THE IMPORTANCE OF ANIMATIONS AND SIMULATIONS IN THE PROCESS OF (E-)LEARNING

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ABSTRACT

This paper discusses about animations and simulations and their irreplaceable use in both, traditional and distance education. The main definitions and a clear distinction of these two terms are included in its first part. In the next part, different kinds of animations and simulations, such as interactive, educational, operational, scientific, 2D, 3D, etc., are in the focus. In the remaining parts, among other, the author is trying to answer the following questions: Why, how and where we use animations and simulations in the educational process?, What are the main benefits of using animations and simulations in the learning environment?

The key issue is the importance of animations and simulations, as well as, recommendations about their proper use in didactic classroom, online training, computer-based training, and in other learning technologies.

Key words: animations, simulations, education, learning.

I. INTRODUCTION

We are witnessing the development process of the computer animation since its beginnings in 1960s. As a result of explosive evolution of computer hardware and software technology as well as fast growing of the theory of computer graphics, computer animation has penetrated to every aspect of life, including television, movie, education, industry, science, etc. The modern computer animation techniques include the special effects, photorealistic scenes or vivid characters in movies, video games and commercials. In recent days researchers, engineers, educators and artists all around the world are working hardly to broaden animation's applications, to to make animator's work more convenient and to make the world more colourful by computer animation. [1]

Computer animation is widely applied in various fields such as movie special effects, advertisements, cartoon, computer games and computer simulation, etc. Unlike traditional perspective of computer animation as a part of computer graphics, many researchers claim that it is an interdisciplinary subject of several areas, such as image processing, digital signal processing, machine vision and artificial intelligence, etc.

Simulations are also widely used in preschool, K–12, the university, the military, business, and by adults. They are replacements for real-world experiences. Sometimes it is impossible to replicate the reality in detail but the technology is becoming good enough that in a specific context they can make learners believe that they have encountered an accurate representation of reality. This belief is enough to begin thinking about how we can use simulations to learn in an authentic way. Allowing us to act virtually in a way that is similar to how we would act in the real world (Shank & Cleary, 1995). [2]

The learner can use the simulation to manage the event by manipulating factors and observing the results, thus realizing the impact of each factor on the simulation.

Simulation offers a way to allow students to work on tasks or projects that would otherwise be impractical, dangerous, or prohibitively expensive. [2] They are cheaper, safer, and more accessible than the real thing in many educational situations without placing the student at risk. [3]

Simulations are more than just an interactive model or a collection of facts with which the learner interacts. It provides the framework for learners to build their existing knowledge and augment existing cases they already have in their memory. They are an experience where learning is both interactive and dynamic. Simulations are adaptable and accommodating, helping students learn underlying theories based on hypothesizing, testing, revising suppositions, and retesting to produce the desired (or expected) outcomes. [3]

Computer simulations are becoming more generally recognised as efficient learning environments where students can explore, experiment, question, and hypothesise about real life situations (natural or social), which would be inaccessible otherwise. [3]

As for the science-teaching context, it's worthy to mention some of the main motives to run simulations, defined by Hartmann. He recognizes simulation as: a technique (to investigate the detailed dynamics of a system), a heuristic tool (to develop hypotheses, models and theories), a substitute for an experiment (to perform numerical experiments, a tool for experimentalists (to support experiments) and as a pedagogical tool (to gain understanding of a process) [4]

Finally, some words about how we can define computer games. Are they some forms of simulations, distinct from simulations, or simply an extension of traditional games?

According many scientific investigations computer games had significant educational value and could be extremely useful if they become part of the school curriculum. Some of them, such as: adventure, quest and simulation type games have a lot of benefit – they create a context in which children can develop important skills.

Generally speaking, the computer simulation community considers digital games to be a sub-category of simulations, and, more specifically, a subset of a particular subclass of simulations known as discrete event simulations (Becker & Parker, 2006).

II. Definitions and categorizations of animations

A. *Some definitions of animations*

- The rapid display of images in sequenced succession that, because of persistence of vision, gives the illusion of movement or of time progression. In other words, each frame of an animation is slightly different from the frame that came before it.
- The creation of simulated images in motion, commonly linked with the creation of cartoons, where drawn characters are brought into play to entertain. More recently, it has also become a significant addition to the rich multimedia material that is found in modern software applications such as the Web, computer games, and electronic encyclopedias. [5]

B. *Kinds of animation*

Follows the list and brief explanations of different kinds of animation:

a) Frame-based animation
b) Computer-generated animation
c) Computer-assisted animation
d) Vector-based animation
e) Sprite-based animation
f) Character animation
g) Spline-based animations
h) 2D animations
i) 3D animations

a) Frame-based animation is the simplest type of animation. It is based on the same principle as the flipbook, where a collection of graphic files, each containing a single image, is displayed in sequence and performs like a flipbook. To produce the illusion of motion, graphic images, with each image slightly different from the one before it in the sequence, are displayed at a high frame-rate (the number of frames of an animation displayed every second).

b) Computer-assisted animation refers to systems consisting of one or more two-dimensional planes that computerize the traditional (hand-drawn) animation process. Interpolation between key shapes is typically the only use of the computer in producing this type of animation (in addition to the non–motion control uses of the computer in tasks such as inking, shuffling paper, and managing data). [6]

c) In computer-generated animation the animator is typically working in a synthetic three-dimensional environment with the objective of specifying the motion of both the cameras and the 3D objects. Motion specification for computer-generated animation is divided into two broad categories, interpolation and basic techniques and advanced algorithms. These somewhat arbitrary names have been chosen to accentuate the computational differences among approaches to motion control. The former group can be thought of as low level because the animator exercises fine control over the motion and the expectations of the animator are very precise. The latter group comprises high-level algorithms in which control is at a coarser level with less of a preconceived notion of exactly what the motion will look like. Use of the term algorithms is meant to reinforce the notion of the relative sophistication of these techniques. [6]

d) Vector-based animation is similar to bitmap-based sprite animation, but instead of using bitmaps for sprites, vector-based programs use mathematical formulas to describe sprites. These formulas are similar to the formulas that describe spline curves.

Because objects are mathematical formulas, and not bitmaps, file sizes are much smaller. Another benefit of vector-based animation is that graphics are scalable; i.e., they can be enlarged without becoming jagged or pixellated. Vector-based animation holds promise for Web animation. Several of the plug-ins and authoring tools listed in Appendix A, such as Sizzler and FutureSplash, use vector-based animation [7]

e) Sprite-based animation is sometimes called cast-based animation, as in a "cast of characters." It is very common in computer arcade games and computer animation programs. Sprite-based animation is similar to the traditional animation technique where an object is overlaid and animated on top of a static background graphic. Sprite-based computer animation is different from flip-book style computer animation in that for each successive frame, you only update the part of the computer screen that contains the sprite. You don't have to update the entire screen display for each frame, as you have to do with flip-book style animation.

File sizes and bandwidth requirements for sprite-based animation are typically less than those for flip-book style animation. Sprite-based animation programs typically use an off-screen buffer to composite frames to provide fast, smooth animation. [7]

f) Character animation is a special branch of animation. It is the kind of animation that you typically see when you watch cartoons. It differs from other kinds of animation, such as motion graphics or animated logos, in that character animation involves complex organic shapes with multiple secondary, hierarchical motions.

Although it is fairly easy to animate a single, rigid bitmap over time, animating a believable "living" character is quite an art and takes a lot of work. The techniques that make animated characters believable can also be applied to inanimate objects. [7]

g) Motion paths are more believable if they are curved, so animation programs enable designers to create spline-based motion paths. (Splines are algebraic representations of a family of curves.) To define spline-based curves, a series of control points is defined and then the spline is passed through the control points. The control points define the beginning and end points of different parts of the curve. Each point has control handles that enable designers to change the shape of the curve between two control points. The curves and the control points are defined in 3D space. Most computer animation systems enable users to change the rate of motion along a path. Some systems also provide very sophisticated control of the velocity of an object along paths. [5]

h) In recent years, computer programs have been developed to automate the drawing of individual frames, the process of tweening frames between keyframes, and also the animation of a series of frames. Some animation techniques commonly used in twodimensional (2D) computer animation are either frame-based or sprite-based. [5]

i) Three-dimensional (3D) animations typically require a longer time to set up and create than 2D animations. 3D computer animations are based on 3D coordinate system, which is a mathematical system for describing three-dimensional space. The X,Y, Z coordinates of points in space are used to define polygons, and collections of polygons make up the definition of three-dimensional objects. Many 3D programs have integrated drawing, modelling, animating, and rendering tools. [5]

III. Definitions and categorizations of animations

A. *Some definitions of simulation*

- Simulation is the representation of certain features of the behavior of a physical or abstract system by the behavior of another system. (Ralston and Reilly, 1983)
- Simulation is “an imitation of some real thing, state of affairs, or process. The act of simulating something generally entails representing certain key characteristics or behaviours of a selected physical or abstract system” (Wikipedia)
- Simulation is “the act of imitating the behaviour of some situation or some process by means of something suitably analogous especially for the purpose of study or personnel training.” (WordNet online dictionary)
- A computer (digital) simulation can be defined as a program that models a system or a process, which can be natural or artificial.
- A computer simulation is any computer-implemented method for exploring the properties of mathematical models where analytic methods are unavailable.
- Alessi & Trollip (2001) define an educational simulation as a model of some phenomenon or activity that users learn about through interaction

B. *Kinds of simulation*

a) Experiental and Symbolic simulations

This categorization is according nature of participant roles and interface with the modelled situation (Psotka, 1995; Vanlehn,Ohlssen, & Nason, 1994).

In an experiential simulation, the participants are meant to view themselves as components within a larger, changeable situation (Brown, 1999). An experiential simulation is one in which the participant is placed in a situation that attempts to offer a degree of verisimilitude, a sense of reality. Experiential simulations can be based upon case studies or scenarios, and include role-play and activity, often collaborative, in an authentic environment that in some way or other reconstructs aspects of real life tasks (Maharg, 2006). [4]

Symbolic simulations are different from experiential simulations. They are more abstracted representations of a system or set of processes. Symbolic simulations “depict the characteristics of a particular population, system or process through symbols… Symbolic simulations comprise two kinds: laboratory-research simulations (users investigate a complex, evolving situation to make predictions or solve problems) and system simulations (users interact with indicators of system components to analyze, diagnose, and correct operational faults in the system). [4]

b) Operational and conceptual simulations (Nurmi, de Jong and Joolingen, 1998)

Conceptual models hold principles, concepts, and facts related to the system being simulated while operational models include sequences of cognitive and non-cognitive operations in the simulated system. In operational simulation, the learning is enacted within a specific evolving situation, and in conceptual simulation, learning the content occurs by inferring and making experiments, which can take place either by using or building simulations. [4]

c) Continuous and discrete simulations (Hartmann, 1996)

In a continuous simulation the underlying space-time structure as well as the set of possible states of the system is assumed to be continuous. Discrete simulations are based on a discrete space-time structure right from the beginning (Wolfram, 1994). [4]

d) Two groups of simulations according to whether their main educational objective is to teach about something (2 subgroups: physical and iterative simulations) or to teach how to do something (2 subgroups: procedural and situational simulations) (Alessi & Trollip, 2001)

Physical simulations. A physical object or phenomenon is represented on the screen, giving the user an opportunity to learn about its underlying principles. We learn from physical simulations by manipulating the various objects or variables and observing how the overall system changes as a result. [4]

Iterative simulations. Quite similar to physical simulations in that they teach about something. The primary difference is the manner in which learners interact with the simulation. Time is generally not included as a variable in iterative simulations. That is, whether slowly, in iterative simulations the learner runs the simulation over and over, selecting values for various parameters at the beginning of each run, observing the phenomena occur without interventions, interpreting the results, and then running it all over again with new parameter values. [4]

Procedural simulations. The purpose of procedural simulations is to teach a sequence of actions to accomplish some goal. In all procedural simulations, whenever the user acts, the computer program reacts, providing information or feedback about the effects the action would have in the real world. [4]

Situational simulations deal with the behaviours and attitudes of people or organizations in different situation, rather than with skilled performance. Situational simulations are the least common type of educational simulation, perhaps because they are more difficult and expensive to develop, given the great complexity of human and organizational behaviour. [4]

e) Interactive simulation

Used frequently within various contexts, the interactive simulation reproduces real or imaginary situations, through software, by creating a dynamic context where participants are required to engage in an experience to turn a problem into reality, and to make decisions respecting the rules and in relation to the aims that must be pursued. [4]

IV. Using animations and simulations in education

A. Using animations in education

Nielson (2000) and Vossen (1997) suggested that instructors use animations:

(1) to draw the learners' attention or alert viewers to new information

(2) to demonstrate navigation in a particular direction,

(3) to create icons for actions that cannot be adequately expressed with a flat, static picture.

B. Using simulations in education

Simulations have the potential to be used in several approaches to teaching and learning. For example, they can be used as: a didactical tool, models and conveyance for complex concepts, to support constructivist learning through learning by doing, for discovery learning, and experiential learning, etc. As a result of implementing properly designed simulation activities, the role of the teacher changes from a mere transmitter of information to a facilitator of higher-order thinking skills (Woolf & Hall, 1995). [4]

Four characteristics have been identified as a contributing to the success of computer simulations for instruction (de Jong, 1991). These are:

(a) a computational model underlying the simulation:
(b) the presence of clearly stated instructional goals:
(c) the ability of the simulation to evoke exploratory learning: and
(d) the opportunity or possibility for learner activity. [4]

Follows some characteristics of a digital simulation in teaching and learning:

– it has an adequate model of a complex real-world problem or situation with which the student interacts,
– a defined role with a set of available actions,
– a data-rich environment that permits a range of strategies from a variety of perspectives,
– feedback in the form of changes in the problem or situation,
– embedded instructional goals, and
– mechanisms for active participation and the promotion interest, which elicits deeper, more expedient, and better retention of understanding of a concept, mastery of a skill or strategy, or acquisition of knowledge. [4]

V. Challenges

Even though clear advantages to using digital simulation for teaching and learning, there are many challenges including:

- The physical interface might be cumbersome.
- Digital simulations may have limited tracking ability with delayed responses.
- Feedback during play may be hard to be included in the immersive experience.
- Digital simulations may require users to switch their attention among the different senses for various tasks. In particular, multisensory inputs can result in unintended sensations and unanticipated perceptions.
- When learning in simulation, users may often feel lost. Accurately perceiving one's location in simulation is essential to both usability and learning.
- Digital simulation environments and tasks are often overwhelming for some students. Digital simulations particularly make demands on students' meta-cognitive skills, and in some cases, place students in complex environments.
- If students are not getting enough guidance or they use a simulation just for simple practicing of their skills, the simulation-based learning does not necessarily lead to a positive attitude towards the learning environment.
- Creating a digital simulation for education is costly and difficult. Simulation creation does not yet have a reliable, affordable set of software tools that can assist the teacher in creating tailor-made simulation environments. Digital simulation systems are difficult to create and maintain, and the skills needed to do so are so far outside a single teacher's usual domain of knowledge. As a result, simulations often have little adaptability; they tend to get used once and then laid aside. As digital simulation technology evolves, some of the challenges to educational design will recede. At present, however, achieving the potential of immersive, synthetic worlds to

enhance learning requires educators' understanding of its effectiveness as well as its challenges and their participation in creating simulations. [4]

VI. CONCLUSIONS

The presented wide spectra of definitions and classifications of animations and simulations indicates their importance, especially in the field of education.

Many objectives of the teaching/learning process could be easily achieved with properly use of well prepared animations and simulations. Animations and simulations are irreplaceable didactic tool when we are talking about promotion of higher level of interactivity in the educational process of any form, whether traditional or distance.

The other benefits of the increased use of animations and simulation in education include: deeper and better retention of student understanding of concept, mastery of a skill or strategy or acquisition of knowledge. Animations and simulations could support constructivistic learning through learning by doing, and can be use for discovery learning, experiental learning, problem-based learning, etc.

The main challenges that remains open are: complexity of animations/simulations, student navigation through animation/simulation, including feedback, adaptability of students and teachers, proper use of animations/simulation according the teaching and learning methods, forms and techniques, adequate use of animations/simulation according the educational goals and objectives, etc.

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