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symbiosis

Alzheimer's Support

An Innovative Approach to Alzheimer's Support

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Problem Targeted

Alzheimer's Disease

Alzheimer's disease (AD), also known in medical literature as Alzheimer disease, is the most common form of dementia. There is no cure for the disease, which worsens as it progresses, and eventually leads to death. It was first described by German psychiatrist and neuropathologist Alois Alzheimer in 1906 and was named after him. Most often, Alzheimer is diagnosed in people over 65 years of age, although the less-prevalent early-onset Alzheimer's can occur much earlier. As the disease advances, symptoms can include confusion, irritability and aggression, mood swings, trouble with language, and long-term memory loss. As the sufferer declines they often withdraw from family and society. Gradually, body functions are lost, ultimately leading to death. Since the disease is different for each individual, predicting how it will affect the person is difficult.

Alzheimer develops for an unknown and variable amount of time before becoming fully apparent, and it can progress undiagnosed for years. On average, the life expectancy following diagnosis is approximately seven years. The cause and progression of Alzheimer's disease are not well understood. Research indicates that the disease is associated with plaques and tangles in the brain. Current treatments only help with the symptoms of the disease. They cannot stop or reverse the progression of the disease.

Alzheimer's disease is also known for placing a great burden on caregivers. Caring for someone with Alzheimer's disease impacts every aspect of daily life. As Alzheimer's patients lose one ability after another, caregivers face pressures wide-ranging from social, psychological and physical elements of the caregiver's life.

Moreover, Alzheimer is one of the most costly diseases worldwide. As it was stated at ADI (Alzheimer's Disease International) and WHO (World Health Organization) report launched on 11 April 2012, the worldwide cost of dementia is estimated to have been US\$ 604 billion in 2010, whereas according to Alzheimer Association in 2012, the direct costs of caring for those with Alzheimer's or other dementias to American society will total an estimated \$200 billion, including \$140 billion in costs to Medicare and Medicaid.

As the world population ages, we truly face a looming global epidemic of Alzheimer's disease. The number of people globally who are living with dementia in 2011 is estimated to be 35.6 million, and epidemiological studies indicate that this number is expected to grow at an alarming rate. It is estimated that numbers will nearly double every 20 years, to 65.7 million in 2030 and 115.4 million in 2050. Much of this increase will be in the developing countries, and will be due to the ageing population.

Proposed solution

Symbiosis: Overview

Within the aforementioned perspective, Alzheimer's is a global problem with dramatic impact and new approaches need to be considered regarding prevention, diagnosis, treatment, confrontation. Following the vision of World Health Organization and Alzheimer's Disease International for innovative approaches to

Alzheimer's Disease, our system, named **Symbiosis**¹, aims at creating a novel environment to facilitate, understand and incorporate the needs of the whole Alzheimer's community (patients, caregivers and doctors).

As for the patient, Symbiosis proposes a fruitful way of natural interaction through state-of-the-art technologies, such as augmented reality (AR) scenarios, body motion tracking and EEG signal processing. All activities from games to AR scenarios are designed and developed to meet the special needs of an AD patient with special emphasis given on the elimination of social exclusion. Mental and physical exercising, a sense of autonomy and increased self-confidence are the primary focus of all applications along with adaptation to personalized behaviour, preferences and needs. In this way, the patient's environment is normalised to his/her needs and not vice versa.

The patient progress is continuously monitored by both caregiver and doctor, offering valuable feedback information that helps them schedule the therapy plan and daily routine and perform the system appropriate adjustments according to it. Moreover, extra services are available for the caregiver including emergency notification from mobile application as well as consulting and psychological support at a specialized forum community.

Symbiosis provides the bed-set not only for exploration of team's abilities to think about and re-design Alzheimer's approach, but also to understand and integrate the needs of the whole community involved i.e., patients, caregivers and doctors, in a joint attempt to facilitate easing of their suffering, provide efficient monitoring and contribute to a better quality of life.

Project Goals

- Establishment of a novel, holistic approach to the special needs imposed by Alzheimer's disease, offering services and tools at three different groups involved in the problem, i.e., Patients; Caregivers; and Doctors.
- Personalization to each patient's specific characteristics through system adaptation and self-regulation procedures.
- Development of adapted user's scenarios following the patient's profile and schedule.
- Assistance to caregiver for preparation, customization and optimization of patients care and monitoring procedure through a continuous update about their progress via well-managed Web Services.
- Doctors' updating via reporting material with statistical analysis options.
- Emphasis on patient's autonomy from caregiver.
- Alleviation of negative feelings and contribution to the sustenance of quality of life in an environment that promotes the real concept of Symbiosis.

Symbiosis Description

Related Theory & Architecture

Alzheimer's Disease is divided into 3 stages with progressive patterns:

¹ Symbiosis (Greek Συμβίωσις), means companionship, from symbioun, to live together, from symbios, living together: syn + bios (life).

- The preclinical stage with no symptoms (45-55 yrs)
- The mild cognitive impairment or MCI with mild mental symptoms (55-70 yrs), and
- The severe fatal stage of the disease (>70 yrs)

Technology can contribute significantly to the problem of Alzheimer's by offering solutions at the MCI stage of the disease. The most significant skills affected at this stage of the disease are: *memory, attention, orientation, visual perception and space perception.*

Based on this fact, and taking into account design considerations, such as customization, extensibility and user-friendly interfacing, we developed a modular architecture consisting of 3 modules with diverse functionalities, i.e., the patient module (P); the caregiver module (C); and the doctor module (D).

All three modules are interconnected and exchange information through Microsoft cloud platform, Azure, supporting in this way the idea of a real Symbiosis (see Fig. 1).

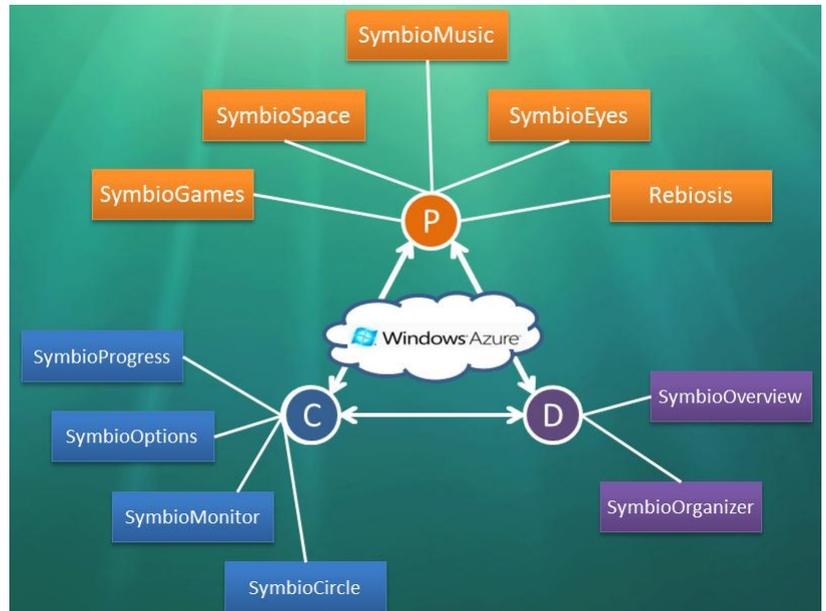


Fig. 1. The modular architecture of Symbiosis and its "Symbiotic" space.

Application components

The main user-interface of Symbiosis is depicted in Fig. 2.

- **Symbiosis Patient Module**
 - **SymbioGames**

SymbioGames is a gaming suite that offers a wide range of games aiming at exercising and improving skills such as memory, attention, orientation, visual and space perception that gradually decline at the MCI stage of the disease. Furthermore, the novel human-computer interaction strategy using Kinect sensor provides a natural user interface (NUI) that introduces the idea of combined physical and mental exercise (Fig. 3).



Fig. 2. The main GUI of the current version of Symbiosis.



Fig. 3. The NUI of SymbioGames suite (left) when targeting a flying bird and revealing a puzzle-photo from the past (right).

○ **SymbioSpace**

SymbioSpace application, using auxiliary auditory and visual effects forms a friendly environment for the patient via augmented reality (AR). It offers patient the opportunity to feel surrounded by a helpful environment that provides feedback and seems to interact with him/her responding to his/her needs for continuous reminding and memory refreshing (Fig. 4).



Fig. 4. Using AR glasses (left), Symbiospace provides to the user additional information for simple tasks, e.g., eating with spoon (right).

○ **SymbioMusic**

Music has power—especially for individuals with Alzheimer's disease and related dementias. And it can spark compelling outcomes even in the very late stages of the disease. When used appropriately, music can shift mood, manage stress-induced agitation, stimulate positive interactions, facilitate cognitive function, and coordinate motor movements. Based on this fact, SymbioMusic offers a variety of musicotherapy scenarios that activate musical expression using Kinect sensor combining music revival and memory refreshment (Fig. 5).



Fig. 5. Using just body movements, SymbioMusic provides to the users (right) collaborative music production with percussions (center).

○ **SymbioEyes**

SymbioEyes incorporating automatic photo shooting, GPS tracking, activity reminder, emergency detection and call, is the all-in-one patient mobile application (Fig. 6-top).



○ **Re-biosis**

Re-biosis application downloads automatically from the cloud all photos taken by SymbioEyes application and creates slideshows. While these slideshows are presented to the patient, the photos are subjected to an emotional tagging procedure stemming from EEG signals processing that takes place at the background. The EEG signals are acquired through Emotiv EPOC headset (Fig. 6-bottom).



Fig. 6. SymbioEyes monitoring patient's location and status (top); Re-biosis captures the emotions of routing photos and uses the positively tagged ones for re-biosis of the causality of the routing, for efficient memory enhancement (bottom).

○ **Symbiosis Caregiver Module**

○ **SymbioSchedule**

Balancing the enormous task of caregiving with other responsibilities, requires diligent planning and organization. SymbioSchedule was developed to meet exactly this requirement. It contains the activity program for the patient as it is scheduled by the doctor.

○ **SymbioProgress**

Also, one of the main aspects of caregiving is the need for constant monitoring. SymbioProgress constitutes the monitoring tool for the caregiver offering an effective overview of patient's progress, as it is depicted through statistics on patient's interaction with **Symbiosis** applications (Fig. 7-top).

○ **SymbioOptions**

Moreover, to achieve personalization and customization of all Symbiosis applications, SymbioOptions provides a control panel where the caregiver can add audiovisual material and adjust the settings of patient's applications.

○ **SymbioCircle**

Grief, depression and anger are common among caregivers making psychological support more than necessary. SymbioCircle is **Symbiosis** forum, where caregivers can find online advice and psychological support as well as exchange opinions with other caregivers who share similar experiences (Fig. 7-bottom).

○ **Symbiosis Doctor Module**

○ **SymbioOverview**

SymbioOverview enables the doctor to have a detailed and daily statistical overview of every patient's progress, compare the progress of many patients and easily categorize them. Since each doctor has many patients, SymbioOverview enables the doctor to have detailed statistical overview of every patient progress in an easily organized and categorized way (Fig. 8).

○ **SymbioOrganizer**

Using SymbioOrganizer the doctor can adjust the activities parameters according to each patient's profile.



Fig. 7. SymbioProgress provides statistics on patient's interaction with Symbiosis (top); SymbioCircle is the Symbiosis forum for caregivers exchanging experiences and opinions (bottom).



Fig. 8. SymbioOverview provides to the doctor statistics on patient's progress.

Products & Services versions

Symbiosis software could be promoted in different versions, each with different applications and hardware components as depicted in Table 1. From the latter, the Symbiosis Basic includes Kinect as the only hardware module and has some limitations in the functionality (targeting mostly the mean user); Symbiosis

Table 1. The Products and services versions of the Symbiosis project, their functionality and their estimated cost.

Products & Services				
Symbiosis Applications/ Hardware	Symbiosis Versions			
	Symbiosis Basic	Symbiosis Pro	Symbiosis Mobile	Symbiosis Net Apps
SymbioGames	✓	✓		✓
SymbioSpace		✓		✓
SymbioEyes	✓	✓	✓	
Re-biosis		✓		
SymbioMusic	✓	✓	✓	
SymbioMonitor	✓	✓	✓	
SymbioOptions	✓	✓	✓	
SymbioProgress	✓	✓	✓	
SymbioCircle	✓	✓		
SymbioOverview	✓	✓	✓	
Kinect	✓	✓		
Emotiv		✓		
ARglasses		✓		
Cost	\$480	\$1450	\$3-10	\$15-20

✓ Limited functionality ✓ Full functionality

Pro is mainly for Alzheimer's centers with full hardware and functionality; Symbiosis Mobile apps are available at the MS Marketplace², whereas the Symbiosis Net Apps is planned for forthcoming developers that could create applications as plug-ins for the Symbiosis platform, according to specific calls/requirements by the Symbiosis team (technical needs) and the collaborating physicians' committee (medical needs).

Technologies used

Cloud computing: MS Azure Platform - **Development Tools:** Visual Studio 2010 Professional - **Other Technologies:** .NET Compact Framework 4.0, Windows Mobile 7.5, Windows 7 Business Edition, C#, XML Web Services, ASP.NET, Silverlight, Windows Presentation Foundation, Bing Maps 3D, Windows Communication Foundation, Expression Blend - **Hardware:** MS Kinect, Emotiv EPOC headset, AR glasses, Windows phone.

Assessment of the opportunity for impact

Innovation Degree and Effectiveness

Symbiosis is a revolutionary system aiming at providing integrated solutions to a series of problems related with Alzheimer. It is the first integrated Alzheimer support system that takes into account patient's response in an adaptive way that fulfills each patient's special needs and provides to caregivers and doctors considerable facilitations. Until now, all technological solutions addressing Alzheimer's, focus on the satisfaction of a specific need. Using cutting-edge technology, **Symbiosis** provides a holistic approach to the problem which deals with the needs of all groups affected by Alzheimer's Disease, both literally and metaphorically. Emphasizing on normalization and personalization, **Symbiosis** proposes a more effective, realistic and complete technological solution.

² In a broader version of Symbiosis, the *iStore* and *Google Play* internet-based markets would also be incorporated.

Impact created

Alzheimer's Associations worldwide refers to Alzheimer's Disease as an epidemic and both medical community and society agrees that Alzheimer's constitutes the great challenge of the 21st century. The World Health Organization characterized Alzheimer's as "a public health priority" and called governments to act on dementia. Moreover, the economic cost related with the disease exceeds \$200 billion per year only for USA, whereas the psychological and emotional cost cannot be quantified. **Symbiosis**, by providing innovative solutions that facilitate all the social groups affected by Alzheimer's directly or indirectly, holds the potential to change/improve drastically their lives. **Symbiosis** provides technological solutions that act as facilitator to the social integration of AD community. The AD patients have greater autonomy, they feel more active through NUI-based gaming/music production and show a collaborative attitude with caregivers, doctors and friends/AD groups. Moreover, caregivers use Symbiosis as an information source about the status of their AD patients and as a means to come even closer by sharing and discussing related problems with a broader community. Finally, physicians handle more AD patients and monitor them more closely, increasing their awareness and their assistive intervention in the AD patients' living.

Performance indicators

The Symbiosis project success will be measured through the project management success (PMS) and project product success (PPS). PMS focuses on cost, time and quality, indicating the degree of the 'efficiency of project execution'. To this end, metrics upon the dimensions of 'within time', 'within budget', 'according to requirements' (quality and functional specifications), 'quality of the project management process' and 'satisfaction of the project member's expectations' will be adopted. PPS focuses on the effects of the project's end-product. Hence, metrics upon System Quality, Information Quality, Service Quality, Information Use, Intention to Use, User Satisfaction, and Net Benefits will be used, following the steps from system creation, experience, and organizational impacts. Moreover, metrics that directly relate to AD patients' deficiencies, like pre- and post-testing of memory sustain, mental efficiency, spatial perception, emotional engagement, and interaction engagement, would provide quantitative performance indicators of the real beneficial effect of Symbiosis in the AD community (see example in the pilot-case study, Fig. 9).

Updates and Improvements of current solution

- Cross-case testing and evaluation of the feedback from the target group, regarding the expandability and functionality of **Symbiosis**, gained through ongoing contact with AD patients, caregivers and doctors at the Alzheimer Center of Thessaloniki and abroad
- Extension of **Symbiosis** to a multilingual system enabling international use.
- Further increase in the variety of games, exercises and AR scenarios.
- Further customization of tasks and scenarios to different Alzheimer's sages and behaviors.

Outline of progress

Microsoft Imagine Cup 2012

Symbiosis Team, with the homonym project participated at Microsoft Imagine Cup 2012 Greek Finals, where it got the First Place and advanced to the Worldwide Finals, Software Design competition at Sydney, Australia (July 5-9, 2012), representing Greece. **Symbiosis** scored at the top 6 teams of the competition out of 75 teams worldwide.

Pilot Case Study

Symbiosis was designed and developed in collaboration with Dr Magda Tsolaki, Neurologist, Professor and Chair, 1st Federal Alzheimer Disease Division. A pilot case study of Symbiosis applications involving 20 MCI patients(ages 58-70) was conducted at the two Alzheimer's Care Centers of Thessaloniki, Greece. Applying interaction engagement metrics pre-

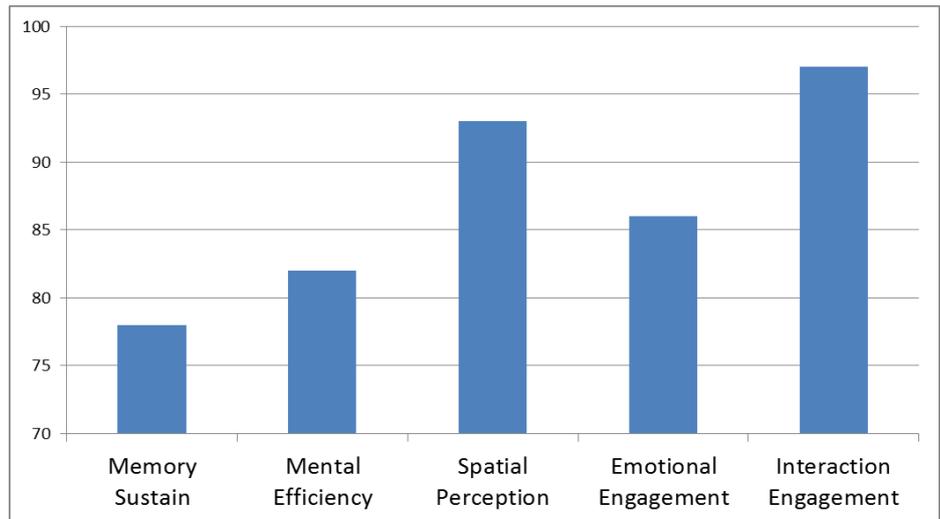


Fig. 9. Mean improvement percentages of five performance indicators between pre- and post-usage of Symbiosis by 20 MCI AD patients.

and post-using Symbiosis, involving: a) successful usages per day/month, b) duration of use, c) recency of use, d) frequency of application abandonments; the results depicted in Fig. 9 have derived. The latter indicate that the use of Symbiosis severely helped the AD patients to increase their spatial perception (mainly due to its NUI) and their interaction engagement (mainly due to the gaming and experiential way of interacting), assisting also to emotional engagement (due to the emotional tagging of images), mental efficiency (due to cognitive games and routing exercises), and memory sustain (due to causality enhancement of actions and relations). These encouraging results foster our motivation to continue the development of Symbiosis, so it could reach a broader user space and assist as many ADs as possible.

Milestones

The milestones schedule of Symbiosis that follows (Table 2) indicates our emphasis on planning for reaching AD's community less than one-year's time, with the transfer from the current prototype version (Symbiosis v0.5) to the commercial one (Symbiosis v1.0).

Table 2. The provisional milestone schedule of Symbiosis.

Month	Milestone	Description
October/November 2012	Patent Preparation/Submission to Industrial Property Organization	IP Protection Initiatives
November 2012	Showcase is available on the Internet	To increase visibility on the Web
December 2012	Startup Funding	To cover initial expenses for starting up
January – October 2013	Ongoing Research	Research for Rebiois and SymbioSpace concepts (Includes EEG analysis, AR glasses improvement)
January 2013	SymbiosisMobile-Pilot Case Study	This includes the Mobile application of Symbiosis, that monitors in real-time the AD's patient location and sends status warnings/alarms to the caregiver
February 2013	SymbiosisMobile-Evaluation	Pilot AD users will evaluate the SymbiosisMobile v1.0 and provide feedback
March 2013	SymbiosisMobile v1.0-Release	Official Release of SymbiosisMobile v1.0
May/June 2013	SymbiosisBasic-Pilot Case Study	This is the basic version of Symbiosis, where basic functionality of SymbiosisMobile and Kinect-based interfacing are included
July 2013	SymbiosisBasic-Evaluation	Pilot AD users will evaluate the SymbiosisBasic and provide feedback
September 2013	SymbiosisBasic v1.0-Release	Official Release of SymbiosisBasic v1.0
November 2013	Research Results Evaluation	Evaluation of all research results
December 2013	SymbiosisNet v1.0	This refers to a Symbiosis marketplace, where other developers could contribute to Symbiosis modules (e.g., new games pallet) according to specific guidelines and doctors' approval

Longterm Milestones:

- 1st Semester 2014 : Pilot Case Study and Evaluation of SymbiosisPro (This is the full version of Symbiosis, where all Symbiosis modules are functional and Kinect-, Emotiv- and AR-based interfacing are all included, incorporating the Research results.)
- 2nd Semester 2014 : Release of SymbiosisPro v1.0, with availability to all users via internet and AD's centers

Team members & Symbiosis' roles



Symbiosis Team (L2R): Dimitris Mandiliotis, Leontios Hadjileontiadis, Kostas Toumpas, Kiki Kaza, and Katerina Kyprioti.

Dimitris Mandiliotis (July 6, 1990) is an undergraduate student at the Electrical & Computer Engineering Dept. of Aristotle University of Thessaloniki. His main interests include communications, signal analysis and mobile devices programming. He is member of the R&D team Symbiosis that ranked among the top 6 teams at Microsoft Imagine Cup 2012 Worldwide Finals, Software Design. He is Vice-President at the IEEE Student Branch of AUTH, is member of various volunteer teams of Thessaloniki and has much experience in organizing scientific and other events. He is also student at the piano class of State Conservatory of Thessaloniki and has diplomas in music Harmony and Counterpoint. He acts in Symbiosis as a software designer/developer.

Kostas Toumpas (November 21, 1990) is an Undergraduate Student at the Dept. of Electrical & Computer Engineering of Aristotle University of Thessaloniki, studying in the Faculty of Engineering. He is a member of team Symbiosis that finished first in the Microsoft Imagine Cup 2012 Regional Finals in Greece and was a finalist in the Microsoft Imagine Cup 2012 World Finals finishing in the top 6. He has submitted a paper, titled "Exploring Optimization Strategies in Board Game Abalone for Alpha-Beta Search" to IEEE CIG 2012, that has been accepted. He was a member of the department's Software Group "DECODE" participating in the organization of the Seminar "Developing Web and Mobile Applications" and he has also participated in the IEEExtreme 5.0 with team ProBusters. He acts in Symbiosis as a game designer/developer.

Katerina Kyprioti (November 7, 1990), is an undergraduate student at the Electrical and Computer Engineering Department of Aristotle University of Thessaloniki, Greece. In 2008 she obtained Apolytirion, a monetary award as part of the sponsorship program "The Great Moment for Education" of Eurobank EFG due to the best GPA and enrolled to the EE Department. She was for 2 years in Software Group DECODE of the department and participated in the organization of the Seminar „Developing Web and Mobile Applications“ based on student initiative. In 2011 she participated in the IEEExtreme 24-Hour Programming Competition as member of „ORama“ Team, with World/Country/University Ranking: 146/3/3 and in 2012 was among the top 6 teams in the World Finals of Microsoft Imagine Cup 2012 (Software Design) Competition as member of „Symbiosis“ Team. She acts in Symbiosis as a network-database-data security designer/developer.

Kiki Kaza (July 27, 1990) is an undergraduate student at the Electrical & Computer Engineering Department A.U.Th. In 2009, she was awarded by the President of the Hellenic Republic, K. Papoulias, for scoring the first grade in Greece at the Greek university entrance examinations. Her interests rest in the area of affective computing and biotechnology and in 2010, she attended as a COST grant student the 5th International Summer School on Emerging Technologies in Biomedicine in Patras. Since 2010, she is secretary at the IEEE Student Branch A.U.Th. and leading member of the software group DE.CO.DE participating in the organization of technical seminars and other activities. She has also participated in IEEExtreme 4 & 5, international programming competitions, scoring 179/1515 and currently is member of the R&D team Symbiosis that ranked among the top 6 teams at Microsoft Imagine Cup 2012 Worldwide Finals, Software Design competition in Sydney. She acts in Symbiosis as an architecture designer/developer.

Leontios Hadjileontiadis (March 14 (π), 1966) is an Associate Professor at the Dept. of Electrical and Computer Engineering of Aristotle University of Thessaloniki, Greece, where he acquired both his Diploma and Ph.D. Degree. He is a faculty member of the Signal Processing and Biomedical Technology Unit, with a vast research experience in Biomedical Engineering and Human-Centered technologies. He is an IEEE Senior Member. Since 2004, he serves as a mentor to student teams that excelled in the worldwide Imagine Cup Competition (Microsoft) with projects involving technology-based solutions for people with disabilities. This year, Prof. Hadjileontiadis was the recipient of the Microsoft Imagine Cup 2012 Faculty Champion Award. He also holds a Diploma in Musicology and a PhD degree (University of York, UK) in music composition. He acts in Symbiosis as a concept/idea founder and team mentor/project manager.

Useful links:

<http://www.e-symbiosis.gr>

http://www.e-symbiosis.gr/Symbiosis_v0.1/Demos.html (for some demos previewing)

<http://www.facebook.com/SymbiosisAlzheimerSupport>