MOBISERV – FP7 248434
An Integrated Intelligent Home Environment for the Provision of Health, Nutrition and Mobility Services to the Elderly

Deliverable

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1 Final publishable summary

1.1 Executive summary

The MOBISERV project has designed, developed and evaluated a system and related services to support independent living of seniors by means of a proactive personal companion robot integrated with smart textiles, innovative sensors, and a smart environment. The main objective has been to increase people’s independence, well-being, and peace of mind. MOBISERV provides people with: nutrition assistance and dehydration prevention by eating and drinking suggestions; a personal health coach encouraging physical activity, monitoring vital signs, and supporting telemedicine services; well-being services for cognitive stimulation and social inclusion; fall detection; a smart home environment including warnings about unwanted situations; video communication, games for entertainment; and a secure portal for family and carers to use, setup, and fine-tune this support system.

With this system, extensive usability and user experience evaluation studies have been performed. The final MOBISERV system prototype and its components like the robot companion have been tested in a large range of studies involving primary users, secondary users (such as partners, formal and informal carers), and tertiary users (such as care managers and policy makers) in various settings such as home labs, people’s own homes, and care homes.

Next to R&D work, the consortium has performed many dissemination activities. A demonstration video has been created and the consortium has provided a joint press release in the final year. The combination of this press release, the website and the video has drawn a lot of attention, both by online and offline media. Next to this, many scientific papers have been written and submitted to journals and conferences. Many non-scientific dissemination activities have been carried out; invited talks, presentations, demonstrations and interviews have been given, and events have been organized or participated in throughout Europe, focussing on target users, professionals from the health care sector, and the general public. The consortium used the final project year to think about future exploitation of the MOBISERV concepts. This has resulted in the development of an extensive project results exploitation and business opportunity plan for follow-up activities of the consortium and/or sub-consortia, including an initial market analysis of several markets in the health care sector and of potential competitors in these fields.

In the past 3,5 years, we have discovered that MOBISERV was a very ambitious project, with many components that could have been research projects on their own. Final integration and implementation of all high-level functionalities in a fully functional system turned out to be very challenging. The related delays have caused several changes in our evaluation plans throughout the project. On the one hand, this makes us believe that there is much to be learned in the near future, but on the other hand we have gained a huge amount of insights and acquired very interesting, promising and motivating findings. These findings have shown both technical as non-technical partners that MOBISERV, or parts of the system, can really add value to people’s lives.
1.2 Introduction & objectives

The main objective of the MOBISERV project has been to design, develop and evaluate a system and service to support independent living and well-being of seniors by means of a proactive personal companion robot integrated with smart textiles, innovative sensors, and a smart home environment. The system will monitor your physical activity and health indicators by means of wearable fabrics, monitors your nutrition habits by smart home sensors, and will offer an extensive secure portal for informal and professional carers to use, setup, and fine-tune the support system.

MOBISERV provides older adults with: 1) nutrition assistance and dehydration prevention by eating and drinking reminders and suggestions; 2) a personal health coach encouraging physical activity and specific exercises, monitoring vital signs, and supporting telemedicine services; 3) well-being services for cognitive stimulation and social inclusion, responding to the user’s emotions; 4) fall detection with direct communication to a care centre; 5) a remote control for the home environment, including warnings about unwanted situations; 6) video communication to friends, family, and health professionals, and 7) games for entertainment.

Next to these end-user services, MOBISERV provides secondary users such as partners, family, informal carers, social carers and professional carers with an online tool to setup, customize, personalize and use the MOBISERV services to support the end-user. It gives family and carers an overview of how the primary user is doing, and it lets them customize and fine-tune aspects of every single MOBISERV function, and of the robot companion system in general.

1.3 Main achievements

System Architecture Design (WP3)

Workpackage 3 provided specification for the first MOBISERV prototype architecture, its software and hardware components, and the interaction between them. Based on the market and standards watch and on feedback from the development and integration processes, these specification have been updated accordingly. In year 3, after the first round of evaluation studies, work package 3 delivered a fully updated specification of the system architecture design, based on the extensive results of the first round of full system prototype evaluation sessions. Furthermore, the interfaces for the MOBISERV system components have been defined with ComDL language to ease the process for third parties for creating new MOBISERV compatible services.
Development of the Nutrition Support System (WP4)

In the first years, workpackage 4 developed first versions of new approaches for nutrition support, including innovative computer vision algorithms to detect eating behaviour, drinking behaviour and facial expressions of seniors. These initial algorithms were systematically tested and improved, to come to the first prototype to be integrated in the MOBISERV system. The nutrition support prototype includes algorithms based on neural networks, self-organizing maps, and novel methods for multidimensional sequence classification. The facial expression recognition prototype includes algorithms that are based on subclasses in the discriminant non-negative matrix factorization, novel SVM classifiers, and a novel dimensionality reduction method combining Random Projections and SVMs in a single iterative optimization framework. For testing, training and evaluating purposes, a large-scale video database “MOBISERV-AIIA Eating & Drinking Database” has been created.

In year 3, work package 4 continued developing and improving the algorithms for eating, drinking and emotion recognition, based on continuous performance tests and on feedback from the results of the first round of full system prototype evaluation sessions, and delivered the final prototypes of the nutrition support system and emotion recognition system. The beginning of year 4 has been used to integrate these components into the final MOBISERV system prototype and perform integration tests.

Development of the Multi-Sensor Embedded System for Health Monitoring (WP5)

In the first 2 years, workpackage 5 designed and developed the first and second version multi-sensor embedded system for vital signs monitoring. This included smart garments for daily and nightly use, small hardware dataloggers hidden in these garments, and intelligent software for detection and analysis of the vital signs data. The main datalogger uses Bluetooth to communicate with the rest of the MOBISERV system, and uses ANT to communicate with a secondary datalogger that is included in the night garments to measure skin temperature. Vital signs that are detected include heart rate, heart rate variability, respiration rate, skin temperature at wrist and hip level, 3-axis acceleration, posture detection, and activity classification.
Based on user evaluation feedback, completely new versions have been created including new garments and a new datalogger, taking into account usability issues and ergonomics for older adults and making a distinction between male and female users. In year 3, work package 5 continued working on improving all parts of the wearable health supporting unit, based on another round of extensive user evaluation sessions in the UK, now covering multiple days in a row. Furthermore, new algorithms have been developed to support real-time fall detection, based on the 3-axis accelerometer in combination with the heart rate eliminating false positives. Year 4 of the project has been used to improve the fall-detection service and to finalize integration with the full MOBISERV system.

**Development of the Information Coordination & Communication System (WP6)**

In the first 2 years, workpackage 6 designed the internal MOBISERV information flow and implemented the resulting coordination and communication system. Based on early evaluation studies, and on the developments of the other WPs, these designs and workflows were adjusted and updated to reflect new or changed requirements. In year 3 and 4, work package 6 focussed on the design and implementation of the online secondary user interface and on the design and implementation of a secure role-based access control (RBAC) system for this online interface. Through this tool, both professional and family carers are able to use the MOBISERV system to support their partner, relative, or client, and to setup and fine-tune the system’s individual services and overall behaviour. Also in year 4, WP6 performed a thorough security analysis of the complete MOBISERV prototype system and took measures to improve on security related issues where needed.

**Development of the Social Robot & System Integration (WP7)**

In the first 2 years, workpackage 7 was dedicated to the design and development of the first MOBISERV robotic platform, in terms of both hardware and software, and to integrating first versions of the WP4, WP5 and WP6 results into this robotic platform in order to build the first complete MOBISERV system prototype. This first prototype has been delivered at the end of year 2, already partially adapted to feedback from early evaluation studies that had been performed using mock-ups, video prototypes, and the existing Kompaï robot.

In year 3, work package 7 started off with installing and further fine-tuning the first MOBISERV system prototype, to be acceptable and ready for the first full user evaluation studies in the UK and the Netherlands. After these extensive studies (performed in WP2) were completed, WP7 started working on improving and extending the robotic platform’s hardware components, and on improving and adjusting the overall MOBISERV application running on this platform. Next to improving the existing
services and overall human-robot interaction, new functionalities have been added as planned to realize the second and final MOBISERV system prototype. Due to high demands of the various MOBISERV functionalities and services, a large part of the software implementation of the second and final MOBISERV system has been redesigned and re-implemented in the beginning of year 4. Therefore, the final prototype has been delivered later than expected in year 4.

**User Requirement, Concept Design & User Evaluation (WP2)**

In the first year, workpackage 2 gathered user requirements, and created usage scenarios, concept designs of the functionality, and specifications of the human-robot interactions. Also, the validation and evaluations plans were developed. Both the requirements & design documents, and the validation & evaluation plans have been updated on a regular basis. In year 2, the first evaluations in the UK and in the Netherlands took place, and results have been reported in several reports on usability and user acceptance. The user requirements, usage scenarios, and concept designs have been updated accordingly.

In year 3, work package 2 performed the first round of individual user trials with the full MOBISERV system, both with end-users as with formal and informal carers. These extensive sessions have delivered the team many findings on usability, usefulness, efficiency, learnability, acceptability, and more. Findings have been reported to the project team, and many improvements and changes have been proposed. A second report has been delivered, including updated scenarios, new requirements on user modelling, context awareness, intelligent rules, and a redesign of the graphical user interface, both for primary users as for secondary users (family, informal carers and professionals). In year 4, the second round of user evaluations took place, with the final MOBISERV system prototype. Due to the system not being ready for longer-term field trials, it has not been possible to fully assess all objectives we had in mind. However, the WP2 team has managed to conduct a large range of studies involving end-users with a range of physical and cognitive disability, formal and informal carers, as well as management staff involved in the care and well-being of older adults.

Over the life-time of the project we had multiple evaluations in different contexts and using a range of methods. These user studies have provided rich knowledge about the context of use and potential barriers, constraints, and criteria for acceptability of a social companion system such as MOBISERV. The team has learned that seniors are receptive to service robots whenever the robot does not interfere with their daily routine too much, and if they can customize the robot’s character, behaviour and appearance. They want to be in control of the robots’ behaviour; the
robot should act in accordance to their preferences. Most valued aspects of the MOBISERV concepts by end-users and carers are 1) companionship; 2) stimulating, motivating and reminding; and 3) the robot’s embodiment and natural interaction.

We have found that there need to be several phases for the introduction and deployment of a personal robotic system. These include initial assessment of individual care needs and the suitability of their living environment for incorporating a mobile robot. Given the limitations of the current technology, only people who are able to speak loudly and clearly, do not have a significant hearing impairment, have no major visual impairment, and are reasonably mobile will be able to use the system. The assessment needs to be holistic and involves understanding not only the person’s functional and medical problems, but also their likes and dislikes, how they like to be spoken to, their interests and hobbies, types of exercises suitable for them, activities they enjoy, types of food and drink, etc. This information can then be used to customise the content of the robot and also change the “personality” of the robot in line with what they desire – an authoritative system, or a social companion, or a carer. To reach user acceptance, a training period of at least a few months is necessary, starting with a short introduction and building up slowly from a few hours to a couple of weeks, at a pace that suits the individual. The person’s mental attitude regarding acceptance of technology of this nature has been found to be a good indicator of the level of ease with which they are able to learn to interact with the system. The determinants of successful training are:

- The user not feeling anxious or intimidated if the robot does not respond as expected, being able to recover from unintended states,
- Less than 1% error in execution of functions
- Completing all tasks
- Being able to respond correctly to reminders and suggestions
- Remembering how to control the movement of the robot
- Correctly remembering how to stop the robot

1.4 Potential impact

Dissemination & Impact so far

In the first years, the consortium produced several versions of the project’s dissemination plans and materials, focussing on the scientific community, on seniors, on their formal and informal carers, and on the general European public. In year 3, new dissemination materials were created, including posters and videos, and the consortium performed many dissemination activities on MOBISERV subcomponents (mainly scientific) and on the integrated system (mainly non-scientific).
A big audience was reached via live presentations at conferences and workshops, via live demos, via papers in journals and proceedings, via printed media, via interviews and items on radio and television, and via online media such as news sites and blogs. Because of the attention gained mainly by the activities aimed at the general public, many new contacts have been made with seniors, informal carers, professional care organizations, and other stakeholders. In year 4, the project team continued performing dissemination activities, more and more focusing on potential end users and the general public. A new project website has been launched, a new project demonstration video has been created, and a press release has been distributed in 7 languages. This press release has been published by many online and offline media throughout Europe and the rest of the world – having quite some impact and generating lots of attention in many media, including national radio and TV. Finally, several public showcase events have been organized in partner countries to highlight the project results to the general public, to open the discussion on social robotics in care, and to create awareness of very nearby future products and services.

**Exploitation & Potential impact**

Next to dissemination of project results, the consortium has been working on several iterations of the MOBISERV future exploitation and business opportunity plans. During the project’s lifetime, these plans have been revised and fine-tuned, based on the on-going developments and on the evaluations with end-users and stakeholders. In the final project period, an extensive joint business opportunity plan has been created, emphasizing and roadmapping several possibilities for concrete business cases and for follow-up research projects. Based on our experience in the project, the consortium foresees a serious impact of technology and services like MOBISERV on society within a couple of years.

### 1.5 Contact details

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