# SHARE-it Intelligent Tutorials

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**INTRODUCTION**

First part of this document is intended to give readers a general idea of the project in its extension. The introduction of the document is dedicated to explain the purpose and goals of the project, followed by a brief introduction of the context were Intelligent Tutorials were developed: SHARE-it project.

Second part of the document, starting from chapter 6, focuses on the specification of the system, describing some important concepts, establishing a hierarchy of actors, analyzing requirements and obtaining Use Cases. There is also a section dedicated to plan which risks might arise as the project starts and how to mitigate them.

Third part of the document, starting from chapter 11, describes the technologies used in the implementation of the system, and how the code has been programmed in order to develop the system.

Last part, starting from chapter 15, has been dedicated to explain in depth how the testing phase ran, which were the results obtained and how deviations were treated. A temporal and economic analysis of the project is also included, as well as a section dedicated to state the conclusions and to draw some future lines of research.
1. MOTIVATION

Nowadays, improvements in the quality of life are raising society’s life expectancy. Therefore, governments are currently searching for new solutions to cope with the ageing of the population, which demands alternatives for taking care of elderly people. Affordable assistive systems for patients staying alone at home are considered to be a solution to institutions and geriatrics, so that it is feasible to take care of older adults remotely.

A considerable amount of systems have been developed to help people compensate for the physical and sensory deficits that may accompany aging. Many of these do not rely on computer technology, such as lift chairs or ergonomic handles. However, an increasing number of devices rely on advanced computer-based technologies [31].

The realization of a complete system for the aid of the elderly to be employed in a complex and real environment such as a health-care institution or a home requires a tight integration of Assistive Technologies (AT), which can support elderly people with cognitive impairments in one or more of the following ways:

(1) by helping alleviate the social isolation that may stem from mobility issues,
(2) by delaying their loss of residual skills and cognitive decline, and
(3) by relieving caregivers from the need of full time care.

Additionally, institutionalization has an enormous financial cost, not only for elders and their caregivers but also for UE governments, which normally pay for nearly 60% of their annual nursing home bill [28]. Therefore, the major scale uses of AT represents a potential saving of enormous amounts of money.

The main purpose of using Intelligent Tutorials (IT) in the context of AT is to develop an intelligent and semi-autonomous system for elderly people with disabilities to assist them on a daily routine, so they do not have to entirely depend on a caregiver. This possibility would increase their quality of life and, at the same time, delay their institutionalization.

Another motivation point in creating such an assistive tool lies in the improvement of the user’s acceptance, mainly in terms of the impact the use of intelligent systems providing medical
services has on elders. Much of the reluctance to use these systems simply arose because AT devices do not fit naturally into the process of care and, as a result, using them requires additional effort. It is also true, but perhaps dangerous, to ascribe some of the reluctance to use AT upon the technophobia or computer illiteracy of healthcare workers and caregivers. Therefore, IT have been designed to be perceived beneficial by users, because otherwise, independently of its true value, they will probably be rejected.

Issues which need to be addressed when designing and implementing IT are: communication, knowledge representation, human-machine interaction and symbolic reasoning, only to name a few. The philosophy underlying this application is to enhance the quality of Elder care by employing an infrastructure of expert systems which cooperate in order to provide services. This requires the design of intelligent agents endowed with advanced learning capabilities, able to process symbolic reasoning and easy to interact with humans at a high level. Therefore, creating such a tutoring service consequently presents an important challenge.
2. PURPOSE AND SCOPE

This bachelor thesis has as its main purpose the development of an application to help individuals suffering from dementia or post-stroke to carry out indoor daily activities, so that they do not have to entirely depend on a caregiver. Users have available a personalized range of tutorials according to their physical and cognitive impairment, which also determines how the information is displayed in terms of interaction.

Furthermore, IT are conceived as an assistive tool to be used on a daily basis for the work out of users with disabilities through basic Activities of Daily Living (ADLs), so that the worsening of their mental faculties and decline physical capacities can be delayed in time.

The most relevant key issues related to the elder care that IT tries to settle are described in the next section.

2.1 Key problems

Average life expectancy in the European Union is one of the highest in the world and is continuing to rise [14]. In 2000, it was 74.7 years for men and 81.1 years for women; in 2010, according to Eurostat’s base scenario, it will be 79.7 and 85.1 years respectively [30].

On the one hand, increasing longevity and increasing survival to acute accidents and diseases imply an increased prevalence of chronic morbidity and disability. Subjects affected by chronic diseases or outcomes of acute events, such as dementia or stroke, represent a heterogenous category of individuals [15]. Moreover, different conditions can be often combined with different severity in individuals users, impairing their self-dependency and worsening their quality of life.

On the other hand, elderly people account for a high percentage of hospitalisation in most European countries. Social services are placed under considerable pressure since it is widely recognised that hospitalization is sometimes not related to the patient’s acute medical condition, but to the need for rehabilitation or for social reasons, such as the lack of family support or absence of economical means.
Consequently, hospitalization is not seen as an appropriate alternative due to its cost: there is an urgent need of delaying users’ institutionalization, facilitating access to specialist care facilities and using technological solution to support their routines at home.

2.2 Tutorials’ Goals

Goals to be pursued by IT are divided according to two relevant actors: users, who might be able to carry out simple daily activities at home with the assistance of tutorials, and caregivers, who might be relieved from the effort that supposes supporting users through every basic task along the day.

In order to verify that IT are successfully achieving the defined goals, the following objectives have to be attained:

- To increase the grade of users’ self-dependency
- To enhance the cognitive functioning and physical abilities of users
- To partially relieve the caregiver’s effort in supporting the user

The ambitious goal of providing support for elders with the use of intelligent systems is not merely aimed at automating certain tasks. The implementation of IT is motivated by the necessity of providing constant care and support for people with disabilities, providing decision making, reminding and warning functionality. Such complex tasks necessarily involve teams of technologies, intelligent sensors and physician’s knowledge.

2.2.1 What the system does not do

IT are intended to support certain ADLs\(^1\) with the purpose of getting users to be more independent on daily routines while they exercise their cognitive abilities such as coordination

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\(^1\) Refer to section 6.2 for detailed explanation of the ADLs
and attention. Collaboration from caregivers is required in order to fulfill the initial and final conditions and solve any unexpected problem.

The range of tutorials designed do not contemplate those involving the user’ mobility on activities such as walking around the house or transferring from beds to chairs. IT not intended neither to substitute caregivers nor to be a tool for rehabilitation, although it can helpful for the users’ functional enhancement.
3. STATE OF ART

IT are based on two different systems:

- the conceptual pattern correspond to the Intelligent Tutoring Systems (ITS), which are based on the learner model, a model constructed from observation of interactions between a learner and a learning system or instructional environment [27].

- the technology used for IT implementation as an intelligent service is a Multi-Agent System (MAS), where several agents considered to be autonomous entities interact with each other in order to share a common goal o pursue their own interests.

Following, both systems are introduced as well as some similar existing systems to be a reference in the AI field regarding technologies for the cognitive support.

3.1 Intelligent Tutoring Systems

Many traditional instructional tutorials present learners with facts and concepts. These methods are effective in exposing people to large amounts of information and testing their recall. By contrast, other systems use simulations and other highly interactive learning environments that require people to apply their skills [8].

ITS typically rely on three types of knowledge, organized into separate software modules [9]:

- The expert module represents subject matter expertise and provides the system with knowledge of what is being taught. It is a computer representation of a domain expert’s subject matter knowledge and problem-solving ability. Regarding IT, expert module is represented by the medical knowledge, especially in terms of guidelines for the proper design and specification.

- The learner module represents what the user does and does not know letting the system know who it is teaching. It evaluates each user’s performance to determine his/her knowledge, perceptual abilities, and reasoning skills.
The *instructor module* enables the system to know how to teach according to the user profile, by encoding instructional strategies used via the ITS user interface.

Plus, ITS include a subsystem for the *interface module*, which provides the means for the final user to interact, usually through a Graphical User Interface (GUI) and sometimes through a rich simulation of the task domain the user is being told to do.

### 3.1.1 Existing ITS for cognitive support

**COACH (Cognitive Orthosis for Assisting aCtivities at Home).** A very similar system to IT in terms of functionality, uniquely aimed at users affected by dementia and based on prompting.

COACH is a prototype of an intelligent, supportive environment being developed to help people with dementia complete ADLs with less dependence on a caregiver. This work represents one of first clinically tested supportive devices to use artificial intelligence techniques. It uses a personal (desktop) computer and a single video camera to unobtrusively track a user during an ADL. By sophisticated estimation of a user’s progress through a task using Bayesian filtering techniques, COACH provides pre-recorded (visual or video) cues to the user when necessary.

This system is divided in different modules, each of which has a different and essential tasks like identifying the users position, deciding to take certain steps depending on the state, or prompting some of the available actions [21].

COACH uses an ubiquitous modeling technique that can adapt to users over time: the POMDP model. The idea is to have a single model and learning technique that can be easily applied to different tasks, without the need to re-engineer the model. The key strengths of the POMDP model are that it is able to deal with uncertainty, it is easy to specify, it can be applied to different tasks with little modification, and it is able to learn and adapt to changing tasks and situations [16].
**SHARE-it Intelligent Tutorials**

**MAPS (Memory Aiding Prompting System).** Another system which also uses tutoring techniques as well as AI technologies is MAPS, which breaks down a task into constituent parts and uses images and verbal instructions for prompting each step. The MAPS project has been designed using the perspective that high functioning assistive technology has two equally important user interfaces: the person with cognitive disabilities and the caregiver.

Computationally enhanced prompting systems can provide a bridge to independence. Unacceptable abandonment rates for high functioning assistive technology are partially driven by difficulties in (re)configuration of the device; typically by a caregiver who is not necessarily technically savvy [4]. MAPS provides an environment in which caregivers can create scripts that can be used by people with cognitive disabilities, so that the system is manually personalized for the specific needs of the user.

This system is strongly based on hardware: a PDA provides error correction functionality via dynamic scripting and ‘panic button’ functionality, while a PC based application provides tools for script creation, modification and sharing with other users. Several different interfaces are displayed depending on the user (patient, installer, caregiver).

**LISTEN’s Reading Tutor.** This device is a good example of an ITS aimed at users with similar capabilities to IT’s target population: users with low reading ability and low cognitive skills.

The Reading Tutor intervenes when the reader makes mistakes, gets stuck, clicks for help, or is likely to encounter difficulty. It may intervene before a story (e.g. to preview new vocabulary), before a sentence (e.g. to insert an automatically generated comprehension question), during a sentence (e.g. to give help on a word), and/or after a story (e.g. to review or post-test words from the story). The system responds with assistance modeled after expert reading teachers but adapted to the technology’s capabilities and limitations [17].

Its interface is designed to keep the interaction simple and to focus attention on the text. Users pick which story to read next, which are composed of a few types of steps.
LISTEN’s also pursue the update of the user cognitive state, continually estimating the users’ reading ability based on how long they hesitate before each word they read. The system later uses this data to adjust the level of stories it chooses on its turn.

### 3.2 Multi-Agent Systems

Agent-based systems technology is particularly attractive for creating software that operates in environments that are distributed, such as elder care institutions and users’ home. As AT get more mature and address increasingly complex applications, the need for systems consisting of multiple agents that have a peer-to-peer communication is becoming apparent [14].

A MAS is a system composed of multiple interacting software entities called *Agents* which continouslsy perform multiple functions: perception of dynamic conditions in the environment, reasoning to interpret perceptions, and determination of the actions to solve problems [32].

![Multiple functioning Agent](image)

**Figure 1.** Multiple functioning Agent

Agents collaborate among themselves interacting through a set of reciprocal actions to achieve the pursued objectives using particular mechanisms and protocols.
An agent dynamically constructs explicit control plans to guide its choices among situation-triggered behaviors. Each agent composing a MAS may have its own task and role, and sometimes a stronger notion is added (Beliefs, Desires, Intentions) [26]. Agents and Multi-Agent Systems are used as a metaphor to model complex distributed processes.

A distributed system is considered to be a collection of independent systems that appear to the users as a single system. Both hardware and software components, which are distributed and connected by network, coordinate and communicate its actions through messages in order to reach a goal. Communication is established by a client-server protocol.

Both approaches share the notion of ‘distributedness’. The area of distributed agent computing is the area in which these approaches intersect, enabling and supporting large-scale, secure and heterogeneous processes.
SHARE-it Intelligent Tutorials

4. SHARE-it

SHARE-it (Supported Human Autonomy for Recovery and Enhancement of cognitive and motor abilities using Information Technologies) project addresses the issues of enhancing the quality of life and independence of elderly people with cognitive and physical dysfunctions. The goal of SHARE-it is to develop a scalable, adaptive system of add-ons to sensor and assistive technology so that they can be modularly integrated into an intelligent home environment to enhance the individual’s autonomy. The system is designed to inform and assist the user and caregivers through monitoring and mobility help.

4.1 Contributions and Objectives

SHARE-it is composed by conjunction of different elements, such as sensor networks, robotic platforms or a MAS in charge of providing assistive services. IT is one of these multiple services that SHARE-it project offers, guiding users on how to carry out daily activities such as housekeeping or cooking according to the grade of their disability.

Moreover, this project is planned to contribute to the development of the next generation of assistive devices for older persons or people with disabilities, so that they can be self-dependent as long as possible. SHARE-it is focused on add-ons to be compatible with existing technologies and to achieve an easier integration into existing systems.

In this context, SHARE-it makes significant contributions to fundamental, long-term research in the following areas [22]:

- C1. Sensor-based environment perception, knowledge acquisition and representation, high-level reasoning and goal seeking behaviors in a real world.
- C2. Verifying software adaptation to human with special needs: both at design and runtime to establish safety, regulatory and security requirements.
• C3. Incorporating shared autonomy: ensuring that software components can be designed to operate in a given intelligent ambiance and adapt to possible changes both in the needs of the user or in the environment.

The objectives of SHARE-it are:

• O1. To explore the benefits of the concept of situated intelligence to build elements (add-ons) that will enhance the autonomy of the target user group in their daily life in their preferred environment.

• O2. To investigate and implement innovative forms of shared autonomy.

• O3. To build appropriate add-ons to standardized technologies to provide ubiquitous sensing, computation and assistance.

• O4. To build adaptive interfaces for the target group.

• O5. To target the various human-delivered assistance and caretaking services as effectively as possible.

4.2 SHARE-it MAS Structure

One of the software components of SHARE-it is the MAS, which in charge of the knowledge engineering, retrieving information from the environment, reasoning to interpret perceptions, and acting to pursue fixed goals. Agents get their input data from other elements within SHARE-it, such the sensor network, the medical history stored in the server, or the mobility platforms.

The MAS is composed by 5 different agents interacting among themselves in order to achieve the desired goals: Patient Agent, Environment Agent, Vehicle Agent, Home Agent and Caregiver Agent, each of them providing different services, as it is illustrated in the MAS schema below.
4.2.1 Patient Agent

The Patient Agent encases most of the cognitive support services oriented to the user such as IT (the service is also known as ADL Tutor). An instantiation of this agent should provide all the available and permitted services to each user such as security, mobility, monitoring and help. Those services will be offered depending on the user disability, so that not only a complex profiling work has to be done with the user, but also a definition of the services to be launched and how to adapt them to the user.

The Patient Agent is in charge of all the functions related to ADLs, such as keeping a track of the current ADLs being performed by the user in order to determine if something important has
been forgotten. This agent is also responsible for managing reminders and requesting help from caregivers on demand or under a set of particular circumstances.

4.2.2 Environment Agent

The Environment Agent gathers information from the environment and gives it semantic meaning relating it to ontological concepts (e.g. the location) used by the agent system [33].

In terms of functionalities, this agent is in charge of the reading from the sensor network, filtering data with a given criteria, managing positioning information and actuator status, and detecting possible emergency situations.

This agent represents an important input for the IT service, since it is responsible of informing not only about the current position of the user but also about the time of changing.

4.2.3 Vehicle Agent

The Vehicle Agent is intended to keep track of different status indicators (stability, battery change level, hardware failures, etc). This agent tracks users’ navigation efficiency, and depending on their profile, the agent make decisions about the degree of control users would have on the navigation [20].

The most remarkable role of the Vehicle Agent is the fall detection, which retrieves information coming from the sensors in the mobile platform, triggering the sending of an alarm via SMS to the caregiver in case of a fall detection [33].

4.2.4 Home Agent

The Home Agent is in charge of retrieving the knowledge extracted by other MAS agents, storing the information and delivering it when requested. Therefore, the Home Agent is not directly connected to the sensors or interfaces, but it is closely connected to other agents related to mobility in order to respond to database queries [33].
The Home Agent has an important role for the IT service, since it stores the user profile and manages any update made by doctors or caregivers.

### 4.2.5 Caregiver Agent

The Caregiver Agent is in charge of delivering information about the status of elders and their environment to caregivers. Keeping in mind that the informal caregivers are not necessarily technical or medical experts, the information is shown in a very simple and intuitive manner [33].

One of the aspects to be carefully considered is the privacy when access to data. This agent guarantees that only authorized subjects access the information related to those users they are in charge of.
5. INTELLIGENT TUTORIALS

IT are conceived as an assistive tool to exercise users with disabilities on a daily basis through the performance of indoor ADLs. It composes a user service of the Patient Agent, integrated at the same time within SHARE-it MAS. Tutorials are displayed to the user through the touch screen assembled on robotic assistive devices. Information inputs are retrieved from the environment sensors (Environment Agent) and the robotic assistive devices (Vehicle Agent) in order to trigger tutorials’ activation depending on the user profile (Home Agent).

Each of the selected ADLs to be performed with IT support is divided into several simple steps where instructions are textually displayed as well as audio recorded. A video accompanies the instruction given, guiding users on how to perform the task. Only when the current step is completed, users can move forward to the next step. Users are also able to request help in case of need.

One of the main purposes of IT is to delay users’ institutionalization, making them easy to stay at home with a reasonably good level of comfort. It is frequent that elderly people with cognitive and physical dysfunctions get worse as time goes by because of the age factor and personal conditions. The IT’s intelligent layer is responsible for the selection of the suitable set of tutorials each user is able to perform according to his/her disability status, and the adaptation of their content whenever the system is informed about changes in the user profile.

Depending on the certain context (e.g. the system detects that the user is in the kitchen via a network of sensors), the service selects a subset of contextual tutorials the user can perform in that location according to his/her profile.

5.1 Target population

From the service’s point of view, people with disabilities are viewed as having certain potential of independent living, each person having an individual need of assistance. Naturally, the level of independence strongly depends on the individual level of disability. IT are conceived to support the independence level each user presents, offering different types and degrees of
assistance. This level of granularity in supporting users is seen as an improvement in the review of the user’s current health status, which is a key piece for enhancing their skills in short and long terms.

Different groups of elders are characterized by large variations in well-being, disability, and health care needs. IT target population has to be put into groups, so that a number of individuals as large as possible can achieve benefits as effectively as possible. Therefore, different groups of disabilities are classified as basic user groups sharing certain characteristics [15]. This classification would be useful to define tutorials’ type of interaction with end-users according to their profile.

![Figure 3. Disabilities’ features affecting IT target population](image)

The typical user defined by the medical team is an elderly patient, with cognitive and/or physical disabilities on mild or moderate degree, co-morbid conditions, functional loss from multiple disabilities, leading to impaired self-dependency.

In order to get a better definition of the target population, most common conditions with high prevalence are considered².

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² Refer to annex A1.1 for a further extensive explanation of the considered disabilities
5.2 Facts and Assumptions

The main facts and assumptions to be considered before the specification and design of IT are listed below. They provide a good vision of the IT service’s boundaries. Functional and non-functional requirements must perfectly fit all the following points.

- ADLs are the concept in which IT are based. They can be loosely defined as a cluster of simple and explicit actions that are done for a purpose.
- Activities to carry out by using any of the tutorials should not be long time consuming so the user does not get distracted or lost.
- It is taken for granted that the initial conditions for the activities to start are fulfilled by the corresponding caregivers.
- Actions to carry out individually to complete an activity are adjusted to the current physical and cognitive conditions of users at anytime.
- The responsiveness of IT can be characterized by the action-reaction principle: whenever the user is willing to move forward to the next step, the system will assume s/he has already completed current step.
- Users have the chance to start over certain steps so that the actions taken before do not disrupt on the tutorial’s performance.
- Although the range of ready-to-serve tutorials depends on the context where the user is located, all the other tutorials are available at any time.
- Doctors and geriatricians together with caregivers are responsible for updating the current cognitive and physical condition of users on their corresponding profile.
- IT are likely to be extended, so that other required tutorials develop in the future will be compatible and easy to integrate with the current system.
- Italian is the language used for the interaction between the system and end-users. The resulting system would be flexible enough to accept other languages configuration.
6. CONCEPTS

The following section is dedicated to make an introduction of several concepts with an important role on the definition of IT service: user profile, which features groups of end-users in order to contextualize and select the most convenient tutorials according to their health status; ADLs, activities in which procedural tutorials are based; ontologies, entities which get its semantic meaning from the input/output information that agents handle; and IT’s interaction workflow, which is a key factor for the success of the service, as it defines how end-users access to available functionalities when interacting with the system.

6.1 User Profile

The medical team supervising the specification of IT has considered two type of chronic disabilities concerning its target population: cognitive impairment and mixed impairment. Following description have been detailed by doctors and geriatricians.

Disability deriving from cognitive impairment: Dementia. Users presenting a mild grade of dementia might present progressive difficulties but can follow established routines at home, while users with a moderate grade of dementia present a significant impaired ability to perform simple daily activities such as bathing or dressing as they become disoriented even in familiar surroundings.

Typically, intellectual and other cognitive functions decline inexorably over 2 to 10 years. Depression affects up to 40% of patients with dementia, usually on a mild or moderate state, and may cause vegetative symptoms such as withdrawal, weight loss or insomnia. Alzheimer is a form of dementia [7].
Disability deriving from mixed impairment: Post-stroke. Stroke is a leading cause of disability. Among survivors, 40% have a moderate functional impairment and 15% to 30% are severely disabled.

After a stroke, many people cannot do activities that require fine coordination, so that they cannot move their hands precisely or coordinate the movement of their hands and eyes. Patients may learn new ways to do activities such as fastening clothes, opening and closing containers, and getting objects that are too far to reach. Some patients are partially or completely blind in one or both eyes. Speech therapists might be necessary to retrain patients to use those muscles involved in speaking and breathing and also help with swallowing problems [15].

In addition to chronic degenerative conditions such as dementia or post-stroke, standard users might be affected by general declines in motor coordination, visual and auditory acuteness, muscle and bone strength, mobility, and sensory perceptions of stimuli (heat and cold) [7].

<table>
<thead>
<tr>
<th>Mental Functions:</th>
<th>Consciousness, Orientation (time, place, person), Intellectual (incl. Retardation, dementia), Energy and drive functions, Sleep, Attention, Memory, Emotional functions, Perceptual functions, Higher level cognitive functions, Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuromuscular Movement Related Functions:</td>
<td>Mobility joint, Muscle power and tone, Involuntary movements</td>
</tr>
<tr>
<td>Sensory Functions and Pain:</td>
<td>Seeing, Hearing, Vestibular (incl. Balance functions), Pain</td>
</tr>
<tr>
<td>Speech Functions:</td>
<td>Voice</td>
</tr>
</tbody>
</table>

*Figure 4. General declines to be considered for the IT’s user profile*

After several discussions with the medical team, the final user profile was specified taking into consideration the previous qualifiers listed, but summarizing its content to the most relevant and descriptive features.
The grade of affection a user can present is expressed using quantifiers: 0 - none, 1 - mild degree, 2 - moderate degree and 3 - severe degree. However, since users suffering from a severe degree of impairment are not considered as target population, this grade is not used to evaluate any of the user profile’s qualifiers except from sound impairment, as tutorials are supported by sound and text at the same time.

Neglect affection refers to a condition which reduces a person’s ability to look, listen or make movements in one half of their environment. Therefore, its quantifiers are ranged differently: 0 - none, 1 - left, 2 – right.

Aphasia affection refers to a language disorder which is presented when there is difficulty in using or understanding spoken and written language. Dual quantifiers are used in this case: 0 – user not affected, 1 – user affected.

Following, the user profile specification is presented. The qualifiers included are diverse enough to facilitate the division of the target population into groups of users sharing similarities in their profile.

**USER PROFILE**

<table>
<thead>
<tr>
<th>QUALIFIERS</th>
<th>QUANTIFIERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual impairment</td>
<td>0 - none 1 - mild degree 2 - moderate degree</td>
</tr>
<tr>
<td>Sound impairment</td>
<td>0 - none 1 - mild degree 2 - moderate degree 3 - severe degree</td>
</tr>
<tr>
<td>Fine coordination</td>
<td>0 - none 1 - mild degree 2 - moderate degree</td>
</tr>
<tr>
<td>Aphasia</td>
<td>0 - no 1 – yes</td>
</tr>
<tr>
<td>Neglect</td>
<td>0 - none 1 - left side 2 - right side</td>
</tr>
<tr>
<td>Dementia</td>
<td>0 - none 1 - mild degree 2 - moderate degree</td>
</tr>
</tbody>
</table>
6.2 ADLs

The selected activities listed below refer to daily tasks whose procedural tutorial might be displayed to elders depending on the type of disability they present. The complexity of every task also defines the number of steps its tutorial is composed by (e.g. cooking pasta tutorial complexity differs depending on the grade of aphasia, dementia and neglect a user presents).

This classification has been specified with the support of the medical team, considering the most common ADLs that a typical user performs, and categorizing them according to locations. Each of the tutorials has been classified, at the same time, according to the grade of impairment a user is permitted to have for its performance.

The process of featuring tutorials according to the type of impairment considered (cognitive and mixed) is a must in order to implement their adaptability to the current user profile.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TUTORIALS</th>
<th>COGNITIVE</th>
<th>MIXED</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOMESTICS</td>
<td>washing the dishes</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td></td>
<td>washing clothes by hand</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td>DRESSING</td>
<td>going outdoors</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td></td>
<td>putting shoes on</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>COOKING</td>
<td>preparing coffee</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td></td>
<td>cooking pasta</td>
<td>Mild/Moderate</td>
<td>Mild/Moderate</td>
</tr>
<tr>
<td></td>
<td>making a sandwich</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>preparing cold soup</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td>MEDICAL</td>
<td>taking drugs</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>GROOMING</td>
<td>morning grooming</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td></td>
<td>brushing teeth</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

*Figure 5.* Tutorials’ classification according to grades of cognitive/mixed impairment
It is important to remark that “Putting shoes on” and “Brushing teeth” tutorials are aimed at users on occupation therapy. Therefore, these tutorials are not aimed at users with mild degree of disabilities.

6.3 Interaction workflow

Due to the type of disabilities presented by IT's target population, most of them implying degeneration of the users’ cognitive abilities, interaction workflow defining tutorials’ life cycle might change from a standard level of comprehension to an easy level where constant interaction is pursued.

One of the more relevant aspects of the system conception is the understanding process of the tutorials’ instructions: it is likely that the user might get distracted or simply forget what s/he was told to do. Elderly population are likely to retain more information when they interact as opposed to when they are just being told facts. Therefore, the system pursues a constant interaction and revision on what the user is doing so s/he can be guided easily. This individual comprehension is guaranteed by using confirmation messages every time the user goes forward to the following step.

There are also certain steps considered to be dangerous, as they involve risky tasks such as turning on the electric cooker. The realization of these steps would be time-controlled for safety reasons.

Regarding the functionality of the service, certain options have to be within reach of users when performing a tutorial: requesting help at any step or exiting the tutorial are options available for the user, who should confirm the action prior to its execution. The possibility of sending an alert might be also available at the first step, when the user checks if all the items are arranged. If any of them is missing, an alert is sent to the caregiver and the tutorial can be cancelled. Both functionalities giving help and sending alerts are implemented as another service within SHARE-it, whose interaction with IT is managed by the MAS.
Final users might participate on the usability validation. It is mainly focused on testing the human-system interaction when following the workflow in Figure 6, detecting functional errors and new values to be added in order to improve the system. It is expected users might use IT on a daily basis, no matter which grade of impairment they are affected by, so that it is really important to receive feedback from doctors and geriatricians prior to its deployment in order to consider any possible deviation.

Figure 6. Interaction workflow for a proper IT service’s usability
6.4 Ontologies

An ontology is the representation of entities, ideas and events, along with their properties and relations, according to a system of categories. The special motivation for using an ontology is that agents are dealing with real-world entities with different grades of connection. Therefore, a vocabulary-like mechanism is needed to refer and manage them [20].

Following, the ontologies developed prior to the IT specification by the technical and medical team are illustrated. Both ontologies refer entities used to implement the contextualization and selection of tutorials to be performed by users.

- **ADL tracking.** The ontology’s concepts are used to discriminate a set of possible activities that the user could be performing.

![ADL Ontology](image)

**Figure 7. ADL Ontology**

- **ADL performance location.** It is also highly important to know where an activity is being performed in order to offer contextual tutorials.
Figure 8. ADL’s Location Ontology
7. ACTORS

Actors are those subjects/objects which take part in a sequence of activities as part of a dialogue with the IT service to achieve some goal. Actors may be end users, other systems, or hardware devices existing outside the system.

7.1 User

The typical end-user has been already defined within the IT’s target population. Users interacting with the system might have mild or moderate disabilities affecting their reasoning capabilities and physical abilities, but are expected to have a low loss of visual and sound acuteness.

A previous introduction to the system must be carried out by caregivers in order to facilitate the human-system interaction, test the system usability, and strengthen the user self-confidence when using new technologies for the first time.

**Actor name:** User

**Role:** Principal actor on the interaction with the system whose difficulties on performing daily activities are intended to be lessened.

**Subject matter experience:** Novice. Users interacts with the system for the first time.

**Technological experience:** Novice. Non-existent knowledge of technology basics.

7.2 Caregiver

There are two types of caregivers: those who are users’ relatives and those who are specialists paid by institutions to give care services to users.

Both type of caregivers are responsible for the cover of daily needs users might have and for giving support on tasks users can hardly carry out by themselves. These tasks differ from those to be performed every day such as dressing or toileting, and those that are important for the independent living of users in the community.
In the application of IT, caregivers have an important role as they are responsible for fulfilling certain requirements in order to assure the proper running of tutorials. For instance, they must gather all the cooking tools on the kitchen counter for the user to perform the cooking task, or they must prepare the right drug dose for the user to take. Additionally, caregivers are responsible for introducing users to the IT application, so they get to know how it works and start interacting with the system.

**Actor name:** Caregiver

**Role:** Personal assistant who is responsible for covering clinical needs of individuals with chronic diseases, assuring their comfort at home and tracking their rehabilitation.

**Subject matter experience:** Advanced. Caregivers already have a strong expertise on assisting users who present widely different and heterogenous functional profiles.

**Technological experience:** Novice. Non-existent knowledge of technology basics is demanded. Caregivers do not need to interact with the system directly.

### 7.3 Other actors

**System administrator.** In charge of the platform maintenance and the system consistency track.

**Health professionals.** Responsible for the system adjustment to the users’ requeriments. They are in charge of monitoring users in order to make an evalution reliable and efficient enough to measure their abilities and cognitive functions such as judgment, language, orientation, calculation, memory or planning.

### 7.4 Hierarchy of actors

Following, a priority is given to each category of actors in order to mark its importance.

**Key Actors.** User and Caregiver. Both users are essential for the success of IT as they could determine if the system achieved the desired goals.
Secondary Actors. There are several secondary actors whose contribution to the proper work of IT cannot be missed:

- **System Administrators**, whose task is the maintenance and update of the system.
- **Health Professionals**, mainly doctors and geriatricians, who are in charge of deciding about the needs of the users according to their state, health condition and physical limitation.
8. TUTORIALS’ PERFORMANCE

Next sections are intended to describe in detail which is the context where IT are conceived, defining those tasks an end-user can perform, which are the conditions to do so, and where the tasks have to take place in order to be properly completed.

8.1 Scenarios

Scenarios are narrative descriptions of typical interactions between the system and the users. Typically, it presents a situation where actors and IT service, among other services of SHARE-it, take part. The main character is a typical user affected by several of the conditions in a certain grade that allow him/her to perform IT without the caregiver support.

Methodology used for describing each scenario includes the following points:

<table>
<thead>
<tr>
<th>Purpose of the scenario:</th>
<th>describes which aspects of the system and its interactions with the user are treated on the scenario.</th>
</tr>
</thead>
<tbody>
<tr>
<td>User description:</td>
<td>a description of the typical user for the scenario. The actor represents an individual of a defined target group.</td>
</tr>
<tr>
<td>Narrative scenario:</td>
<td>describes an example of interaction between the user and the system.</td>
</tr>
<tr>
<td>Structure of the scenario:</td>
<td>a reference to the user profile and to those tasks end-users can carry out within the current scenario.</td>
</tr>
<tr>
<td>Role of the IT service:</td>
<td>describes the interactions between IT and the technology SHARE-it uses.</td>
</tr>
<tr>
<td>Role of communications:</td>
<td>describes which elements of the SHARE-it technology need to be available and active in the scenario.</td>
</tr>
</tbody>
</table>

The scenarios following introduced have been described in the context of SHARE-it project by the medical and technical team, and have been used during the experimentation phase in order to test IT service.
8.1.1 Scenario 1: Alberto takes his drugs

**Purpose of the scenario:** this scenario highlights how useful the medical tutorial is to support users’ therapy.

**User Description:** Alberto is a 78 years old who lives with his daughter. She works most of the day. He has been diagnosed with a very early Alzheimer Disease, causing a mild cognitive disability. His major impairments are related to recent memory and to executive functions (planning the sequence of actions).

**Narrative Scenario:** Alberto has to take some pills as part of his drug therapy after breakfast, in the middle of the afternoon, and at dinner. Since he suffers from memory impairment he cannot always remember that. Early in the morning, before leaving home, Alberto’s daughter subdivides the proper amount of the different drugs that have to be taken during the day in three boxes with different colour. At 10:00 a.m. the touch screen integrated on the wheelchair shows a reminder and sound alarm inviting Alberto to take his pills. The corresponding intelligent tutorial shows the instructions on how to take his medication. Eventually, the system asks Alberto to confirm to have taken his drugs.

**Structure of the scenario:**

<table>
<thead>
<tr>
<th>Disability</th>
<th>Degree</th>
<th>Disease</th>
<th>Scenario</th>
<th>Functional Category</th>
<th>Activity of Daily Living</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td>Mild</td>
<td>Alzheimer</td>
<td>Home</td>
<td>Medical</td>
<td>Take medication</td>
</tr>
</tbody>
</table>

**Role of the IT service:** the *patient-agent* detects that therapy time has arrived and shows a reminder followed by the corresponding tutorial on how to take the prescribed medication on the touch screen. Once the the tutorial workflow is completed, a confirmation message is shown asking the user to confirm that the medication has been taken.

**Role of Communications:** Alberto requires a wheelchair to move around, equipped at least with on-board PC connected to the environment via Wi-Fi.
8.1.2 Scenario 2: Pietro goes to the church

**Purpose of the scenario:** typical interaction of a user with a mild degree of mixed impairment moving from an indoor to an outdoor environment on the wheelchair.

**User Description:** Pietro is an 80 years old man who lives with an informal caregiver. He suffers from a mild mixed disability after stroke with a hemiparesis and impairment in the executive function.

**Narrative Scenario:** Two years ago, Pietro suffered from a stroke. He recovered well and at the moment he needs only a light support to walk. Sometimes he is not confident enough in the sequence of actions needed to reach a goal. Today is Sunday and his caregiver has his day off. At eleven in the morning Pietro gets a reminder that it is time to get ready to go to the church. Tutorials on how to put on his shoes and overcoat are displayed on his wheelchair touch screen.

**Structure of the scenario:**

<table>
<thead>
<tr>
<th>Disability</th>
<th>Degree</th>
<th>Disease</th>
<th>Scenario</th>
<th>Functional Category</th>
<th>Activity of Daily Living</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed</td>
<td>Mild</td>
<td>Post-stroke Hemiparesis</td>
<td>Home</td>
<td>Dressing</td>
<td>Put on shoes Put on overcoat</td>
</tr>
</tbody>
</table>

**Role of IT service:** the *patient-agent* engaging all the services available for the user requires the *home-agent* the suited tutorials for the situation. A reminder is launched prior to the execution of the tutorial about some basic issues related to prerequisite:

1. Are you wearing your shoes?
2. Are you wearing your overcoat?

**Role of Communications:** all devices communicate with the *home-agent* and the IT via Wi-Fi.
8.1.3 Scenario 3: Francesca cooks pasta

Purpose of the scenario: typical interaction between the system and a user affected by a moderate degree of mixed impairment on a daily routine.

User Description: Francesca is a 67 years old female who lives at home, assisted by Chiara, a professional caregiver. She has a moderate mixed disability post-stroke. Last year she suffered from a stroke of the left hemisphere: she cannot walk but she’s able to use her arms and she uses a wheelchair. She suffers from aphasia as well.

Narrative Scenario: Today is Sunday and Chiara is on her day off until late afternoon. Francesca and Chiara decided, yesterday, to have maccheroni al sugo for lunch. Before leaving the house, Chiara arranged all the ingredients and kitchenware (pots, dishes, etc) to cook pasta on the kitchen table. At 12 a.m. Francesca is hungry. She moves from the living room to the kitchen driving her wheelchair on autonomous navigation mode. Francesca ask for help in meal preparation to the system through the touch screen. The corresponding tutorial shows how to cook pasta step by step. Each graphical representation exactly corresponds to the real things on the table, otherwise aphasia would prevent her from recognizing the exact objects.

Structure of the scenario:

<table>
<thead>
<tr>
<th>Disability</th>
<th>Degree</th>
<th>Disease</th>
<th>Scenario</th>
<th>Functional Category</th>
<th>Activity of Daily Living</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed</td>
<td>Moderate</td>
<td>Post-stroke Aphasia</td>
<td>Kitchen</td>
<td>Cooking</td>
<td>Preparing pasta</td>
</tr>
</tbody>
</table>

Role of the IT service: once the user reaches the kitchen, the *patient-agent*, after engaging the IT service, requests the *home-agent* the appropriate tutorial for the situation that will offer the user help on how to prepare the meal with the ingredients. The information is shown on the suitable format according to the user profile stored by the agent.

Role of Communications: since Francesca drives to the wheelchair on her own, the *environment-agent* checks if she is in the kitchen via Wi-Fi and the *patient-agent* offers the tutorial to cook pasta on request. The touch screen integrated with the wheelchair
SHARE-it Intelligent Tutorials

 communicates directly with its local PC. Wi-Fi can also be used to download cooking pasta instructions into the local PC.

The following two scenarios have been specifically created for the IT specification in order to include tutorials from those categories not yet considered. Both scenarios have been reviewed by the medical team.

8.1.4 Scenario 4: Anna does the housework

**Purpose of the scenario:** this scenario shows the typical interaction of a user with a mild degree of cognitive impairment, due to the evolution of her disease.

**User Description:** Anna is a 75 years old who lives with her 80 years old husband. He suffers from diabetes and arthritis but is in a good condition. Anna fell down six months ago when she was leaving home and needs a wheelchair to move around. She had an operation two months ago and is having rehabilitation twice a week. She is suffering from dementia on a early stage and is unable to recognize sounds due to age related deafness.

**Narrative Scenario:** Anna had dinner with her husband and she wants to wash the dirty dishes. She is suffering from the earliest symptoms of her dementia so she forgets how to go on with tasks at certain point. She can barely hear anything with the right ear. His husband has gathered all the washing items on the kitchen counter next to the sink and has put all the dirty dishes on one side. The intelligent tutorial shows Anna how to wash the dishes on request.

**Structure of the scenario:**

<table>
<thead>
<tr>
<th>Disability</th>
<th>Degree</th>
<th>Disease</th>
<th>Scenario</th>
<th>Functional Category</th>
<th>Activity of Daily Living</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed</td>
<td>Mild</td>
<td>Dementia Deafness Hip fracture</td>
<td>Kitchen</td>
<td>Housekeeping</td>
<td>Washing dishes</td>
</tr>
</tbody>
</table>
Role of the IT service: the patient-agent detects dinner time has passed and Anna is in the kitchen, so offers her the washing dishes tutorial among others. As it knows the user functional profile, it automatically offers the configuration of the assistant with the voice mode off.

Role of Communications: this scenario involve that both the environment and patient agent and the wheelchair are connected via Wi-Fi, so that the IT service gets an input of the current place and time. Anna interacts with the wheelchair via a touch screen.

8.1.5 Scenario 5: Stefano receives the visit of a friend

Purpose of the scenario: this scenario shows the typical interaction of a user with a moderate degree of cognitive impairment with the IT service.

User Description: Stefano is a 73 years old suffering from Parkinson at a primary stage. His tremor and rigidity are becoming evident. Difficulties with abstract thought and memory are affecting him too. He lives with an informal caregiver who has taken Saturday morning off.

Narrative Scenario: In an hour, Stefano will receive the visit of a close friend at home. His caregiver has helped him getting out of bed and has prepared him breakfast before leaving. Next, he needs to tidy himself up. He has good coordination but has motor problems because of his stiffness. His tremor is little perceptible but it is not a physical handicap. When he goes into the toilet with the walker, a pack of tutorials to be performed on that context shows up: washing hands and face, brushing teeth, shaving and hair combing. The intelligent tutorial guides him step-by-step on how to complete the tasks considering his motive condition and tendency to disorientation.

Structure of the scenario:

<table>
<thead>
<tr>
<th>Disability</th>
<th>Degree</th>
<th>Disease</th>
<th>Scenario</th>
<th>Functional Category</th>
<th>Activity of Daily Living</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td>Moderate</td>
<td>Parkinson</td>
<td>Bathroom</td>
<td>Grooming</td>
<td>Washing face, hands</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Brushing teeth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Shaving</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hair combing</td>
</tr>
</tbody>
</table>
Role of the IT service: the patient-agent detects Stefano is in the bathroom at early morning, so offers him the pack of grooming tutorials among others. As the service knows about his motive condition, instructions are displayed to facilitate the performance of the activity as long as Stefano sticks to the flow of actions.

Role of Communications: this scenario involve the environment agent and i-Walker connected via Wi-Fi, so that the IT service gets an input of where the user is. Stefano interacts with the tutorial via a touch screen.

8.2 Activities’ Description

Each of the scenarios described in the previous section includes several ADLs to be performed. It is necessary to remark that users suffering from a severe degree of disability cannot use tutorials due to their physical and mental condition.

Next, activities in which tutorials are based are detailed by the following points:

<table>
<thead>
<tr>
<th>Activity name:</th>
<th>identification string for the activity.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity definition:</td>
<td>what the activity is about.</td>
</tr>
<tr>
<td>Activation:</td>
<td>Actions that trigger the start of the tutorial.</td>
</tr>
<tr>
<td>Items needed:</td>
<td>material needed for the proper performance of the activity.</td>
</tr>
<tr>
<td>Preconditions:</td>
<td>specification of what needs to be arranged before the task starts.</td>
</tr>
<tr>
<td>Activity workflow:</td>
<td>specification of the step-by-step actions composing the activity.</td>
</tr>
<tr>
<td>Extensions:</td>
<td>Alternatives to the defined workflow for the activity.</td>
</tr>
<tr>
<td>Contraindications:</td>
<td>description of those users who are not allowed to carry out this activity for safety reasons.</td>
</tr>
</tbody>
</table>
8.2.1 Domestics

Domestics include those housekeeping activities demanding low effort from users. Activities such as sweeping or ironing have been ruled out due to the required physical capabilities.

<table>
<thead>
<tr>
<th>Activity name:</th>
<th>WASHING THE DISHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity definition:</td>
<td>It consists of soaping and rinsing the dirty dishes. The clean dishes are put on the draining board to get dry.</td>
</tr>
<tr>
<td>Activation:</td>
<td>This tutorial is offered after daily meals: breakfast, lunch and dinner.</td>
</tr>
<tr>
<td>Items needed:</td>
<td>Latex gloves, scourer, soap, plug, dishcloth, plastic draining board.</td>
</tr>
<tr>
<td>Preconditions:</td>
<td>• All the items must be arranged at the kitchen counter • It is supposed the sink has two sides • The draining board must be empty</td>
</tr>
</tbody>
</table>

Activity workflow:

1. Make sure none of these items is missing: latex gloves, a scourer, soap, a plug, a dishcloth, a plastic draining board
2. Put on the latex gloves
3. Place all the dirty dishes at the right side of the sink
4. Block the sink with the plug
5. Turn on the tap to fill the left side of the sink with water
6. Turn off the tap when the sink is half filled
7. Pour a trickle of soap into the water so it gets soapy
8. Place all the dirty dishes at the left side of the sink, into the water
9. Pour a trickle of soap on the scourer
10. Softly rub each dish with the soapy scourer and place it on the right side of the sink. *Repeat step 10 until there is no dish left.*
11. Turn on the tap and rinse each dish over the left side of the sink, placing it carefully on the plastic draining board. Rinse first cups and glasses, then plates and cutlery, and lastly pans, pots and similar kitchenware. *Repeat step 11 until there is no dish left.*
12. Dry the sink borders with the dishcloth
13. Take off the latex gloves
Extensions:
One or more items are missing (1)
1. Report an alert
2. End of Use Case
All the clean dishes do not fit on the draining board (11)
1. Carefully place the remaining dishes on the right side of the sink.
One of the dishes breaks into pieces (10, 11)
1. Report an alert
2. End of Use Case

Contraindications: It is not indicate for those users suffering from:
• ipoision for safety reasons (e.g. not seeing clearly knives)
• essential tremors
• users affected by hemiparesis that specially affect strength and sensibility on hands and fingers

Activity name: WASHING CLOTHES BY HAND
Activity definition: It consist of washing your soiled clothes by hand and hang them up to dry
Activation: This tutorial is just offered upon request.
Items needed: a basin, soiled clothes, liquid detergent
Preconditions:
• All the items must be arranged at the kitchen counter
• It is supposed there is a place to hand the clothing items to dry
• If the user suffers from sensitivity deficit, it is required to use cold water

Activity workflow:
1. Make sure none of these items is missing: a basin, soiled clothes, liquid detergent
2. Add all the soiled clothes to the basin
3. Fill the basin with warm water
4. Pour liquid detergent right on the basin
   For each clothing item you need to wash, repeat step 5:
5. Take a bumpy surface and rub it up against the item
6. Let the clothes soak for about 20-30 minutes
7. Put your hands in the water and moosh the clothing around
8. Once you are done mooshing, drain out the water
   
   *For each clothing item, repeat step 9-10:*

9. Rinse each item under the running water till all the soap is out
10. Hand it up to dry

**Extensions:**

One or more items are missing (1)
1. Report an alert
2. End of Use Case

**Contraindications:** There is no specific contraindications

---

### 8.2.2 Dressing

This category is specific for tutorials which help users to get dressed in order to go out. There is a special tutorial on how to put shoes on aimed at users requiring special needs.

<table>
<thead>
<tr>
<th>Activity name:</th>
<th>GOING OUTDOORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity definition:</td>
<td>It consists of getting ready to go out. The user puts on his shoes, puts on a jacket/overcoat and finally locks the door.</td>
</tr>
<tr>
<td>Activation:</td>
<td>The tutorial is offered whenever the user is going out and the system has this fact registered.</td>
</tr>
<tr>
<td>Items needed:</td>
<td>Chair, shoes, socks (if necessary), cardigan or jacket, home key.</td>
</tr>
</tbody>
</table>
| Preconditions: | - All the items have to be arranged on the user’s bedroom. Either the cardigan or the jacket are supposed to be hanging on the clothing hook or on a visible place where it would be easy to get
  - In order to put on the shoes correctly, only flat shoes and trainers without laces are considered to be valid
  - The user’s wheelchair would be accepted instead of the chair
  - The user is not supposed to have an orthopedic leg or arm
  - The cardigan/jacket does not need to be done up |
### Activity workflow:

1. Make sure none of these items is missing: a chair, socks (if necessary), shoes, a cardigan or jacket, main door’s key
2. Sit down on the chair and put on the shoes
3. Stand up and put on the cardigan or jacket
4. Take the main door’s key
5. When leaving home, lock the main door using the key
6. Keep the key on your pocket

### Extensions:

One or more items are missing (1)
1. Report an alert
2. End of Use Case

The user is wearing slippers (2)
1. Remove your slippers and place them aside

The user needs to use/change socks (2)
1. Take off both your left and right worn socks if wearing any. Place them aside
2. Put on the clean socks

The user is not already wearing a shirt/t-shirt/cardigan (3)
1. Report an alert
2. End of the Use Case

### Contraindications:

Tutorial not aimed at users who cannot go outdoors.

<table>
<thead>
<tr>
<th><strong>Activity name:</strong></th>
<th>PUTTING SHOES ON</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity definition:</strong></td>
<td>It consists of sitting down and putting on the shoes with the help of a special splint and a shoeborn. This tutorial is aimed at users requiring occupational therapy.</td>
</tr>
<tr>
<td><strong>Activation:</strong></td>
<td>The tutorial is offered whenever the user is going out and the system has this fact registered.</td>
</tr>
<tr>
<td><strong>Items needed:</strong></td>
<td>Chair, shoes, splint, socks, shoeborn.</td>
</tr>
</tbody>
</table>
Preconditions:
- All the items have to be arranged on the user’s bedroom
- In order to perform the task correctly, only flat shoes and trainers without laces are considered to be valid
- The user’s wheelchair would be accepted instead of the chair

Activity workflow:
1. Make sure none of these items is missing: chair, shoes, splint, socks, shoeborn.
2. Sit down on the chair
3. Cover all the splint with the left sock
4. Put the tip of your left foot inside the sock and slip it inside using the splint’s strips
5. Take the shoeborn and use it to help you slip your left foot into the shoe
6. Cover all the splint with the right sock
7. Put the tip of your right foot inside the sock and slip it inside using the splint’s strips
8. Take the shoeborn and use it to help you slip your right foot into the shoe

Extensions:
One or more items are missing (1)
1. Report an alert
2. End of Use Case

The user is wearing slippers (2)
1. Remove your slippers and place them aside

Contraindications: There is no specific contraindications.

8.2.3 Cooking

Different levels of difficulty in terms of coordination are required depending on the cooking activity, so the range of tutorials within this category varies according to the user profile. Basic cooking skills are involved as all the tasks detailed are easy to perform.
<table>
<thead>
<tr>
<th><strong>Activity name:</strong></th>
<th>PREPARING COFFEE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity definition:</strong></td>
<td>it consists of preparing coffee for an espresso.</td>
</tr>
<tr>
<td><strong>Activation:</strong></td>
<td>the tutorial is offered whenever the user is on the kitchen and it is a morning or evening hour.</td>
</tr>
<tr>
<td><strong>Items needed:</strong></td>
<td>An espresso maker, a jug filled with water, 4 spoons of ground coffee, a coffee cup, a coffee spoon, an alarm clock, sugar, a carton of milk.</td>
</tr>
</tbody>
</table>
| **Preconditions:** | • All the items must be arranged at the kitchen counter  
• The espresso maker must be detached into 3 pieces  
• It is supposed that the cooker is electric  
• The user knows how to turn on the cooker and set the alarm |
| **Activity workflow:** | 1. Make sure none of these items is missing: an espresso maker, a jug filled with water, ground coffee, a coffee cup, a coffee spoon, an alarm clock, sugar (if necessary), a carton of milk (if necessary)  
2. Fill ¾ of the espresso maker base with water  
3. Fit the piece with little holes on top of the base and fill it with the ground coffee  
4. Screw the two remaining pieces tightly  
5. Turn on the furthest ceramic hob of the electric cooker and place the espresso maker  
6. Set the alarm clock to ring after 5 minutes  
7. Check if the top of the espresso maker is filled with coffee. *Repeat this step till all the coffee has come up to the top or the alarm clock rings.*  
8. When the coffee has come up to the top, turn off the ceramic hob  
9. Carefully pour the coffee on the cup |
| **Extensions:** | One or more items are missing (1)  
1. Report an alert  
2. End of Use Case  
The user likes a sweeter coffee (9)  
1. Add the 2 teaspoons of sugar to the coffee  
The user likes some milk in the coffee (9)  
1. Add a trickle of milk to the coffee |
### CONTRAINDICATIONS:

It is not indicate for those users suffering from:

- ipovision for safety reasons (e.g. not seeing clearly knives)
- essential tremors
- users affected by hemiparesis that specially affect strengh and sensibility on hands and fingers
- users suffering from dysphagia

Medical assesment should indicate the level of deficit limiting this activity.

<table>
<thead>
<tr>
<th>Activity name</th>
<th>COOKING PASTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity definition</td>
<td>it consists of boiling fresh pasta and prepare it to be served.</td>
</tr>
<tr>
<td>Activation</td>
<td>the tutorial is offered whenever the user is on the kitchen and it is time to prepare a meal.</td>
</tr>
<tr>
<td>Items needed</td>
<td>100 grams of fresh pasta, salt, sauce, 1 liter of water, a pot, scissors, a colander, a wooden spoon, a fork, an alarm clock, kitchen mitten, a plate.</td>
</tr>
</tbody>
</table>
| Preconditions | • All the items must be arranged at the kitchen counter  
• It is supposed that the cooker is electric  
• It is supposed the user knows how to turn on the cooker and set the alarm clock |

**Activity workflow:**

1. Make sure none of these items is missing: 100 grams of fresh pasta, salt, sauce (if necessary), 1 liter of water, a pot, scissors, a colander, a wooden spoon, a fork, an alarm clock, kitchen mitten, a plate
2. Fill the pot with 1 liter of water
3. Turn on the furthest ceramic hob of the electric cooker and place the pot to heat up
4. Add a dessert spoon of salt to the water
5. Open the packet of pasta with a scissors
6. When the water comes to the boil, add the 100 grams of fresh pasta
7. Stir the water with the wooden spoon from time to time
8. Set the alarm clock to ring 5 minutes after the water boils again
9. Place the colander on one side of the sink and open the tap a little bit
**Activity workflow:**

1. Make sure none of these items is missing: 100 grams of fresh pasta, salt, sauce (if necessary), 1 liter of water, a pot, scissors, a colander, a wooden spoon, a fork, an alarm clock, kitchen mitten, a plate
2. Fill the pot with 1 liter of water
3. Turn on the furthest ceramic hob of the electric cooker and place the pot to heat up
4. Add a dessert spoon of salt to the water
5. Open the packet of pasta with a scissors
6. When the water comes to the boil, add the 100 grams of fresh pasta
7. Stir the water with the wooden spoon from time to time
8. Set the alarm clock to ring 5 minutes after the water boils again
9. Place the colander on one side of the sink and open the tap a little bit
10. When the alarm clock rings, turn off the ceramic hob
11. Carefully pour the content of the pot into the colander using the kitchen mitten
12. When the pasta is drained, spread it on the plate

**Extensions:**

One or more items are missing (1)

---

**Activity name:** MAKING A SANDWICH

**Activity definition:** it consists of preparing a sandwich made of ham and mozzarella.

**Activation:** the tutorial is offered whenever the user is on the kitchen and it is time to prepare a meal.

**Items needed:** 4 slices of ham, 4 slices of fresh buffalo-milk mozzarella, 2 slices ciabatta (1 inch thick), a plate, basil.

**Preconditions:** All the items must be arranged at the kitchen counter

**Activity workflow:**

1. Make sure none of these items is missing: 4 slices of ham, 4 slices of fresh buffalo-milk mozzarella, 2 slices ciabatta (1 inch thick), a plate, basil
2. Place the ham on one ciabatta slice and the mozzarella on the other
3. Garnish with basil
4. Close the sandwich and place it on a plate
# SHARE-it Intelligent Tutorials

## Extensions:

One or more items are missing (1)

1. Report an alert
2. End of Use Case

## Contraindications:

It is not indicated for those users suffering from dysphagia

## Activity name:

PREPARING COLD SOUP

## Activity definition:

It consists of preparing a cold vegetable soup.

## Activation:

The tutorial is offered whenever the user is on the kitchen and it is time to prepare a meal.

## Items needed:

1 liter of chicken stock, 2 bay leaves, ground pepper, a pot, 30 grams of noodles, a wooden spoon, an alarm clock, a ladle, a soup dish.

## Preconditions:

- All the items must be arranged at the kitchen counter
- It is supposed that the cooker is electric
- It is supposed the user knows how to use the electric cooker and set the alarm clock

## Activity workflow:

1. Make sure none of these items is missing: 1 liter of chicken stock, 2 bay leaves, ground pepper, a pot, 30 grams of noodles, a wooden spoon, an alarm clock, a ladle, a soup dish
2. Fill the pot with 1 liter of chicken stock, 2 bay leaves and the ground pepper
3. Turn on the furthest ceramic hob of the electric cooker and place the pot to heat up
4. When the chicken stock comes to the boil, add the 30 grams of noodles
5. Set the alarm clock to ring 3 minutes after the soup boils again
6. Stir the soup with the wooden spoon from time to time
7. When the alarm clock rings, turn off the ceramic hob
8. Serve the soup into the dish using the ladle

## Extensions:

One or more items are missing (1)

1. Report an alert
2. End of Use
8.2.4 Medical

Medical tutorial is aimed at those users who need to take prescribed drugs daily to alleviate their diseases’ symptoms. In order to separate the doses that need to be taken along the day, different coloured boxes are used (e.g. green box for morning dose and yellow box for evening dose).

<table>
<thead>
<tr>
<th><strong>Contraindications:</strong></th>
<th>It is not indicate for those users suffering from:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• ipovision for safety reasons (e.g. not seeing clearly knives)</td>
</tr>
<tr>
<td></td>
<td>• essential tremors</td>
</tr>
<tr>
<td></td>
<td>• users affected by hemiparesis that specially affect strength and sensibility on hands and fingers</td>
</tr>
<tr>
<td></td>
<td>• users suffering from dysphagia</td>
</tr>
<tr>
<td></td>
<td>Medical assessment should indicate the level of deficit limiting this activity.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Activity name:</strong></th>
<th>TAKING DRUGS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity definition:</strong></td>
<td>it consists of indicating users it is time to take the prescribed dose and guide them on how to do it.</td>
</tr>
<tr>
<td><strong>Activation:</strong></td>
<td>the tutorial is offered whenever the user requires to take a dose due to medical prescription (generally in the morning, after midday or in the evening). Its activation is preceded by a reminder.</td>
</tr>
<tr>
<td><strong>Items needed:</strong></td>
<td>specific labeled box, a glass of water.</td>
</tr>
<tr>
<td><strong>Preconditions:</strong></td>
<td>caregivers are in charge of filling the labeled boxes with the right dose according to the user’s profile.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Activity workflow:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Make sure none of these items is missing: specific labeled box, a glass, a bottle of water</td>
</tr>
<tr>
<td>2. Grab the red* labeled box and take out the top</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>For each of the pills you have to take, repeat steps 3-5:</td>
</tr>
<tr>
<td>3. Take a pill and put it into your mouth but do not swallow it yet</td>
</tr>
<tr>
<td>4. Take a glass of water and have a drink to swallow the pill. Have another drink of water to make the ingestion easier</td>
</tr>
</tbody>
</table>
8.2.5 Grooming

Grooming tutorials are essential to enhance the self-esteem and independence of users, since the tasks to perform have a direct effect on themselves. The morning grooming tutorial is offered after the user wakes up.

<table>
<thead>
<tr>
<th>Activity name:</th>
<th>MORNING GROOMING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity definition:</strong></td>
<td>it consists of a set of activities to perform in the early morning: washing hands and face, brushing teeth, hair combing and shaving (if necessary).</td>
</tr>
<tr>
<td><strong>Activation:</strong></td>
<td>the tutorial is offered whenever the user enters the bathroom for the first time on a day.</td>
</tr>
<tr>
<td><strong>Items needed:</strong></td>
<td>pump dispenser, cleanser, a towel, a manual toothbrush, toothpaste, a plastic cup, a hair comb, an electric shaver</td>
</tr>
<tr>
<td><strong>Preconditions:</strong></td>
<td>• All the items must be arranged close to the washbasin</td>
</tr>
<tr>
<td></td>
<td>• If the user suffers from sensitivity deficit, it is required to use cold water</td>
</tr>
<tr>
<td><strong>Activity workflow:</strong></td>
<td>1. Make sure none of these items is missing: a pump dispenser, a cleanser, a towel, a manual toothbrush, toothpaste, a plastic cup, a hair comb, an electric shaver.</td>
</tr>
<tr>
<td></td>
<td>2. Get soap from the pump dispenser and wash your hands</td>
</tr>
<tr>
<td></td>
<td>3. Wash your face using the cleanser</td>
</tr>
</tbody>
</table>
**Activity workflow:**

1. Make sure none of these items is missing: a pump dispenser, a cleanser, a towel, a manual toothbrush, toothpaste, a plastic cup, a hair comb, an electric shaver.
2. Get soap from the pump dispenser and wash your hands
3. Wash your face using the cleanser
4. Wet your hands using the towel
5. Squeeze some toothpaste onto the toothbrush and brush your teeth
6. Fill the plastic cup with water and have a sip to rinse your mouth
7. Comb your hair using the hair comb
8. Use the electric shaver to shave your stubble

**Extensions:**

One or more items are missing (1)

1. Report an alert
2. End of Use Case

---

**Activity name:** BRUSHING TEETH

**Activity definition:** It consists of cleaning oneself teeth using toothpaste. This tutorial is aimed at users requiring occupational therapy.

**Activation:** the tutorial is offered upon request.

**Items needed:** a manual toothbrush, toothpaste, a plastic cup.

**Preconditions:**

- All the items must be arranged close to the washbasin.
- If the user suffers from sensitivity deficit, it is required to use cold water.

**Activity workflow:**

1. Make sure none of these items is missing: a toothbrush, toothpaste, a plastic cup
2. Squeeze some toothpaste onto the toothbrush
3. Turn on the tap to wet the toothpaste a little
4. Use short, back-and-forth brushing motions to clean the outside and inside surfaces of the teeth with the toothbrush, as well as the chewing surfaces

It is not indicate for those users suffering from:

- ipoision for safety reasons (e.g. not seeing clearly the razor)
Activity workflow:
1. Make sure none of these items is missing: a toothbrush, toothpaste, a plastic cup
2. Squeeze some toothpaste onto the toothbrush
3. Turn on the tap to wet the toothpaste a little
4. Use short, back-and-forth brushing motions to clean the outside and inside surfaces of the teeth with the toothbrush, as well as the chewing surfaces
5. Brush along the gum line. Make sure to brush your back molars and tongue to remove bacteria
6. Turn on the tap to fill the plastic cup with water
7. Have a sip of water to rinse your mouth
8. Spit out the water into the washbasin. Repeat step 5 to 7 again.
9. Turn on the tap to clean up the washbasin and your toothbrush

Extensions:
One or more items are missing (1)
1. Report an alert
2. End of Use Case
9. REQUIREMENTS

9.1 Actors’ interaction

IT are aimed at users being able to perform daily basic activities with the caregivers’ checking. The medical user profile, defined by doctors and pediatricians, is updated everytime the users’ capabilities change. The service is part of the Patient Agent, where the contextual information – location of the user at any moment - is gathered from the enviroment sensors.

The following diagram shows all the possible interaction flows among entities (actors and IT service) that can occur within the system.

![Figure 9. Interaction flows among actors and the IT service](image-url)
9.2 Functional Requirements

Requirements are all those needs that key actors have in the context where IT will be used. All these requirements together describe the behavior of the service and the functionalities that the system is supposed to accomplish.

<table>
<thead>
<tr>
<th>Requirement:</th>
<th>SELECT A TUTORIAL UPON REQUEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>The system shall allow the user to select any of the tutorials available</td>
</tr>
<tr>
<td>Rationale:</td>
<td>The aim of the service is to facilitate users performance of certain ADLs</td>
</tr>
<tr>
<td>Fit criterion:</td>
<td>The user is able to select any tutorial addressed to him/her</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirement:</th>
<th>TUTORIAL CATEGORIZATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Tutorials are grouped into categories according to their relation</td>
</tr>
<tr>
<td>Rationale:</td>
<td>Tutorials are classified in order to simplify the selection of activities to carry out</td>
</tr>
<tr>
<td>Fit criterion:</td>
<td>The user notice there is several subsets of tutorials depending on their common subject</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirement:</th>
<th>STEPS CONFIRMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Every tutorial’s instruction is validated asking the user whether s/he has understood the indications given</td>
</tr>
<tr>
<td>Rationale:</td>
<td>Comprehension of each step composing the tutorial is guaranteed by using conformation messages</td>
</tr>
<tr>
<td>Fit criterion:</td>
<td>The user acknowledges s/he has successfully performed the instruction given and accept the confirmation message</td>
</tr>
</tbody>
</table>

| Requirement: | TUTORIAL BUTTON |
**SHARE-it Intelligent Tutorials**

<table>
<thead>
<tr>
<th>Description:</th>
<th>The GUI must include a “tutorial” button</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rationale:</td>
<td>The “tutorial” button allows the user to display the list of categorized tutorials that s/he can perform</td>
</tr>
<tr>
<td>Fit criterion:</td>
<td>The user acknowledges there is a visible and recognizable button to access tutorials</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirement:</th>
<th>HELP BUTTON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>The GUI must include a “help” button</td>
</tr>
<tr>
<td>Rationale:</td>
<td>The “help” button allows the user to transfer the explicit help query to the Help Assistant Management service</td>
</tr>
<tr>
<td>Fit criterion:</td>
<td>The caregiver acknowledges that the user is asking for extra help</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirement:</th>
<th>QUIT BUTTON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>The GUI must include a “quit” button when displaying any tutorial step</td>
</tr>
<tr>
<td>Rationale:</td>
<td>The “quit” button allows the user to exit the current tutorial at any step</td>
</tr>
<tr>
<td>Fit criterion:</td>
<td>The user acknowledges there is a visible and recognizable button to quit a tutorial while being active. The system displays a confirmation message when the button is clicked.</td>
</tr>
</tbody>
</table>

### 9.3 Non-Functional Requirements

Non-functional requirements are those describing criteria that can be used to judge proper operation of IT, rather than specific behaviours. Non-functional requirements define constraints on the design and implementation of IT service.
9.3.1 Look & Feel requirements

<table>
<thead>
<tr>
<th>Requirement:</th>
<th>SIMPLE AND EASY SERVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>The interface, which is in charge of displaying the IT service, must be user friendly to all kind of users considered to be interacting.</td>
</tr>
<tr>
<td>Rationale:</td>
<td>It is essential that the interface is easy to use since IT are based on the interaction with users having disabilities. It has to be adaptable to the user’s cognitive condition.</td>
</tr>
<tr>
<td>Fit criterion:</td>
<td>Any user shall be able to know how to interact with the system and how to request services in less than three tries.</td>
</tr>
</tbody>
</table>

9.3.2 Usability requirements

<table>
<thead>
<tr>
<th>Requirement:</th>
<th>USABLE SERVICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>The simplicity of the tutorials shall make users to have a good perception of the system in order to be willing to use it in future occasions.</td>
</tr>
<tr>
<td>Rationale:</td>
<td>By norm, users prefer services easy to use and which do not imply an unnecessary waste time.</td>
</tr>
<tr>
<td>Fit criterion:</td>
<td>Final users find tutorials easy to use. They do not need to have prior technological experience.</td>
</tr>
</tbody>
</table>

9.3.3 Operational requirements

<table>
<thead>
<tr>
<th>Requirement:</th>
<th>FAST DISPLAY OF DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>The result of a query shall be showed as faster as possible.</td>
</tr>
<tr>
<td>Rationale:</td>
<td>Final user must obtain data in a fast way.</td>
</tr>
<tr>
<td>Fit criterion:</td>
<td>The searching response time will be inferior to 0.5 seconds.</td>
</tr>
</tbody>
</table>

Requirement: ACCESSIBILITY
## Support and Maintenance requirements

### Requirement: SET-UP REQUIREMENTS
**Description:** No external set-up required.
**Rationale:** The system must be easy to integrate.
**Fit criterion:** The user will be able to use the system without installing any extra software.

### Requirement: SCALABLE SERVICE
**Description:** The system shall be scalable or extended easily.
**Rationale:** The system should be able to deal with a considerable number of tutorials.
**Fit criterion:** The system runs properly when being extended.

### Requirement: DATA INTEGRITY
**Description:** The system must guarantee the data integrity of any information introduced by users.
**Rationale:** The system must avoid data mistakes and any inconsistency which may affect users.
**Fit criterion:** The system must be consistent with data content at any time.
9.4 Use Cases

9.4.1 Use Cases Diagrams

Use Cases describe how actors interact with the system in order to achieve a goal, specifying who can execute a certain action towards the IT service. Following diagrams show, for each of the users contemplated, the possible actions to carry out in order to fulfill functional requirements.

![Actor's specialization diagram](image1)

**Figure 10.** Actor’s specialization diagram

![Use Cases related to the User actor](image2)

**Figure 11.** Use Cases related to the User actor
Since Doctors/Geriatricians update the user profile using another service, the subsequent Use Case is not relevant for the specification. Caregivers do not interact directly with the system, they are responsible for assuring tutorials’ preconditions and instruct users in how the application works.

Figure 12. Use Cases related to the System

Figure 13. Use Cases related to the Administrator actor
9.4.2 Use Cases Specification

Following, the complete specification of each Use Case from the diagrams above is presented, detailing preconditions to be fulfilled before executing the action and how to validate that the goal has been achieved successfully.

<table>
<thead>
<tr>
<th>Use Case</th>
<th>REQUEST TUTORIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The user request a certain tutorial to be performed</td>
</tr>
<tr>
<td>Primary Actor</td>
<td>User</td>
</tr>
<tr>
<td>Preconditions</td>
<td>Preconditions defined for the activity of the requested tutorial must be fulfilled</td>
</tr>
<tr>
<td>Validation criteria</td>
<td>The requested tutorial is initiated successfully by the user</td>
</tr>
</tbody>
</table>

**Main Success Scenario:**
1. The user clicks on the GUI’s “tutorials” button
2. The user chooses the category of the tutorial
3. The user chooses which tutorial s/he is about to perform

<table>
<thead>
<tr>
<th>Use Case</th>
<th>PERFORM TUTORIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The user performs the requested tutorial confirming each of the steps</td>
</tr>
<tr>
<td>Primary Actor</td>
<td>User</td>
</tr>
<tr>
<td>Preconditions</td>
<td>Preconditions defined for the activity of the requested tutorial must be fulfilled</td>
</tr>
<tr>
<td>Validation criteria</td>
<td>The requested tutorial is performed successfully by the user</td>
</tr>
</tbody>
</table>

**Main Success Scenario:**
For each of the tutorial’s steps:
1. The user follows the instructions given
2. The user confirms s/he has performed the current step in order to move into the following

| Use Case:                | QUIT TUTORIAL                                               |
## SHARE-it Intelligent Tutorials

<table>
<thead>
<tr>
<th>Description:</th>
<th>The user exits the current tutorial at any step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Actor:</td>
<td>User</td>
</tr>
<tr>
<td>Preconditions:</td>
<td>The current tutorial has to be started</td>
</tr>
<tr>
<td>Validation criteria:</td>
<td>The requested tutorial is quitted successfully by the user</td>
</tr>
<tr>
<td><strong>Main Success Scenario:</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>The user clicks on the GUI’s “exit” button</td>
</tr>
<tr>
<td>2.</td>
<td>The user confirms s/he wants to escape the tutorial</td>
</tr>
<tr>
<td>3.</td>
<td>The system leads the user to the main menu of the GUI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Use Case:</th>
<th>ASK FOR HELP / REPORT AN ALERT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>The user asks for help / report an alert while performing a tutorial. This use case concerns a functionality implemented by another service within SHARE-it which collaborates with IT service.</td>
</tr>
<tr>
<td>Primary Actor:</td>
<td>User</td>
</tr>
<tr>
<td>Preconditions:</td>
<td>The current tutorial has to be started</td>
</tr>
<tr>
<td>Validation criteria:</td>
<td>The help request has been processed and the user is informed that the caregiver will contact him/her for assistance</td>
</tr>
<tr>
<td><strong>Main Success Scenario:</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>The user clicks on the GUI’s “help” button at any of the tutorial’s steps</td>
</tr>
<tr>
<td>2.</td>
<td>The system transfer the query to the caregiver through the Help Assistance Management service</td>
</tr>
<tr>
<td>3.</td>
<td>The system informs the user that s/he will be contacted by the caregiver for assistance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Use Case:</th>
<th>LIST TUTORIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>A list of tutorials the user can perform according to his/her profile is offered through the GUI</td>
</tr>
<tr>
<td>Primary Actor:</td>
<td>System</td>
</tr>
<tr>
<td>Preconditions:</td>
<td>The user profile has been initialized or updated</td>
</tr>
<tr>
<td>Validation criteria:</td>
<td>A set of tutorials adapted to the user profile is listed</td>
</tr>
</tbody>
</table>
Main Success Scenario:
1. A list of tutorials according to the user’s physical/cognitive condition is sent from the Patient Agent to the Interface Manager
2. The system shows the list through the GUI when clicking on the “tutorials” button

<table>
<thead>
<tr>
<th>Use Case:</th>
<th>OFFER CONTEXTUAL TUTORIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>A subset of tutorials are displayed to the user depending on the context</td>
</tr>
<tr>
<td>Primary Actor:</td>
<td>System</td>
</tr>
<tr>
<td>Preconditions:</td>
<td>Location has to be changed.</td>
</tr>
<tr>
<td>Validation criteria:</td>
<td>Certain tutorials are displayed whenever the user context changes</td>
</tr>
</tbody>
</table>

Main Success Scenario:
1. The system detects that the user’s location has changed
2. The system preselect a subset of tutorials for the user to be performed according to the new context
3. The system displays the subset of tutorials regardless of no explicit demand

<table>
<thead>
<tr>
<th>Use Case:</th>
<th>SYSTEM MAINTENANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Maintance and update of the system</td>
</tr>
<tr>
<td>Primary Actor:</td>
<td>Administrator</td>
</tr>
<tr>
<td>Preconditions:</td>
<td>Not specified</td>
</tr>
<tr>
<td>Validation criteria:</td>
<td>The system is adjusted to the user needs and profile changes.</td>
</tr>
</tbody>
</table>

Main Success Scenario:
1. The system administrator acknowledges there are updates to be executed.
2. Updates are carried out.
3. The system administrator informs doctors and caregivers of the changes.
10. RISK ANALYSIS

10.1 New Problems

There are several issues affecting users and caregivers that might appear after they start using IT. Regarding these issues prior to its consequences is a key factor for their prompt resolution.

10.1.1 Users and Caregivers Problems

Users. Using tutorials instead of being guided and supported by a caregiver allows users to become more independent. However, it adds a new intermediary between the user and caregivers/doctors. As a result, it can be significantly more complicated for users who do not manage new technology to accept the introduction of a new assistant as part of their therapy.

Another important issue is the user perception of the system. It is likely that users misunderstand instructions or perform in the wrong way regardless of the system accuracy. In order to minimize its impact on the tutorial performance, help is available for the user at any of the tutorial’s steps.

Caregivers. IT activation needs certain efforts to be made from caregivers in order to work successfully. It is probable that initially, the system results unattractive for grown-up caregivers. Therefore, the tutorials’ efficiency must be proven to be higher than using the traditional method to assist users.

10.1.2 Follow-up Problems

The tutorials’ usage entails an update of the user profile. Delays on the profile modification can lead to a deprecated system, where end-users might be using a service which does not fit their needs and misconceives their physical and mental condition.
10.2 Risks

A risk in the context of software is any damage that can occur anytime and affect the development course. Since risks are harmful by nature, the only way to minimize its effects is to detect the potential risks during this early stage of the project, analyze its impact, and plan how to deal with them in order.

10.2.1 Personnel shortfalls

IT can fail due to personnel interaction. It cannot be assumed that all the users involved in the use of tutorials would achieve the expected experience. In order to mitigate this risk, a proper control over the whole system is needed to detect and deal with situations in which actors do not interact as expected.

10.2.2 Developing the wrong functions

These both risks deal with developing the wrong service. It could be that the resulting system does not suit the requested functionalities or that the user interface is not appealing to them. In order to mitigate the probability of these risks, it is necessary to validate the fulfillment of use cases, functional and non-functional requirements. Regarding the user interface, it is highly recommended to prototype the interface in order to be tested by the final users, so that they can provide feedback as early as possible.

10.2.3 Continuous stream of requirements changes

If the system requirements are continually changing, the schedule will never be accurate. A change in the current requirements impacts all the development’s phases and add time and resources to the plan. In order to deal with this type of situations, iterations where new requirements are collected must be established.
10.2.4 Table of risks

<table>
<thead>
<tr>
<th>Risk</th>
<th>Probability</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel shortfalls</td>
<td>50%</td>
<td>Very critic</td>
</tr>
<tr>
<td>Developing the wrong functions</td>
<td>30%</td>
<td>Very critic</td>
</tr>
<tr>
<td>Continuous stream of requirements changes</td>
<td>30%</td>
<td>Critic</td>
</tr>
</tbody>
</table>
11. TUTORIALS’ MODULE RELATIONS

IT service is part of the Patient Agent. Its presentation layer corresponds to the GUI, which was implemented as another part of the SHARE-it project. IT service and GUI communicates through DLA Connections using data packages. Following, there is a brief explanation of these concepts.

- **GUI.** The Graphical User Interface plays an important role on the tutorials’ display, as it is the main front end for users and the way they interact with the service content, accessing to its functionalities.

- **DLA.** It is an architecture used to develop cooperative systems with different interacting modules distributed along several machines. This mechanism of communication is based on a central element that manages the access and storage of the shared data from the other modules. When the IT service wants to send some information to the GUI or vice versa, a DLA input/output connection is opened and a defined DLA package with the requested data is sent.

Following, there are defined the different interaction schemas concerning IT service between GUI and the Patient Agent layer:

### LIST OF TUTORIALS – CONTEXTUAL TUTORIALS

<table>
<thead>
<tr>
<th>Patient Agent</th>
<th>Interface Manager</th>
<th>GUI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Caregiver/Doctor selects user profile</td>
</tr>
<tr>
<td></td>
<td>Send user profile (qualifiers + quantifiers)</td>
<td></td>
</tr>
</tbody>
</table>
## SHARE-it Intelligent Tutorials

<table>
<thead>
<tr>
<th>Select List of Tutorials (name + numOfSteps+ N [index + step text + media type+ media]) according to user profile</th>
<th>Displays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select subset of Contextual Tutorials (name) according to Location</td>
<td>Displays</td>
</tr>
<tr>
<td>Sends confirmation of step (name + index + update)</td>
<td></td>
</tr>
</tbody>
</table>

### SELECT A TUTORIAL

<table>
<thead>
<tr>
<th>Patient Agent</th>
<th>Interface Manager</th>
<th>GUI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>User selects a tutorial</td>
</tr>
<tr>
<td></td>
<td>Sends request (name + update)</td>
<td></td>
</tr>
<tr>
<td>Sends tutorial (name + numOfSteps+ N [index + step text + media type+ media])</td>
<td></td>
<td>Displays</td>
</tr>
<tr>
<td></td>
<td>Sends confirmation of step (name + index + update)</td>
<td></td>
</tr>
</tbody>
</table>

Several different DLA\(^3\) packages are in charge of representing interactions between the IT service and the GUI through the Patient Agent [20].

\(^3\) Refer to section A1.2 to find out more about this architecture
11.1 DLA Package: TutorialList

- From Rolland/GUI to Patient Agent and vice versa
- From iWalker/GUI to Patient Agent and vice versa
- Sent whenever the user profile is initialized or updated

When the user profile is initialized or updated through the GUI, the intelligent layer of the system selects a list of tutorials for the user to perform. The selection is made according to the type of conditions affecting the user, and is sent to the GUI for display.

```c
struct Tutorial {
    char tutorial[128];       // name
    char activityCategory[64]  // category of the tutorial’s activity
    int numOfSteps;           // number of steps for the tutorial
    TutorialStep steplit[25]  // where ‘n’ refers to the number of
                                // steps a tutorial has. Set to
                                // 25 as max number
}

struct TutorialStep {
    char steptext[1024];     // text describing one tutorial step
                            // the name of the media file (if any)
    char media[64];          // to be shown
}

struct TutorialList {
    Tutorial tutorials[11];  // Where 'n' refers to the number of
                            // available tutorials. Set to 11
                            // arbitrarily
}
```

11.2 DLA Package: SelectedTutorial

- From Rolland/GUI to Patient Agent
- From iWalker/GUI to Patient Agent
- Sent whenever the user requests a tutorial
struct SelectedTutorial
{
    char tutorial[128] // name of the tutorial
    int update;        // [1,..., 2147483647] number that changes
    // from one selection to another to allow
    // identification of new selection
}

11.3 DLA Package: ConfirmationTutorialSteps

• From Rolland/GUI to Patient Agent
• From iWalker/GUI to Patient Agent
• Sent whenever the user confirms a tutorial step

struct ConfirmTutorialStep
{
    char tutorial[128] // name of the tutorial
    int step;          // [1,..., 2147483647] number that changes
    // from one selection to another to allow
    // identification of new selection
}

11.4 DLA Package: ContextualTutorials

• From Patient Agent to Rolland/GUI
• From Patient Agent to iWalker/GUI
• Sent whenever the system detects a user is within a defined location

struct ContextualTutorials
{
    int numOfContextTuts; // number of available contextual tutorials
    TutorialName tutorials[11] // name of the tutorial
}

struct TutorialName
{
    char name[128];
}
12. JADEX

12.1 Introduction to JADEX

JADEX is an agent-oriented reasoning engine for writing rational agents with XML and the JAVA programming language. Thereby, JADEX represents a conservative approach towards agent orientation for several reasons. One main aspect is that no new programming language is introduced. Instead, JADEX agents can be programmed in the state-of-the-art object-oriented integrated development environments (IDEs) such as Eclipse.

Agents represent active components with individual reasoning capabilities. This means that agents can exhibit reactive behavior (responding to external events) as well as pro-active behavior (motivated by the agents own goals).

12.1.1 The BDI Model of JADEX

The most interesting and widespread agent architecture is the Belief-Desire-Intention (BDI) architecture, introduced by Bratman as a philosophical model for describing rational agents [25]. It consists of the concepts of belief, desire and intention as mental attitudes that generate human action. Rao and Georgeff [26] transformed this model into a formal theory and an execution model for software agents, based on the notion of beliefs, goals, and plans.

JADEX facilitates using the BDI model in the context mainstream programming, by introducing beliefs, goals and plans as first class objects that can be created and manipulated inside the agent. In JADEX, agents have beliefs, which can be any kind of Java object and are stored in a Belief Base. Goals represent the concrete motivations (e.g. states to be achieved) that influence an agent's behavior. To achieve its goals the agent executes plans, which are procedural recipes coded in Java. The beliefs, goals and plans of the agent are defined by the programmer and prescribe the behavior of the agent.

http://jadex.informatik.uni-hamburg.de/bin/view/About/Overview
Reasoning in JADEX is a process consisting of two interleaved components. On the one hand, the agent reacts to incoming messages, internal events and goals by selecting and executing plans. On the other hand, the agent continuously deliberates about its current goals, to decide about a consistent subset, which should be pursued [10].

### 12.1.2 Agent Specification

The complete definition of an agent is captured in a so called *agent definition file* (ADF). The ADF is an XML file, which contains all relevant properties of an agent (e.g. the beliefs, goals and plans).

To develop applications with JADEX, the programmer has to create two types of files: XML agent definition files (ADF) and JAVA classes for the plan implementations. The ADF can be seen as a type specification for a class of instantiated agents. To start an agent, first the ADF is loaded, and the agent is initialized with beliefs, goals, and plans as specified.
12.2 Tutorials’ JADEX classes

In the next subsections, the BDI model is explained for the beliefs, goals and plans defining the Patient Agent behaviour for the two functionalities of the IT service: selection of the tutorial list and contextual tutorials. Several different java classes are executed as plans (means-end reasoning) to handle incoming events and to pursue internal goals.

12.2.1 List of Tutorials

The list of tutorials a user can perform is sent to the GUI through the DLA connection when the user profile is either initialized or updated. This set of tutorials is selected according to the physical and cognitive conditions the user presents.

ProfileGUI.java. When the Patient Agent is launched, a JFrame for the caregiver/doctor to introduce the user profile is displayed. If the accept button is pressed, the corresponding facts on the Belief Base related to the user’s conditions (visual impairment, sound impairment, fine coordination, aphasia, dementia, neglect) are updated. Consecutively, these new values are transformed to bytes and sent to the GUI through the DLA Connection interactionProfileConn.

Following, a new goal is created and dispatched in order to select the suitable list of tutorials for the user according to his/her profile. To reach this goal, a plan needs to be executed: RuleEnginePlan.

RuleEnginePlan.java. Within this class, a set of rules composing the intelligent layer of the system are run for the tutorials’ selection. The corresponding facts on the Belief Base related to the available tutorials (Grooming, PreparePastaSimple, PreparePastaComplex, PrepareCoffee, GoingOut, Therapy) are updated once the selection is made.

Following, a new goal is created and dispatched in order to send the list of selected tutorials to the GUI for display. To reach this goal, a plan needs to be executed: TutorialListPlan.
**TutorialListPlan.java.** This class specifies in its body which are the actions to be taken for initializing the list of tutorials for the end-user. A data structure is initialized where, for each of the tutorials, the following attributes are contained: number of required steps, tutorial’s category, the name of the tutorial, and its set of steps. Although the sum of tutorials the initial list can contain is set to maximum 11 arbitrarily, it can be further extended. When the list of tutorials is completed, its data structure is transformed to bytes and sent to the GUI through the DLA Connection `tutorialListConn`.

![Figure 15. Patient Agent’s behaviour related to the List of Tutorials](image)

### 12.2.2 Contextual Tutorials

One of the most important features regarding IT service is the possibility of offering certain tutorials to the target users depending on the context. The input information of where users are located is retrieved from the network sensors via the Environment Agent, which closely collaborates with the Patient Agent for this purpose.
Within the Belief Base there are two beliefs related to the contextualization: the location, which contains the name of the place itself taken from the ontology, and the location\_change, a boolean that indicates if the location has changed or not.

Two different events can trigger the update of contextual tutorials:

1. **Change in the Location.**

   **SaveLocationPlan.java.** This plan is in charge of handling the update of the location belief every time the Environment Agent informs to the Patient Agent that the user’s location has changed. A new goal is created and dispatched to update the contextual tutorials. In order to reach this goal, a plan needs to be executed: **UpdateContextualTutPlan.**

   ![Diagram](image)

   **Figure 16.** Patient Agent’s behaviour when the user’s location changes

2. **Change in the user profile.**

   **TutorialListPlan.java.** When the user profile is initialized or updated, the list of convenient tutorials for the user to perform is selected. Consequently, as the contextual tutorials are a subset of these tutorials, a new goal is created and dispatched in order to update the
contextual tutorials according to the current location of the user. To reach this goal, a plan needs to be executed: *UpdateContextualTutPlan*. 

**Figure 17.** Patient Agent’s behaviour when the User Profile changes

`UpdateContextualTutPlan.java`. Within this class, the current room where the user is located is used to discriminate the subset of contextual tutorials to be offered to the end-user. The initial location is set to be the corridor, where no contextual tutorial is activated. Once the list of contextual tutorials is selected, its data structure is transformed to bytes and sent to the GUI through the DLA Connection `contextualTutorialsConn`.

While a specific range of tutorials are served to users when they change location, all the other tutorials are also available, since the personalized list of tutorials is sent through the DLA Connection before the update of contextual tutorials is handled. The subsets of tutorials selected according to the available locations are:

- Location: Kitchen → Category: Cooking and Domestics
- Location: Living-room → Category: Therapy
- Location: Bedroom → Category: Dressing
- Location: Bathroom → Category: Grooming
13. RULE-BASED EXPERT SYSTEM

The necessity of introducing an intelligent layer on the system arises when human reasoning has to be simulated using medical knowledge in order to take decisions. The expert system will be responsible for selecting the list of tutorials according to the user’s needs.

Other AI methods, such as a Case-Based Reasoning System (CBR), have been considered in order to implement this expert system. However, the cost of its implementation was determined to be much higher than using a reasoning engine based in rules.

The type of deductive reasoning a Rule Engine uses is based on a knowledge base where rules are activated as conditions have a positive evaluation, generating new facts as a result. In contrast, CBR is a method based on experience, where a case base is created and extended when the current case have no similarities with previous cases. This would be a complex approach to a solution for the human reasoning the systems needs to simulate.

13.1 JESS

JESS\(^5\) is a Rule Engine and scripting environment written entirely in JAVA language by Ernest Friedman-Hill at Sandia National Laboratories. JESS allows to build software that has the capacity to reason using supplied knowledge in the form of declarative rules. One of the main advantages JESS offers among another Rule Engines is its simplicity to be integrated with any other JAVA application, as it is MAS.

JESS has two relevant features concerning inference rules: it uses a more efficient and fast pattern matching algorithm (the Rete algorithm), and Backwards chaining, a method that starts with a list of goals and works backwards to see if there is data which will allow it to conclude any of these goals.

13.2 Knowledge Base

A Rule-Based Expert System is made up of many such inference rules. They are entered as separate rules and it is the inference engine that uses them together to draw conclusions. Medical knowledge has been used to establish the knowledge base for this reasoning process.

Doctors and geriatricians supervising the SHARE-it project have determined, for each of the existing tutorials, the grade of severity allowed for those conditions that define the user profile. The two tables below illustrate this classification.

Regarding the possible grades, four values are generally used for evaluating severity of visual impairment, sound impairment, fine coordination and dementia: 0 - meaning the user is not affected, 1 - mild grade, 2 - moderate grade, and 3 - severe grade. However, severe grade is only considered for sound impairment. Regarding the rest of the conditions, possible values are: 0 – not affected, 1 – affected, for aphasia; 0 - none 1 - left (left side), 2 - right (right side) for dementia.

### PHYSICAL CONDITIONS

<table>
<thead>
<tr>
<th>Tutorial</th>
<th>Visual impairment</th>
<th>Sound impairment</th>
<th>Fine coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washing the dishes</td>
<td>0,1</td>
<td>0,1,2</td>
<td>0,1</td>
</tr>
<tr>
<td>Washing clothes by hand</td>
<td>0,1,2</td>
<td>0,1,2</td>
<td>0,1</td>
</tr>
<tr>
<td>Going outdoors</td>
<td>0,1,2</td>
<td>0,1,2</td>
<td>0,1,2</td>
</tr>
<tr>
<td>Putting shoes on</td>
<td>0,1,2</td>
<td>0,1,2,3</td>
<td>0,1,2</td>
</tr>
<tr>
<td>Preparing coffee</td>
<td>0,1,2</td>
<td>0,1,2</td>
<td>0,1</td>
</tr>
<tr>
<td>Cooking pasta (Simple)</td>
<td>0,1</td>
<td>0,1,2</td>
<td>0,1</td>
</tr>
<tr>
<td>Cooking pasta (Complex)</td>
<td>0,1</td>
<td>0,1,2</td>
<td>0</td>
</tr>
<tr>
<td>Preparing cold soup</td>
<td>0,1</td>
<td>0,1,2</td>
<td>0</td>
</tr>
<tr>
<td>Making a sandwich</td>
<td>0,1,2</td>
<td>0,1,2</td>
<td>0,1,2</td>
</tr>
<tr>
<td>Taking drugs</td>
<td>0,1,2</td>
<td>0,1,2,3</td>
<td>0,1</td>
</tr>
<tr>
<td>Morning grooming</td>
<td>0,1</td>
<td>0,1,2,3</td>
<td>0,1</td>
</tr>
<tr>
<td>Brushing teeth</td>
<td>0,1,2</td>
<td>0,1,2,3</td>
<td>0,1</td>
</tr>
</tbody>
</table>
COGNITIVE CONDITIONS

<table>
<thead>
<tr>
<th>Tutorial</th>
<th>Aphasia</th>
<th>Neglect</th>
<th>Dementia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washing the dishes</td>
<td>0</td>
<td>0,1</td>
<td>0,1</td>
</tr>
<tr>
<td>Washing clothes by hand</td>
<td>0</td>
<td>0,1</td>
<td>0,1</td>
</tr>
<tr>
<td>Going outdoors</td>
<td>0,1</td>
<td>0,1,2</td>
<td>0,1</td>
</tr>
<tr>
<td>Putting shoes on</td>
<td>0,1</td>
<td>0,1,2</td>
<td>0,1,2</td>
</tr>
<tr>
<td>Preparing coffee</td>
<td>0</td>
<td>0,1,2</td>
<td>0,1</td>
</tr>
<tr>
<td>Cooking pasta (Simple)</td>
<td>0</td>
<td>0,1,2</td>
<td>0,1</td>
</tr>
<tr>
<td>Cooking pasta (Complex)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Preparing cold soup</td>
<td>0</td>
<td>0,1</td>
<td>0,1</td>
</tr>
<tr>
<td>Making a sandwich</td>
<td>0,1</td>
<td>0,1,2</td>
<td>0,1</td>
</tr>
<tr>
<td>Taking drugs</td>
<td>0,1</td>
<td>0,1,2</td>
<td>0,1,2</td>
</tr>
<tr>
<td>Morning grooming</td>
<td>0,1</td>
<td>0,1,2</td>
<td>0,1,2</td>
</tr>
<tr>
<td>Brushing teeth</td>
<td>0,1</td>
<td>0,1,2</td>
<td>0,1,2</td>
</tr>
</tbody>
</table>

Although there is an extensive range of tutorials, some of them have not been considered for the implementation of the Rule Engine, since they were not characteristic enough to differentiate a group of users. However, the implementation fulfills those requirements related to scalability, allowing the service to be extended easily.

Tutorials considered for the implementation and testing phase are: Going outdoors, Preparing Coffee, Cooking pasta (simple), Cooking pasta (complex), Taking drugs and Morning grooming.

Two different cooking pasta tutorials were considered when creating the knowledge base for the Rule Engine, depending on the user general degree of impairment: mild (complex tutorial) or moderate (simple tutorial). Complex cooking pasta includes holding and carrying heavy kitchenware while simple does not.
13.3 Working Memory

The working memory containing the knowledge repository is composed by 7 facts, whose content and relations are defined on a template.

- One fact for the user profile, where every slot corresponds to one of the conditions: visual impairment, sound impairment, fine coordination, aphasia, neglect, dementia.
- Six facts corresponding to the available tutorials. Each of these facts has two slots: its name and a Boolean value indicating if the tutorial is selected or not.

In the execution of the Rule Engine several files are involved:

**RuleEnginePlan.java.** This class declares an instance of the Rule Engine and reset the working memory to assert the initial fact. It calls the *UserProfile.clp* file, containing the templates, queries, facts and rules definition. Once all these structures are defined, the current values of the user profile fact are retrieved from the Belief Base of the Patient Agent, and asserted into the working memory. Following, the Rule Engine is run to assert the rest of facts and execute the rules.

Finally, a query is used to retrieve the group of tutorials selected by the Rule Engine according to their Boolean value. Results obtained are used to update the corresponding beliefs on the Belief Base.

**UserProfile.clp.** This is a JESS file containing all the templates, queries, facts assertions and rules definitions.

Each of the rules created for the inference reasoning correspond to one of the tutorials and follows the same pattern: the current values of the user profile conditions are compared with those indicated in the knowledge base. If the condition is evaluated positively, the fact corresponding to that tutorial in the working memory is modified, setting his Boolean value to true. A warning message is also printed out.
14. MEDIA RECORDING

Videoclips used for illustrating each of the available tutorials were recorded in Casa Agevole and in the Fondazione Santa Lucia facilities (adapted bathrooms for patients and occupational therapy area) during the summer-autumn 2009 in Rome. The IT specification in section 8.2 was used to record the footages, following the steps composing each tutorial.

Medical assessment was extremely valuable in order to fix important issues regarding the video recording: what was the best angle for filming, which was the proper order to present the items needed, how the actor should act in front of the camera, etc.

Additionally, several changes were introduced while recording, since medical considerations such as including a new cooking pasta tutorial for those users not able to carry a pot or generalizing the morning grooming tutorial to enlarge its target population were taking into consideration.

Audio samples in Italian were recorded voice-over by Dr. Nadia Tini and added to videoclips during the experimentation phase, as a significant improvement to get users focused on the instructions given.

Figure 18. Recording of the Grooming and Going Outdoors tutorials
Figure 19. Recording of the Preparing Coffee and Preparing Pasta tutorials
**TESTING**

Performance engineering is the process by which software and hardware are tested and tuned with the intent of realizing the required performance. The testing cases of the IT service are included within the testing phase of SHARE-it project, which execute scenarios 1, 2 and 3. These scenarios have put the different technologies and integrated services (among which there is IT service) to the test with the aid of 15 Italian volunteers.

We are using some of those concepts to analyze the following three aspects of SHARE-it architecture’s quality of service [23]:

- Performance (response times)
- Scalability (throughput)
- Reliability (availability and functional integrity)

Without a strategy, performance engineering is simply an exercise in trial and error.

**15. TEST CASES**

**15.1 Testing Cycles**

Designing test cases can be time consuming in a testing schedule, but they are worth giving time because they can really avoid unnecessary retesting or debugging or at least lower it. In our case, engaging volunteers with disabled conditions in testing IT with real activities is a guaranteed way of ensuring that the service is usable, effective and consistent.

---

6 Refer to section 8.1 for a further explanation of IT’s Scenarios
15.1.1 Plan of Action

When getting prepared for an on-site demonstration it is necessary to plan in advance the following points:

i. Pre-Test, self-assessment checklist
ii. Have all necessary software and hardware at worksite
iii. Test all job functions with Assistive Technology running
iv. Reconfigure settings and configurations if necessary
v. Developed scripts for usability

(i) was devised as a pre-test where the medical team assessed the technologies involved in the test case —called scenario— as to confirm that each element of the SHARE-it architecture was compliant with the specification and that the integration of all involved elements (including IT service) was also safe and consistent. This pre-test also covered (ii) and (iii).

Figure 20. Deployment of sensor network in Casa Agevole
The test site for SHARE-it was *Casa Agevole*, a pre-existing facility in Fondazione Santa Lucia that was enhanced with the deployment of a network of sensors used for the contextualization of the IT service.

When it was necessary, the medical team indicated some elements to be modified and/or reconfigured before the real test with the volunteers in order to address point (iv).

### 15.1.2 Experimentation

Before addressing the technical evaluation of the SHARE-it elements interacting with IT in the 3 scenarios used at the experimentation phase, it is important to clarify some issues regarding the whole process.

On the one hand, the decision to deploy the whole architecture in Casa Agevole in order to approach in as much as possible a *real* house. Taking into consideration that all the facilities at Casa Agevole are contained in a 60m², it is easy to understand that mobility tended to be challenging when using robotic platforms where the touch screen was integrated.

On the other hand, another aspect to consider is the dynamics of the experimentation, since the service presented to the first volunteer (ID01) and the one presented to the last volunteer significantly differs. New possibilities of interaction or refinements appeared in the first testing and they were implemented *in situ*. This method was very instructive and interesting but modified the perception that volunteers had about the system and, therefore, users’ perception was better at the end of the experimentation phase.

Regarding the teams participating in the evaluation of the testing, there was a cluster of 7 people permanently in Casa Agevole supporting experiments and evaluating the process. This constant revision assured a very stable evaluation criteria during all the testing phase.
16. OUTCOMES

16.1 Tutorials’ Experimentation Results

In this section, the results from the three selected scenarios testing the IT service are described, along with those changes requested and implemented for each scenario.

16.1.1 Scenario 1: Alberto takes his drugs

The first scenario tested on the experimentation stage entailed launching a reminder followed by the corresponding tutorial. Some of the components were not available at that moment (like some domotic sensors), although it did not affect the functionality of the IT service and its connection to others. IT usability strongly depended on the proper operation of the GUI, as the therapy tutorial was offered through it. Being the first time tutorials were performed by the users, considerable changes were made until they started to fit the user and medical requests.

**Functional Evaluation:** The following table synthesizes the functional evaluation of the therapy tutorial within the context of scenario 1. The *Task Execution* columns evaluate the execution of the task defined by the service while the *Service Support* evaluate the degree of support that this service supposed to the test user. A scale from 0 to 7 was used, being 7 the best score.

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>TASK</th>
<th>VOLUNTEER ID</th>
<th>VOLUNTEER ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorials</td>
<td>Therapy Tutorial</td>
<td>5  5  5  5  6</td>
<td>4  2  5  1  5</td>
</tr>
</tbody>
</table>
Some users were not able to interact successfully with the therapy tutorial since they were not told about how the tutorial’s flow worked. Therefore, it was agreed that some pre-training was needed in order to guide them.

Regarding the tutorial’s presentation, several changes were applied to its functionality in order to improve usability. Most of these changes were requested by the medical team when users encountered serious difficulties at performing the activity. The most significant ones were:

- Introducing a forced delay between the tutorial-steps in order to let the volunteers perceive the information after a few seconds for orientation.

- Removing the confirmation-phase between each tutorial-step, leaving a unique confirmation at the end of the tutorial. It was proven that this functionality to pursue users’ interaction was actually more confusing than helpful. Instead of the confirmation-screen, a timer (implemented by the GUI developer) would show a dialogue asking users if they want to proceed or to repeat a step when no action was perceived after a certain period of time.

- Dividing the first tutorial step (the one asking the user to make sure none of the items to perform the activity were missing) into two different steps, since users tended to be distracted by the length of the instruction during the testing.

- Audio support was requested to be added to the videoclips, as users react easier to voice instructions than to text guidelines.

**Technical Evaluation:** the therapy tutorial operated robustly and quickly, being handled in less than 0.5 seconds, an acceptable response. DLA connections were proved to be working as the list of tutorials was properly initialized and the therapy tutorial was launched and served to the GUI as expected.

As the therapy tutorial had one of the main roles in the scenario, being the first time it was tested with the target users, a lot of feedback was gathered. Some additional functionalities affecting the technical implementation of IT service were required, such as substituting all integrating sound with video for a better comprehension.
**Outcomes:** Although volunteers get used to the tutorials workflow broadly, some encountered difficulties interacting with a computer, as they were not accustomed to new technologies. This fact was explicit by trying to issue vocal commands after finishing an step performance or being confused with the interaction-flow. However, after a few trials and further explanations they eventually became familiar with the application. This fact was encouraging, confirming IT as a good assistive technology.

This scenario was very profitable in terms of feedback for checking the specification (technical and functional) of the IT service and improve its presentation to end-users.

---

**INTELLIGENT TUTORIALS**

<table>
<thead>
<tr>
<th>Volunteer ID</th>
<th>Present</th>
<th>Active Role</th>
<th>Stable</th>
<th>Reaction Time</th>
<th>Execution Errors</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>5</td>
<td>□</td>
<td>Too many confirmation steps were detected in between tutorial steps</td>
</tr>
<tr>
<td>2</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>5</td>
<td>□</td>
<td>Maybe sound could be integrated to videos for better understanding</td>
</tr>
<tr>
<td>3</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td>□</td>
<td>The user got used to the tutorials after a few trials</td>
</tr>
<tr>
<td>4</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td>□</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td>□</td>
<td></td>
</tr>
</tbody>
</table>
16.1.2 Scenario 2: Pietro goes to the church

This scenario requested to display a reminder, a way for the user to reach the corresponding tutorial. After the experience of testing the previous scenario, IT service was more consistent and usable, which made it more appropriate for its target population.

Functional Evaluation: The following table synthesizes the functional evaluation of IT service for scenario 2. The Task Execution columns evaluate the execution of the task defined by the service while the Service Support evaluate the degree of support that this service supposed to the test user. A scale from 0 to 7 was used, being 7 the best score.

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>TASK</th>
<th>VOLUNTEER ID</th>
<th>VOLUNTEER ID</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Tutorials</td>
<td>Going Out Tutorial</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

On the one hand, the going out tutorial brought up a new situation: guiding users on which steps ought to be followed before leaving home but performed in different places, so users were not static during the tutorial and had to kept their concentration when moving around. In all cases, mobility was not perceived as a hindrance when following the tutorial.

On the other hand, users were told how the interface worked before starting to perform the activity, so that they could be able to respond to the tutorial’s workflow properly.

Regarding the tutorial’s presentation, changes previously applied to its functionality proved to be adequate in order to get more dynamic and simple guidelines.

Technical Evaluation: the going out tutorial operated robustly and run flawless as was expected. The incoming tutorial was handled in less than 0.5 seconds, being an acceptable response.
Audio samples were recorded and added to the videoclips to make the understanding process easier. Voice guidelines proved to be very effective in terms of focusing users on what the instructions ask them to do.

This scenario presented a tutorial that had to be followed dynamically on different places of the house, compared to others that have all the steps performed in the same spot. This fact was not reflected negatively in the technical execution.

<table>
<thead>
<tr>
<th>Volunteer ID</th>
<th>Present</th>
<th>Active Role</th>
<th>Stable</th>
<th>Reaction Time</th>
<th>Execution Errors</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td></td>
<td>The user did not want to follow the tutorial.</td>
</tr>
<tr>
<td>14</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Outcomes:** the IT service stood out to be one of the most effective one, providing clear instructions on daily activities. Although there was an upgraded level of complexity regarding the user mobility in order to perform instructions, results obtained suggest that no extra mental workload was added for the users. Changes previously applied to the tutorials’ presentation proved to be positive, since users’ reluctance toward the application was reduced.
16.1.3 Scenario 3: Francesca cooks pasta

The focus of this testing phase was to consolidate the results from previous phases and to integrate the now available US localization system (sensors) in the scenario execution. Localization was crucial in this scenario in order to detect when the user entered in the kitchen in order to offer him the contextual tutorial.

**Functional Evaluation:** The following table synthesizes the functional evaluation of IT service for scenario 3. The *Task Execution* columns evaluate the execution of the task defined by the service while the *Service Support* evaluate the degree of support that this service supposed to the test user. A scale from 0 to 7 was used, being 7 the best score.

<table>
<thead>
<tr>
<th></th>
<th>Task Execution Results</th>
<th>Service Support Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SERVICE</strong></td>
<td><strong>TASK</strong></td>
<td><strong>VOLUNTEER ID</strong></td>
</tr>
<tr>
<td>Tutorials</td>
<td>Cooking Pasta Tutorial</td>
<td>6 6 6 6 6</td>
</tr>
</tbody>
</table>

After two scenarios tested, tutorials’ presentation were much more suitable for the target users, specially when testing with volunteers suffering from a moderate disability. In general, the service was perceived as very useful in supporting end-users.

Cooking scenario also presented two different cooking tutorials depending on the user profile: male users followed a preparing coffee tutorial while females followed a cooking pasta tutorial. The cultural background and age of the users lead this distinction, as male users were not used to cook food.

---

7 Male volunteers performed Preparing Coffee Tutorial
SHARE-it Intelligent Tutorials

Technical Evaluation: the last scenario did profit from the collected experiences from the previous test-runs. After implementing the numerous changes and suggestions from the medical partners, IT service was able to suit most of the required needs.

The US localization system worked properly in order to offer a contextual tutorial, proving that the integration between the different agents was profitable.

The cooking tutorial operated robustly and run flawless as was expected. The incoming tutorial was handled in less than 0.7 seconds due to the localization process, being an acceptable response.

<table>
<thead>
<tr>
<th>Volunteer ID</th>
<th>Present</th>
<th>Active Role</th>
<th>Stable</th>
<th>Reaction Time</th>
<th>Execution Errors</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td>□</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td>□</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td>□</td>
<td>They were triggered manually</td>
</tr>
<tr>
<td>19</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>6</td>
<td>□</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>7</td>
<td>□</td>
<td></td>
</tr>
</tbody>
</table>

Outcomes: the cooking tutorial was performed in Casa Agevole kitchen using real kitchenware that was the same shown in the recorded videos, in order to make easier for users having cognitive disabilities to recognize the tools to use. In addition, there was a certain level of complexity on performing such a tutorial, as it involved different skills and good coordination in order to perform the activity as expected.

Contextual tutorials were also proven to work properly, being displayed when the system acknowledged that users when changing their location.
CONCLUSIONS

17. TEMPORAL AND ECONOMIC ANALYSIS

17.1 Temporal Analysis

The project phases included in the temporal analysis are:

- **Specification.** This phase includes the introduction to the SHARE-it project (5 days), the research on the technologies to use (28 days), the State of Art description (8 days), and the analysis of the system in terms of requirements and use cases (6 days). Also a risk analysis (2 days) is included in the project, as deviations are likely to occur.

  Considering that during this early phase of the project the time dedicated was approximately 4 hours per day, the sum of time consumed for the specification was:

  \[ 49 \text{ days} \times 4 \text{ hours/day} = 196 \text{ hours} \]

- **Design.** This phase includes the interaction workflow design (4 days) and the content description (7 days), referring to the ADLs and scenarios design.

  Considering that during this phase of the project the time dedicated was approximately 8 hours per day, the sum of time consumed for the design was:

  \[ 11 \text{ days} \times 8 \text{ hours/day} = 88 \text{ hours} \]

- **Implementation.** This phase includes the coding of the IT’s functionalities (28 days) as well as the implementation of the Intelligent Layer using a Rule-Based Expert System (8 days).

  Considering that during this phase of the project the time dedicated was approximately 6 hours per day, the sum of time consumed for the implementation was:

  \[ 36 \text{ days} \times 6 \text{ hours/day} = 216 \text{ hours} \]
For the video recording (4 days), a technical expert was hired, working 4 hours/day:

4 days x 4 hours/day = 16 hours

Figure 21. Temporal analysis schema

- **Testing.** This phase includes all the experiments tested in *Casa Agevole* (17 days), considering time dedicated to correct functional errors and implement new changes requested by the technical and medical team.

Considering that during this phase of the project the time dedicated was approximately 8 hours per day, the sum of time consumed for the testing was:

17 days x 8 hours/day = 136 hours

- **Documentation.** The writing of the report started the first day, including the motivation and the introduction to the technologies. However, most of the documentation was reviewed after the testing phase.
Considering that during this phase of the project the time dedicated was approximately 4 hours per day, the sum of time consumed for the documentation was:

49 days x 4 hours/day = 196 hours

An approximation to the total amount of hours dedicated to the project results from the sum of hours every phase took:

196 + 88 + 216 + 16 + 136 + 196 = 848 hours

17.2 Economic Analysis

There are three important aspects to take into consideration when doing an economic analysis:

- **Hardware.** Applicable expenses to the development platform of the application.
- **Software.** Applicable expenses from the acquisition of those computer tools used during the different phases of the project.
- **Human Resources (HR).** Applicable expenses to those tasks carried out as a researcher, analyst or programmer.

**Hardware expenses.** Considering that the analysis of the IT service solution, the development of the application and the individual testing have been carried out in the same computer, expenses arises from the cost of the following device:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PC Intel Core Duo T7500 2.22 GHz 4GB RAM Memory, 120 GB Hard Disk</td>
<td>700€</td>
</tr>
</tbody>
</table>

**TOTAL** 700€
The computer used during all the project, whose characteristics are described in the table above, was powerful enough to fulfill non-functional requirements related to operability, such as fast display of contents and data integrity.

In this cost breakdown, the purchase of a video camera is not included, as a technical expert was hired for the video recordings.

**Software expenses.** Computer tools used during the different phases of the project are listed below. Some software components of the SHARE-it project has been used during the testing phase, such as the GUI or the DLA server.

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eclipse Classic 3.5.1</td>
<td>0€</td>
</tr>
<tr>
<td>Java SE Development Kit 6</td>
<td>0€</td>
</tr>
<tr>
<td>JADEX BDI Agent System v2.0</td>
<td>0€</td>
</tr>
<tr>
<td>Microsoft Word 2007</td>
<td>150€</td>
</tr>
<tr>
<td>JESS Version 7.1p2</td>
<td>0€</td>
</tr>
<tr>
<td>Subversion client Tortoise SVN</td>
<td>0€</td>
</tr>
<tr>
<td>Windows Movie Maker Video Editing</td>
<td>0€</td>
</tr>
<tr>
<td>Gantt Project Tool</td>
<td>0€</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>150€</strong></td>
</tr>
</tbody>
</table>

It was intended to use as many open source tools as possible during the different phases of the project. Therefore, software expenses arises from the MS Office package’s license for using MS Word 2007. The rest of the software can be downloaded for free and installed easily.
**Human Resources expenses.** The time invested in the project is distributed among the different phases as detailed in the previous section, the temporal analysis.

Considering that a analyst, a programmer and a media technical expert are needed in order to cover the different HR needs of the project, expenses breakdown is estimated as follows:

<table>
<thead>
<tr>
<th>Individual</th>
<th>Development Stage</th>
<th>Hours</th>
<th>Cost/hour</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyst</td>
<td>Specification + Design + Documentation</td>
<td>380h</td>
<td>40€</td>
<td>15200€</td>
</tr>
<tr>
<td>Programmer</td>
<td>Implementation + Testing + Documentation</td>
<td>452h</td>
<td>30€</td>
<td>13560€</td>
</tr>
<tr>
<td>Media Technical Expert</td>
<td>Video Recording</td>
<td>16h</td>
<td>25€</td>
<td>400€</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>848h</td>
<td></td>
<td>29160€</td>
</tr>
</tbody>
</table>

The total economic cost of the project result from the sum of the hardware, software and HR expenses analyzed:

<table>
<thead>
<tr>
<th>Type of Cost</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware Expenses</td>
<td>700€</td>
</tr>
<tr>
<td>Software Expenses</td>
<td>150€</td>
</tr>
<tr>
<td>Human Resources Expenses</td>
<td>29160€</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>30010€</td>
</tr>
</tbody>
</table>
18. CONCLUSIONS

Currently, elderly people with cognitive and physical impairment usually end up in hospitals and geriatric institutions, with the subsequent high expenses their relatives accumulate. Moreover, it is proven that a familiar environment facilitates the patients’ enhancement and their willingness to become more independent from caregivers.

Some of the most relevant goals that IT pursue are, on the one hand, to increase the standard of care by augmenting the user’s autonomy, and on the other hand, to make caregivers’ work easier and more profitable. Having these goals in mind, it is right to assert that the solution that IT service offers is a proof of concept of the beneficial impact that next generation of AT will have in elders’ everyday routines.

The SHARE-it experimentation phase represented an important source of new information and knowledge for the improvement of the IT application. Testing scenarios allowed not only to prove that simple use of software facilitates the integration of AT into the care process, but also to reaffirm that neither external support is directly needed nor prior technological experience is required for the reinforce of users’ autonomy. The test site choosen for the experimentation phase - Casa Agevole - allowed a tight control of decision on the environment without any loss of realism.

The testing phase also led to identify that part of the IT success heavily depends on the personalization, since different persons with different disability profiles can have a different approach to their autonomy accomplishment.

18.1 Future lines of research

Considering the outcomes obtained after testing IT, several improvements can be applied to the service as a future work.

Firstly, to achieve a more complex personalization based on an extended user profile. The more accurate the interaction would be, the better approach to the user’s autonomy: too much
SHARE-it Intelligent Tutorials

support could be as negative as too little, undermining residual capabilities or just stressing the user.

Secondly, an extension of the available tutorials would be very profitable, adding new routine activities whose procedural tutorial might help the user to become more independent. These activities could be focused on different hours along the day for a more functional service.

Thirdly, to expand the target population by aiming the IT service at general users requiring occupational therapy for cognitive enhancement. Most of the activities this type of subjects performs consist on very concrete and simple actions. Therefore, the tutorials’ design would be adapted to a new set of requirements.

Lastly, to integrate the IT service with one of the other services that the MAS offers: the Biometric Cognitive Module. The main goal would be to track users by means of the biomedical measures in order to know how they react when performing tutorials (e.g. the user is too much stressed or in the contrary, s/he in a good mood). Retrieving this information, new goals can be pursued by creating different flows of interaction in case the user presents a certain emotional state.

We are now at the very beginning of a new research regarding assistive intelligent tools, as the presented model for tutoring users with disabilities has been enhanced by very fruitful interaction with real patients and, therefore, the system has the necessary inputs to be improved and enriched. Additional challenges will require collaboration with colleagues having expertise in machine learning, natural language processing, robotics and machine vision.
APPENDIX

A1. GLOSSARY

A1.1 Medical terms

(by alphabetical order)

ALZHEIMER. The most common form of dementia. In the early stages, the most commonly recognized symptom is memory loss, such as difficulty in remembering recently learned facts. As the disease advances, symptoms include confusion, irritability and aggression, language breakdown, long-term memory loss, and the general withdrawal of the sufferer as their senses decline. Gradually, bodily functions are lost, ultimately leading to death.

APHASIA. Language disorder which is presented when there is difficulty in using or understanding spoken and written language or is completely lost the ability to do either. A person with aphasia may think normally, so using baby talk is inappropriate.

APRAXIA. Neurological disorder characterized by loss of the ability to execute or carry out skilled movements and gestures, despite having the desire and the physical ability to perform them. Apraxia may be accompanied by a language disorder (aphasia).

AUDITORY AGNOSIA. Inability to recognize sounds.

CAREGIVER. Personal who gives medical assistance and caring support to the user at home.

COGNITIVE IMPAIRMENT. Capacities of the nervous system are limited or impaired with difficulties exhibited in one or more of the following areas: use of memory, control and use of cognitive functioning, sensory and motor skills, speech, language, organizational skills, information processing, affect, social skills, or basic life functions.

DALTONIC. Inability to distinguish red from green.

DEMENTIA. Progressive decline in cognitive functions affecting memory, attention, language and problem solving. Higher mental functions are affected first in the process. Especially in the later stages of the condition, affected persons may be disoriented in time (not knowing what
day of the week, day of the month, or even what year it is), in place (not knowing where they are), and in person (not knowing who they are or others around them).

**DYSPHAGIA.** Sensation that suggests difficulty in the passage of solids or liquids from the mouth to the stomach.

**HEMIPARESIS.** Paralysis affecting only one side of the body.

**HIP FRACTURE.** A break of the top part of the femur bone where it connects to the pelvis. Only a small portion of patients retain their previous mobility, while about 20% will require nursing home care.

**IPOVISION.** Visual acuity below 1/10.

**MIXED IMPAIRMENT.** Simultaneous presence of motor and cognitive disability on a patient.

**NEGLECT.** Unilateral spatial neglect is a condition which reduces a person’s ability to look, listen or make movements in one half of their environment. This can affect their ability to carry out many everyday tasks such as eating, reading and getting dressed.

**PARKINSON.** It is characterized by muscle rigidity, tremor, a slowing of physical movement and, in extreme cases, a loss of physical movement. Secondary symptoms may include high level cognitive dysfunction and subtle language problems.

**PATIENT.** Individual with cognitive or mixed impairment (cognitive and physical). Regarding the system, usually is known as ‘user’.

**PRESBYOPIA.** Condition where the eye exhibits a progressively diminished ability to focus on near objects with age.

**STROKE.** It occurs when the brain does not get sufficient oxygen. Damage on the right side of the brain may impair movement and sensation on the left side of the body. Damage on the left side of the brain may affect movement on the right side. Speech and language, vision loss, breathing, swallowing, balance, hearing, and bladder and bowel function may be affected.

**VISUAL AGNOSIA.** Loss of ability to recognize objects, faces and words.
A1.2 Technical terms

(by alphabetical order)

**ADLs (Activities of Daily Living).** Basic tasks a person needs to carry out daily, such as dressing, cooking and toileting.

**AT.** Assistive Technologies.

**DLA (Distributed and Layered Architecture).** DLA Architecture is used to develop cooperative systems with different interacting modules distributed along several machines. It implements a distributed shared memory model, with a central element that manages the access and storage of the shared data from the other modules.

**ENVIRONMENT AGENT.** Its basic target is to distribute the information from all available sensors to all the agents interested.

**GUI.** Graphical User Interface.

**HOME AGENT.** Represents the home entity, which will be situated in a home server. Among its objectives are to maintain the monitoring of the users, to manage their daily living activities and their profiles.

**IT.** Intelligent Tutorials.

**i-WALKER.** Assistive device with four conventional wheels and two degrees of freedom that improve user’s stability and safety while walking. It may support up to 50% of the user’s body weight, being ideal for weak knees or ankles or severe balance problems. The intelligent Walker has two handles that the user holds with both hands for interaction.

**MAS (Multi-Agent System).** Small software entities – software agents – with special capabilities (autonomous, reactive, pro-active and social) are used instead to interact in a flexible and dynamic way to solve problems more efficiently.

**PATIENT AGENT.** An instance of this agent should provide all the available and permitted services to each user, such as security, mobility, monitoring and help services, or those that could be added in the future. Patient-agents runs in PDAs or Ultra-Mobile PCs.
ROLLAND. Semi-autonomous wheelchair which is able to function safely indoors and outdoors in appropriately set-up environments.

SHARE-it. Supported Human Autonomy for Recovery and Enhancement of cognitive and motor abilities using Information Technologies. European project which includes ADL tutor as one of its multiple service.

WI-FI. Wireless networking technology that uses radio waves to provide wireless high-speed Internet and networks connections.
A2. STORYBOARDS

The GUI that has been implemented by another developer, fulfills the functional requirements and use cases of the IT specification for the tutorials’ display. Workflows defined when performing a tutorials have been also considered. Medical assessment has been involved during the design, in order to develop a suitable interface whose target population is elderly people.

![Figure 22. List of tutorials (categories) - screen shot](image)
1. Controlla che ci sia tutto: scatola, bicchiere, bottiglia d’acqua

OK, fatto

**Figure 23.** First step of tutorials - screen shot

Chiudere

**Figure 24.** Last step of tutorials - screen shot
Hai veramente bisogno di aiuto?

- SI
- NO

**Figure 25.** Request for help / Report an alert - screen shot
REFERENCES


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