Assistive Robots as Future Caregivers: The RAPP Approach

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Abstract. As our societies are affected by a dramatic demographic change, the percentage of elderly and people requiring support in their daily life is expected to increase in the near future and caregivers will not be enough to assist and support them. Socially interactive robots can help confront this situation not only by physically assisting people but also by functioning as a companion. The rising sales figures of robots point towards a trend break concerning robotics. To lower the cost for developers and to increase their interest in developing robotic applications, the RAPP approach introduces the idea of robots as platforms. RAPP (A Software Platform for Delivering Smart User Empowering Robotic Applications) aims to provide a software platform in order to support the creation and delivery of robotic applications (RApps) targeting people at risk of exclusion, especially older people. The open-source software platform will provide an API with the required functionality for the implementation of RApps. It will also provide access to the robots' sensors and actuators employing higher level commands, by adding a middleware stack with functionalities suitable for different kinds of robots. RAPP will expand the robots' computational and storage capabilities and enable machine learning operations, distributed data collection and processing. Through a special repository for RApps, the platform will support knowledge sharing among robots in order to provide personalized applications based on adaptation to individuals. The use of a common API will facilitate the development of improved applications deployable for a variety of robots. These applications target people with different needs, capabilities and expectations, while at the same time respect their privacy and autonomy. The RAPP approach can lower the cost of robotic applications development and it is expected to have a profound effect in the robotics market.

Keywords: robotics, elderly; inclusion, assisted living, cloud robotics.

1 Socially Assistive Robotics in an Ageing Europe

Continued advances in science and technology and general improvements in environmental and social conditions have increased life expectancy around the world. As a result, the world's population is aging and our societies are undergoing a dramatic demographic change (Fig. 1). In Europe, the share of people aged 65 years or over in

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the total population is projected to increase from 17.1% to 30.0% and the number is projected to rise from 84.6 million in 2008 to 151.5 million in 2060. Similarly, the number of people aged 80 years or over is projected to almost triple from 21.8 million in 2008 to 61.4 million in 2060. In the near future, caregivers will not be enough to assist and support these rising numbers of elderly and people requiring some sort of help in their daily life [1]. An imminent threat of exclusion arises as people in need will be provided by nothing more than basic care and their social life will be endangered and diminished.

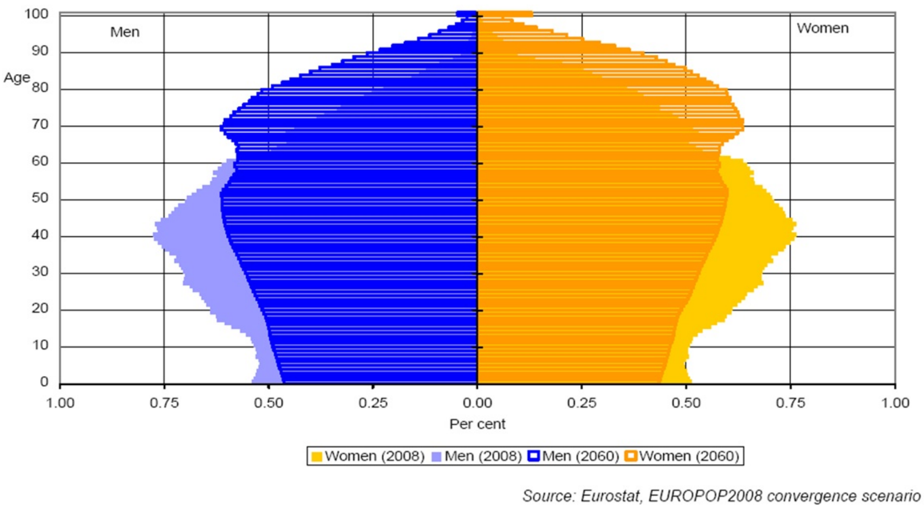
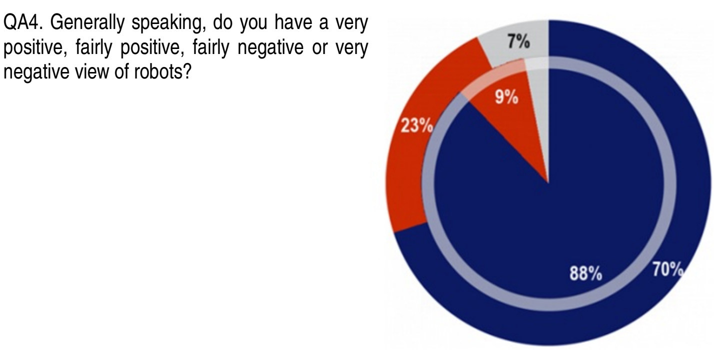


Fig. 1. Population pyramid for EU27, 2008 vs. 2060

Robots can help alleviate this situation not only by physically assisting people, but also by functioning as a companion for groups of people in danger of social exclusion [2–5]. Apart from providing assistance with daily tasks, robots will be able to socially interact with people to guarantee their inclusion. Although recent European studies (see http://ec.europa.eu/public_opinion/archives/ebs/ebs_382_fact_dk_en.pdf) indicate that there is resistance towards having elderly people minded by a robot, when given the choice of robotic care versus moving into a care facility, the resistance disappears (Fig. 2). Another study from Georgia Tech showed that seniors favored robotic help for household chores but not for personal needs such as getting dressed, bathing, etc. (http://www.sciencedaily.com/releases/2012/10/121025161518.htm). This knowledge and the spreading aging demographics of EU and other countries are propelling research into home healthcare robots. The numerous stakeholders in robotic healthcare (family members and caregivers, healthcare providers, technology providers, aging or disabled individuals) have similar goals: to provide independence, preserve dignity, empower those with special needs and provide peace of mind to the end users.



	EU27	DK
Total 'Positive'	70%	88%
Total 'Negative'	23%	9%
Don't know	7%	3%

Source: http://ec.europa.eu/public_opinion/archives/ebs/ebs_382_fact_dk_en.pdf

Fig. 2. Public attitude towards robots according to EU Commission

Socially Assistive Robots (SAR) can be perceived as an intersection of Assistive Robots (AR) and Socially Interactive Robots (SIR) [2]. ARs refer to robots giving aid or assistance to human users and include rehabilitation robots, mechanical rollators, companion robots or even robotic arms to support the physically disabled. These can be utilized in a heterogeneous set of environments, such as schools, hospitals, rehabilitation centers or households. On the other hand, SIRs comprise a much more general group, as they describe robots able to communicate, or in general, interact with a human user. Of course, apart from the interaction, SIRs must exhibit a set of social skills. In [3] and [4] Breazeal and Fong et al. categorize social robots into seven overall classes, differentiating in their social interaction complexity:

1. *Socially evocative*: robots that require input from humans to start socializing.
2. *Social interface*: robots providing an interface to users, usually for communication purposes.
3. *Socially receptive*: robots that can learn from social interaction.
4. *Social*: robots capable of high social skills, requiring serious models of social cognition.
5. *Socially situated*: robots surrounded by a social environment, in which they should recognize users or other agents.
6. *Socially embedded*: robots situated and socially structured in a social environment, partially aware of human interaction schemes.
7. *Socially intelligent*: robots showing aspects of human social intelligence.

In order for a robot to be classified as SRI, it should be able to showcase some human social characteristics, such as express or perceive emotions, communicate with high level dialogue, learn/recognize models, establish social relations, use natural cues, possess a distinctive character, and learn or develop extra social skills [4]. Furthermore, an important aspect of SIRs is their morphology, as a classical "robotic" or "mechanical" shape may be inappropriate for HRI (Human-Robot Interaction). The commonly accepted morphologies include anthropomorphic, zoomorphic or caricatured robots. Of course, social robots must possess means of interaction in order to express their artificial emotions and communicate appropriately with the end user. Such skills include speech, as a way to provide and accept information or commands, facial expressions to easily showcase emotions (since humans can usually identify emotional conditions by observing another human's face) and body language, including gestures and body movement, aiming to enhance the deployment of social skills. Finally, SRIs can help elders, humans with physical impairments, in convalescent care or cognitive disorders, as well as students. Of course, socially interactive robots can perform a wide ensemble of tasks according to the needs of the respectful user, including tutoring, physical therapy, daily life assistance or encouragement of emotional expression (e.g. in the case of autistic children).

Both an abundance of articles on the bright future of robotics and the increasing sales volumes of robots indicate that we are possibly facing a trend break for this industry [6]. The idea of robots as platforms will inevitably lower the cost for small and medium size developers to experiment with robots, develop applications for them and, ultimately, enter the market. The applications will add extra value to the robots themselves, making them more attractive and useful for wider audiences, leading to even lower prices and more affordable robots for everyone. The ability of robots to use particular applications according to their owners needs will make them a highly customized and personalized product for everyone and persons with disabilities can certainly benefit from such a personalization. It is thus evident that the use of robots as platforms will position the software developer who will provide these platforms at a strong competitive advantage with respect to the market.

As robots become progressively integrated into our daily lives, they must increasingly deal with situations in which socially appropriate interaction is vital. In such settings, it will not be sufficient for a robot to simply plan its actions to perform particular tasks; instead, the robot must also be able to satisfy social goals and obligations arising through its interactions with people in real-world settings. As a result, a robot should be equipped with not only the necessary physical skills to perform tasks in the world, but also with social skills to understand and respond to the intentions and needs of the people it interacts with.

A robot can only achieve tasks and perform missions based on what it knows, which is primarily captured within the robot's internal knowledge representation. This representation is usually very specialized to the individual robot and often very loosely defined. With the growing complexity of behaviors robots are expected to perform, as well as the need for multi-robot, human-robot collaboration and knowledge reuse, the need for a standard and well-defined knowledge representation is becoming more apparent.

Since increased longevity is often accompanied by a decline in health and the onset of various impairments, the ability of the elderly to continue an independent life is diminished, thus increasing the risk of social exclusion. RAPP aspires to facilitate advanced technological solutions to this problem, aiming either to treat a specific disability factor or to provide alternative interaction methods for the elderly. RAPP will take into consideration the real needs and expectations of the elderly and will provide a framework of high motivation and trust for them. The proposed technologies will be integrated with the surrounding social environment and help older people remain socially active while maintaining acceptable levels of independence and autonomy. RAPP will function as a new paradigm for developing robotic applications, which is expected to minimize the respective economic costs and to usher in a new attitude for the adoption of advanced technologies by the elderly.

2 The RAPP Approach

An overview of the proposed RAPP approach is depicted in Fig. 3. The overall architecture clearly shows that RAPP has been designed as a distributed system [7], where the Platform and the Store are provided as cloud services, and the Client is located on the robot side. The RAPP platform includes the RAPP API, a wrapper library to the corresponding robot and cloud APIs, and container of several core robotic applications like path planning, navigation, image recognition, etc.

RAPP is different from the established technologies in this domain, by the fact that it tries to combine several different functionalities into a single system implementation. More specifically, the system consists of a web (cloud) part, containing the RApp-Store (Robotic Applications Store), the knowledge pool and inference methodologies, and the robot-component representing each robotic device that can download and install RApps. The cloud-part also provides services for the execution of heavy duty computations on the web instead of the robot. The component that bridges together the entire system is HOP, a toolset for programming the Web Of Things [8],[9]. The different modules comprising the RAPP architecture have been defined either on a technological level (i.e. different implementation layers), or at a conceptual level (i.e. data mining module).

Of particular note within the overall RAPP platform, is the RAPP Improvement Centre (RIC). It resides within the cloud component and is in charge of performing the required Machine Learning (ML) and Data Mining (DM) processes, either upon request by a robotic application (RApp), or as a standalone process.

Finally, the RAPP ontology enables the description and mapping of robots' hardware and software methods, the activities needed to be performed, the environment in which the robots need to operate and the relationships among other robots and/or people. The RAPP repository will be eventually organized based on the RAPP ontology concepts and will allow the secure management and anonymization of user profiles (measurements, statistics, events, etc.), as well as the collection of large scale heterogeneous data.

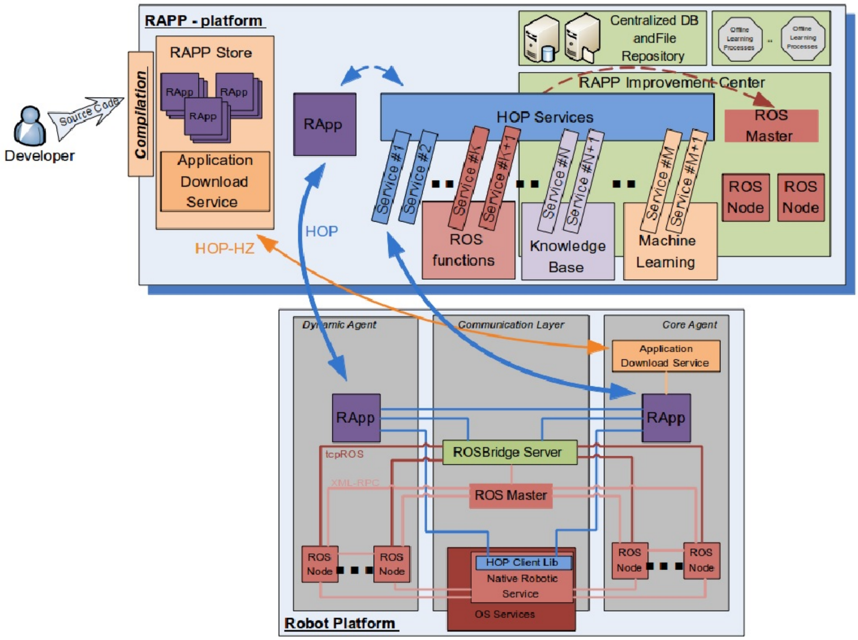


Fig. 3. Overall RAPP system architecture

2.1 RAPP's Social Objectives

RAPP aspires to foster the development of robots and robotic applications to encourage social, emotional, and cognitive empowerment of people at risk of exclusion, and in particular elderly people, including those with social or cognitive deficits. The need for this technology is driven by critical societal problems requiring sustained, personalized support, supplementing the efforts of caregivers, social workers, clinicians and relatives attending the elderly.

RAPP's social objectives can be summarized as follows:

- To create an accessibility and usability ecosystem for the development of robotic applications, linking interface developers, device makers, service providers and user communities.
- To provide robotic software solutions towards augmenting the participation and independent living of the older persons in modern societies.
- To integrate real-time monitoring of user needs, to improve user experience and learning potential, and to adapt contents and interfaces.
- To design application paradigms for all people at risk of exclusion, notably elderly persons, and to provide novel accessibility solutions for them, enhancing their quality of life.
- To support the creation and deployment of innovative robotic-based solutions in order:

- To lessen or to eliminate a person's functional disabilities regardless of their impairments,
- To motivate and "include" those affected by other societal factors, and
- To facilitate acquisition of skills on the use of robots.

3 The RAPP Robots and Scenarios

RAPP's short-term objective is to include two robotics platforms into the RAPP development cycle:

1. The Aldebaran's NAO humanoid robot, and
2. The INRIA's ANG-light robot.

The reason behind the use of two rather different robots should be obvious. We need to demonstrate platform interoperability and to provide evidence for the generalization of the RAPP concept by wrapping different capabilities through the RAPP API. In addition, it has not yet been resolved as to whether humanoid or custom robotic platforms are better suited for robotic aid's needs, thus we have to study both approaches and shed some light in either direction.

3.1 Pilot Cases – Inclusion RAPPs

The RAPP's wide implementation scope introduces an obvious challenge concerning its validation. The platform's utility and usability will be evaluated through three pilot cases. These pilot cases will demonstrate the desired functionality and RAPP's goals, whereas the RAPP efficiency will be assessed against the corresponding situations. The three pilots are briefly summarized below.

Pilot 1: Mild cognitive impairment – Memory ball
A set of robotic applications has been designed for the NAO robot to support people with cognitive problems via a selection of serious games. These games use a controlled sequence of Q&A (Questions and Answers) to improve a person's memory and to assist them in locating lost or misplaced items (e.g. keys, glasses, etc). The involved stakeholders in this case are elderly people with mild cognitive impairment (e.g. first stages of Alzheimer's disease or dementia).

Pilot 2: RAPP for technology illiterate people
A set of robotic applications has been designed for the NAO robot to train people to interact with computers, smart devices and tablets via a serious Q&A game. In this case, the involved parties are individuals or groups of elderly people having difficulties using computers and smart devices, or accessing the Web.

Pilot 3: Mobility assistance and activity monitoring
A set of robotic applications has been designed for the ANG-Light rollator in order to provide mobility assistance, combined with activity monitoring to elderly people.

ANG-Light is a robotic walker developed by INRIA. This pilot addresses the particular needs of elderly people with mobility impairment.

4 Conclusions

RAPP has the potential to substantially impact the effectiveness of healthcare, activity monitoring, and education for the elderly. Furthermore, the technological tools developed will serve as the basis for enhancing the lives of elderly and other groups requiring specialized support and intervention. By establishing a brand name for the RAPP store hosting socially assistive robotic applications, the project will create a central authority for the distribution of high-quality, peer-reviewed information, which will function as a coherent focal point for enhancing health care and user empowering services by robots.

The RAPP approach is holistic, as it examines the needs of people with disabilities through their entire spectrum, i.e. from their starting point as a need to be satisfied till their fulfillment by means of using a robot-stemming service within an existing home environment and with no assumptions about the existence of appropriate infrastructure or relevant services. It is only the human user with his/her needs and the robot, existing to serve them using the appropriate mix of RApps. The RAPP approach is highly cross-disciplinary because it relies on the collaboration of IT specialists, human factors experts, rehabilitation and assistive technology professionals, medical staff and psychologists as well as user interface and human-computer and human-robotic interaction designers. RAPP has been implemented based on the two hypotheses that the underlying technology should be transparent to the end-user and that solutions should be offered as turn-key ones. Much of the under-the-hood infrastructure, the various platforms that make use of this infrastructure, and the plethora of services that run on the different platforms, need to seamlessly cooperate for the exchange of data and information. This transparent integration process will increase the utility of each distinct RAPP component, be it a piece of hardware, or software or a related service.

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