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Ambient Assisted Living and Ageing: Preliminary Results of RITA Project *

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Abstract— **The ageing of population is a social phenomenon that most of worldwide countries are facing. They are, and will be even more in the future, indeed trying to find solutions for improving quality of life of their elderly citizens. The project RITA wants to demonstrate that an update of the current socio-medical services with an Ambient Assisted Living (AAL) approach could improve the service efficiency and the quality of life of both elderly and caregiver. This paper presents the preliminary results obtained in RITA.**

I. Introduction

The current demographic trend shows that elderly population is quickly increasing. Official publications report that at the end of 2009 the 11% of worldwide persons were older than 60 years [1] and in 2010 the 17,4% of EU27 population was over 65 years old with an old-age dependency ratio[1] equals to 28,4% [2]; experts foresee that in 2060 this value will arrive to 30,0 % and 58,5% respectively [2]. Italy and in particular Tuscany Region reflect this tendency: in 2010 the elderly people were the 20,2% on a national scale and 23,3% region-wide. Such a demographic context is inducing both international and local communities to promote novel actions for guaranteeing the ageing well of the population and to investigate new strategies, both economically and socially sustainable. Since 2007 European Union (EU) is promoting the social and technological research field of Ambient Assisted Living (AAL), mainly by funding the AAL Joint Programme and the E-Inclusion FP7 Unit. Within AAL technicians and sociologists are working together to find out how Information and Communication Technologies (ICT) could be integrated in formal and informal socio-medical services for elderly persons in order to: (1) improve the quality of life (QoL) of these subjects; (2) maintain them as longer as possible independent, active and involved in the community; (3) guarantee, at the same time, their safety and health; (4) reduce the burden of formal and informal caregivers that follow and support elderly during their life. These studies could benefit all stakeholders of AAL, that are not only the elderly and private caregivers, professional service providers, research organisations and industries, but also policy-makers, standardisation organisations, media, insurance companies, public administrations, etc. In fact besides having a positive impact on elderly, caregivers and therefore community life they are also an economic opportunity for enterprises and public administrations. Among the several interesting AAL projects and researches currently going on, we would like to mention three: (i) eCAALYX project that "aims at building a remote monitoring system targeting older people with multiple chronic diseases" [3] via a comfortable and smart garment linked to a smart phone; (ii) Persona project, that is developing a modular system, with minimal invasiveness in the environment, to monitor the daily activities of the elderly subject [4]; (iii) Domeo Project, that developed two ad-hoc open robotic platforms adaptable to personalized homecare services, as well as cognitive and physical assistance [5].

Similar considerations on the importance ageing well are shared by also other extra-Europe countries such as Japan, South Korea and US that are promoting researches in the sectors of wearable sensors and health monitoring devices, smart homes, pervasive and ubiquitous sensor networks and robotics (e.g. [6]-[10]).

This paper is focused on RITA, an AAL project born in local context of Pisa district (Tuscany, Italy) that studies and tests novel ICT solutions integrated in some socio-medical services. A multidisciplinary group, made up by technological and juridical researchers, socio-medical organizations, caregivers and elderly subjects, is studying the specific reality of old persons in Pisa and is designing socio-medical services based on ICT technologies. Here we show preliminary results of RITA researches, consisting on results of surveys involving elderly subjects and caregivers about needs, quality of life and services related to the ageing and on preliminary prototypes of RITA technologies developed on the base of the survey results. In the next months, the RITA system will be completed and tested in the context of some socio-medical services provided to elderly in Pisa, and will be reported in future communications.

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[1] The old-age dependency ratio is defined as the ratio between the total number of persons aged 65 and over, generally economically inactive, and the number of persons of working age (from 15 to 64).

II. Research Methodology

A. Work Method

The project RITA is adopting a User Centered Design approach involving the different actors of the project, i.e. elderly persons, informal and formal caregivers and socio-medical organizations, in order to: (i) study the real problems of the elderly from Pisa, (ii) design possible AAL solutions and services for the specific local needs, (iii) test them with these users. In particular the project follows four work steps:

Phase 1 Analysis of QoL and needs

Phase 2 Analysis of socio-medical services

Phase 3 Design of AAL services and tools

Phase 4 Test and assessment of prototypes.

The first two phases were performed at the beginning of the research activity in order to be aware of the local context in terms of both service offer and main needs of elderly population. The gathered information helped to identify the most useful AAL technological services that could be designed and implemented in Pisa areas. Furthermore these studies were conducted also to acquire information about usability and acceptability requirements that should be observed during the prototype design. Currently RITA is in Phase 3 and the research team is developing some prototypes of AAL technologies, to be refined, completed and tested in the next few months (Phase 4). This latter part will be reported in future communications.

B. Description of Surveys

Elderly and caregivers taking part to Phase 1 and Phase 2 were recruited thanks to the support of Società della Salute zona Pisa (SdS-Pisa), a public welfare organization, and also with the help of 13 private and public socio-medical organizations and associations working with elderly persons in Pisa District. In Phase 1, 211 elderly persons (Table I) were were interviewed about their quality of life (QoL) and needs, as well as about the services received by socio-medical organizations. In Phase 2, 68 caregivers (13 informal, i.e. elderly relatives, and 55 formal, i.e. socio-medical workers and volunteers) (Table II) were interviewed about quality of services (QoS). The participation to the surveys was voluntary and anonymous, so results are not referable to the specific participants.

Even if other studies investigated elderly needs and QoL (e.g. [11]-[12]), this analysis was implemented also in RITA because to understand the specific service context of Pisa (Italy) and design technological services useful in this geographical area. Starting from ADL [13] and IADL scales [14], WHOQOL-BREF and WHOQOL–OLD [15], two new investigation questionnaires were designed using both 5-points Likert scale, for collecting easily information and comparing answers, and also open-ended questions allowing subjects to express freely their opinions. The first tool investigates the health state of elderly, their ability to carry out ADL and IADL tasks, if they are followed by a caregiver and which kind of services/helps they receive and which are the main necessities they have. This questionnaire was proposed both to elderly and caregivers. The QoL tool investigates the general perception of elderly about their life and its quality and their satisfaction about health, daily life, autonomy, social relation, hobbies and environment in which they live; moreover users should define the degree of influences of these factors in elderly perception of QoL. In both questionnaires also general information about the user and his/her life where acquired in order to rightly interpret and understand the elderly answers. This questionnaire was drawn up by elderly.

For the second work phase another questionnaire was developed for investigating when caregivers started to help the old persons, how many time during the week they supply this service, which kind of assistance they provide, for which reason they carry out this activity, if this service influences their work and their life, if the elderly benefits of public services, the cost of service. Moreover they expressed their opinion about the quality of current services (QoS), what could improve the elderly QoL, and possible effects of AAL technological services.

III. Results of Surveys

A. Perceived Quality of life and Needs

The 78% of involved old men and 81% of old woman have some health problems and follow at least a medical therapy but they meet their general doctor one or two times per month. The 61% of men and 72% of women live alone or together his/her old partner and have contact with their descendant family mainly via phone calls and one/two visits per week. Especially interviewees over 75 years spend most of the day at home, and they go out only for shopping and to elderly clubs one time per week. The services received by many elderly consist generally in the help by family members and private caregivers in physical and IADL tasks (i.e. to take care of house) and in managing administrative and economic business. Furthermore most old persons living alone receive one time per week a visit by a volunteer that keeps company for one hour.

TABLE I. Information about Elderly Involved in RITA

Number of Elderly				
Gender	***65-75 Years***	***Over 75 Years***	***Unspecified age***	**TOT**
Men	24	24	4	**52**
Women	36	120	3	**159**
TOT.	***60***	***144***	***7***	***211***
Age of Elderly				
Gender	**Min.**	**Max**	**Mean**	**SD****
Men	65	100	76	9
Women	65	103	80	8

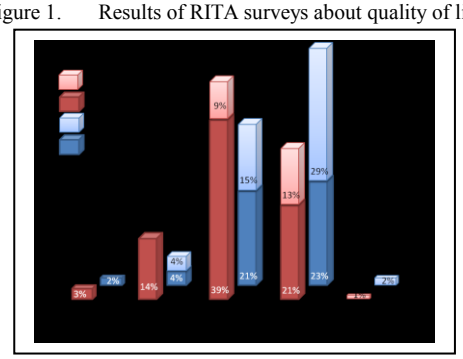
** SD means standard deviation

TABLE II. Information about Caregivers Involved in RITA

	Formal Caregivers				**Informal Caregivers**		
Gender	*Men*	*Women*	*TOT*		*Men*	*Women*	*TOT*
	22	33	55		8	8	13
Role	*Health workers*		*Volunteers*		*Family*	*Private carers*	
	23		32		13	0	
Age	*0-40*	*41-60*	*60+*	*ND****	*0-40*	*41-60*	*60+*
	12	22	16	5	0	2	11

*** ND means not declared

Figure 1. Results of RITA surveys about quality of life



Results about perception of own QoL (see Fig. 1) are peaked around "good" and "so-so" but they display a discrepancy between men and women (see Fig. 1), with a sensible shift of positivity in favour of men (52% good and 36% so-so) rather than women (34%-48% respectively). About the factors and aspects that mainly influence their QoL, a clear distinction could be made between over-75 that indicated mainly health and motor problems and under-75 that pointed at getting out of home and attending cultural and recreational activities. All the age groups highlighted the importance of being autonomous, staying at home, feeling safe and maintaining frequent contacts with family and friends. At the questions "Which are your main needs and the consequent services and supports you would like to receive?", all of them are scared of not being suddenly helped if they feel ill and are also afraid of loneliness by itself. Therefore they strongly ask a more frequent presence of caregivers.

B. Socio-medical Services

The informal caregivers involved in Phase 2 are all relatives of senior people and the 80% are themselves over 60 years old. They think that the quality of socio-medical care is sufficient (only the 11% of formal caregivers disagreed) and respondent to elderly needs. However they complain of high burden: the 46% of them has been assisting their relative since more than 5 years, the 77% do it continuously every day and this strongly influenced their life, in particular the 23% affirmed that this assistance weighted on their job. As a consequence, they would like to be supported in the caregiving in order to have more time for themselves while being sure that seniors are fine and safe.

The 58% of the formal caregivers involved in Phase 2 are volunteers that mainly keep company to the elderly and carry out some errands for them; the other are socio-medical workers. They all reported that old persons spend too much time alone inside home and hence they need to be involved in social activities and to meet other persons also outside their houses.

About the introduction of technologies in assistance services for elderly, the 91% of formal caregivers believe that these new types of interventions could increase the QoS, the 82% think that technology could improve the security of elderly during the day and the 77% foresee that they could have consequently positive effects on elderly QoL. Furthermore informal caregivers expressed interest in systems to monitor the elderly during their absence. These results confirm the importance of allowing elderly to live independently in their houses and meanwhile monitoring them also remotely through tele-assistive systems for guaranteeing users' safety.

IV. RITA Prototypes and Services

The outcomes of the surveys were elaborated together with socio-medical experts of SdS-Pisa in order to identify specific ICT-based services that could be implemented for optimally helping elderly and caregivers in terms of both QoL and QoS. Phase 1 pointed out that in Pisa the elderly: (1) desire more attention about their health and that their doctors and caregivers would be more informed about it; (2) would stay at their home as long as possible maintaining their autonomy and independence but in a safe and secure context; (3) need to carry out social activities to reduce their sense of loneliness and general negative feelings. Phase 2 highlighted that caregivers are willing to follow more carefully the elderly but cannot sustain other burden; therefore they hope that technologies could help them to monitor old persons, especially during their absence, and inform them in case of possible dangerous events. Starting from these remarks, during the Phase 3 the multidisciplinary research team conceived a specific AAL system designed for increasing elderly security all day long and everywhere. The RITA system (Fig. 2) is made of four main modules:

(1) an *health module*, thought to acquire some basic biomedical signals (heart rate, temperature and breathing) in order to monitor the subject's health and alert caregivers and health and care providers in case of anomalies;

(2) a *wearable module*, conceived to evaluate the posture and to localize the user both at home and outdoor: this information should be used to recognize eventual falls and to monitor position and motor activation of user in daily life;

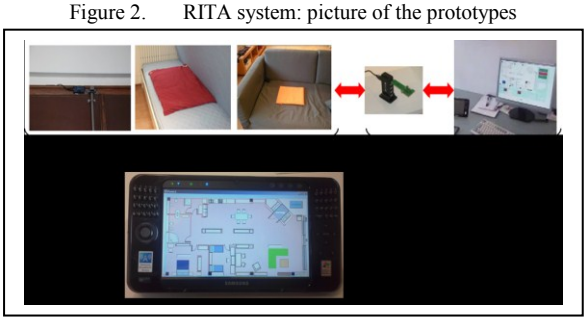
(3) an *environmental sensor network*, set in domestic space, that acquires information about the environment (i.e. opened/closed door) and the user presence and interaction (i.e. user is on sofa or bed);

(4) an *Ambient Intelligence (AmI) infrastructure*, that should integrate information acquired by the other modules to recognize events and provide caregiver reliable information about the status of the user.

At the current stage of Phase 3, the hardware design of wearable module and environmental network are completed, and the research team is working on the strategies for the module embedded processing, the AmI infrastructure and the design of the health module.

The prototype of RITA wearable module can be fixed to the user belt and integrates: (i) inertial sensors (iNEMO-M1, STMicroelectronics) to monitor posture and motor activity, (ii) a GPS receiver and GSM/GPRS module (GM862-GPS, Telit) for outdoor localisation, (iii) a ZigBee module (SPZB250M, STMicroelectronics) for indoor localization, (iv) two antennas for GPS and ZigBee modules and (v) a rechargeable Lithium battery. Data acquired from the 9-axis inertial sensors (accelerometer, magnetometer, gyroscope) will be process by the microprocessor embedded in the board to recognize posture and potential falls. The eventual alert is then sent to caregiver via GSM/GPRS module or through the AmI if the user is in outdoor or home contexts, respectively.

Figure 2. RITA system: picture of the prototypes



Furthermore, the caregiver could verify the location of the assisted user through a web interface via a two-step procedure: first, he/she could check the presence of wearable module in the indoor ZigBee network and then, in negative case, he/she could query the GPS receiver to spot the user outdoor on a devoted GoogleMaps application.

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The environmental sensor module is a network of wireless sensors based on ZigBee technology (SPZB250, STMicroelectronics) and spread all around the house with focus on specific location. This network includes some small anchor nodes that work like "indoor GPS receiver" for the user localisation and also other sensors to acquire information about some crucial environmental components. The anchor nodes measure the relative RSSI signal of the ZigBee sensor integrated in the wearable module, an information that is converted into a module-anchor distance estimation by using a specific strategy based on HATA model [16]-[17] and thus allows to locate the user in a specific room. This information allows to identify the user presence in the home and also to localize him/her in the specific room. The environmental components of the RITA network consist in proximity sensors (integrating a ZigBee module as well) pointing out the opening/closing of main door and windows and ad-hoc mat and cushion sensors recognizing the user presence on bed and sofa, respectively.

The experimental Phase 4 will take place in the next months, once all prototypes will be refined and completed (including the health module, now missing). With the collaboration of SdS-Pisa, the RITA system will be integrated in some Pisa socio-medical services and tested to evaluate the effective outcomes on elderly QoL and on service burden of caregivers. This subject will be reported elsewhere once completed.

V. Conclusion and Future Work

The RITA project is developing some AAL solutions able to support elderly and some socio-medical organizations of Pisa (Italy) in daily life. The Phase 1 and Phase 2 of the project were devoted to the study of Pisa contexts of socio-medical services, perceived QoL and needs of the elderly. Results obtained from this analysis inspired the development of the RITA system (Phase 3) that could monitor fragile elderly living at home mainly alone and help caregiver to control and preserve his/her physical and psychological well-being. In the next months RITA work team will: (1) carry out a further study to investigate the user approach to technologies and investigate the acceptability and usability aspects related to AAL systems; (2) develop the health module and integrate it in the AmI infrastructure (Phase 3); (3) test the RITA system and its modules with real elderly and caregivers in order to evaluate the system performance, verify its usability and acceptability and the efficiency of these services (Phase 4).

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References

[1] World Health Organization, *World Health Statistics 2011*, Paris: WHO Library Cataloguing-in-Publication Data, 2011, pp.151–161.

[2] Eurostat, *Demography Report 2010 - Older, more numerous and diverse Europeans*, Publications Office of the European Union, 2011.

[3] M. N. Boulos, S. Wheeler, C. Tavares , R. Jones, "How smartphones are changing the face of mobile and participatory healthcare: an overview, with example from eCAALYX", *BioMedical Engineering OnLine*, 2011.

[4] M. Amoretti, S. Copelli, F. Wientapper, F. Furfari, S. Lenzi, S.Chessa, "Sensor data fusion for activity monitoring in the Persona ambient assisted living project", *J Ambient Intel Human Comput*, 2011.

[5] C. Granata, M. Chetouani, A. Tapus, P. Bidaud, V. Dupourqué, "Voice and graphical -based interfaces for interaction with a robot dedicated to elderly and people with cognitive disorders", *Proc. IEEE Int. Symp. Robot and Human Interactive Communication*, 2010.

[6] Jin Kim, Hyeok-soo Choi, Hui Wang, Nazim Agoulmine, M. Jamal Deen, and James Won-Ki Hong, "POSTECH's U-Health Smart Home For Elderly Monitoring and Support", *Proc. IEEE Int. Symp. on World of Wireless Mobile and Multimedia Networks*, 2010.

[7] N. Agoulmine, M. Jamal Deen, Jeong-Soo Lee, and M. Meyyappan, "U-Health smart Homes", *IEEE Nanotechnology Magazine*, 2011.

[8] V. Stanford, "Using Pervasive Computing to Deliver Elder Care", *IEEE Pervasive Computing*, 2002, pp. 10–13.

[9] S. Duval, C. Hoareau, and, H. Hashizume, "Age in Ubiquitous Computing: A Thin Thread", *Proc. 3rd Int. Conf. Convergence and Hybrid Information Technology*, 2008.

[10] Minseong Kim, Suntae Kim, Sooyong Park, Mun-Taek Choi, Munsang Kim, and Hassan Gomaa, "Service Robot for the Elderly", *IEEE Robotics & Automation Magazine*, 2009, pp. 34–45.

[11] R. Fernández-Ballesteros, "Quality of Life in Old Age: Problematic Issues", *Applied Research Quality Life*, vol. 6, 2011, pp. 21–40.

[12] L. Corner, K. Brittain, and J. Bond, "Social aspects of ageing", *Psychiatry*, vol.3, issue 12, 1 December 2004, pp. 5–7.

[13] S. Katz, A. B. Ford, R. W. Moskowitz, B. A. Jackson, and M. W. Jaffe, "Studies of illness in the aged. The index of ADL: a standardized measure of biological and psychosocial function.", *JAMA*, 1963.

[14] M. P. Lawton, and E. M. Brody, "Assessment of older people: Self-maintaining and instrumental activities of daily living.", *Gerontologist*, vol. 9, 1969, pp. 179–186.

[15] M. Power, K. Quinn, S. Schmidt, and the WHOQOL-OLD Group, "Development of the WHOQOL-Old module", *Quality of Life Research*, vol. 14, 2005, pp. 2197–2214.

[16] M. Hata, "Empirical Formula for Propagation Loss in Land Mobile Radio Services", IEEE Transactions on Vehicular Technology, 1980.

[17] D. Lymberopoulos, Q. Lindsey, and A. Savvides, "An Empirical Characterization of Radio Signal Strength Variability in 3-D IEEE 802.15.4 Networks Using Monopole Antennas", *Proc. EWSN 2006*, LNCS 3868, pp. 326–341, Springer-Verlag Berlin Heidelberg 2006.