Chapter 1
A Survey of Cognitive Assistants

Angelo Costa and Paulo Novais and Vicente Julian

Abstract Cognitive Assistants is a subset area of Personal Assistants focused on ubiquitous and pervasive platforms and services. They are aimed at elderly people's needs, habits, and emotions by being dynamic, adaptive, sensitive, and responsive. These advances make cognitive assistants a true candidate of being used in real scenarios and help elderly people at home and outside environments. This survey will discuss the cognitive assistants' emergence in order to provide a list of new projects being developed on this area. We summarize and enumerate the state-of-the-art projects. Moreover, we discuss how technology support the elderly affected by physical or mental disabilities or chronic diseases.

1.1 Introduction

The term Personal Assistants (PA) is originated from the Ambient Assisted Living (AAL) area that encompasses the advances in the ICT area that are focused in providing direct care on activities of daily living and related tasks. The AAL area focuses on overall technologies that provide healthcare, assistance and rehabilitation to elderly or disabled people (with cognitive and physical impairments), promoting independent living, active aging and aging in place. Therefore, the need for the distinction is required due to the fact that not all PA technologies belong to AAL and vice-versa. Recently PA have gained traction and there are several projects with interesting results.

Angelo Costa
Centro ALGORITMI, University of Minho, Braga, Portugal, e-mail: acosta@di.uminho.pt

Paulo Novais
Centro ALGORITMI, University of Minho, Braga, Portugal e-mail: pjon@di.uminho.pt

Vicente Julian
Departamento de Sistemas Informáticos y Computación. Universitat Politècnica de València, Valencia, Spain e-mail: vinglada@dsic.upv.es

The need for projects on these areas comes from the increasing numbers of elderly people that need technological solutions on their daily lives []. Most of the elderly are fragile and need assistance to perform certain tasks. While most try to overcome these issues however they can and at great physical and psychological cost, some are unable to perform those tasks at all. Moreover, population aged 65 or older is projected to increase from an estimated 520 million in 2010 to nearly 1,5 billion in 2050 [38]. With the growth of elderly population comes the increase of mental and physical diseases like Alzheimer, dementia and mobility problems.

Population Reference Bureau [27] states that about 20 million North Americans assist elderly people performing daily activities, and that 70% need constant care. Monetarily speaking, in 2010 the spending in care of people with dementia ascended to 604 billion dollars, and with the increase of population its expected the increase of costs [38]. The health-care costs dedicated to dementia patients is estimated to be in the UK roughly £26 billion a year [26]. Two-thirds (£17.4 billion) is paid by people with dementia and their families, either in unpaid care or in private social care. Thus it is expected that the continuous increase of the elderly population will produce an economical disadvantage to their families and society.

One way to address this issues is with the use of technological devices that are able to help and simplify the execution of daily tasks. Low cost health-care systems can be built to diminish the burden of the caregivers with minimal transitional periods and with a high level of usability. Technological devices can help to break social and physical barriers that elderly people and caregivers have and enable independent living with a high rate of success.

Governments have already observed that these advances can be very advantageous. The European Union has and keeps promoting and funding projects on this area [14] through several calls to action.

Also, there is the European Innovation Partnership on Active and Healthy Aging (EIP AHA) that is constituted by several actors that work in conjunction to propose new ideas and pursuit technological developments directed to the elderly population; it aims to continually increase the levels of the elderly health population and by 2020 [15].

In terms of policies and protocols, there are in practice some projects that tackle those issues through compilation of information on existing services and private and public initiatives, and conduction of representative surveys within the elderly population.

The AALIANCE project [33] built a guideline for development and research in the AAL area, as well as some policies that should be implemented at the European level. It is clear that there is a great interest in the PA and AAL area, were state of the art advances are currently being produced.

This work aims to provide an overview of the cognitive assistants inside the PA area, focusing on technologies and approaches for aging population in home environments. More specifically, we will present the concept and usage of cognitive assistants, which are constituted by platforms, services and tools that help the users overcome their cognitive disabilities through discreet and ubiquitous devices.

This chapter is structured as follows: Section 1.2 presents the cognitive assistants projects and their setting in the PA area; Section 1.3 presents the conclusions.

1.2 Cognitive Assistants

Cognitive Assistants (CA) are well integrated in the PA area and constitute a larger portion of that area. The CA have as the social goal the production of tools that help people with cognitive disabilities to perform activities of daily living. Therefore, most of the advances produced on this area are software platforms, as the target users do not have any motor disability or only have mild motor disabilities caused by their psychological impairment.

Projects on this area seem to move towards a unified system that is able to interconnect to external services and create an extended technological environment [20]. This environment will be greater that the sum of the parts due to the possibility of data and sensor fusion, thus making available complex information that otherwise was unavailable. As a toy example, and for easy envisioning, we can take two sensors that when not unified could bring a large amount of problems that are the smoke and flood detection; if there is a fire the sprinklers will be activated, the flood sensor will be activated and stop the sprinklers thus allowing the fire to spread; this process would be in cycle until one of the sensors stopped working. Therefore, with this example we can observe that interconnected systems can build interesting information when working together.

The following projects are a display of what is being developed currently conceptually and architecturally. They are a small sample that serve the goal of presenting a heterogeneity representation of solutions within the CA area.

1.2.1 DayGuide

The DayGuide project [3] aims to provide a reminders associated to locations and guidance, a social platform for share and organization of tasks, through a mobile phone.

It is designed to be used by elderly people suffering from mild cognitive impairment (MCI) in aging at home perspective. This project is fairly new and shows signs of being on an initial development phase, as showed by the interface on Figure **??**.

In terms of operation, the authors present the following toy example: *"When the person with dementia opens the entrance door, s/he receives specific reminders depending on time of the day, outside weather conditions and diary."* The reminders are expected to be presented visually and well as aurally. Furthermore, their partnership has the ability to tap to an care-center environment with 60 persons that can be used for tests and validation.

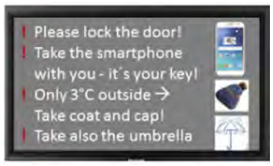

Fig. 1.1: DayGuide expected interface.

1.2.2 Active@Home

The Active@Home project [1], which is very recent and currently does not present large developments, focuses on active people and how to maintain them active. Their approach is to promote game-based exercises designed for elderly people that engages them through dance and Tai Chi activities. The main goal is to avoid falls by keeping the elderly physically and cognitively exercised, improving their balance.

The technological implementation uses televisions (or large display devices) to show animated virtual characters performing the exercises, and capture the exercise execution by the viewers through wearable sensors. The information of the sensors will help to determine if there is an decay of the physical condition and if there is any undetected health problem. In terms of cognitive assistance, this project helps to detect cognitive illnesses and uses physical exercises to juggle their memory and remember previously done activities.

1.2.3 CoME

The CoME project [2], is a platform for monitoring and interacting with elderly people. The platform counts with wearable sensors to constantly monitor the elderly people and with smartphones to visually interact with them and to receive self-reports from them. Moreover, the smartphone will be used to show tutorials about how to perform certain activities and used by the caretakers to localize and receive health reports from their care-receivers.

In Figure 1.2 is showed the architecture of the project. We can observe a complex CA platform that includes all the actors and several services that are aimed at maintaining and improving the cognitive status of the main system actors. The platform is intended to be deployed at each elderly home, connecting them to a central service that provides information to the formal and informal caretakers, thus promoting the aging in place concept. Therefore, the platform also pushes the idea that it helps the caretakers by relieving them of the burden and stress of the constant supervision.

In terms of technological solutions, Figure 1.2 shows that it is a typical client-server structure with a high volume of communications between them. It is not

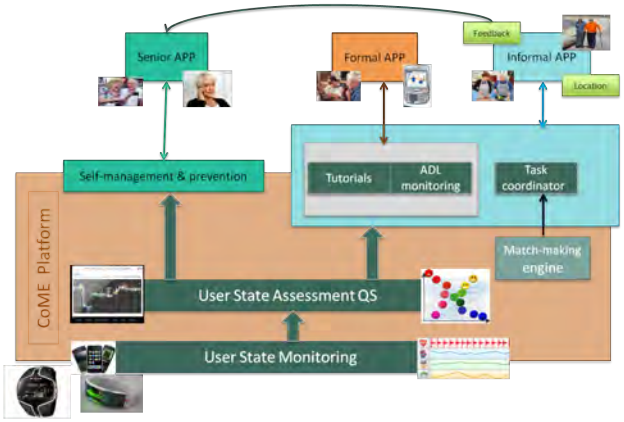

Fig. 1.2: CoME architecture.

specified if there will be any local processing system for the wearables data or the smartphone data.

1.2.4 DALIA

The DALIA project [39, 9] is an wrapper for the ANNE virtual assistant, providing ANNE with the abilities of linear integration with external services and a service-oriented architecture. ANNE is a virtual assistant in the shape of a human-looking avatar endowed with speech and face recognition and speech capabilities.

The combined platforms result in an platform-independent virtual assistant, showed in Figure 1.3, that has the following abilities:

- Easy communication with family and friends through the virtual assistant;
- Appointments calendar and automatic reminders;
- Documenting events and keeping memories;
- Emergency call and fall detection;
- Localisation of lost items;
- Health status monitoring and motivation for physical or mental activity tasks.

1.2.5 EDLAH2

The EDLAH2 project [4] aims to use gamification procedures on elderly people resorting to tablet technology. By showing appellative visual interfaces, as showed

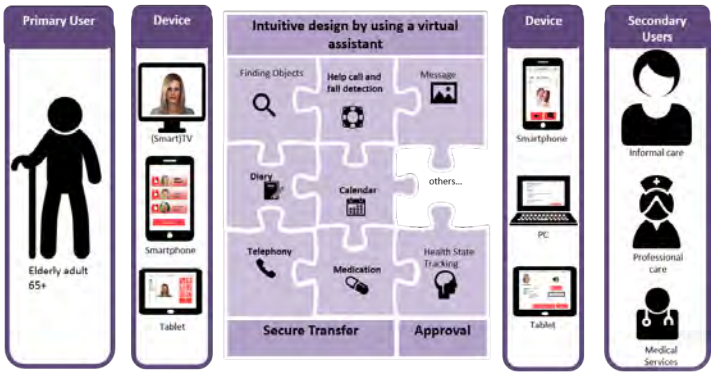

Fig. 1.3: DALIA architecture.

in Figure 1.4, it helps elderly people to have a smooth interaction with normally difficult technology.

Being the evolution of the EDLAH project [7], it uses gamification to tap into the basic desires and needs of the user impulses, promoting status and achievements.

Fig. 1.4: EDLAH2 visual interfaces.

The objective is to be as appealing as possible and to have a greater incentive to be used, engaging elderly people into the use of new technologies, as seen in Figure 1.4. Moreover, it may improve the mental health, physical health, social integration, and self-esteem. It will be employed positive reinforcement suggestions and messages, that cater to the user progress and imply further usage of the applications and tablet.

In terms of gamification the execution process will give awards gained by using other services, e.g. web browsing, games, visualizing photos, and those points will be put in a leader board constituted by a closed set of friends, or the general community, or just personal classification (if one wishes not to be compared).

This PA may be considered as active, as it requires direct interaction from the users for it to work and influence them. Nacke et al. [22] refer that casual and continuous gaming among elderly people using digital devices show a noticeable

increase in cognitive development and physical development. Thus this project is an assistant in terms of assisting the cognition health of its users.

1.2.6 iGenda

The iGenda project [11, 10, 13, 12] is a cognitive assistant that focuses on elderly people and their caregivers through management of daily events and activities. The idea behind this project is to use technology to tackle the issues of forgetting activities and by remembering announcing them to the elderly they shuffle through their memories, thus exercising their cognition. Furthermore, the iGenda promotes playful activities (physical and psychological) that enable the elderly to have an active aging.

The iGenda works in two fronts: active aging and aging at home. By taking into account the users' profile and their health issues, the iGenda plans the appropriate activities to each user, being them more outgoing or more homely.

The idea behind using events and activities is supported by several studies that defend using activities and social interaction help to maintain the cognition levels and help stopping the Alzheimer's advance [30, 35, 34, 29, 6, 36, 28, 19, 37, 25, 16, 5].

The iGenda also is designed to the caregivers, allowing them to manage the activities, schedule new activities or visualise the elderly vital signs (when a wearable device is used). Therefore, it decreases the caregivers' stress coming from the constant care-receiver monitoring and allowing them to monitor several people at the same time.

In terms of operation, the iGenda runs on smartphones or devices with web browsers and is transparent to the users, only warning them when there is an critical interaction required or if the system detects that the users are not performing the activity that was planned at that time.

The iGenda is implemented over multi-agent platforms that are modular and easily scalable. An overview of the architecture is showed in Figure 1.5.

Currently the iGenda developments are in the emotion detection area and the persuasive area. The goal is to gather unbiased information from the users emotional state and how they respond to certain activities suggestions, and to justify using natural language and human concepts the reason why one activity was suggested over others through persuasion processes.

1.2.7 M3W

The M3W project [24, 23] aim is to develop a mental wellness tool for self-usage to measure and visualise mental changes and tendencies, and to give indications, alarms or reports This tool is directed to the elderly and their relatives, friends, and physicians.

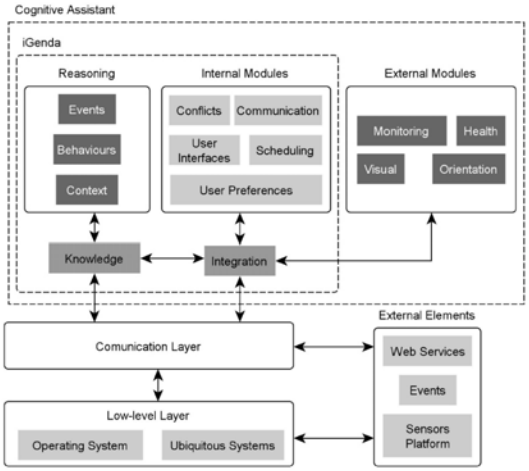

Fig. 1.5: iGenda architecture.

The goal is to create an personal health record through historic values and show the positive or negative progression of the health condition.

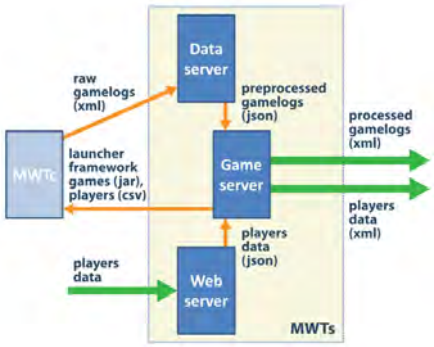

Fig. 1.6: M3W architecture.

To evaluate the users, this project uses cognitive games that are designed directly to improve the cognition of the users following the works of [8, 21, 31]. They improve the attention, executive functions (decision making, mental flexibility, planning, and problem solving), memory (visual memory, spatial memory, and working memory), and language. The architecture of execution can be seen in Figure 1.6.

Like the EDLAH2 project, this CA requires direct interaction from the users, being in the paradigm of assisting through interaction.

1.2.8 MyGuardian

The MyGuardian project [32, 18] aims to use technology to facilitate the elderly mobility, keeping their autonomy and dignity. The generated tool helps the users and caregivers by guiding the elderly and reporting situations of confusion or risk to the caretakers. The caretakers have the additional feature of coordinating the daily tasks step-by-step. To this, the interfaces are simple and easy to understand, as seen in Figure 1.7.

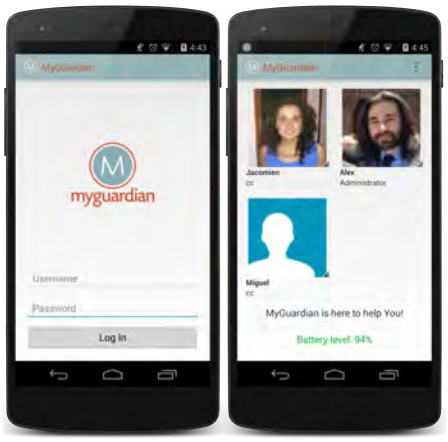

Fig. 1.7: MyGuardian mobile interfaces.

This project is built with different visual interfaces to different users, each one specific to their role and needs, they are:

- Senior: a mobile application for trading information and capturing data. The elderly are able to communicate with their caregivers by voice and automated messages, having a panic button for emergency situations. The data captured by a wearable device is sent to the server for further processing;
- Caregiver: a mobile application for caregivers that allows communication with the elderly, tasks coordination, and emergency situations;
- Call-center: a web portal for professional caregivers to support the elderly and their informal caregivers;
- Senior Coordination Service: the server service that dynamically distributes care tasks and responsibilities between volunteer caregivers and professional caregivers.

In terms of cognition, the application helps the elderly to remember where they should be next, jogging their memory at the same time. Moreover, the application is intended to be used lightly and with minimal interaction, as it is constantly monitoring the users, and only in specific cases it should be used by the elderly.

1.2.9 PersonAAL

The PersonAAL project [17] consists of a software platform that monitors the behavior of the elderly through sensors systems and adaptively displays information and health-related suggestions on various devices at home through intuitive user interfaces.

The environment explores a model-based structures, thus they may have the ability of predicting some actions and adapt to changing contexts. This project is inserted in the concept of aging in place, in the sense that the available technological elements empower the elderly to perform activities of daily living without the need of additional help.

Fig. 1.8: PersonAAL example application.

Technologically the project boasts the ability of being able to use several different platforms to interact with the users, e.g. PC, TV, and smartphone, and different mediums according to the users likes, e.g. video, animation, voice, and gesture. One example can be seen in Figure 1.8. The users will be discretely monitored through sensor systems, and in certain cases, monitored actively with wearable sensors that specifically monitor health points.

In terms of usage, although the interaction with the user is very much active, requiring response from the users, it is mainly transparent to the users until required by them.

1.3 Conclusion

This work presents the state of the art of the CA area through some very recent projects, here the oldest one is 6 years old. The CA showed touch an array of different social areas and show that there is still a lot of issues to resolve. The complexity of the human being way of think and act is very complex and there is no still a way to translate them to computer systems, and the current developments of these translations efforts resolve into long term and very complex projects. From this work we may observe that only to emulate basic aspects of activities scheduling and daily tasks execution takes a lot of effort.

We believe that we are witnessing a new dawn in terms of personal and cognitive assistants, with ever increasing projects and tools. These are areas that is now being extended due to the society high demand of products directed to the elderly. What we foresee is the adoption of these tools by young adults as they become more heterogeneous and features diverse.

The Personal Assistants area is ample and several projects fit on it due to the scope and versatility of the theme. The application area is mostly composed by resoning, health, personalization and robotics, ethic and social issues projects. The reasoning area deals with high-level implementations of PA. In this area projects that are very domain specific but essential to the development of PA. Although they may not be considered fully fledged PA projects, they can contribute to other projects, like voice recognition, among others. The health domain consists in projects that aim to assist people with complicated medical issues that are unable to perform certain tasks and need an specific assistant that provides help in directly or indirectly perform those tasks. The personalization consists in projects that aim to enhance the users senses using technological resources (e.g. augmented reality, active information, audio guidance, etc.) or in PA that adjust to the users' profile and adapt themselves to provide an immersive experience. The robotics domain consists in projects that aim to use robots (mostly humanoids) to provide direct assistance to the users. One goal is to project a human presence and interact physically with users. Another aim is to increase the ability to understand the environment and the users and their needs. Finally, there is the area of ethic and social issues that does not present any application projects per se, but deal with societal issues like the ethical ramifications of total and constant monitoring and the society position over sensible topics.

Acknowledgements

Angelo Costa thanks the Fundação para a Ciência e a Tecnologia (FCT) the Post-Doc scholarship with the Ref. SFRH/BPD/102696/2014. This work is also supported by COMPETE: POCI-01-0145-FEDER-007043 and FCT Project Scope: UID/CEC/00319/2013 and partially supported by the MINECO/FEDER TIN2015-65515-C4-1-R.

References

1. Active@home (2017). URL http://www.active-at-home.com. Accessed on 2017-04-07
2. Come (2017). URL http://come-aal.eu. Accessed on 2017-04-07
3. Dayguide (2017). URL https://www.dayguide.eu. Accessed on 2017-04-07
4. Edlah2 (2017). URL http://www.edlah2.eu. Accessed on 2017-04-07
5. Abbott, R.D., White, L.R., Ross, G.W., Masaki, K.H., Curb, J.D., Petrovitch, H.: Walking and dementia in physically capable elderly men. Jama **292**(12), 1447–1453 (2004)
6. Akbaraly, T., Portet, F., Fustinoni, S., Dartigues, J.F., Artero, S., Rouaud, O., Touchon, J., Ritchie, K., Berr, C.: Leisure activities and the risk of dementia in the elderly results from the three-city study. Neurology **73**(11), 854–861 (2009)
7. Anagnostopoulos, G.G., Deriaz, M.: Automatic switching between indoor and outdoor position providers. In: 2015 International Conference on Indoor Positioning and Indoor Navigation (IPIN). Institute of Electrical and Electronics Engineers (IEEE) (2015). DOI 10.1109/ipin.2015.7346948
8. Anguera, J.A., Boccanfuso, J., Rintoul, J.L., Al-Hashimi, O., Faraji, F., Janowich, J., Kong, E., Larraburo, Y., Rolle, C., Johnston, E., Gazzaley, A.: Video game training enhances cognitive control in older adults. Nature **501**(7465), 97–101 (2013). DOI 10.1038/nature12486
9. Auinger, K., Kriegel, J.: Identifikation von nutzeranforderungen durch kreativtechniken am beispiel des europäischen aal projekts dalia. In: e-Health 2014 – Informationstechnologien und Telematik im Gesundheitswesen, pp. 277–282 (2013)
10. Carneiro, D., Gomes, M., Costa, Â., Novais, P., Neves, J.: Enriching conflict resolution environments with the provision of context information. Expert Systems pp. n/a–n/a (2013). DOI 10.1111/exsy.12049
11. Costa, Â., Castillo, J.C., Novais, P., Fernández-Caballero, A., Simoes, R.: Sensor-driven agenda for intelligent home care of the elderly. Expert Systems with Applications **39**(15), 12,192–12,204 (2012). DOI 10.1016/j.eswa.2012.04.058
12. Costa, A., Julián, V., Novais, P.: Advances and trends for the development of ambient-assisted living platforms. Expert Systems **34**(2), e12,163 (2016). DOI 10.1111/exsy.12163
13. Costa, A., Novais, P., Simoes, R.: A caregiver support platform within the scope of an ambient assisted living ecosystem. Sensors **14**(3), 5654–5676 (2014). DOI 10.3390/s140305654
14. EuroHealthNet: European policies and initiatives. URL http://www.healthyageing.eu/european-policies-and-initiatives. Accessed on 2017-04-07
15. European Commission: European innovation partnership on active and healthy ageing. URL https://ec.europa.eu/eip/ageing/home_en. Accessed on 2017-04-07
16. Fabrigoule, C., Letenneur, L., Dartigues, J.F., Zarrouk, M., Commenges, D., Barberger-Gateau, P.: Social and leisure activities and risk of dementia: a prospective longitudinal study. Journal of the American Geriatrics Society **43**(5), 485–490 (1995)
17. Ghiani, G., Manca, M., Paternò, F., Santoro, C.: End-user personalization of context-dependent applications in AAL scenarios. In: Proceedings of the 18th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct - MobileHCI '16. ACM Press (2016). DOI 10.1145/2957265.2965005
18. Gustarini, M., Wac, K.: Smartphone interactions change for different intimacy contexts. In: Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, pp. 72–89. Springer International Publishing (2014). DOI 10.1007/978-3-319-05452-0_6
19. Karp, A., Paillard-Borg, S., Wang, H.X., Silverstein, M., Winblad, B., Fratiglioni, L.: Mental, physical and social components in leisure activities equally contribute to decrease dementia risk. Dementia and geriatric cognitive disorders **21**(2), 65–73 (2006)
20. Kunnappilly, A., Seceleanu, C., Lindén, M.: Do we need an integrated framework for ambient assisted living? In: Ubiquitous Computing and Ambient Intelligence, *Lecture Notes in Computer Science*, vol. 10070, pp. 52–63. Springer Nature (2016). DOI 10.1007/978-3-319-48799-1_7
21. McNab, F., Varrone, A., Farde, L., Jucaite, A., Bystritsky, P., Forssberg, H., Klingberg, T.: Changes in cortical dopamine d1 receptor binding associated with cognitive training. Science **323**(5915), 800–802 (2009). DOI 10.1126/science.1166102

22. Nacke, L.E., Nacke, A., Lindley, C.A.: Brain training for silver gamers: effects of age and game form on effectiveness, efficiency, self-assessment, and gameplay experience. CyberPsychology Behavior **12**(5), 493–499 (2009)
23. Pataki, B., Hanák, P., Csukly, G.: Computer games for older adults beyond entertainment and training: Possible tools for early warnings - concept and proof of concept. In: Proceedings of the 1st International Conference on Information and Communication Technologies for Ageing Well and e-Health. Scitepress (2015). DOI 10.5220/0005530402850294
24. Pataki, B., Hanák, P., Csukly, G.: Surpassing entertainment with computer games: Online tools for early warnings of mild cognitive impairment. In: Communications in Computer and Information Science, pp. 217–237. Springer Nature (2015). DOI 10.1007/978-3-319-27695-3_13
25. Podewils, L.J., Guallar, E., Kuller, L.H., Fried, L.P., Lopez, O.L., Carlson, M., Lyketsos, C.G.: Physical activity, apoe genotype, and dementia risk: findings from the cardiovascular health cognition study. American journal of epidemiology **161**(7), 639–651 (2005)
26. Pool, J.: Alzheimer's Society guide to the dementia care environment. Alzheimer's Society (2015)
27. Population Reference Bureau: America's aging population. Tech. rep., http://www.prb.org/pdf11/aging-in-america.pdf (2011)
28. Rovio, S., Kåreholt, I., Helkala, E.L., Viitanen, M., Winblad, B., Tuomilehto, J., Soininen, H., Nissinen, A., Kivipelto, M.: Leisure-time physical activity at midlife and the risk of dementia and alzheimer's disease. The Lancet Neurology **4**(11), 705–711 (2005)
29. Sanders, A., Verghese, J.: Leisure activities and the risk of dementia in the elderly. Research and Practice in Alzheimer's Disease **12**, 54–58 (2007)
30. Scarmeas, N., Levy, G., Tang, M.X., Manly, J., Stern, Y.: Influence of leisure activity on the incidence of alzheimer's disease. Neurology **57**(12), 2236–2242 (2001)
31. Smith, G.E., Housen, P., Yaffe, K., Ruff, R., Kennison, R.F., Mahncke, H.W., Zelinski, E.M.: A cognitive training program based on principles of brain plasticity: Results from the improvement in memory with plasticity-based adaptive cognitive training (IMPACT) study. Journal of the American Geriatrics Society **57**(4), 594–603 (2009). DOI 10.1111/j.1532-5415.2008.02167.x
32. Tsiourti, C., Joly, E., Wings, C., Moussa, M.B., Wac, K.: Virtual assistive companions for older adults: Qualitative field study and design implications. In: Proceedings of the 8th International Conference on Pervasive Computing Technologies for Healthcare. ICST (2014). DOI 10.4108/icst.pervasivehealth.2014.254943
33. Van Den Broek, G., Cavallo, F., Wehrmann, C.: AALIANCE Ambient Assisted Living Roadmap (Ambient Intelligence and Smart Environments). IOS Press (2010)
34. Verghese, J., LeValley, A., Derby, C., Kuslansky, G., Katz, M., Hall, C., Buschke, H., Lipton, R.B.: Leisure activities and the risk of amnestic mild cognitive impairment in the elderly. Neurology **66**(6), 821–827 (2006)
35. Wang, H.X., Karp, A., Winblad, B., Fratiglioni, L.: Late-life engagement in social and leisure activities is associated with a decreased risk of dementia: a longitudinal study from the kungsholmen project. American journal of epidemiology **155**(12), 1081–1087 (2002)
36. Wang, J., Zhou, D., Li, J., Zhang, M., Deng, J., Tang, M., Gao, C., Lian, Y., Chen, M.: Leisure activity and risk of cognitive impairment: the chongqing aging study. Neurology **66**(6), 911–913 (2006)
37. Wilson, R.S., De Leon, C.F.M., Barnes, L.L., Schneider, J.A., Bienias, J.L., Evans, D.A., Bennett, D.A.: Participation in cognitively stimulating activities and risk of incident alzheimer disease. Jama **287**(6), 742–748 (2002)
38. World Health Organization: Global health and aging. Tech. rep., National Institute on Aging, National Institutes of Health, U.S. Department of Health and Human Services (2011)
39. Zach, H., Peinsold, P., Winter, J., Danner, P., Hatzl, J.: Using proxy re-encryption for secure data management in an ambient assisted living application. In: Lecture Notes in Informatics – Proceedings of the Open Identity Summit 2015, pp. 71–83 (2015)