Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 138 (2018) 72–79

Procedia Computer Science

www.elsevier.com/locate/procedia

CENTERIS - International Conference on ENTERprise Information Systems / ProjMAN - International Conference on Project MANagement / HCist - International Conference on Health and Social Care Information Systems and Technologies, CENTERIS/ProjMAN/HCist 2018

Using Pervasive and Mobile Computation in the Provision of Gerontological Care in Rural Areas

Carlos R. Cunha [a,b,*], Vítor Mendonça [b], Elisabete Paulo Morais [a,b], Joana Fernandes [b]

[a] Applied Management Research Unit (UNIAG), Portugal
[b] Polytechnic Institute of Bragança, Mirandela, Portugal

Abstract

The provision of gerontological care in rural areas represents an increased management challenge. Framed by the Portuguese Northeast reality, this paper reflects on the role and potential of pervasive and mobile computing in the management of gerontological care, specially in rural areas, explaining the potential of fusion between gerontology and technology and presents a conceptual model to frame it. Finally, it presents a software prototype developed for Android smartphones, capable of assist a gerontological care provider in some of their operational practices.

Keywords: gerontology; conceptual model; prototype; health and care providers; rural areas

1. Introduction

Demographic change in industrial countries is a challenge for societies, economically but also as socially. Current

* Corresponding author. Tel.: +351 300 029 965.
E-mail address: crc@ipb.pt

10.1016/j.procs.2018.10.011

R&D efforts show that assistive information and communication technologies can successfully contribute to all dimensions of elderly's quality of life. Technologies can empower them to control their health problems, compensate functional disabilities and increase their safety [1] and also enable a closer and real time monitoring of several health parameters that can help healthcare providers to make more timely and effective decisions. But at the same time, if technology can shape a new approach for gerontology, Deist & Latouille [2] point some significant questions: Are the elderly ready to use this technology? Do they feel able to use it, and under what conditions? According to Fischer et. al. [3], elderly people approach the Internet and health information technology differently than younger people, but have growing rates of adoption. Still, elders face many barriers in using technology for healthcare. Despite all the challenges, health information technology may be able to help older people in independent living and to be able to stay in their own homes longer and "will aid care delivery in an environment of a shortage of carers." [4].

Elders' acceptance of innovative technology in their everyday life can be a success key factor for the major players in elders' life such as: governments, healthcare providers and technology providers [5]. However, these technologies not often are adapted to elders' needs and limitations, and consequently are often rejected by them. They usually lack a set of features that elders perceive as useful to their daily life, that are the communications with their health care providers [6].

This paper, starting to review the state-of-art of gerontechnology, present a Demographic characterization of the Portuguese Northeast rural area and a conceptual model to frame the most important dimensions of the pervasive and mobile computing in the context of gerontology. Finally, it presents a software prototype developed for Android smartphones, capable of assist gerontological care providers in some of their operational practices.

2. Gerontechnology Review

Gerontechnology is as a multidisciplinary model that uses technology to innovate in the geriatric field [7,8]. The International Society of Gerontechnology (ISG) considers that ''gerontechnology creates solutions to extend the working phase in society by maximizing the vital and productive years in the life span, consequently reducing costs in later life''.

A recent report [9] demonstrates that in older adults, use of technology is on the rise, some older adults remain isolated from digital life altogether. Therefore, while the development of technology is moving forward very quickly, a lot of questions are left without response, particularly regarding today's oldest populations.

According to Lam & Lee [10] the "Use of gerontechnology seems a synthesis of person, technology, and environment''. This means that gerontechnology must be involved in the full spectrum of human activities, encompassing health and behavior, activities of daily living and accommodation, communication and autonomy, mobility and transport, job and leisure (think of age-friendly cities and hospitals).

Gerontechnology is an interdisciplinary field combining gerontology and technology for the development of these systems, that is, systems for health, housing, mobility, communication, leisure, and work of the elderly.

The development of these systems is a challenging activity requiring disciplines as different as artificial intelligence, human computer interaction, and engineering to work together in order to provide solutions able to satisfy growing demands. The stakeholders must be able to create systems that are as intelligent as to be able to detect falls or emotion, usable so as to be able to be exploited by people with mobility problems, and reliable and autonomous so as to be able to monitor health and mobility. Gerontechnology is related to [11]: Telehealth and telemedicine services: as medical knowledge has expanded over the past decades, it is impossible for health practitioner to be constantly available; Communication devices for seniors: there is a sustained effort for developing technical systems that enable older people to stay more independent and secure. Mobile data access is also a hot topic in this case; Social networks for the elderly: the design of specific social networks and augmented human- computer interfaces for the older people is currently a big challenge; Lifelong learning for mental health: computer- based knowledge acquisition and representation, web services, and the semantic web, as well as learning/teaching can provide an alternative solution that, otherwise, would require a series of human experts; Mobility and rehabilitation technologies: from an expert systems perspective, mobility and rehabilitation technologies are closely related to Biomedical Engineering. Ontological engineering and sensor databases are the core of this topic; Assistive technologies and devices: the elderly have to be provided with alternative human computer interfaces, such as alternative (computer) input devices, on-screen keyboards, reading tools, screen readers, voice recognition programs, and so on; Household accident detection:

thanks to advanced intelligent technologies, personal medical alert systems are now being developed. Core to this topic is the construction of expert system architectures with powerful perception capabilities; Emotion/affect/mood recognition and regulation: affective computing is a hot topic in the artificial intelligence arena. The topic can be faced by means of different AI techniques, case- based reasoning being a clear example; Personalised ambient adaptation: personalisation using computational intelligence and data engineering is mandatory in this field; Social/care robots and agents: these two interrelated topics are clearly linked to knowledge- based systems where reasoning about knowledge and short- term planning is mandatory.

There are some projects that cover the above topics. For example, the project "Nutrition for Elder Care: a nutritional semantic recommender system for the elderly" presents a nutritional recommender system, Nutrition for Elder Care, intended to help elderly users to draw up their own healthy diet plans following the nutritional experts guidelines. The system has been developed with the intensive use of Semantic Web technologies pursuing knowledge sharing and reuse between different applications and agents and the discovering of implicit new knowledge [12].

The project developed by Lago, [13] introduces a representation for modelling long‐term behaviour patterns that can be customized according to context features and a similarity measure to compare daily living observations to these patterns. This representation formalizes the elements to monitor by an AAL solution, considers the variability due to context features, and is able to detect and explain anomalies in a meaningful way. The paper shows the expressive capabilities of the model by mining patterns in three datasets and showing how the anomalies found can be explained in terms of context characteristic that differ from the expected. In the future, this can be used to send notifications to caregivers, enabling them to take better care decisions.

Costa, Julián, and Novais [14] presents iGenda and its evolution, the UserAccess, with the main objective of developing an AAL platform. It features an analysis of the latest developments and points future directions for the work. These projects display the importance of the interoperability of the platforms, demonstrating a case study for AAL development.

The paper entitled "Ontological Modelling and Rule‐Based Reasoning for the Provision of Personalized Patient Education" by [15] proposes a personalized approach to patient education that is tailored to the individual characteristics and health objectives of the patient. Personalized features will enhance the comprehensibility and usability of the process of medical education. Taking this personalization into consideration, this paper introduces a conceptual architecture to create a Web‐based personalized patient.

In [16] is described an approach to monitoring the physical activity carried out by aging adults in order to establish guidelines for their rehabilitation process and to ensure the welfare of this segment of the population. The entire system uses solely a smartphone to recover all the required information, specifically the phone based accelerometer data. The core of the algorithm Ameva is used to develop an innovative selection, discretization and classification technique for activity recognition.

3. Demographic Characterization of the Portuguese Northeast Rural Area

The current demographic context in Portugal, due to medical progress, improvement of working conditions, increase of general wellbeing and decrease of the birth rate, presents an aging population that will intensify in the next decades [17].

This phenomena, the increase in the proportion of elderly people in the total population, is referred to as demographic aging. It occurred as a result of a change in the mortality and fertility paradigm, from a very high rate to a very low [17].

In this context, the Terras de Trás-os-Montes (TTM), the core of the Portuguese Northeast, that encompasses nine municipalities, namely Alfândega da Fé, Bragança, Macedo de Cavaleiros, Miranda do Douro, Mirandela, Mogadouro, Vila Flor, Vimioso e Vinhais, with 110,759 people in 2015 is one of the most difficult regions of the country regarding population demography, underdevelopment and isolation. It is a region with an estimated aging index in 2013 of 262.3 [18]. The region faces now a reality where there are almost three times more "older people" (individuals over 65 years of age) than individuals with less than 15 years of age [19]. In fact, although the forecasting for Portugal indicates that in 2060 people over 65 years of age will be 32% of the population, according to the data of the National Institute of Statistics the people over 65 from TTM are already 28.9% of the total, while the group of young under 15 years of age reach 10.3% [19].

The increase in the elderly population and the changes in families' daily life is changing the paradigm for elderly support. In fact, there are less people being able to look after their parents or living close by and due to the isolation of the townships the elderly are becoming more and more isolated. This situation reinforces the need to develop means of support to better attend this particular group [20].

The main aspects to consider to measure life quality of the elderly are family support and social activities, however there is a great number of seniors that live alone, lost their partners (emotional loneliness) or lost their close friends or neighbours (social loneliness) [17]

It is a fact that with age some losses will occur and the social network will decrease and so a higher sense of loneliness and seclusion will appear [21]. In addition, the studies regarding the senior population state that those that live alone have the highest poverty rates [17]. Following this it is understood that poverty limits the individuals' ability to find a transportation to participate in social events or to attend medical appointments and it increases the probability of the elderly to become more isolated [22].

Due to the regions' characteristics another aspects makes their life difficult is the fact that public services, such as hospitals, medical centers, Finances, and others are far away and require some sort of transportation.

This is a major problem for local and central government since they are aware of the situations but they cannot provide support to all the isolated and elder population and we face now some serious cases where they depend on their neighbours that are about the same age and facing the same problems.

This conducts to more fragile health and more visits and stays in the public hospitals and to a low quality of life for this group. In fact, one of the aspects that can also be associated with lower life quality and decrease of health is the decrease of ability to perform daily tasks and consequently there is an increase of depression in the elderly [21]. According to the National Institute of Statistics approximately 50% of the senior population has severe difficulty or cannot perform at least one of the six day-to-day activities. These difficulties affect almost 1 million seniors in Portugal and more than half live alone or with other elders [23]. This brings a problem of public health with major costs.

This demographic aging is only a social problem since there is a very low, inadequate or even inexistent response from the social services to face the present situation and there is no connection with civil society. Even the existing ones, such as nursing home, have a major cost and they have the downside of cutting all the connection between the elderly and his previous life, increasing the loneliness and sometimes enabling a depressive state [17,23,24]. Some professionals that work with this group recognize that are very few vacancies in the system and so the majority has no one controlling if they are taking their medications or even to take them to medical appointments [25].

One mechanism that is positively related with the increase of health and other indicators is social involvement or support and positive psychological state. Some studies with intervention programmes on elders identified three important dimensions to monitor and intervene, namely depression, loneliness and life quality [20].

Social support can be regarded in an objective way, considering the dimension of the network and the type of support received, more functional or more relational [21].

The formal support network can be regarded as public or private organizations while the informal or natural support network represents family members, friends or neighbours. The social network of an elder is formed by both the formal and the natural support networks [17]. If the natural support network is inexistent or rather small, then there is an increase on the dependency on formal support.

Along with the network there is also the sense of control from the elderly that increases its evaluation of satisfaction or life quality, with this it is understandable that a higher sense of control from the elderly will lead to higher participation.

In a study conducted in 2004 by Alemagno, Niles e Treiber in [26] the computer was used to help the senior citizens to control the medication that each had to take during the day and they evaluated this study as being very positive and having a positive impact in their health.

The formal response often focuses in a reactive form rather than a preventive form. In this sequence, we intend to connect the formal network with the natural network and optimize the impact of both.

4. Proposed Conceptual Model

The recent evolution of technology allows today that a varied number of vital health parameters can be measured. Also, the development of mobile-based applications has brought more intuitive manipulation interfaces for widespread

use. However, the application of technology in the health sector still presents, in our opinion, a significant lack of integration with the already established information systems of the main health care and care support providers.

As far as rural areas are concerned, where the population is older and isolated, this problem is even more serious. In order to contribute to the development of integrated solutions to support the elderly and isolated populations of the rural regions (in particular), a conceptual model is proposed to promote an integrated vision of the cycle of medical care and gerontological support care. This integrated model includes a broker perspective that, in rural areas, where the population is aging and with a high rate of info-exclusion, it is an important determinant of success, so that it is possible to have intermediates that help less able people to deal with technology. A Community perspective will be, in our opinion, an important asset.

According to the contextualization previously presented, the development of platforms based on Information Technology is fundamental to promote and facilitate the health and care services to the elder populations. These technologies should enable caregivers to monitor indicators and respond to requests, in order to avoid constant displacement to services and therefore increase their comfort level.

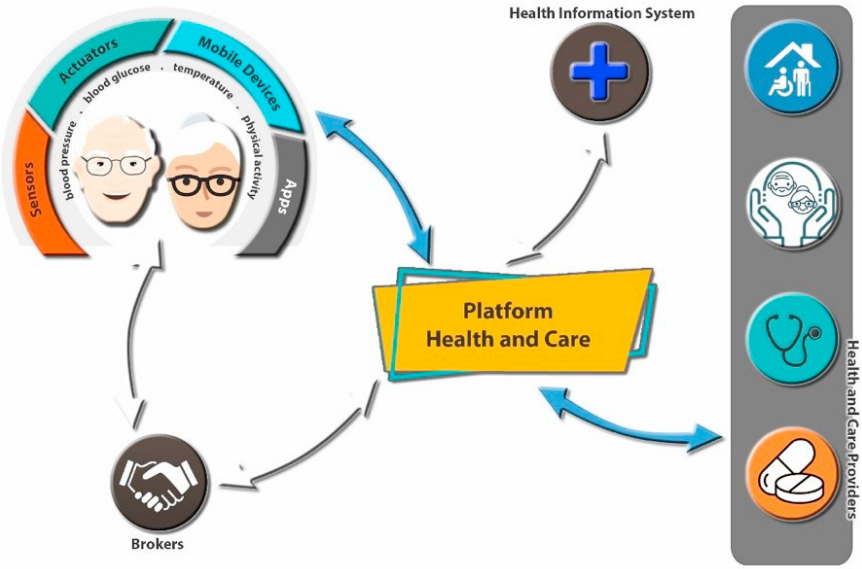

Fig. 1 – Conceptual Model

As outlined in figure 1, a technological platform is proposed to maintain a constant connection between the elderly users who need health and care services and the providers of those services. For this, it should be possible to integrate technologies, such as: sensors, actuators, mobile devices, applications, that allow the monitoring of physiological indicators, for example: blood pressure, blood glucose levels, indicators of physical activity, among others.

The platform should also allow users to make requests as well as receive feedback, serving as an agent that facilitates communication between users and service providers.

In the case where users do not have autonomy, the model includes the intermediary agents – "Brokers", which may be a family member, a neighbor or a public service institution. The model also allows it to be integrated with the information system of the National Health System.

The model presented shows a view of active aging support and a decentralization of health care in its monitoring and reporting components. Thus, as far as the health component is concerned, we will tend to liberate health care providers, in aspects that can be performed in an automated way without the need for elders' or medical staff travel (this is especially relevant in rural environments). As for the gerontological care providers, we will be contributing to a more efficient management of their activities and a more effective response to the not always predictable needs of the elderly and their physical and emotional well-being.

5. Developed Prototype

In order to test part of the proposed approach, a mobile application and also a desktop application has been developed, which aims to facilitate the registration and manipulation of data on elderly people, employees and care services of Mirandela's "Santa Casa da Misericórdia (SCMM)", and on the provision of services to elders in their homes. With the mobile application, it is still possible to trace and optimize routes for the same service provision, as well as generate statistics on the different services provided.

In order to guarantee the interoperability among the different systems developed, we have used Web Services (SOAP based) for remote manipulation, and XML files, to store the data locally. In the case of the mobile application, the data inserted by the user are first recorded in XML, and if the web service is available and the application is connected to the internet, the data is read and manipulated by the web service, using the methods provided by the same thus allowing communication with and manipulation of the database. If the data has been recorded only in offline mode, it is possible to synchronize with the database as soon as it is desired and there is internet connection, in order to keep all the information homogeneous. Figure 2 present the framework used to develop the prototype.

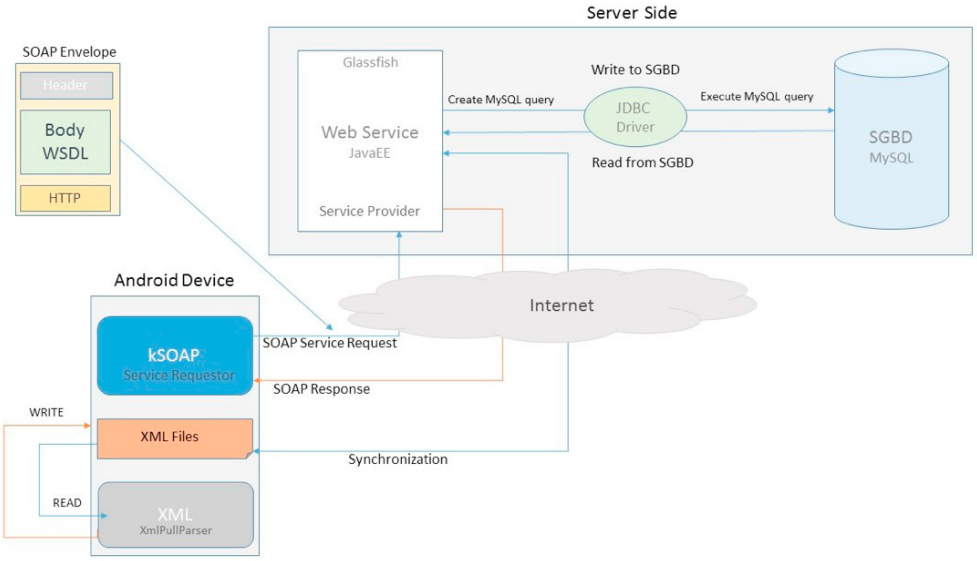

Fig. 2 - Prototype Framework

The presented prototype allows to manipulate the information of elderly people and SCMM employees, allowing the insertion, removal, search and listing of the same. Due to the fact that the employees provide various services to a number of elderly people that varies from day to day, dispersed throughout the Mirandela-region, it is still possible to select the users to visit, and based on this information the fastest route to the effect in order to optimize the whole process. Subsequently, for employees add the services provided to a particular user, it is sufficient to select the same in a list of users made available by the application, and to choose the services that will be rendered to the same, all this information being automatically registered in local files and online Database. In the absence of internet connectivity, this information is stored locally, and it is possible afterwards to synchronize all this information, once Internet access is checked again (this is particularly important since there are parts of the region without mobile data connection). In figure 3 is some screenshots of the desktop application, where the manager can plan the elders care services to provide and also manage the employers that will do them.

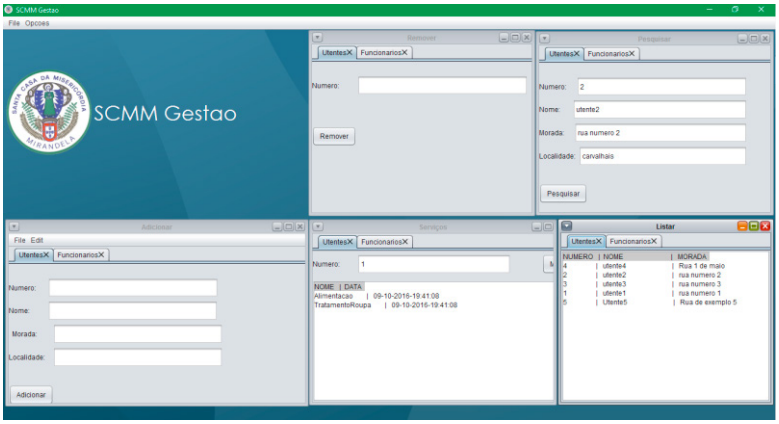

Fig. 3 - Desktop Application Screenshot.

The mobile application, responsible for help the care providers, in the field, to record all the care services provided is presented in figure 4 where can be seen some screenshots focusing the care-services, elder's personal information, trace and optimize routes and graphics statistics about services provided.

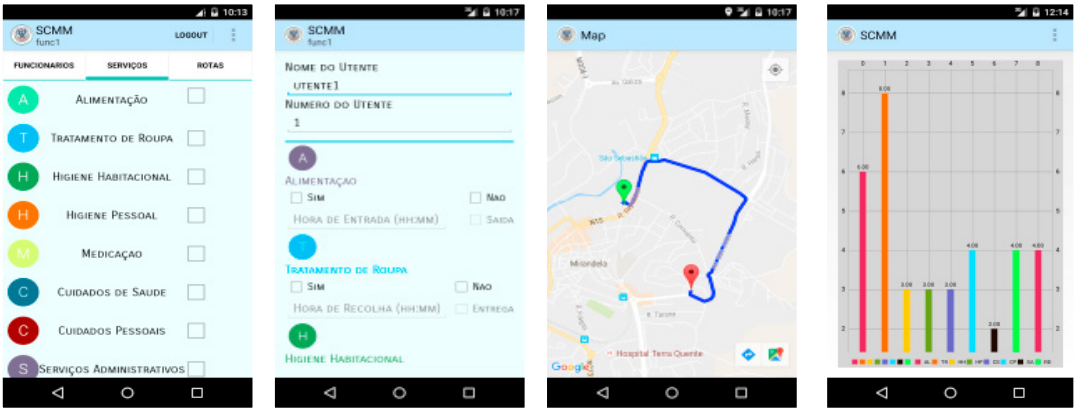

Fig. 4. Mobile Application (screenshots example).

6. Conclusion and Final Remarks

This paper reviewing the gerontechnology concept and presenting a summary demographic characterization of the Portuguese northeast rural area expect to be a contribution to a better understand about how should be the future of health and care provider's information systems approach. Also is connected the formal network with the natural network of heath and care systems. In our view, supported by the population that will increasingly be familiar with the use of technology, there is an urgent need to develop integrated support platforms for health care and gerontology care.

Promoting more active and decentralized aging will help increase the satisfaction of the elderly population and optimize health resources. It will also promote a more active and committed role for citizens who will become more aware and collaborative given the increase of their participative power in the monitoring and reporting of their own health and needs.

Acknowledgments

UNIAG, R&D unit funded by the FCT – Portuguese Foundation for the Development of Science and Technology, Ministry of Science, Technology and Higher Education. UID/GES/4752/2016.

References

[1] Christian Siegel, Thomas Ernst Dorner, Information technologies for active and assisted living—Influences to the quality of life of an ageing society, International Journal of Medical Informatics, Volume 100, April 2017, Pages 32-45, ISSN 1386-5056.

[2] F. Le Deist, M. Latouille, Acceptability Conditions for Telemonitoring Gerontechnology in the Elderly, IRBM, Volume 37, Issue 5, 2016, Pages 284-288, ISSN 1959-0318.

[3] Shira H. Fischer, Daniel David, Bradley H. Crotty, Meghan Dierks, Charles Safran, Acceptance and use of health information technology by community-dwelling elders, International Journal of Medical Informatics, Volume 83, Issue 9, September 2014, Pages 624-635, ISSN 1386-5056.

[4] J. Soar, Y. Seo, Health and aged care enabled by information technology, Annals of the New York Academy of Sciences, 1114 (2007), pp. 154–161.

[5] Rana Mostaghel, Innovation and technology for the elderly: Systematic literature review, Journal of Business Research, Volume 69, Issue 11, November 2016, Pages 4896-4900, ISSN 0148-2963.

[6] Fábio Ferreira, Flávio Dias, João Braz, Ricardo Santos, Roberto Nascimento, Carlos Ferreira, Ricardo Martinho, Protégé (2013): A Mobile Health Application for the Elder-caregiver Monitoring Paradigm, Procedia Technology, Volume 9, pp. 1361-1371, ISSN 2212-0173.

[7] Sheets DJ, La Buda D, Liebig PS. (1997) Gerontechnology. The aging of rehabilitation. Rehab Manag; 10: 100–2.

[8] Graafmans J, Taipale V. Gerontechnology (1998). A sustainable investment in the future. Stud Health Technol Inform; 48: 3–6.

[9] Smith A. Pew Research Center. Older adults and technology use; 201[Available at: http://www.pewinternet.org/2014/04/03/older-adults-and-technology-use/ (Access date: 9 April 2018

[10] Lam JCY, Lee MKO (2006). Digital inclusiveness - longitudinal study of internet adoption by older adults. J Manage Info Syst; 22: 177–206.

[11] Antonio Fernández-Caballero, Pascual González, Elena Navarro, Diane Cook, Special Issue — Pervasive Computing for Gerontechnology, Pervasive and Mobile Computing, Volume 34, January 2017, Pages 1-2, ISSN 1574-1192

[12] Espín, V., Hurtado, M., and Noguera, M. (2016). Nutrition for Elder Care: a nutritional semantic recommender system for the elderly. Expert Sys: J. Knowl. Eng. 33, 2 (April 2016), 201-210. DOI: https://doi.org/10.1111/exsy.12143

[13] Lago, P., Jiménez-Guarín, C. and Roncancio, C. (2015). Contextualized Behavior Patterns for Ambient Assisted Living. In *Proceedings of the 6th International Workshop on Human Behavior Understanding - Volume 9277*, Albert Ali Salah, Ben J.A. Kröse, and Diane J. Cook (Eds.), Vol. 9277. Springer-Verlag New York, Inc., New York, NY, USA, 132-145. DOI=http://dx.doi.org/10.1007/978-*3-319-24195-1_10*

[14] Costa, A., Julián, V., and Novais, P. (2017). Advances and trends for the development of ambient-assisted living platforms. Expert Systems, 34:e12163. doi: 10.1111/exsy.12163.

[15] Quinn, S., Bond, R., and Nugent, C. (2017). Ontological modelling and rule-based reasoning for the provision of personalized patient education. Expert Systems, 34: e12134. doi: 10.1111/exsy.12134.

[16] Concepción, M., Morillo, L., Garcia, J. and González-Abril, L. (2017). Mobile activity recognition and fall detection system for elderly people using Ameva algorithm, Pervasive and Mobile Computing, Volume 34, Pages 3-13, ISSN 1574-1192.

[17] Freitas, (2011). Solidão em idosos - Percepção em Função da Rede Social (Dissertação de mestrado). Retrieved from http://repositorio.ucp.pt/bitstream/10400.14/8364/1/SOLID%C3%83O%20EM%20IDOSOS.pdf

[18] INE (2014). Índice de envelhecimento por Local de residência (NUTS - 2002); Anual - INE, Estimativas anuais da população residente. Retrieved from http://www.ine.pt

[19] INE (2016). Série Estimativas Provisórias Anuais da População Residente (atualizado 2016). Retrieved from http://www.ine.pt

[20] Teixeira, L. (2010). Solidão, depressão e qualidade de vida em idosos: um estudo avaliativo exploratório e implementação-piloto de um programa de intervenção (Dissertação de mestrado). Retrieved from http://repositorio.ul.pt/bitstream/10451/2608/1/ulfp037460_tm_tese.pdf

[21]Costa, A. (2012). Envelhecimento, tristeza e depressão (Monografia). Retrieved from https://sigarra.up.pt/ffup/pt/pub_geral.show_file?pi_gdoc_id=530333

[22] Sibley, J., Thompson, H., & Edwardh, J. (2016). Seniors: Loneliness and Social Isolation. Community Development Halton, Burlington, ON. Retrieved from http://www.cdhalton.ca/images/pdf/Seniors-Loneliness-and-Social-Isolation.pdf

[23] INE (2012). Dia Internacional das Pessoas com Deficiência. Destaque 30 de novembro de 2012. Retrieved from http://www.ine.pt

[24] Hartmann Júnior, J. & Gomes, G. (2014). Depression in institutionalized elderly: the singularities of grief seen in its diversity. Sociedade Brasileira de Psicologia Hospitalar, 17(2).

[25]Ferreira, P. (2015, September 21st). Os caminhos do pão por entre a pobreza. Retrieved from https://www.publico.pt/2015/09/21/local/noticia/os-caminhos-do-pao-por-entre-a-miseria-1708231

[26] Miranda, L. & Farias, S. (2009). Contributions from the internet for elderly people: a review of the literature. Interface - Comunicação, Saúde, Educação, 13(29). Retrieved from http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1414-32832009000200011