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Use of Augmented Reality for the Simulation of Basic Mechanical Physics Phenomena

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Abstract. The augmented reality (AR), has been cataloged like the technology that will have greater penetration in the education sector in the second decade of the XXI century. According to the report horizon 2016, the first research of AR in education point out a positive impact, in collaborative learning and autonomous learning; because it allows potentiating reality with virtual information that can be supported in curricular contents. The present article exposes the development of a prototype with AR technology that simulates the uniform rectilinear movement and free fall of the subject of mechanical physics. The research is of technological development type. Included in three phases: Initially the functional and non-functional requirements were determined, then the architecture was designed using UML diagrams and finally the prototype was developed. As a result, we obtained a mobile prototype with AR with two functions, the first one allows to simulate the movement of a vehicle at a constant speed, the second allows to simulate the fall of objects that are being attracted by gravity. A technical feasibility study was carried out in which the prototype was installed in different mobile devices, without errors. It is concluded that AR has several characteristics that can be applied to educational environments to increase students' motivation and make them live experiences that are limited access in classrooms.

1. Introduction

The integration of information and communication technologies (ICT) in the field of education has allowed the evolution of the educational model. In the beginning, the model was centered on the faculty who were responsible for finding and providing the necessary information while the students appropriated knowledge through technology as a resource for transmitting information; in this model the theories of Behaviorism and Objectivism were the protagonists. Recently the model has undergone changes focusing on the students, who have gone from being receptors to being knowledge providers and the teacher has to do the guiding tutor role, looking for the student to generate knowledge using technology in an interactive way; this new model the theories that star it are Cognitivism, Constructivism and Constructionism [1].

One of the technologies that is penetrating the field of education in recent years is the so-called Augmented Reality (AR) [2]. This technology allows digital information to be enriched with real physical scenarios using a digital camera; the applications with this technology are generally developed for operating systems of mobile devices (Tablets or Smartphones) that, due to their portability, can contribute to delocalized learning, where any scenario can be transformed to be used in a formative way [3].

Locating the use of AR in regard to higher education can be applied in various areas of knowledge. In social science subjects recreating heritage, allowing knowing historical and cultural events of a region. In areas of mathematics they facilitate the explanation of abstract models, illustrating mathematical objects and facilitating the understanding of their location in space; in subjects such as physics they allow the simulation of laboratories that recreate physical phenomena; those and more applications can be given to AR, and be used by students both inside and outside the classroom.

Finally, it can be said that technology is fundamental in the life of man. Allowing to revolutionize the behavior of this in the different sectors (economic, social, educational); in what comprises education, day by day the use of technologies contributes to the teaching and learning processes, however it must be emphasized that the technological factor must be accompanied by human talent to generate transformative processes.

2. Augmented Reality (AR)

According to Horizon Report: 2016 Higher Education Edition, augmented reality increases access to information, generating new uses of technology in learning processes [2]. Currently the use of AR is more accessible by different users due to the boom that mobile devices have had. The characteristics of this technology allow students to build knowledge, which makes the student an active subject in their training process [4].

The following authors Buitrago-Pulido, Cabero Almenara & Díaz Marín, Gutiérrez, Duque, Chaparro, & Rojas, Cabero Almenara, Vázquez Cano, & López Meneses, Martínez-Pérez & Morales Segura, Diaz, Fava, Banchoff, Schiavoni, & Martin, with their publications that AR is a technology that allows to combine in real time digital information and physical information through different technological supports, to create This forms a new enriched reality. The elements that must interact to allow the use of reality increases are: An electronic device with camera, a software that has the properties of reflecting the information on the screen when activating the camera of the device and a trigger known also as "trigger" or activator of the information (2D images, marker, objects, and 2D codes). The combination of these three elements must comply with three basic properties to make up an AR system: a) combine real and virtual objects in a real environment, b) alignment of real and virtual objects with each other, and c) execute them interactively and in time real [5].

This technology can be cataloged in different levels depending on the type of components used when implementing it (see table 1) [6].

Table 1. Augmented Reality Levels

Level	Description
Level 0: **Linked with physical world**.	By using bar codes or QR codes, the RA application creates a link to the real physical world by generating content associated with that code.
Level 1: RA with markers.	At this level the application makes use of the so-called marked which can be in 2D or 3D, for the first we have black and white images and color images, for 3D we use recognition of real objects.
Level 2: RA without markers.	At this level, the applications use the GPS, the compass and the accelerometer of the device to determine the location and orientation of the user and add points of interest in the real world.
Level 3: Increased Vision.	This last level involves devices such as Google Glass, high-tech contact lenses or others that, in the future, will be able to enrich the user's context with additional information.

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3. Methodology

This study is of technological development nature. According to Colciencias "this type of research generates as a result the development of software that produces advances in the generic approaches for the capture, transmission, storage, recovery, treatment or presentation of information" [7]. The purpose of this research is to generate a software prototype that simulates the physical phenomena of uniform rectilinear motion and free fall as the first stage.

To carry out the investigation, three phases were developed (see figure 1):

In the first phase, the requirement survey of the system was carried out using different techniques. With the documentation analysis technique, an analysis of the mechanical physics course plan was made to obtain information on the functional requirements and non-functional requirements of the prototype. Through interviews conducted with teachers in the area of physics, it was possible to have specific aspects of the dynamics of the activities to be developed in the prototype. And finally with the work tables (Workshops) it was possible to have relevant information about the different technologies to be used for the development of the prototype.

In the second phase after having the requirements of the program, we proceed to design the architecture of the augmented reality prototype using UML language (unified modeling language) creating the different diagrams (use case, interaction, state and classes) that allow defining the structure of the system. To be able to precede with the codification stage and creation of the graphic interface of the prototype.

Finally, in the third phase, the prototype of the different interfaces of the prototype is developed and the creation of the C # programming language script that allows the program's functionality.

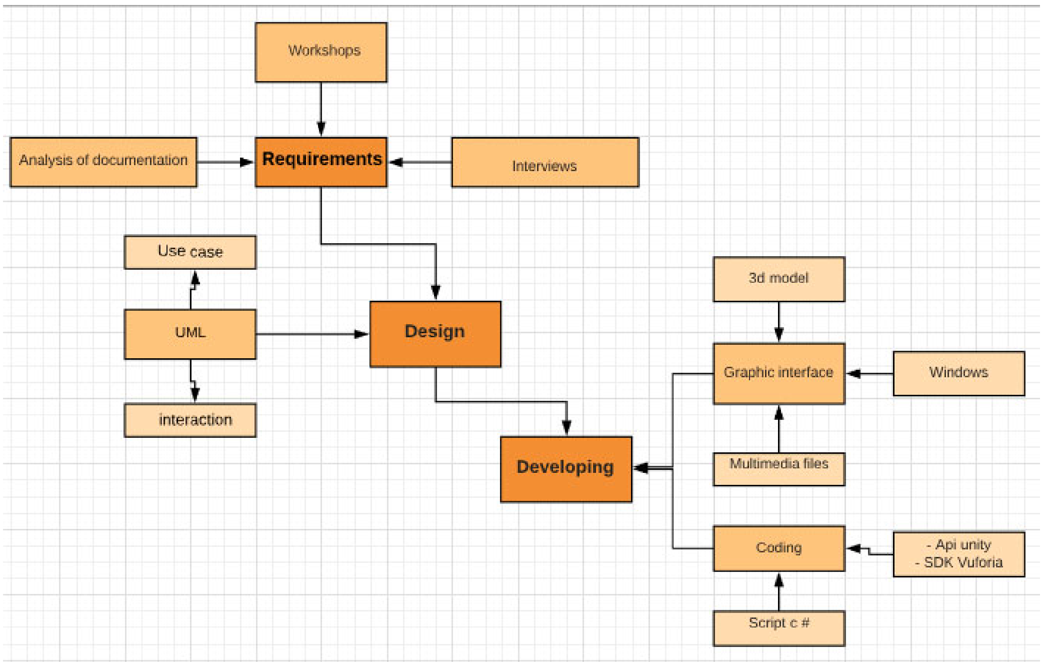

Figure 1. Prototype diagram

4. Results

In the present investigation, the following results were found:

In the phase of raising requirements, a search was started in different academic databases, where it is evident that AR is being studied by different authors of the XXI century, being implemented in the different levels of student training, starting from the basic primary to higher education.

Emphasizing the advantages that this technology offers to the educational sector. the following are listed: it creates a friendly, playful and educational environment; fosters a positive and creative attitude in the student; strengthens the learning of curricular contents through its association of real and virtual information; it is a constructivist resource; promotes ubiquitous and mobile learning; contributes to the increase of attention and concentration; allows the simulation of remote laboratories and phenomena difficult to experience; It can be applied to existing educational physical resources.

In addition, in this phase the Mechanical Physics course plan of the Antonio José de Sucre University Corporation, Corposucre is analyzed, where it is observed that the subject is subdivided into 4 academic units (see table 2).

Table 2. Units of Subjects Plans for Mechanical Physics – Corposucre

Academic Unit	Unit Name
Academic Unit nº 1	Movement in one Dimension
Academic Unit nº 2	Vectors
Academic Unit nº 3	Movement in two Dimensions
Academic Unit nº 4	Laws of Newton
Academic Unit nº 5	Work, Power and Energy Transfer

Unit 1 focuses on the explanation Movements with Constant Acceleration and Free Fall of the Bodies and Launching Up. it is also specified in the subject plan that the learning outcome for this unit is to allow the student to recognize the basic concepts of mechanical physics, as well as the different approaches methods of physics to solve problems of specific situations in the environment. And the resources that are used to teach the classes of this unit are ICT tools (slides and activities of documents written in moodle platform), texts and documents, work guides.

In the design phase, the IDE Netbeans platform was used to create the UML diagrams.

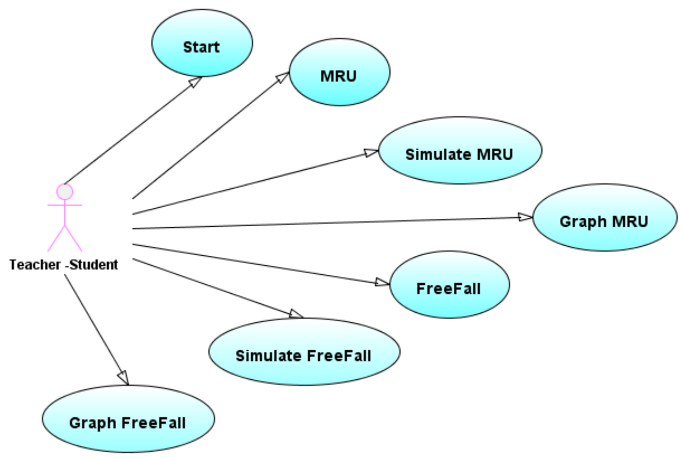

Figure 2. Prototype use, Case Diagram. The following diagram illustrates in a general way the relationship of the actor (teacher - student) with each of the characteristics of the system.

In the development phase Unity 3D platforms were used, which provides us with free of charge the ease of manipulation of virtual objects and the Vuforia SDK that allows using augmented reality technology.

4.1 Prototype AR (Graphic interface and operations)

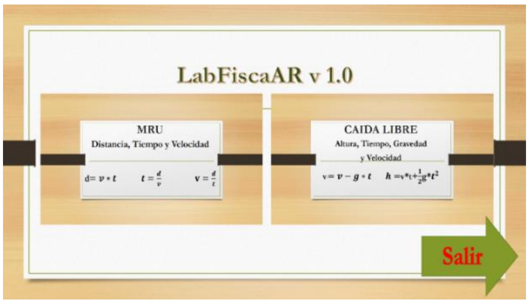

Figure 3. Initial screen of the prototype. Illustrates the name of the application, the exit button, plus the options of uniform rectilinear movements and free fall.

Figure 4. MRU interface. Illustrates a definition and the equations that are involved in the uniform rectilinear movement, allows to perform calculations knowing two of the variables that interfere in the equations.

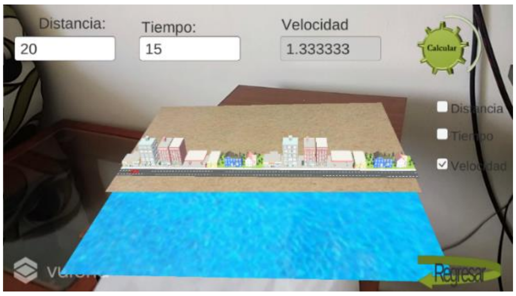

Figure 5. MRU simulator. Reflects a scenario of a vehicle that travels a track at the speed that indicates the equations that are involved in the phenomenon.

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Figure 6. Free Fall Interface. Illustrates a definition and the equations that are involved in the free fall movement, allows to perform calculations knowing two of the variables that intervene in the equations

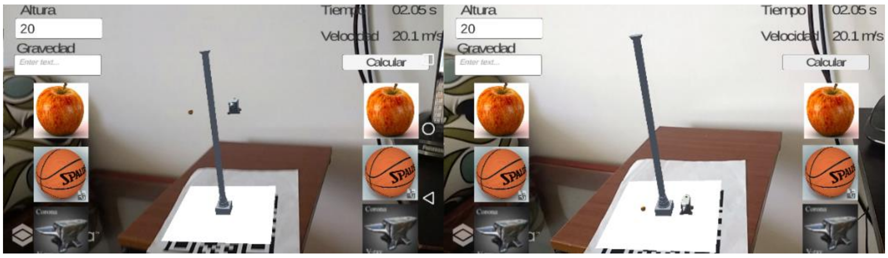

Figure 7. Free Fall Simulator. It reflects a scenario of two objects which can modify their height and the gravity that intervenes to know the time and the final speed.

4.2 Feasibility study

Once the software prototype has been developed, the feasibility of both the technical and the economic part is reviewed.

4.2.1Technical feasibility.

Checking the technical aspects of the prototype to be able to carry out its implementation in Corposucre, It is observed that the minimum hardware and software requirements that a device must have for its execution are (see table 3):

- Mobile device with integrated video camera.
- 1.5 Ghz processor.
- RAM capacity 1.5 GB.
- Android operating system version 5.0.

This allows the prototype to be at the reach of Corposucre's community of the programs of the faculty of engineering sciences, due to the great part of the students and teachers of its community has mobile devices of mid-range.

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Table 3. Tests on mobile devices.

Device	Operating system	Version O.S	Processor	RAM	Performance	Resolution
Samsung Note Galaxy 3	Android	5.0	Qualcomm quad-core , 2.15 GHz	3 GB	Excellent	Excellent
Moto 4G	Android	7.0	1.5GHz Qualcomm Snapdragon 617 eight-core	2 GB	Very good	Very good
Samsung Galaxy S5	Android	6.0	quad-core a 2.5GHz	2 GB	Very good	Very good
Samsung Galaxy j5	Android	6.0	Qualcomm Snapdragon 410 a core 1,2 GHz	1.5 GB	Very good	Very good
Moto E XT1021	Android	4.4.2	1.2Ghz Dual-Core ARM Cortex-A7	1 GB	Acceptable	Acceptable
Huawei p20	Android	8.1	Kirin 970, eight-core, 2.36GHz.	6 GB	Excellent	Excellent

4.2.2. Economic feasibility.
Reviewing the cost-benefit relationship once the prototype was developed for the corporation, it was determined that it has the human and technical resource for the development of software prototypes with augmented reality technologies. On the other hand, there are different multimedia materials with free license for their use, which can be used for the development of this type of applications. It is recommended to acquire the license of some tools used in the development of the project to avoid watermarks.

5. Conclusions
It is concluded that thanks to the fact that mid-range mobile devices have a medium-low cost, the students community can have access to application with technology AR. AR allows the simulation of different scenarios or events that are limited access for teachers and/or students due to economic, abstract or risk factors, ensuring that a large part of the academic community accesses these resources. The study of AR in the education sector should be further deepened and more educational experiences should be generated, in order to validate the real impact it can have on the teaching and learning processes. The construction of applications with AR is available to all, because there are several free platforms for the development of these, as well as a large community that provides information on how to implement it in software development.

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