Addressing Maslow’s deficiency needs in smart homes

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Addressing Maslow’s deficiency needs in smart homes

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In their review of the different elements of smart homes, Franchimon & Brink¹ state that matching of existing technologies of home automation, robotics, and tele-health (including geriatric telecare and telemedicine) is required to assure an optimal quality of life in our aging society. However, the roll-out of smart homes leaves much to be desired. Besides technology issues to be solved, business models are lacking to remove vendor locks, and to combine with other types of business (health care, entertainment, security, etc.)²⁻⁴.

Even more important is the discrepancy between user needs and offered functionalities⁵. Earlier, Maslow’s⁶ hierarchy of deficiency needs was proposed as a framework for catching user values in design and development of technologies for a longer vital life⁷.

Maslow⁶ identified consecutive layers of deficiencies in needs of human subjects: (i) physiological, (ii) safety related, (iii) concerning a sense of love and belonging, (iv) esteem related, and (v) room for self-fulfillment or self-actualization. The more basic physiological needs (such as breathing, eating, walking) have to be fulfilled before the higher deficiencies (such as social and safety needs) start to matter.

Smart home elements may not only address the needs of daily life directly, they may also become sources of new need deficiencies, such as loss of mastery over one’s own situation (esteem related). Since older adults generally do not wish to have technologies in their homes before they need them, the smart-home systems must have a large degree of adaptability with different functionalities activated at different times⁸.

Although all levels of needs are neither age- nor culture dependent, their diversity increases with age and varies among cultures⁹. In addition, the variation in individual demands broadens as one goes from the basic to the higher deficiencies to be supported⁸. Both progressed age and support of higher-level deficiencies call for a broadening of the range of ICT (Information and Communication Technology) supports to guarantee well-being.

Smart-home initiatives, such as related to Ambient Assisted Living (AAL), specifically aim at improving the well-being of older people by using relevant ICT-innovations. Aim of this study is to elucidate the coverage of end-user needs by published complete smart-home systems in development.

Keywords: smart home, user needs, Maslow, aging-in-place
Maslow’s deficiency needs

**Methodology**

**Project selection**

Our sample of running smart-home projects to be analyzed, originates from reports published between 1990 and 2010. We used ‘home automation’ and ‘smart home’ as keywords in Web-of-Knowledge, Science Direct, Google Scholar, and the database of European Research Projects. Initially this resulted in 900 publications. The following inclusion criteria were applied in a second step of selection: (i) the system had been implemented; (ii) it contained system-integration software (for instance, middleware), and (iii) it was described in detail. A total of 28 smart-home prototypes or concepts, described between 1993 and 2010, remained, and were described in 39 publications originating from Asia, Europe, North America, and Oceania.

**User-needs analysis**

For each selected project, we extracted included functionalities and classified them by Maslow’s hierarchy of deficiency needs. Functionalities that serve a physiological aim like tele-care, physical health (monitoring), or food preparation, are categorized in the lowest, physiological layer of deficiency needs.

The second layer (safety) includes functionalities to improve safety or security, such as fall detection and activity monitoring. Although ‘weather forecast’ does also have an entertainment component we chose to consider it as a form of safety, since weather conditions may be unsafe for older persons.

The third layer (social) covers functionalities that support social activities or interactions.

Cognitive training and energy saving are both included in the fourth layer (esteem). Although these functionalities, especially energy saving, also relate to other layers, the main intended result of both is a higher level of self-esteem. In addition, being master over the system is esteem-related. Two aspects of this mastery could be found in the descriptions of the systems: end-user installation and end-user adaptation.

Entertainment and multimedia are both leisure activities and for that reason mapped to the highest level of needs.

**System-integration analysis**

Four levels of system integration were recognized:

(i) Stand-alone: a system with a functionality that does not communicate with the outside world or other applications in the home (for instance, a motion sensor wired to a local alarm);

(ii) Tele-devices: systems that communicate with the outside world but do not require additional devices (for instance, a panic button);

(iii) Interconnected: the system has multiple functionalities; applications that provide these functionalities require additional applications for optimal performance of the system as a whole (for instance, a home automation system that controls both heating and lighting); and

(iv) Fully integrated: a system that includes all functionalities in the home (prototypes using a universal platform).

**Results**

All levels of deficiency needs are addressed in smart-home prototypes and concepts, but emphasis lies on the lower levels of deficiency needs, with 21 applications pertaining to physiological needs, 17 concerning safety and security, 11 addressing social relations, 2 related to esteem, and only 1 covering self-actualization (Table 1).

Looking at individual smart-home projects reveals that about half (15 of 28) are restricted to the lower deficiency needs dictated by physiology and safety. Among them are projects on all levels of system integration. Only in one case (Smart House Osaka) is the end-user master over the adaptation of the system (Table 2).

Interconnected smart home systems are most common in our sample of prototypes and concepts (15 of 28). They are dominant in the support of the lower levels of deficiency needs (9 of 15), but also support social relations (5 of 15), esteem related issues (2, but with no or doubtful support of end-user installation or adaptation), and self-actualization needs (2, but without support of end-user installation or adaptation) (Table 2).

One of the interconnected systems, MPOWER that allows for support of the four lower Maslow levels, claims easy installation and adaptability by the end-user. However, this could not be supported by the specifications of the system architecture.

None of the 28 prototypes or concepts allows for supportive functionalities on all levels of deficiency needs, but all of them include some physiological and safety needs. When the highest and most complicated level (self-actualization) is included (6 cases), the majority (4 cases) are fully integrated systems. Only in case of fully integrated systems is the end-user master over the system and may install or adapt it at will (Table 2).
### Maslow's deficiency needs

Table 1. End-user needs addressed by published multifunctional ICT-systems for aging-in-place, as sorted by need-deficiency level according to Maslow6

<table>
<thead>
<tr>
<th>Need deficiency level</th>
<th>Specific needs addressed</th>
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</table>
| Physiology            | Activity coach17,18  
Activity level monitoring17,19–34  
Blinds, curtain and window control19,21,30,32,35–37  
Blood glucose, oxygenation, and pressure monitoring18,21,26,38,39  
Body movement, temperature and weight monitoring17,24–26,34,38–40  
Food supply monitoring41  
HVAC control17,35,36,42–44  
Heart rate monitoring17,26,34,39,45–47  
Kitchen use, meal reminding19–21,29,33,45,48  
Medication use and reminding19,21–23,27–32,40,48  
Nutrition advisor17,27,28  
Personal hygiene assistant40  
Remote access to monitored data19,24,25,32  
Remote (snail)mailbox checker40  
Remote rehabilitation22,23,27,28  
Respiration rate monitoring39,45  
Shopping assistant7,28  
Sleeping pattern19,22,23,32,40  
Sweating monitoring39  
Tele-care18,49  
Toilet use monitoring48  |
| Safety                | Activity detection17,20–23,28–31,33,34,37,39,43–47,50,51  
Alarms (burglary, fire, smoke, community)19–21,26,29–31,33,39–41,46,47,49,52,53  
Automatic lighting, lighting control17,19,21,32,35–37,42,43,52–54  
Bath and cooker monitoring21,54  
Control of oven, microwave, washing machine40,41  
Door camera42  
Fall detection17,21,27,28,30,31,39,49  
Flood detection17,25,29,40,41  
Home-access control21–23,27,28,40,49  
Memory support, including item localization26,54  
Panic button22,23,27,28,30,31,43,49  
Person identification39  
Pressure sensors (bed, chairs, floor)30,31,34,39,45–48  
Room occupancy monitoring19,21,24,25,32,39,44,48  
Room temperature monitoring19,20,24,25,30,31,33,38,39,46,47,50,51  
Security cameras19,32  
Weather forecast21  |
| Social relations      | Activity reminder19,26,32,35,36  
Distant dining40  
Group cooking21  
Internet access21–23,30,31,49–51  
Message service24,25  
Photo viewer42  
Reminding services21–25,27,28,35,36,40–43  
Social media17,21,26  
Tele-consulting27,28  
Videophone21,27,28  
VoIP calls38  |
| Esteem related        | Cognitive training12,24,25,40  
Energy saving35,36,52,53  |
| Self-actualization    | Entertainment, including multimedia21–23,35,36,38,40,52,51  |
Maslow’s deficiency needs
discussion
Our results show that all deficiency-need classes of Maslow may be addressed by modern smart-home elements, but none of the smart-home systems analyzed extend over all classes of personal and environmental deficiencies. Most systems in our sample introduce additional esteem-related problems by not allowing the end-user to easily install or adapt the system.

The ‘e-Home’ system and ‘Gloucester’s Smart-House’ support higher levels of needs, but leaves out the most basic ones (Table 2). We expect that these omissions will hamper a massive roll-out of smart homes that aim to support aging-in-place. But still, most smart-home applications focus on the lower levels of deficiency needs. This has to be expected since these lower levels have to be fulfilled before the higher levels start to matter. For a full support of aging-in-place the higher levels have to be included. This, however, is more complex. For example, a virtual dress-couch that helps you to choose your clothes might improve your confidence (self-esteem), but needs an extensive database and sensor system of life style, mood, weather conditions, and requirements for the occasion. In addition, the variation in personal needs among adults tends to increase with age.

### Table 2. Addressed levels of Maslow's need deficiencies6, and system integration of smart-home prototypes and concepts published between 1990 and 2010, sorted by year of publication; x=at least one item addressed in the stated category; ±=presumably; ?=data missing

<table>
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<tr>
<th>Need deficiency level</th>
<th>End-user maintenance option</th>
<th>System integration</th>
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<td>Physiology</td>
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### Discussion
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In our sample of 28 smart-home prototypes and concepts it was not possible to assess operational reliability (safety level), easy maintenance (esteem level), and affordability. Future research on smart-home systems should include tests and reports on these technology-related barriers. Another weak point of our analysis is the general nature of Maslow’s classification. The actual acceptance of a specific technology depends on the support of specific needs by specific characteristics of the technology, rather than the support of needs in general. Maslow’s hierarchy remains, however, useful as a first global assessment. It can be considered as a guide to make sure that no group of needs is forgotten and no new deficiencies in needs are introduced.

Systems adapted to the highest deficiency-need classes generally show the highest level of system integration. They commonly allow the end-user to install and adapt his or her smart home without the intervention of a technician. This way the user may freely choose and change the functionality of the system by implementing or removing certain applications, as soon as new needs arise or old ones loose value. Apparently a high level of system integration is not only needed from a technological point of view, but also to strengthen the user value of smart-home systems.

Although fully integrated systems could have the best performance in theory, there are a number of challenges to overcome. Most research projects result in proof-of-concept, but these concepts are rarely developed further or entered the market.

The domain of smart homes develops fast. The universAAL project and AALOA (Ambient Assisted Living Open Association), two initiatives supported by the European commission and started after 2010, have taken promising steps by aiming to design, develop, evaluate, standardize, and maintain a common service platform for Ambient Assisted Living, but the implementation of support at all levels of human deficiency needs has not been included in these initiatives. In addition, a recent review stresses the understanding of end-user needs to develop effective and efficient smart-homes, but does not propose a tool or theory to implement this in design and development.

The Maslow hierarchy may act as a guide to developers and marketeers to address all levels of human deficiency needs. The resulting total user value may ease integration and market introduction of smart homes for aging in place.
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17. OASIS project; www.oasis-project.eu/; retrieved December 18, 2012
21. MONAMI project; www.monami.info/; retrieved December 18, 2012
22. SOPRANO project; www.soprano-ip.org; retrieved August 24, 2012
25. MPOWER project; www.sintel.no/Projectweb/ MPOWER/; retrieved December 18, 2012
27. PERSONA Project; www.aal-persona.org/; retrieved November 1, 2011
29. Mahoney DF, Mahoney EL, Liss E. AT EASE: Automated Technology for Elder Assessment, Safety, and Environmental monitoring. Gerontechnology 2009;8(1):11-25; doi:10.4017/ gt.2009.08.01.003.00
34. Matsuoka K. Aware home understanding life activities. Conference on Smart Homes and Health Telematics, ICOST 2004, Singapore, September; 2004; pp 186-193
41. Easy Line+ project; www.easylineplus.com/; retrieved December 18, 2012
42. 12HOME project; www.12home.org/; retrieved December 18, 2012
43. Ornstein B. Smart Care. Gerontechnology 2001;1(1):79-80; doi:10.4017/ gt.2001.01.01.014.00
Maslow’s deficiency needs


49. ExperTel; http://expertel.org/; retrieved December 18, 2012


53. RWTH Aachen University. eHOME; http://se.rwth-aachen.de/ehome; retrieved December 18, 2012


56. AALOA. AAL Open Association; http://aaloa.org/; retrieved December 18, 2012

57. universAAL project; http://universaal.org/; retrieved December 18, 2012