Education and Culture DG
Lifelong Learning Programme

LARGE PROJECT

Learning Augmented Reality Global Environment

LIFE LONG LEARNING PROGRAMME – KEY ACTIVITY 3 ICT

[DURATION: November 2011 – October 2013]

SYSTEM DESIGN METHODOLOGY

[WORK PACKAGE 4: System design / Deliverable 1]

PREPARED BY THE PROJECT CONSORTIUM

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REVISION HISTORY

REVISION NUMBER	DATE	COMMENT
1.0	March 30th, 2012	System Design Methodology- Deliverable 1 of WP-4- System Design

Contents

WP 4- SYSTEM DESIGN

The purpose of this WP is to provide the necessary description of the design of the proposed solution. Having in mind the general direction of the desired solution – creating and using a Learning Augmented Reality Global Environment (LARGE) for a new type of education/training, there is no known system design methodology, which can be applied.

This WP 4 consists of 5 deliverables:

- D4.1- System Design Methodology
- D4.2- Detailed Design of the Platform
- D4.3- Detailed Design of the CTM
- D4.4- Platform Prototype
- D4.5- Development project team meeting

The system design methodology (deliverable 4.1) covers the things as follows: feasibility study, existing environment study, functionality of the software, requirements specification, technical system options and logical design.

Next step after creating the system design methodology is to implement it for the particular design. LARGE detail design covers the **specifications** of LARGE platform (deliverable 4.2) and the Content Tool Manager (deliverable 4.3). The detail design of the LARGE platform corresponds to the identified requirements, summarized during WPs 2 and 3. The platform detailed design defines the **architecture** of the platform, **technologies** that will be used during the development phases, system **capabilities** and **functionalities**, development **standards**, definition of **users** and their roles into the system, definition of **content types** and their characteristics, definition of **system requirements** for implementation of the platform, **test methods** to be used in quality assurance. The Content Tool Manager's (CTM) detailed design describes the **characteristics** of CTM (deliverable 4.3) – how will it work and what users will be able to do with it.

Aiming to have a most effective and clear system design, facilitating the system development phases, and to ensure a higher quality of the system, as a part this WP 4- System Design- a prototype of the system is created (deliverable 4.4), which visualizes and simulates the operational characteristics of the system/software.

DELIVERABLE 4.1- SYSTEM DESIGN METHODOLOGY

Brief project determination and definition: Knowledge is a key issue in the Europe 2020 Strategy. One of the priorities of the strategy is smart growth is driven by complex interactions between technical, social, economic, and human factors. The project - **Learning Augmented Reality Global Environment (LARGE) -** is designed to create a new type of learning environment that support the educational/training institutions in delivering their curriculum in the most attractive and effective for the learners way. The Augmented Reality is an innovative technology, which is

used in many areas of the social and economic life – marketing and advertising, entertainment industry etc., but is poorly used for educational purposes – only in some individual cases due to its complex nature. Aim of the project is to build a global environment, based on this technology, simplifying the process of augmented reality content creation, allowing all educational/training institutions to benefit from its undoubted advantages. This Global Environment consists of a platform, serving as a basis for the system and an integrated content development tool- Content Tool Manager, which will allow the creation of appropriate educational/training AR content by the target groups.

From the end users' point of view the system could serve:

- as a web based platform, using Internet connection (Online);
- as a computer based platform (Intranet- local networks- Offline);
- to create augmented reality applications on their own using the development part of the platform.

The System Design Methodology (Deliverable D4.1)- **covers** the things as follows:

1) Study and analysis of the necessity and the goals of the system
2) Existing environment study – as the software is innovational, how it will be implemented by organizations. This will answer the questions how existing learning models will be implemented in the new system, what is applicable and what is not;
3) Functionality of the software – what the system will do, how users will interact with it, how it will be distributed, what will be its impact;
4) Requirements specification – full logical specification of the system;
5) Technical system options – definition of hardware, software, resources needed;
6) Logical design – this stage defines the main methods of interaction in terms of menu structures and command structures. The outcome of this stage is a data catalogue

1. STUDY AND ANALYSIS OF THE NECESSITY AND THE GOALS OF THE SYSTEM

There are 2 items to reveal:

- technical aspect (development)
- and organizational aspect (user implementation).

1.1. THE NECESSITY OF THE SYSTEM

The typical structure of AR system, described in many resources, is shown on Fig. 4.1

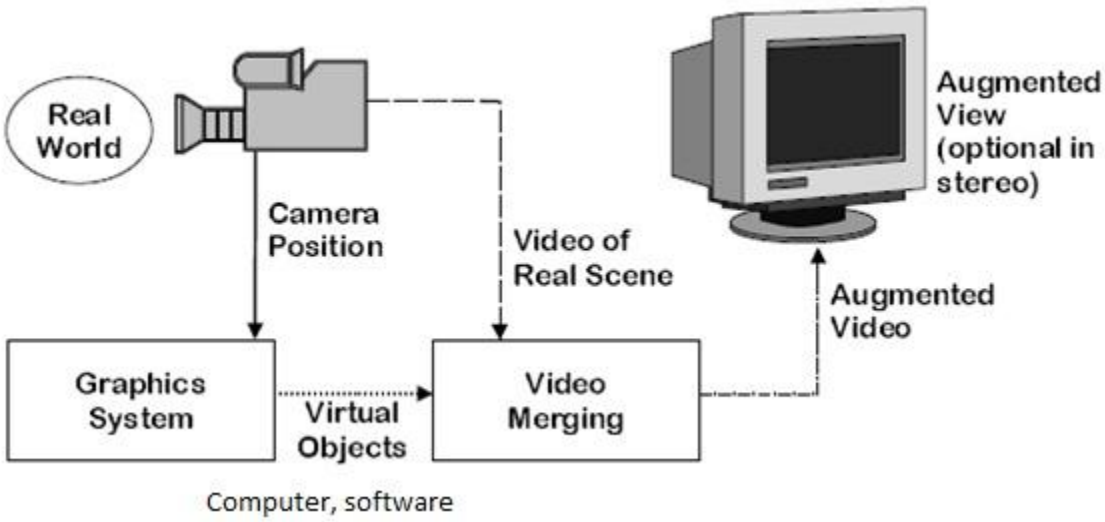

Fig.4.1.

Specifically, AR has the potential to engage and motivate learners in exploring material from a variety of different perspectives that would have otherwise not been possible in the real world. AR is a variation of Virtual Reality (VR) that also uses virtual objects. However, AR differs from VR in that AR is a mixed reality that combines the real and virtual imagery, while VR immerses the user inside a computer generated virtual environment. Hence, AR *supplements* reality rather than *supplanting* it. ***AR bridges the gap between the real and virtual world in a seamless way***.

1.2. THE GOALS OF LARGE SYSTEM

The **general goal** of LARGE system is to develop a software platform, which will realize the augmentation of the learning and the educational processes.

This platform needs to allow users to operate in a ubiquitous computing environment. LARGE system will support the project target groups in educational content presenting in a qualitatively new way through providing of more influential, completely realistic, individualized and flexible training approaches and improvement of their abilities for delivering an optimized education, professional qualification and for better inclusion and placement of the learners on the labour market through developing and exploiting innovative ICT services for lifelong learning.

1.3. TASKS OF LARGE SYSTEM

The **project's concrete tasks** are:

1) to raise the attractiveness and thus the effectiveness of the educational resources and the education in general;
2) to bring the education closest to reality;
3) to increase the motivation of all parties in the educational/training process;
4) to stimulate the creativity of both educators and learners;
5) to support and encourage the discovery based learning, through effective usage and understanding of any kind of information around us.
6) to improve the current education/training processes by establishment of an appropriate environment for multi-dimensional learning. It will increase the effectiveness of the educational and training process and will improve the communication an interaction between learners and educators all over Europe.

1.4. USER INTERFACE AND EXPERIENCE

Tracking and visualization are only a part of the aspects of Augmented Reality. There are several contributing technologies that have to be combined.

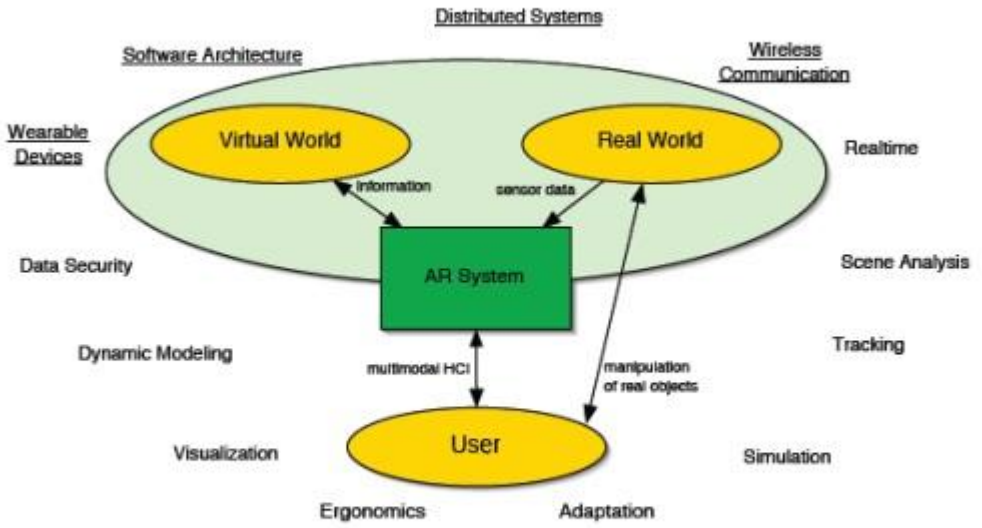

Figure 1.3: Informal model of Augmented Reality as multi-medial combination of real and virtual world data [76].

Fig. 4.2

Figure 4.2 shows an informal model of an Augmented Reality system that combines real world and virtual world objects (or data). Real world data are accepted over webcamera and data of the virtual world are queried from an information system- computer or server- hosting. Real and virtual data are combined in human-computer interaction (HCI) devices.

2. EXISTING ENVIRONMENT STUDY

It is well known fact that the educational institutions still are relatively slow in adopting information and communication technologies. What's wrong with today's schools? Even the most modern, advanced educational institutions (universities) are frustratingly outmoded in terms of teaching students. The entire process of giving lectures, taking notes, reading facts from books, and taking final exams is a throwback to institutions of learning dating back to the Renaissance. Remarkably, very little has changed today: with notable exceptions, the vast majority of university professors continue to bore students with ineffective, non-interactive approaches to education that result in little more than the professor's notes becoming the students' notes without passing through the minds of either.

Informational technologies started their entering in the learning and education processes. What is already in use are:

- Internet content demonstration;
- Digital presentation, audio and video content;
- Moodle platform;
- Interactive boards.

As an emerging technology AR promises to radically enhance both the quality and "bandwidth" of educational processes. A tiny computer, perhaps worn on the wrist or around the waist, would recognize the geometry and content of the user's immediate environment and overlay that environment with meaningful images and sounds for a specific purpose.

From the user's point of view, he or she would apparently see and hear other people, objects, or events taking place right in front of or around them. These augmented perceptions would appear to be completely real. In technical terms, they would be rendered by the wearable computer with light shading that takes into account both the ambient and directional light sources found in the user's immediate environment.

But these rudimentary applications are just the beginning. The more advanced applications of augmented reality have to do with learning. Augmented reality technology holds the promise of immersing individuals in experiential learning environments. Instead of reading about the Civil War in a textbook, a student could observe battles or conversations as if they were there. Animated, lifelike historical figures would seemingly appear right in front of them. The student would see and hear events at a level unmatched by today's outmoded lecture formats.

The applications are tremendous: students could learn anatomy by walking through a human body and observing the functioning of biological systems. Students could learn geography

by "flying" around the globe, visiting any city they wished, zooming in and out of detailed renderings of geopolitical regions. Students could learn chemistry by observing, at a simulated microscopic level, chemical structures and reactions. These are but a few of the many potential applications.

The big advantage of LARGE is that it allows a soft transition from a current learning models to new, augmented ones. The core curriculum of the content would be like this which is in use. The LARGE will expand the scope and the deepness of the educational process:

- ✓ LARGE system has important implications for education. It holds potential for enhancing learning and teaching in the area of educational technology.
- ✓ However, despite the fact that many AR researches have been done, AR learning in a real classroom setting is still at its infancy. The effectiveness of AR in enhancing teaching and learning still needs to be further researched by assessing learners' levels of involvement and motivation. The integration of AR systems with the traditional learning and teaching pedagogy needs to be carefully designed and evaluated.
- ✓ LARGE provides a simple way of progressing to the teaching, learning and training in education.
- ✓ Lastly, the cost and other issues associated with mass deployment of AR systems still need to be addressed.

Barriers in front of the educational bodies for widespread adoption of AR

- ✓ Regulation - particularly people & place recognition services, not on Gov radar yet?!
- ✓ Poor User Interface (UI)- cluttered screen & hard to navigate
- ✓ Perception - AR perceived as superficial &dubious value by consumers
- ✓ Experience – Some applications need bigger processing power – some apps run at below 7 frames per sec, battery drain etc.
- ✓ The open tools are a little clunky & definitely buggy

What will drive widespread adoption?

- ✓ Value - That AR is seen as a useful life & entertainment addition. Better education
- ✓ Better User Interface - larger screens, wrap glasses and tablets (see Gary's video)
- ✓ Social Integration- Foursquare/Gowalla meets Layar/Junaio = TagWhat, Urbanspoon etc:
- ✓ Experience - Richer 3D game-like applications, faster FramePerSecon, more natural recognition. Lock-on improved using combinations of GPS, WiFi & 3/4G

- ✓ Ubiquitos - Average prediction of users of ARto be greater than 50% in 2 years (2012). Already most location browsers are on Android, iPhone & Symbian

3. FUNCTIONALITY OF THE SOFTWARE

3.1. WHAT WILL LARGE SYSTEM DO?

1) **Augmented Reality** is to superimpose graphics over real-world environments in real time.
2) **In Flash**, this is usually done with a webcam and a marker card. When you hold the card up to the webcam, Flash is able to detect the orientation of the marker and superimpose, in this case, a 3d model and video and picture on top of it.
3) **FLARToolKit or FLARManager** are the names of the Libraries, written by Actionscript which will be used in order to implement AR in our project. This library was created by Saqoosha and is based on NyARToolkit 2.0.0. It is available as open source under the GNU General Public License
4) **PV3D** is the abbreviation of Papervision 3D. This is a realtime 3D engine also available as open source from here. Another option is to use Away 3D engine.
5) The system will support the users during the preparation of **3D content** of AR scenarios. This means using of suitable 3D graphic software program and export 3D materials in a needed format to LARGE software.

The software which will be developed for this project must give the capabilities to operate as follows:

I. Creating/developing AR applications, which includes:

1. -camera parameters setting;
2. -creating markers (black&white)- flat 2D image triggers;
3. -registering these markers;
4. -internally developing of AR applications for computers users with Windows OS, which allows:
    - -adding **3D objects**;
    - -adding **video**;
    - -adding **2D pictures**.

II. Deployment of the developed applications on computers with Windows OS (offline), or web based (online) using of the applications, allowing

1. real time markers **recognition**
2. real time 3D content, video and 2D objects **rendering**.

III. Managing the content, needed for AR scenarios.

This includes a preparation of:

- 3D objects;
- 2D materials- pictures, text;

- Video;
- Audio- sounds, effects.

The Content Tool Manager, which will be developed, will service for arrangement of the above listed ingredients of the content.

3.2. THE INTERACTIONS OF THE USERS WITH LARGE SYSTEM

The **educators** will use the system as follows:

-offline during the lessons;
-for creating applications;
-for sharing applications;
-they are able to use the system online if they need it.

The **learners** will use the system as follows:

-offline and online for educating;
-for creating applications;
-for sharing applications.

3.3. THE DISTRIBUTION OF LARGE SYSTEM

As it was mentioned in item 3.2, the main ways to distribute LARGE are:

-Online- web based;
-Offline (standalone).

The using of online or offline modes are both for using and/or creating applications and/or sharing them.

3.4. LARGE SYSTEM IMPACT

There are 2 possible directions of LARGE system impact and scope:

- Horizontal;
- Vertical.

Horizontal means to enlarge one and the same educational content between more communities, schools, universities, etc. As an example- geography content to penetrate to attract more users no matter what school/university/group they attend.

Vertical means to create more and more examples for one and the same educational course.

4. REQUIREMENTS SPECIFICATION

The scope of LARGE system and the preliminary requirements are shown in Table 4.1.

Table 4.1

Requirements	Subsystems/ Processes belonging to LARGE			Do not belong LARGE software
	AR Creator	AR Deployer/Installer	Content Tool Manager (CTM)	
Marker drawing	No	No	No	By 3rd party simple editor
Creation and registering the marker	Yes	No	No	No
Setting camera parameters	Yes	No	No	No
Developing tracking scenario	Yes	No	No	No
Developing AR scenario	Yes	No	No	No
3D object designing	No	No	Yes	By 3rd party 3D software
3D object exporting for AR purposes	No	No	Yes	By 3rd party 3D Collada exporter
Adding 3D objects	Yes	No	No	No
Adding 2D objects	Yes	No	No	No
Adding video	Yes	No	No	No
Adding effects- lights, sounds,	Yes	No	No	No
Programming on Actionscript	Yes	No	No	No
Constant testing the current state of the application	Yes	No	No	No
Rendering	Yes	No	No	No
Exporting the final application	Yes	No	No	No
Creating output executable file for offline usage by computers	No	Yes	No	No

Creating output resource folder for online usage	No	No	No	No

5. TECHNICAL SYSTEM OPTIONS

No special equipment is needed. LARGE as a platform and the software for preparing and deploying the AR educational applications will use standard PC and laptops computing system, possessing web- cameras and standard monitors/screens.

5.1. HARDWARE MAPPING

A PC computer or laptop web camera is obligatory. LARGE system is using under Windows OS.
For online deployment the browsers like Mozilla, Internet Explorer and Google Chrome is planned to be used
Flash player is a tool, which is used for playing the AR scenarios of the applications.

5.2. SOFTWARE MAPPING

We present an abstract software mapping, based on the notion, that the core of the software of LARGE is Flash technology.

Why Flash?

I. FLASH SETUP

1. We simply create a Flash 'container', which links to a Flash Script file which has that runtime script and links to an attached the "ready to go" code libraries which are:
2. Flex SDK lib – which embeds AR data inside flash handless detection
3. Papervision3D code – deals with the import, position and rendering of 3D models

II. MARKER SETUP

The simple steps once you have the Flash hierarchy ready are:

1. Design a marker, start the MarkerGenerator.air application.

2. Hold up your paper pattern to the camera, when it is 'red' highlighted click save pattern.
3. Save it as FLARPattern.pat in the FLAR folder. Check your new pattern works

III. MODEL /content SETUP

For the purposes of this demo we are going to only originate a single static 3D model. This ready to go AR bundle is scripted Papervision3D models in the 'collada' 'digital asset exchange' format. You have two options to create a replacement model in your project

1) Use the free tool SketchUp 7 thttp://sketchup.google.com/ (installer in folder) make or get "ready made" models from http://sketchup.google.com/3dwarehouse/ (within the tool) and export as a collada model (triangulate, only selection and texture mapes)
2) Note generally use a low polygon count (less than 1500) & low rez texture files. Blender, 3dsMax and Maya and others can be used for this
3) Place new 1) 3D model, 2) textures and 3) txt files in the 'models' folder - to save time give the model the same name as the one already in there 'model.dae' (perhaps you might like to rename the other one to 'model0.dae' for example). Also place associated textures in the 'images' folder and the textures.txt file, the level above in the 'models' folder.

6. LOGICAL DESIGH

6.1. APPROACH

A key concept in LARGE designing, is the notion of software architecture. A well-known concept to handle the complexity of systems is to divide the problem into several parts. Applying this concept to software architectures we identify 3 main parts of LARGE software architecture:

-1st-a software for creating the AR applications- AR creator;

-2nd- a software for deploying/installing the AR applications- AR installer;

-3th- Content Management Tool- CTM

We focus on constant using of LARGE that supports educators and learners in their everyday activities.

First part of the software is designed as a SDK (software development kit), which unites different functions and answers all the requirements, shown in Table 4.1 for AR creator.

Second part is designed as a unity of folders and SWF file.

Third part is a CTM, which arranges the needed interactive content, which is used by the applications.

6.2. USER INTERACTS WITH LARGE THROUGH 4 WAYS:

1) The main- for controlling the content, which is connected with an application.

   For this purpose the user uses a trigger image, a computer with a web camera, and a LARGE software for deploying- offline or online. The user controls the content through the trigger images- markers.
2) for preparing an interactive content- 3D objects, video, pictures, text, sounds, etc.

   For this purpose the user uses CTM software and 3rd party software, if it is needed, for 3D content preparation.
3) for creating the applications.

   For this purpose the user uses a Creator part of LARGE system software.
4) for installing the applications.

   For this purpose the user uses a Deployer/Installer part of LARGE system software.