Review of Activity Measuring Techniques For Assisted Living Systems

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***Abstract*—An individual's Activities of Daily Living (ADL) are difficult to accurately measure in Ambient Assisted Living (AAL) systems. Such ADLs are invariably, in part, verified using technologies requiring key user interactions. The User Interface (UI) applied to these living systems is critical in order that the elderly achieve their daily living milestones of health supervision, social engagement, physical movement or daily prompts. In order to bootstrap effective machine learning necessitates accurate daily user interaction. This paper reviews AAL system interface's and seeks to establish if ADL measurement accuracy could improve if UI's were prioritised within system development.**

Keywords-*Ambient Assisted Living: Measurement Techniques: Activities of Daily Living.*

I. INTRODUCTION

Population aging is an issue in the European Union with those aged 65 years or over increasing from 17.1% to 30.0% in 2060 (84.6 million in 2008 to 151.5 million people in 2060) [1]. As we age our health becomes more complicated and our ability to sense accurately, disseminate information at speed and conduct various tasks simultaneously decreases dramatically. Consequently elder's living independent lives, find that over time their ADL performance diminishes they become burdened with daily chores and AAL UI's unburden them from the ADL's limiting their daily lives. Multiple UI's assist the elderly such as, the MONAmI project encouraging social participation [2], the i2Home project UI [3] and the Universal Remote Console (URC). ADL interfaces for the kitchen have also been addressed in the SWEET-HOME project utilising voice command for automating a home, with a speech activated assistive kitchen and the Smart Kitchen [3] offering nutritional advice on food in real time. The research spotlight on AAL and ADL systems has concentrated on UI's enabling elder's to live independently. ADL monitoring is difficult to measure accurately and research conducted in purpose-built labs is not representative of the systems available for commercialisation or those being currently used in homes on a daily basis. UI design is critical within the area of AAL as its success dictates a system's usability. Good User Interface (UI) design regularly quote Neilsen's 10 usability heuristics [4] in conjunction with Shneiderman's 8 golden rules [5], whilst other design principles [6] are utilised less frequently. Research studies within the area of UI's for the elderly include a universal interface design [7] using touch-based and multimodal user interfaces. Viewing the elderly as a combined age group has been encouraged yet their user interaction could be observed for usability as two separate groups of (65-80yrs) and (80+yrs) [8]. Several research studies acknowledge that UI usability between younger and elderly adults is very different [9] but not between the two elder age groups [10]. This paper reviews AAL system UI's, their subsequent usability for users and seeks to raise the question, that if greater emphasis was placed upon UI design could ADL measurement subsequently improve.

Section II deals with Buxton's framework and how humans interact with Ambient Assisted Systems, thereafter Section III reviews UI design guidelines and they're subsequent inculcation in the various systems throughout Europe. The original framework of Buxton is extended in Section IV to incorporate subtle human-computer interactions. Section V in turn proffers UI usability recommendations while Section VI examines the conclusions drawn from this review of UI methodologies applied to AAL systems and the methods available for measuring human-computer interactions in order to facilitate ease of use and uptake.

II. HOW HUMANS INTERACT WITH COMPUTERS

A basic framework categorising the subject areas of computing [11] (see Fig.1), constituted a foreground and background, indicative of conscious and un-conscious tasks. This framework established how humans interacted with computers and that the success and failure of AAL systems relied upon the technological ability of the user. All interactions, whether implicit or explicit, were in the foreground when required [12], otherwise in the background. AAL interaction ought to be ubiquitous, operating in the background as the user interacts in the foreground.

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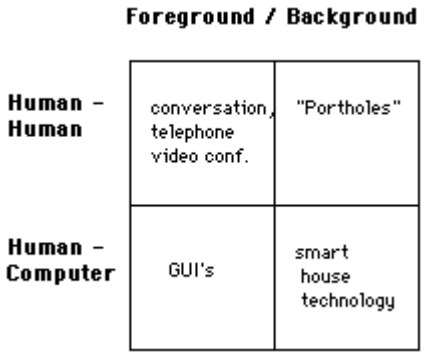

Figure 1. The Basic Model

The UI's should incorporate features such as, ease of use for medical professionals, carer's or elder's and be productive in their ability to enable effective human-computer interaction. Systems utilising UI's that support effective user interaction result in greater uptake [13]. Conversely varying UI's on different devices affect user uptake and impede the older user's ability to successfully navigate the technology [14]. Commonality in UI design for the elder user should be central to best practice guidelines and it's prioritisation within AAL system development is paramount in order to improve usability and ADL measurement possibilities.

III. UI DESIGN REVIEW

A. UI Research Design Approaches

Usability is fundamental to good UI design [15] and the pivotal role it plays has received significant coverage in conjunction with the challenge of interweaving technological advancement into our modern lives. The UI needs to facilitate the user in executing their desired tasks and this occurs if the interaction is intuitive and seamless. Designing for interfaces must include those factors which influence how humans interact with, and process information, while executing other tasks [16]. Ambient Intelligence (AmI) [17] over time has permeated many computer science areas of together with engineering, biosciences and education. The involvement of Human-centered Computing (HCC) [18] approaches to interface design has resulted in more effective methodologies being implemented. Many typical AAL system users have no medical or technological training, yet are often required to input and assimilate data spanning both these fields. Systems acclaimed to be most effective have utilised icons to represent ADL's**.**

B. A Review of ADL Measurement Techniques in Assisted Living Systems

Previous reviews of AAL systems [19] have expressed concerns regarding UI development costs and data protection issues which have produced inefficient designs leading to insufficient uptake. Design frameworks that support adaptable UI's for user's with complex medical and social needs is a goal for AAL researchers [20]. System effectiveness has been reviewed and several productive systems developed, UniversAAL [21] being Europe's leading research platform. Projects such as, Soprano [22], Persona [23], Amigo [24], Oasis [25] and MPower all strive to work toward the goal of a baseline open source platform for researchers. Europe's prominent AAL systems are reviewed to ascertain the emphasis ascribed to UI design and it's role within the system's architecture. AAL systems proclaiming self-organisation include Persona an AmI system with a UI framework, platform modules and it aims to offer independent living options for elder's. Self-learning ambient systems such as Soprano rely on the user for inputting manual commands conveyed through sensors and actuators, UI's for medicinal reminders [26] physical exercise programs and social interactivity. Soprano's Ambient Middleware (SAM) is the technical core which receives user commands. Systems promoting independent rural living include Remote [27] for those with conditions, such as hypertension, asthma, Alzheimer's and Parkinson's disease. Tele-healthcare services [28] record daily biometric readings in conjunction with physical movements and at-risk scenarios UI's enabling the complex health needs of the users and their technological abilities are offered on several devices and the project was considered a success in that sensor monitoring decreased cardiac mortality rates.

Open source platforms such as MonAMI assist elder's with ADL's, improving security and health monitoring living options [29] via user friendly UI's for wearable devices. User-friendly interfaces are accessible through internet browsers encouraging social interaction with family/friends thus supporting independent living options. Emerge [30] assists elder users with monitoring and accident prevention through sensors providing ambient supervision and reasoning in emergency situations. ADL evaluation [31] is logged and deviations from expected routine behaviours enable swift detection of situations requiring intervention. The Human Capability Model (HCM) is the resultant medical file of the elder created in association with their medical experts. The I-Living Project developed an assisted living environment for embedded devices (sensors, actuators & displays) which could operate individually or cooperatively in the Assisted Living Hub (ALH) [32]. The Secure Active Aging: Participation and Health for the Old (SAAPHO) Project facilitates elder involvement as it prioritises usability features by utilising interface tools to increase user interaction and uptake. Another project, which focused on the importance of interface usability for ADL monitoring, was the Home Sweet Home project in Ireland which evaluated the impact of tele-monitoring on an elder's life. The physiological and mental health, living environment factors and ADL reminders was evaluated for its effect, if any on the participants lives. A simple user-friendly interface

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supervises each user's health and well-being through the information collated from various sources including, environment sensors, video conferencing and other enabling services.

IV. UI DESIGN FRAMEWORKS

In 2008 the basic Human-Computer interaction framework was expanded to include an axis of relevant criteria, (see Fig. 2) [33] accommodating more subtle, implied interactions that occur as humans and machines exchange information. Traditional computing can manifest as implicit or explicit and interactive exchanges are along a continuum that either demand a user's attention with a command or responds to a command initiated by the user. Reactive interactions are typically user initiated while proactive are system initiated. AAL systems demand implicit and explicit communications as a consequence of user demands for unobtrusive systems. Achieving a information exchange is the key to success and it cannot appear within the user's attentional foreground. AAL systems need to be in the foreground if required by the user and fade into the background when the need for them has been responded to.

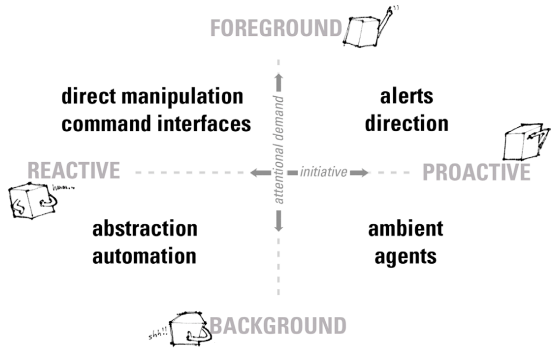

Figure 2. Implicit interaction framework with a range of interactive system behavious.

The original framework and the extended version contends that human-computer interactions can be plotted along a continuum of activities counter-balanced against the degree of invasiveness for the user. Critical to the evaluation of UI design is the emphasis in AAL systems of the scales of balance for the user. The goal is system adaptivity whereby it assists when requested or when a scenario requires direct intervention. This evaluation theory encourages independence not isolation, inclusion not exclusion and facilitates communications from either direction. AAL systems that acknowledge UI design guidelines and prioritise these have the ability to be truly effective in assisting the user with their ADL's. If standardisation within assisted living development became a goal then the possibility of improving and harmonising ADL measurement would ensue as a result.

V. RECOMMENDATIONS

This paper postulates that pre-existing UI design guidelines for the elderly should be adhered to when creating and implementing AAL systems in unison with Nielsens and Shneiderman's usability guidelines. The four primary areas of focus in designing for the elder user include vision, hearing, mobility & cognition, with specific suggestions for each area of concern. AAL UI design should incorporate dynamic interfaces capable of autonomically adapting to the specific needs associated with the user's age and medical condition progression. Representation from both distinct elder groups is required when testing systems to ensure increasingly complicated daily living needs are accommodated. AAL designers acknowledge the UI usability differences between these two elder groups yet continue to combine them into a single homogeneous group when designing and testing systems. A reasonably healthy 65yr old with IT skills has radically divergent AAL system requirements to an 85yr old with limited mobility, attention span and IT skills.

VI. CONCLUSION

Ambient systems provide users with daily living assistance. They generally present in a myriad of forms, providing condition specific forms of support, are more or less ambient and demand greater or lesser user interaction. UI's affect uptake which impacts directly upon usability. Those achieving commercial success have tended to employ highly stylized and easily recognisable icons to represent ADL's. Given ambient systems require subtle user interactions from an audience which will become progressively more infirm then perhaps the only solution is that of multi-modal UI's [34] which are dynamic and fulfill the users needs at any given point in their health continuum. Adaptivity of the system interface tracking the longitudinal progression of age, circumstance and condition is paramount for system adoption and persistence. This benefits users as the interfaces remain familiar and gracefully and seamlessly evolve to reflect the capabilities of the senior citizen as their condition/age progresses. Research has shown [35] that an AAL system providing UI's for elder's that exhibits reasonable functionality, is both physically and cognitively usable and consequently has the ability to extend the independent lives of those using them and impact positively on those assisting the elder. This paper advances the view that AAL usability will be improved, firstly as a result of UI prioritisation within system development facilitating ADL measurement and secondly through the development of adaptive interfaces sensitive to the evolving needs of the individual.

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