ADAPTIVE WORKFLOWS OF HOME-CARE SERVICES

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Addressed problem and motivation

A framework for adaptive home-care services
- Proposed approach
- System architecture

Adaptive monitoring plan generation
- The adaptation loop
- Runtime model for monitoring plans
- A case study: monitoring the user lunch

Conclusion & future work
Ambient Assisted Living (AAL) is opening new frontiers in healthcare domain.

Multiple and independent units (robots, cameras, microphones, wearable sensors etc.) coexist and cooperate to assist patients in their daily routine.

Social robots will be used in the next future in many application domains, which span from entertainment, education to health-care.

Socially Assistive Robots focuses on helping human users through social rather than physical interaction

**Personal Assistance:**
Monitoring and Reminders -> Improve Wellbeing

**Entertainment:**
Activity Suggestions -> Prevent Cognitive Reserve

**Stimulation:**
Cognitive exercises
Each user has their own personality, health conditions, and needs which may vary and evolve over the time.

Assistive technologies may require structural intervention in patient’s home incurring in high deployment cost

Assistive technologies may cause discomfort, so leading to low acceptability

Assistive tasks are provided by heterogeneous devices that need to coexist and cooperate to assist patients

Changes may occur in both patient’s state and environmental conditions
The patient’s home is equipped with cheap assistive technology avoiding structural interventions.

The system takes into account the user cognitive and personality profile.

A software infrastructure that generates adaptive plans to monitor the adherence of patients to their daily routine.

An assistive plan is represented as workflow of services, where each service represents a monitoring task.
Why Service-Oriented approach?

To represent the heterogeneous tasks involved in the monitoring plan in a uniform way

To decouple the functionalities required for a monitoring plan from the way they are performed

To adapt/change part of the workflow as soon as certain events are detected
The proposed system architecture is adopted:

Smart Environment

SOA Middleware

Data Layer
he patient’s home is equipped with a variety of sensors and actuators. In this project the following devices are deployed:

- A Pepper robot
- Turtlebot 2
- iBeacons
- Polar M600 Smartwatch

Avoid structural intervention keeping the deployment cost as low as possible.

Different devices allow performing the same assistive tasks with different interaction modalities.
leverage the following data to encode the user’s profile:

**Daily Routine:** a set of daily activities that the user has to carry out throughout the day

**Personality Profile:** assessed through the Neo-pi-3 test. Big-five factors (neuroticism, openness, extraversion, conscientiousness, agreeableness)

**Cognitive Profile:** assessed through the CDR (Clinical Dementia Rating) test. Cognitive abilities (education, attention, memory, fluency, language, visuospatial)

The user’s profile is modeled as a set of predicates in a logical formalism:

```
patient("John");
autonomy("John", high);
state("John", normal);
acceptance("John", high);
```
Goal: functional specification of desired states to be addressed. The middleware adopts linear temporal logic to express temporal-dependent conditions.

Abstract capability: high-level description of a service. It defines a contract, i.e. when/why the corresponding service may be executed.

Concrete capability: realizes an abstract capability by encapsulating all the details of a real implementation of a service as offered by a service provider. Characterized by non-functional attributes (QoS).

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check Posture</td>
<td>Estimates the patient’s posture e.g. “sitting”, “walking”, “standing”, “lying”</td>
</tr>
<tr>
<td>Check Location</td>
<td>Provides patient’s location e.g. “kitchen”</td>
</tr>
<tr>
<td>Check Heart Rate</td>
<td>Provides the patient’s heart rate</td>
</tr>
<tr>
<td>Check Activity</td>
<td>Check if a certain activity is being done</td>
</tr>
<tr>
<td>Remind Activity</td>
<td>Reminds user of a planned activity</td>
</tr>
<tr>
<td>Remind Medicines</td>
<td>Reminds user to take medicines</td>
</tr>
<tr>
<td>Alert Caregiver</td>
<td>Alerts caregiver for unexpected/dangerous situations</td>
</tr>
</tbody>
</table>

**TABLE I**
A subset of Abstract Capabilities

<table>
<thead>
<tr>
<th>Name</th>
<th>Service Provider</th>
<th>Reliab.</th>
<th>Inte.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ask Patient [Activity]</td>
<td>Patient (human)</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Ask Caregiver [Activity]</td>
<td>Caregiver (human)</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Robot Estimate [Activity]</td>
<td>Pepper (robot)</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Sensor Estimate [Activity]</td>
<td>Smart-watch (device)</td>
<td>Low</td>
<td>None</td>
</tr>
</tbody>
</table>
The feedback-loop for the monitoring plan generation and adaptation:
Goals are triggered by conditions and observations.

To achieve a goal, the Proactive Means-End Reasoning combines abstract capabilities.

The QoS manager instantiates each abstract capability considering the user’s profile.
Starting from a triggered goal the system generates an abstract workflow, composed of abstract capabilities:
Each abstract capability has to be instantiated by a concrete one and executed:

```
patient("John");
autonomy("John", high);
state("John", normal);
acceptance("John", high);
```
During the execution, muted conditions may require reconfiguration of the whole workflow.
During the execution, muted conditions may require reconfiguration of the whole workflow.

patient("John"); autonomy("John", high); state("John", agitated); acceptance("John" low);
A robotic system for monitoring the Activities of Daily Living of home patients affected by mild neurological disorders

A middleware for automatically generating personalized monitoring plans adapted to specific patient’s needs

The plan is not completely defined at design time and its generation is based on a dynamic orchestration of services

The actual service implementations are selected according to the way a monitoring activity is carried out, represented in terms of QoS parameters evaluated against patient’s profile

Future work regards the refinement of concrete services selection mechanisms by introducing fuzzy techniques for the QoS parameters evaluation