LLM Publishable summary

What is LLM?

Long Lasting Memories (LLM) is an EU project that has implemented an integrated ICT platform which combines state-of-the-art cognitive exercises with physical activity in the framework of an advanced ambient assisted living environment, while respecting ethical and legal boundaries. By combining cognitive exercises and physical activity LLM delivers an effective countermeasure against age-related cognitive decline, as well as and cognitive impairment seen in the early stages of degenerative brain diseases, thus actively improving the quality of life of the elderly and significantly prolonging the time they can remain independent at home.

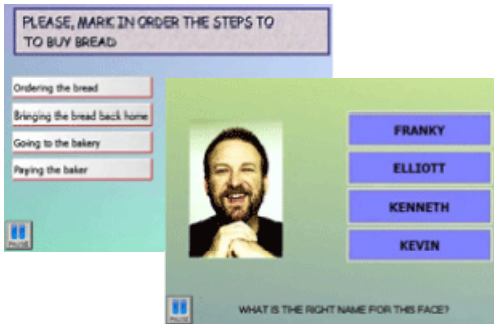
LLM Service

Figure 1: LLM service

The LLM service is designed to comprise of three existing interoperable components which perform complementary and interactive tasks to provide the system's services:

- The **Physical Training Component (PTC)** is based on the **Fit For All** system developed by the Lab of Medical Informatics of the Aristotle University of Thessaloniki (LLM partner No.1). Fit For All is a game platform that can help elderly people to exercise and maintain their physical status and well being through an innovative, low-cost ICT platform, such as the Wii Balance Board.

- The **Cognitive Training Component (CTC)** is designed to support cognitive exercises provided by specialised software. Two CTC components have been selected:
  - **BrainFitness** (by PositScience), a state-of-the-art product in the United States. It speeds up and sharpens auditory processing - the listening system of the brain. By improving the quantity and quality of what the brain takes in through sound, it drives an overall improvement in thinking, focus, and memory.



- **Gradior** (by INTRAS, LLM partner No.7), a program which offers a structured evaluation and neuropsychological rehabilitation system. This system permits cognitive training and the recovery of higher cognitive functions in people who show cognitive deficit / deterioration with few technical requirements for the therapist or the professional that supervises the performance of the elderly individual.

- The **Independent Living Component (ILC)** is based on the **eHome** system, which is a network of distributed, wirelessly-operating sensors connected to an embedded system (the e-Home central unit) combined with an easy to use information and communication interface for the elderly . It includes features such as intelligent learning of normal and exceptional patterns of behaviour (dangerous situations or indicators for emerging health problems), relevant alarms, voice and video telephony and senior specific internet access . eHome is a an outcome of a project funded by the Austrian Research Promotion Agency (FFG).

Target Groups

The LLM service can be installed in individual homes, day care centres, or formal medical settings, enabling personalized and monitored physical and cognitive training of its users. Meanwhile, users are able to take advantage of features of an independent living solution. The following are the types of users of the LLM service:

- Older people in general, and older people living independently inside an LLM environment, utilising its Ambient Assisted Living (AAL) services (normal or with cognitive problems, see below).
- Visitors to day care centres: healthy elderly people as well as patients with Mild Cognitive Impairment (a pre-dementia stage characterizing ~20% of people >65 years-old) and patients in the early stages of Dementia due to various causes (Alzheimer's Disease, Vascular Dementia, Parkinsonian Dementias, etc).
- Hospitalised users, who may use the AAL environment while following the cognitive training and may also use the physical training component as complementary to their physiotherapy sessions.
- Actors directly interacting with the end-users: These are close relatives and friends of the end users, formal and informal care persons and care organisations and their representatives.
- Providers of end user support services, i.e. "professionals" acting as de facto "prescriptors" of the service

  and public administrations promoting and backing public-private-partnerships and funding initiatives under

  the corresponding National Programmes.
- Decision-makers, supporters and other stakeholders: They include all those who have, in one way or another, an interest in seeing the LLM service or outputs in the market, and include private or institutional investors, government bodies, social security managers, insurance companies, industry bodies and technology providers, professional networks, CSOs and NGOs, etc.

Project Pilots

LLM service was tested and validated in 4 EU Member countries (Austria, Greece, Spain and Cyprus). LLM pilots were held in up to five consecutive rounds of testing of 3 months each (exercising periods of 8 weeks and pre and post intervention testing). Testing was focused upon elderly volunteers who provided feedback to help improve the solution to meet user expectations. Testing was conducted in accordance with relevant regulations for the protection of the participants; all test protocols utilise good ethical practices and comply with European and national legislation.

Greece: In **Thessaloniki**, pilots run under the scientific co-ordination of Aristotle University of Thessaloniki (AUTH, LLM partner No.1). The LLM intervention was first installed and run in one room located at the buildings of the **Greek Association of Alzheimer Disease and Relative Disorders – St. Eleni**. However, the following few iterations of the trials also used different sites as follows:
-6 Municipality-operated social (community) centres (**Kalamaria**: 1st Open Protection Centres of the Elderly (1st KAPI), Kifissias Open Protection Centres of the Elderly (2nd KAPI Kifissias); **Sykies**: 1st Open Protection Centres of the Elderly (1st KAPI Sykies), Neapoli 1st Open Protection Centres of the Elderly (1st KAPI Neapoli), Neapoli 2nd Open Protection Centres of the Elderly (2nd KAPI Neapoli); **Thermi**: Tagarades Open Protection Centres of the Elderly (KAPI Tagarades).
-2 **parish community centres** of the Holy Bishop of Thessaloniki (http://www.imth.gr/): St Nicolaos & St Dimitrios Church at Harilaou; St George's Church at Neapoli.
-**Chariseio** Elderly Care Foundation
-Psychiatric **Hospital of Katerini** (http://www.psynpo.gr/)
-LLM was also on display at one (1) private gym for dissemination and marketing purposes.
-Collaborators: General University **Hospital** of Thessaloniki **AHEPA** (http://www.ahepahosp.gr/en_index.asp); in specific, the Cardiologic Clinic of General University Hospital of Thessaloniki AHEPA has provided free cardiology examinations to LLM Participants. Similarly, the General **Hospital** of Thessaloniki "**Ag. Dimitrios**" (http://www.oagiosdimitrios.gr/), and in specific the Cardiologic Clinic of the hospital has provided clinical tests to LLM participants. Finally, Greek trials were benefited from a loan of equipment kindly offered to LLM by Nintendo Hellas (http://www.nintendo.gr/el-gr/Default.aspx); the technological support of Nintendo Hellas was crucial for the LLM pilots.
Piloting in **Athens** took place in municipal and other societal facilities selected for their access to the target population. In Athens pilots run under the scientific coordination of the Cognitive Neurology –Extrapyramidal Disorders Unit of the **1st and 2nd Neurology Department**, Medical School, University of Athens (partner No.13) which is a specialized unit for in and out-patient comprehensive evaluation of patients with MCI and different causes of dementia (e.g. Alzheimer's disease, Vascular dementia, etc) and movement disorders (e.g. Parkinson's disease). Athens trials run in the city of Athens and two of its suburbs: 1) at a specially adapted locus in the **University Campus** in Athens, 2) the Day Care Center of a non-profit organization for care in elderly people in **Glyfada "IASIS**" 3) in the Day Care Centers of the Athens Association of Alzheimer's Disease and Related Disorders (**AAADRD**) and 4) the primary care medical center of the **municipality of Holargos**.
In addition to the above 15 home installations were run in Athens, Thessaloniki and elsewhere in Greece.
Austria: The Municipality of Schwechat (LLM partner No.12) evaluated the LLM service in the **"Living Lab Schwechat"** in cooperation with the research institute CEIT RALTEC (LLM partner No.5). In Schwechat the LLM system was tested by five people with a focus on the deployment of the service in private households. All test participants live alone in their private homes where they perform the LLM training – consisting of physical and cognitive exercises – independently. Most of the features the independent living component offers are designed to provide additional support and safety for exactly this group of people. The LLM systems in Schwechat are thus deployed and evaluated with the highest possible range of functions.
Spain: INTRAS (LLM partner No.7) tested the LLM solution in three provinces of the region of Castilla-León (Zamora, Valladolid and Salamanca), which is the Spanish region with a high percentage of elderly people and in the city of Vigo. The LLM services involve 200 patients in 3 Memory Clinics, an Alzheimer's Center and 3 Residential Facilities. INTRAS, having developed its own software for memory training (GRADIOR), tested the physical component with both the BrainFitness software and the Gradior software. The BrainFitness was tested in one of the Memory Clinics and one Residential Facility while the Gradior was tested in the other 2 Memory Clinics, 2 Residential Facilities and the Alzheimer's Center. Pilot sites included: Memory Clinics, **Valladolid & Zamora; Alzheimer Reference Center, Salamanca; Residential Facility, Valladolid; Residential Facility, Zamora; Residential Facility, Vigo**.
Cyprus: University of Cyprus (LLM partner No.14) acted as pilot location for the LLM solution in Cyprus. The pilot locations were the Clinics and day care centres founded and supervised by the Cyprus Institute of Neurology and Genetics, as well as, a combination of senior centres, elderly nursing homes, and individual homes. The Independent Living Component (ILC) was installed in one house (room) located in **Pafos** area. The CTC intervention was performed in the two social services centre, in Nicosia and in Pafos area, in a comfort room equipped with 10 personal computers (PCs) and an equal number of headphones in groups of 10 participants maximum in each service centre. The second room was equipped with both the PTC equipment.

Lessons Learnt

The LLM project has provided a comprehensive approach to validation of the integrated solution, including technical, usability, marketability, and scientific aspects. A methodical evaluation process has been applied to arrive at the overall conclusion that commercial LLM deployment is feasible and that the potential for a sustainable business model is high. Key lessons learnt and their implications for the future development and deployment of LLM include:

Technology

- Broad distribution will require rigorous planning and testing to ensure availability of appropriately localized systems, including variable availability of hardware components.
- A formal product management approach is required to identify and prioritize technical and features/functions of the LLM service to support the future product development process.
- Organisational and technical infrastructure is required to achieve a supportable technical deployment, and to ensure systems are aligned with data protection regulations.

User Acceptance

- Participants were extremely positive in their responses (across all measures) of LLM. Approximately 84% of the participants who provided feedback described LLM as being easy to learn and use.
- Training with the LLM program made 94% of the participants feel mostly positive (they felt it was fun, they liked it, they felt cheerful after training with it, they felt refreshed and calm).
- 95% of participants believed that exercising through LLM was beneficial for them, most felt LLM was amusing and they enjoyed their sessions with it and LLM met their expectations. The majority of participants felt quite satisfied with LLM.
- In large part this positive user acceptance has led to the intention of several LLM partners to continue providing LLM services to users in the piloting environments for some time after the project's end (AUTH, NKUA, INTRAS, and UCY).
- Users have provided, throughout the project's term, specific feedback that has enhanced usability over the course of the project, and which will be examined to further improve the system in moving into a commercialization phase.

Scientific

- Combined physical exercise and Cognitive Training (full LLM), leads to significant improvements in both episodic memory (the capacity to learn and retain new information) and working memory (the capacity to hold and cognitively manipulate new information) in the elderly.
- Longer training durations and more training sessions induces stronger improvements of long-term memory function. Based on this we recommend a continuous training regimen which is associated with long-lasting memory improvements.
- Follow up measurements (which continue) are encouraging; they indicate that LLM effect lasts for 6 months; then users need to repeat LLM before 1 year elapses to continue to reap positive impacts.

Publication Plan:

LLM will seek top level publications in the following journals: Neuroscience & Biobehavioural Reviews (two review articles are in preparation); articles focusing on different aspects of the results in the Annals of Neurology, the Journal of Alzheimer's Disease, Biological Psychology, the International Journal Of Psychophysiology, Health Policy, JAMIA, IEEE Trans Inf, Tech Biomedicine and other technical journals.

Sustainability model & Contact info

The strategic impact of the LLM project lies on its ambition to proposing an innovative ICT solution towards the benefit of older people and especially those suffering from age-related cognitive decline. The feedback showed a great interest of public authorities and private institutions. Furthermore, quality aspects of the service and its benefits to elderly people were measured during the trials. Analyses of results demonstrate that seniors maintain their mental capacity and in most cases there seems to be an improvement between the pre- and post-neuropsychological assessments. Preliminary results also revealed that LLM is both useful and effective in terms of usability and adaptability to the users' needs. LLM will be marketed in two offerings, either as a full package (ILC+CTC+PTC) or a light one (CTC+PTC), in order to be able to address a wider market range, of care centres and homes that can afford a cheaper version of LLM service and do not need the independent living component.

Interested Citizens may visit the LLM web site or contact the LLM partner in their country, or visit our **Linked in group**, our **Facebook group**, our **Youtube channel** and our **Slideshare channel**.

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