The role of people identification in a social robot*

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Abstract— **This paper proposes a new service model for ICT-based service robots to support elderly people, which benefits from the platform's ability to recognize persons and from having access different types of elderly information, such as their preferences or disabilities. The common existing paradigm in Ambient Assisted Living (AAL) solutions is that of a platform that holds different, generic services that fulfil the average elderly needs. This type of approach fails to promote an enduring robot's acceptability and usability, in the sense that services fail to adapt to elderly changing needs along time. In this paper we present a service model which uses an XML format representation, and discuss its implementation in a mobile robotic platform within the scope of the SocialRobot project. The proposed service model goes beyond the models existing in state of the art daily task assistant robots. While being executed, services accept multiple different sources of information as arguments and use them to best fit the service provision to the end user. This paper also presents our solution for person recognition and discusses other alternative solutions, their pros and cons in the envisioned real use case scenarios. Initial tests show a highly flexible and adaptable service provision. Services can be expanded or new services created without incurring in additional costs emerging from the intervention of expert technicians, contributing thus to an affordable solution for the AAL market.**

I. INTRODUCTION

This paper presents a new service model for assistant robotic platform which is user-centric. The core of the proposed solution is divided two fold: 1) the knowledge of user information, which is provided by different people in their social network (the so called Virtual Care Team); and 2) the ability of the robotic platform to recognize persons, exploring such knowledge to provide personalized services.

The problem of population ageing is motivating research efforts towards the creation of technologies which are able to continuously assist and support people in their daily lives. The need for robotics and ICT technologies in the are of Ambient Assisted Living (AAL) is so noticeable, that they are rapidly being taken up by the market as health and social care profitable solutions in terms of deliverance and efficiency [1].

Using robotic technologies to improve monitoring and assistance services has been target of keen research by different groups and with a strong support of the European Commission. Already several FP6, FP7 and AAL research projects have and are dedicating efforts to go beyond the development of mechanical and technological challenges to equip platforms with ICT services and functionality that are useful and accepted by elderly people in personal support and the care domains. Such projects notably include CompanionAble [2], Echord-Astromobile [3], both providing mobile robotic platforms that support older people to preserve independence and safety at home. The main services provided in these robots are activity scheduling, tele-presence, monitoring and medicine scheduling. Other robots support people with one or more light physical disabilities, focusing on health, nutrition, well-being and safety, including the capability to monitor vital signs or detecting falls, gaming, etc. Florence [4], KSERA [5], Mobiserv [6] are some remarkable examples. Some worthy technological mentions in the field of assistance service robots that are used in some of these projects are Care-O-Bot [7] and the Robot Maid [8]. These platforms are equipped to provide visual and audio interaction and common sensing technologies to perceive the environment and the elderly.

A common property of these and other service robots, is that they are pre-programmed with specific services and knowledge at the manufacturing stage, and as a consequence they often fail to properly cope with the constantly changing needs of elderly people. The presented concepts and service models have been defined and are currently being developed within the scope of the Social Robot project [9], whose main goal of developing a mobile platform for personalized care provision, adaptable throughout the platform's presence in the elderly life.

A. THE SOCIAL ROBOT CONCEPT

The SocialRobot project is multidisciplinary, involving valences that range from end-user assessment to engineering and Information and Communication Technologies (ICT), and are then combined to provide a user-centric robotic platform that is capable of assisting elderly people in their daily life, meeting their specific needs. In SocialRobot, the innovation emerges not only from the area of innovative software and robotics technologies and their appropriate integration for elderly care but also from the development and support of an innovative elderly practice-oriented social community care model that integrates new types of advance elderly social interaction with advanced robotic monitoring and care & wellness services. It focuses on the identification of end-users particular wishes and needs in terms of what factors, relationships, communication and daily care assistance

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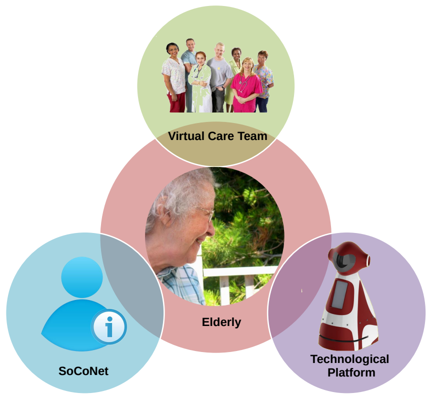

Fig. 1. Elderly on the center, surrounded by the robot, VCT, equipments, Soconet. NEEDS TO BE MODIFIED

routines are meaningful to be generated in order to provide the best possible care provision to the elderly. The social community model encourages and supports communication, assistance and self-management of the elderly, promoting seamless connection and interaction of different people (like carers, family members, friends, neighbors) from all ages at any time where the robot will act as a form of an intermediate agent between the elderly and the social care community. The information about the elderly is maintained in the Social care Community network (SoCoNet) secure database. This database has a supporting interface which allows both the robotic platform or a VCT member to add, remove or update information. Services are actively provided by a robotic platform, which in the SocialRobot project is a mobile robot. The goal of the project is to promote the maximum interaction between the elderly, family, friends, carers supported by the robotic platform and the intelligent repository of information (see Fig. 1).

B. SoCoNet - Knowing the Elderly

The SoCoNet is a core component of the Social Robot solution. With the elderly at the centre of its structure, it is a web-based virtual collaborative social community network, enabling the effective administration and coordination of the user (Person) profiles and Virtual Care Teams (VCTs) around the elderly person (see Figure 2). This tool is supported by a set of services whose main objective is to ensure that the elderly will have a unique and personalized profile of disabilities and abilities, special needs and preferences. These profiles can be adapted through the life of the platform and are used by the service models to promote personalized care provision. In order to promote modularity, the SoCoNet components and schema are designed, developed and maintained independently from the robotic platform. Information management is mainly maintained by VCT members, which have the ultimate responsibility of ensuring data correctness. From the robot's perspective, there are methods responsible for retrieving and storing the required data for service provision and, when necessary, update the database table contents. The following items will describe the main information categories present in the SoCoNet database, according to the illustration in Figure 2.

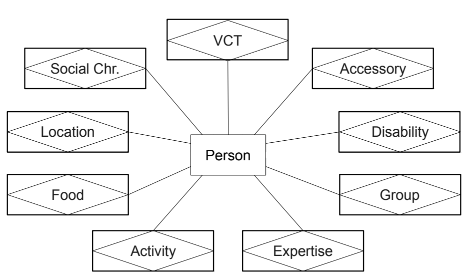

Fig. 2. Soconet schema simplified to the first information layer.

- **Person**: Stores general information about all the users of the system.
- **VCT**: consists of people (members) of different ages (young and old) and roles (relatives, friends, neighbours, care professionals, etc.) that can assist, collaborate and actively communicate with the elderly.
- **Group**: Stores a list of all possible groups that a Person can belong to (i.e., Golf group, Dancing Group, Photograph Group, etc.).
- **Food**: Stores a list of different food that can be included in the food menu.
- **Location**: Stores a list of all possible locations (specific locations) that a Person may like or do not like to visit (i.e., the park, the hospital, the cinema, etc.).
- **Expertise**: Stores a list of all possible expertise a Person may have in a certain domain (electrical engineering, doctor, sports, gardening, etc.).
- **Social Characteristic**: Stores a list of all possible social characteristics that the Person may have. Such social characteristics are for example (does not like water activities, does not like outdoor activities, does not like to see very handicapped people, etc.)
- **Accessory**: Stores information about all possible accessories a Person may need. Such accessories can be eyeglasses, walking sticks, cars, mobile phones, umbrellas, coats, medicine, etc.
- **Disability**: Stores a list of all possible disabilities a Person may have (hearing problems, sight problems, walking problems, etc.).

Albeit being defined separately, these different information items can be related between each other. For example, an accessory "Water Bottle" may be associated to a specific activity like "Yoga". Such associations allow a wide range of combinations that will maximize the use of the available information for a detailed and highly personalized service provision.

II. SERVICES PERSONALISATION

In SocialRobot we propose a service model that is highly adaptable to deal with similar scenarios, maximizing the exploitation of the information existing in the SoCoNet database. Preference and priorities for different persons allow each user to have an engaging and personalized experience with the robot, which is different from all the others because it satisfies their personal needs based on their own preferences and behaviour profiles.

Existing robots are built to provide generic services which are programmed a priori upon analysis of end-user group requests. However, elderly needs keep changing, caused for a number of different factors. Hence, such service approach may become outdated shortly. The most commonly observed service provision in state of the art robots is often limited to monitoring and reminding of activities or medication scheduling. This apparently seems a good approach to address the most standard scenarios, with the ability to provide the same services in different places like at home or care centres.

However, in this paper we highlight two categories of everyday use-case scenarios, justifying why this approach is likely to become obsolete or, at least, insufficient. In multiple user environments, under the current paradigm, the same service is repeated to all users along time, which eventually will reflect a decrease of user acceptability and loss of interest. Additionally, a service might require specific information to be properly executed, whereas such information might not be available at the programming stage. For example, if an older person is diagnosed diabetes, a cooking advice service needs to start avoiding suggesting recipes using sugar.

A. *SERVICE MODEL*

The use of a semi-structured data model will enable the knowledge base to represent the large variety of different information sources in a uniform manner. The proposed service model is operationally implemented using an XML structure (see Figure 3), which benefits from being human and machine readable. It represents a structure of different functions that are required to provide a service and whose execution can be synchronous or not. It is also possible to link these functions in a more flexible manner, for example adding importance or priority to each of them, bundle various functions together or even state preconditions for each function. Moreover, such approach promotes the independence of the actual service description from service knowledge, allowing thus for greater flexibility. Because the data in the SoCoNet database is also represented in XML format, it facilitates an easier and more sophisticated matching and blending between knowledge and service descriptions. The platform's service capabilities is divided into two separate functional stages:

1) **Service Interpretation.** A parsing system that is responsible for interpreting the service XML definition, verify its integrity and generate the operational sequence of functions that the platform has to execute;
2) **Operational Execution.** Given a machine readable service description, the execution engine will ensure that each low-level function is called and retrieves the necessary data to advance in the function pipeline. The order of execution, if existent, is defined by priority weights. Once all functions have been called, the service is considered terminated.

```xml
<!--Service XML Example Using Pseudo Code Variables-->

<Service>
    <Name> SR-Meal_Suggestion </Name>
    <Description>
    "30 minutes before meals, the robot checks for standing by elderly and tries to match to
    elderly preferred meals.
    </Description>
    <Function>
        <CallbackName="Face_Recognition"/>
        <InputType="UInt8[]"/>
        <Output="UInt32"/>
        <Order="1"/>
        <Priority="High"/>
        <Mandatory="Yes"/>
    </Function>
    <Function>
        <CallbackName="Get_User_Preferred_Meals"/>
        <InputType="UInt32"/>
        <Output="String"/>
        <Order="2"/>
        <Priority="High"/>
        <Mandatory="Yes"/>
    </Function>
    <Function>
        <CallbackName="Match_Meals"/>
        <InputType="String"/>
        <Output="BOOL"/>
        <Order="3"/>
        <Priority="High"/>
        <Mandatory="Yes"/>
    </Function>
    <Function>
        <CallbackName="Voice_Synthesis"/>
        <InputType="String"/>
        <Output="BOOL"/>
        <Order="4"/>
        <Priority="High"/>
        <Mandatory="Yes"/>
    </Function>
</Service>
```

Fig. 3. Service XML Structure

The details on the functional stages and the system architecture can be found on [10], where the framework that supports the development of the robotic platform tools is the Robotic Operating System (ROS), while the SoCoNet database and the interacting web-methods are developed in MsSQL and Java respectively. The following real scenario describes the execution flow from the service described in Figure 3.

> *It is 30 minutes to lunch time, and the robot is facing an older person, who is sitting in the sofa, to provide an alerting service. It calls the recognition function to identify who is in from of it. Upon an accurate identification, it queries the database for that persons favourite meals. Then it compares that information with the lunch menu for that day. In case there is a match, it calls a speech synthesis module to tell the person that in 30 minutes, his favourite food is going to be served for lunch.*

The fact that these functions accept arguments is a key property in the proposed service model. In this context, the identity of the person who is interacting with the platform is probably the most relevant argument. This strategy allows the SocialRobot platform to retrieve information that is specific to a particular user, such that the provided service meets that user's particular needs. Therefore, an accurate recognition of the person is essential for this model to exhibit its full potential.

III. ELDERLY RECOGNITION

To recognize the elderly, we use computer vision and machine learning. This is justified by the presence of video cameras in most common platforms that are used in related AAL solutions. We selected face recognition because, while interacting with the robot, the user has to face it, allowing thus the face to be recognized. It is a well developed research area and for testing purposes we have currently implemented a classical algorithm based on the so called eigenfaces (the basis of this method can be found on [11]). Briefly speaking, this is a method that applies the Principal Component Analysis algorithm to a 8-bit coloured image of a face, thus generating a feature vector that can be used for classification purposes. For recognizing the observed person face, we implemented a Bayesian classifier. Given an Eigenface feature vector $X = [x_1, ..., x_m]$ as evidence, the classifier poses the following Bayesian question:

$$P(Y = y|X = [x_1, ..., x_m]) \tag{1}$$

where $y \in Y$ represents a single identity. Feature models are represented by Gaussian distributions trained with images from the recognizable elderly. We use entropy the classification entropy H as a measure of classification confidence, defining a threshold ρ to decide whether we use the classified information or not. This is done to ensure that the service does not wrongly fetch incorrect data from SoCoNet database. We are currently studying the viability of an alternative method, which is more robust to occlusions and illumination changes [12]. The cases where the recognition fails are discussed in the following section.

IV. DISCUSSION AND CONCLUSIONS

The literature in person recognition is vast. There are dozens of methods and technologies that can be used to identify a person, as we already see in our daily life. Some of these methods require explicit user cooperation in order to obtain a positive recognition. Notable examples of these processes include fingerprint or eye scanning. Other studies address person recognition from their movement. By encoding the signals generated from human movements, machine learning methods are able to discriminate between different persons. An indirect way of recognizing persons is to have them wearable sensors, like RF-ID bracelets, that will allow them to be identified. The following Table I summarizes some of the most prominent person recognition methods, their pros and cons as analysed in the context of the SocialRobot project.

In assistant robots for AAL scenarios, it is desirable to avoid wearable sensors or technologies which do not make persons feel comfortable. We need also to consider prominent technologies, available in most platforms which are cameras and microphones. In SocialRobot, given that the robot may also operate in multi-user environments, we have primarily discarded recognition using voice and focused on face recognition. Future developments may incur on a hybrid recognition scheme, using the audio signal when feasible, to support/corroborate the recognition using facial images. When recognition is deemed impossible, the platform is prepared to request the user to explicitly identify him/herself using the available interfaces, in this case, a touch screen. However, the goal is to minimize these situations and prepare the robot for a timely, personalized response to meet the elderly needs under the present conditions given the maximum available information.

TABLE I
ESTABLISHED PERSON RECOGNITION METHODS PROS AND CONS DISCUSSED IN THE CONTEXT OF THE SOCIALROBOT PROJECT.

Fingerprint & Eye Scanning	**PROS:** Well developed research; Guarantee of recognition;
	CONS: Required specific sensing device; Elderly may find it intrusive because it is a common method used for security reasons.
Face Recognition	**PROS:** Well developed research; Reasonable accuracy; Technologically easy to implement; Recognition can be done in background; A wide range of available methods.
	CONS: Sensitive to occlusions, illumination changes.
Voice Recognition	**PROS:** Well developed research area; Reasonable accuracy when input sound is clean; Technologically easy to setup; Recognition can be done in background.
	CONS: Not adequate for multi person and noisy environments, such as care centres.
Action based	**PROS:** Very active research area using mainly Gait based recognition.
	CONS: Emerging research area; Not mature and robust enough technology to be used of-the-shelf in set-ups that don't include wearable sensors.
Typing Patterns	**PROS:** Recognition occurs while the user types in a keyboard.
	CONS: Most elderly people type slowly, which makes it hard to detect usable patterns.

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