The internet of aged people doing things daily

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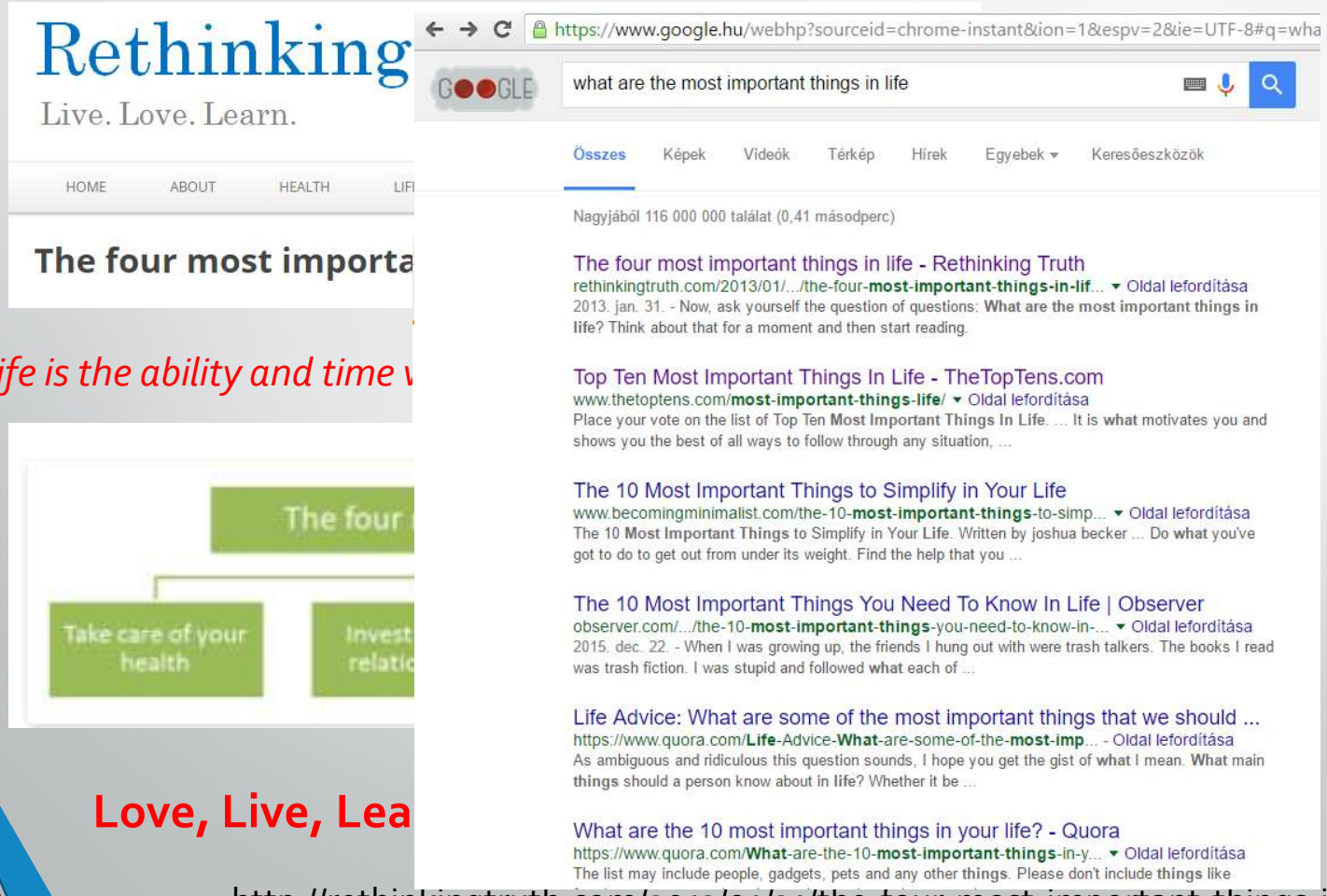
3RD INTERNATIONAL CONFERENCE ON INFORMATION AND COMMUNICATION TECHNOLOGIES FOR AGEING WELL AND E-HEALTH
APRIL 28, 2017 | PORTO, PORTUGAL

ICT4AWE 2017
3rd International Conference on Information and Communication Technologies for Ageing Well and e-Health

What are the most important "things" in your life?



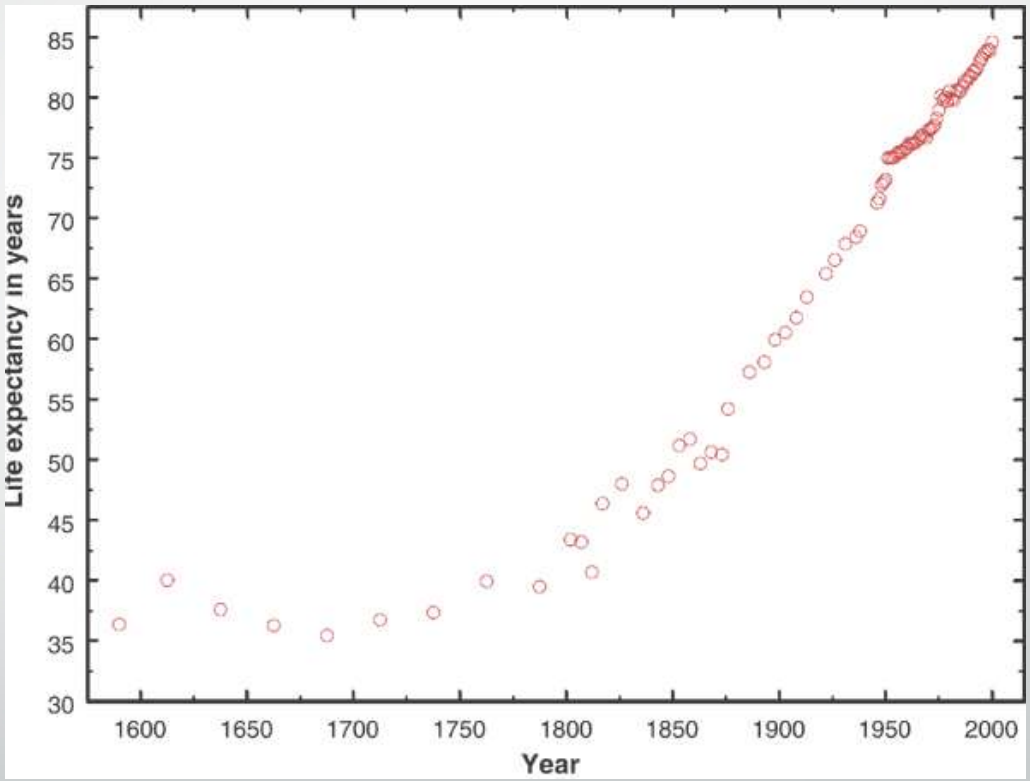
http://rethinkingtruth.com/2013/01/31/the-four-most-important-things-in-life/

Live healthy

Brain Health

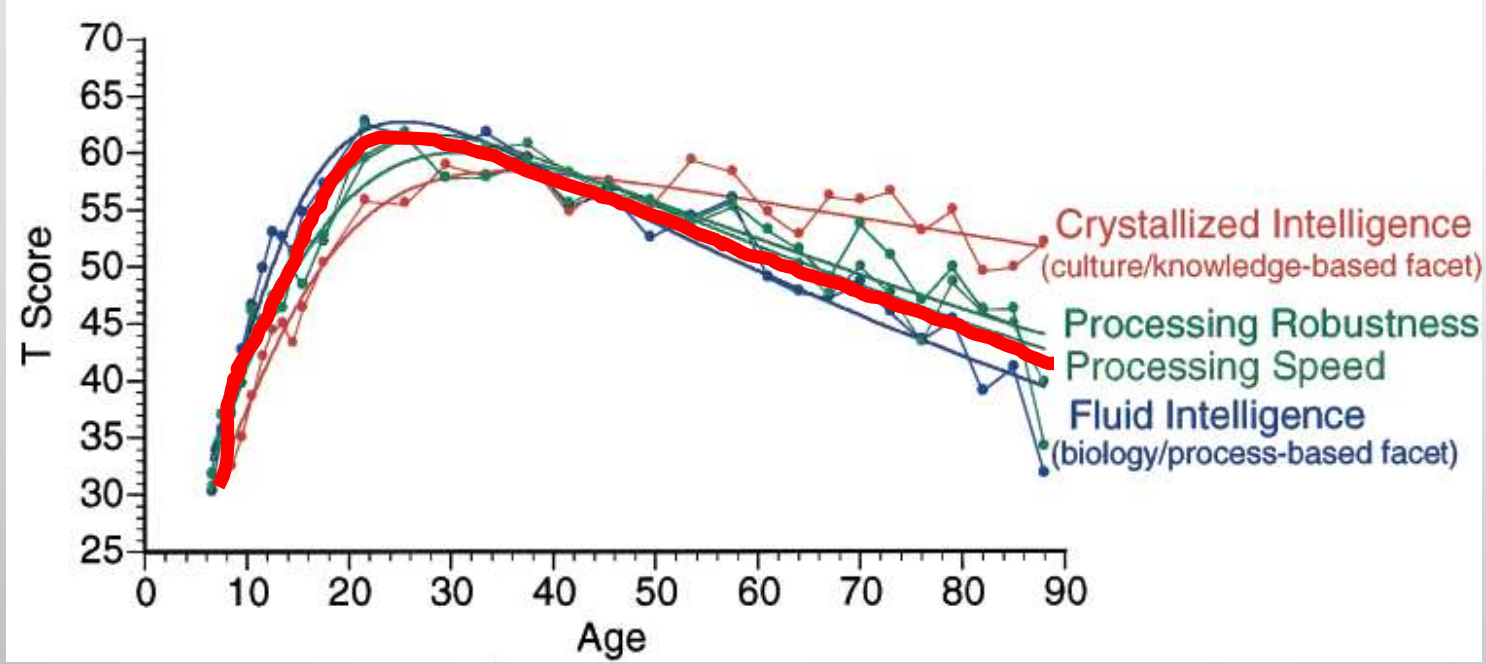
Ageing

We live longer



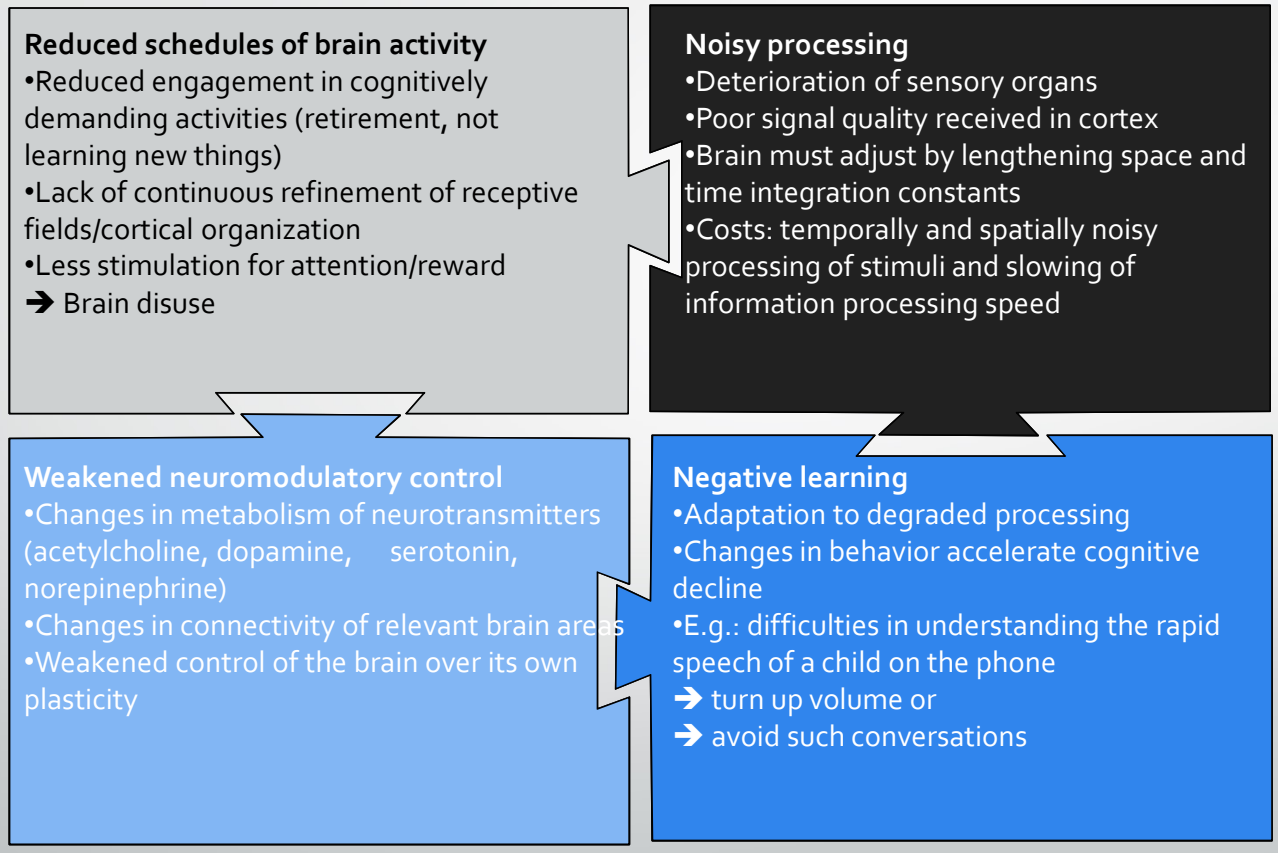
Ageing consequences…

Our abilities decline…



Li et al. (2004), Psychol Sci; Li et al. (2009), Psychol Res

In aging, negative cortical plasticity has four mutually reinforcing components that create a downward spiral of degrading brain function

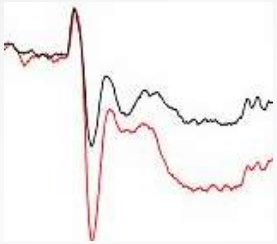


LLMcare 2014

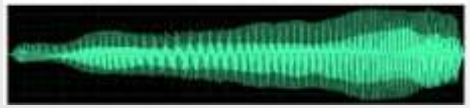
Mahncke, Bronstone, & Merzenich (2006), *Progress in Brain Research*

Different modalities…
are affected … and … exploited

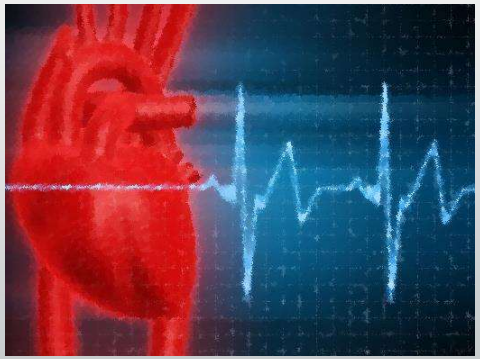
Brain Activity via EEG



Facial characteristics via cameras



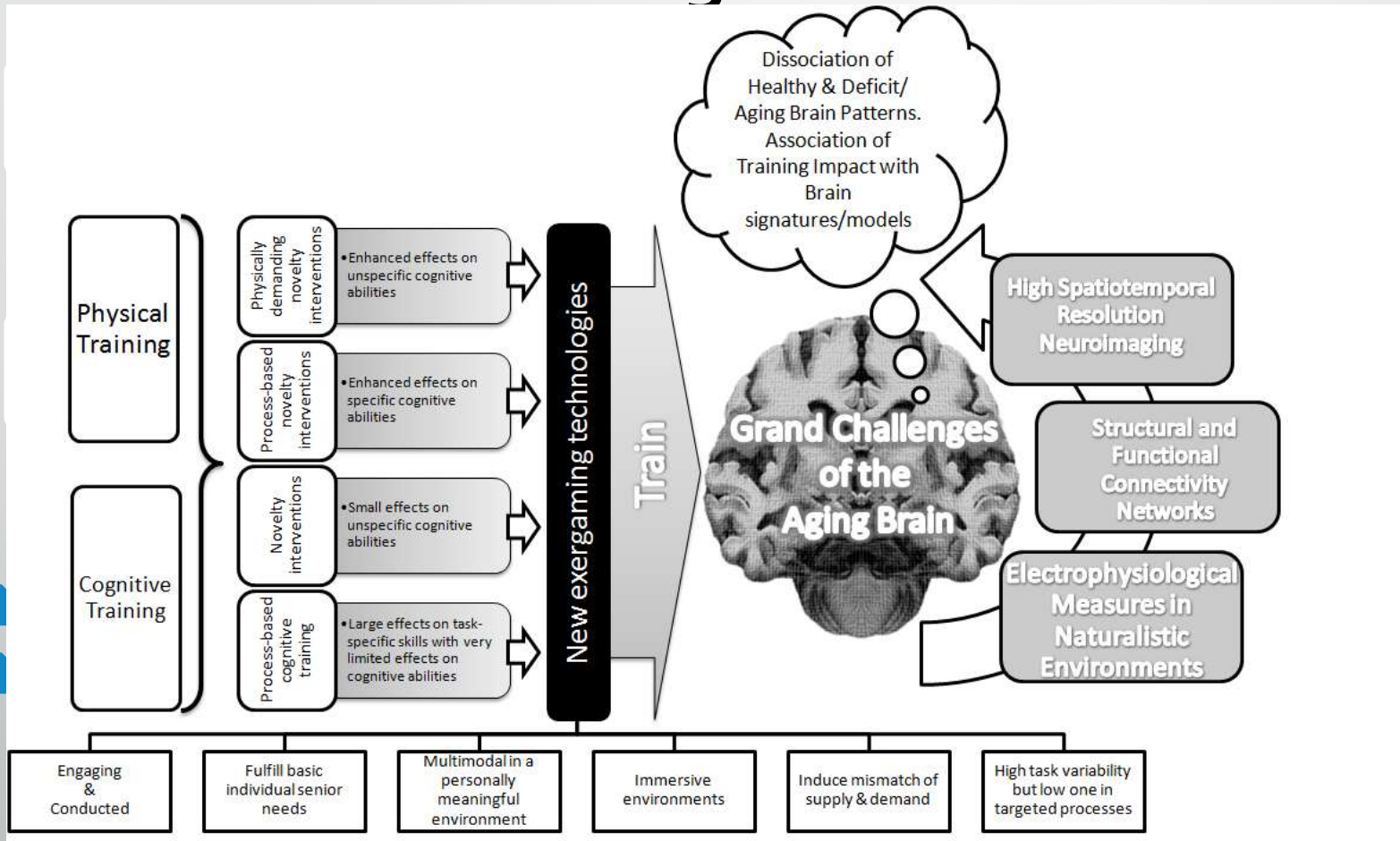
Voice via microphones



Heart Rate via ECG

Posture, gestures via fisheye camera

Prevention of Cognitive Decline



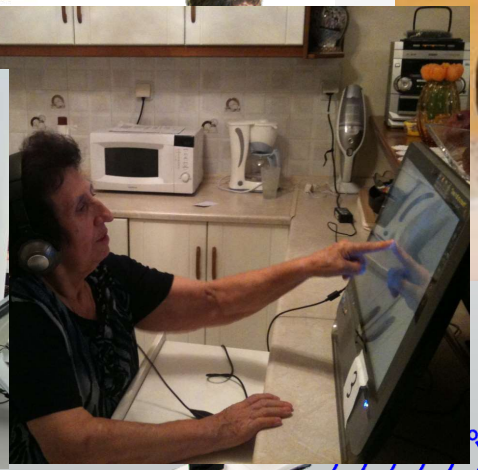
P.D. Bamidis et al.
Neuroscience and Biobehavioral Reviews 44 (2014) 206–220

(2014) 206–220

Learn, Live

Training...

LLMcare product/service



Moved

Sensor Library Code

http://www.youtube.com/watch?feature=player_embedded&v=ilABZtm8eGM

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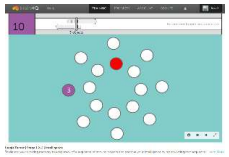
LLM Intervention - Videos

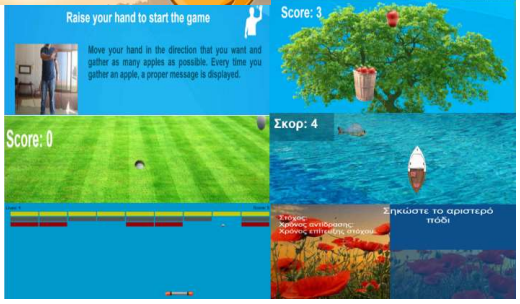
Cognitive Training

- Attention
- Brain Speed
- Memory
- People Skills
- Intelligence
- Navigation



Physical Training

- Aerobic endurance
- Flexibility
- Balance
- Strength



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European Innovation Partnership on Active and Healthy Ageing
CANDIDATE REFERENCE SITE

European Network of Living Labs

THESS AHALL

LLM Care
Long Lasting Memories
Mind and body fitness for life

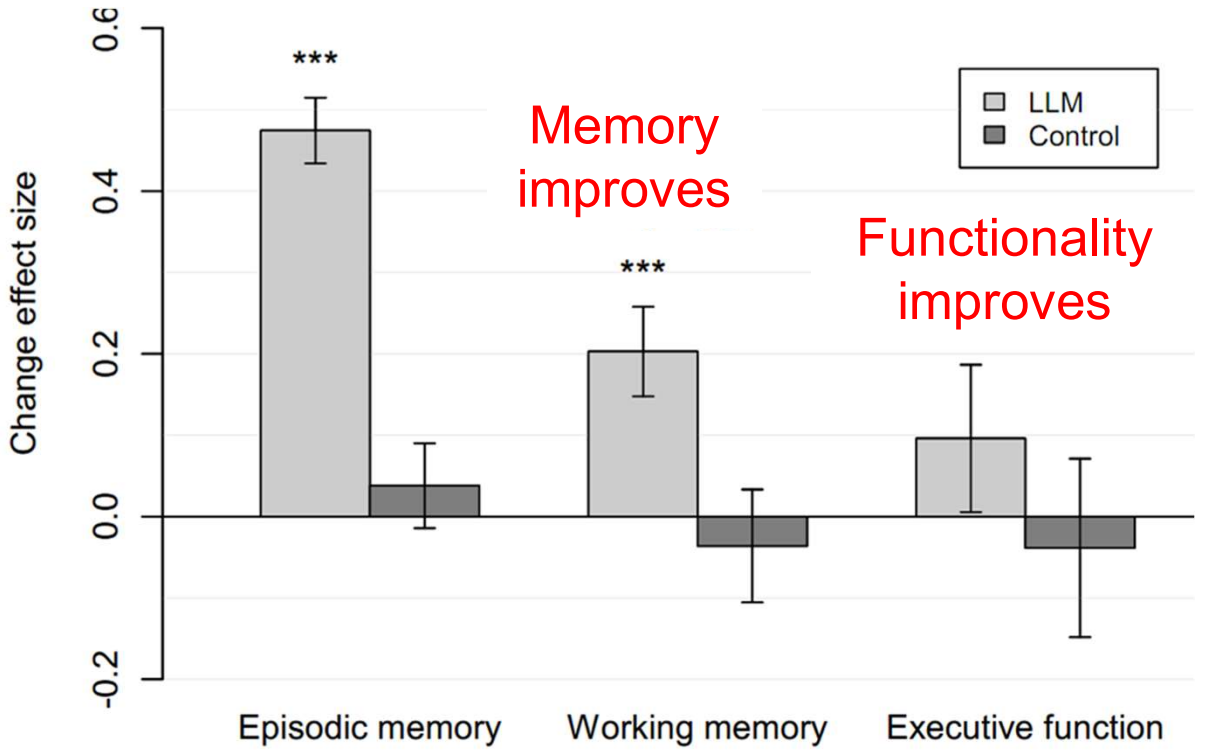
best practice in
elderly health-care

EIP on AHA
candidate
Reference Site

multi-dimensional
evaluation
of results

LLM Care
Long Lasting Memories
Mind and body fitness for life

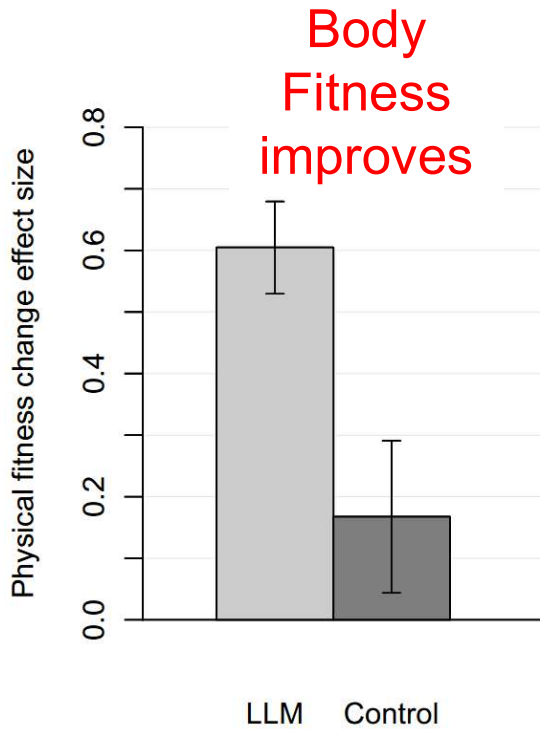
scientific results → competitive advantage



Bamidis PD. et al. Gains in cognition through combined cognitive and physical training: the role of training dosage and severity of neurocognitive disorder Frontiers in Aging Neuroscience, 2015, DOI=10.3389/fnagi.2015.00152

LLM Care
Long Lasting Memories
Mind and body fitness for life

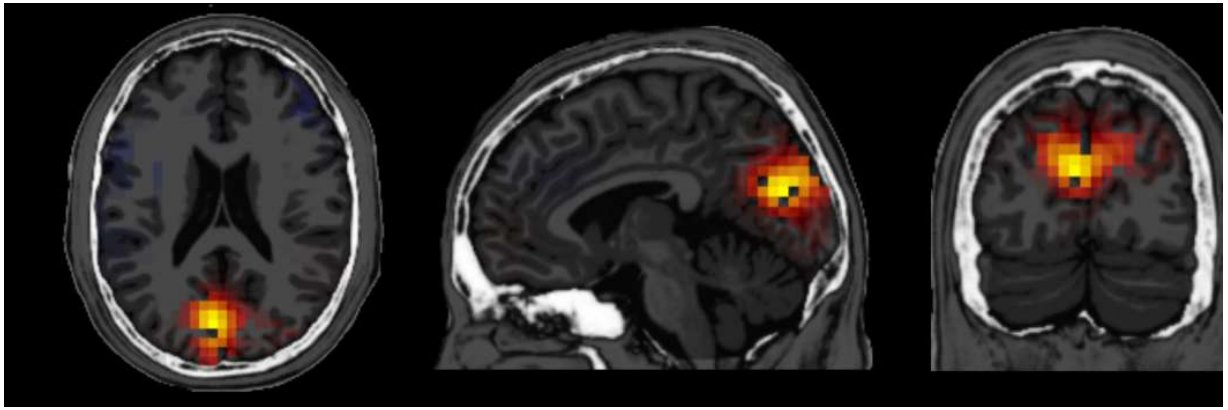
scientific results → competitive advantage



Bamidis PD. et al. Gains in cognition through combined cognitive and physical training: the role of training dosage and severity of neurocognitive disorder Frontiers in Aging Neuroscience, 2015, DOI=10.3389/fnagi.2015.00152

LLM Care
Long Lasting Memories
Mind and body fitness for life

scientific results → competitive advantage



After training, brain noise is reduced in some areas

Styliadis. et al. Brain regions responsible for results of combined cognitive and physical Training Neural Plasticity, 2015; doi: 10.1155/2015/172192.

LLM Care
Long Lasting Memories
Mind and body fitness for life

scientific results → competitive advantage

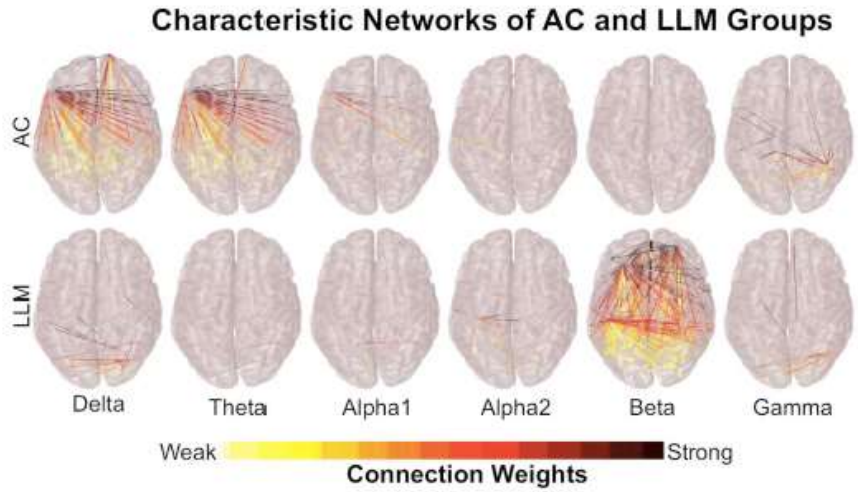


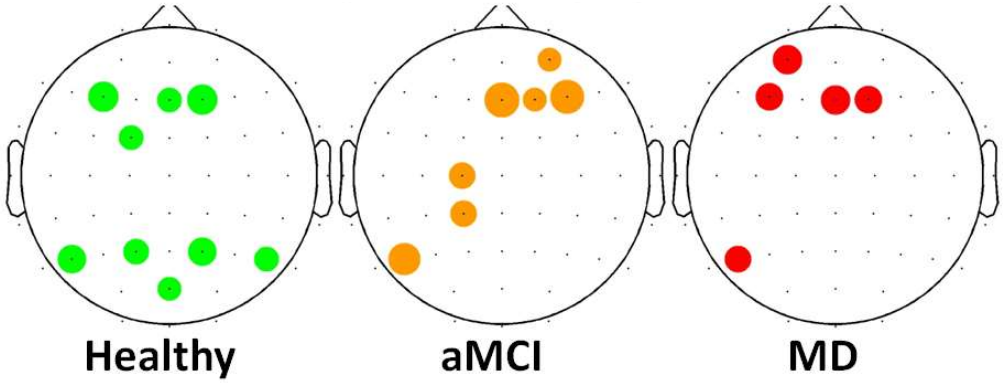
FIGURE 2 | Cortex plots illustrate the characteristic networks for both groups and for each frequency band. Each edge represents the inversed *p*-value, extracted by the *t*-test comparison between PRE and POST conditions and corrected using FDR. The LLM group shows stronger effect in the beta-band's network, while AC affects only delta and theta networks. This result is produced by one node in the left fronto-temporal area, which seems to be connected mostly with long distance nodes. Long distance couplings, especially in low frequencies, are probably due to low frequency signaling and not due to synchronous activity, so this effect cannot be interpreted as a solid one.

Klados et al, Beta-band functional connectivity is reorganized in mild cognitive impairment after combined computerized physical & cognitive training Frontiers in Neuroscience, 2016, doi: 10.3389/fnins.2016.00055

LLM Care
Long Lasting Memories
Mind and body fitness for life

scientific results → competitive advantage

…we can monitor re-organisation in healthy and diseased brains



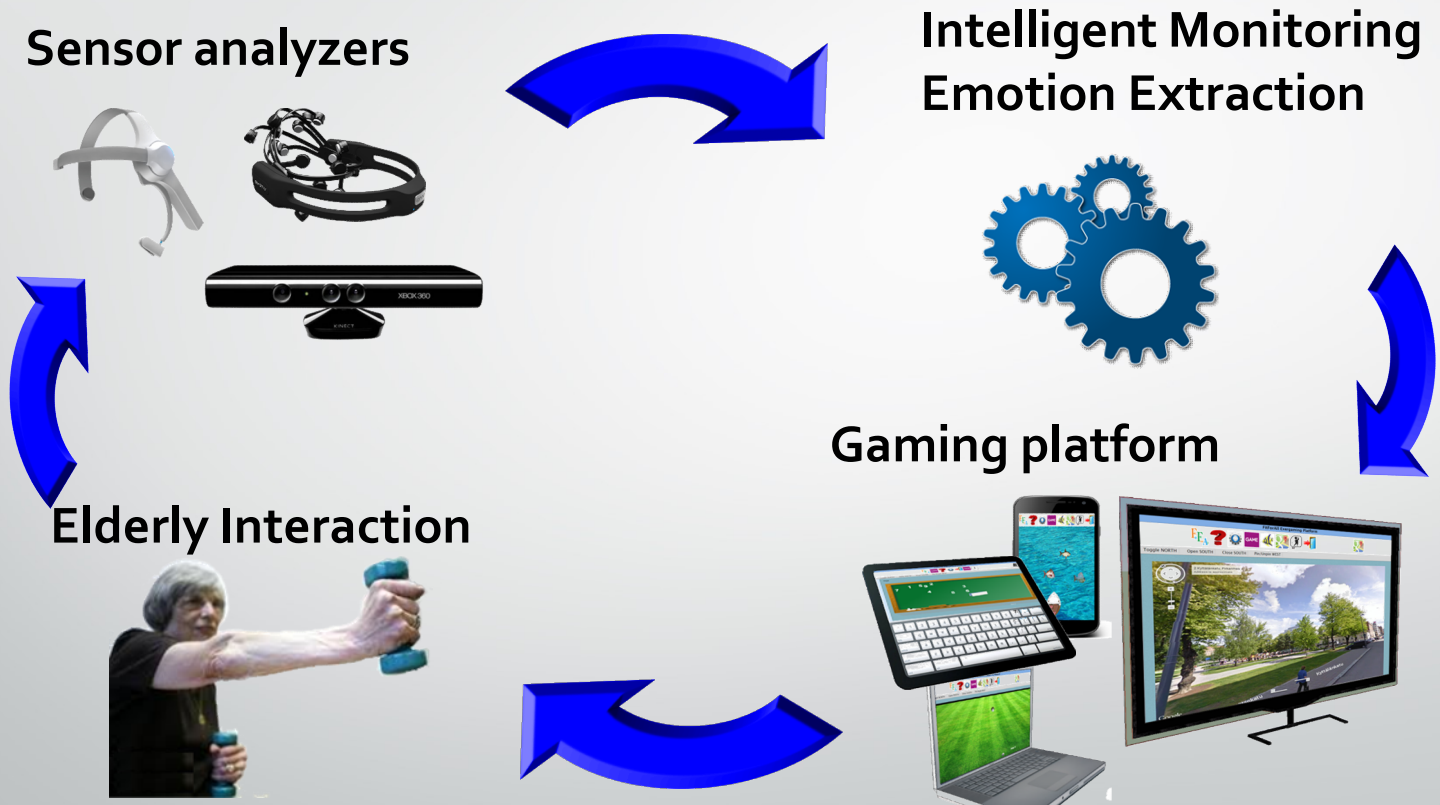
Frantzidis CA, Vivas AB, Tsolaki A, Klados MA, Tsolaki M, Bamidis PD. Functional disorganization of small-world brain networks in mild Alzheimer's Disease and amnestic Mild Cognitive Impairment: an EEG study using Relative Wavelet Entropy (RWE). Front Aging Neurosci. 2014;6:224. doi: 10.3389/fnagi.2014.00224.

Learn, Live, Love

Increase positive emotions through training…

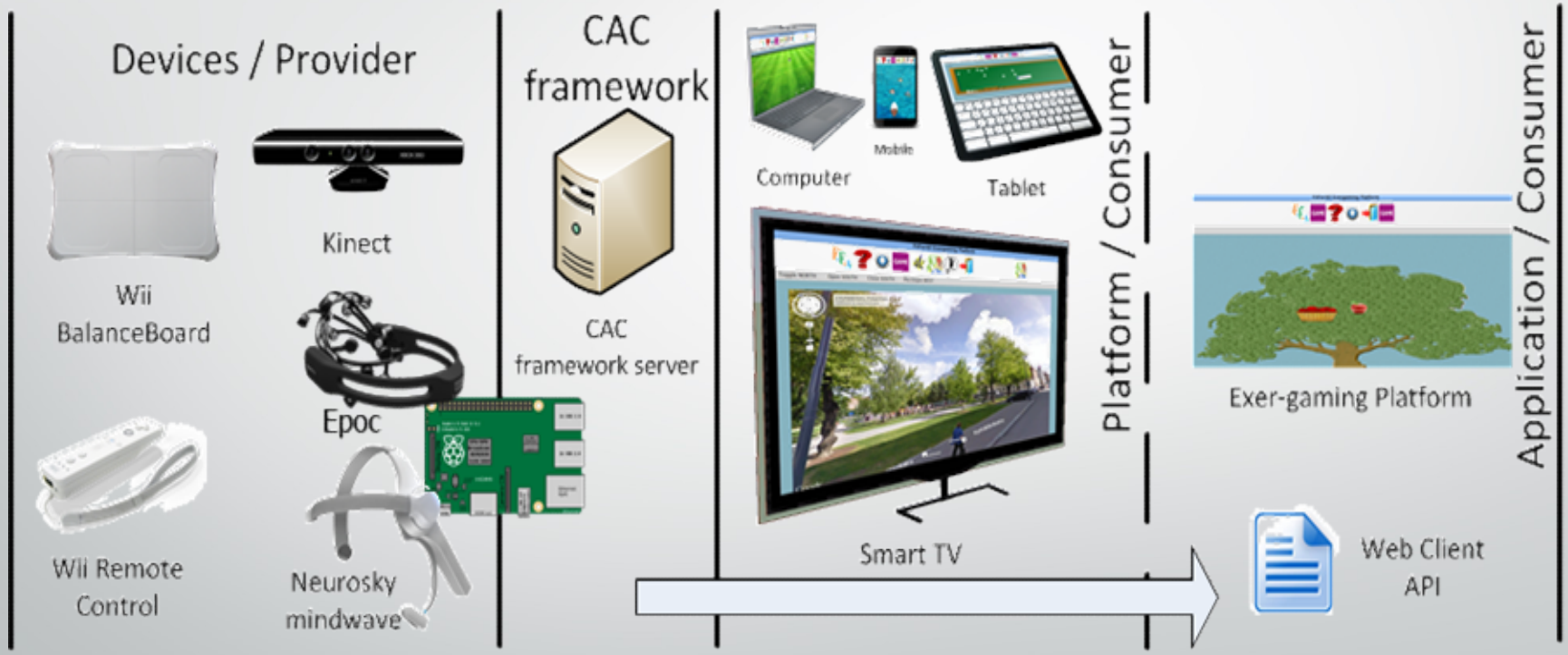
& IoT

Back in 2013, our vision…



C. Styliadis, E. Konstantinidis, A. Billis, and P. Bamidis, "Employing affection in elderly healthcare serious games interventions," in *Proceedings of the 7th International Conference on PErvasive Technologies Related to Assistive Environments*, 2014, p. 32.

CAC Architecture



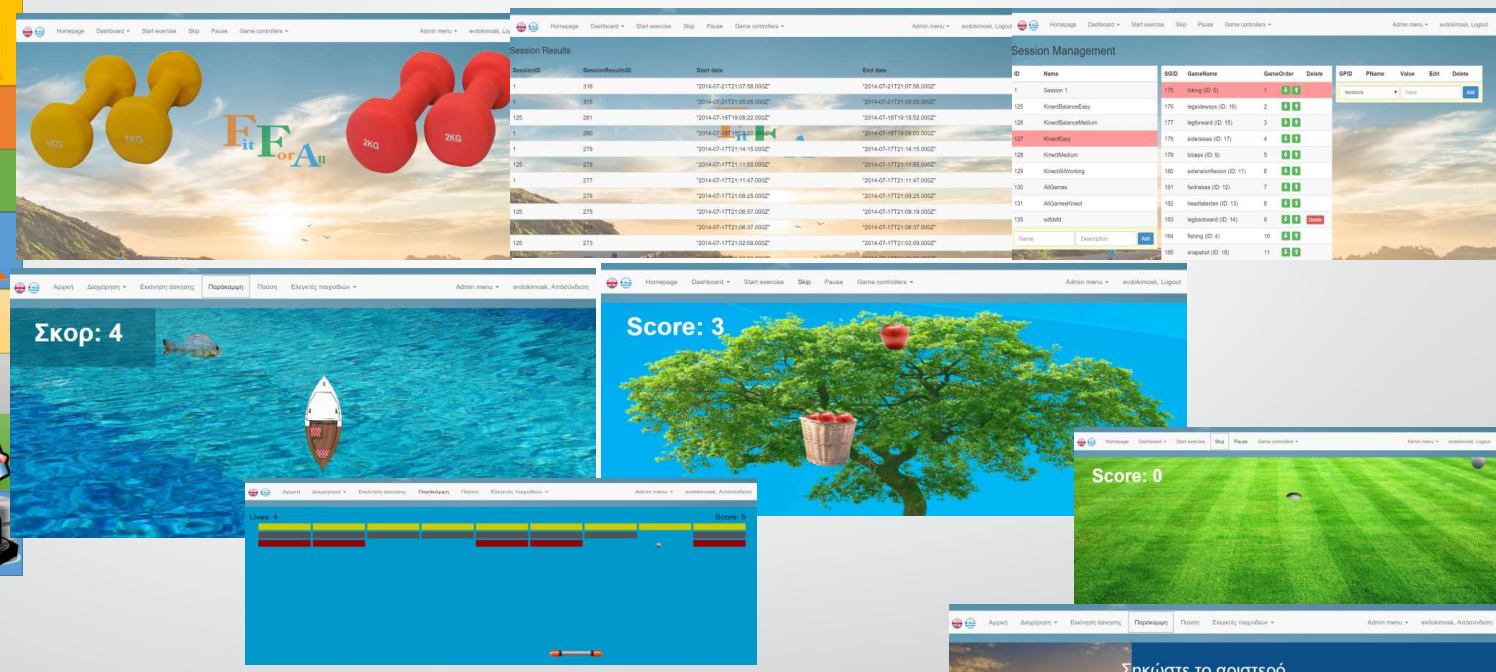
www.cac-framework.com

CAC-framework

- Has the role of an intermediary, in order to allow the connection of a series of controllers and applications.
- Adapted to controller information streaming (e.g. skeleton, RGB image, center of pressure, EEG signal)
- Aligned with the publish/subscribe IoT approach

E. I. Konstantinidis, P. E. Antoniou, G. Bamparopoulos, and P. D. Bamidis, "A lightweight framework for transparent cross platform communication of controller data in ambient assisted living environments," *Inform Sciences*, vol. 300, pp. 124–139, 2014.

Exergames and new technologies

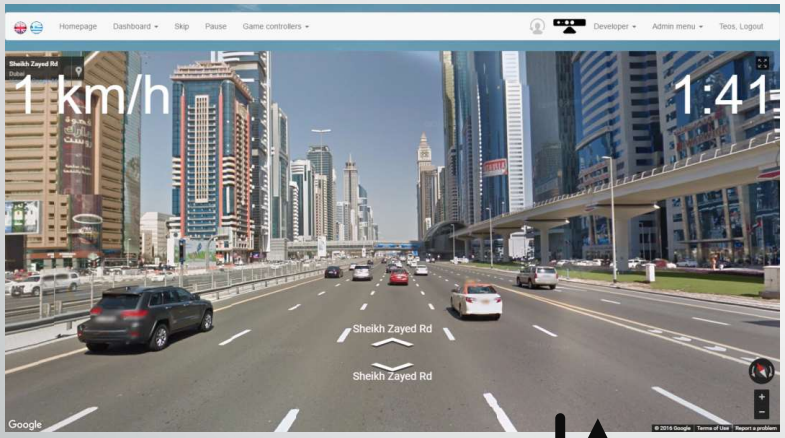


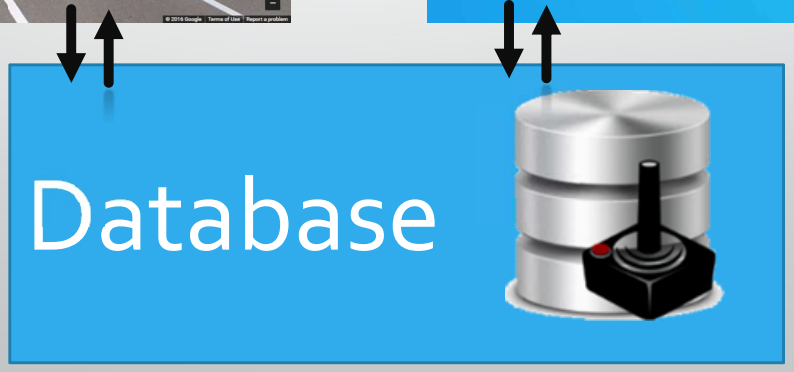
- **Subscribes** to the IoT cac-framework.com to get access to the controllers data streams
- **Publishes** gaming events to standard IoT communication protocols

E. Konstantinidis, G. Bamparopoulos, & P. Bamidis, "Moving Real Exergaming Engines on the Web: The webFitForAll case study in an active and healthy ageing living lab environment," *IEEE J. Biomed. Health Inform, 2016*

Vision realisation

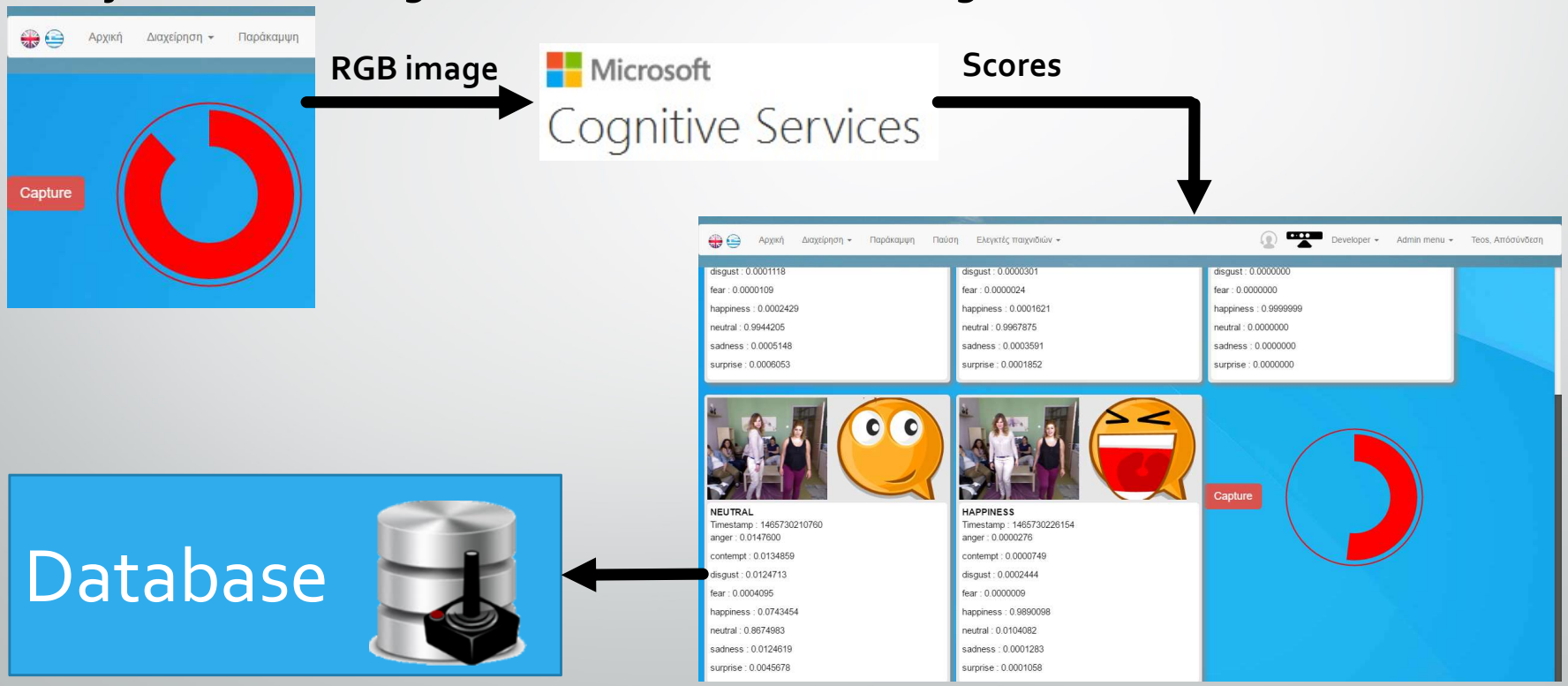
- Emotional self-appraisal by users (subjectively)





Vision realisation

- Objective recordings of emotions (Microsoft Cognitive Services)



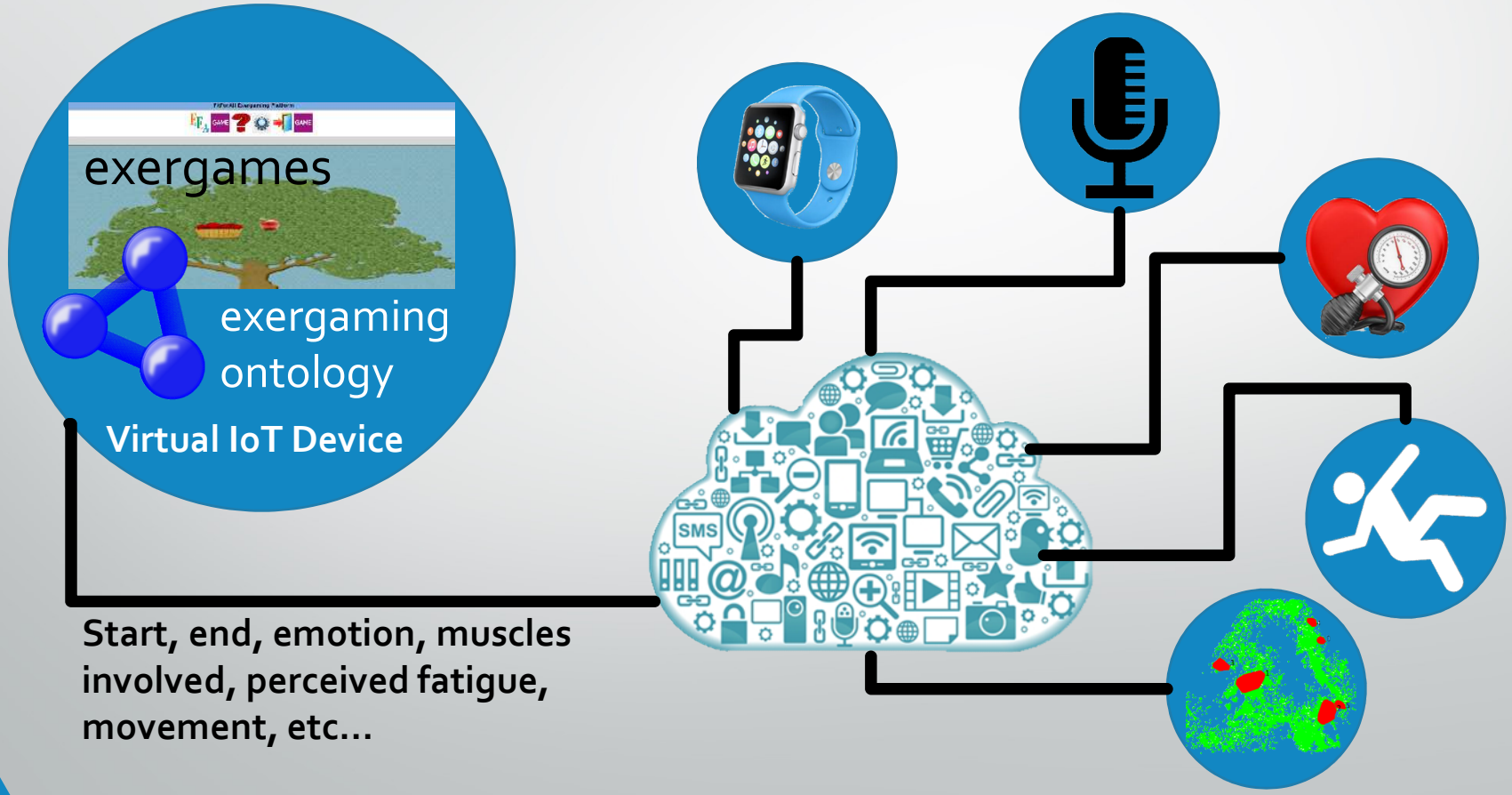
Preliminary results

237	05-25	Nature	Happy	City	Happy	Nature	Very Happy	
237	05-30	Nature	Happy	City	Very Happy	Nature	Very Happy	
265	06-01	City	Very Happy	City	Very Happy	Nature	Very Happy	
265	06-08	City	Happy	City	Very Happy	Nature	Very Happy	

- Perceived emotional state (subjectively) by selecting the corresponding emoticon after hiking either in a virtual city or in virtual nature (screenshots).
- Emotion as an additional in-game metric

E. I. Konstantinidis, P. D. Bamidis, A. S. Billis, P. Kartsidis, and S. G. Papageorgiou, "Physical training in-game metrics for cognitive assessment: evidence from extended trials with the FitForAll exergame platform," *Front. Aging Neurosci.*, vol. In prep., 2017

Serious games as virtual, IoT enabled, devices



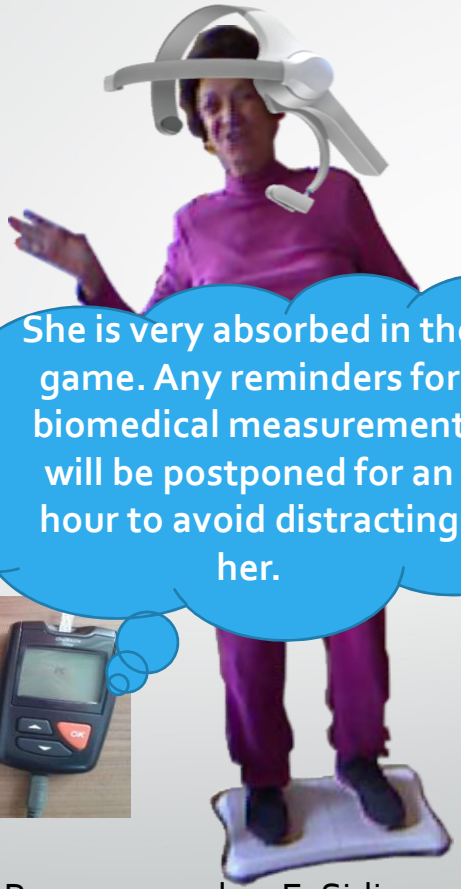
Why IoT in exergames?

- Ecologically valid information
- Consumable at real time by the environment (e.g. justification of high blood pressure)
- Build on top of exergaming information without modification requirements of the exergames

Current vision …

She is excited. Let's challenge her more by increasing training intensity

She is very absorbed in the game. Any reminders for biomedical measurement will be postponed for an hour to avoid distracting her.



The brain wave patterns have changed over time. Let's inform the doctor.

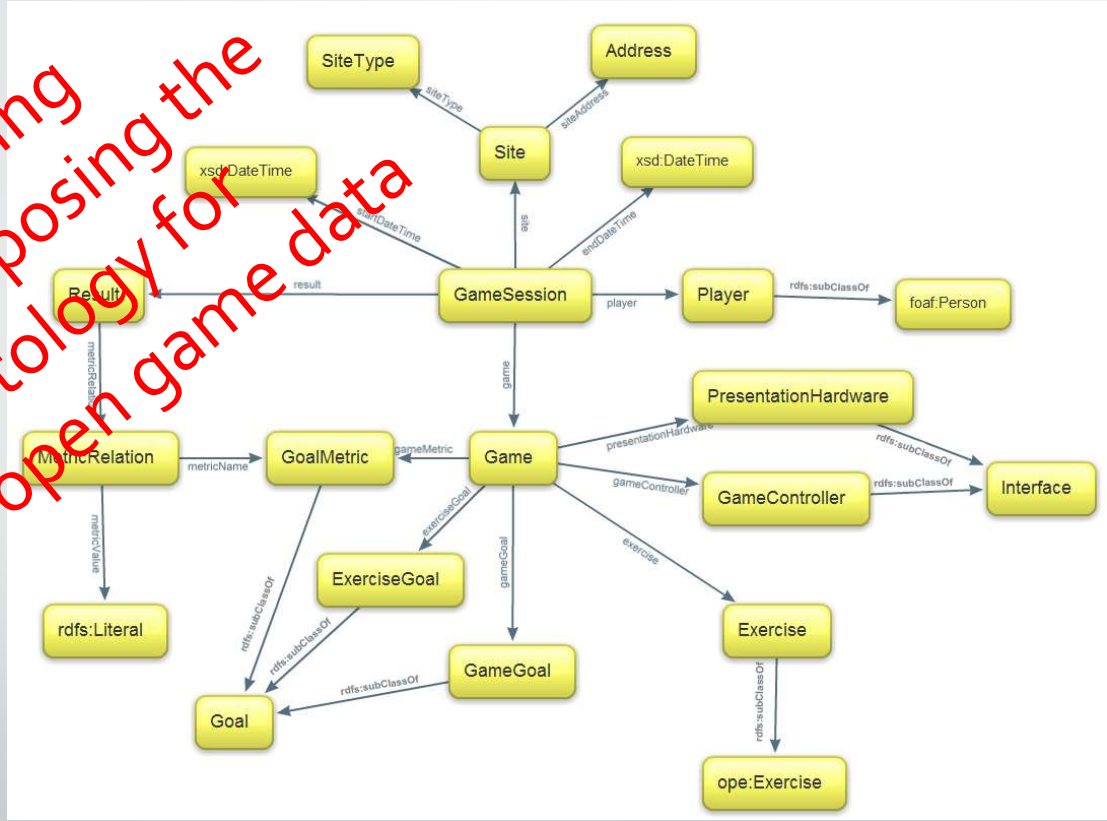
She is very active. She will need some rest. Warn light room

E. Konstantinidis, N. Conci, G. Bamparopoulos, E. Sidiropoulos, F. De Natale, and P. Bamidis, "Introducing Neuroberry, a platform for pervasive EEG signaling in the IoT domain," in *Proceedings of the 5th EAI International Conference on Wireless Mobile Communication and Healthcare*, 2015.

How are we going to achieve our vision? IoT semantics

- IoT is not only linking connected devices (technical interoperability), but also their information (semantic interoperability)
- Semantic technologies in IoT can support:
  - Interoperability
  - Effective data access and integration
  - Resource discovery
  - Reasoning and processing of data
  - Knowledge extraction (for automated decision making and management)

Our contribution to IoT semantics



Towards exergaming commons: composing the exergame ontology for publishing open game data

G. Bamparopoulos, E. Konstantinidis, C. Bratsas, and P. D. Bamidis, "Towards exergaming commons: composing the exergame ontology for publishing open game data," *J. Biomed. Semantics*, vol. 7, no. 1, p. Article nr 4, Dec. 2016.

Inspire, Learn, Live, Love

IoT facilitation of exergaming/training and senior daily living activities "on the wild"

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webFitForAll expansions with NAO robot - Video

www.llmcare.gr

USEFIL project – The Opportunity

- …in charge of integrating technologies
- ….and introducing them to elderly people
- …perhaps … pre-pilot the system with real users by integrating progressively new systems… asking the seniors to utilize them … on the go…
- Given that entering seniors homes is too intrusive
- … thought of some space/Lab … for the integrating and pre-piloting…
- …turn this space into an ecologically valid space for seniors: sofa, some flower pots, a living room table, a TV and some canvas illustrating home views (kitchen, library, table, etc.)

Our first ecologically valid, active and healthy ageing e-home/living lab Video

https://www.youtube.com/watch?v=wxcvuY2zBHs

European Network of Living Labs

Active and Healthy Ageing Living Lab

http://www.aha-livinglabs.com

- Located in the Aristotle University of Thessaloniki, Lab of Medical Physics
- Vision for a permanent living lab where elderly people could test and evaluate new applications, devices and approaches coming either from our group or external groups - researchers or companies (e.g. SMEs)
- The Active and Healthy Ageing Living Lab

E. I. Konstantinidis, A. S. Billis, C. Bratsas, A. Siountas, and P. D. Bamidis, "Thessaloniki Active and Healthy Ageing Living Lab: the roadmap from a specific project to a living lab towards openness," in *9th International Conference PErvasive Technologies Related to Assistive Environments (PETRA)*, 2016.

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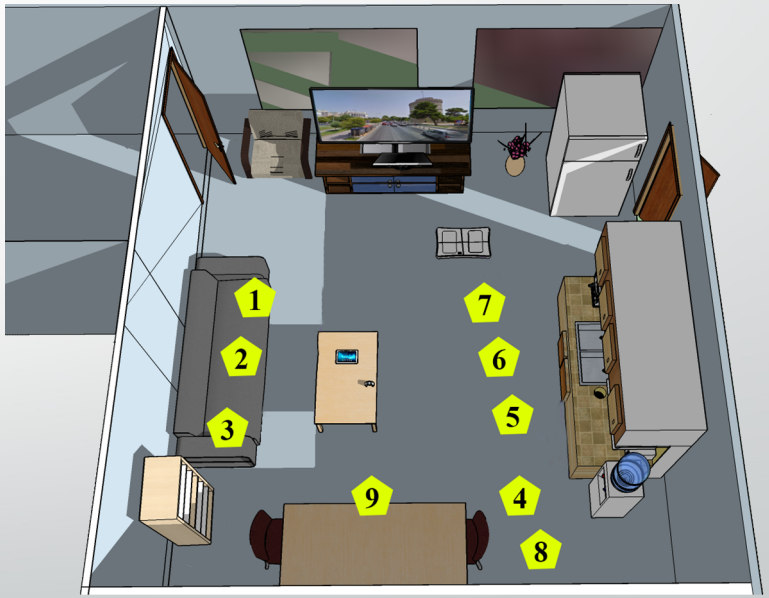
Pilots Video in YouTube

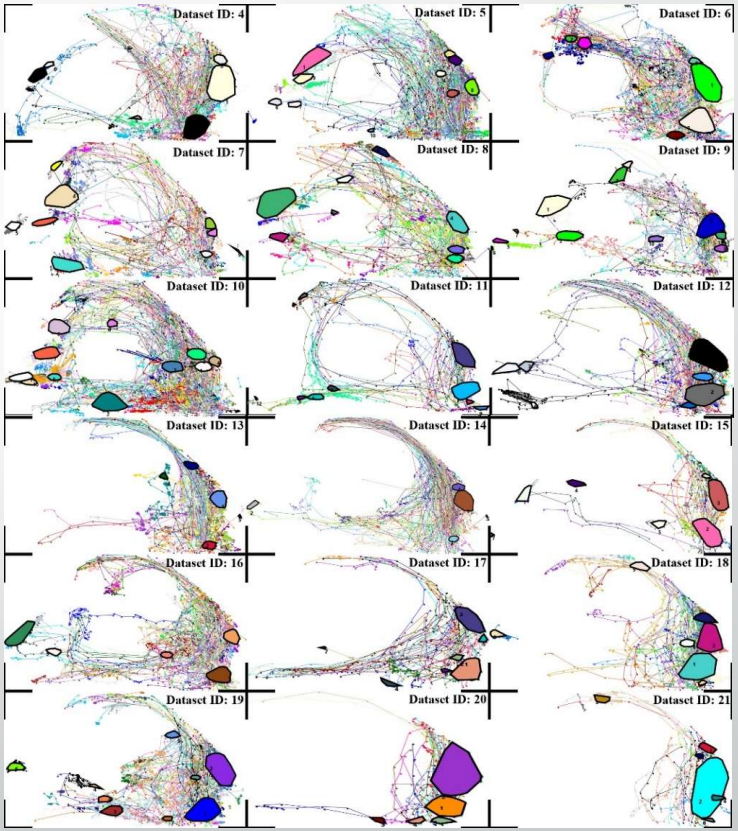
https://www.youtube.com/watch?v=4B7hggKdfEM&feature=youtu.be

Kinect **publishing** peoples' indoor location in the ThessAHALL

- A processing module was "listening" (**subscribed**) to the people's indoor location
- At the end of each day, the module was analyzing the streamed information and produced the most visited position in the ThessAHALLExperimental Datasets
- Experimental datasets: capturing the personnel's daily transitions in the AHA LL for a period of 26 days.



Results from Experimental Datasets



E. I. Konstantinidis and P. D. Bamidis, "Density based clustering on indoor kinect location tracking: A new way to exploit active and healthy aging living lab datasets," in Proc. *IEEE 15th International Conference on Bioinformatics and Bioengineering (BIBE)*, 2015, pp. 1–6.

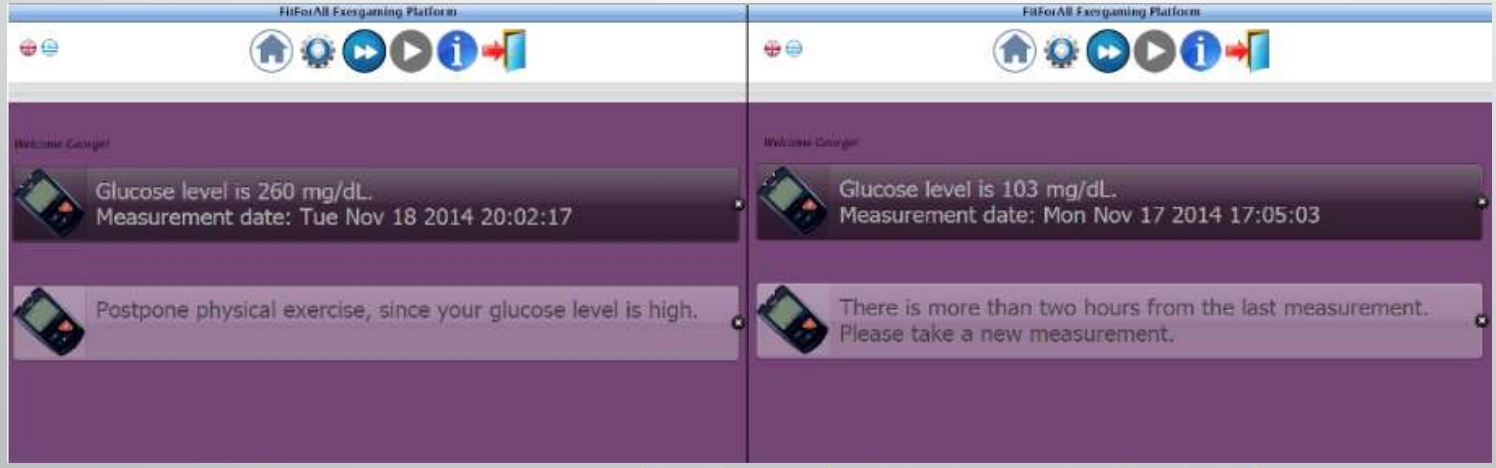
Exergaming empowered by IoT healthcare monitoring

Prior to starting an exergame, the system checks if a glucose meter is connected to the XMPP server

If the blood glucose level is too high, a message is shown to the user suggesting them to continue the exercise later on

It requests for a new glucose measurement if the date of the last one exceeds a defined time interval

Incorporates provisions towards increasing the seniors' health self-awareness by rewarding the seniors with game achievements when they have a health measurement as part of the game



Konstantinidis EI, Bamparopoulos G, Billis A, **Bamidis** PD. Internet of things for an age-friendly healthcare. Stud Health Technol Inform. 2015;210:587-91.

The UNCAP project on Active & Healthy Aging

- UNCAP: Ubiquitous iNteroperable Care for Ageing People
- UNCAP delivers an interoperable platform based on open industrial standards
- …leveraging on existing technologies for biosensing, indoor/outdoor localisation and home-automation.
- Result: an open source, scalable and privacy-savvy ecosystem compatible with existing Personal Health Record systems, that can deliver novel services that can help aging people (incl. those with cognitive impairments) live independently and with dignity.

Summary

- Foster IoT concepts towards the development of applications for the promotion of Ageing well and Active Ageing
- IP ready IoT-enabled glucose meter device
- FitForALL utilizes XMPP messaging protocol and the incorporation of the CAC framework for distributed, cross-platform communication
- Further scenarios, applications and devices exploitations are underway in an effort to accumulate evidence for the successful implementation, integration as well as exploitation of the aforementioned infrastructure in the AHA domain but also elsewhere.

Demo:
https://www.youtube.com/watch?v=4RYH3Iludyo

Konstantinidis EI, Bamparopoulos G, Billis A, **Bamidis** PD. Internet of things for an age-friendly healthcare. Stud Health Technol Inform. 2015;210:587-91.

… in the wild…

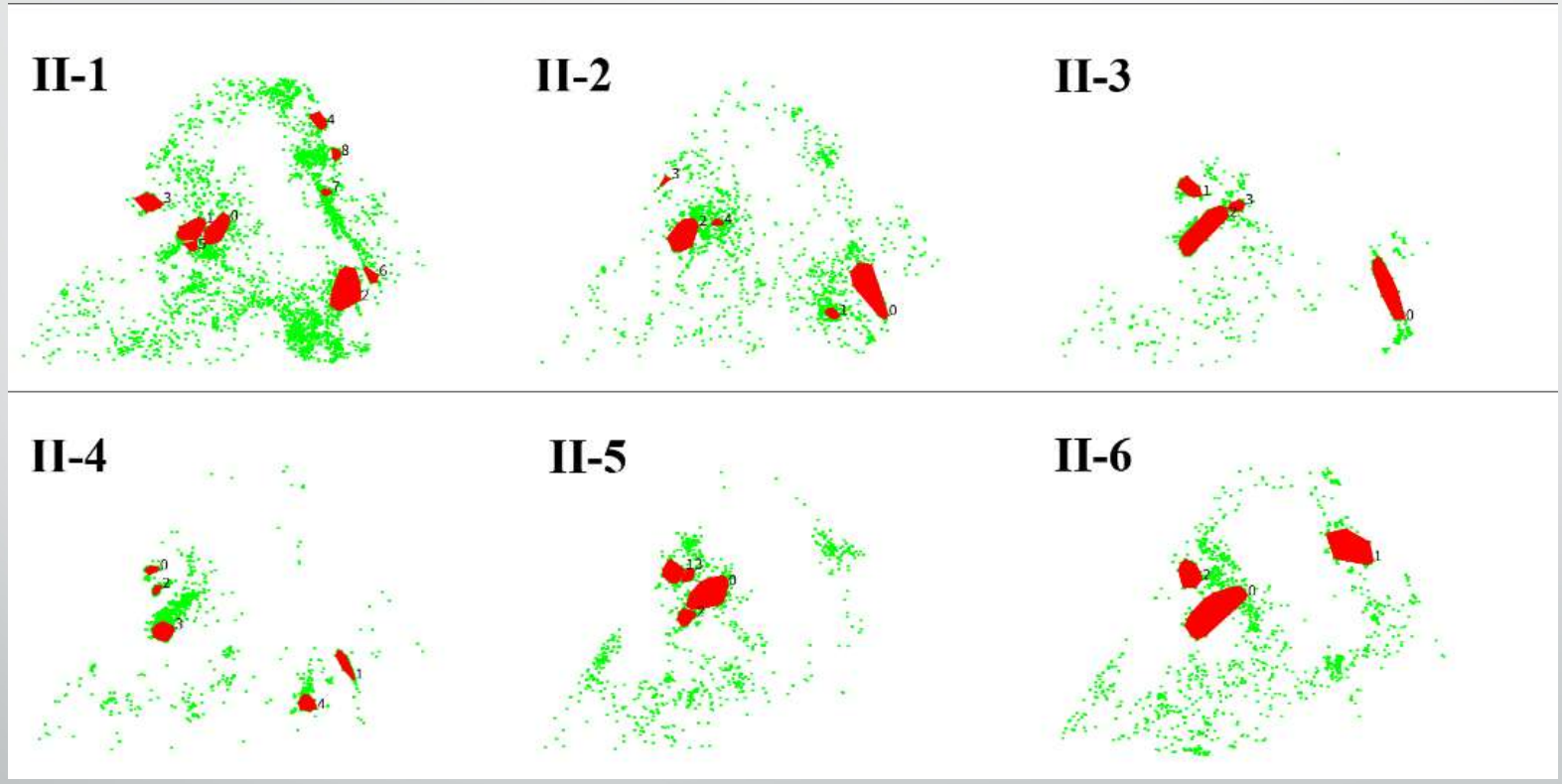
Challenges and Opportunities

- **Why is it so important**
  - Real life
  - Not a controlled environment
  - Final destination of all the advancements on the field
- **Why is it not trivial**
  - Build trust with seniors to open their homes
  - Avoid visiting them too often for technical purposes
  - Ease of use
  - Processing power available

Experiment in seniors' homes

- The infrastructure was already deployed to seniors' homes as part of the USEFIL project
- **Given the IoT architecture, the deployment of the indoor analytics client was very convenient.**
- Deployment in 2 seniors' homes capturing their daily transitions in their living rooms for 6 days.

Illustrative depiction of the daily trajectories and HDRs extracted from a senior's home

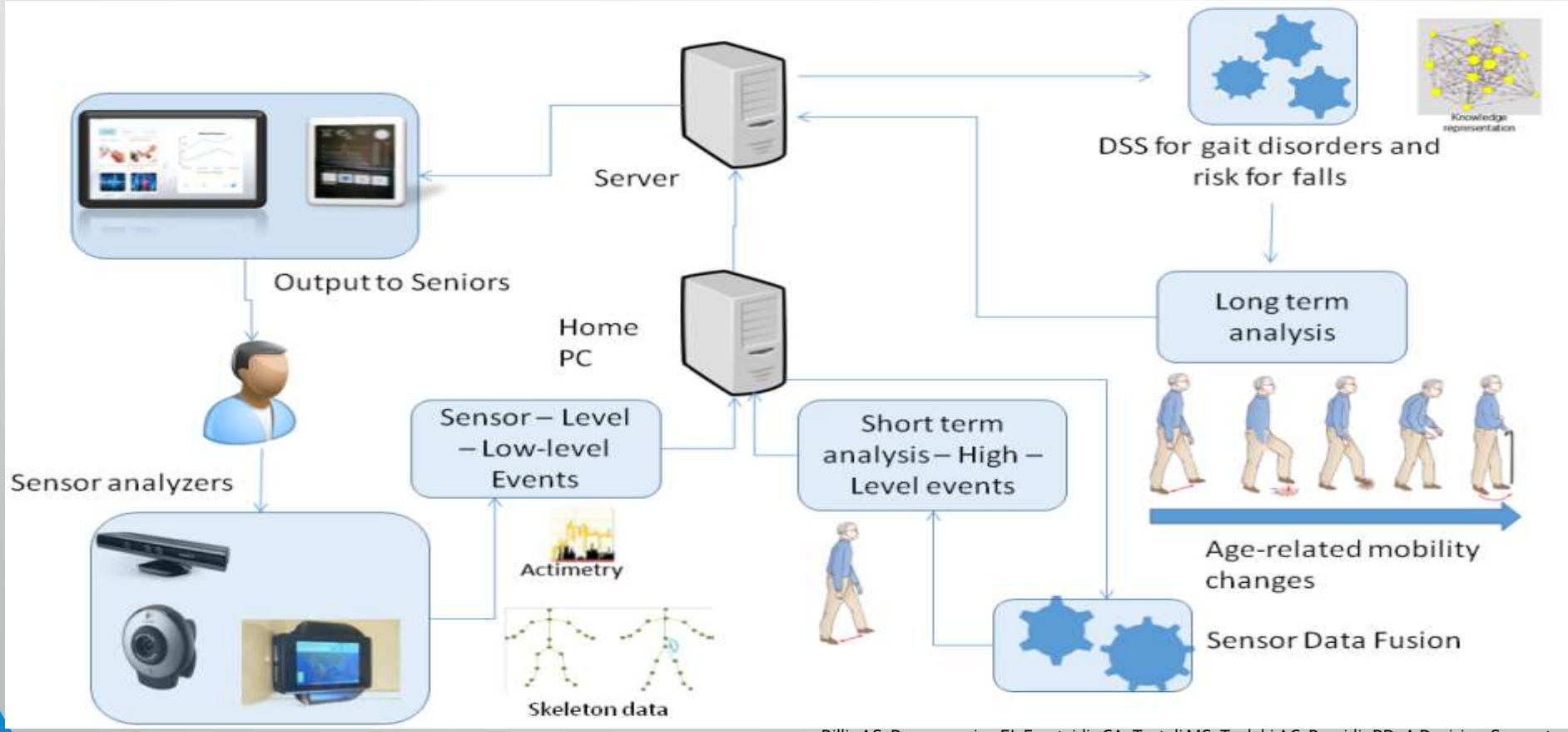


E. I. Konstantinidis, A. S. Billis, L. Plotegher, G. Conti, and P. D. Bamidis, "Indoor Location IoT Analytics 'in the wild': Active and Healthy Ageing Cases," in *XIV Mediterranean Conference on Medical and Biological Engineering and Computing, MEDICON*, Paphos, 2016, pp. 1225–1230.

Indoor Location IoT Analytics "in the wild"

- The analysis of the most visited indoor positions was taking place every so by the component analysis
- The output of the analysis was available by the same the component analysis **to the rest of the devices** through IoT architecture
- **Thus, the same the environment senses, analyzes, and produces information useful back to it.**

Intelligent monitoring approach



Billis AS, Papageorgiou EI, Frantzidis CA, Tsatali MS, Tsolaki AC, Bamidis PD. A Decision-Support Framework for Promoting Independent Living and Ageing Well. IEEE J Biomed Heal Informatics 2015;19:199–209.

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1 year home installation recordings

Enabling active and healthy ageing decision support systems with the smart collection of TV usage patterns

Antonis S. Billis[1], Asterios Batziakas[1], Charalampos Bratsas[2,3], Marianna S. Tsatali[1], Maria Karagianni[1], Panagiotis D. Bamidis[1] ✉

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[3]Open Knowledge Foundation Greece, 54 124 Thessaloniki, Greece
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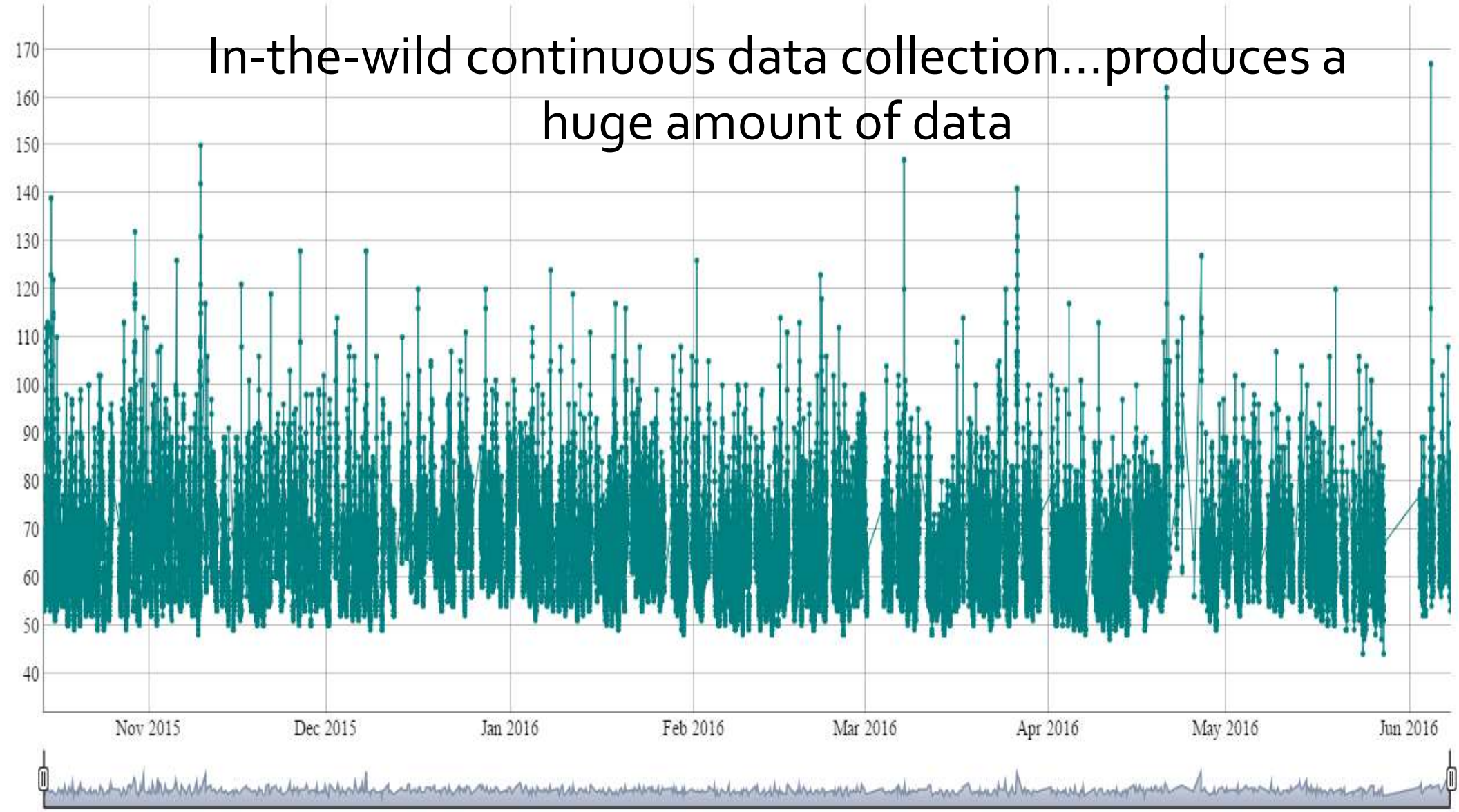
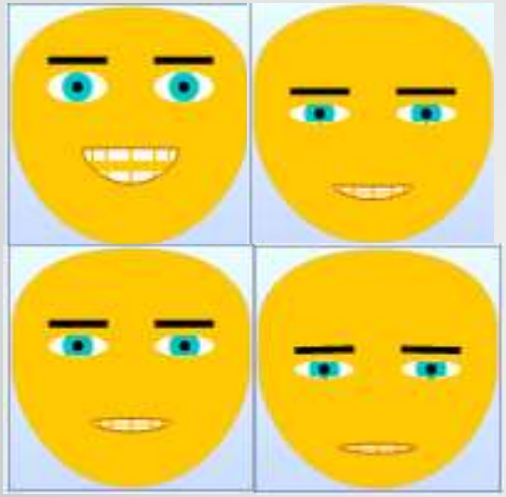
Published in Healthcare Technology Letters; Received on 26th November 2015; Revised on 8th February 2016; Accepted on 9th February 2016

In-the-wild continuous data collection…produces a huge amount of data

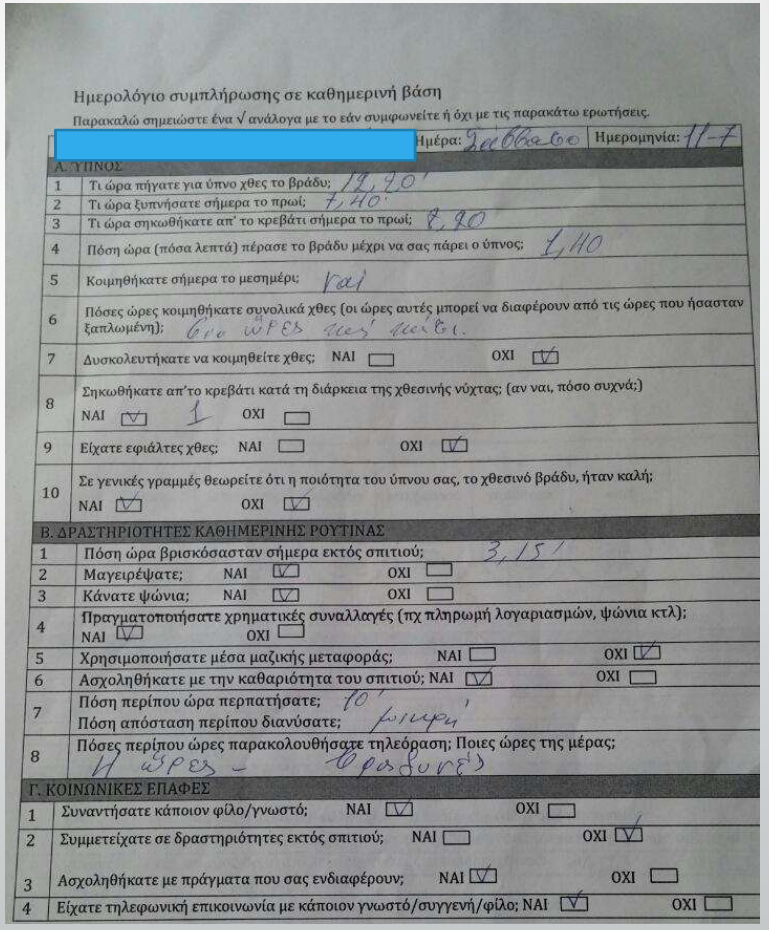


Emotion self-tracking



[AffectButton: a method for reliable and valid affective self-report]

Broekens, J., & Brinkman, W.-P. (2013). International Journal of Human-Computer Studies, 71(6), 641-667.



Ημερολόγιο συμπλήρωσης σε καθημερινή βάση

Παρακαλώ σημειώστε ένα √ ανάλογα με το εάν συμφωνείτε ή όχι με τις παρακάτω ερωτήσεις.

[redacted] Ημέρα: Δευτέρα Ημερομηνία: 11-7

Α. ΥΠΝΟΣ

1	Τι ώρα πήγατε για ύπνο χθες το βράδυ;	12,20'
2	Τι ώρα ξυπνήσατε σήμερα το πρωί;	7,40'
3	Τι ώρα σηκωθήκατε απ' το κρεβάτι σήμερα το πρωί;	8,20
4	Πόση ώρα (πόσα λεπτά) πέρασε το βράδυ μέχρι να σας πάρει ο ύπνος;	1,10
5	Κοιμηθήκατε σήμερα το μεσημέρι;	Ναί
6	Πόσες ώρες κοιμηθήκατε συνολικά χθες (οι ώρες αυτές μπορεί να διαφέρουν από τις ώρες που ήσασταν ξαπλωμένη);	δύο ώρες περίπου.
7	Δυσκολευτήκατε να κοιμηθείτε χθες; ΝΑΙ ☐ ΟΧΙ ☑	
8	Σηκωθήκατε απ'το κρεβάτι κατά τη διάρκεια της χθεσινής νύχτας; (αν ναι, πόσο συχνά;) ΝΑΙ ☑ 1 ΟΧΙ ☐	
9	Είχατε εφιάλτες χθες; ΝΑΙ ☐ ΟΧΙ ☑	
10	Σε γενικές γραμμές θεωρείτε ότι η ποιότητα του ύπνου σας, το χθεσινό βράδυ, ήταν καλή; ΝΑΙ ☑ ΟΧΙ ☑	

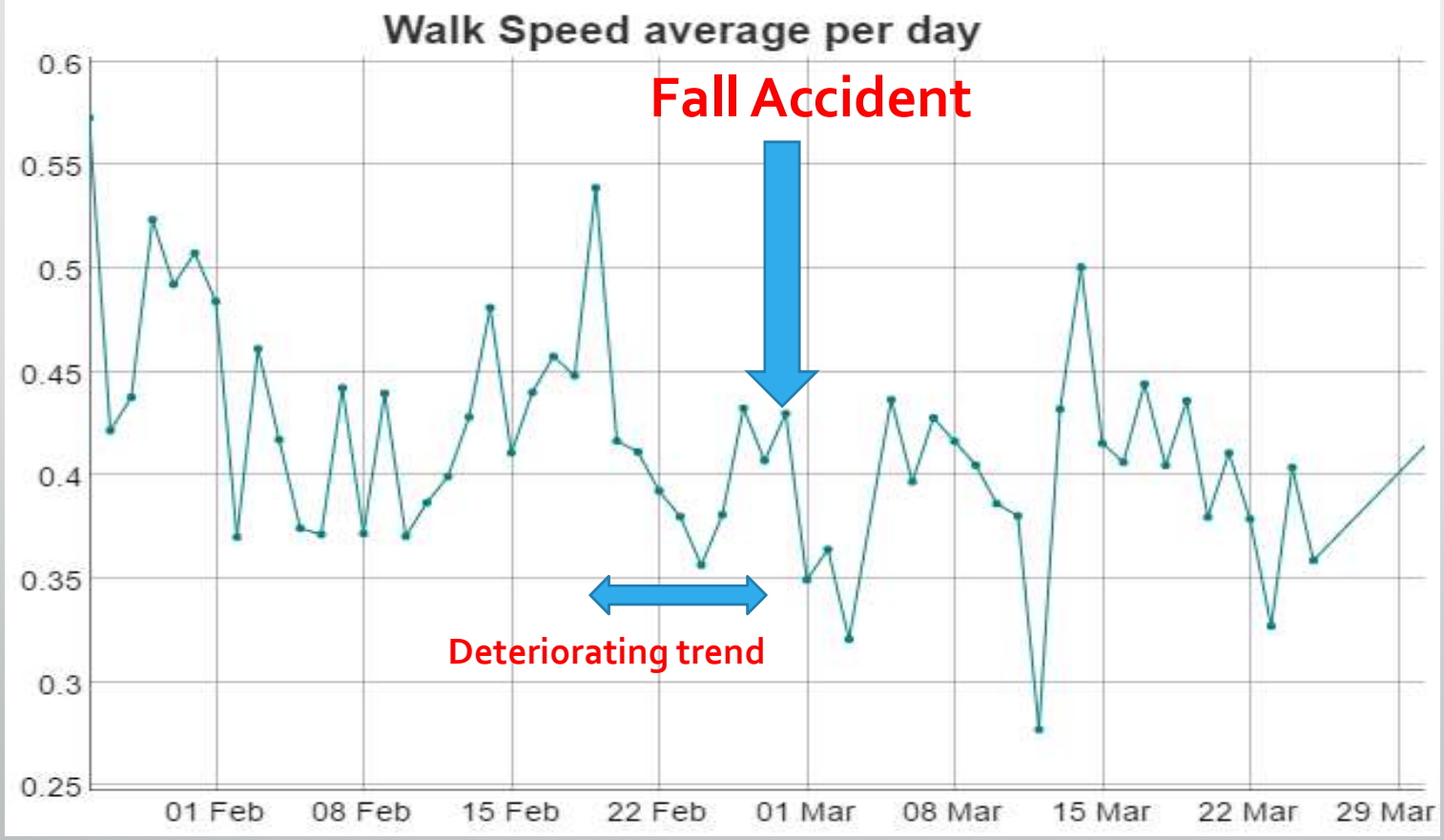
Β. ΔΡΑΣΤΗΡΙΟΤΗΤΕΣ ΚΑΘΗΜΕΡΙΝΗΣ ΡΟΥΤΙΝΑΣ

1	Πόση ώρα βρισκόσασταν σήμερα εκτός σπιτιού;	3,15'
2	Μαγειρέψατε; ΝΑΙ ☑ ΟΧΙ ☐	
3	Κάνατε ψώνια; ΝΑΙ ☑ ΟΧΙ ☐	
4	Πραγματοποιήσατε χρηματικές συναλλαγές (πχ πληρωμή λογαριασμών, ψώνια κτλ); ΝΑΙ ☑ ΟΧΙ ☐	
5	Χρησιμοποιήσατε μέσα μαζικής μεταφοράς; ΝΑΙ ☐ ΟΧΙ ☑	
6	Ασχοληθήκατε με την καθαριότητα του σπιτιού; ΝΑΙ ☑ ΟΧΙ ☐	
7	Πόση περίπου ώρα περπατήσατε; 10' Πόση απόσταση περίπου διανύσατε; μισμυ	
8	Πόσες περίπου ώρες παρακολουθήσατε τηλεόραση; Ποιες ώρες της μέρας; Η ώρες - βραδυνές	

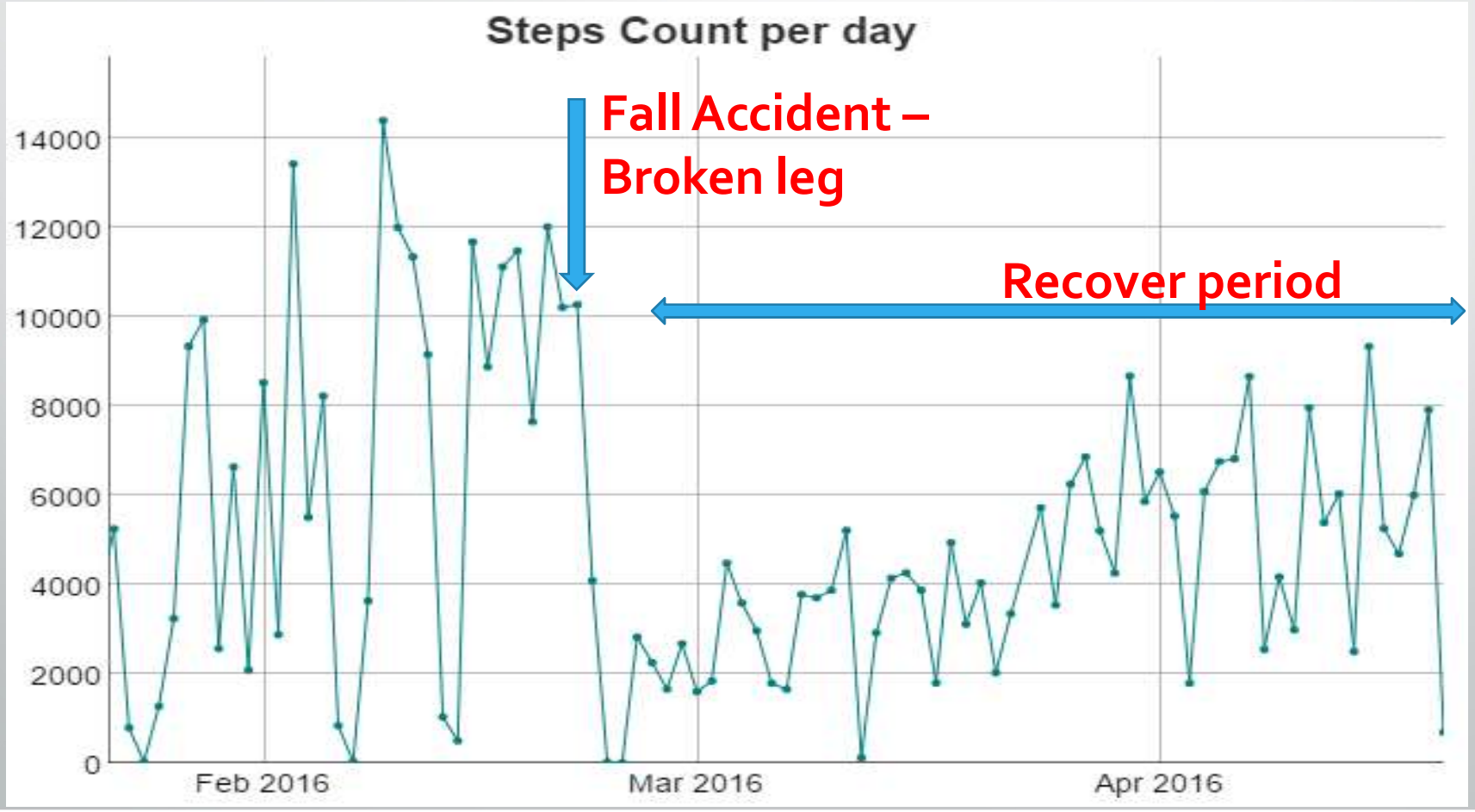
Γ. ΚΟΙΝΩΝΙΚΕΣ ΕΠΑΦΕΣ

1	Συναντήσατε κάποιον φίλο/γνωστό; ΝΑΙ ☑ ΟΧΙ ☐	
2	Συμμετείχατε σε δραστηριότητες εκτός σπιτιού; ΝΑΙ ☐ ΟΧΙ ☑	
3	Ασχοληθήκατε με πράγματα που σας ενδιαφέρουν; ΝΑΙ ☑ ΟΧΙ ☐	
4	Είχατε τηλεφωνική επικοινωνία με κάποιον γνωστό/συγγενή/φίλο; ΝΑΙ ☑ ΟΧΙ ☐	

Case Study I – Fall Accident



Case Study 2- Fall accident



Identification of adverse events in the wild using correlation networks

Case study I (unpublished data: please do not reproduce)

- We compare two periods of time: The first one includes the fall incident (day 12) and the second one represents a stable period.

	Mean Degree	Mean Density	Mean Average Path Length	Mean Strength
Fall period	0.1333	1.2	8.210	0.4104
Stable period	0.07125	0.6417	7.691	0.6511

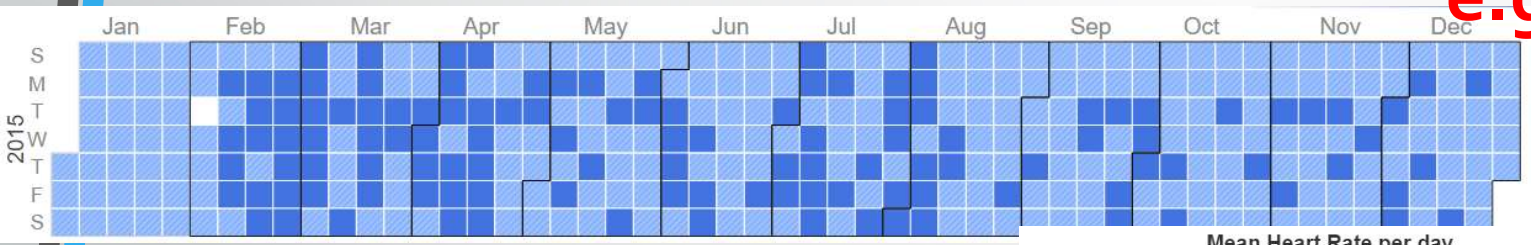
Anova Test Results
Mean Density $F(1,46)=12.58$ $p< .001$,
Mean Degree $F(1,46)=12.58$ $p< .001$
Mean Strength $F(1,46)=8.962$ $p< .001$

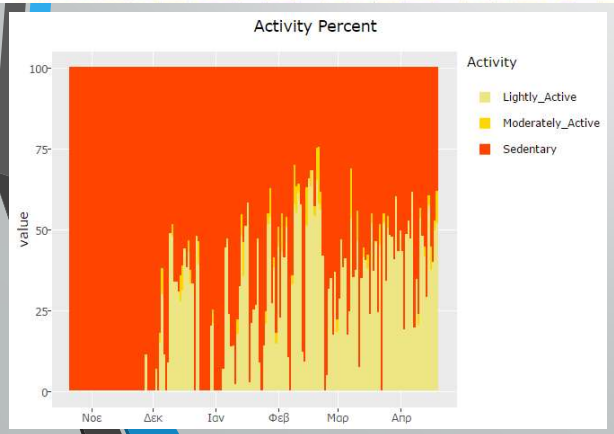
Visual analytics – from data to insights

Billis, A. S., Batziakas, A., & Bamidis, P. D. (2015). Towards a Quantified-Self web application for seniors' self-tracking. In 2015 International Conference on Interactive Mobile Communication Technologies and Learning (IMCL) (pp. 315–317). IEEE. http://doi.org/10.1109/IMCTL.2015.7359610

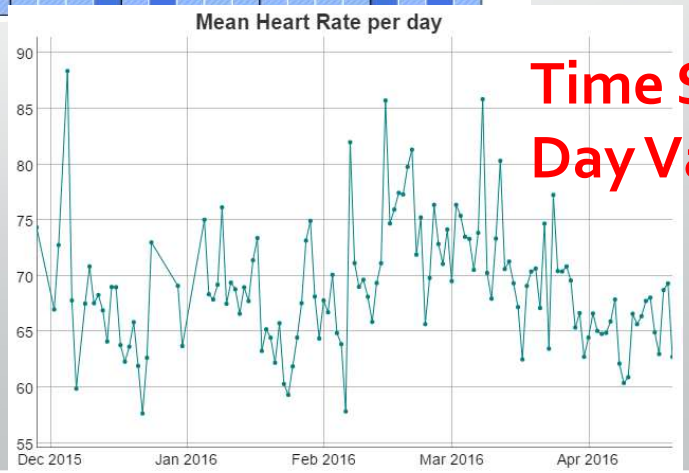
- Seniors ask about the collected data…
- We have to provide them feedback…
- …but what kind of feedback?

Adherence Maps, e.g. Tablet Usage





Comparison Percentages



Time Series – Day To Day Variation

Looking into the future of IoT Analytics

- IoTs, such as wearables, enable
  - much finer temporal sampling
  - over much longer longitudinal time scales
- Thus, leading to:
  - Accuracy improvement,
  - earlier detection,
  - Healthcare services personalization, and
  - Cost reduction by reducing expensive lab procedures that are unnecessary

From Living Labs to seniors' homes

Lab settings

Living Lab settings

a few-household settings

Large Scale Household IoT Trials

-Evidence
-Societal Impact
-Ecosystem

Intelligent Parkinson early detection guiding novel supportive interventions

An EU Horizon 2020 Research Project

i·PROGNOSIS

European Commission

Horizon 2020
European Union funding
for Research & Innovation

Is physical activity beneficial for patients with Parkinson's disease?

ARISTOTLE UNIVERSITY OF THESSALONIKI

Literature… conclusion

- It seems that physical exercise can be beneficial for people who suffer from Parkinson's disease.

- However, different types of exercise have different influence regarding balance, gait, motor action and falls.

ARISTOTLE UNIVERSITY OF THESSALONIKI

So, lets give it a go!

- Fighting Parkinson's disease with LLM Care…

- Within the H2020 projects:
  - iPrognosis
  - UNCAP

ARISTOTLE
UNIVERSITY
OF THESSALONIKI

Parkinson's Video

LLM Care
Long Lasting Memories
Mind and body fitness for life

Street activities with Patient Associations

Co-design, Co-pilot Living Lab Commons

- T
- C
- T
- S

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USEFIL
Unobtrusive Smart Enviroments For Independent Living

UNCAP
Ubiquitous iNteroperable Care for Ageing People
GA 643555

Co-funded by
the Horizon 2020 Framework Programme
of the European Union

i·PROGNOSIS
Intelligent Parkinson early detection guiding
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LLM Care
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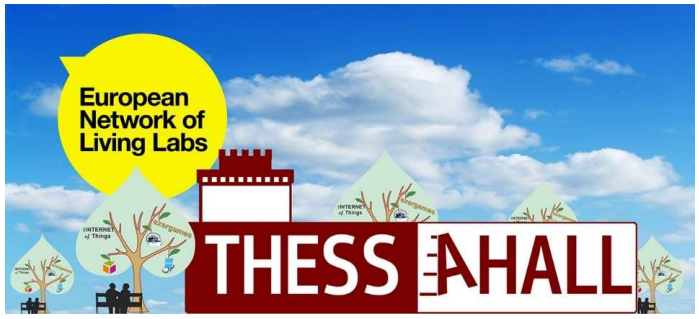
Mind and body fitness for life



Thank you for your attention…

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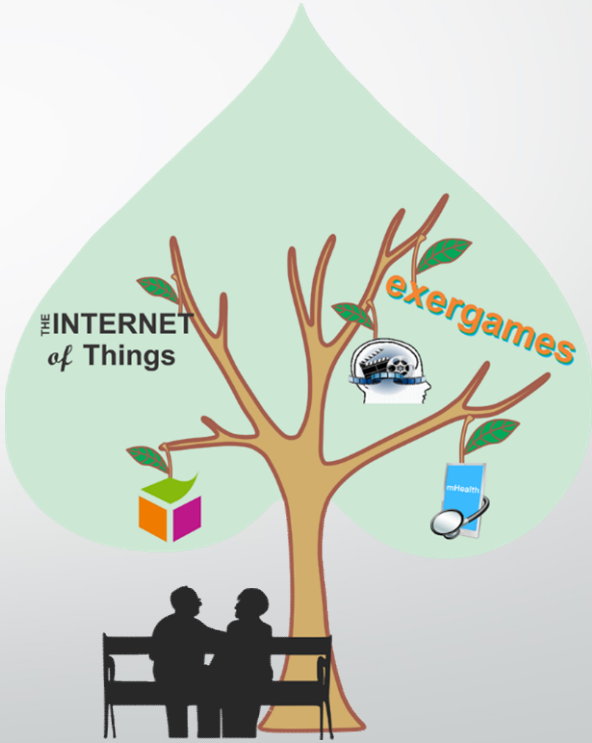
ICT4AWE 2017

3rd International Conference on Information and Communication Technologies for Ageing Well and e-Health



http://medphys.med.auth.gr/group/asoss