Ella4Life virtual assistant – user centered design strategy - evaluation following labolatory tests

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***Abstract*— In the paper, we summarize the evaluation of Anne4Care system after laboratory tests. A group of end users, seniors over 55 years of age, rated a virtual assistant by completing a questionnaire. The objectives of the pilot evaluations are mainly to assess the feasibility, usability, acceptance and functionality of the system and the ability of the potential target user to use the system and receive valuable information from it to help them address the complex needs of elderly people. The results of the assessment will be taken into account during further product development.**

Keywords—virtual assistant, elders supporting, active ambient living, user experience, AAL

I. Introduction

The use of external knowledge, from the group of target users, is increasingly important when developing new, innovative products. Creating and then satisfying the needs of end users is the basis for a good implementation and marketing strategy. The active involvement of users and a clear understanding of context of use are the key strengths to overcome the main barriers in applying technology for seniors. This strategy represents the core of the User-Centered Design (UCD), a design philosophy which encompasses various methodologies and techniques which seek to involve the end-user in the design process with the end-user being defined as the 'person who will ultimately be using the product'. The goal of UCD is to optimise the usability, human factors and hence the user experience (UX) of a product.

The scope of Ella4Life project is to facilitate the elders stay healthier and live a more quality life. The proposed integrated solution, Ella4Life, helps people in need, in daily activities or stay in contact with the professionals or informal caregivers and live a more pleasant life, independent and safe at home. The Ella4Life is presented as a virtual avatar, integrating with telematics technology and sensor monitoring solution. The system will be tested in four different countries. The pilot evaluations will be setting up in Switzerland. After the first experiences Netherland, Poland and Romania will follow.

This multi - site design will allow evaluating the Ell4Life system in different social and cultural contexts. Overall, the multinational approach proposed will ensure wide acceptability of the developed technology and prepare the possibility of Europe - wide deployment after project life.

II. State of the Art

A. Health status home monitoring

Continues monitoring of health indicators is vital for elders, for improving the quality of their life and ageing well. Also, there are informatized healthcare devices customized for monitoring health condition that better respond to special needs of elder people and can prevent health worsening and later care dependency in life [1]. The idea of smart homes systems with embedded diagnostic/monitoring devices for health status monitoring is becoming more and more popular [2]. Cardiac patients could be monitored using cover for beds and chair or even toilets. Authors in [3] e.g. estimates systolic blood pressure from pulse arrival time what was calculated from photoplethysmogram and ECG measured nonintrusively from a femoral artery via a toilet seat apparatus. The reliability and validity of measurement during sleep and bed rest using bed temperature monitor is presented in [4]. The temperature changes were recorded from the temperature sensor sheet. The body movements and sleeping period were obtained as well. Body movement was identified from the temperature changes profile in the bed. The research was conducted on 14 seniors also with disabilities. Results indicated the potential use of the bed temperature monitor for characterizing quality of sleep in the elderly. Another study [5] researchers have been developing a non-conscious physiological monitor installed in a bath, a lavatory, and a bed for home health care. By evaluation on 3 patients with cardiac infarct or sleep apnea syndrome in their homes, patients' health condition such as body and excretion weight in the toilet and apnea and hypopnea during sleeping were successfully monitored. The combination of data from multiple sensors from home health monitoring systems is described in [6]. Data fusion gives more objective predictive factors than signals analysed separately. Blood pressure monitoring system basing on cloud storage and analysis is presented in [7]. Wireless data transfer and further daily measurements and trends analysis could be a standard for

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hypertension treatment. Also mobile solutions are more and more popular in blood pressure monitoring [8]. The study shows that BP home monitoring may be useful for patients with high BP diurnal fluctuations, increased risk factors, diabetes, kidney disease or headache. Mobile applications allow you to teach the patient how to take measurements, ensure regularity of measurements and finally allow visualization of results and analysis of trends. The next stage in the design of home vital signs monitoring systems will be the use of the advantages of IoT technology, integration of many devices and services [9]. When we talk about special sensors like eChair or ebathtub but also classic ECG devices, then you can think about redesigning microprocessor systems controlling devices so that it becomes possible to implement hardware deep learning algorithms for on-line data analysis [10].

B. Integrating Patient-Generated Observations

Patients or end users become one of the main actors during data generation and analysis. We collect a large amount of data collected during the diagnosis process, during treatment and further during health monitoring [11]. The key problem is programmed and conscious acquisition of information from patients, which later facilitates their analysis. It is important to manage the process of creating surveys and questionnaires and to develop tools for analysing results. This is very important for oncological patients during and following cancer treatment [12][13].

User involvement is a strategy to ensure that the requirements and needs of older people are known and respected at every stage of the project. This is important in the patient-researcher relationship [14] and client-innovator [15]. Based on these findings, we use a customer-oriented strategy in the Ella4Life project. End-users have been involved in the development of the three different solutions and technologies (Anne, Emma, sensors) through previous organized focus groups. Their commitment led us to the conclusion that we must work together to create an integral solution instead of three different ones. Elders' perspectives about self-monitoring and using specially developed sensor technology for measuring health indicators is presented in [16]. Fig. 1 summarizes how the idea of Ella4life system is recognized by group of seniors in different countries across the Europe.

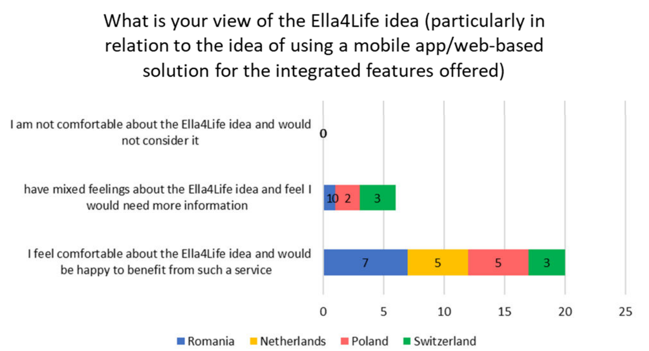

Fig. 1. View of the Ella4Life idea.

All respondents are positive about the proposed solution, although there are differences between countries in the approach to the possibility of using it in personal life. In Poland, seniors are rather sceptical about the possibility of implementing this solution during their lifetime.

III. SYSTEM ARCHITECTURE

A. Anne Client System Overview

Anne is the main application that the senior will work with (Virtask B.V. Netherlands [17]). She will accompany him every day and support him. The client consists of the core and the frontend. They both run locally on the machine and connect to each other via websockets. The core can run multiple instances, allowing the core to spawn itself (e.g. for separating ASR and TTS functionality). The core is written in C++/C99. Anne works on a tablet that runs the operating system Microsoft Windows 10. After testing, it was determined that the Surface Go (4415Y) model meets the performance requirements and was chosen as the base hardware platform. The main screen is presented in Fig. 2.

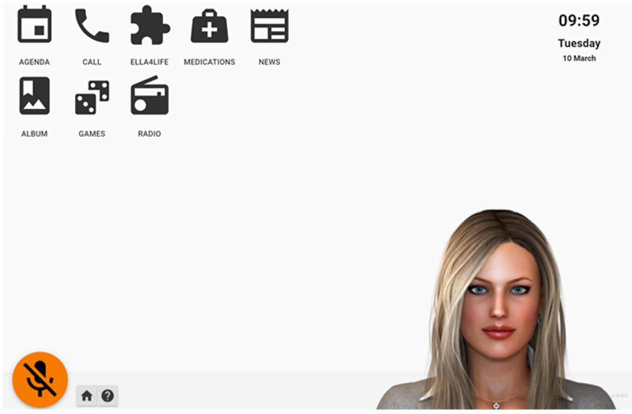

Fig. 2. User screen with main activities.

The core itself can work offline, meaning that the ASR and TTS functionality do not require an internet connection. This is important because the target group (elderly) are both very dependent on basic interaction via voice and mostly also have worse inter-net than the average consumer. The core also monitors machine state, weather battery level goes too low, etc. It also regularly checks if there are updates available and will, after notifying the user, update the software with newer versions. System offers a broad number of functionalities including: News – configured new's channels, Radio – streaming internet radios, Calendar/Agenda, Video conferencing, Medication - shows calendar with medication for each day etc., Album (personal media) - shows images, videos and other media content.

An example of My Agenda activity is shown in Fig. 3. All appointments from the agenda are displayed, and the virtual avatar can read them in natural language and alert will be display just before the event.

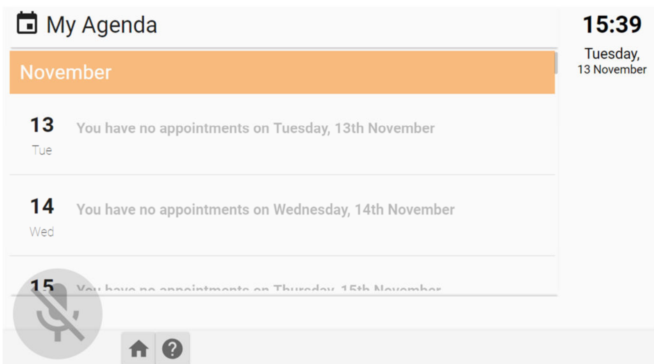

Fig. 3. My Agenda activity screen.

Content for these activities can be entries, can be added or uploaded using the web based Dash-board by the senior itself or by the caregiver: formal or by the family members. This solution requires the creation of a user account on the server, with a login and password.

Speech synthesis and recognition work locally without any internet connection (no cloud solution for speech). The parameters of the reproduced speech are shown in Figure 4. The user can set the chattiness, speed and level of speech recognition. This should be set to the user's personal preferences or senior cognitive decline.

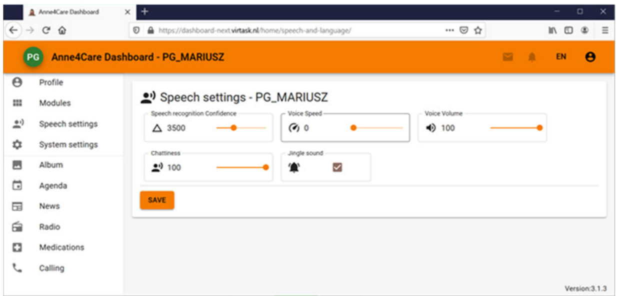

Fig. 4. My Agenda activity screen.

The system can work 24 hours a day and 7 days a week. It requires power connection almost permanently but because it is a tablet so there are no obstacles to use it also in a mobile way during walks or activities in the garden. However, the system can be put to sleep mode at night when there is no activity and there is no need to take medicine to save energy.

B. Emma subsystem architecture

Emma is a mobile solution and has a working connection with several e-health self-management solutions. She stimulates her users to lead an active, less sedentary and healthy life. Besides stimulating self-management, she also connects the user to their informal caregiver and the professionals within several fields of chronic diseases. This connection makes it possible to monitor the disease and act and instruct when needed and not when planned. Emma connected self-management platform for chronically ill patients and elderly (by Medicine Men, Netherlands [18]). The platform is cloud-centred and connects clients with their informal and professional caregivers. Information from mobile sensors, including smartwatch, scales, oxygen saturation meters, thermometer and blood pressure meters is stored and processed on the Emma cloud server.

In collaboration with Microlife, Emma uses the Microlife BP A6 monitor with Bluetooth. The meter is validated for accurate measurements and can be used at home. The scenario is that the Emma user has a monitor at home. He can choose to do measurements at random intervals or via the week measurement protocol, where he must measure twice a day during specific hours (in the morning and in the evening) for a whole week. The week measurement is a professional protocol according to the European Society of Hypertension guide-lines [19][20]. How it works is as follows: the patient will do a measurement with the meter (week measurement will give a reminder to measure). After this is done, the patient will go into the Emma 6 app and press the sync button. This will start the sync process in the app. The patient then needs to press a button on the meter so that the Bluetooth of the meter turns on. The connection will then be established between the two devices and if it goes without problems, the app will send the measurements to the Emma servers. An examples of user main screens are shown in figures 5a – 5d.

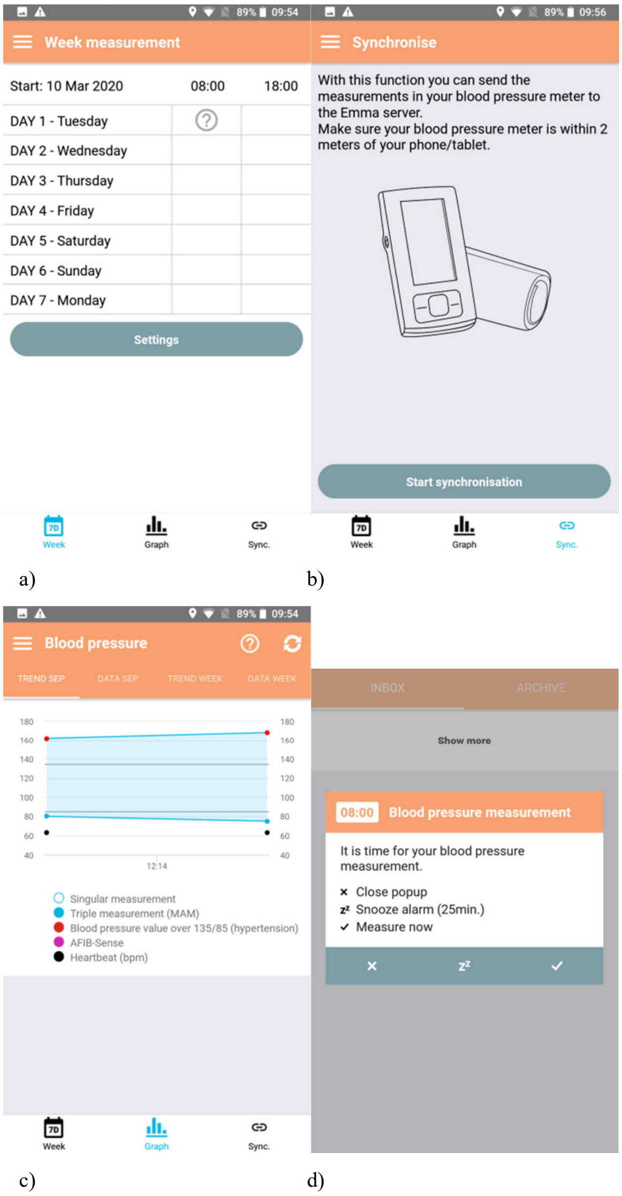

Fig. 5. Emma6 screens; a) week schedule of measurements with results, b) synchronise procedure with Emma server, c) the graph representation of the measurements, d) the reminder alert.

IV. Methods

The group is recruited from volunteers, voluntarily, people who usually do not know each other, but can share their experiences and express their opinions. According to the criterion established in the project, people aged 55 and older were selected in three ranges: 55–65; 66-75 and 76+ years, preferably with a balanced distribution. According to the assumptions, the target group consists of healthy people who are active or people with minor health problems. We are interested in people with at least minimal experience in the field of ICT (information and communication technologies), mobile applications and the www environment, because the Ella4Life solution is based on technology and human-computer interaction.

The tests will be carried out independently in 4 countries of the scientific consortium: the Netherlands, Switzerland, Romania and Poland. Social groups in these countries are different, and you probably can't transfer testimonials from one country to another. This has already been proven in previous surveys [16]. The questions we want to be answered are:

- is there a connection between the age of the elderly people and their willingness to use Ella4Life? For example, when people are relatively vital and younger, between 55 and 70, will they be willing to use Ella4Life and follow her instructions?
- is there a connection between the presence of chronic diseases and the willingness to use Ella4Life? For example are people not having a chronic disease willing to use Ella4Life to stay healthier?
- is there a connection between the age of the elderly people and their need to be assisted in the use of technical and/or digital devices? For example, when people get older will they get problems handling all the electronic and digital devices and will they thus be willing to use Ella4Life and will they be able to learn how to communicate with her?
- overall when Ella4Life contributes to a healthier lifestyle, more self-management and supports people in their wish to stay independent, what will people be willing to invest, financially as well as in time and attention in a system like Ella4Life to make it possible to stay independent and self-supporting?

In this article we present the results of research on a group of seniors from the Netherlands. The group consisted of 36 volunteers of both sexes. Mean age is 63 years. Detailed numbers of age ranges are shown in Table I.

TABLE I. AGE'S GROUP OF VOLUNTEERS

	Age range		
	55-65	***66-75***	***75+***
quantity	23	10	3

During installation of the product(s) at their homes the end users received a personal training in how to use the tablet and the blood pressure device. They also received a printed copy of the manual. Some of the end users turned out to be incredibly involved and contacted us weekly with questions and suggestions. All end users filled in the questionnaire. The questionnaire consisted of 80 questions about age, education, material status, family status and a group of questions about health (now and a year earlier) and directly related to the Ella4Life system.

V. RESULTS

Our findings from the lab test are as follows:

- Most (80%) of the end users thought the concept was great and believed there is a large market / need for a product like Ella4Life. Although they also mentioned that the current product is still far from being 'ready'.
- Roughly a quarter of the end users believed that the big commercial companies like Google would actually win the race and were sceptical weather this product would be ready in time.
- The vast majority of the end users mentioned that if the product would be finished they would definitely buy or rent the product because they felt more comfortable in buying a 'local' concept like Ella4Life instead of a solution from a multinational like Google.
- End users perceived the avatar as cold and distant. And not particularly personal (see Fig.2).
- End users perceived the 'home' button as too small. Especially for elderly with tremors/parkinsonism (see Figs.2 &3).
- End users were enthusiastic about the blood pressure device. Yet they thought it could be better integrated within the virtual avatar and did not like the idea of a separate app installed on their private phone.
- Before the virtual assistant speaks (i.e. reminds someone to measure their blood pressure) a notification signal should be given. Just like on train stations; you will first hear a loud 'ring tone' before vocal text is given.
- Make one good looking and easy to ready integrated manual and let it be a part of the virtual assistants menu / functionalities.

We are now analyzing the correlations between dependencies in the questionnaire to answer the questions posed earlier. We noticed a correlation between the need for a solution and the respondent's health status and education. People with higher education would be more likely to approve this solution, just like people with health problems. Further dependencies are still being analysed.

VI. CONCLUSION

This article is about understanding the perceptions of older people about attitudes, habits, and needs for health and self-control. The results help us customize and offer them the best product that integrates new technologies and support older people to remain healthier and live a better life. The results of qualitative research and investigation of older people from four European countries show a differentiated perception of older people in self-control and the use of sensor technology to measure health indicators, and even contradictions. The discoveries made us address them as two clusters: one group of seniors who are positive about the use of integrated devices in everyday life, and one group of seniors who want to take advantage of the benefits of self-monitoring sensors habits every day. We will continue testing on senior groups also in other countries, i.e. in Poland and Romania, and carry out surveys to compare the results obtained.

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REFERENCES

[1] M. Kaczmarek, A. Bujnowski, J. Wtorek, A. Polinski, Multimodal Platform for Continuous Monitoring of the Elderly and Disabled, Journal Of Medical Imaging And Health Informatics, vol. 2, issue 1, pp. 56-63, DOI: 10.1166/jmihi.2012.1061, 2012.

[2] Qin Ni, A. Belén, G. Hernando, I. Pau de la Cruz, The Elderly's Independent Living in Smart Homes: A Characterization of Activities and Sensing Infrastructure Survey to Facilitate Services Development, Sensors 2015, 15, 11312-11362; doi:10.3390/s150511312, 2015.

[3] J. H. Shin, G. S. Chung, K. K. Kim, J. S. Kim, B. S. Hwang, K. S. Park, Ubiquitous House and Unconstrained Monitoring Devices for Home Healthcare System, 6th International Special Topic Conference on ITAB, Tokyo, pp. 201-204, 2007.

[4] T. Tamura, S. Miyasako, T. Fujimoto and T. Togawa, Monitoring bed temperature in elderly in the home [ECG/body movements], Proceedings of 18th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Amsterdam, 1996, pp. 57-58 vol.1. doi: 10.1109/IEMBS.1996.656844, 1996.

[5] K. Motoi et al., A fully automated health-care monitoring at home without attachment of any biological sensors and its clinical evaluation, 2009 Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Minneapolis, MN, 2009, pp. 4323-4326, doi: 10.1109/IEMBS.2009.5333712, 2009.

[6] D. A. Clifton et al., Towards assisted living via probabilistic vital-sign monitoring in the home, IET Seminar on Assisted Living 2011, London, pp. 1-6, doi: 10.1049/ic.2011.0022, 2011.

[7] B. Yip, H. W. Hirai, Y. Kuo, H. M. Meng, S. Wong and K. K. F. Tsoi, Blood Pressure Management with Data Capturing in the Cloud among Hypertensive Patients: A Monitoring Platform for Hypertensive Patients, 2015 IEEE International Congress on Big Data, New York, NY, 2015, pp. 305-308, doi: 10.1109/BigDataCongress.2015.50, 2015.

[8] M. Chetan and C. Moldovan, New trends in BP home monitoring, 2017 10th International Symposium on Advanced Topics in Electrical Engineering (ATEE), Bucharest, 2017, pp. 301-304, doi: 10.1109/ATEE.2017.7905140, 2017.

[9] M. D. Valdes Pena, J. J. Rodriguez-Andina, M. Manic, " The Internet of Things: The Role of Reconfigurable Platforms," in IEEE Industrial Electronics Magazine, Vol. 11, Issue 3, pp.6-19, Sep. 21, 2017. DOI: 10.1109/MIE.2016.2615575, 2017.

[10] R. Fernandez Molanes, K. Amarasinghe, J. Rodriguez-Andina and M. Manic, "Deep Learning and Reconfigurable Platforms in the Internet of Things: Challenges and Opportunities in Algorithms and Hardware," in IEEE Industrial Electronics Magazine, vol. 12, no. 2, pp. 36-49, June 2018. DOI: 10.1109/MIE.2018.2824843, 2018.

[11] M. D. Wang, Biomedical Big Data Analytics for Patient-Centric and Outcome-Driven Precision Health, 2015 IEEE 39th Annual Computer Software and Applications Conference, Taichung, pp. 1-2, doi: 10.1109/COMPSAC.2015.343, 2015.

[12] C. Maramis et al., "Using Electronic Patient Reported Outcomes to Foster Palliative Cancer Care: The MyPal Approach," 2019 IEEE 19th International Conference on Bioinformatics and Bioengineering (BIBE), Athens, Greece, pp. 405-409, doi: 10.1109/BIBE.2019.00079, 2019.

[13] U. Lakshmi, M. Hong and L. Wilcox, Integrating Patient-Generated Observations of Daily Living into Pediatric Cancer Care: A Formative User Interface Design Study, 2018 IEEE International Conference on Healthcare Informatics (ICHI), New York, NY, pp. 265-275, doi: 10.1109/ICHI.2018.00037, 2018.

[14] C. C. Yang, S. Lin, M. C. Kim and L. Jiang, ACTONNECT: A Platform to Support Patients and Researchers Collaboration, 2014 IEEE International Conference on Healthcare Informatics, Verona, pp. 369-369, doi: 10.1109/ICHI.2014.64, 2014.

[15] T. Feng, D. Cai, Z. Zhang, B. Liu, Customer involvement and new product performance: The jointly moderating effects of technological and market newness", Industrial Management & Data Systems, Vol. 116 No. 8, pp. 1700-1718. https://doi.org/10.1108/IMDS-11-2015-0457, 2016.

[16] M. Kaczmarek, M. Velciu, L. Spiru, A. Bujnowski, A. Andrushevich, E. Birrer, „Methodology for assessing end-user requirements in the Ella4Life project: elders' perspectives about self-monitoring", The Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Berlin, 23-27.07.2019.

[17] http://www.virtask.nl/wordpress/en/about-virtask#.

[18] https://medicinemen.eu/en/.

[19] Guideline for Blood Pressure Monitoring, Journal of Hypertension, 26:1505-1530, 2008.

[20] https://www.eshonline.org/guidelines/blood-pressure-monitoring/