European Commission
Information Society and Media

SEVENTH FRAMEWORK PROGRAMME

FAll Repository for the design of Smart and sElf-adaptive Environments prolonging INdependent livinG

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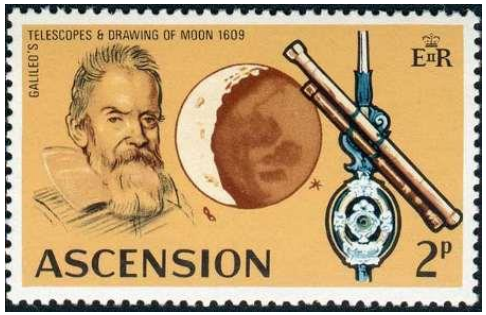
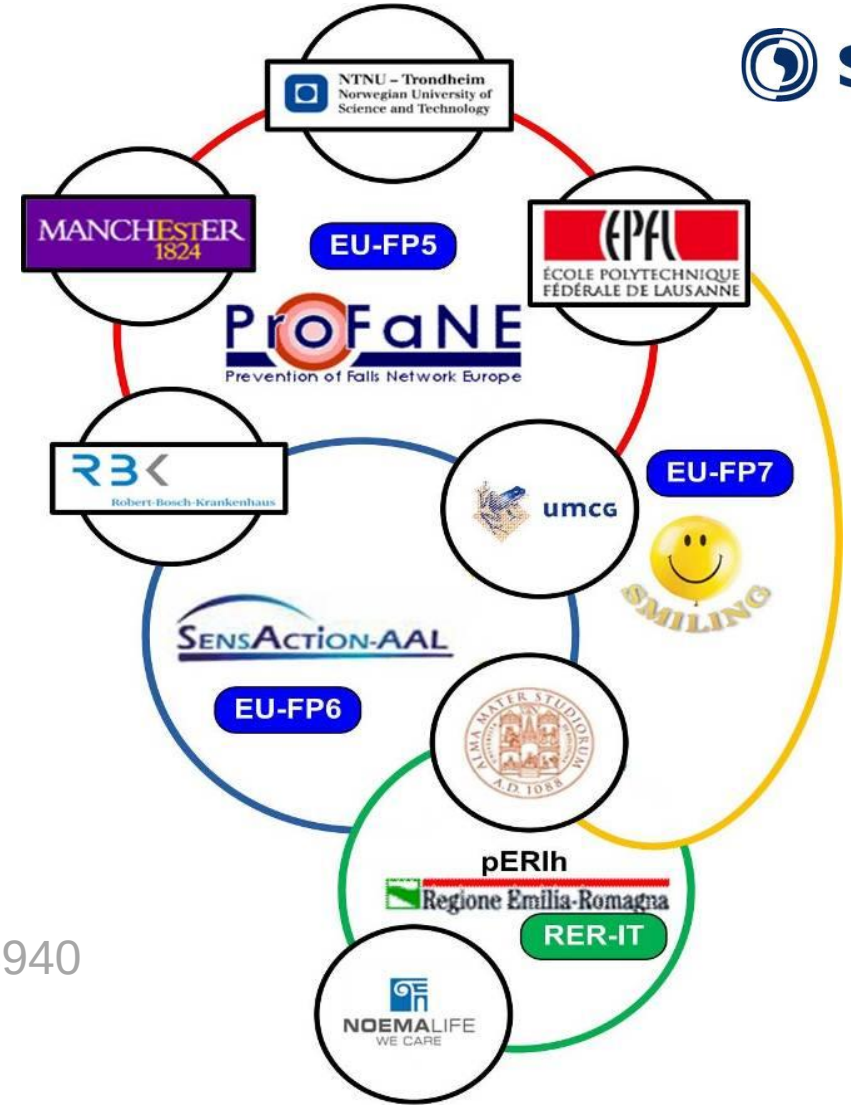
Nomen omen?

Farseeing – *adjective*, having or showing awareness of and preparation for the future. *Synonyms:* farsighted, forehanded, forethoughtful, forward, forward-looking, prescient, proactive, provident, visionary. *Related Words:* careful, cautious, heedful; discerning, insightful, perceptive, prudent, sagacious, sage, sapient, wise. *Rhymes:* sightseeing, well-being. *First known use:* 1598.



The consortium



SINTEF

Deutsche Sporthochschule Köln
German Sport University Cologne

SST Azienda Sanitaria Firenze
Servizio Sanitario della Toscana

bticino

Start date: 1-1-2012
End date: 31-12-2014
Grant Agreement no. 288940

FARSEEING

European Commission
Information Society and Media

SEVENTH FRAMEWORK PROGRAMME

FARSEEING: learning from falls how to prevent falls

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Dealing with the missing evidence base in falls research

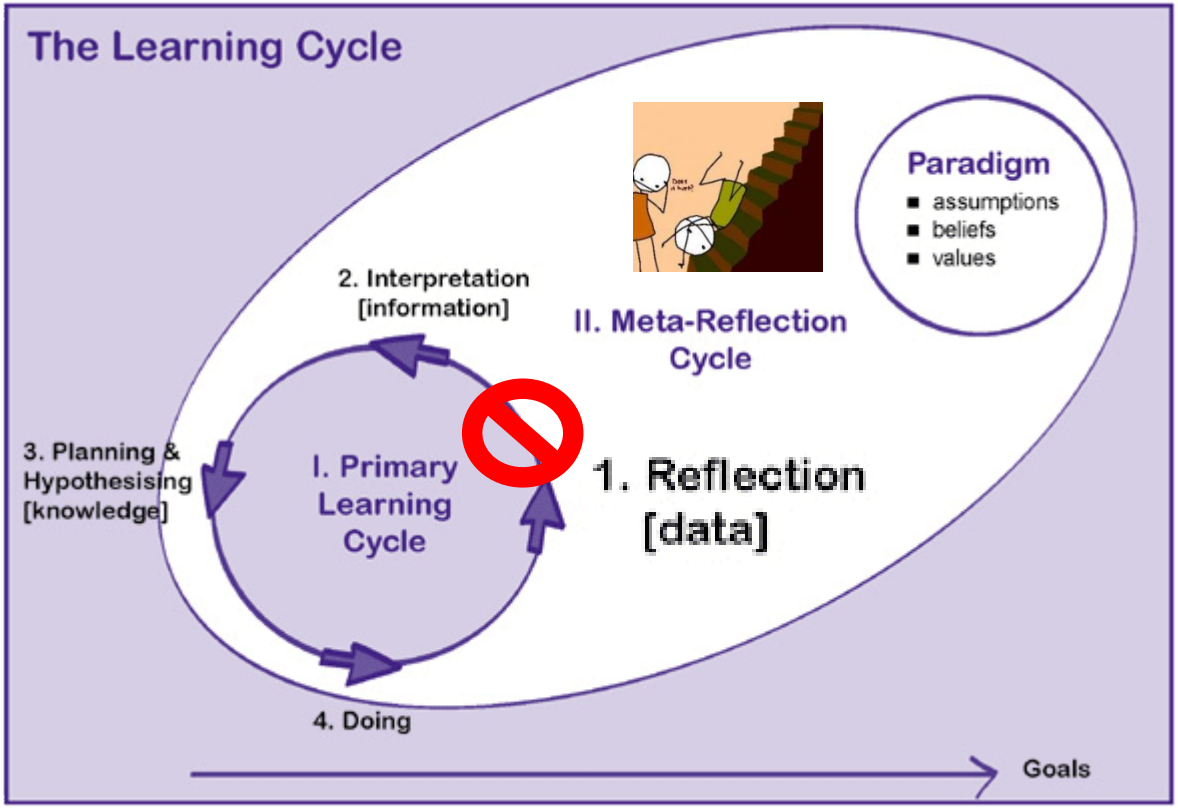


Table 2: Study and reporting characteristics

Characteristic	n=97 (%)
Population type	
Healthy young	73 (75.3)
Healthy old community dwelling	1 (1.0)
Frail old community-dwelling	0 (0.0)
Sheltered living	1 (1.0)
Hospital	5 (5.2)
Other	9 (9.3)
Unknown	8 (8.2)
Studies including real-world fall data	**6 (6.2)**
Backward falls	1 (16.7)
Mixed directions	2 (33.3)
Direction not available	3 (50.0)

Schwickert et al., ZGG, in press

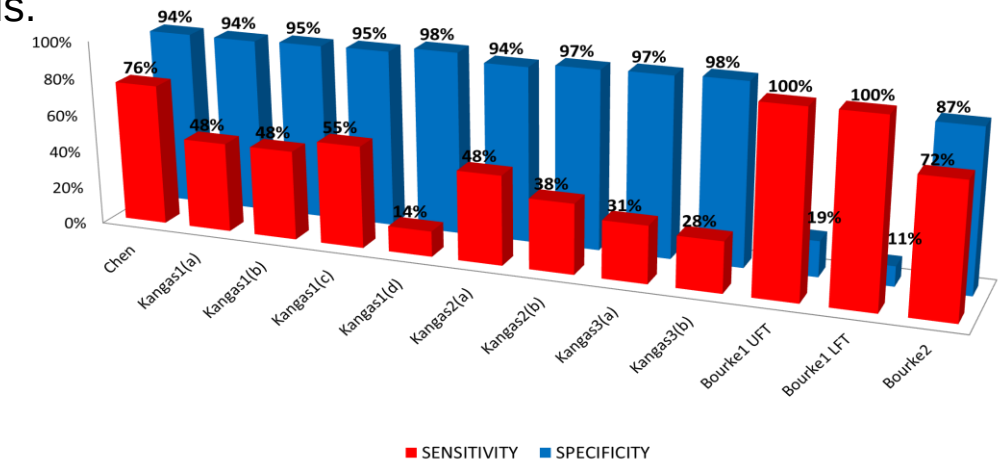
Objectives

- Valid **real-world fall data** can lead to a major breakthrough in scientific and clinical knowledge which is required in order to achieve substantial ICT-related improvements in the areas of fall prevention and fall detection. This is prerequisite not only for developing effective intervention strategies but also for implementing acceptable services and business models.
- The FARSEEING architecture allows collecting, storing and processing data related to mobility and falls in a way which is **maximally transparent** to end-users through the flexible and seamless integration of different ICT solutions.

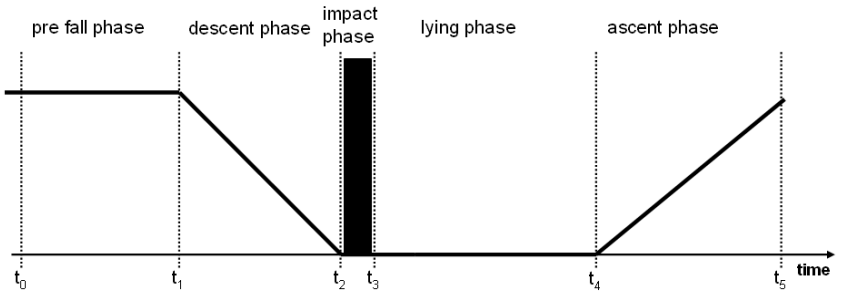
Ingredients for such an original recipe include: *smartphones, wearable and environmental sensing units, home automation devices, database & information systems, users interfaces, and telemedical services*.

Knowledge generated so far

- Bagala et al., PLoS One 2012: Evaluation of accelerometer-based fall detection algorithms on real-world falls.



- Becker et al., ZGG 2013: Proposal for a multiphase fall model based on real-world fall recordings with body-fixed sensors.



- Becker & Chiari, Lancet 2013: What videos can tell us about falling.

… and what they can't

THE LANCET

Volume 376 · Number 9734 · Pages 1–68 · July 3–9, 2010 www.thelancet.com

What videos can tell us about falling

In 2004, a videotape of a fall by Fidel Castro, then Cuban President, gained extensive press coverage and elicited a range of reactions.[1] The sequence captured a key shot for researchers who study falls. In the film, Castro, after one of his exhausting speeches and probably dazzled by lights, misses a step, starts falling after an unsuccessful stepping attempt, and turns in the air to reduce the impact of his head on the ground at the expense of an upper limb; the fall resulted in a broken shoulder and patella.

Falls and fall-related injuries are a major health burden. Despite many epidemiological studies of predisposing risk factors,[2] many assumptions and decisions about falls are still based on subjective and often biased information.[3] Fewer than 10% of falls are witnessed and, even when reports are available, they often do not provide detailed and objective information about the context and circumstances of the fall, or what happened during the fall. This absence of understanding is one of the reasons why efforts to prevent falls have had little success, although some progress has been achieved.[4–6]

In *The Lancet*, Stephen Robinovitch and colleagues' present results of an observational study of videotaped falls. They extensively studied falls in two long-term care institutions in British Columbia, Canada, between 2007 and 2010, using more than 200 public video cameras that were preinstalled for safety purposes. With a well-defined protocol, they were able to match staff incident reports of falls to video footage, making this a unique study. The researchers recorded 227 falls by 130 individuals whose mean age was 78 years (SD 10). Studies of this type are important because falls by elderly people are much more frequent in long-term care facilities than in the community; more than 90% of all hip fractures are caused by falls, and 20% of all hip fractures occur among residents of long-term care.[6]

Robinovitch and colleagues' report provides some important findings. Among these is the high occurrence of falls caused by incorrect weight shifting (the most frequent cause of falls, 93 [41%] of 227 falls) and external perturbations, such as hit or bump events (which accounted for 25 [11%] falls). A further notable aspect is the improved understanding of the role of poor ergonomic design and environmental factors—eg, of the 48 falls caused by trip or stumble, 14 were attributable to a foot catching on equipment and 12 to a foot catching on furniture. This understanding should lead to revised housing norms and improved design of furniture and assistive devices. However, the study has some major limitations. Robinovitch and colleagues present data from publicly accessible spaces and not from private areas, such as bedrooms and toilets. More than 50% of falls in long-term care facilities occur in private areas that cannot be supervised by video footage.[3] Other objective approaches are needed to study falls in these rooms, such as sensors worn on the body. Although some findings might apply to people who depend on care but live at home, independent seniors probably have different risk factors and environmental cofactors that contribute to falls. Thus, the findings might not be applicable to community-dwelling seniors.

Where could this study take fall prevention research? Robinovitch and colleagues build a strong case for classification of falls and a taxonomy of causes leading to falls. Currently, falls are most often presented as composite endpoints. Video footage, including that captured by members of the public with smartphones, will be one valuable source of information to generate new research hypotheses. High-speed video footage can also be used to study balance recovery reactions and landing responses in other groups, such as children and athletes.

To study falls in the community, we will need a technological shift. Evidence provided by Robinovitch and colleagues of the movement patterns that lead

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See Online/Articles http://dx.doi.org/10.1016/S0140-6736(12)61263-X

Comment

to falls is helpful in guiding the design of sensor-based fall monitoring systems. The next step will require coordinated action and possibly an open-access database that would allow real-world fall data, obtained through different sensors, to be shared. This objective is included in the roadmap of the research community, and is currently being funded by the European Commission.

For the **European Commission research project**, see http://farseeingresearch.eu

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We declare that we have no conflicts of interest.

1 BBC News. Castro breaks knee, arm in fall. Oct 21, 2004. http://news.bbc.co.uk/2/hi/americas/3761748.stm (accessed Sept 12, 2012).
2 Deandrea S, Lucenteforte E, Bravi F, Foschi R, La Vecchia C, Negri E. Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis. *Epidemiology* 2010; **21**: 658–68.
3 Zecevic AA, Salmoni AW, Speechley M, Vandervoort AA. Defining a fall and reasons for falling: comparisons among the views of seniors, health care providers, and the research literature. *Gerontologist* 2006; **46**: 367–76.
4 Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev* 2009; **2**: CD007146.
5 Cameron ID, Murray GR, Gillespie LD, et al. Interventions for preventing falls in older people in nursing care facilities and hospitals. *Cochrane Database Syst Rev* 2010; **1**: CD005465.
6 Becker C, Cameron ID, Klenk J, et al. Reduction of femoral fractures in long-term care facilities: the Bavarian fracture prevention study. *PLoS One* 2011; **6**: e24311.
7 Robinovitch SN, Feldman F, Yang Y, et al. Video capture of the circumstances of falls in elderly people residing in long-term care: an observational study. *Lancet* 2012; published online Oct 17. http://dx.doi.org/10.1016/S0140-6736(12)61263-X.
8 Rapp K, Becker C, Cameron ID, et al. Femoral fracture rates in people with and without disability. *Age Ageing* 2012; **41**: 653–58.
9 Rapp K, Becker C, Cameron ID, König HH, Buchele G. Epidemiology of falls in residential aged care: analysis of more than 70 000 falls from residents of Bavarian nursing homes. *J Am Med Dir Assoc* 2012; **13**: 187.e1–6.

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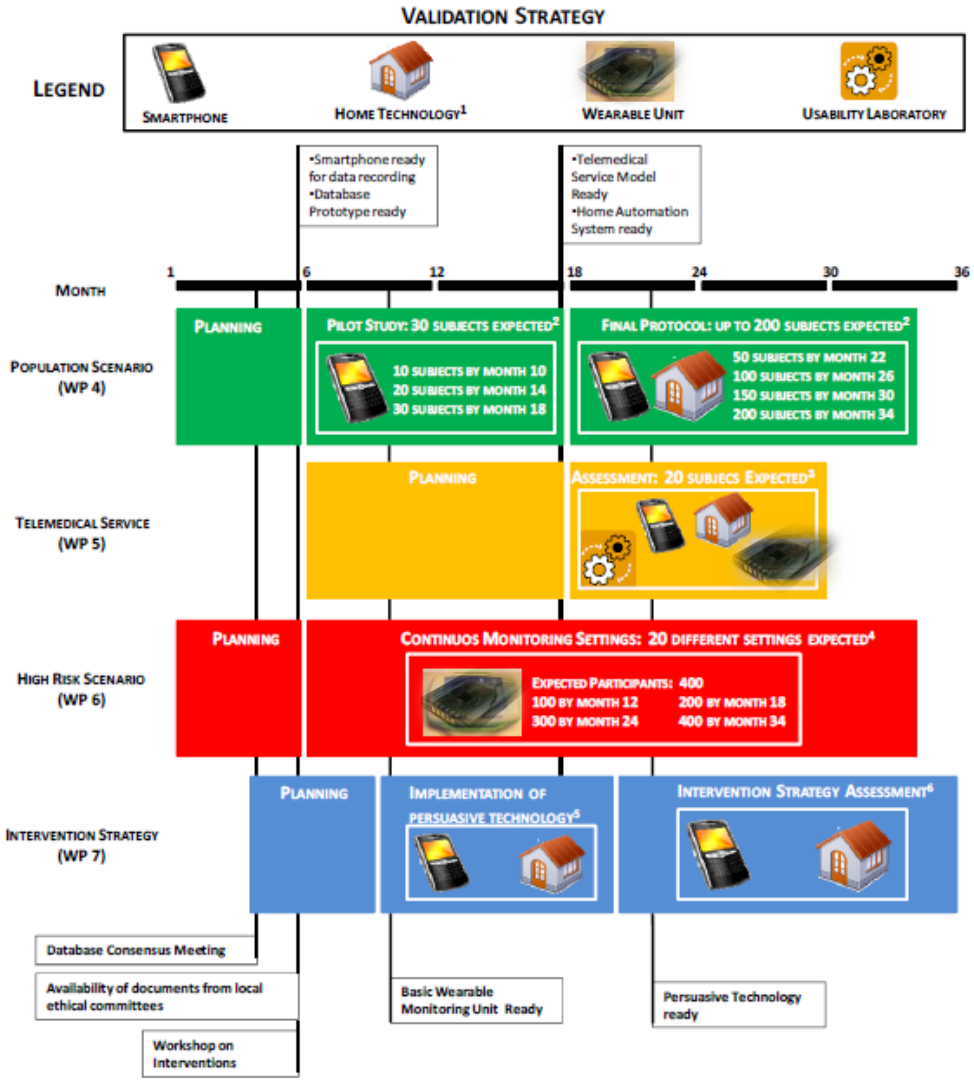
THE RECIPE

Project strategy

INTERVENTION

Validation strategy



Fall risk < 30%

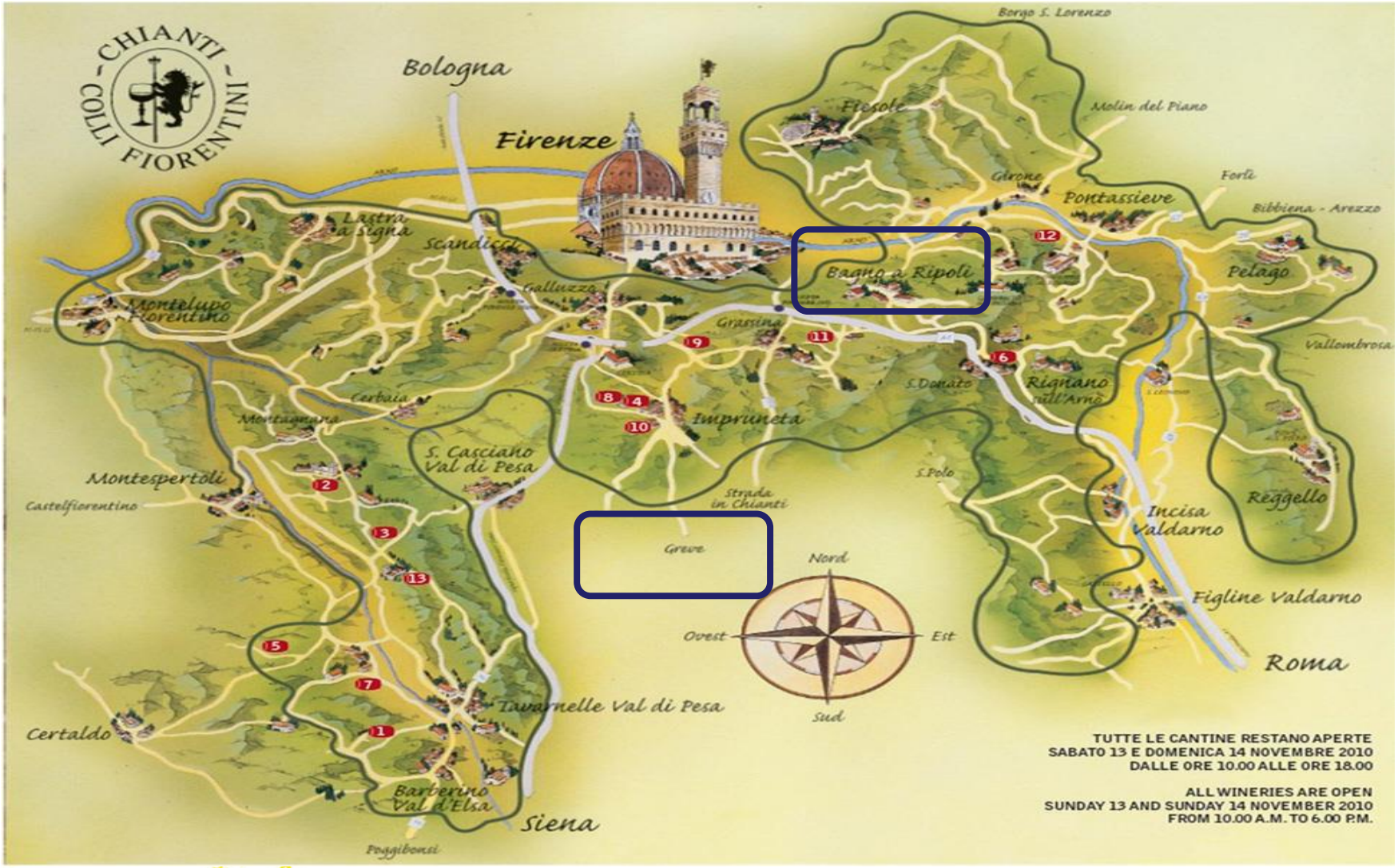
Fall risk > 50%

Population scenario: The InCHIANTI study

http://www.inchiantistudy.net/

Its goal is to translate **epidemiological research** into **geriatric clinical tools** that make possible more precise diagnosis and more effective treatment in older persons with **mobility problems**.

Population scenario: The InCHIANTI study



Population scenario: The InCHIANTI study

Home Interview

- MMSE
- Social Network
- CESd
- OMS
- Quality of sleep
- Therapy
- Incontinence
- Questionnaire on falls
- Physical activity
- Questionnaire on foot
- Food Questionnaire EPIC

Blood test
Instrumental Exam

- Blood test standard
- Biological bank
- EKG 12 Canal
- pQCT leg 4% 16 % 33% 66%
- ENG leg Motor nerve conduction velocity
- BIA (Body Impedenziometric Assessment)
- Color doppler scan neck vessels, index of Winsor

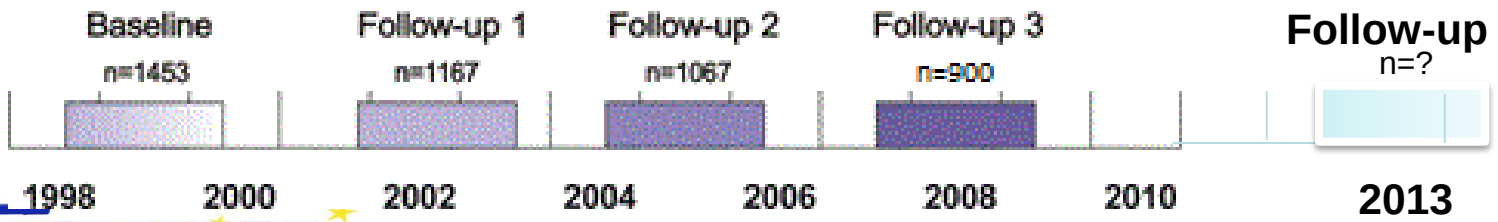
Medical Examination

- Family history
- Remote pathological assessment
- Deseases assessment
- Trail Making Test
- Questionnaires on pain
  - Spine
  - Knee
  - Hip
- Clinical examination

Tests of Performance

- Perdue Pegboard
- Short Physical Performance Battery (SPPB)
- Tests of walking
  - 4mt usual pace and fast pace
  - 7mt test with different conditions
- Tests of endurance
  - 400 mt
  - 60mt with increased body weight
- ROM leg
- Power Rig leg
- Muscle Strenght arm and leg

InCHIANTI Study time-table



Study Protocol – [excerpt]

Gait Lab

Power Rig

Purdue Pegboard

GAITRite

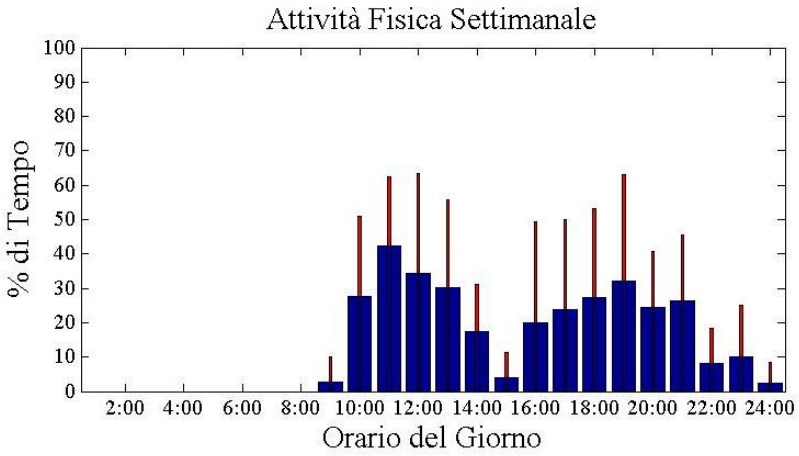
Corridor 25 cm width

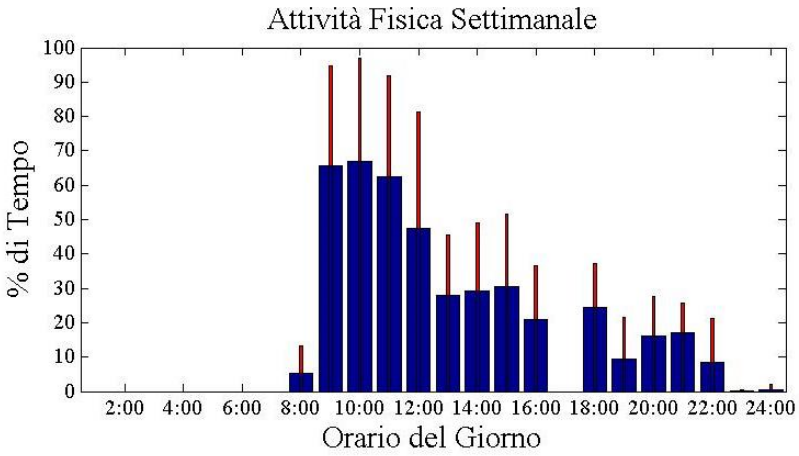
Handgrip

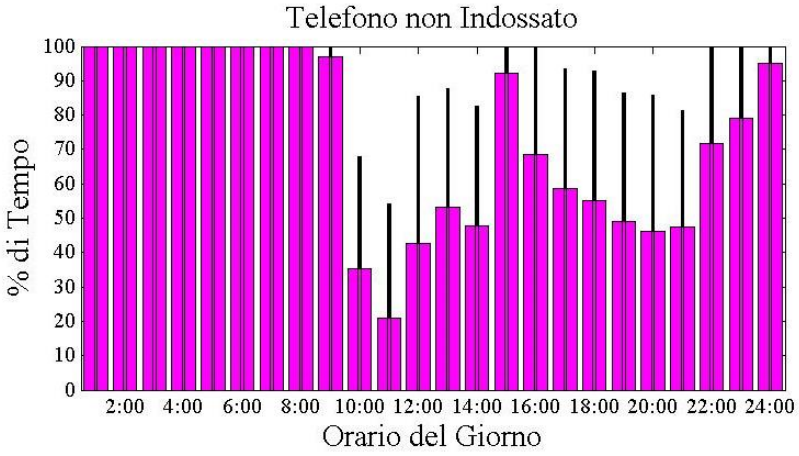
Stairs

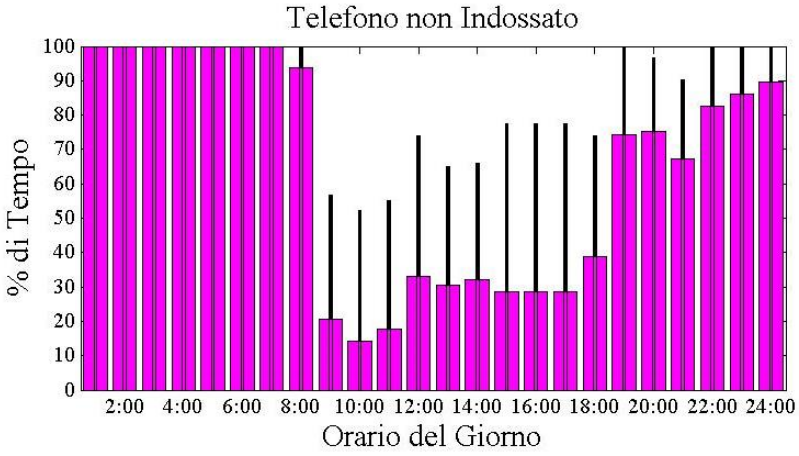
Dinamometer

Study Protocol – [excerpt]









+ 7 days of physical activity monitoring at home

Tele-healthcare Satisfaction Questionnaire – Wearable Technology (TSQ-WT)

Robert-Bosch-Krankenhaus

The University of Manchester

	TSQ-WT	0	1	2	3	4
	I … agree/disagree with this statement	strongly disagree	mostly disagree	neither agree nor disagree	mostly agree	strongly agree
1	*I can benefit from this technology.*	❑	❑	❑	❑	❑
2	*The use of this technology/method requires effort.*	❑	❑	❑	❑	❑
3	*The use of this technology/method is an interesting challenge for me.*	❑	❑	❑	❑	❑
4	*I feel there is too much supervision by this technology/method.*	❑	❑	❑	❑	❑
5	*Using this technology/method improves my physical well-being.*	❑	❑	❑	❑	❑
6	*Wearing this device (parts of the device) is comfortable.*	❑	❑	❑	❑	❑
7	*The effort of using this technology/ method is worth while for me.*	❑	❑	❑	❑	❑
8	*The technology/method is reliable according to my estimation and experience so far.*	❑	❑	❑	❑	❑
9	*This technology/method reminds me of loosing my independence.*	❑	❑	❑	❑	❑
10	*I use this technology/method by request of others (e.g. physician, therapist, relatives).*	❑	❑	❑	❑	❑
11	*This technology/method evokes unpleasant feelings.*	❑	❑	❑	❑	❑
12	*I am pleased with the size of the device (parts of the device).*	❑	❑	❑	❑	❑
13	*I am confident I'm getting the most out of this technology/method.*	❑	❑	❑	❑	❑
14	*This technology/method is easy to use.*	❑	❑	❑	❑	❑
15	*The use of this technology/method is making me feel older than I am.*	❑	❑	❑	❑	❑

	TSQ-WT	0	1	2	3	4
16	*I'm sure that my personal data are stored or processed in an appropriate way.*	❑	❑	❑	❑	❑
17	*This technology/method enhances my social contacts.*	❑	❑	❑	❑	❑
18	*I would wish another look and design of the device (parts of the device).*	❑	❑	❑	❑	❑
19	*This technology/method is helping me to achieve my goals.*	❑	❑	❑	❑	❑
20	*I feel safe when using this technology/method.*	❑	❑	❑	❑	❑
21	*I (would) feel embarrassed using this technology/method visible around others.*	❑	❑	❑	❑	❑
22	*The use of this technology/method may have unpredictable negative consequences for me.*	❑	❑	❑	❑	❑
23	*This technology/method helps me to maintain or increase my independence (e.g. with regard to mobility, communication, medication).*	❑	❑	❑	❑	❑
24	*I am pleased with the weight of the device (parts of the device).*	❑	❑	❑	❑	❑
25	*I would recommend this technology/ method to other people in my situation.*	❑	❑	❑	❑	❑
26	*I feel good while using this technology/method.*	❑	❑	❑	❑	❑
27	*I like to use technological products or systems like this technology/method.*	❑	❑	❑	❑	❑
28	*This technology/method forces me to disclose personal facts that I prefer to keep to myself.*	❑	❑	❑	❑	❑
29	*The use of this technology/method has a positive effect on me.*	❑	❑	❑	❑	❑
30	*The body-worn parts of the device are difficult to adjust (fix, fasten).*	❑	❑	❑	❑	❑

Users & psychological perspectives about ICT technologies for ageing well

SYSTEMATIC REVIEW: KEY ADVICE FOR AN IMPLEMENTATION

How patients perceive concept of ICT and the intervention in the home likely to influence their acceptance and thus its success.

Hawley-Hague et al., Int. J. Med. Inf., submitted

- The importance of social element
- Involving participants throughout the process
- Feedback messages should be gentle and non-judgemental.
- Any messages need to be tailored and person centred.
- Consideration of barriers and motivators to intervention as well as how it is delivered.

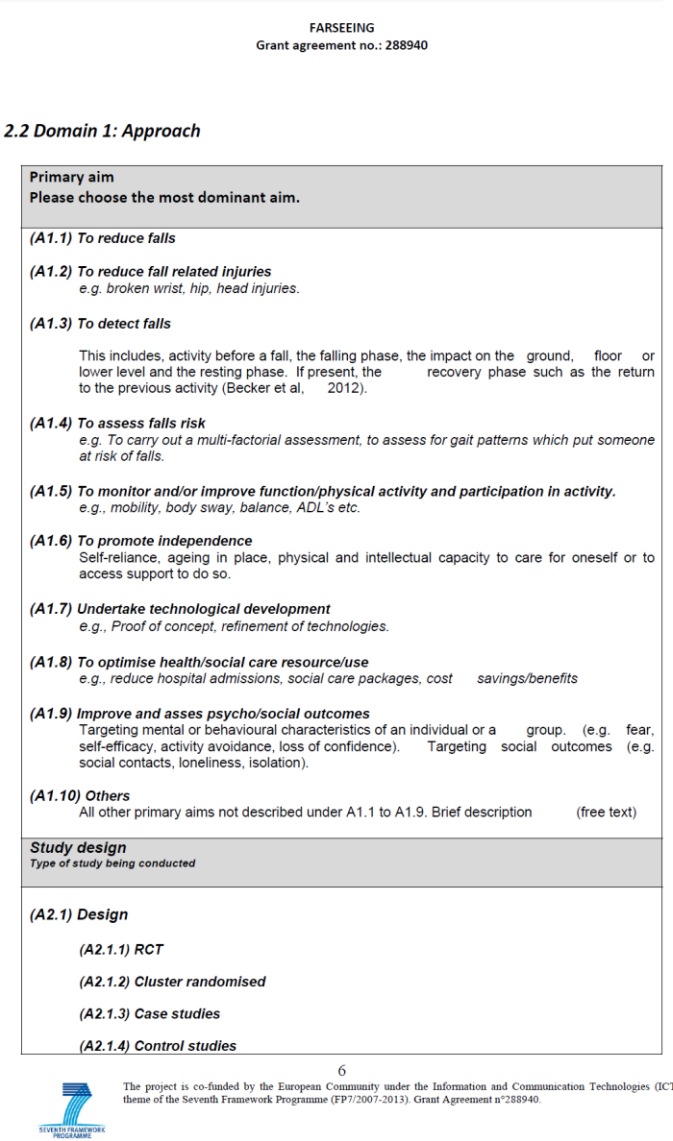
Users & psychological perspectives about ICT technologies for ageing well

TAXONOMY OF TECHNOLOGIES

TAXONOMY AIM:

AIM: "To classify and describe studies which use ICT devices to detect falls, monitor or promote movement-related function and physical activity in fall prevention"

Electronic tool accessible by the FARSEEING website available by the end of 2013



FARSEEING
Grant agreement no.: 288940

2.2 Domain 1: Approach

Primary aim
Please choose the most dominant aim.

(A1.1) To reduce falls

(A1.2) To reduce fall related injuries
e.g. broken wrist, hip, head injuries.

(A1.3) To detect falls

This includes, activity before a fall, the falling phase, the impact on the ground, floor or lower level and the resting phase. If present, the recovery phase such as the return to the previous activity (Becker et al, 2012).

(A1.4) To assess falls risk
e.g. To carry out a multi-factorial assessment, to assess for gait patterns which put someone at risk of falls.

(A1.5) To monitor and/or improve function/physical activity and participation in activity.
e.g., mobility, body sway, balance, ADL's etc.

(A1.6) To promote independence
Self-reliance, ageing in place, physical and intellectual capacity to care for oneself or to access support to do so.

(A1.7) Undertake technological development
e.g., Proof of concept, refinement of technologies.

(A1.8) To optimise health/social care resource/use
e.g., reduce hospital admissions, social care packages, cost savings/benefits

(A1.9) Improve and asses psycho/social outcomes
Targeting mental or behavioural characteristics of an individual or a group. (e.g. fear, self-efficacy, activity avoidance, loss of confidence). Targeting social outcomes (e.g. social contacts, loneliness, isolation).

(A1.10) Others
All other primary aims not described under A1.1 to A1.9. Brief description (free text)

Study design
Type of study being conducted

(A2.1) Design

(A2.1.1) RCT

(A2.1.2) Cluster randomised

(A2.1.3) Case studies

(A2.1.4) Control studies

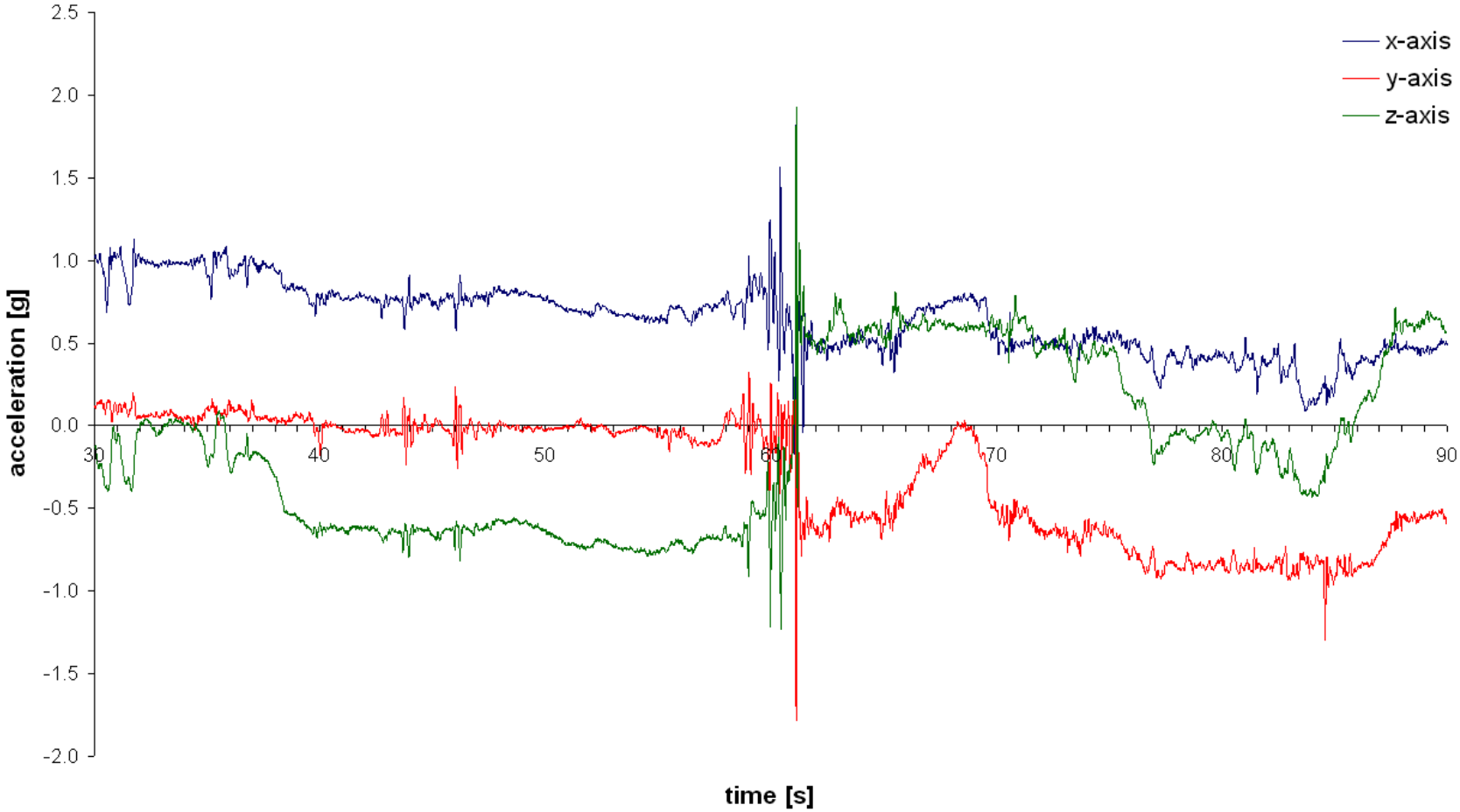
6

The project is co-funded by the European Community under the Information and Communication Technologies (ICT) theme of the Seventh Framework Programme (FP7/2007-2013). Grant Agreement n°288940.

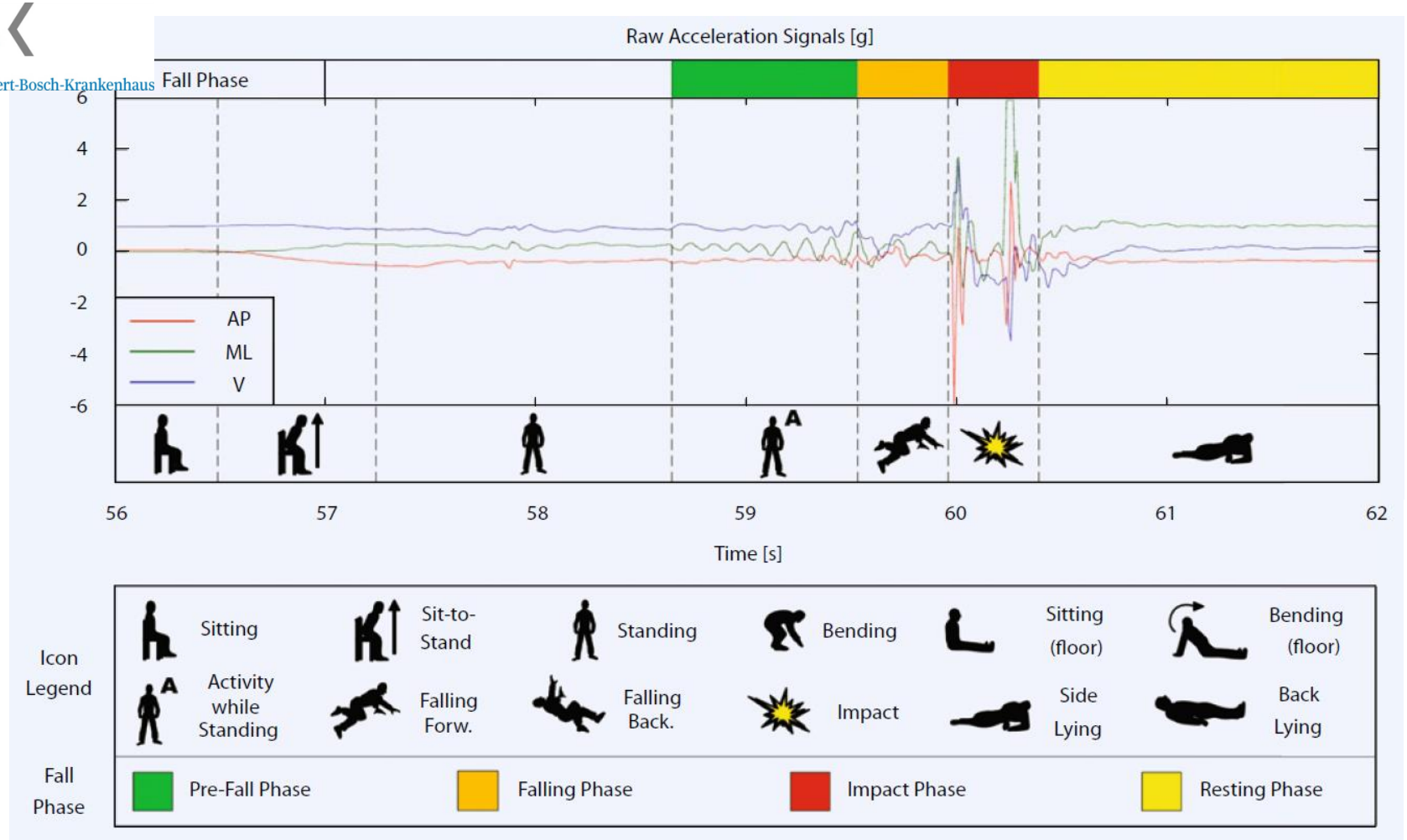
High-risk scenario: real world falls

Robert-Bosch-Krankenhaus

Samsung Galaxy S II. Sampling frequency: 100 Hz, signal range ± 2g



High-risk scenario: real world falls



Populating the database

Data collected so far and systematic screening of the scientific literature

•limited methodological agreement in body-worn sensor-based fall detection

• methodological pitfall in not using a standardized fall model and fall definition

→ Standardization may improve comparability and increase quality of outcomes

• lack of contextual information concerning falls

→ research agenda should include:

- fall reporting guidelines for incident verification
- a shared fall definition and
- a shared fall data concept

• lack of real-world fall recordings

→ existing algorithms not feasible for real-world falls

Consensus Process

FAll Repository for the design of Smart and sElf-adaptive Environments prolonging INdependent living

DELIVERABLE D 6.1

Publication of standard fall data format

Document Type:	Deliverable
Dissemination Level:	PU (public)
Editor:	RBMF
Document state:	Draft
Document version:	0.2
Contributing Partners:	All
Contributing WPs:	WP6
Estimated P/M (if applicable):	8
Date of Completion:	10/07/2012
Date of Delivery to EC:	01/08/2012
Number of Pages:	45

PUBLIC DELIVERABLE

The project is co-funded by the European Community under the Information and Communication Technolo theme of the Seventh Framework Programme (FP7/2007-2013). Grant Agreement n°288940.

TABLE OF CONTENTS

Also published as: Klenk et al., Development of a standard fall data format for signals from body-worn sensors: the FARSEEING consensus. Z Gerontol Geriatr 2013 (in press)

Modelling personalised fall risk

Example: Logic Programs with Annotated Disjunctions approach

Risk Factors Ontology

- Wearable sensor
- Smarthome

OR to P(d|e)

Higher Bound LPAD

Average risk LPAD

Lower Bound LPAD

Prolog interpreter

Subject profile

Higher bound

Average fall probability

Lower Bound

Cattelani et al., LPAD-based fall risk assessment from odds ratios. Proc. CILC 2013

Modelling, designing & assessing telemedicine services

SINTEF

- We are to model, design, and assess telemedicine services for **detection of real-world falls**, **assessment of fall risk** and **exercise counseling**.
- In order to be implemented successfully in real life, technologies are being developed and tested using an iterative process. Testing in **usability laboratories** is a part of such an iterative process and can improve the technologies to be developed: smartphone apps, communication of data between an older person, a healthcare worker and a smartphone or smart house technology, and exergames.
- End-user acceptability is also measured.

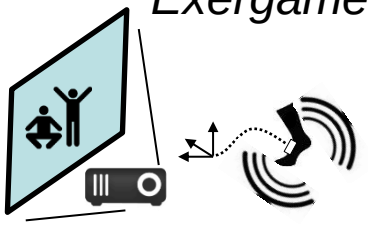
Usability Lab at NTNU, Trondheim

Self-adaptive intervention based on smart home activity

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

SEVENTH FRAMEWORK PROGRAMME

Exergames



Activity monitoring

→intensity of lying/siting/standing/walking

Barcoding of physical activity

monitoring time

Low intensity

High intensity

Measure Entropy

Change the level of exercise

Paraschiv-Ionescu et al., Barcoding human physical activity to assess chronic pain conditions. PLoS One 2012

FARSEEING

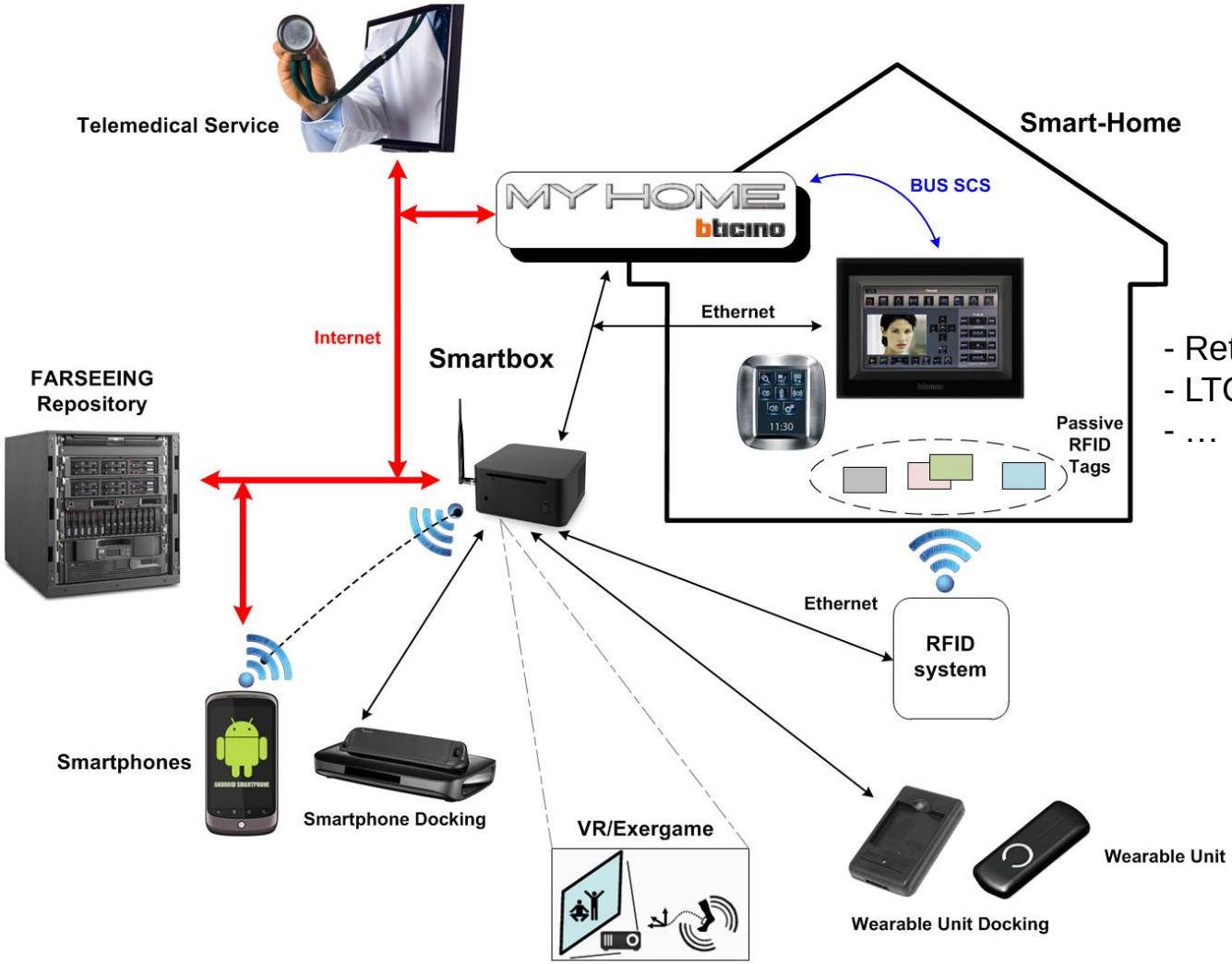
The EIP-AHA perspective

PROFITER

Prevention of Falls Initiative in Emilia Romagna

SOME INGREDIENTS

The FARSEEING Architecture



- Retirement Houses
- LTCs
- …

Smartphone Apps

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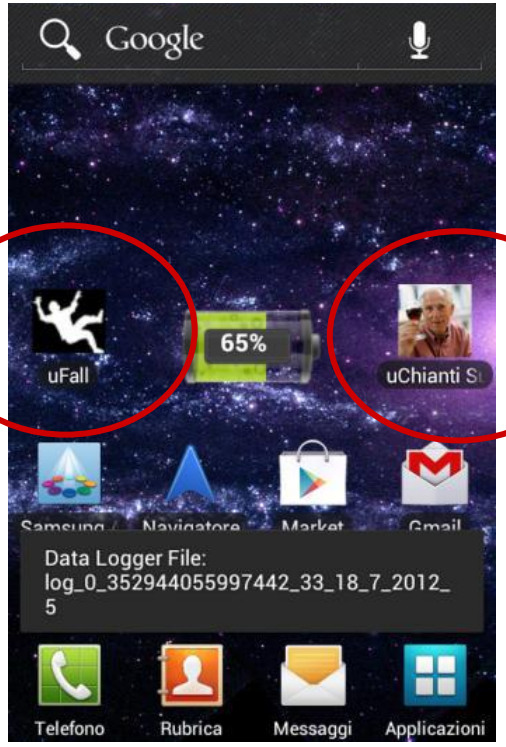
Smartphone-based solutions for fall detection and prevention: the FARSEEING approach

uFALL

uTUG



uCHIANTI

uMYHOME

http://farseeingresearch.eu/

Thanks for your attention