Exploring Pervasive Service Computing Opportunities for Pursuing Successful Ageing

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Abstract. Pervasive Service Computing for Elderly applies service composition and pervasive computing into assisting elderly Activities of Daily Life. Taking advantages of context-awareness and service-oriented computing, Pervasive Service Computing expects to bring brilliant opportunities for pursuing global successful ageing. This paper proposes a Pervasive Service Computing for Elderly (PSC4E) framework for improving Quality of Life of elderly people, through providing being-, becoming-, and belonging-based services in context of population ageing trends, an elderly service provisioning model, and related studies.

Keywords: pervasive computing, service computing, pervasive healthcare, elderly

1 Introduction

Population ageing is a trend reflecting the increase in the number and proportion of elderly people in society. Population ageing implies a decline in the proportion of the population composed of children, and an increase in the proportion of elderly adults. Four major findings are given to population ageing in United National Human Development Report [8] as follows: 1) The world's number of elderly people is expected to exceed the number of children for the first time in 2045. 2) Population ageing results in universal reduction of productiveness. 3) Population ageing has major consequences and implications for all facets of human life. 4) Population ageing is enduring. The proportion of elderly has been rising steadily since 1950, passing from 8% in 1950 to 11% in 2009, and is expected to reach 22% in 2050. This paper cites age 65 as the entry point of becoming an elderly person. Ageing has a significant negative impact on society, including high caregiving costs, a growing burden to family caregivers [1], inadequate medical resources, and shortage of medical services in rural areas.

Successful ageing is regarded as an ultimate goal to address the ageing issue. Six dimensions of successful ageing are suggested in [2, 3] such as reduced physical disability over the age of 75, good self-ratings, greater length of normal life, etc.

Pursuing successful ageing has been targeted by adopting Information and Communication Technology (ICT) in the healthcare industry for years, in the name of pervasive healthcare computing [7], e-Inclusion [48], and Ambient Assisting Living (AAL) [49]. On-demand access to medical information anywhere and anytime has brought benefits to physicians and patients. More advanced applications like personal and assistive robotics can assist elderly persons and people with disabilities [4]. Efforts have also been made for facilitating elderly and disabled person's independence at home through smart environments [5][6]. Stanford [7] has pointed out that pervasive computing promises a significant improvement in quality of life for the elderly.

We consider successful ageing equal with independent ageing, that is, with the ability to complete basic daily activities without personal assistance. Pervasive Service Computing (PSC) aims to facilitate users' everyday activities by ubiquitously supporting them with network-accessed web services [13][19]. We believe that Pervasive Service Computing can improve independent ageing by delivering personal services that match each elderly person's particular needs. The main contribution of this paper is shaping this vision to the concept of Pervasive Service Computing for Elderly (PSC4E). We emphasize PSC4E as an emerging technology for achieving successful ageing.

The remainder of the paper is organized as follows: Section 2 presents National Center for Medical Rehabilitation Research (NCMRR) elderly impairment model for research on the navigation of independent ageing. Section 3 reviews Quality of Life domains and indicators of independent ageing. Section 4 studies the PSC4E service model. Section 5 presents the PSC4E framework. Section 6 presents a brief literature review. Conclusions and discussions are drawn in section 7.

2 NCMRR Elderly Disability Model

The elderly commonly have conditions that limit their daily activities. The National Center for Medical Rehabilitation Research (NCMRR) [45] defines five overlapping research domains relevant to studying disability.

Pathophysiology refers to the aberration from normal physiological and developmental processes. Research focuses on cellular, structural, or functional events subsequent to injury, disease, or genetic abnormality.

Impairment is a loss or abnormality at the organ level. Such organ impairment may cause difficulties with movement, hearing, vision, or cognition.

Functional limitation refers to lack of ability to perform an action within the range of an organ system. Function is the performance of an action for which a person or thing is especially fitted or normally used.

Disability is defined as a limitation in fulfilling tasks to expected levels. Research focuses on the successful adaptations made by individuals with disabilities.

Societal limitation refers to lack of ability to perform societal activities. Research examines the effectiveness of different rehabilitation interventions with the societal institutions.

3 Quality of Life Domains and Indicators

The concept of independent ageing is receiving growing attention around the world. Independent ageing links to the quality of life (QOL) of the elderly. The Centre for Health Promotion at University of Toronto defines QOL as the degree to which a person enjoys the important possibilities of his or her life [9]. The QOL domains and indicators, which apply to both younger and elderly people, are:

Being domain includes the basic aspects of "who one is," and has three indicators: Physical Being, Psychological Being, and Spiritual Being. **Becoming domain** refers to the purposeful activities carried out to achieve personal goals, hopes, and wishes. The three indictors in this area are Practical Becoming, Leisure Becoming, and Growth Becoming. **Belonging domain** includes a person's fit with his/her environment, and has three indicators: Physical Belonging, Social Belonging, and Community Belonging. Table 1 presents these three domains' indicators.

Table 1. Quality of life indicators

Indicator	Specification
physical being	physical health, personal hygiene, general physical appearance
psychological being	psychological health, self-esteem, self-concept and self-control
spiritual being	personal values, personal standards of conduct, spiritual beliefs
practical becoming	domestic activities, meeting health or social needs
leisure becoming	activities that promote relaxation and stress reduction
growth becoming	activities that improves knowledge and skills
physical belonging	home, neighborhood, community
social belonging	intimate others, family, friends, neighborhood and community
community belonging	adequate income, health and social services, recreational programs, community events and activities

4 Service Model for the Elderly

The Activities of Daily Living (ADLs) are a defined set of activities necessary for normal self-care. Six activities are defined by the Veteran Review Board [11]. Results in [12] suggest that the ADLs performed by elderly and the general population are similarly affected by need, enabling, and predisposing factors. From caregivers' perceptions, Roberto [1] presented assistances needed in personal and instrumental ADLs. This paper categorizes services needed by elderly into the following three groups:

Being-based elderly services are intended to help elderly to identify the help they need and the situation. These kinds of services keep both elderly people and their caregivers informed of issues and solutions for physical health (personal hygiene, nutrition, exercise, clothing, and general physical appearance), psychological health (mental and emotional), and spiritual health. **Becoming-based elderly services** seek to help elderly carry out purposeful activities such as domestic activities, and seeing to health or social needs. **Belonging-based elderly services** enable elderly people to connect with their families, friends, neighborhoods, or communities.

5 The Framework

Powered by context awareness and service computing, the framework, Pervasive Service Computing for the Elderly (PSC4E), defines an embedded, user-friendly computing and communication environment. This computer-enabled environment helps elderly users to easily access the above defined services, which currently must usually be physically delivered by caregivers. With wireless sensing devices embedded in the physical environment, PSC4E is available to deliver being-based services to help elderly people identify their health status. PSC4E provides timely transfer of information on people's health status to their caregivers, enabling real-time monitoring of activities and health conditions. PSC4E is also able to deliver becoming-based services, such as seeing a doctor or buying medicines. And PSC4E delivers belonging-based services to help elderly people at home to communicate with friends and doctors. The elderly can access PSC4E services via home tablets [46], smart phones, touch screens, or digital TVs. We propose a PSC4E framework (Figure 1) to pursue independent ageing through ubiquitously accommodating being-based, becoming-based, and belonging-based services. The four layers of the framework are presented next.

Context-aware middleware. Context is any information characterizing the situation of a task session, or interaction between a user and his/her service world. Context is categorized into five aspects, namely user context, peer context, process context, physical context, and service context [13][14]. A typical context-aware middleware has components of context sensing, context modeling, and context reasoning. Context sensing collects data from physical sensors measuring the elderly person's health condition, and his or her local environment. Context modeling abstracts description of sensing data. Context reasoning examines the contextual information and determines the elderly person's situation. Context Toolkit [15] and Context Fabric [16] are examples of general purpose context-aware middleware; CAMPH [17] and HYCARE [18] are context-aware middleware examples dedicated to healthcare.

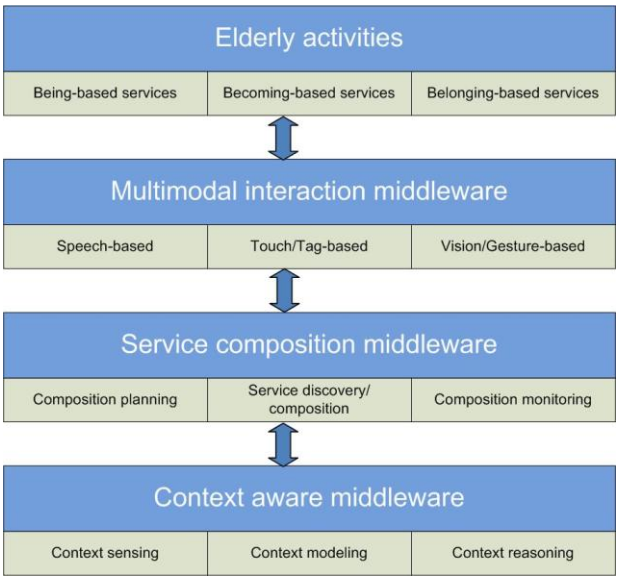

Fig. 1. The PSC4E Framework.

Service composition middleware. Service composition describes a model of developing applications by integrating internet-accessible and discoverable loosely-coupled Web services [19]. A general purpose service composition middleware consists of components for composition planning, service discovery, service composition, and composition monitoring. Composition planning analyzes elderly persons' service requests, and initiates a work plan that composes the available services in the service repository to satisfy the service request. Service discovery matches services in the service repository against service requirements (input/output and QoS, etc.), and ranks them. Service composition establishes invocations and bindings among selected services, evaluates the plans, and identifies the best plan for the execution. The monitoring engine executes the plan and controls composition execution.

Multimodal interaction middleware. As elderly people commonly have reduced abilities in areas such as vision, hearing and touch, we must provide them with multiple interactive interfaces. There are several different human computer interaction techniques which can help. PSC4E multimodal interface design [20] aims to adapt itself to the elderly person's needs using interactive visual, gesture, touch, speech, or tag-based interactions.

Elderly services and activities layer. From the application point of view, the elderly often suffer from severe activity limitations, which may involve mobility, hearing, speaking, cognition, and social skills. Elderly service research focuses on systematically identifying basic needs for assisting elderly people's ADLs, and abstracting those needs as a service middleware of being-based services, becoming-based services, and belonging-based services that facilitates various agile healthcare application developments.

6 Related Studies

Assisting People with Movement Impairment. Movement impairment can make it difficult or impossible to use the hands, to walk, or move the trunk and neck [21]. Assistive devices that can compensate for movement impairment are such as canes, walkers, or wheelchairs. Recent advances in wheelchairs have produced "smart wheelchairs," which employ multimodal user interfaces with the user's senses of seeing, hearing, touch, taste, or smell [40–42][22][23] [24].

Assisting People with Visual Impairment. High-tech assistive products include video magnifiers, such as the pocket-sized pico, which gives an inverse white on black image [21]. There are many studies of Human-Computer Interfaces which can support interactions for blind people [25]. Alonso [26] presents a set of guidelines for blind user interface design. Evreinov [25] introduces a novel automated book reader as an assistive technology tool for blind persons. Challis [27] presents a system for the non-visual presentation of music notation. Albert [28] introduces a system that permits blind students to both create and explore mathematical graphics without assistance.

Assisting Deaf and Hard-of-Hearing. Hearing loss impacts on isolation and depression. To help with this, low tech assistive devices include vibrating alarm clocks and smoke detectors [21]. In the high tech realm, one example is development of smart phones with voice to text translation. Kakuta [29] created a prototype of VUTE, a communication aid system based on motion pictograms that can be used for hard-of-hearing people in emergency situations. Lozano [30] has studied techniques and algorithms for the detection and classification of household sounds. Ottaviano [31] presented a web tool called Gym2Learn, which focuses on metacognition and reading comprehension processes in hearing impaired students. Bumbalek [32] presented a web-based e-Scribe prototype for real-time speech transcription. Othman [33] proposed a web-based application to edit sports news in sign languages to keep deaf people informed of sports results.

Assisting People with Speech Impairment. Schultz [34] studied silent speech recognition based on Electromyography. Hamidi [35] developed a customizable speech recognition interface, CanSpeak, for the user. Gebert [36] demonstrated the conception and implementation of a language laboratory for speech reading.

Assisting People with Cognitive Problems. About 10% people over age 65 have cognitive impairments [21][4]. To cope with this, a special thematic session organized by Edler [37] aimed to study guidelines for accessible information to the World Wide Web. Bohman [38] examined the structure, navigation, language and the presentation of information on web sites in order to make internet accessible for people with reading problems. Matausch [39] presented a study on Easy-to-Read and its impacts on the support of people with specific learning difficulties.

Smart and Assistive Environments. Many studies concern smart and assistive environments. Morandell [40] organized a series of workshops on Ambient Assisted Living, in terms of ICT-based homecare and social interaction of elderly persons. Øystein [41] surveyed reports on the use of a GPS-based localization and tracking device for use in dementia care. Joan [42] developed the concept of a friendly and adapted robotized kitchen. Roel [43] presented the user-centered design of a medicine dispenser for persons suffering from Alzheimer's disease.

7 Conclusions and Future Work

ICT-based healthcare applications are evolving to improve the quality of life of the elderly. Current ICT-based applications [7] include mobile telemedicine; remote patient monitoring; location-based services; pervasive access to medical data; health-aware mobile devices; and lifestyle incentive management. There are several challenges to overcome in providing technological solutions in healthcare for the elderly [44]. PSC4E advances pervasive healthcare and incorporates emerging web services into healthcare service delivery. Taking advantages of context awareness and service composition, we regard PSC4E as a next generation technology targeting at an integrated platform for delivering personalized elderly healthcare, and supporting elderly people's ADLs through a simple unified user interface. In the study course of pervasive service computing, we have already implemented context-aware and service-oriented application prototypes for assisting campus activities, e.g., music recommendation and multimedia annotation [47]. Our plan is to implement prototypes to the elderly healthcare area based on our earlier work, to gain experience about the application, and verify the PSC4E framework. Future tasks in PSC4E are initially identified as follows:

Ontology-based PSC4E context modeling. To facilitate elderly people's ADLs through personal service delivery, PSC4E needs to adapt to context changes and user configurations. Context modeling provides structures for capturing contextual information surrounding elderly persons. Context modeling is available for converting contextual information to a usable form through interpretation. Ontologies are widely accepted as instruments for the modeling of context information. This task explores ontology engineering and context modeling in information management for PSC4E.

PSC4E activity modeling. PSC4E targets delivering services for facilitating elderly user's ADLs at a high level. This gives rise to PSC4E activity modeling. PSC4E aims to present a representation mechanism for rules, conditions, constraints, controls, and data dependencies in elderly people's ADLs.

PSC4E in Cloud Computing. Cloud computing describes a model of sharing a pool of configurable computing resources in a rapid-provisioning, minimal management manner. PSC4E in Cloud Computing aims to study the application of Cloud Computing in delivery of elderly services and health data.

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References

[1] Roberto, K.A.: The Elderly Caregiver: Caring for Adults with Developmental Disabilities. SAGE, Newbury Park, CA (1993)
[2] Rowe, J.W., Kahn R.L.: Human Aging: Usual and Successful. Science. 237, 143–149 (1987)
[3] Strawbridge, W.J., Wallhagen, M.I., Cohen, R.D.: Successful Aging and Well-being: Self-rated Compared with Rowe and Kahn. The Gerontologist. 42, pp. 727–733 (2002)

[4] Davenport, R.D.: Robotics. In Mann, W.C. (ed.) Smart Technology for Aging, Disability, and Independence: The State of the Science. pp. 67–110. John Wiley & Sons, Inc., Hoboken, NJ (2005)
[5] Kidd, C.D., Orr, R., Abowd, G.D., Atkeson, C.G., Macintyre, I.A.B., Mynatt, E., Starner, T.E., Newstetter, W.: The Aware Home: A Living Laboratory for Ubiquitous Computing Research, In: Proceedings of the Second International Workshop on Cooperative Buildings, Integrating Information, Organization, and Architecture. pp. 191–198, (1999)
[6] Dowdall, A., Perry, M.: The Millennium Home: Domestic Technology to Support Independent-Living Older People. In: Proceedings of the 1st Equator IRC Workshop, pp.1-15, (2001)
[7] Stanford, V.: Using Pervasive Computing to Deliver Elder Care. IEEE Pervasive Computing. 1, 10–13 (2002)
[8] United Nations,: World Population Ageing 2009, http://www.un.org/esa/population/publications/ WPA2009/WPA2009_WorkingPaper.pdf. Accessed by March 9, 2010
[9] Schalock, R.L.: Quality of Life for People with Intellectual and Other Developmental Disabilities: Applications Across Individuals, Organizations, Communities, and Systems. American Association on Intellectual and Developmental Disabilities. Washington, DC (2007)
[10] Dennis R., Browna, I., Renwicka, R., and Rootmana, I.: Assessing the Quality of Life of Persons with Developmental Disabilities: Description of a New Model, Measuring Instruments, and Initial Findings. International J. of Disability, Development and Education. 43, 25–42 (1996)
[11] Veteran Review Board. Activities of Daily Living, http://www.vrb.gov.au/pubs/garp-chapter16.pdf. Accessed by March 9, 2010
[12] Coulton, C., Frost, A.K.: Use of Social and Health Services by the Elderly. J of Health and Social Behavior. 23, 330–339 (1982)
[13] Zhou, J., Gilman, E., Palola, J., Riekki, J., Ylianttila. M., Sun, J.: Context-Aware Pervasive Service Composition and Its Implementation. Personal and Ubiquitous Computing. 15, 291–303 (2011)
[14] Zhou, J., Riekki, J.: Context-Aware Pervasive Service Composition. In: Proceedings of International Conference on Intelligent Systems, Modeling and Simulation, pp. 437–442 (2010)
[15] D. Salber, D., Dey, A.K., Abowd, G.D.: The Context Toolkit: Aiding the Development of Context-Enabled Applications. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems: The CHI is the Limit, pp. 434–441 (1999)
[16] Hong, J.I.: The Context Fabric: An Infrastructure for Context-Aware Computing. In: Proceedings of CHI' 02 Extended Abstracts on Human Factors in Computing Systems, pp. 554–555 (2002)
[17] Hung, K.P., Tao, G., Wenwei, X., Palmes, P.P., Jian, Z., Wen, L.N., Chee, W.T., Weng, T., Nguyen, H.C.: Context-Aware Middleware for Pervasive Elderly Homecare. IEEE J. on Selected Areas in Communications. 27, 510–524 (2009)
[18] Du, K., Zhang, D., Zhou, X. Mokhtari, M., Hariz, M. and Qin, W.: HYCARE: A Hybrid Context-Aware Reminding Framework for Elders with Mild Dementia. In Helal, S., Mitra, S., Wong, J., Chang, C., Mokhtari, M. (eds.) Smart Homes and Health Telematics, pp. 9–17. Springer Berlin, Heidelberg (2008)
[19] Zhou, J., Gilman, E., Riekki, J., Rautiainen, M., Ylianttila, M.: Ontology-Driven Pervasive Service Composition for Everyday Life. In Margaria, T., Steffen, B. (eds.) Leveraging Applications of Formal Methods, Verification, and Validation, pp. 375–389. Springer Berlin, Heidelberg (2010)
[20] Zhou, J., Junzhao, S., Athukorala, K., Wijekoon, D.: Pervasive Social Computing: Augmenting Five Facets of Human Intelligence. In: Proceedings of Ubiquitous Intelligence

& Computing and 7th International Conference on Autonomic & Trusted Computing (UIC/ATC), pp. 1–6. Springer, Berlin, Heidelberg (2010)
[21] Mann, W.C., Ed: Aging, Disability and Independence: Trends and Perspectives. In Mann WC.(eds.) Smart Technology for Aging, Disability, and Independence: The State of the Science. John Wiley & Sons, Inc., Hoboken, NJ (2005)
[22] Kim, H., Ryu, D.: Smart Wheelchair Based on Ultrasonic Positioning System, In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 1014–1020. Springer Berlin, Heidelberg (2006)
[23] Mayer, P., Panek, P., Edelmayer, G., Nuttin, N., Zagler, W.: Scenarios of Use for a Modular Robotic Mobility Enhancement System for Profoundly Disabled Children in an Educational and Institutional Care Environment. In Miesenberger, K., Klaus, J., Zagler, W and Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 1021–1028. Springer Berlin, Heidelberg (2006,)
[24] Simpson, R.C.: Smart Wheelchairs: A Literature Review. J. Rehabil. Res. Dev. 42(4), 423–436 (2005)
[25] Evreinov, G.: Blind and Visually Impaired People: Human Computer Interface. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 1029–1030. Springer Berlin, Heidelberg (2006)
[26] Alonso, F., Fuertes, J., González, Á., Martínez, L.: A Framework for Blind User Interfacing. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 1031–1038. Springer Berlin, Heidelberg (2006)
[27] Challis, B.: Accessing Music Notation Through Touch and Speech. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 1110–1117. Springer Berlin, Heidelberg (2006)
[28] Albert, P.: Math Class: An Application for Dynamic Tactile Graphics. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 1118–1121. Springer Berlin, Heidelberg (2006)
[29] Kakuta, M., Nakazono, K., Nagashima, Y., Hosono, N.: Development of Universal Communication Aid for Emergency Using Motion Pictogram. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 308–311. Springer Berlin, Heidelberg (2010)
[30] H. Lozano, H., Hernáez, I., Picón, A., Camarena, J., Navas, E.: Audio Classification Techniques in Home Environments for Elderly/Dependant People. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 320–323. Springer Berlin, Heidelberg (2010)
[31] Ottaviano S., Merlo, G., Chifari, A., Chiazzese, G., Seta, L., Allegra, M., and Samperi, V.: The Deaf and Online Comprehension Texts: How Can Technology Help? In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 144–151. Springer Berlin, Heidelberg (2010)
[32] Bumbalek, Z., Zelenka, J., Kencl, L.: E-Scribe: Ubiquitous Real-Time Speech Transcription for the Hearing-Impaired. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 160–168. Springer Berlin, Heidelberg (2010)
[33] Othman, A., El Ghoul, O., Jemni, M.: SportSign: A Service to Make Sports News Accessible to Deaf Persons in Sign Languages. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 169–176. Springer Berlin, Heidelberg (2010)
[34] Schultz, T.: ICCHP Keynote: Recognizing Silent and Weak Speech Based on Electromyography. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 595–604. Springer Berlin, Heidelberg (2010)

[35] Hamidi, F., Baljko, M., Livingston, N., and Spalteholz, L.: CanSpeak: a Customizable Speech Interface for People with Dysarthric Speech. In: Proceedings of the 12th International Conference on Computers Helping People with Special Needs: Part I, pp. 605–612. Springer Berlin, Heidelberg (2010)
[36] Gebert, H., Bothe, H.: LIPPS—A Virtual Teacher for Speechreading Based on a Dialog-Controlled Talking-Head. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 621–629. Springer Berlin, Heidelberg (2010)
[37] Edler, C., Peböck, B.: Easy-to-Web: Introduction to the Special Thematic Session. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 630–633. Springer Berlin, Heidelberg (2010)
[38] Bohman, U.: The Need for Easy-to-Read Information on Web Sites. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 634–640. Springer Berlin, Heidelberg (2010)
[39] Matausch, K., Peböck, B.: EasyWeb—A Study How People with Specific Learning Difficulties Can Be Supported on Using the Internet. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 641–648. Springer Berlin, Heidelberg (2010)
[40] Morandell, M. and Fugger, E.: Results of a Workshop Series on Ambient Assisted Living, In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 288–291. Springer Berlin, Heidelberg (2010)
[41] Dale, Ø.: Usability and Usefulness of GPS Based Localization Technology Used in Dementia Care. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 300–307. Springer Berlin, Heidelberg. (2010)
[42] Aranda, J., Vinagre, M., Martín, E., Casamitjana, M., Casals, A.: Friendly Human-Machine Interaction in an Adapted Robotized Kitchen. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 312–319. Springer Berlin, Heidelberg (2010)
[43] de Beer, R., Keijers, R., Shahid, S., Al Mahmud, A., Mubin, O.: PMD: Designing a Portable Medicine Dispenser for Persons Suffering from Alzheimer's Disease. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) Computers Helping People with Special Needs, pp. 332–335. Springer Berlin, Heidelberg (2010)
[44] Varshney, U.: Pervasive Healthcare, Computer, 36, 138–140, (December, 2003)
[45] National Institutes of Health, Research Plan for the National Center for Medical Rehabilitation Research, http://www.nichd.nih.gov/publications/pubs/upload/plan.pdf. Accessed by March 9, 2011 (March 1993)
[46] Archos 7. Home Tablet, http://www.archos.com/ Accessed by March 9, 2011 (2011)
[47] Zhou, J., Riekki, J., Ylianttila, M., Zhou, J., Tang, F., Guo, M. State of the art on Pervasive Service Computing. In: Proc. International Workshop on Ubiquitous Healthcare and Welfare Services and Supporting Technologies, pp. 1-6. (2010)
[48]e-Inclusion, e-Inclusion,http://ec.europa.eu/information_society/activities/einclusion/index_en.htm. Accessed by March 9, 2011 (2011)
[49] AAL, Ambient Assisted Living Joint Programme, http://www.aal-europe.eu/ Accessed by March 9, 2011 (2011)