Interactive Virtual Avatars. Design & Application Challenges for Future Smart Homes

Zlatogor Minchev[1,2], Luben Boyanov[1,3]

[1]Institute of ICT / [2]Institute of Mathematics & Informatics, Bulgarian Academy of Sciences

[3]University of National and World Economy

Acad. Georgi Bonchev Str., Bl. 25A, 1113, Sofia, Bulgaria

zlatogor@bas.bg, lb@acad.bg

Abstract. Today, technological progress is opening vast perspectives for modern digital solutions and services evolution. This however is closely related to some resulting cyber threats challenges, emerging from users' understandings and interactions with future technologies. The paper is initially outlining some users' beliefs for future smart homes realities automation, noting the avatars role and the resulting multiple cyber threats aspects. Further, description of a home automation system, providing interactive communication trough virtual assisting agent – ALEX is given. Users' preferences and engineering challenges, concerning ALEX avatar are also noted. Finally, results usage for security advancing in the new digital world is discussed.

Key words. home automation, smart homes, cyber security, virtual assisting agents, avatar engineering

1. Introduction

Modern digital world is constantly progressing, facing a number of different technological solutions and services developments towards digital society. Key challenges in this process are the users' multiple services necessities in future smart homes [1].

Presently, the interactive social networks environment of communication, together with the 4G broadband Internet multimedia access, are producing a number of challenging virtual and augmented realities combinations with possible smart homes integration.

These however are generating a significant set of unrevealed cyber threats [2], [3], [4] for both users and smart homes (e.g. social engineering, privacy data control or even malware and targeted attacks towards new smart infrastructure).

An important point here is also the development of virtual assistants with different applications. Here it should be noted that practically this concept is also related to soft bot agents' embodiment, or "avataring" [5] regarding their appearance and character.

A special focus on the topic is the interactive digital assistance [6], used as a convenient (intelligent) human-machine interfacing, closely related to Building Automation Systems [7] and due to its mobility control capabilities – to Internet of Things [8], combining virtual and physical objects.

Initially, the paper shows two preliminary questionnaire based studies on: (i) modern users' beliefs for smart homes automation progress as new virtual/augmented digital realities, noting possible robots and avatars application; (ii) experts' multifaceted evaluation towards resulting cyber threats in future smart homes as element of the new digital world.

Further on, an experimental approach for engineering smart home, voice controlled virtual assisting agent – ALEX is considered. Different aspects of users' preferences,

towards ALEX avatar: appearance, character and voice for achieving better realism are also studied.

Finally, results usage for security advancing in the new digital world is discussed.

2. Trends of users' beliefs and cyber threats for future smart homes

An initial questionnaire based (q-based) survey amongst 180 students from University of National & World Economy – Sofia was performed for outlining the boundaries of technological developments and potential cyber threats. Their beliefs in five years' time horizon, concerning smart homes automation, new digital realities integration, robots and avatars usage were studied. Generalization of this survey results is given on Figure 1.

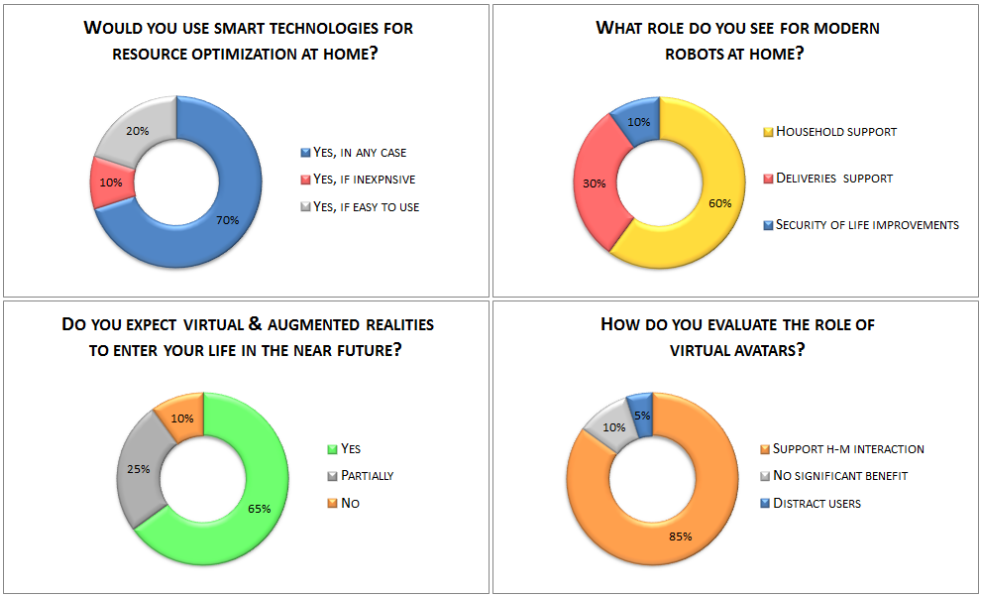


Figure 1. Q-based survey results about modern users' beliefs for smart homes automation, new digital realities integration, robots and avatars usage amongst 180 participants.

Evidently, the participants' beliefs for the next five years are assuming mostly (70%) usage of smart technologies for resource optimization of future smart homes. The majority of innovations, concerning home robots (60 %) applications are related to household support. These are combined with the broader integration of digital realities (virtual & augmented) in the everyday life (65 %), together with the expected Internet of Things technological boom [9]. As the smart homes new technologies are also related and to interface progress, the implementation of avatars in the human-machine interaction is quite assumed (85 %) to grown up, too.

This technological trends progress is related to a number of resulting cyber threats. Being emerging technologies as a whole, another recent study for their connectivity with web technologies is outlining their high significance for the near future and at the same time define uncertainties, influencing the next 30 years [10].

The negative influence towards way of life, incorporating stress and overweight, accentuating on communication via mobile smart phones in social networks is another trend noted recently [3].

These, provoked a multifaceted ("Human Factor", "Digital Society", "Governance", "Economy", "New Technologies", "Environment of Living") q-based survey on smart homes regarding different cyber threats (*Targeted Attacks*, *Compromised Devices*, *Malware*, *Technologies Influence*, *Privacy & Alienation*) in the digital world. The threats were harmonized with Red Book [2] recent discoveries, concerning cyber security for the next ten years.

The survey incorporated 75 national and international experts in the cyber security area (see Figure 2), interviewed in the framework of EU SysSec system security network of excellence [11] and DFNI T01/4 smart home [12] research projects.

Threat/Area	Human Factor	Digital Society	Governance	Economy	New Technologies	Environment of Living
Targeted Attacks						
Compromised Devices						
Malware						
Technologies Influences						
Privacy & Alienation						

Figure 2. Q-based survey results about multifaceted evaluation towards resulting cyber threats in future smart homes as an element of the new digital world amongst 75 experts.

Three-level evaluation scale ("red" – severe, "yellow" – high and "blue" – uncertain) for cyber threats was accomplished.

The accomplished results are nominating horizontally: *Privacy & Alienation* as highest cyber threat, together with *Targeted Attacks*. The rest of the threats are rather uncertain towards the evaluated facets. The most critical facet is the "Human Factor" and most uncertain – "Digital Society".

This makes the future smart homes a critical infrastructure with an important multirole of their inhabitants, being a rather important component of human-machine interaction and posts the significance of virtual assistants as a new technological trend [13].

These preliminary studies results are just outlining the technological progress of smart homes automation and the resulting cyber threats as users' beliefs. What however is challenging here is to find a reliable validation framework and focus.

As outlined in [3] a scenario based approach and test-bed environment constructive validation could be used. But a natural follow-up, concerning the interface design deeper exploration is provided here after. The accent is given to avatar interface of a smart home automation system through virtual assisting agent – ALEX engineering that will be further noted and discussed.

3. Experimental engineering of smart home automation system with virtual assisting agent

The idea for smart home automation system engineering is rather intuitive and there exist some prototypes [13] but its practical implementation could be quite complex and unique, in accordance with the environment and the level of automation.

Specific moments in such system design are the human-machine interface, agent intelligence organization and multiple communication channels arrangements.

The presented concept here (see Figure 3) is implementing users' interfacing trough virtual assisting agent with human based avatar, voice communication, together with multiple channel device (actuators) controlling and limited level of artificial intelligence decision logic, using "condition-action" agent-environment communication [14].

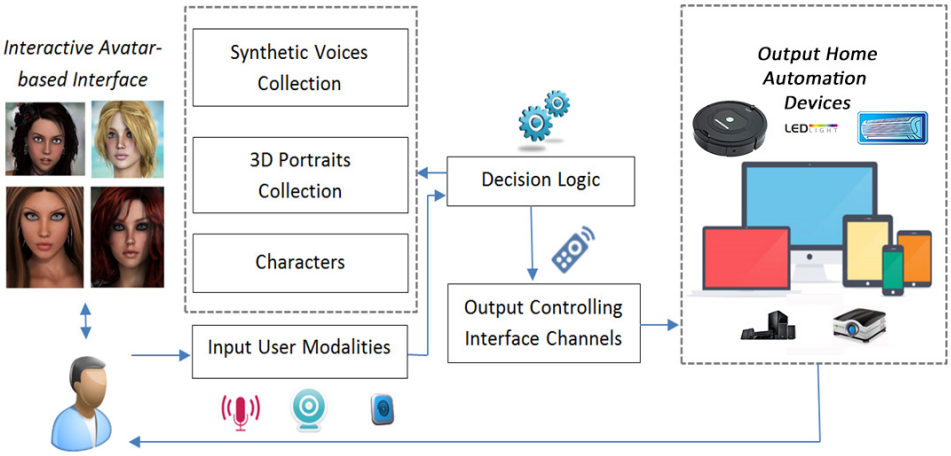


Figure 3. Engineering concept for smart home automation system design with interactive avatar based interface implemented in virtual assisting agent.

As it is clear from Figure 3 the system encompasses four basic modules: (i) input avatar-based interactive interface (a synthetic combination of voice, face, character and resulting behavior features); (ii) decision logic (a rule-based "condition-action" system that practically generates the agent intelligence); (iii) output controlling interface channels (like: Wi-Fi, Bluetooth, ZigBee, IrDA, ANT, etc.), (iv) output controlling devices (like: smart TVs, projectors, audio systems, home cinema\theatre solutions, home robots, lighting, conditioning, etc.). The input-output system connectivity uses human-in-the-loop feedback. Here is used voice control as input modality, but other users' activities (e.g. gestures, face emotions or even biometric body signals [15]) could also be added.

Experimental Prototyping

The real prototyping of the concept from Figure 3 was experimentally implemented by using a combination of commercial-off-the-shelf solutions, together with own created software and hardware modules. The working environment was MS Visual Studio 2010 Express©. Voice control, provided from a Plantronix© ML18 hands-free system and Bluetooth communication was used as input modality.

The avatars interface was designed by combining four DAZ Studio© models (blond, red, brown and black) with four IVONA© artificial voices (Salli, Emma, Amy, Kimberly). The working environment for avatars experimental study was CrazyTalk© Pro v 7.11 and the standard built-in flirting character. As output multimedia home device was used a SONY© KDL-32HX750 3D Smart TV.

The input digital assistant avatars were shown on a separate transparent screen with holographic effect via a SONY© Vaio Pro 13 ultrabook and Epson EH-TW5200 multimedia projector.

The control was performed via the SONY IR remote channel (using preliminary commands recordings, translated through the headphone or USB port and Arduino IR dongle) and programmatically concerning MS Windows© Media Player 12 functionalities (including: volume stepwise up/down level change, screen size – normal vs full, track list control). The working environment was MS Windows 7/8.

Voice recognition and synthesizing of user input commands and avatars speech were organized with MS SAPI 5.3, defining own grammar rules set. The decision logic

implements own rule-based system with intuitionistic fuzzy sets application for intuitive uncertainty copying and effective ambient noise suppression similar to [16].

As one of the key problems in creating such system is basically related to avatars' realistic development a more detailed description of the process is further given.

Avatar Users' Evaluation

Generally, to create a realistic artificial avatar interface is quite comprehensive design task. So, for the present study, a user-based evaluation was accomplished.

The process organization covered two basic stages: (i) initial participants' current emotional state evaluation, (ii) rating via questionnaires selected input 3D models and synthetic voices collections.

Two focus groups of 57 participants were used: 42 young generation high-school students (18 male and 24 female, averaged age 17.5 years) and 15 adult researchers (8 female and 7 male, averaged age 45 years).

The initial emotional state was evaluated [17] via an instruction for choosing a photography (Object A – garden, Object B – fireworks, Object C – desert, Object D – seal specimens) and melody sound (Sound 1 – carousel, Sound 2 – bizzing, Sound 3 – robin, Sound 4 – country night specimens) from Center for the Study of Emotion and Attention, University of Florida IAPS/IADS databases [18].

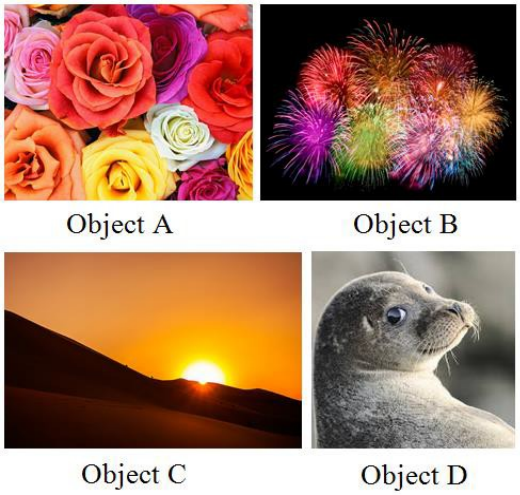


Figure 4. Emotional image stimuli collection replicas to IAPS.

The studied subjects produce the overall positive emotional state, choosing mostly Object D (95 %, VAR = 0,3) and melody Sound 3 elements (98 %, VAR = 0,2).

The second task of the groups was to put together four DAZ Studio© 3D models' faces (Object 1, Object 2, Object 3 and Object 4, see Figure 5) and IVONA voices (Voice 1 – Amy, Voice 2 – Emma, Voice 3 – Kimberly, Voice 4 – Salli) [17].

They were pronouncing one and the same word sequence with normal speech speed, equal duration, volume level, typical flirting character and mouth-to-text synchronization.

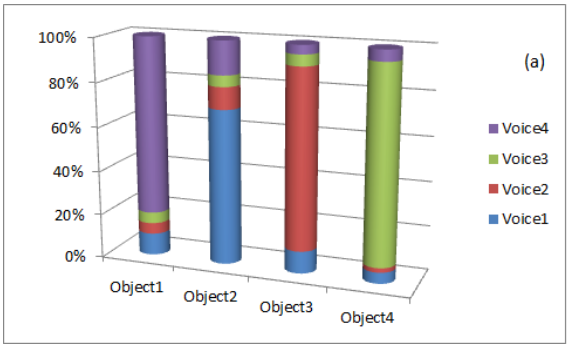
Here it should be noted and some other similar studies on the problem, referring users' predisposition towards: trustworthiness, competence, dominance, extroversion, regarding human face and voting [19], which are partially addressing the avatar design problem.

Object 1 Object 2

Object 3 Object 4

Figure 5. Implemented avatars DAZ Studio© 3D face models.

The averaged results for two groups (Figure 6) have shown a dominated preference for Voice 4 vs Object1 of Group I (a) and Voice2 vs Object 1 for Group II (b).



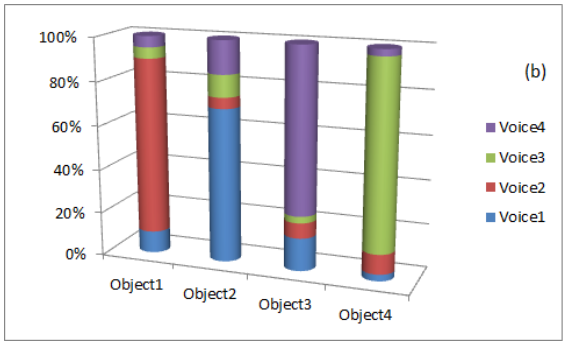


Figure 6. Averaged results for avatars faces and voices combinations for Group I (a), VAR = 0,35 and Group II (b), VAR = 0,45.

The most common avatar combination selection from this survey was: Object 1 and Voice 4 combination that was named "ALEX" – Avatar Live EXample.

A live video demo of ALEX virtual assisting agent is available on-line from [20].

Discussion

Our current research efforts are showing some promising results, concerning smart home automation and integration of interactive virtual assisting avatars.

The practical development however requires design, interface communications and intelligence balancing.

Additional sensors information has to be considered for further integration, following the Internet of Things fast progressing trends.

The resulting future smart homes potential cyber threats challenges are also progressing with the new avatar interface and many hidden, unexpected threats for the digital users are emerging.

Special accent has to be given to social engineering as avatars interface could produce overtrust in certain situations from regular daily life in the future smart homes.

Another focus for cyber security advancing is related to new critical infrastructure looming and the natural communication channels raised securities demands, facing the future environment of living evolution.

Acknowledgement

The authors express gratitude for the technological support to: "A Feasibility Study on Cyber Threats Identification and their Relationship with Users' Behavioural Dynamics in Future Smart Homes, Research Grant "Funding of Fundamental & Applied Scientific Research in Priority Fields", Bulgarian Science Fund, Ministry of Education Youth and Science, 2012-2015, DFNI-T01/4", www.smarthomesbg.com.

A special appreciation for the context definition and q-based survey maintenance is given to: Joint Training Simulation & Analysis Center team and EU Network of Excellence in Managing Threats and Vulnerabilities for the Future Internet – SysSec, FP7 Grant Agreement No. 257007, 2010 - 2014, www.syssec-project.eu.

References

1. Boyanov, L. Modern Digital Society, Lik Publishing House, Sofia, 2014 (in Bulgarian)
2. Markatos, E., Balzarotti, D., Minchev, Z., et al, The Red Book. Roadmap for Systems Security Research, SysSec Consortium, September, 2013, http://www.red-book.eu/ [Online]
3. Minchev, Z. and Boyanov, L. Smart Homes Cyberthreats Identification Based on Interactive Training, ICAICTSEE – 2013, July, 72 – 82, 2014, http://icaictsee-2013.unwe.bg/proceedings/ICAICTSEE-2013.pdf [Online]
4. Boyanov, L., Minchev, Z. Cyber security Challenges in Smart Homes, In Proceedings of NATO ARW "Best Practices and Innovative Approaches to Develop Cyber Security and Resiliency Policy Framework", Ohrid, Macedonia, June 10-12, 2013, Published by IOS Press, NATO Science for Peace and Security Series - D: Information and Communication Security, 38, 99-114, 2014
5. Faloon, G. Using Avatars and Virtual Environments in Learning: What do They have to Offer?, British Journal of Education Technology, Vol. 41, No.1, 108 – 122, 2010
6. Reeves, B., The Benefits of Interactive Online Characters, Stanford University, http://www.sitepal.com/pdf/casestudy/Stanford_University_avatar_case_study.pdf [Online]
7. Brambley, M., et al. Advanced Sensors and Controls for Building Applications: Market Assessment and Potential R&D Pathways, U.S. Department of Energy, Contract DE-AC05-76RL01830, 2005, http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/pnnl-15149_market_assessment.pdf [Online]

8. Höller, J., Tsiatsis, V., Mulligan, C., Karnouskos, S., Avesand, S., Boyle, D. From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence, Elsevier, 2014
9. Balzarotti, D. (Editor) Final Report on Threats on the Future Internet: A Research Otlook, SysSec Consortium, September, 2014, http://www.syssec-project.eu/m/page-media/3/syssec-d4.4.pdf [Online]
10. Minchev, Z. Security of Digital Society. Technological Perspectives and Challenges, In Proceedings of Jubilee International Scientific Conference "Ten Years Security Education in New Bulgarian University: Position and Perspectives for the Education in a Dynamic and Hardly Predicted Environment" Sofia, Planeta – 3 Publishing House, 438-444, 2013 (in Bulgarian)
11. SysSec Project Web Page, http://www.syssec-project.eu [Online]
12. DFNI T01/4 Project Web Page, http://smarthomesbg.com [Online]
13. Automated Avatar Is Home's Personal Electronic Greeter, Smart Home, April, 2013, http://www.electronichouse.com/daily/smart-home/an-avatar-is-born/ [Online]
14. Russel, S., Norvig, P. Artificial Intelligence: A Modern Approach, 3rd Edition, PEARSON, 2009
15. Ioanidis, S., Stamatogiannakis, M., Petsas, T. (Eds.) Advanced Report on Cyberattacks on Lightweight Devices, SysSec Consortium, September, 2013, http://www.syssec-project.eu/m/page-media/3/syssec-d7.3- CyberattacksLightweightDevices.pdf [Online]
16. Minchev, Z. An Intuitionistic Fuzzy Sets Application in Infrared Object-Reflecting Sensors of a Mobile Robot, Notes on Intuitionistic Fuzzy Sets, Vol. 10, No. 4, 82 – 85, 2004
17. Minchev, Z., Boyanov, L. Interactive Virtual Avatars. Design & Application Challenges for Future Smart Homes, Presentation Slides, ICAICTSEE – 2014, Sofia, UNWE, October 24-25, 2014, http://snfactor.com/snfactor/sites/files/zm_lb_smart_home_unwe_ICAICTSEE_2014_talk.pdf [Online]
18. Center for the Study of Emotion and Attention, University of Florida IAPS/IADS Data Bases, http://csea.phhp.ufl.edu/media.html [Online]
19. Olivola, Ch., Funk, F., Todorov, A. Social Attributions from Faces Bias Human Choices, Trends in Cognitive Sciences, Vol. 18, Issue 11, 566–570, November 2014
20. ALEX Video Demo, http://snfactor.com/snfactor/sites/files/clips/Alex_intro.wmv [Online]