An Ambient Assisted Living Technology Platform for Informal Carers of the Elderly - iCarer

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Abstract

For most families with elderly relatives, care within their own home is by far the most preferred option - both for the elderly and their carers. However, frequently these carers are the partners of the person with long-term care needs, and themselves are elderly and in need of support to cope with the burdens and stress associated with these duties. When it becomes too much for them, they may have to rely on professional care services, or even use residential care for a respite. In order to support the carers as well as the elderly person, an ambient assisted living platform has been developed. The system records information about the activities of daily living using unobtrusive sensors within the home, and allows the carers to record their own wellbeing state. By providing facilities to schedule and monitor the activities of daily care, and providing orientation and advice to improve the care given and their own wellbeing, the system helps to reduce the burden on the informal carers.

1. Introduction

The world population is currently suffering progressive ageing which can have dramatic effects on health systems due to increasing costs and a higher demand of socio-healthcare services to maintain the elderly's independence and quality of life. The four major themes that are important for older adults to age in their own homes and community are [1];

- safety and independence,

- social interaction,

- use of technology,

- the desire for support.

In addition, many older adults prefer to age in their own home rather than in an assisted living facility, even though they require long-term care due to diseases associated with ageing and assistance in their Activities of Daily Living (ADLs) [2]. Therefore, a significant increase in care responsibilities, which is typically performed by family and friends, appears and implies a need for innovative support approaches for family members and their carers.

This demographic change will lead to significant and interrelated modifications in the health care sector and technologies promoting independence for the elderly. Therefore, an enormous interest is growing in the use of technological solutions and specifically Information and Communication Technologies (ICT) to support elderly people to live independently for longer period in their homes and connect the older adults to geographically dispersed family and friends. In order to deal with this issue, the Ambient Assisted

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Living (AAL) initiative [3] promotes the creation of products, systems and solutions based on ICT for the support of the elderly's life independence. AAL services can be enclosed in the Ambient Intelligence (AmI) concept which implies a seamless environment of computing, advanced networking technology and specific interfaces providing users with context-aware, personalised, adaptive, ubiquitous and interoperable systems [4]. Additionally, AAL might need to support or collaborate with informal carers, such as relatives and friends, who play important roles in the lives and care of older adults [5] and [6].

2. Technological Needs

In order to initially establish the needs and concerns of the elderly and their carers, domain analysis was carried out. In a business context, a system would generally be based purely on pcs and servers, and the end users would probably be the primary stakeholders. They would be interviewed and user stories solicited. However for AAL systems, the sensors and AmI are as necessary as the servers, and the end users include formal care organisations, informal carers and the elderly. It is thus difficult to apply the usual open interview techniques since they may have no ideas of what they want from such systems. To provide an initial perspective on the problems and concerns of the stakeholders, without rejudging what is important to them, an automated method of finding contextual information was applied. Lexical analysis of over 34000 words from different Alzheimers Carers' forum threads has indicated some of the key concerns of the carers and issues for the elderly [7]. Although the terms 'mum', 'mother', 'dad' and 'care' obviously dominate, the terms 'social', 'health', 'friends', 'services', 'people' were used surprisingly frequently, whereas specific care issues were not so dominant. These appeared to indicate that the carers were more concerned about the general well-being of the older adult.

The intelligent care guidance and learning services platform for informal carers of the elderly (iCarer) project has made an attempt to produce a platform that offers informal carers adaptive, personalised support. It allows them to schedule and monitor their Activities of Daily Care (ADC), and to assess their own wellbeing in terms of stress and sleep. It provides orientation and e-learning advice to assist the carers in their ADC, and to help them improve their own wellbeing. It monitors activities of daily living for the elderly person via unobtrusive home sensors. The captured data is analysed by the platform, so that it acts as a 'Virtual Carer' when the human carer is absent, giving support to the older adult, and informing the carer when daily activities are not occurring as normal. In addition, iCarer provides wider e-learning services and

a learning network to support the informal carers. Consequently, the informal carer has the opportunity to expand their knowledge via the expertise of experts and fellow carers, supporting them and reducing their stress. Interaction and coordination between formal and informal carers will be enhanced by the use of the iCarer platform, allowing more flexible and reliable organisation of their care activities within their own private lives.

3. iCarer Platform

Considering the contextual situation of the elderly and their carers, the iCarer project proposes a personalised and adaptive platform to offer informal carers support by monitoring their ADC and psychological state, as well as providing an orientation to help them to improve the care provided. Monitored information will be collected using occupancy/activity sensors installed in their homes. Registered data by the monitoring system will be analysed and fed into the iCarer platform in order to model the ADC based on behavioural patterns. Based on this information, the platform can infer possible problems in the informal carer's activities/status [8]. Thus, the platform will act as a "virtual care" providing support to the carer with recommendations to solve the identified issue. In addition, if the carer is away at the time from the older adult's home, the iCarer platform will provide support to the older adult in case an activity is done incorrectly. iCarer will also provide e-Learning services through an informal carers' learning network portal. This will help to improve the coordination between formal carers and informal carers, offering the informal carers flexibility to better organise and combine their assistance and social activities. The platform is aimed at informal carers living with older adults (co-residents, commonly another elderly adult) who suffer cognitive impairment at any stage (from mild to severe).

The platform comprises four stages of: monitoring, inferring, informing and ultimately assisting the carer of an older adult as shown in Figure 1. Unobtrusive sensors around the house are used to monitor activities of older adults and send data to the Cloud for analysis. To infer activities from the data, Computational Intelligence techniques are used to determine the activities and whether these are as expected. If the activities change from the usual pattern, fuzzy models are used to deduce potential problems e.g. with sleep behaviour. Once a problem is identified, the carer is warned about the problem, and offered strategies to solve it, and hence reduce their stress.

In order to achieve the previous goals defined, the iCarer platform will be composed of a suite of modules, which provide the different services to support the
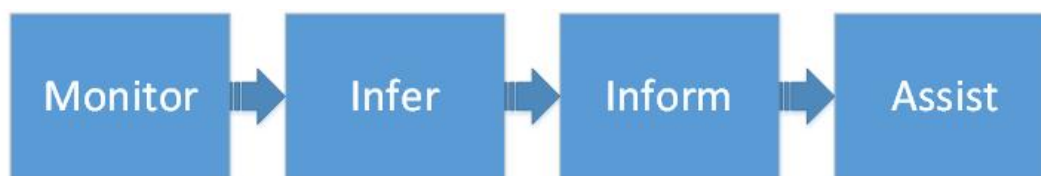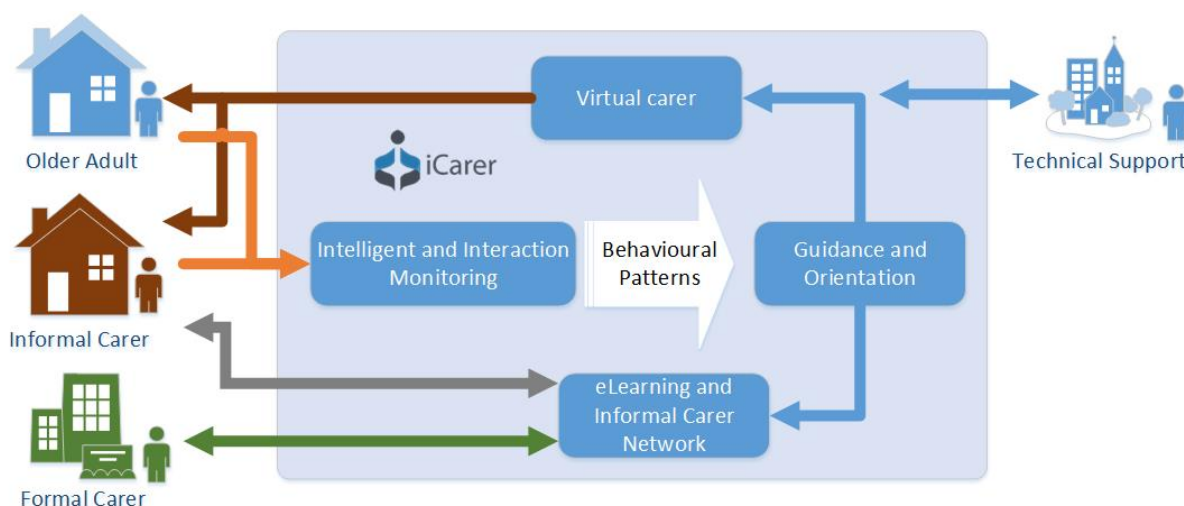
Figure 1. Stages of iCarer platform.

Figure 2. The iCarer platform architecture.

informal carer, as shown in Figure 2 and described briefly below.

- Intelligent and Interaction Monitoring - The iCarer platform provides a monitoring environment where the assistance tasks (ADCs) are monitored to detect early symptoms of carers' burden and stress.

  Questionnaires are aimed at assessing the informal carers' care activities, daily life behaviour and quality of life. On the other hand, a set of sensors (room occupancy sensors, bed sensors, motion sensors, electrical appliance usage sensors, etc.), will be deployed in the home to record the actions that carers and the elderly perform.

- Guidance and Orientation - After analysing the data monitored, behavioural patterns of both informal carers and older adult will be inferred in this module. In the case of the informal carer, once the behavioural patterns have been inferred, this module is also responsible to determine if a problem is occurred in assistance tasks. On the other hand, older adult's behavioural patterns will be generated in order to automatically infer problems in ADL execution. The problem detection is personalised by means of the ontology described in this paper, which manages

knowledge about the platform users' profiles [9], [10].

- Virtual Carer - The iCarer platform through this module proposes a service to support the care process reducing the carer's burden. Once the informal carer's problem or mistake is detected in ADC or ADL performance, the "Virtual Carer" will provide them with suitable guidance to improve the care activity or reduce the burden level of the informal carer. The virtual carer module will be respond the most appropriate recommendation to the informal carer depending on their needs or preference.

- eLearning and Informal Carer Network - By employing a content management system (CMS) this module will offer to the carer a personalised selection of video based e-Learning contents in order to reduce their workload and improve the effectiveness of the provided care. Additionally, a video e-Learning authoring tool, based on AMELIE [11], is provided for creating and editing video contents about the assistance tasks that informal carers perform. In addition, informal carers will be able to share contents through an informal learning network and contact other carers, sharing experiences and creating

an informal carers community. Moreover, as a support service to the informal carers, the iCarer platform will offer a management and coordination service to allow carers to work collaboratively in their care duties by sharing their care schedules and coordinating with their older adult's activities.

4. Results

Figure 3 shows the view of the system provided to carers and the elderly users to set up and schedule activities of daily care. Figure 4 and Figure 5 show some data as processed by the system during recent trials. The trials used only a limited set of sensors in order to validate the overall system. As can be seen by the dates and times, the system records individual sensor activations, and processes them via the ontology and the inferencing engine into higher level activities e.g. bathroom usage. These activities are then compared against the profiles set up for the individual users which indicate their expected normal patterns of behaviour. The fuzzy inferencing which follows the data processing then uses the differences between the profile and the observed behaviours to recognise the presence of any problems ie cases where the behaviour was significantly different from that expected. For example, the frequency of using the bathroom might be much higher than normal, and perhaps warn of some medical issue that needs to be investigated by the carer. These problems are shown in the screenshot of Figure 5, which also shows that the problems inferred have been passed on to the Virtual Carer part of the iCarer system. The Virtual Carer then uses the basic metadata about the problem to send through some recommendations for the carer of the elderly person. These recommendations then turn up as emails or texts that indicate any advice needed, or suggested self-help available from the Content Management System.

Figure 6 shows a summary of the individual activities of daily living for a few of the trial users. As can be seen, there are signifcant differences even in the overall totals of the daily activities, which could be helpful to any carer worried about their older adult. The figure shows, for example, that users CAD2 made only 3 visits to the kitchen for food, drink etc within the day, whereas user CAD12 made 31 visits in the same period. Variation in this over time may indicate some longer term changes in their behaviour, e.g. development of cognitive impairment.

5. Conclusions

Informal carers feel thrown into the caring role without receiving enough assistance, lacking education and training for their role as carers. Informal carer's quality of life will be improved by detecting their
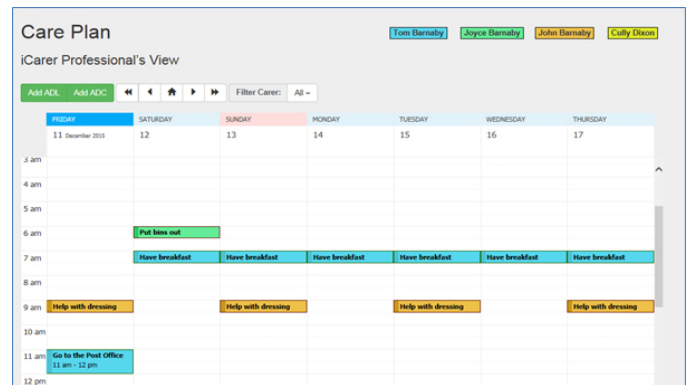

Figure 3. Activities and daily living(ADL) and activities of daily care (ADC).

StartDateTime	ActivityMetadata	LocationMetadata	UserID
8/30/2016 12:48:18 PM	LivingroomADL	Livingroom	CAD8@ · ·
8/30/2016 12:46:02 PM	Diet	Kitchen	CAD8@
8/30/2016 12:45:45 PM	LivingroomADL	Livingroom	CAD8@
8/30/2016 12:45:30 PM	Diet	Kitchen	CAD8@
8/30/2016 12:38:55 PM	LivingroomADL	Livingroom	CAD8@
8/30/2016 12:59:33 PM	UsingToilet	Bathroom	CAD3@
8/30/2016 12:58:32 PM	LivingroomADL	Livingroom	CAD3@
8/30/2016 12:57:38 PM	UsingToilet	Bathroom	CAD3@
8/30/2016 12:57:28 PM	LivingroomADL	Livingroom	CAD3@
8/30/2016 12:57:01 PM	Diet	Kitchen	CAD3@
8/30/2016 12:27:35 PM	LivingroomADL	Livingroom	CAD3@
8/30/2016 12:47:50 PM	Diet	Kitchen	CAD12@
8/30/2016 11:51:44 AM	LivingroomADL	Livingroom	CAD12@
8/30/2016 11:02:25 AM	Diet	Kitchen	CAD8@
8/30/2016 12:27:01 PM	Diet	Kitchen	CAD3@

Figure 4. A screenshot of activities.

burden and stress before it becomes overwhelming, by improving the assistance they provide and by increasing their social interactions and support. The informal carers have individual characteristics which have to be considered when a solution or service is offered to them, and so iCarer ensures that they can coordinate their own personal activities with the care tasks that they have to perform. The unobtrusive nature of sensors allows the carer and the elderly to carry out their normal ADL without additional stress caused by interference from external carers or obvious intrusive camera monitoring.

The use of an ontology provides a number of advantages for such a system. Although only a few sensor types have been used so far, extra sensors could be added at any time to the ontology, and the

Owner	ADL	Location	DateInferred	DateProblem	isSentVC
CAD2	UsingToilet	Bathroom	8/30/2016 11:10:13 AM	8/29/2016 10:26:10 PM	✔
CAD12	Sleeping	Bedroom	8/30/2016 11:10:12 AM	8/29/2016 5:22:52 PM	✔
CAD3	Sleeping	Bedroom	8/30/2016 11:10:11 AM	8/29/2016 5:18:39 PM	✔
CAD8	Sleeping	Bedroom	8/30/2016 11:10:09 AM	8/29/2016 5:18:16 PM	✔
CAD3	Diet	Kitchen	8/30/2016 11:10:12 AM	8/29/2016 7:38:33 AM	✔
CAD4	Diet	Kitchen	8/30/2016 11:10:11 AM	8/29/2016 5:49:37 AM	✔
CAD4	UsingToilet	Bathroom	8/30/2016 11:10:11 AM	8/29/2016 5:39:05 AM	✔
CAD8	Diet	Kitchen	8/30/2016 11:10:10 AM	8/29/2016 5:28:05 AM	✔
CAD8	UsingToilet	Bathroom	8/30/2016 11:10:10 AM	8/29/2016 4:46:24 AM	✔
CAD12	Diet	Kitchen	8/30/2016 11:10:12 AM	8/29/2016 4:06:39 AM	✔
CAD12	UsingToilet	Bathroom	8/30/2016 11:10:12 AM	8/29/2016 1:18:51 AM	✔

Figure 5. A screenshot of inferred problems.

DateCalculated	Activity	UserId	StartTimeInSec	MaxDurationInSec	AvgDurationInSec	MinDurationInSec	Frequency
8/29/2016 12:00:00 AM	UsingToilet	CAD12@icarer.eu	4731	5809	154	10	27
8/29/2016 12:00:00 AM	Sleeping	CAD12@icarer.eu	62572	12818	30179	47	6
8/29/2016 12:00:00 AM	Diet	CAD12@icarer.eu	14799	2846	64	6	31
8/29/2016 12:00:00 AM	Diet	CAD2@icarer.eu	77271	2400	1213	26	3
8/29/2016 12:00:00 AM	UsingToilet	CAD2@icarer.eu	80770	186	71	8	6

Figure 6. Summary of the individual activities of daily living.

inferencing would be able to take account of them to generate higher level activities. Thus the system can be future-proofed against changes and improvements in the underlying sensor technology. The inferencing is an automatic aspect of the ontology, and so needs no explicit rule base. The fuzzy inferencing which is used for the problem identification needs more information in terms of comparison against the normal profile of the elderly person (or indeed the carer themselves). Thus this has to use a fuzzy model in order to be more flexible.

References

[1] Van Hoof, J., Kort, H.S.M., Rutten, P.G.S., Duijnstee, M.S.H.: Ageing-in-place with the use of ambient intelligence technology: Perspectives of older users. Int. journal of medical informatics 80(5), 310–331 (2011)

[2] Hossain, M.A., Ahmed, D.T.: Virtual caregiver: an ambient-aware elderly monitoring system. IEEE Transactions on Info. Tech. in Biomedicine 16(6), 1024–1031 (2012)

[3] Kubitschke, K., Cullen, K., Müller, S.: ICT and Ageing: European Study on Users, Markets and Technologies, Final Report (2010)

[4] Aarts, E., de Ruyter, B.: New research perspectives on Ambient Intelligence. Journal of Ambient Intelligence and Smart Environments 1(1), 5–14 (2009)

[5] Bamidis, P.D., Antoniou, P., Sidiropoulos, E., others: Using Simulations and Experiential Learning Approaches to Train Careers of Seniors. In: Computer-Based Medical Systems (CBMS), 2014 IEEE 27th Int. Symp. on. pp. 119–124. IEEE (2014)

[6] Carretero, S., Stewart, J., and Centeno, C. (2015). Information and communication technologies for informal carers and paid assistants: benefits from micro-, meso-, and macro-levels. *European Journal of Ageing*, 12(2):163–173.

[7] Amato, F., Santo, A. D., Moscato, V., Picariello, A., Serpico, D., and Sperli, G. (2015). A Lexicon-Grammar Based Methodology for Ontology Population for e-Health Applications. In *Complex, Intelligent, and Software Intensive Systems (CISIS), 2015 Ninth International Conference on*, pages 521–526. IEEE.

[8] Mahmoud, S., Lotfi, A., and Langensiepen, C. (2016). User activities outliers detection; integration of statistical and computational intelligence techniques. *Computational Intelligence*, 32(1):49–71.

[9] Chi, Y.-L., Chen, T.-Y., and Tsai, W.-T. (2015). A chronic disease dietary consultation system using owl-based ontologies and semantic rules. *Journal of Biomedical Informatics*, 53:208 – 219.

[10] Langensiepen, C., Lotfi, A., Chernbumroong, S., Moreno, P., and Gomez, E. (2016). A new way to build multifacetted ontologies for elderly care. In *Proceedings of the 9th ACM International Conference on PErvasive Technologies Related to Assistive Environments, PETRA 2016, Corfu, Greece, June 29 - July 1, 2016.* ACM, New York.

[11] Sànchez-Gonzàlez, P., Oropesa, I., Moreno-Sànchez, P., Martinez-Moreno, J. M., Garcia-Novoa, J., and Gòmez, E. J. (2014). AMELIE: Authoring Multimedia-Enhanced Learning Interactive Environment for e-Health Contents. In *XIII Mediterranean Conference on Medical and Biological Engineering and Computing 2013*, pages 1443–1446. Springer.