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Augmented reality mobile app development for all☆

José Miguel Mota[a,*], Iván Ruiz-Rube[a], Juan Manuel Dodero[a], Inmaculada Arnedillo-Sánchez[b]

[a] *Department of Computer Engineering, University of Cádiz, Puerto Real (Cádiz), Spain*
[b] *School of Computer Science and Statistics, Trinity College, Dublin, Ireland*

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ABSTRACT

Lack of programming skills is a barrier to the engagement of teachers in the development and customisation of their own applications. Visual Environment for Designing Interactive Learning Scenarios (VEDILS), a visual tool for designing, customising and deploying learning technologies, provides teachers with a development environment with a low entry threshold. Current mobile devices are equipped with sensors and have sufficient processing power to use augmented reality technologies. Despite the heavy use of mobile devices in students' lives, the use of augmented reality mobile applications as learning tools is not widespread among teachers. The current work presents a framework comprising the development tool and a method for designing and deploying learning activities. It focuses on the augmented reality components of the authoring tools, which allow users to create their own mobile augmented reality learning apps. It also present the results of the evaluation of the framework with 47 third-level educators, and two case studies of classroom implementations of mobile augmented reality apps developed by these educators. The results illustrate the suitability of the framework and authoring tool for supporting users without programming skills in developing their own apps.

1. Introduction

In Technology Enhanced Learning (TEL) research, ubiquitous and mobile technologies and serious games, Augmented Reality (AR) and Learning Analytics (LA) provide a means of improving users' experiences and satisfaction in enriched, multimodal learning environments [1]. While TEL research takes advantage of technological innovations in mobile hardware and software, significant developments in user modelling and penalisation techniques have placed students at the center of the learning process [2], and AR has had the effect of increasing the motivation of students [3].

AR technology refers to the inclusion of virtual elements in views of actual physical environments, in order to create a mixed reality in real time. It supplements and enhances the perceptions humans gain through their senses in the real world. AR provides various degrees of immersion and interaction, which can help to engage students in e-learning activities. For instance, in AR learning environments, motivational factors related to attention and satisfaction are rated more highly than for slide-based environments [3].

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* Corresponding author.
E-mail addresses: josemiguel.mota@uca.es (J.M. Mota), ivan.ruiz@uca.es (I. Ruiz-Rube), juanma.dodero@uca.es (J.M. Dodero), macu.arnedillo@scss.tcd.ie (I. Arnedillo-Sánchez).

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Society increasingly demands efficient and skilled professionals. In view of this, a particularly valuable skill for educators is the ability to create their own e-learning experiences [4]. Doing so endows educators with agency over the technology; that is, the ability to place this at their service rather than being driven by it [5]. However, the full potential of technology is often underutilised in teaching. Barriers include the need for programming skills to develop customised AR experiences [6] and the lack of education-specific authoring tools [7]. The translation of concepts and instruments into end-user computer systems is a complex task, requiring the involvement of computer specialists; the development of education-oriented programming environments therefore remains a challenge [8].

Visual block-based programming environments, where users drag and drop blocks together to write code, provide novices with an alternative for learning programming. This has proven successful in classrooms and informal learning settings [9,10]. It is also suitable for early-stage programming teaching, for instance the *One Hour of Code*[1] initiative or with tools such as *Scratch*[2] or *App Inventor*.[3]

Based on the potential that block-based visual programming languages have shown in overcoming the barriers faced by educators when developing mobile applications, we developed VEDILS [11]. This is built on top of App Inventor, and is extended with modules that allow the integration of AR and LA features into mobile applications. VEDILS is embedded in the VEDILS Framework, which is a four-phase method comprising: 1) the design and development of new components; 2) training; 3) iterative design; and 4) assessment. To evaluate this authoring tool, a series of workshops were conducted with 47 third-level educators. During these, the participants completed tasks aimed at improving their knowledge of the visual block-based programming language, and developed an app. In addition, two case studies were undertaken of classroom implementations of the mobile augmented reality learning apps developed by the participants.

This paper presents the VEDILS Framework and focuses on the AR components of the VEDILS tool, which allow users to create their own mobile augmented reality learning apps. It also presents the initial results from the evaluation by educators. The remainder of this paper is structured as follows: Section 2 describes the state of the art; Section 3 presents the VEDILS Framework, outlining the stakeholders and stages of this system; Section 4 describes the authoring tool and explains the AR components; Section 5 presents the results of the workshops; Section 6 reports on two case studies of apps developed with this tool; and finally, Section 7 presents the conclusions and describes future work.

2. Related work

New instructional environments based on multimodal interaction (for instance, gesture interaction, voice recognition, AR, tactile interaction or artificial vision), have emerged as delivery formats which are readily available to teachers. It is easier to motivate [12] and involve students when e-learning experiences are based on these types of interaction [13]. In particular, AR enhances the perception of users and improves their interactions with the real world, displaying information that users cannot detect directly using their senses [14].

There are two taxonomies of AR application in terms of development: 1) marker-based tracking, which requires labels containing a coloured or black and white pattern; and 2) marker-less tracking, which uses the mobile device's GPS or image recognition systems to identify a location. Both make use of sensors such as accelerometers and gyroscopes to determine the location, orientation and direction of the mobile device. AR systems look for a predefined pattern in order to identify a match and a reference position, and the virtual information (sounds, 2D images, 3D models, etc.) is then superposed on the live image. Researchers have highlighted the potential of AR in engaging and motivating learners, for instance when explaining or evaluating topics, conducting lab experiments, playing educational games and augmenting information, among others [3].

When developing e-learning activities with AR, teachers can use various AR authoring tools. A classification according to the schema outlined in [15] is presented below:

- *Low-level libraries:* These provide only basic computer vision integration. Some of the best-known libraries and frameworks are ARToolKit [16], Aruco [17], Wikitude[4] and Vuforia.[5] All of these require coding/scripting skills and the use of graphical utilities to project and manipulate virtual objects.
- *High-level programming environments:* These simplify the development process by providing the infrastructure required to build applications with AR. Examples of these tools are Studierstube[6] and osgART [18]. They include all the functions needed to develop AR applications, such as scene graph rendering, networking, window management, support for input devices and so forth. These environments usually require programming abilities; developing AR applications with these is therefore a time-consuming and demanding task.
- *GUI-based tools for non-programmers:* These do not require programming skills in order to generate AR applications. Examples of these are APRIL [19], AMIRE [20] and DART [21]. Several other high-level authoring tools exist, such as Layar,[7]

[1] https://code.org/learn.
[2] https://scratch.mit.edu/.
[3] http://appinventor.mit.edu.
[4] http://www.wikitude.com/.
[5] https://developer.vuforia.com/downloads/sdk.
[6] http://studierstube.icg.tugraz.at/main.php.
[7] https://www.layar.com/.

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