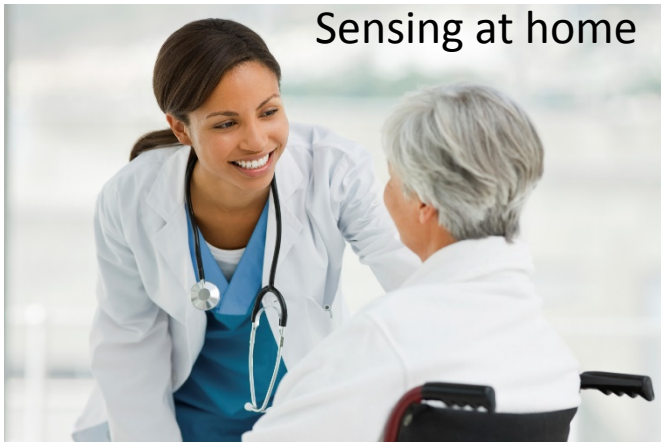
Possible attacks at hospital ICT infrastructure

Room for a new player?

https:

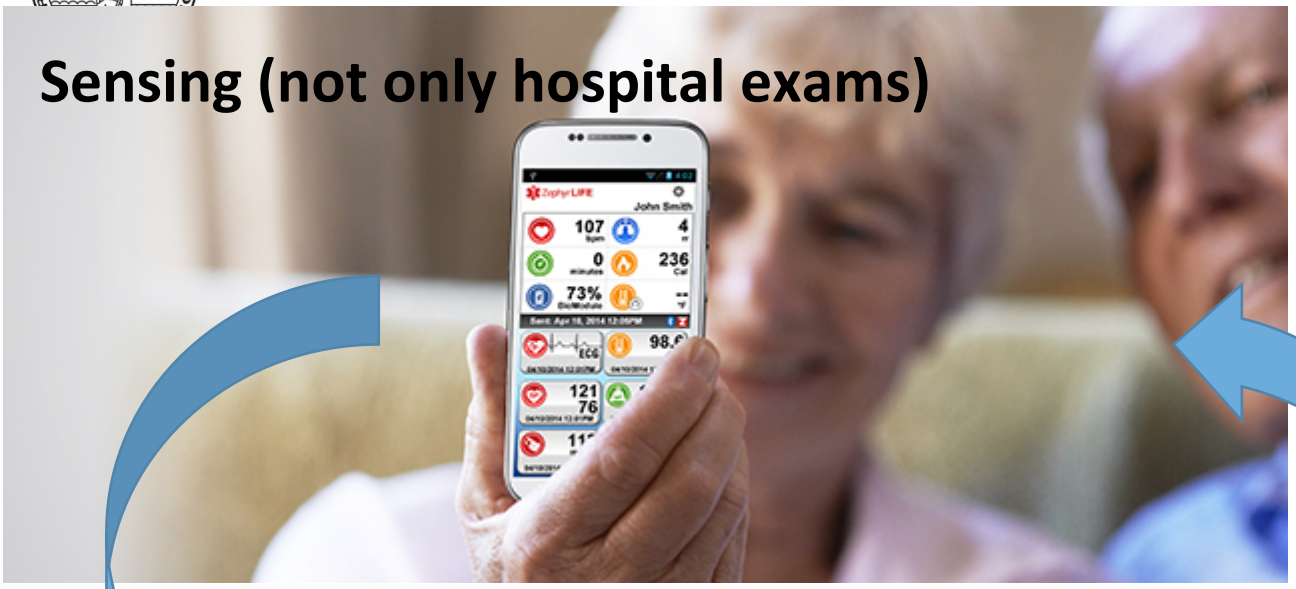
Service provider:
- Storage
- Interface
- Communication

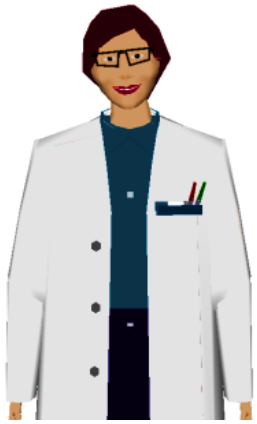
https:



Problems:
- Interface with hospital PAC
- Who pays for the service?

New vision of care





Reasoning

Action (prescription)

How to increase lifestyle

Video games

- Serious games -> Educational games
- Exergames -> Games under an exercise

REWIRE FP7 project, ended December 2014. Platform to enable autonomous rehabilitation at home (http://www.rewire-project.eu – video on YouTube)

How to increase adherence?

Journal of Diabetes Science and Technology
Volume 6, Issue 4, July 2012
© Diabetes Technology Society

SYMPOSIUM

Video Games for Diabetes Self-Management: Examples and Design Strategies

Debra A. Lieberman, Ph.D.

Modular structure
Simplicity of use

Decision making games: *Captain Novolin* 1992, *Packy & Marlon*, 1994, *INSULOT*, 2005).

Knowledge transfer (basic information, social situations): *Diabetes Education for Kids*, 2003, *Starbright Life Adventure Series*, 1999, *Builup Blocks, 2004*). Evaluation through on-line questionnaires.

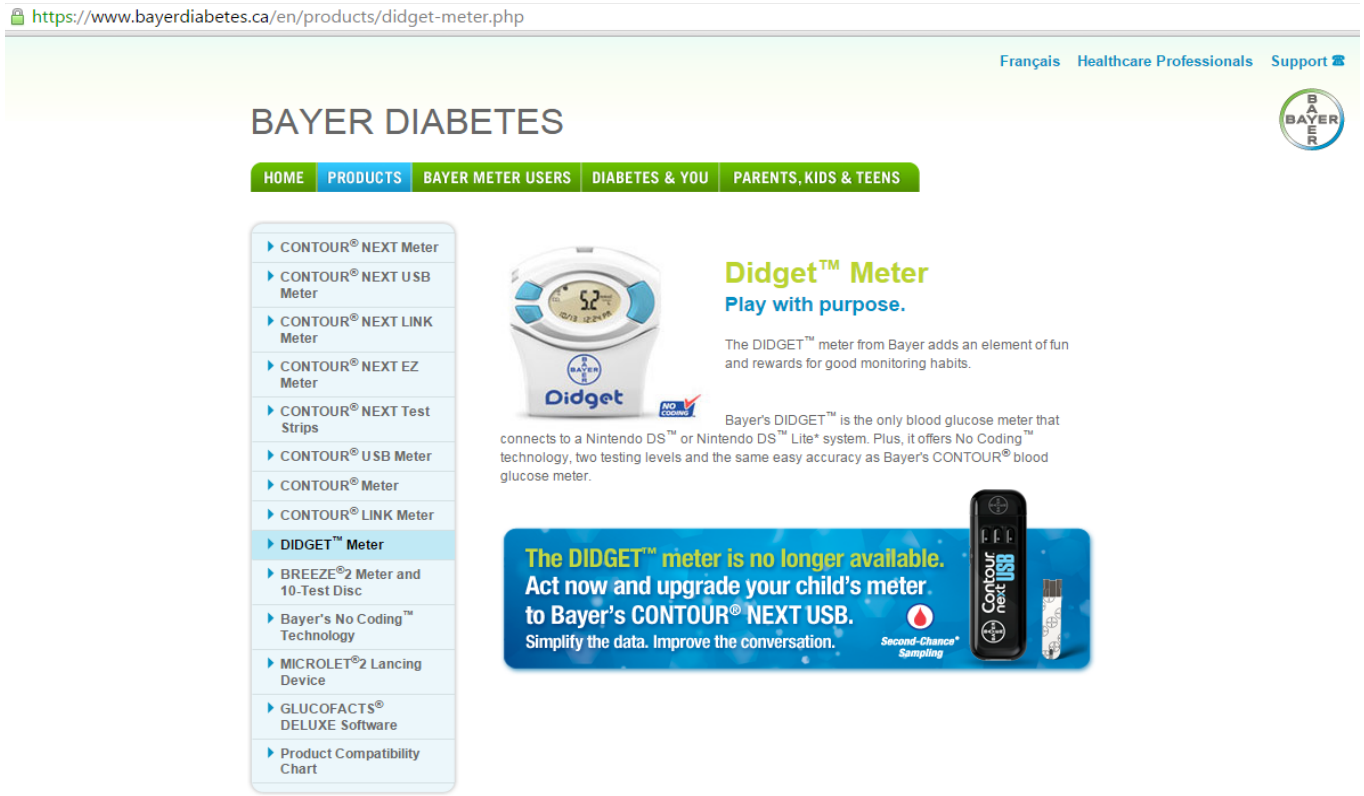
Games with indirect knowledge transfer (*Detective*, 2004, *The Magi and the Sleeping Star*, 2014)

http://themagigame.net/

Third person care (inspired to Tamagotchi): *Egg Breeder*, 2004; *Diabetic dog*.

Increasing adherence in new generation games

Games data are taken from patient's ecosystem.
Didget, 2015 (glucose meter from Bayer, connected with Nintendo). Adherence is elicited.



Glymetrix Diabets Game, 2009. Knowledge integrated into an extensive clinical system that supports guidelines.
GRIP, integrated with Personal EHR.

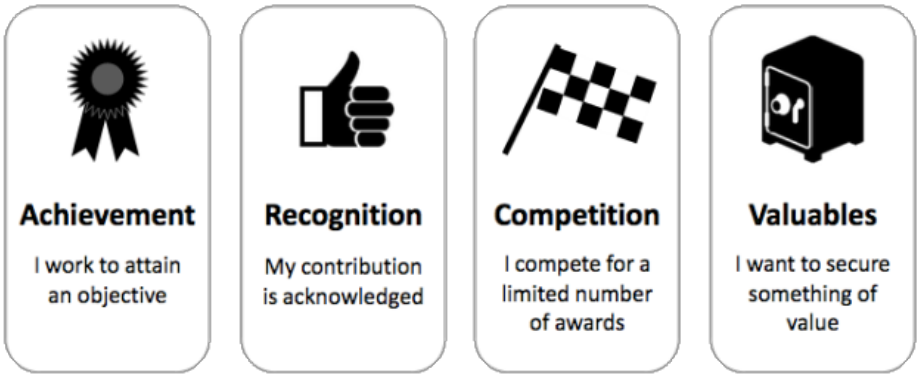
Shall we see more social aspects in multimorbidity patients management?

Gamification – collaboration – competition

A virtual community to increase collective knowledge of patients

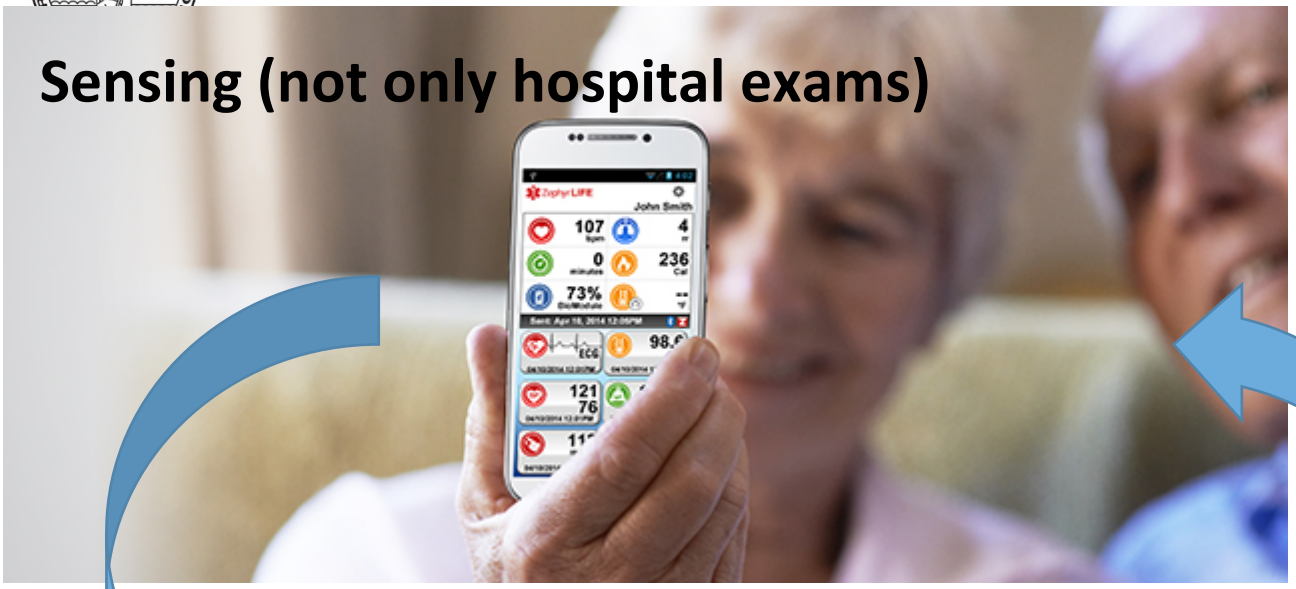
HealthSeeker, 2011. **Friends that support friends (e.g. «Stupid cancer»). Collective knowledge of patients is built up.**

Patient of the month

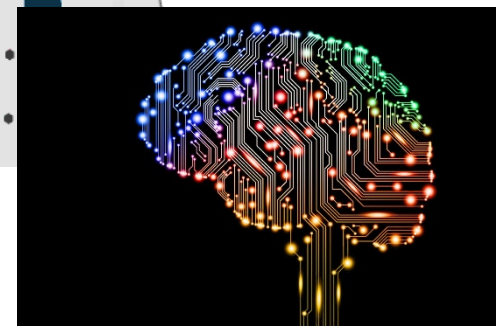


Is this the way to go?

New vision of care



Reasoning

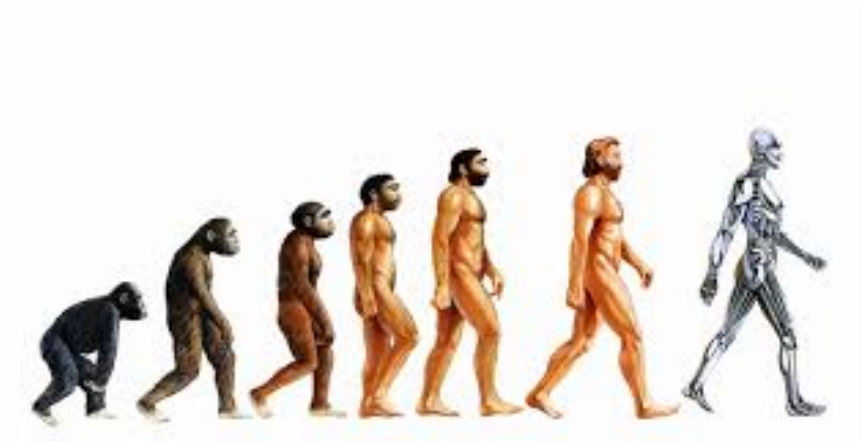


AI support

Action: prescription (patient increased knowledge)

Thank you for your attention

Technology is becoming organic,
Nature is becoming technological
«Brian Arthur, SFI»



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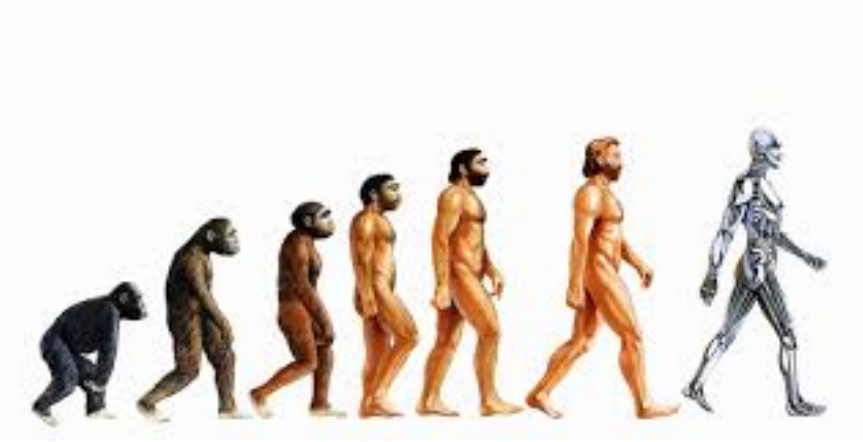
STVDIORVM · MEDIOLANENSIS · VNIVERSITAS

aisi
lab

The two approaches

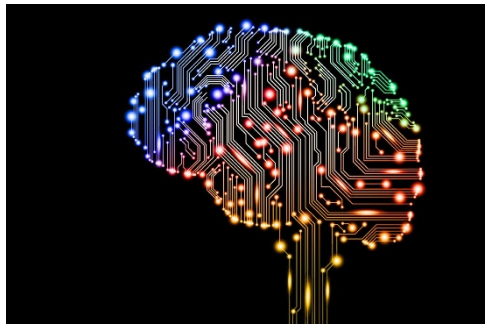
The sensorized human.



Technology is becoming organic,
Nature is becoming technological
«Brian Arthur, SFI»

The sensorized objects

Artificial Intelligence



Thank you for your attention!

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Intensive social aspects

Data transmission does not stop at the phone, or display device, but continues to a Web server.

This allows to provide a gamification framework on top of fitness exercises.

Gamification is the use of game thinking and game design elements (including game mechanics) in **non-game contexts**. These game mechanics are designed to shape a game's dynamics (e.g., competitive behaviour) and emotions (e.g., anticipation) in order to engage players (e.g. users, customers, employees, voters).

Typical medium is virtual communities and typical feed-back are leader boards and virtual prizes.

Competition (results) and cooperation (information exchange) => Gamification and socialization.

What is the legacy for patients and clinicians?

Multimorbidity problems

Uijen AA1, van de Lisdonk EH. **Multimorbidity in primary care: prevalence and trend over the last 20 years**. Eur J Gen Pract. 2008; 14 Suppl 1:28-32.

Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study

Karen Barnett, Stewart W Mercer, Michael Norbury, Graham Watt, Sally Wyke, Bruce Guthrie

2012 – The Lancet

For GP:
New guidelines for focusing on multimorbidity to support this care.
More time and knowledge is required.
Continuous education.

For Patient:
Multiple primary care and GP visits have to be arranged. Multiple drugs intake.

For Specialists:
Polypharmacy and adverse drug reactions have to be taken into account: the latter have increased over recent years.