The internet of aged people doing things daily

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Groups of:
- Assistive technologies and Silver Science
- Neuroscience of Cognition and Affection
- Health Services Research
- Medical Education Informatics

http://medphys.med.auth.gr
What are the most important “things” in your life?

“Life is the ability and time we have to interact with, and experience the world.”

Love, Live, Learn.

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:

**Reduced schedules of brain activity**
- Reduced engagement in cognitively demanding activities (retirement, not learning new things)
- Lack of continuous refinement of receptive fields/cortical organization
- Less stimulation for attention/reward
  ➔ Brain disuse

**Noisy processing**
- Deterioration of sensory organs
- Poor signal quality received in cortex
- Brain must adjust by lengthening space and time integration constants
- Costs: temporally and spatially noisy processing of stimuli and slowing of information processing speed

**Weakened neuromodulatory control**
- Changes in metabolism of neurotransmitters (acetylcholine, dopamine, serotonin, norepinephrine)
- Changes in connectivity of relevant brain areas
- Weakened control of the brain over its own plasticity

**Negative learning**
- Adaptation to degraded processing
- Changes in behavior accelerate cognitive decline
- E.g.: difficulties in understanding the rapid speech of a child on the phone
  ➔ turn up volume or
  ➔ avoid such conversations

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

- Cognitive decline → Quality of Life deterioration in seniors

- Non-pharmacological arsenal:
  - Physical exercise
  - Cognitive exercise

- Proper training → neural plasticity changes → slow down or invert cognitive decline (Smith et al., 2009).

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

Training...
LLMcare product/service

http://www.youtube.com/watch?feature=player_embedded&v=ilABZtm8eGM
LLM Intervention - Videos

Cognitive Training

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

Physical Training

- Aerobic endurance
- Flexibility
- Balance
- Strength

Bamidis, ICT4AWE 2017
EIP on AHA candidate Reference Site

multi-dimensional evaluation of results
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
scientific results $\Rightarrow$ 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
After training, brain noise is reduced in some areas

scientific results → competitive advantage

Klados et al, Beta-band functional connectivity is reorganized in mild cognitive impairment after combined computerized physical & cognitive training
Learn, Live, Love

Increase positive emotions through training... & IoT
Back in 2013, our vision...

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

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

Vision realisation

• Emotional self-appraisal by users (subjectively)
Vision realisation

- Objective recordings of emotions (Microsoft Cognitive Services)

![Diagram showing RGB image, Microsoft Cognitive Services, and database with scores]
Preliminary results

- 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

Serious games as virtual, IoT enabled, devices

- exergames
- exergaming
- ontology
- Virtual IoT Device
- Start, end, emotion, muscles involved, perceived fatigue, movement, etc...

Cloud connecting to various devices and sensors.
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.

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

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

Inspire, Learn, Live, Love
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.)

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

https://www.youtube.com/watch?v=wxcvuYzzBHs
Active and Healthy Ageing Living Lab

- 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 PErvasiveTechnologies Related to Assistive Environments (PETRA), 2016.

http://www.aha-livinglabs.com
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.
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.

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=4RYH3lludyO

... 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

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

1 year home installation recordings

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

Antonis S. Billis\textsuperscript{1}, Asterios Batziakas\textsuperscript{1}, Charalampos Bratsas\textsuperscript{2,3}, Marianna S. Tsatali\textsuperscript{1}, Maria Karagianni\textsuperscript{1}, Panagiotis D. Bamidis\textsuperscript{1} \vspace{1mm}

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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
Case Study I – Fall Accident

- Fall Accident
- Deteriorating trend
Case Study 2- Fall accident

- Fall Accident – Broken leg
- Recover period
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.

<table>
<thead>
<tr>
<th></th>
<th>Mean Degree</th>
<th>Mean Density</th>
<th>Mean Average Path Length</th>
<th>Mean Strength</th>
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</thead>
<tbody>
<tr>
<td>Fall period</td>
<td>0.1333</td>
<td>1.2</td>
<td>8.210</td>
<td>0.4104</td>
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<tr>
<td>Stable period</td>
<td>0.07125</td>
<td>0.6417</td>
<td>7.691</td>
<td>0.6511</td>
</tr>
</tbody>
</table>

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


• 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
Is physical activity beneficial for patients with Parkinson’s disease?
• 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.
So, let's give it a go!

- Fighting Parkinson’s disease with LLM Care...

- Within the H2020 projects:
  - iPrognosis
  - UNCAP
Parkinson’s Video
Street activities with Patient Associations

Bamidis 2017
ThessaAHALL is eager in accommodating research experiments for pilot trials towards commercialization.

Contact us if you think that we could collaborate and co-create.

ThessaAHALL board will evaluate your proposal for collaboration.

Success stories already...

https://www.facebook.com/thessahall/

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pdbamidis@gmail.com

Follow @bamidis

in Twitter
Intelligent Parkinson early detection guiding novel supportive interventions
Thank you for your attention...

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