Dementia Ambient Care:
Multi-Sensing Monitoring for Intelligent Remote Management and Decision Support

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Introduction

- Instances of dementia increasing worldwide
  - By 2060 the people aged 80 and above will triple
  - Care ratio is decreasing rapidly as worldwide population increases

  - WHO: currently 35.6 million people have dementia
  - Every 20 years people with dementia double

- People cannot live independently
  - Hospitalization, nursing homes expensive for healthcare systems, individuals and their families
  - People prefer to stay at home, sense of independence, safety

Motivation

- ## Social impact:
  - PwD require 10 – 24 hr care per day
  - In S. Europe care is ofen provided by family members
  - PwD, family members cease to be active members of society/workforce
- ## Financial impact
  - Very expensive for families, healthcare systems
  - Aging workforce already a serious problem, fewer able people
- ## Current Clinical approach:
  - Clinical workflow mostly questionnaire based
  - Medication not effective: from 2003 – 2011 no medications approved
  - Johnson & Johnson, Pfizer and Eli Lilly studies of 5 years with 2 medications and 2400 patients, cost of 270.000.000 $: NO RESULTS

Motivation

- Technological solutions for Ambient Assisted Living:

  - Enhance clinical workflow to provide clinicians with continuous, comprehensive information of PwD, their condition and its progression

  - Provide PwD a sense of safety, increased independence

  - Relieve informal carers of financial, work, psychological burden

- First AAL solutions in the market rely on

  - Pressure, contact, motion sensors, not so much A/V

- Dem@Care:

  - Multimodal comprehensive monitoring for continuous, comprehensive lifestyle and behaviour profiling

  - Personalized adaptive feedback and intelligent decision support

  - Two closed loops: for PwD and Carers

Overview

Patient closed loop

At home treatment

Clinician closed loop

Health Status Assessment

SEVENTH FRAMEWORK PROGRAMME

Multimodal sensing

- Wearable sensors:
    - Physiological: WIMU, DTI – 2
    - Life- logging sensors: SenseCam
    - Audiovisual: wearable microphone, GoPro camera

- Ambient sensors:
    - Gear 4 Sleep Clock
    - Static camera: Sony Kinect, ASUS RGB-D

Physiological sensing – lifelogging

- Physiological sensing:
  - Objective, comprehensive picture of health: sleep quality, anxiety etc
  - Comorbidities often present with dementia
  - Rapid response in case of emergency (e.g. a fall)
  - Increased sense of safety and security for PwD and carers
- Life – logging:
  - Provides comprehensive objective picture of the person's day
  - Very helpful for reminiscence therapy, especially visual diaries

Audio sensing

- Audio recordings at the Greek Association for Alzheimers Disease and Related Disorders (GAADRD)

Audio sensing

- **Audio testing at GAADRD**
  - Tested 90 volunteers aged 65 and above
  - Healthy, MCI, early AD
  - Both genders
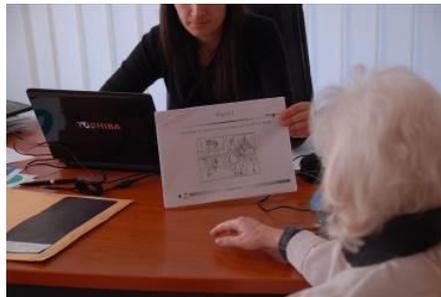
- **Tests for memory, vocal abilities under cognitive load**
  - 83.3% correct detection of the person's condition
  - Motivation for further studies with larger populations for even higher detection rates of the person's condition

Visual sensing

- **Static RGB – D camera:**
  - Person, posture localization in pre-defined areas of a room
  - Smoothed tracking, re-identification of person (e.g. after occlusion)
  - 3D geometric and semantic information, event models
  - High recognition rates for ADLs
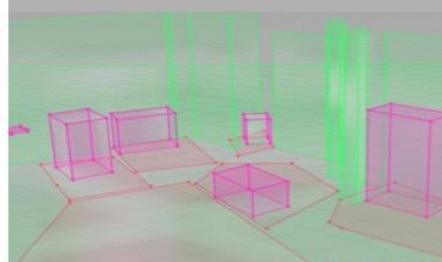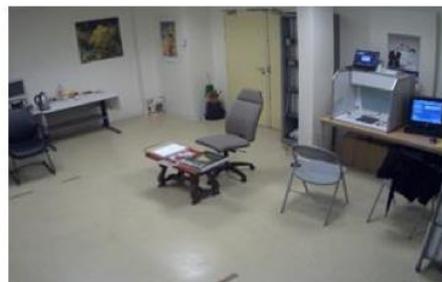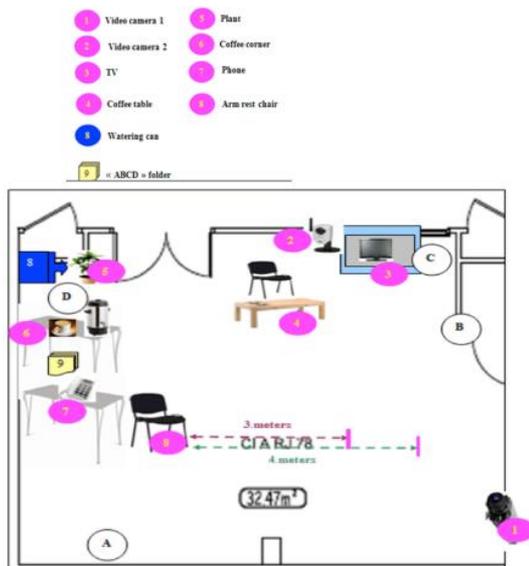
Visual sensing

- Wearable GoPro camera:

  - Saliency map extraction to improve object recognition

Visual sensing

- **Static RGB camera:**
  - Dense multi–scale sampling in Motion Boundary Activity Areas (MBAAs),
  - Tracking, extraction of HOGs, HOFs.
  - Statistical sequential change detection (SSCD) on HOFs
  - BoW - SVM framework with SoA results
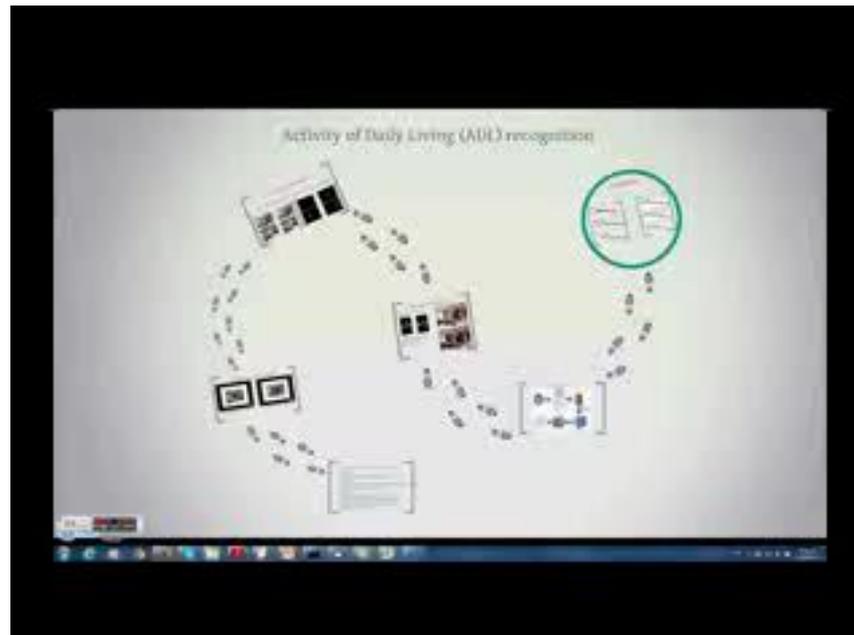
High-Level Behaviour Interpretation & Assessment
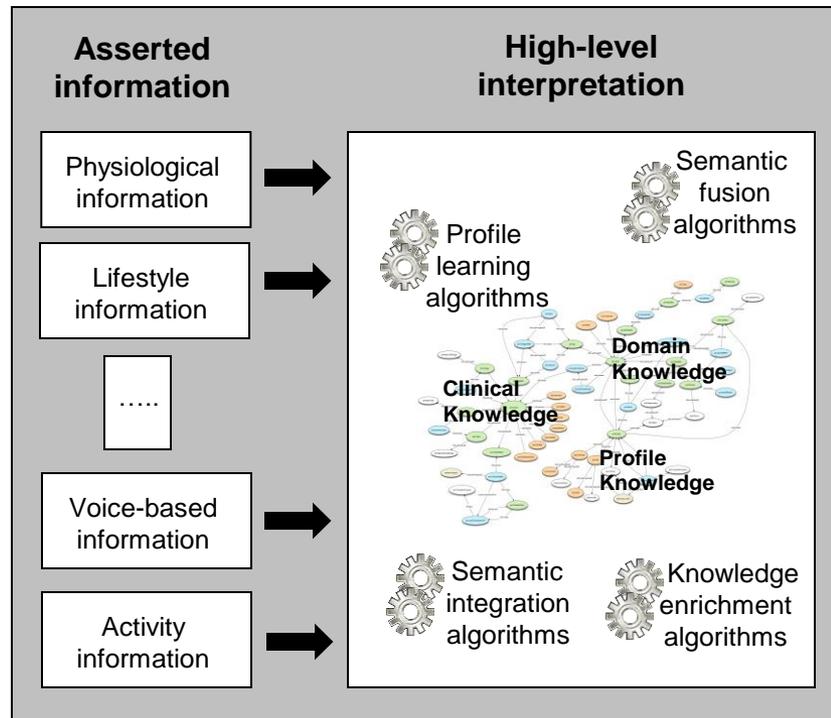
High-Level Behaviour Interpretation & Assessment

- Semantic integration of the captured low-level information and understanding of the situation (context) and behaviour of the patient
  - inference of complex activities/situations, clinically relevant situations, problems & abnormal situations, possible contributing factors, etc.
  - daily/weekly/monthly summaries for clinical follow up

- PwD behaviour profile learning & knowledge enrichment for tailored assessment
  - behaviour profiling (trends, habits & routines)
  - activity/behaviour patterns discovery & update
  - refine & enrich background knowledge (e.g. clinical assessment rules)

High-Level Behaviour Interpretation & Assessment

- **Hybrid interpretation framework**
  - enhance ontology expressivity with rule formalisms

- **OWL 2 ontologies**
  - formal modelling of sensors (cameras, microphones, etc), physiological & lifestyle observations, location & object information, voice-based indicators, atomic/complex activities, clinical problems, etc.

- **SPARQL rules**
  - temporal structure and semantics of complex activity patterns
  - abnormal behaviours recognition
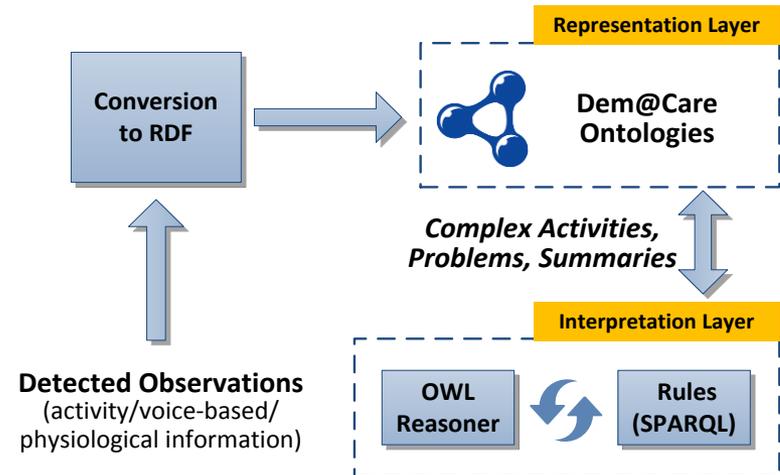
Benchmark ADL datasets

- KTH, Weizmann: very popular, simple, not ADLs

Boxing Clapping Waving

Walking Jogging Running

Benchmark ADL datasets

- University of Rochester Activities of Daily Living (URADL)
  - 12 actors behind a counter, no significant anthropometric variations
  - Constrained environment
  - Useful for quick comparisons

Benchmark ADL datasets

- **KIT Robo – Kitchen Dataset**
  - More realistic, more freedom of movement
  - 17 actors, 14 activities (more anthropometric variations)
  - Counter Top, Room Setup scenarios

Dem@Care ADL datasets

- **Recorded at GAADRD, two datasets**

- **Realistic room setup for common ADLs**

- **Anthropometric variations:**
    - Elderly participants over 65 yrs old
    - Both genders
    - With dementia (MCI to AD), healthy volunteers
    - 32 actors in the first, 25 in the second dataset

- **Informed consent of use in Dem@Care**

- **Multi – sensor recordings:**
    - Physiological: WIMU, DTI – 2
    - Audio, wearable video, static video

Dem@Care ADL datasets

Feedback to Pwd

- Very simple, discreet feedback to PwD
- Intuitive, enabling
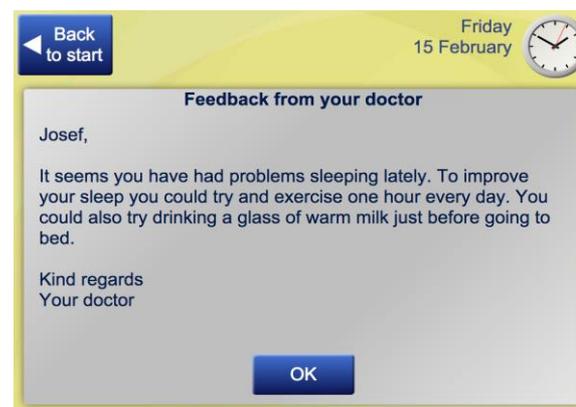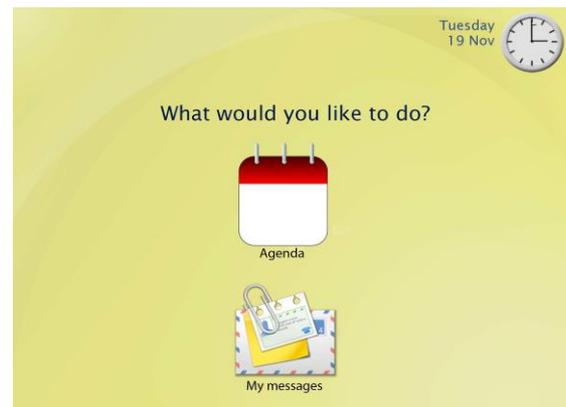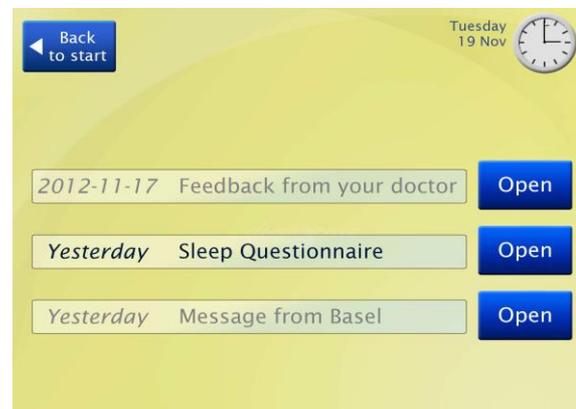
Feedback to Carers

- Very detailed, continuous, focus on problems, causes
- 5 target areas: sleep, exercise, sociability, mood, eating
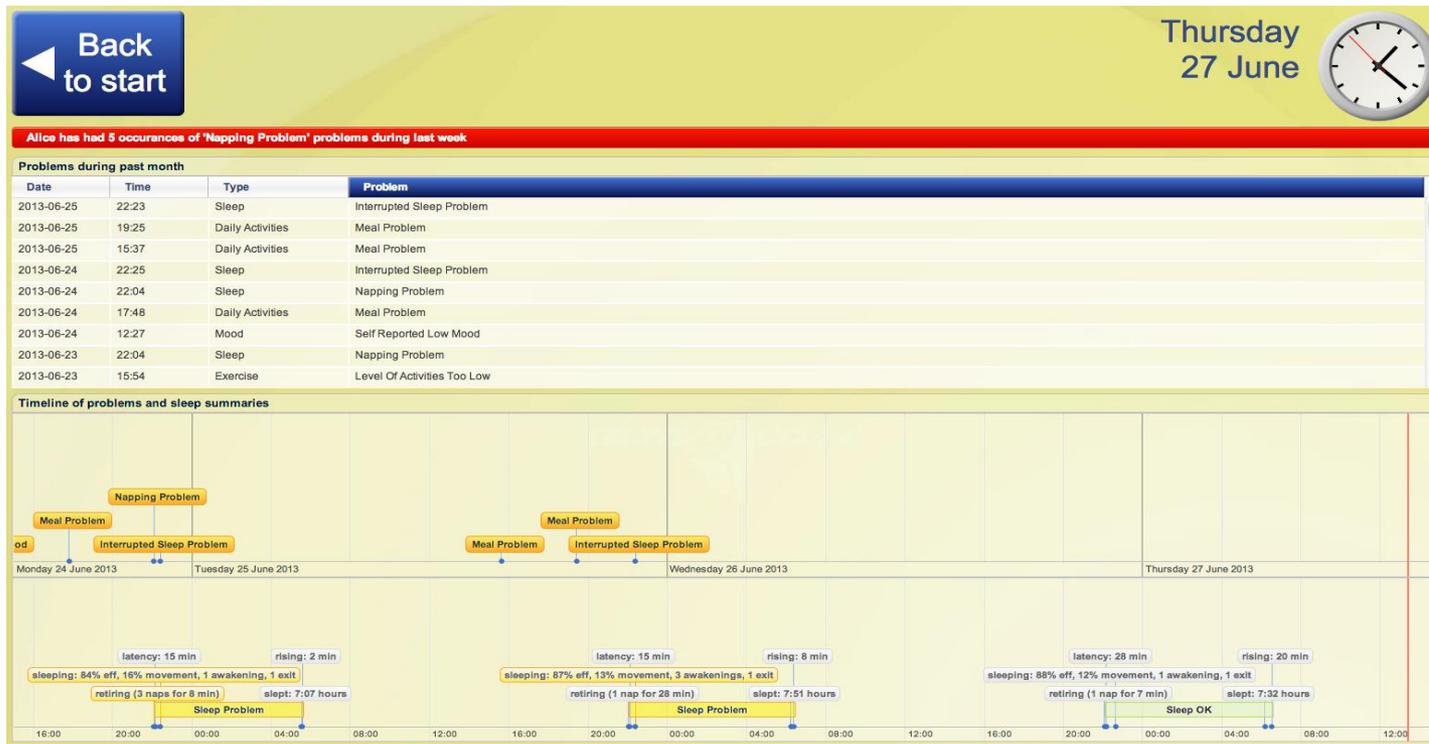
Pilot Deployments

- Three types of pilots in three countries:
  - lab, nursing home, home, France, Ireland, Sweden.

- Iterative, modular depending on the environment
- Dem@Lab:
  - In a controlled environment for clinicians
  - More precise diagnosis
- Dem@NursingHome:
  - strong focus on professional carers
  - Monitoring, alarms
- Dem@Home:
  - monitoring the daily life of PwD
  - for quality of life, respite

Conclusions – challenges

- Promising enabling technology for PwD and carers
- Numerous discreet multi-sensing solutions available
- PwD eager to participate and use such solutions

Challenges:
- Difficult to integrate multiple sensing technologies
- Recruiting significant numbers of users at–home
- Familiarity of users with technologies
- Technological advances