Hybrid possibilistic and probabilistic semantic modelling of uncertainty for scalable human activity recognition

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1 Introduction: Activity Recognition in Artificial Intelligence

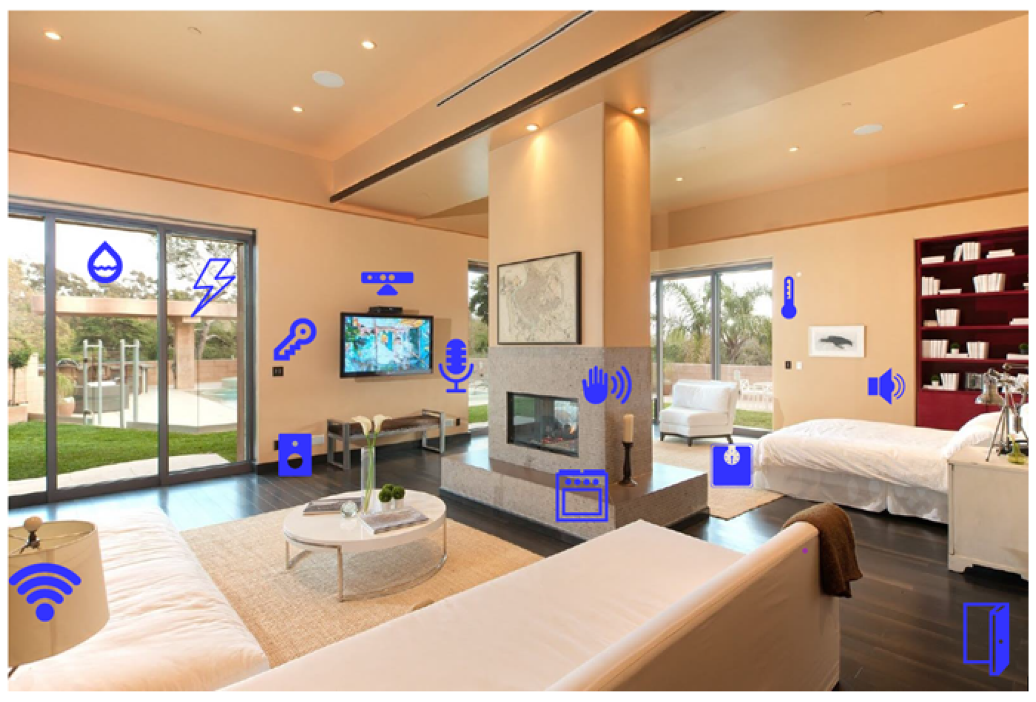

Figure 1: Activity recognition in Ambient Intelligence [1]

Human activity recognition (Fig. 1) is a challenging but crucial task in Ambient Intelligence and Ambient Assisted Living because it requires:

- Context-awareness and heterogeneous sensor data.
- Large amounts of annotated data for a robust model.
- Expert domain knowledge representation to achieve interpretable models and automatic reasoning.
- Handling diverse uncertainty sources: missing sensor readings, sparse, incomplete, imprecise or vague data [2].

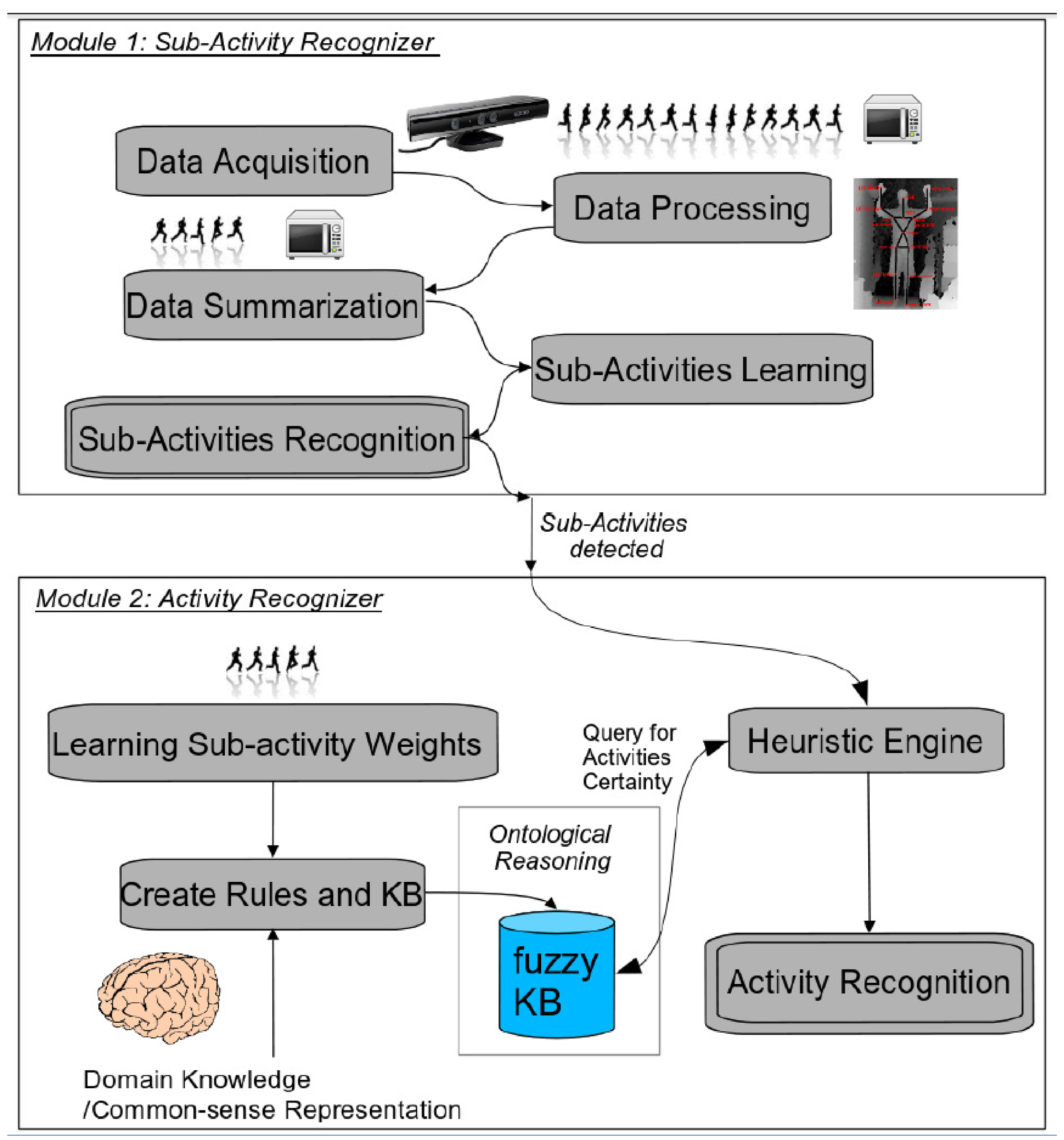

Figure 2: Current hybrid activity recognition system [2]

2 Research Questions

Current systems for activity recognition use hybrid data-driven and knowledge-based techniques. For instance, accurate and robust activity recognition can be achieved by combining supervised machine learning, together with semantic technologies such as ontologies and fuzzy logic[1][4, 2]. However, many challenges remain:

- Multiple human sensing (parallel/interleaved activities).
- Automatic ontology learning and evolution (the challenge is to decrease the considerable amount of work to model knowledge with rules).
- Scalability while preserving real-timeness.

We aim to answer:

- Can we automatically and seamlessly blend supervised and unsupervised learning, i.e., semantics and statistics?
- Can machine learning be used to facilitate the extraction of interpretable, intuitive and rich rules and classes when these are unknown, or vaguely expressed?

[1]fuzzyDL: http://gaia.isti.cnr.it/straccia/software/fuzzyDL/intro.html
[2]PSL: http://psl.umiacs.umd.edu

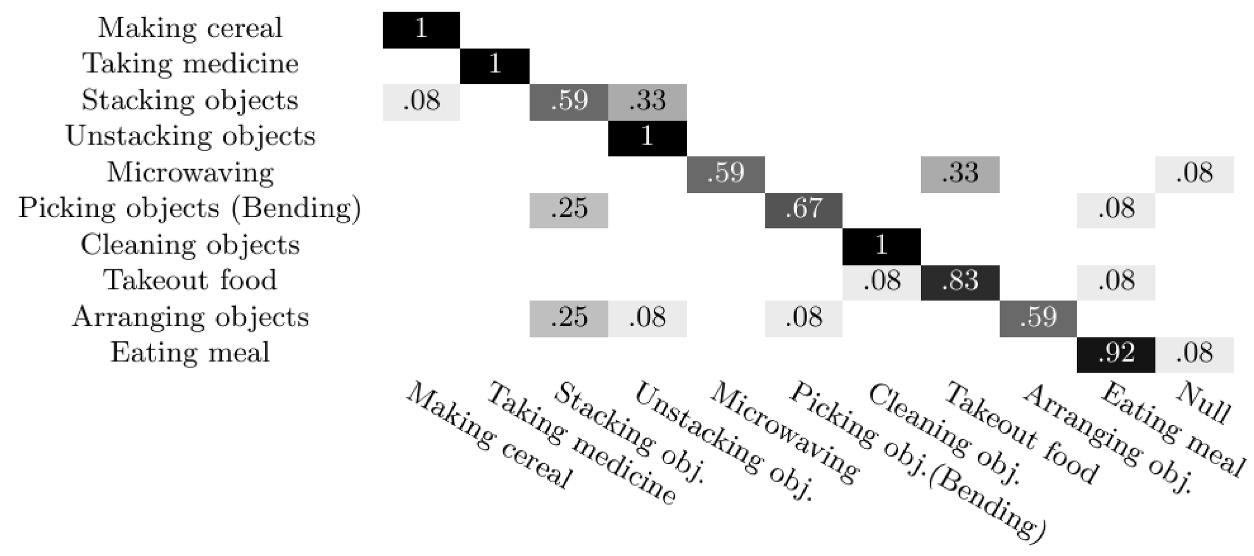

Figure 3: Confusion matrix for activity recognition accuracy [2]

3 Proposal: Activity Recognition with Probabilistic Soft Logic

PSL is an open source probabilistic modelling framework[2][3] that expresses collective inference problems and maps logical rules to convex functions (defining a hinge-loss Markov Random field):

- *Predicate*: relationship, property or role.
- *Atom*: (continuous) random variables.
- *Rule*: dependencies or constraints.
- *Set*: define aggregates.
- PSL Program = Rules + Input Database.

PSL supports declarative features, and lifted models which capture common repeated patterns of dependencies, and serve to define semantics using fewer parameters and better generalization when exploiting commonalities. PSL provides scalable (convex optimization) learning (through most probable explanation (MPE) inference).

PSL applications include image segmentation, stance-detection in forums, sentiment analysis, drug target prediction, latent social groups and trust, ontology alignment, recommender systems, knowledge graph extraction, document classification, spammer detection, etc.

Example of PSL rule:
m.add rule: performsMove(MedicineBox, P, T1) & PerformsDrink(WaterGlass, P, Tn)) $\gg$ *PerformsTakingMedicine(Tn), weight : 10;*

Figure 4: CAD-120 Cornell Activity Dataset [4]

4 Expected Results

By adding PSL as a probabilistic component to the symbolic, semantic, and possibilistic system in [1, 2] , the objective is to:

- Improve scalability to real life datasets for online, real-time recognition.
- Reduce (domain expert) knowledge engineering manual work.
- Automatically capture cyclic dependencies, and learn rule weights & latent variables.
- Handle time in data streams naturally.
- Adapt dynamically to changes, through ontology learning and evolution, e.g., for distinguishing between regular events and anomalous (accidental) ones.

Acknowledgements

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