# Interactive Informative Unit Based on Augmented Reality technology

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**Abstract**

*In the present contribution we shall introduce the IIUBAR system, which represents an Interactive Informative Unit Based on Augmented Reality technology (AR), provided by the Augmented Reality Toolkit (ARToolkit) API. After invoking the potential of the proposed system in educational contexts, theoretical concept behind the ARToolkit package as well as advantages and disadvantages of the possible solutions will be brought to discussion.*

***Keywords**:* Augmented reality, interactive interface, educational virtual environment.

Learning and teaching are two complex, continuous and complement processes. Started from the early ages, learning has to find continuously motivational factors in order to become effective and evolutive. Only when an abstraction level of knowledge in a specific domain is reached, then teaching may appear as complement to learning, with a constructive feedback as one of the side-effects.

## 1. Introduction

The widest dissemination form of learning environments in our days still remains the World Wide Web. It is most probably because this technology represents the basis for the online education and it offers knowledge to students independently to the moment, the place and the time duration of the learning act.

It doesn't matter if we talk about static or dynamic Web-based pages or if the learning environment is a multimodal (multimedia) 2D or 3D metaphor of a real pedagogical situation that is too dangerous or too expensive to be re-created basis on real means.

What we think that really matters is the possibility to transform the usual actors, students and teachers, into involved active actors. To this end, we want to install them the sensation that they represent active parts of the learning/teaching process. This way we catalyze the creational state-of-mind as well as the self-confidence at individual level as premises of long-duration collaboration between the individuals.

Other human related aspects have to be taken into account, as motivation, emotion, satisfaction, and error, at individual level as well as at competitive or collaborative levels. In this matter, not rare are the situations in which the lack or inaccessibility of information becomes a stress factor in everyday life. If for a person who possesses all physical means this incommodity is easy to overcome, for a handicapped person this could represent a real challenge.

The technology of the third millennium makes itself noticed more and more in the design of assistance systems for people with disabilities.

Without any distinction between these two categories of users, in the current work we present an original solution based on augmented reality technology: the implementation of an interactive information unit (IIUBAR) which targets a wide range of people, usable both in informative and educational situations.

In the following we present our reasons in using mixed realities in public educational and informative contexts. Next, after a brief review of some of the most important achievements in the field of AR, we offer a general description of the IIUBAR system followed by a section destined to discussions. We close with conclusions and possible directions of development of the IIUBAR system.

## 2. Potential impact on virtual learning

Many of the current solutions for virtual or augmented reality systems are designed to be manoeuvred by a single user, thus limiting the access to the application. When using such an application in virtual learning, the experience gained by the user will only be from the sole interaction with the system. From general experience, learning efficiency grows directly proportional with communication, collaboration and motivation.

To achieve these key factors of learning, one faces the problem of designing the learning system. As the three factors are human in nature, the system must include more than one user (learner) to achieve the desired efficiency.

Only few of these systems take a group-oriented approach regarding the learning efficiency issue. Having a group-oriented system would ensure that an exchange of information between users will occur, and that the individual experiences of one user may complement the ones of another, and vice-versa; in this way, users practically participate in the development of the learning environment, while gathering more information, and keeping themselves highly motivated through this process. Paraphrasing, the users become teachers for each other, and information flow is eased.

The IIUBAR system may be used by groups of users with the role of enhancing the experience gained from the learning material. Among the possible uses of the system are the following three scenarios (but not only).

Generally, the system may be used in any public spaces as interactive and informative access point (see *figure 1*). In particular, the virtual information stand in thematic museums may be used to animate the static nature of these locations, making them more attractive to visitors, and simultaneously providing the user with extra information (see *figure 2*). Of course, the potential of the IIUBAR may be proved also in interactive classes by providing 360° panoramas with unlimited possibilities in the matter of content. For example, the system can be used in geography classes to give the learners an experience of some of the places they have never visited before; the impact on the user would be greater than a regular image, because of the simple but effective physical action of rotating the viewpoint in the virtual environment.

*Figure 1.* IIUBAR in practice: up-overview, down-detailed view

*Figure 2.* Using IIUBAR in museums – detailed view

## 3. Presentation of the technology used

One of the challenges that the development of the mixed reality environment poses is determining the position of the observer. This information needs to be extracted from the image taken with a camera. To resolve this issue, ARToolkit (ARToolkit, 2007) relies on computer-vision algorithms with which it can detect and recognize markers (the symbols are each associated with a 3D model inside the application). These algorithms are similar to those used by the artificial neural network technology in that of processing signals in general, and of images or sounds, in particular.

### *3.1. Theoretical basics – the functioning mechanism*

In the following section we shall describe the steps taken in the algorithm that ARToolkit uses for image processing:

- The first step consists of capturing the image.
- After which applying a filter is necessary for localizing the marker. This filter is also known as the binarization step, in which the initial data is transformed, by colour differencing, into a black and white picture that can now be easily represented with binary code, and thus stored for further processing.
- The edge detection takes place: the contour lines' positions are estimated, which are afterwards parameterized.
- The marker's corners are calculated at a sub-pixel level.
- The obtained image is normalized.
- The known symbols are loaded into the application and associated with the real situation.
- The marker's homography is calculated (Homography is a mathematical concept that is defined as the relation between two geometrical figures, so that any point in one of the figures corresponds to one and only one point in the other, and vice-versa).
- Relative transformations between the camera and the marker are calculated, and optimizations are applied. This results in parameters which are to be used by the application.

This algorithm is repeated for every frame of the video capture.

Latest attempts to overcome the limits of the current solution imply the use of neural networks to solve the problem of marker detection and interpretation (Gomez *et.al*, 2007).

The main strength of neural networks is correlating information with pre-made templates and even adapting the templates to environment changes.

The learning and pattern recognition abilities are possible because of the adaptive sensibility of the neurons that are the basic elements of these networks, sensibility also known as adaptive threshold.

Using this technology may revolutionize the adaptability of the system, making it resilient to luminosity changes that are so frequently encountered in real scenarios and giving it the ability to recognize also real objects, apart from markers.

### *3.2. Current solutions*

ARToolkit is a software library meant for creating augmented reality, based on the 2D and 3D graphics API named OpenGL. Usage of ARToolkit is in continuous growth at international scale for the possibilities that it offers and the open-source license under which it is distributed.

The prime strength of ARToolkit is to make the direct interaction between the user and the virtual environment more intuitive. This way, occasional users who do not possess technical skills may find the system accessible.

Among the applications built based on this platform we can mention (ARToolkit, 2007):

• ARCO: *Augmented Representation of Cultural Objects* – a research project financed by the European Union having the goal of developing techniques for museums to create 3D models of the exhibitions online (ARCO, 2003),

• Component assembly or machinery manipulation environments with applicability in a wide range of domains such as physics, chemistry or constructions (FaiMR, 2003; ARToolkit, 2007),

• Applications in virtual learning, interactive lessons which help pupils or students to gain a better understanding of the phenomena that they study; an example in this sense would be the virtual theatre meant for children of pre-scholar and scholar age, presented in (Popovici *et.al*, 2006),

• Games and other entertainment or educational applications (Billinghurst *et.al.*, 2001; Park and Woo, 2005).

Nevertheless, ARToolkit API it is not the only available technology in augmented reality. Just think the virtual reconstructions of historical sites (Vlahakis, 2002; Papagiannakis, 2004).

## 4. About the IIUBAR system

IIUBAR exemplifies an easy-to-use informative and educational system. It is characterized by a natural, real-time interaction with the user. The system is formed of a rotating stand, on which a computer (laptop) is placed that processes the information received from two webcams to create a mixed environment by superimposing a 3D virtual model over the real images (see *figures 1* and *2*).

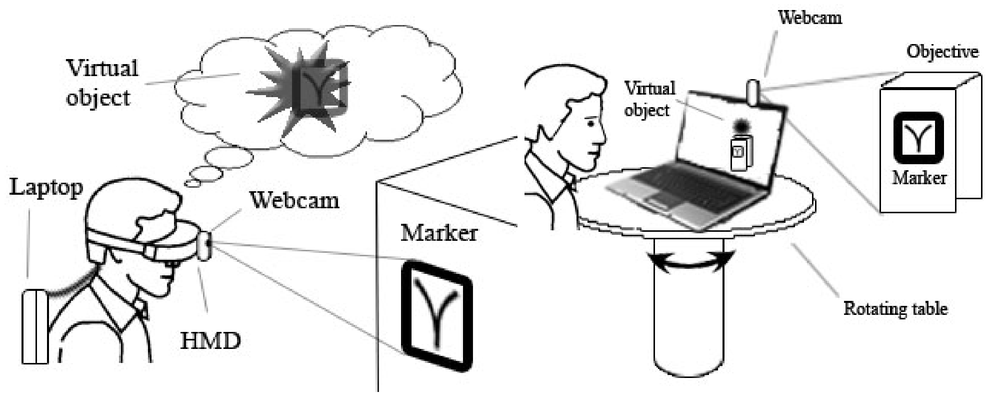
When implementing the IIUBAR system, there were three different solutions taken into consideration.

• Mobile system with one marker per objective,
• Fixed system with one marker per objective,
• Fixed system with one marker per environment.

In the following paragraphs we consider useful the observations made based on the analysis of the implementation possibilities of the system. Thus we will specify details about each solution and will argument the solution chosen for final implementation.

### *4.1. Mobile system with one marker per objective*

The system configuration in this case assumes that a marker is created for each and every objective from the real world, and that a 3D model is associated with each marker. The hardware solution relies on linking and synchronizing a webcam and a HMD (head mounted display) with a laptop that would be bared by the user (see *figure 3.a*).




a) b)

*Figure 3.* a) Mobile; b) Fixed – configuration with one marker per objective

**Advantages:** Because of the portability of the HMD, this configuration proves a high level of mobility, without binding the user to one point.

**Disadvantages:** As the HMD, and thus the camera, moves simultaneous with the user, the stability of the captured images is below average. Because these images are the only modality for the user to perceive the environment, this version is not feasible.

### *4.2. Fixed system with one marker per objective*

The configuration in this case is simplified in the sense that a touring table is used in place of the HMD (see *figure 3.b*).

**Advantages:** The lack of the trepidations that we found in the previous version makes this configuration superior in the sense of image clarity.

**Disadvantages:** Having a fixed point from which the detection is made, the markers found far away from the system are not clearly detected, nor able to be visualized. Thus the system's capacity to provide the solicited information decreases dramatically.

### *4.3. Fixed system with one marker per environment*

To combine the advantages of the two previous solutions, for the final implementation we opted for the fixed solution with a single marker per environment.

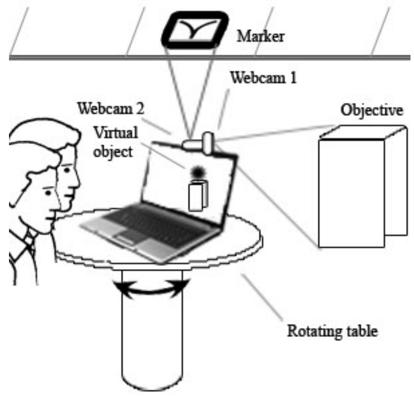



*Figure 4.* Fixed configuration using a single marker

This version assumes two modifications: one at the hardware level and the other at the software level. The hardware change is represented by an additional camera, so that we are able to split assign each the roles of harvesting real images and the other of detecting the rotation angle relative to the marker. The software change is executed through three important steps:

- Adapting the standard ARToolkit application named "twoview" so that using models created in VRML (Virtual Reality Modeling Language) format is possible.
- Changing the transformation matrix used for storing the position parameters of the marker. This is necessary because the rotation of the 3D model has to be done around a different axis than the one of the markers rotation.
- Information received from the detecting camera (webcam 2 from figure 4) must be used to generate the 3D model over the images taken from the camera that observes the real environment (webcam 1 from figure 4), unlike the example in which each camera was used for a separate image interpretation process.

The present configuration benefits from a 360$^o$ vision field, by using the rotating stand that was introduced in the previous version, and from an significantly superior image clarity and resolution, made possible by combining the images of the two webcams.

The first webcam is placed to receive real images on a horizontal direction, while the second is directed vertically to detect the marker that is placed above the IIUBAR system (*Figure 4*).

Webcam 2 will supply the application with the rotation parameters of the system relative to the marker. With the help of these parameters, the viewpoint of the user can be determined. Thus the correct superimposing of the 3D model becomes possible, so that a complete interactive environment is obtained that responds to the users actions in real-time.

**Advantages:** Because the way in which it was design, this system has a high sensibility to the user's orientation; it is adaptable to the environment in which it is placed (changing the 3D model one can satisfy the requirements of any new environment); it benefits from a very high image stability.

These qualities gain more importance when placing the system into a real collaborative context, this is exactly the case of group visits in a real scenario (for example an university campus).

**Disadvantages:** The lack of mobility because of the fixed stand on which the system is placed, and the necessity of installing it indoors.

## 5. 3D environment

The language used for building the virtual 3D models is VRML (Virtual Reality Modeling Language). There are several reasons for which we opted for this language. Firstly, the VRML standard is supported by the ARToolkit platform and permits the rapid description of complex geometries, unlike OpenGL. Secondly, using this file format, the IIUBAR system is easily adaptable to different configurations of the real environments.

An exceptionally important factor in creating the model is relating it to the space in which the system will be placed. For an optimum functionality, prior measurements are required to determine the distances between the positions where virtual objects are to be placed. The lower the measurement error is, the higher the precision with which the virtual and real worlds overlap (see *figure 5*).

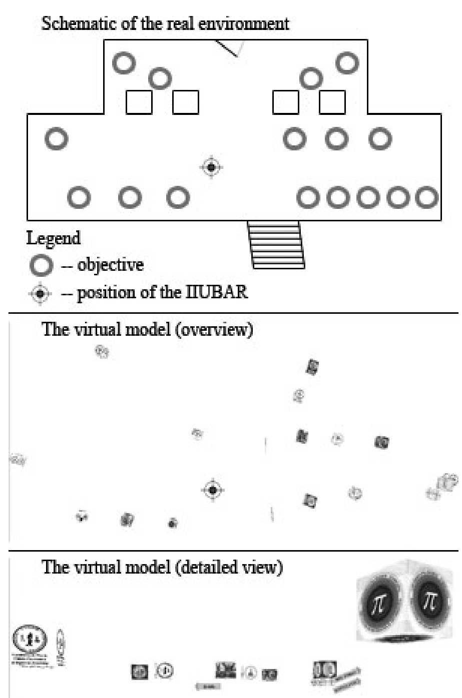



*Figure 5.* The virtual 3D model and the scenario schema

Also another aspect that must not be overlooked is the camera calibration. Without a correct calibration, the 3D model may not entirely fit the environment, because the optical distortion produced by the camera. This problem can be solved by using the ARToolkit utilities named „calib_camera2", „calib_param" or „calib_distorsion".

## 6. Conclusion

We consider that the potential of this platform is well above average. Firstly, it requires a very low level of knowledge for proper use. Secondly, the assembly costs are at minimum. Thirdly, it proves a great level of accessibility and also the application may be adapted to contain more information, for user satisfaction.

The system may be successfully used as a public information stand, inside institutions. Although it has many advantages, the IIUBAR system's drawback would be the fact that it can only be installed indoors.

## 7. Acknowledgements

The present system has been implemented in the Laboratory of Virtual and Augmented Reality Research (CERVA, 2007) and is supported by the TOMIS project, no: 11-041/2007, by the National Centre of Programs Management, PNCDI-2 – Partnerships program.

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