MEDNARODNA PODIPLOMSKA ŠOLA JOŽEFA STEFANA

JOŽEF STEFAN INTERNATIONAL POSTGRADUATE SCHOOL

Context-Aware MAS for Remote Elderly Care

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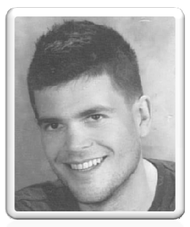

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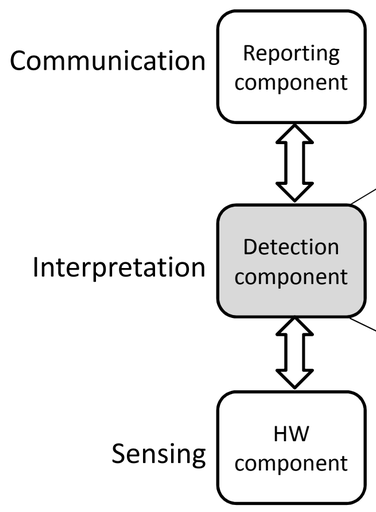
MULTI-AGENT SYSTEM (MAS)

A multi-agent system is a collection of software agents that work in conjunction with each other cooperatively or competitively to achieve some individual or collective task. Multi-agent systems can be used to solve problems which are difficult or impossible for an individual agent or monolithic system to solve.

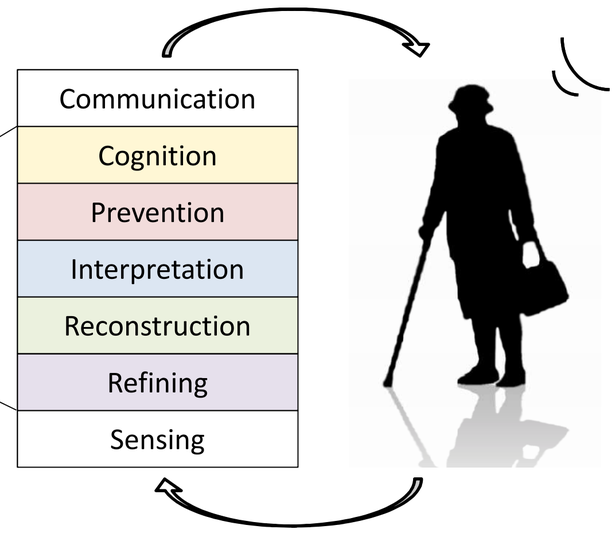
REMOTE ELDERLY CARE

Care at home is often preferable to patients and is usually less expensive for care providers than institutional alternatives. New developments in assistive technology are likely to make an important contribution to the remote care of elderly people improving older people's safety, security and ability to cope at home. Systems introduced in this context are mainly focused on fall detection, meaning that they are capable of recognizing simple hazardous situations, triggering alarms and notifying caregivers or relatives.

Components of a typical care system architecture

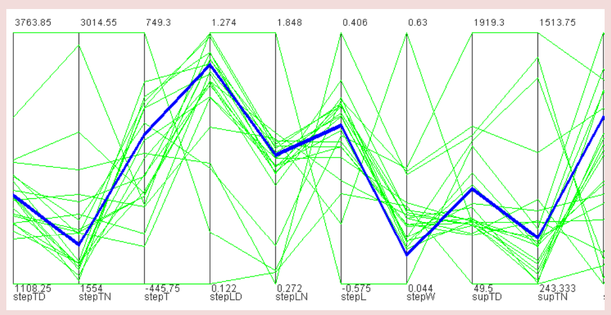


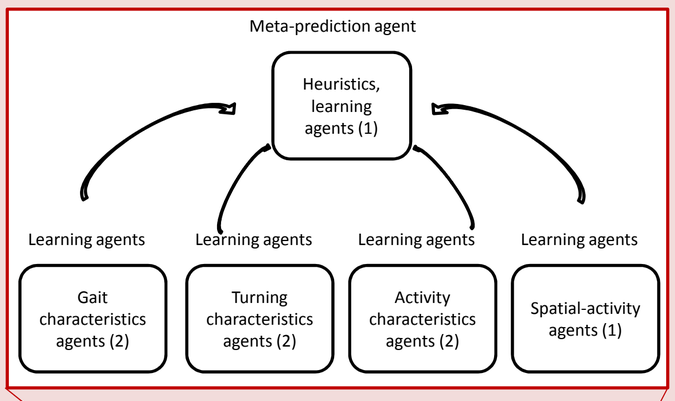
Cognitively-enhanced architecture



OUR SOLUTION

We aim at augmenting the scope of detection component (marked gray) by enriching it with more complex schemes for reconstruction, interpretation and prevention. In particular, we present a complex MAS architecture able not only to detect falls from sensor data but also to reason from context and moreover, to recognize unusual behavior as an indicator of a potential health problem. On the right is illustrated the subsumption architecture that organizes agents into groups, and groups into hierarchical context awareness. The architecture is further elaborated below in the middle figure presenting interactions between agent groups. Particular group is presented in one of the surrounding boxes with corresponding color.





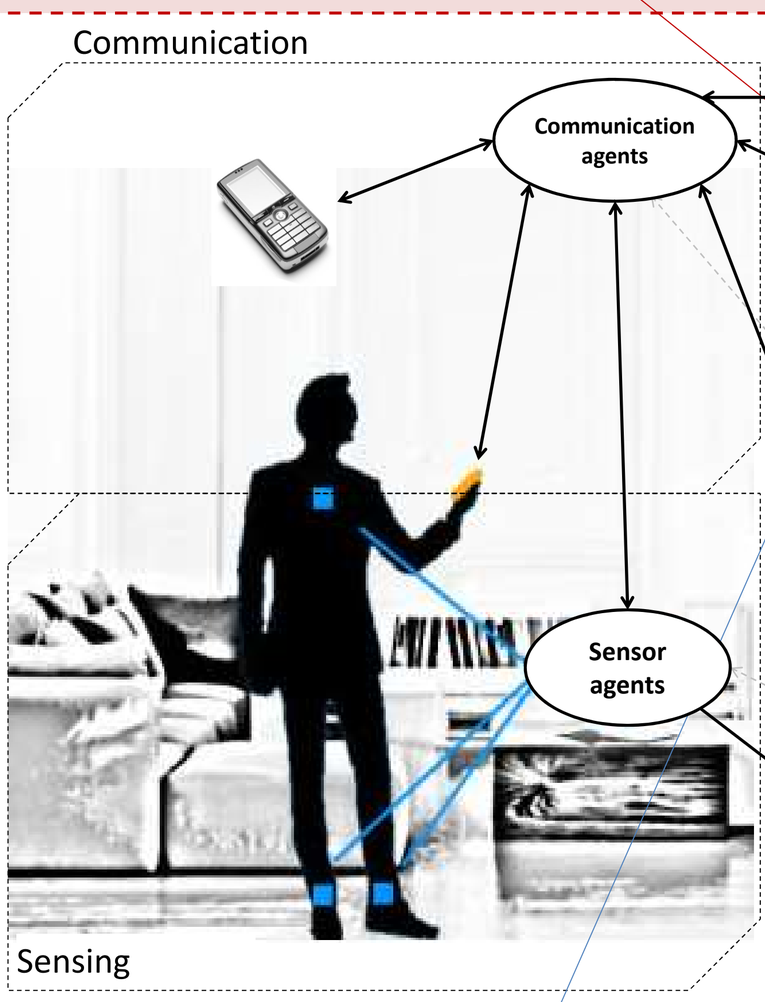
PREVENTION AGENTS

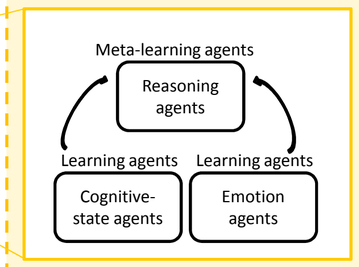
A set of agents observe user's behavior, where each of them collects specific subset of behavior data ranging from posture characteristics to daily activities. These agents automatically build behavior models that are constantly updated and classify the current behavior to recognize changes that might lead to a disease or illness. Since each agent only partially observes user's behavior, an integration agent collects their observations and merges them into the final behavior observation.

Figure on the right shows measured behavior of gait characteristics agents. Each measured attribute is presented on one vertical axis, while green intersecting lines are previous measurements of normal behavior. New measurement, marked with blue line, represents new measurement.

RESULTS

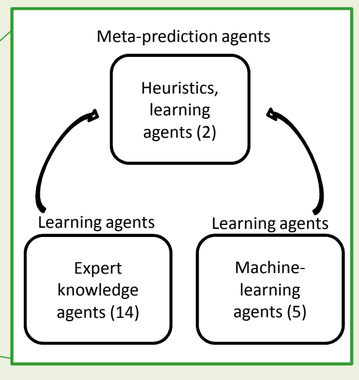
We have designed two sets of experiments showing the capabilities of the interpretation and prevention group of agents. The first experiment was devoted to fall detection where we presented complex situations that can be easily misinterpreted by an acceleration-based fall detector. The system successfully recognized all falls and had some problems recognizing sliding from the chair. However, the system raised only one false alarm, achieving overall accuracy of 91.33 %. The second experiment verified how the prevention group of agents adapts to a person and detects disabilities. After two training days, the user started limping (third day) and walking slow (fourth day), which was successfully recognized by at least one statistics-agent group.





COGNITIVE AGENTS

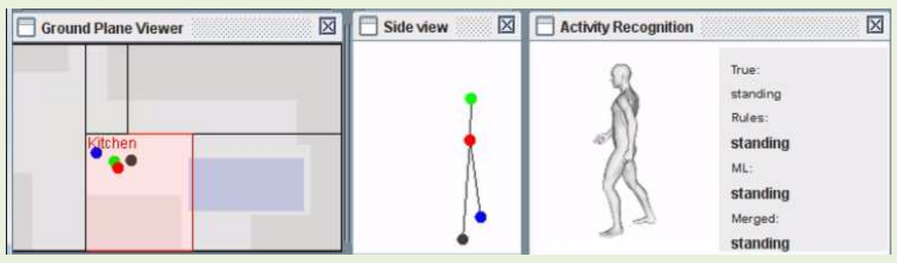
The system design includes the cognitive state of the user, although not implemented yet in the tested version. The cognitive layer will include the attributes related to the cognitive state of the user (heart rate, blood pressure, voice etc.), thus constructing not only the physical, but also the cognitive state of the user. These agents use the cognitive state to perform reasoning on a wider spectrum of information with an integrated reasoning strategy.



RECONSTRUCTION AGENTS

The reconstruction agents determine location and posture of a person at a specific time. There are two competitive agent groups performing this task, namely machine-learning and expert-knowledge agents. The final decision is made by meta-prediction agents that combine their classifications by exploiting the power (accuracy) of particular agents.

Three figure below show: top view of the apartment (left) indicating area where the user is; side view (middle) showing skeleton of the user as seen; and recognized activity (right), i. e. how the system perceives the current posture of the user by various agents.

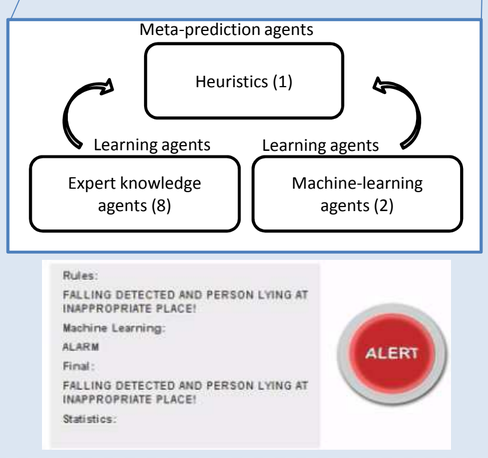


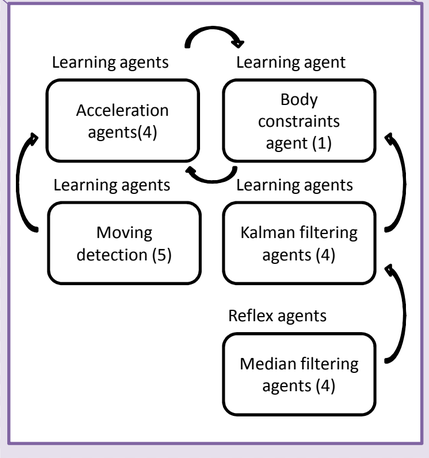
INTERPRETATION AGENTS

The interpretation group of agents contracts physical awareness of a person in the environment and detects emergency situations which are caused by a fall or a sudden health problem. These situations are reflected by a person lying or sitting at an inappropriate place (e.g. on the ground) for a prolonged period of time.

The group is structured similar as the reconstruction agent group: it consists of expert knowledge agents, prediction agents based on machine-learning algorithms, while the final decision is made by the meta-prediction agent.

The image below group architecture shows explanations of alarm messages triggered by the particular subgroup.

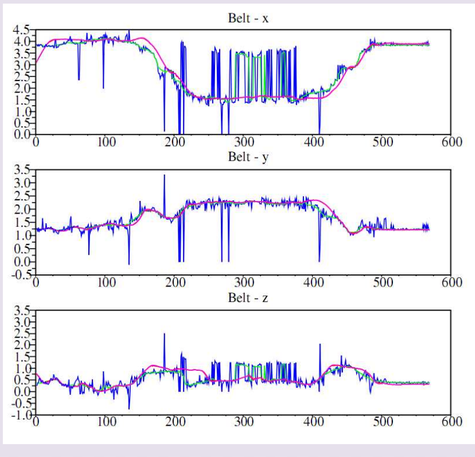




REFINING AGENTS

These agents filter noise (using not only one method such as Kalman's filter, but five independent methods in the form of agents that provide their observations), compute derived attributes and map raw data with the human body model. In this way they provide a uniform presentation of all available data of the body.

Three graphs on the right present *x, y* and *z* coordinates of a tag attached to the belt. The vertical axis is distance (meters) while horizontal axis is time (1/10 of a second). The blue line presents original data as provided by sensing agent, the green line is after the median filtering is applied and the red line after the agent that takes into account constraints of human body.



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