ORKESTA Comprehensive Solution for the Orchestration of Services and Soci-Sanitary Care at Home

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Abstract
In this paper we present the main goals of the ORKESTA project. This is an industrial project carried out by a consortium of companies aimed at providing products and services contributing to improve the wellbeing of the old adults and enlarge the years of independent life. To this end the consortium collaborates with the Vicomtech Tecnological Center and the Speech Interactive research Group at the UPV/EHU. Both provide speech and language technologies to the project.

Index Terms: integrated care, older adults, care at home, silver economy, personalized care, emotions from speech, speech processing, human-computer interaction, depression indicators

1. Context and Motivation
ORKESTA project is an Industrial Research project that focuses on conducting first-rate research on the key technological components to be able to massively deploy in our society a new proactive model of long-term integrated care for older adults in their home. We foresee that this kind of approach is key to ensure the sustainability of social and health care and the continuous improvement of the quality of life of the older adults over the coming decades.

ORKESTA, led by ALCAD Electronics S.L. brings together the strategic interests of each and every one of the companies that make up the consortium. These strategic interests are based on the generation of new products and services around aging (Silver Economy), and on the early adoption of solutions adapted to real environments by organizations that offer services related to the care of the elderly and/or dependents.

In contrast to the reactive model in use today, ORKESTA’s proactive model seeks to monitor the comprehensive status of the older adult for early detection and intervention and thus increase the amount of independent and healthy years while reducing costly interventions such as hospitalizations or admissions to residences.

ORKESTA puts the older adult at the center and provides the orchestration of all the agents that participate in care, integrating both the health field, the social care and general services (hygiene, food, laundry, shopping, etc.), facilitating both face-to-face intervention at home, as well as remote attention or automated attention. All this thanks to the development of solutions based on cutting-edge technology, under a rigorous research process directed and guided by professionals dedicated to caring for people. Figure 1 shows the concept of the project.

2. Objectives and expected results
The challenges faced by ORKESTA stem from the integration of the different services and the different technologies provided by the partners, as well as their improvement and deployment. On this integration, the challenges faced are the adaptation to the environment of the home and of the older adult person, speech technologies, as well as image detection and analysis. Also in adherence to care plans for the older adult and the early identification and management of alterations and trends. And the creation of effective user interfaces for the different actors that will make use of data analytics.

The ORKESTA technological solution is organized in three logical layers:
• O-SEG Integrated Care Infrastructure. This layer consists of a common space to gather information about the older adult, collecting all the data and results of the interventions carried out by the different agents of the care ecosystem. This facilitates the coordination between different agents, in order to provide the Personalized Care Plan that each person requires.
Figure 1: Main concept: ORKESTA puts the elderly person at the center and solves the orchestration of all the agents that participate in care

- O-TEK Technology Solutions Layer. This layer includes a set of disruptive technologies to support the care of the older adults and facilitates economies of scale to guarantee the sustainability of care over time. These technologies are specifically voice interaction, cognitive vision, the internet of things, cybersecurity, biometrics, artificial intelligence and Big Data.
- O-SIR Layer of Integrated, Sustainable and Resilient Services. Lastly, this third layer proposes the use of the two previous ones to deploy new care services the older adult that allow simple and effective coordination between different agents, thus achieving greater sustainability of care and greater resilience of our society.

3. Speech Technologies in ORKESTA

ORKESTA proposes Spoken Dialogue Systems (SDSs) with state-of-the-art Voice Interaction (VI) technologies for the automated care of the elderly and in-house assistance. Understanding, guiding and responding accordingly to this end-users is essential to deliver an immersive experience. Therefore, Conversational Assistants rely on a knowledge base to guide and model the communicative exchange. SDSs provide a voice-based interaction in the retrieval of human-spaces digital information in order to support lifestyle and well-being in end-users. These elements are empowered by the natural user interfaces deployed on diverse architectural devices such as smart speakers along with IoT sensors or noise cancelling microphones.

In addition, conversational assistants are also en excellent framework to monitor spontaneous emotional states. In particular ORKESTA is interested in early detection of depression indicators. To this end the project will develop technologies for the automatic analysis of the user speech during conversations. Additional data extracted from the user while monitoring at home will also be considered along with the features automatically extracted.

3.1. Voice-based assistant to support home tasks

ORKESTA explores both, commercial and development chatbot creation frameworks in combination with Speech Recognition, Speech Emotion Detection and Speech Synthesis technologies to build Voice Interaction Virtual Assistants. The SDS built to assist the elderly at home with speech processing and interaction capabilities is composed by the next main modules:

- A Wake Up Word Detection (WuW) module capable of triggering attention from the virtual assistant when idle to start the speech recognition process and recognize voice commands. Calling their virtual assistant by its name can be gratifying for individuals that usually experiment loneliness, as they feel a more human-like voice exchange.
- An Automatic Speech Recognition (ASR) module, adapted to convert elder user voice into relevant text transcriptions to be processed, as it is easier to have an interaction with an aged individual through voice than through a text chat.
- A Natural Language Understanding (NLU) module, which extracts relevant semantic tags from the users text input into intents.
- A Dialogue Manager (DM) which takes semantically formatted data as input and uses a Decision Tree model built from the information inserted by experts in the systems Knowledge Database to determine which is the next state of the dialogue. The DM not only applies a set of rules to the input to navigate through the decision tree, but also takes into account other relevant data such as dialogue attributes that do not come from the conversation. The DM returns a new set of semantic tags that describe the meaning of the response that must be generated.
- A Natural Language Generation (NLG) module that produces a natural language human-like text response derived from the semantic tag response. This is crucial in an elderly support framework where the message should be clear, adjusted to the context, respectful and grammatically correct.
- Conversational Skills including filling questionnaires, checking their agenda, tutorials and setting reminders for medication. These different logics with specific NLU, DM and NLG modules enable additional interaction capabilities such as repeating or passing steps, getting additional information or contacting professionals are connected to the principal dialogue system and triggered by certain commands given by the user. Skills also take into account specific task Knowledge Databases and process different inputs that can differ from the main virtual assistant pipeline.
- A Text to Speech (TTS) Synthesis module that provides useful spoken feedback to the elderly.

As a core module of the architecture, to put Conversational Skills in use and schedule appointments to elder people, remind them about their medication or ask them how well they feel physically; field professionals must fill reminders, events and tutorials with a graphical user interface (GUI) to be presented to end-users.

Regarding the on-site character of the virtual assistant service at home for the elderly proposed in ORKESTA and
the identification of several Basque Language speakers, this assistant solution manages with ease conversations in both Spanish and Basque Languages. In addition to the relevant data stored related to the Skills dialogue flow, data produced by end-users interactions is collected and saved as complete conversations in a Knowledge Database (KDB) which may be helpful to provide valuable insights of the individuals progression. Moreover, caregivers are able to check questionnaire responses or schedule new reminders through the Skills GUI. In ORKESTA all these components are put together with the core Conversational Assistant modules (NLU, DM, NLG and Skills) varying the location of their deployment but operating in harmony.

In ORKESTA some voice technologies are being embedded on the edge, so that they can be deployed within smart home speakers. Advances on the deployment of embedded Deep Learning (DL) algorithms are carried out to fulfill the tasks of ASR and WuW detection. Smart home devices with low-resource ARM-based boards have been identified to fit modest DL models suitable for inference on a more network independent, private, power-efficient and environmentally aware platform. On top of that, embedded ASR and WuW detection systems will provide a low-latency experience regarding a voice-interactive exchange due to the lack of need to transfer large amounts data to the cloud to be processed which makes it an excellent choice in real-time use cases. Concerning smart IoT devices, ORKESTA works towards the integration of the conversational assistant with smart wearables and sensors to monitor and follow-up elderly welfare continuity and their environment (i.e. smart sensors and metrics). These devices that feature technologies such as RFID and NFC generate a lot of (frequently uninterrupted series of) data through sensors, antennas or trackers for heterogeneous machinery (i.e. energy meters, water pumps, valves). In order to exploit this information from the virtual assistant side, appropriate API middlewares are being implemented allowing to transmit and process structured data tailored to the DM capabilities.

3.2. Speech-based indicators of depression

As an output of the project, ORKESTA is aimed at providing Sustainable, Integrated and Resilient Services (SIR) to improve the wellbeing of elderly People. In this context, SIR 4 proposes a comprehensive approach to loneliness aimed at providing Emotional and Psychological Support. In this framework ORKESTA will research in the field of emotion recognition in the elderly through voice analysis during their interaction with the ORKESTA platform. The aim of this technology is to be able to monitor the user’s emotional state in a non-intrusive way in order to detect potential emotional changes that are indicators of loneliness or depressive states. In particular, the project will analyse interactions between elderly and psychologists as well as depression scores of the users. Then in deep analysis of speech signal and discourse will be carried out in order to extract relevant features that will feed advanced computational models.

4. Consortium

The consortium consists of seven companies lead by ALCAD that share the strategic goals of generating new products and services aimed to participate in the so called Silver Economy.

- ALCAD1: responsible for providing technological products, as a part of a new innovative orchestration of all the systems (audio interaction, cognitive vision, IoT, medical devices, Smart Metering, intelligent access, etc.) for home appliance.
- EUROHELP2: in charge to generate a new concept of Big Data infrastructure for the collection and analysis of new generation information and to the management tools of the entire ORKESTA solution.
- ODEI - grupo teknei3: in charge of the management of the identities of users and professionals, and of researching new biometric systems for secure facial identification for access control.
- TESA4 responsible for developing an intelligent high-security home access system for both the elderly and professionals accessing homes.
- CASER Residencial5: in charge of leading the collection of requirements, the supervision of the developments, and the validation of the pilots in a real use environment
- GUREAK6: coordinates the integrated services to be piloted and focuses in the collection of requirements and validation of the pilots.
- INVIZA- Clínica Asunción7: participates in the collection of requirements, in the piloting and validation of the resulting integrated services.
- INGETEK8: develops solutions for the home care for the elderly, delving into the analysis of consumption data through artificial intelligence to detect possible risk situations

These consortium of companies has subcontracted some technical work to:

- Fundación Vicomtech, Basque Research and Technology Alliance (BRTA): responsible and of the development of the Voice-based agent
- Speech Interactive Research Group at the Universidad del País Vasco (UPV/EHU): in charge of providing depression indicators extracted from the speech analysis.

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