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Technology Enhanced Learning and Augmented Reality: An Application on Multimedia Interactive Books

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Abstract

Multimedia Interactive Book (miBook) reflects the development of a new concept of virtual interpretation of traditional text books and audio-visual content. By encompassing new technological approaches, using augmented reality technology, allows the final user to experience a variety of sensorial stimuli while enjoying and interacting with the content; therefore enhancing the learning process. miBook stands for a global educational intention to enable people not only to access but also to appropriate intellectually valuable contents coming from different linguistic and cultural contexts.

Keywords: *multimedia, interactive book, mobile technology, augmented reality, technology enhanced learning*

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1. Introduction

Cognitive resources of a given society are influenced by the importance and constant evolution of Information and Communication Technology (ICT) and therefore by the effects of introducing such innovations into the daily life of general population, companies and institutions. Such modifications require an additional learning capacity, innovation or creativity, necessary to access actual conditions of information and knowledge.

The representation of the real world in a virtual space can provide multiple perspectives and points of view. Nowadays, without multimedia the teaching and learning process would be inefficient or, at least, boring.

This paper presents previous research results, practical development and testing of a product called miBook, which uses the concept of augmented reality interfaces, and proposes a novel tool that may impact learning efficiency.

This paper is organized as follows:

- after the introduction some related work is presented (section 2), followed by the presentation of the concept of enhanced learning tool, known as Multimedia Interactive Book – miBook (section 3) as well as the definition of the tool features and detail of major advantages in the field of learning;
- in section 4 is presented the miBook usage cases and some quality results;
- section 5 resumes the drawing of some conclusions, addresses relations with mobile learning and describes future work.

2. Literature Review

Among several authors that stand for more learner-centered models, Gardner (1993, 1999) simply introduces a different approach in defining and measuring human intelligence and proposes that human beings have a wide "intelligence" range, which is then deployed into various forces or talents - the criteria established to determine the capabilities that are usually considered as intelligence. Gardner (1993, 1999) has identified and focused on eight different “intelligence forces”:

1. Verbal / Linguistic: ability to read, write and communicate using language;
2. Logical / mathematical: capacities used for reason and calculation;
3. Geographic: awareness of spatial relations, shape and color;
4. Musical: sensitivity to sound, tone and rhythm;

5. Body / kinesics (the study of body position, posture, movement, and facial expression in relation to communication): both related to a precise knowledge of movement and body control ;
6. Interpersonal: ability for socialization, cooperation and understanding people;
7. Intrapersonal: introspective ability to reflect and to manage our own feelings and behavior;
8. Natural affinity with nature and world: the capacity to understand how it works.

Considering nowadays technology state-of-art, the predominance of lecture-based models may represent an obstacle to the efficiency of educational systems. The majority of schools are not yet prepared for the new learning environments; sometimes due to insufficient budgets (which are in most cases unaffordable) and teaching designers, and in some cases due to unawareness of adequate learning materials.

Recently, Henrich and Sieber (2009), after a 6 years research on information retrieval in blended learning and pure e-learning scenarios, presented that critical success factors for technology enhanced learning approaches are derived from the creation, utilization and maintenance of courses[6]. In short, they argue that *"taking into account the nature and stability of the presented content, as well as a thorough consideration of the affordable creation and maintenance effort, are crucial for the success of such concepts"* (Henrich and Sieber, 2009, pp. 117-147).

Augmented Reality (AR) is a multidisciplinary field of computer science, involving areas like 3D Computer Graphics, Computer Vision and Human-Computer Interaction, which deals with the combination of real-world and computer-generated data (virtual reality), where computer graphics objects are blended into real video footage in real time.

According to Azuma et al. (2001), AR requires the following 3 characteristics/processes: (1) combines real and virtual environments; (2) is interactive in real-time; (3) registers 3D objects in real environments.

There are some recent advances in Augmented Reality in the area of medical displays, information and sports and entertainment (Zhang et al., 2009) and commercial applications. Medical imaging technology is an example of AR application. During the last decades, AR provided physicians with an increasing amount of patient specific anatomical and functional data. In this context, AR is proposed as a paradigm, bringing new visualization and interaction solutions into perspective. Recent work by Sielhorst et al. (2008) describes how AR technology facilitates surgical workflow or how 3D user interfaces can reveal their power in tasks where reduction to 2D is problematic.

[6] Adequate content presentation and representation, as well as interaction concepts and didactic considerations concerning cost-benefit ratio of animations, applets, and multimedia elements.

Up until now, AR applications oriented to education have not been so deeply exploited. Mishra and Sharma (2004; pp. 27-28) suggest interactive multimedia learning as *"computer-based learning systems that provide interactive user controls to choose media elements like text, images, sound, video and animation in an integrated manner and influence effective learning".* They also add that the multimedia when integrated within an instructional design provides a necessary base to meet the learning objectives (Mishra and Sharma, 2004; Shin, 2004). Animation, audio and video elements support informative and emotive aspects of learning (Wu and Chao, 2008).

The "MagicBook" (Billinghurst et al., 2001) presented an interface which allows readers to look at one book and enjoy the story seeing its virtual models by using augmented reality displays. MagicBook's interface uses pictures from "normal books" with text and pictures on each page. These pictures have thick black borders that are used as marks for a computer vision-based head-tracking system.

Bastos and Dias (2008) introduced a novel approach to real-time scale, rotation and luminance invariant natural feature tracking. They propose a solution to the camera pose initialization registration and tracking problem in the field of AR, using totally automatic procedures. In this case, black borders aren't needed any longer as tracking marks and thus books may have its natural, traditional aspect concerning pictures. The technique is applicable for the case of several simultaneous planar objects with arbitrary topologies and natural textures, and has been used as an underlying technology in miBook framework.

This late work has allowed further possibilities in the field of educational contents and enhanced learning. Nevertheless, the actual major challenge relies on the continuous development of this innovative idea as an underlying technology in the field of enhanced and mobile learning and to develop the ideal business models so that this innovation may be accepted in the market.

3. Multimedia Interactive Book

Multimedia Interactive Book (miBook[7]) is a new tool providing a responsive environment and an interactive learning, which handles with different types of content. It may represent a notable instrument for enhanced learning (for individual use or in the classroom) as well as it can represent a great step forward, regarding the enhancement of current digital libraries. Additionally, the integration of different

[7] miBook is a novel product/service developed in 2005 by SbH – Solutions by Heart, Ltd. [http://www.mibook.org, 24/04/09], [http://www.solutionsbyheart.com 24/04/09] in collaboration with GITICE, Research Center from Universidad de Huelva (Spain) and ADETTI from ISCTE (Portugal).

interactive teaching materials will provide a better learning environment that will allow students to step forward in their learning experiences, both in the classroom as well as in their home place.

miBook is the combination of a printed book (or its digital format) with the respective audiobook and its 3D models (as well as the 2D graphics). Using Augmented Reality and Multimedia, as frameworks to present and interact with audio-visual content, miBook represents a major facility in order to enhance mental comprehension of its content, by allowing a faster knowledge acquisition.

Technologically, miBook environment consists of a handheld camera, a personal computer (to generate user's individual scene views), and a physical book. miBooks uses "normal books" with text and pictures on each page and have an additional audio content – the correspondent audiobook.

By supporting a real-time AR texture-tracking algorithm, which uses the novel feature detection technique from Bastos and Dias (2007) (see Figure 1), the enhancement of global algorithm performance allows the support of different hardware profiles, both in desktop and mobile setups. It also includes the possibility of tracking several images/textures at the same time and it supports several 3D standard formats (3DS, VRML, OBJ, DXF, Cal3D, among others). As we can see on Figure 1, there is no need to have the black borders as tracking marks. The first picture on Figure 1 (left side) is the 2D sheet of a book and the right side one shows a 3D object registration where someone is interacting in real time with miBook. As for interactivity enhancement, miBook features provide a physic engine to enable scientific simulations. It will also enable audio storytelling with virtual elements interaction (Script) and both artificial intelligence and speech recognition algorithms for user guidance. All features may be available both in desktop and mobile (PDA or Smartphones) setups, being one of the biggest breakthroughs for the AR community.

These innovative technological approaches allow a rich end user experience concerning sensorial stimuli, allowing for an enjoyable simultaneous interaction with the content (e.g. reading, hearing and display of static images and moving in 3D virtual models through augmented reality[8]), thus enhancing the learning process.

[8] Augmented Reality technology features for miBook are developed since 2005 by ADETTI (Associação para o Desenvolvimento das Telecomunicações e Técnicas de Informática) from ISCTE (Instituto Superior das Ciências do Trabalho e da Empresa) [http://www.adetti.pt/ 24/05/09] in collaboration with SbH – Solutions by Heart, Ltd. [http://www.mibook.org 24/05/09], [http://www.solutionsbyheart.com 24/05/09]

Figure 1 – Example of virtual object registration in a real scene in miBook[9] (texture image and registered scene)

The service and technology-based products development impacts every aspect of our lives and books are no exception (several types of contents and not only books). From classic printed books to audiobooks, electronic books and other possible audio-visual contents, the innovation process surrounds every natural aspects of audio-visual evolution.

The global access of population to printed literature, written contents and audio-visual content is already disseminated in a wide variety of media. But when it comes access and learning effectiveness and/or efficiency, and due to actual technological possibilities, the answer is ambiguous and depends on individual groups of users' needs and requirements and different purposes for accessing different type of information material. There is an increasing number of educators adopting learner-centered models in which students are engaged in problem solving and inquiry activities (Land and Hannafin, 1996; Mclellan, 1996; Stratford et al., 1998).

miBook may represent an adequate solution for a transition in teaching-learning models given that it is focused on the improvement of the interactive learning experience, by exploring optimal combinations of educational materials, learning methodologies and capabilities of common devices. miBook supports for traditional

[9] Extracted from the miBook "Greek Mythology", Vol. I; SbH – Solutions by Heart, Ltd. Left-side image: texture image copyright SbH – Solutions by Heart, Ltd.; right-side image: registered scene, copyright ADETTI from ISCTE.

pedagogical approaches, such as reading books or viewing pre-recorded classes, as well as innovative pedagogical approaches by providing rich media (automatically generated audiobooks and/or 3D virtual interpretations of educational context), during reading, watching or listening.

The application of the miBook solution to new forms of learning can be naturally and fully under control of users (both students and educators). The new interactive way of linking traditional pedagogical approaches (such as reading printed books), common devices capabilities (like handheld devices with camera) and the potential of multimedia technologies (audiovisual interpretation technologies) can provide a better understanding, knowledge acquisition and enhanced learning experience. Accordingly, this solution stands for an educational methodology based on natural learning (e.g. learners may in fact achieve knowledge by individual construction held through the learning process).

miBook aims to provide an integrated access point over a diversity of content formats, respecting the plurality of people educational needs and skills. First step, in every educational process, will lie on the assessment of what has been achieved in leading countries and on the definition of a direction that should be taken to foster digital libraries, audiovisual and written information. The presented solution may contribute to move forward on state-of-the-art by introducing new means of using, interacting and enhancing traditional educational concepts and contents.

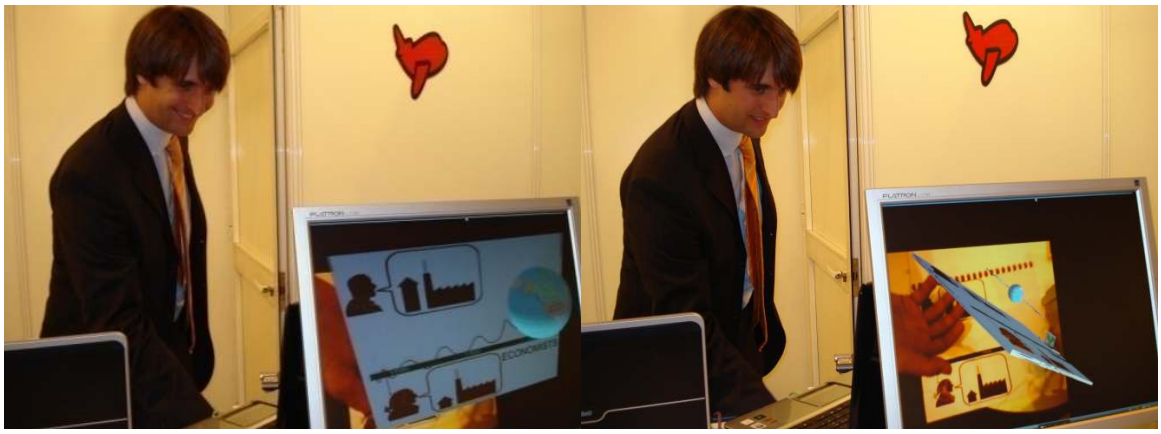
AR is helpful providing a significant enhancement to the user's cognitive perception of the real world and situational awareness, both indoor and outdoor environments, as it is appropriate for mobile or fixed workplaces. Virtual objects generated by AR systems can display information that the user cannot directly detect using his senses. This information conveyed by the user can also help while performing real-world tasks.

4. miBook Usage Evaluation

Nowadays learners have access to many types of educational materials. However, traditional books still play a significant role in education. There is a need for an educational process to integrate the mentioned media resources in a way that facilitates their usability. It is a long time since there is common knowledge that listening is fundamental area of development in learning languages (Rost, 1994; Vandergrift, 1999) but at the time, learning by listening has also been regarded as one the most problematic areas for students to use a variety of different approaches, skills and strategies (Wilson, 2003).

If we imagine that we have to explain to someone what is and how does it feels to listen before that person actually listens to any audiobook it is easy to guess we would have hard task to perform. When we get to the field of AR, one can also imagine the difficulty in explaining what is and what it feels like interacting with miBook. That is something that we just will really understand when actually experiment. Anyway, *Figure 2* illustrates the interaction between the learner and miBook content. The learner is listening to the audiobook (abridged version) while seeing the physical book itself (detecting the differences from the original written text / 2D pictures and the audio resume) as well as he can explore and interact simultaneously with the 3D virtual objects' registration. Left and right side of the photo regard the interaction with exactly the same sheet of the book, the difference consists in the chosen type of exploration of the same content – in this case, the learner is interacting with the evolution of the economies graphic and he explores the several aspects he desires. miBook's vision is to accelerate each individual's acquisition of knowledge and learning skills, through the provision of a responsive and inspiring learner environment, which enables him/her to "illustrate" educational materials (traditional printed books, audio-visual, 3D virtual models).

Figure 2 – Human interaction with miBook contents[10]



A preliminary usability evaluation of miBook was carried out with 5 adults[11]. They were exposed to a simple task - to interact with miBook content in AR context - and they answered a satisfaction questionnaire related to the task. We have concluded that the miBook's enhanced features impact on learning process:

1. Adding visualization to a standard text book will enhance its value as an educational material;

[10] International Conference on Economics, SIMO IFEMA-Madrid, Spain 2007, Copyright SbH–Solutions by Heart, Ltd.
[11] 5 adults randomly chosen during the SIMO IFEMA-Madrid (2007)

2. The visualized text is easier to understand, and thus learning process will be fostered;
3. Audio-visual content is more attractive than standard text books;
4. Adding visualization features to a standard text book creates a new media concept and possibilities, resulting in completely new educational instruments;
5. A very intuitive and easy to use authoring tool will allow for unlimited creativity during educational material preparation.

6. Conclusions and Future Directions

Computer graphics have become much more sophisticated, looking all too real. In the near future the researchers plan to make the graphics on the TV screen or computer display and integrate them into real world settings. This new technology called augmented reality, further blur the line between reality and what is computer generated, improving what we see, hear, feel and smell.

The concept of innovation has been described in terms of research as discovery, development, imitation and adoption of new products, new processes and new organizational forms (Dosi, 1988), while Lundvall (1992) says almost all innovations reflect previously existing knowledge, combined with new forms of use.

Following the European Commission definition innovation consists of the successful production, assimilation and exploitation of novelty in the economic and social spheres (European Commission, 2003[12]). Among other factors, the importance of economic competence is crucial, given that the use and benefit from enhanced learning depend on efficient systems (Howells and Roberts, 2000). A modern society requires the fast adoption of an overall education and a training program for all ages at all levels. For this modern society to become real it is necessary to change global economies in what concerns to innovative business models, efficiency and information sharing. Words must be put into action to promote a completely new learning paradigm.

In this work I have presented, through a technological approach, a novel tool that can provide a better understanding, knowledge acquisition and enhanced learning experience.

Distribution through electronic channels, such as Internet, presents specific needs to business models and content production design. This fact is due to several reasons. First of all, the difficulty in creating value for a global (and heterogeneous) audience.

[12] European Commission Communication, 11th March 2003, "Innovation policy: updating the Union's approach in the context of the Lisbon strategy" (COM, 2003, 112 final - Not published at the *Official Journal*).

Then, all the technological issues related to content access and mobility. Internet is no longer a computer exclusive and recent trend in medium consolidation show the way services and products should act, if they want to succeed in electronic environments. Mobile devices (PDAs, Smartphones, integrated multimedia readers…) will gradually allow the incorporation of augmented reality (AR) applications and contents, voice recognition tools, file formats converters and advanced search functionalities. Firms should keep in mind all ways of content access and usage possibilities. Up until now, mobile hardware performance has favored classic software concepts that use simple graphics. The next step will move toward 3D graphics. Although the average mobile devices are technologically behind a specialized game machine, it is obvious where the market is heading. The migration of the software supporting augmented reality into mobile environment is by itself a considerable advance on the state-of-the-art. The implementation of this technology in handheld devices will soon provide valuable results for evaluation in learning processes context.

Solutions presented by miBook also aim at boosting innovation through cross-fertilization between science, business and education resources. It is clear that conceptual ideas must be transformed into real market-oriented innovations. The big challenge is actually to draft the methodology process of designing and to integrate interactive multimedia into the existing teaching and learning scenarios.

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