The DemaWare Service-Oriented AAL Platform for People with Dementia

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Outline

1. Introduction
2. State of the art
3. DemaWare Components
4. DemaWare Architecture
5. Semantic Interpretation
Introduction

- Goals
  - Timely diagnosis and assessment of People with Dementia
  - Support various target pilot scenarios
    - Labs, Homes, Nursing Homes

- DemaWare is an AAL platform to unify
  - Data retrieval from heterogeneous sensors
  - Multi-modal analysis algorithms
  - Semantic knowledge storage and interpretation
Related Work

- OpenAAL [8], FamiWare [9]
  - Support knowledge management, Service composition, fusion etc.
  - Yet lacking diverse hardware support

- Various existing middleware e.g. for smart homes
  - AIM [12], Hydra [13], aWESoME-S [11], [14]
  - Do not provide higher-level functions
DemaWare Components

- SleepClock (Gear4) logs sleep states, time, duration and interruptions
- Wristwatch (Philips DTI2) logs moving intensity, skin conductance and temperature
- An ambient depth camera (Asus or Kinect) is used for detecting the user’s location (within zones) and performed activity (Complex Activity Recognition)
- A camera closer to the user is used for activity recognition using different models (Human Activity Recognition)
DemaWare Components (2)

- A wearable camera (GoPro) is used for object, room and activity detection
- Wireless microphones are used for Offline Speech Analysis, which returns various dementia indicators
- The Knowledge Base (KB) Manager stores all detected events, measurements and activities in a semantically enhanced format
- The Semantic Interpretation (SI) module performs analysis on collected data to infer higher-level information, sensor fusion and complex event detection
DemaWare

- Some components work on various, remote platforms (OS), some online and some offline
- Need for
  - complex data transfer under common schema
  - Uniform, platform-independent API
- DemaWare unifies all components under WSDL/SOAP, using an XML/XSD Exchange Model
- Meanwhile real-time events are streamed to the KB-service
- Various GUIs visualize data according to scenarios
- GUI backend modules coordinate data collection and processing
Semantic Interpretation

• Need to integrate and process data of different sensors and modalities
  ▫ e.g. contact sensors, cameras, microphones
• By combining different modalities we can infer more about the *context*
  ▫ any information that can be used to characterise the situation of an entity (e.g. the condition of the patient)
• Use of OWL ontologies and rules
  ▫ Ontologies provide the domain vocabulary for representing activity-related contextual information (*representation layer*)
  ▫ Rules define the structure and semantics of the complex activities (*interpretation layer*)
Event Ontology
Interpretation Layer

- Hybrid of OWL reasoning and SPARQL rule execution for inference of complex activities
- Key inferencing tasks:
  - **Temporal reasoning**: SPARQL rules to identify temporal dependencies
  - **Complex correlations**: SPARQL rules to overcome OWL’s tree model property (composite activities)
  - **Assertion of new individuals**: SPARQL rules to generate composite activity individuals
Example

• Night sleep monitoring scenario in an ambient assisted living environment
  ▫ Atomic activities: \{NightSleep, OutOfBed, InBathroom\}
  ▫ Complex Activities: \{BedExit, Nocturia\}
    • BedExit: An OutOfBed incident during a NightSleep (classification of OutOfBed in the BedExit class)
    • Nocturia: An incident that involves a BedExit incident and an InBathroom incident (composition of a Nocturia incident out of a BedExit incident and an InBathroom incident)
Rule for classifying an OutOfBed into the BedExit class

CONSTRUCT {
  ?y a BedExit;
  hasClassifier ?x.
}
WHERE {
  ?x a NightSleep;
  hasStartTime ?st1;
  hasEndTime ?et1;
  hasActor ?p.
  ?y a OutOfBed;
  hasStartTime ?st2;
  hasEndTime ?et2;
  hasActor ?p.
  FILTER (:contains(\?st1, \?et1, \?st2, \?et2))
}

Rule for composing a Nocturia instance

CONSTRUCT {
   ?new a Nocturia;
   hasStartTime ?st1;
   hasEndTime ?et1;
   hasActor ?p;
   hasSubActivities ?x;
   hasSubActivities ?y.
}
WHERE {
   ?x a BedExit;
   hasStartTime ?st1;
   hasEndTime ?et1;
   hasActor ?p.
   ?y a InBathroom;
   hasStartTime ?st2;
   hasEndTime ?et2;
   hasActor ?p.
   FILTER(
      :contains(?st1, ?et1, ?st2, ?et2)
   )
   BIND(:newURI(?x, ?y) as ?new)
   FILTER NOT EXISTS {?new a [] .}
}
Conclusion

The system so far enables:

- Both real-time and offline data collection and processing
- Collection and processing of multi-modal data
- Fusion and Semantic Interpretation of data
- Various assessment scenarios
- Data visualization
Future Work

• Enrich real-time data collection
  ▫ Energy data for powered appliances
    • Detect cooking, lighting, watching tv etc.
  ▫ Motion from objects
    • Detect book reading, watering plants, taking pills etc.
  ▫ Wearable wristband
    • More acceptable 24/7
    • Detect daily physical activity patterns
• Extensive pilots to infer patterns based on data
• Extended AAL @Homes
Thank you
References