Semantic and Fuzzy Modelling and Recognition of Human Behaviour in Smart Spaces. A case study on Ambient Assisted Living.

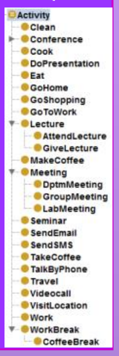
Natalia Díaz Rodríguez (ndiaz@abo.fi)

TUCS (Turku Centre for Computer Science), Department of Information Technologies, Åbo Akademi University, Turku, Finland

Department of Computer Science and Artificial Intelligence, University of Granada, Spain

One of the major limitations of the Ambient Intelligent systems today is the lack of semantic models of those activities on the environment, so that the system can recognize the specific activity being performed by the user(s) and act accordingly. In this context, we address the general problem of knowledge representation in Smart Spaces. The main objective is to develop knowledge-based models, equipped with semantics to learn, infer and monitor behaviours in Smart Spaces. Moreover, it is easy to recognize that some aspects of this problem have a high degree of uncertainty, and therefore, the developed models will be equipped with mechanisms to manage this type of information. As an added value, this system should be sufficiently simple and flexible to be managed by non-expert users, thus facilitating the transfer of research to industry. To do this, we will develop graphical models to represent human behaviour in Smart Spaces, in order to provide them with more usability in the final application. As a result, human behaviour recognition can help assisting people with special needs, in remote monitoring and many other use cases.

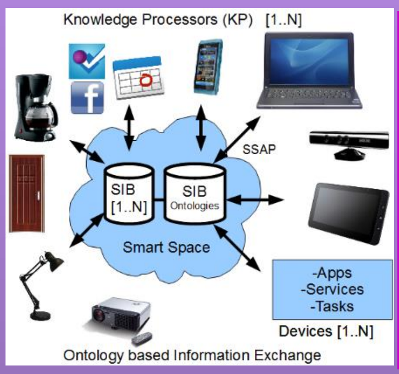
HUMAN ACTIVITY RECOGNITION: One of the biggest challenges within Ambient Intelligence and Ubiquitous computing. There is a need to tackle heterogeneous sensor information, adaptability to changes in behaviour or user, dealing with missing sensor readings, real-time recognition and reasoning with imprecise, vague or incomplete information, among others.



What is missing in existing approaches?

- Underlying semantic capabilities for context-awareness
- Support for imprecise, vague, uncertain, incomplete expressions. Human behaviour is undeterministic.
- General purpose visual language for interacting with the Smart Space in near natural language.
- As a drawback, traditional machine learning methods require re-training when new sensors/activities/users are included.

AIM: Enhance *data-driven* (statistical, probabilistic) methods with *knowledge-driven* activity recognition for context-awareness, higher level inference and more interpretable, meaningful and semantic reasoning.



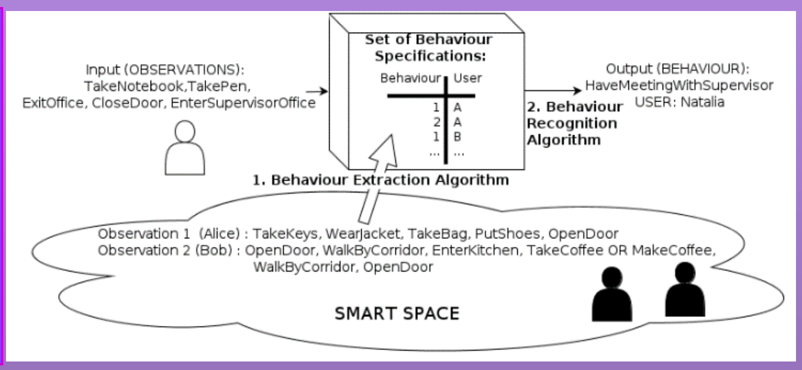
PROPOSAL:

•A fuzzy ontology for activity modelling and recognition in Ambient Assisted Living in smart environments

•A heuristics-based algorithm for real-time ontological inference of daily activities

•An architecture for adapting classical crisp approaches to support automatic uncertainty reasoning.

•A visual language model with underlying semantic capabilities for end-users with non-technical knowledge, to program the behavior of the Smart Space



METHODS

- SEMANTIC WEB TECHNOLOGIES AND ONTOLOGIES: deal with context-awareness. Machine readable standards **RDF and OWL**: independent knowledge sharing minimizing redundancy.

- FUZZY LOGIC, FUZZY ONTOLOGIES AND RULE-BASED SYSTEM to reason with imprecise and vague knowledge. FuzzyDL (Description Logics) reasoner.

- END-USER RULE-BASED VISUAL LANGUAGE for rapid development of mash-ups applications with IF-THEN rules in ubicomp environments.

RESULTS

1) A **Fuzzy Ontology** to model actions, activities, behaviours, locations, time relations and different types of users (individual and groups).

2) Combination of computer vision with semantic models that:

-Enhance context-awareness in dynamic environments

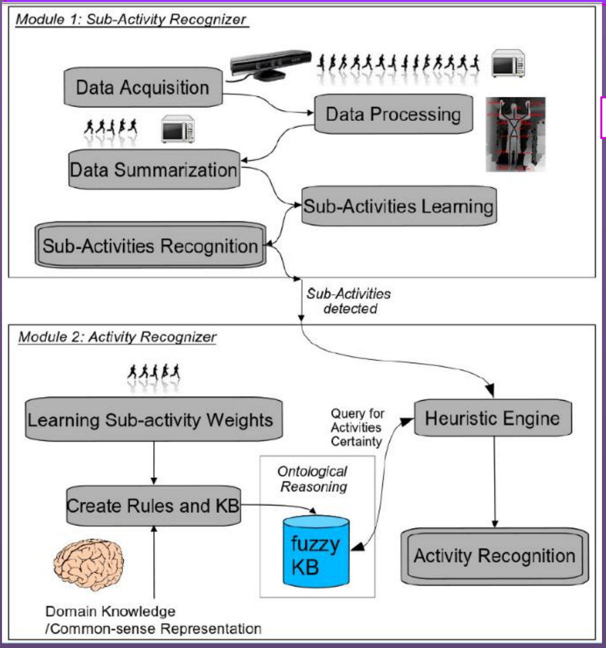
-Improve accuracy and the model interpretability and expressibility (closer to natural language)

-Avoid retraining with new input data (e.g. sensors)

3) Validation: Precision: 84.1/ 90.8%, Recall: 97.4/ 98.1%, Accuracy: 82.9/91.07 % for CAD-120 (Cornell Activity Dataset [Koppula et al.], above) in real/ ideal situation resp.

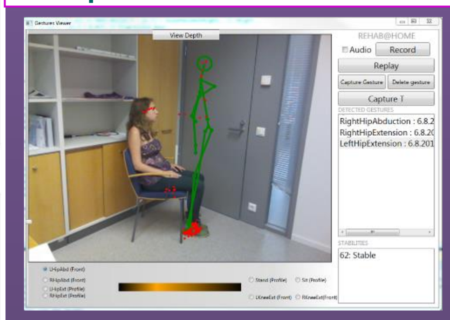
4) More robust, fuzzy modelling of human activities to tackle imprecision, vagueness & uncertainty. Easing looseness and flexibility of the model.

5) Our **visual language** allows: User-customized applications, No knowledge of programming nor Semantic Web required. Graph based, simple IF-THEN rules, Publish/subscribe architecture (Smart-M3). Support for modelling imprecise knowledge.

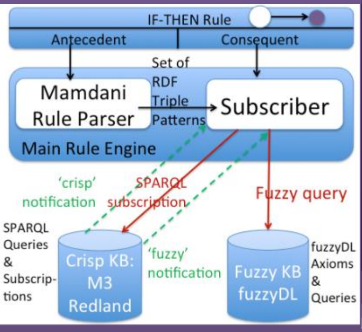


<- Hybrid Activity Recognition

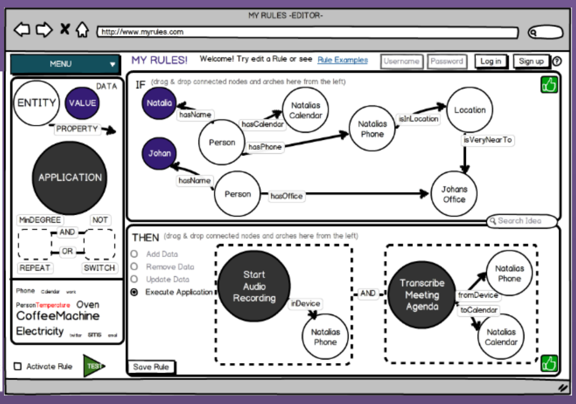
Example:Remote Rehabilitation



Hybrid Crisp/ Fuzzy Architecture



Mapping Visual Rule to SPARQL Query



***APPLICATION DOMAINS*:** Smart Spaces, home automation, e-health, active healthy ageing, monitoring systems, process guidelines–e.g. nursing-, remote rehabilitation, etc.

FUTURE WORK: Multi-user scenarios, parallel/interleaved activities, An alternative reasoner that supports retractability for continuously changing data streams for more efficient and consistent knowledge inference. Big data scaling for real-time assistance.