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MEANINGFUL LEARNING IN MATHEMATICS EDUCATION: A PROPOSAL OF DEVELOPING A PROTOTYPE OF AN AUGMENTED REALITY TOOL TO SUPPORT THE TEACHING OF CALCULATION

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ABSTRACT

This paper presents the proposal of developing a prototype of a support tool to teaching of calculation, considering the principles of David Ausubel's meaningful learning theory, given the difficulty of interaction and visualization that learners present in the traditional teaching model. The tool developed uses advanced techniques of image processing and introduces a differentiated approach to the concept of augmented reality. In this way, it will be exposed the main concepts and aspects that allows the application of augmented reality as a teaching tool, considering its main characteristics and its basic foundations necessary for an optimized utilization of its resources, thereby providing the evolution in the teaching-learning process.

KEYWORDS

Augmented Reality, Virtual Reality, Meaningful Learning, Education, Teaching of Calculation, Mathematics.

1. INTRODUCTION

The inclusion of information technology in education must be seen as a support for the teacher, an additional instrument in your classroom, where they can use those resources put at their disposal. At this level, the computer is explored by expert teacher in its potentiality and capacity, enabling simulations, practices or even experience situations, and could even suggest abstract conjecture, fundamental to the understanding of a knowledge or a knowledge model that is being built (Borges, 1999).

The teacher and learner must explore the maximum of all the resources offered by technology. When the technology is used in the service of emancipatory education, the learner gains in quality teaching and learning. The real function of the educational apparatus should not be to teach, but to create an environment of learning and facilitate the process of learner's intellectual development (Rocha, 2008).

The teaching of calculation has been subject of diverse questioning in forums, due to the difficulties presented by the learners in its learning (Barros, 2008). Inserted in this context, the objective of this research is to use multimedia resources in the elaborations of calculation's didactic material, aiming the improvement in the instruction process and learning in this discipline. The research was based in the David Ausubel's theoric/methodologic paradigm, entitled meaningful learning.

In this way, it will be presented the proposal of developing a prototype of a support tool to teaching of calculation. The general objective of the support tool is build an interactive environment to assist and encourage the construction of knowledge necessary for understanding the proposed content. The use of the virtual reality together the augmented reality in this type of support tool, it can contribute and improve in a significant way the assimilation of concepts viewed, when it provides a favorable environment to learning.

The central idea is offer a tool accessible via Web to improve the learning, through an attractive and motivating multimedia scenario, thereby providing the evolution in the teaching-learning process.

2. THE MEANINGFUL LEARNING AND THE AUGMENTED REALITY

The learning theory presented by Ausubel et al (1980), proposes to launch the basis for understanding how human being constructs meanings and thereby point the way to the elaboration of teaching strategies that facilitate a meaningful learning.

For Ausubel et al (1980), the learning can be processed between the extremes of the mechanical learning and the meaningful learning. The mechanical learning is needed and inevitable in case of entirely new concepts for the learner. The mechanical learning happens when new information are absorbed in a literal way without interacting with relevant concepts existing in the learner's cognitive structure. Simply, the learner receives the information and stores it, so that it remains available for a certain time interval. In the absence of any other information which can be combined it, it remains in the cognitive structure in a static way. In this case, the learner will only reproduce the content exactly the same way that it was presented to him. Because, there was not an understanding of the structure of the information presented, and thus the learner will not be able to transfer this learning to solve equivalents problems in other contexts

On the other hand, when the learner is faced with new information and is able to establish connections between this material and his previous knowledge on related subjects, he will be building personal meanings for this information, transforming it into knowledge, in meaning about the content presented. This construction of meanings is not a literal apprehension of information, but it is a substantive perception of the material presented, and thereby configures itself as a meaningful learning (Tavares, 2004).

Many authors agree that there are many reasons for using the virtual reality in education. Thus, the virtual reality together the augmented reality combines particularities and attributes that makes this combination an ideal tool to help effectively the meaningful learning.

Unlike the virtual reality, which transports the user to the virtual environment, the augmented reality keeps the user in your physical environment and transports the virtual environment to the user's space, allowing the interaction with the virtual world more naturally and without training or adaptation (Tori et al, 2006). The augmented reality provides an increase of the human perception, allowing the learner to better identify the information from the context in which he is inserted. Because it requires interaction, encourages the active participation of each learner within a preview process, contributes significantly to the motivation of learning, encourages creativity and gives opportunity for new experiences, ensuring a better understanding of the concepts proposed and favouring to him better conditions for the acquisition and construction of their knowledge (Zorzal et al, 2008).

3. AUGMENTED REALITY TOOL

Conventional augmented reality applications use predefined patterns that when it is recognized generate a predetermined result. Thus, this tool want to present a differentiated approach to the concept of augmented reality, a dynamic augmented reality, with no predefined patterns and results.

This differentiated approach enables performing experiments according to user's need, without the need for generating a new code for the interpretation of each pattern supplied by him. The system must interpret any pattern supplied by the user as input and process a satisfactory result to this pattern as output.

The whole process performed by the tool is described step-by-step below and it also can be seen on video at http://www.gaia.uel.br/gaia/prodproc.

3.1 The Pattern and Image Acquisition

Over a white plane surface, for example, a whiteboard or even a paper, you can mark several random points using a simple pen, as demonstrated in Figure 1.

Grid lines can also be used to facilitate the location and marking of the points. However, the grid lines color must be lighter and softer than the pen color chosen, to avoid possible failures during the patterns recognition process.

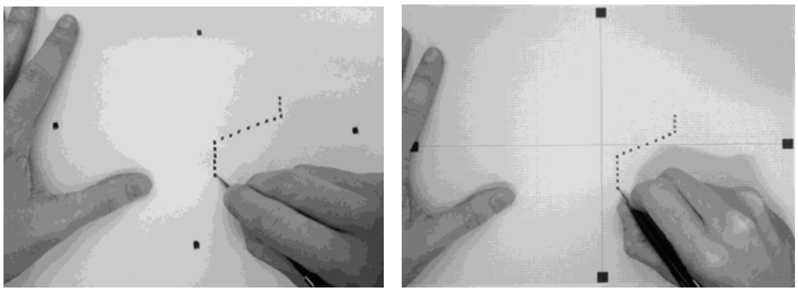

Figure 1. White plane surface: (a) whiteboard and (b) paper with grid lines

The first step performed by the system is the image acquisition captured from the Webcam shown above in Figure 1.

3.2 Pre-Processing

The objective of this step is to prepare the image in order to increase the chances for success of the following steps. These steps are divided in four parts: converting the color image to a grayscale image, calculating the histogram values, calculating the threshold value and thresholding image.

Once the color image is converted to a grayscale image, the threshold value is found and used in the thresholding operation. In this step is identified the value where there is the highest concentration of dark tones pixels. After the value identified, the thresholding operation is applied in the image.

3.3 Segmentation

The objective of this step is isolate relevant objects to the desired application. In this work was needed to implements an adaptation of the 8-way recursive Flood Fill algorithm. The adaptation performed in the algorithm allows the identification of the maximum and minimum values of the x,y coordinates of the filled region. This algorithm allows us to find the approximate location of the point. This algorithm runs in two moments: during the segmentation of the limits from useful area and segmentation of the points marked with pen.

3.3.1 Segmentation of the limits from useful area

The execution of the algorithm is needed to identify the limits (top, bottom, right and left) of useful area. The scan starts from the top towards the bottom until it finds the first black pixel. When the black pixel is found, the adaptation of recursive Flood Fill algorithm is executed.

The same algorithm is applied from bottom toward the top, from left to right, and finally, from right to left. With the result of the execution of this algorithm will be possible to identify the maximum and minimum values of the x,y coordinates of each region filled.

3.3.2 Image Rotation and Translation

The image rotation is needed when is presented any inclination the axis of the coordinates system from the captured image in relation to the reference axis for the analysis. The rotating movement is performed to position the image on the y-axis.

After the rotation, the translation movement is required. The translation movement is needed to align the axis of the coordinates system from the captured image to x-axis, in other words, exactly at the origin, as in the previous step has been performed the alignment with respect to the y-axis.

3.3.3 Segmentation of the Points Marked with Pen

This step happens just after the correction of the inclination angle of the image. The execution of the algorithm is required to identify each one of the points marked with the pen. The same algorithm applied in the segmentation of the limits from useful area is used for execution of this step. However, with a behavior a little different. The scan starts from the top towards the bottom, from left to right until it finds a black pixel.

When a black pixel is found and the adaptation of the recursive Flood Fill algorithm is executed, instead of stopping the execution of the algorithm, the scan restarts from the next pixel of the black pixel found previously until analyze all pixels.

3.4 Representation and Description

Once extracted the maximum and minimum values of the x,y coordinates for each of the points, the average between this coordinates is calculated, and the approximate location of each of the points is found.

At this time, all relevant information were extracted from the image to begins the 3D processing. However, the processing of this information requires the normalization of the image reference system to the view plane reference system of 3D content.

The normalization is required to keep the same proportion of the image coordinates when represented in the view plan reference system of 3D content, regardless of the size of the usable area of the work surface.

3.5 Application of the Augmented Reality

The group of points previously extracted from the image build a segment that, when rotated 360° clockwise around the y-axis, generate a geometric solid. The rotation is performed incrementing the angle specified by Ø and producing N columns of points around the y-axis.

For this system, the increment angle Ø is defined a value equal to 3. Thus, we can calculate the variable N by the formula below:

$$N = \frac{360}{Ø}$$

Each segment generates a slice. The coordinates of each adjacent slice are arranged in quadrilaterals (quads). Each quad is specified by four points, each being represented by coordinates x, y and z. The points are arranged in counterclockwise order so that the normal of the quad remains facing outside.

Figure 2a shows how two quads are defined. The coordinates x, y and z of each point are stored in ascending order.

The quads build a ring at a time, starting at the bottom of the segment until it reaches the top. The values of x and z for each of the points are obtained, as shown in Figure 2b, by treating the original value of x as the hypotenuse of the angle given, and projecting it to the x-axis and z.

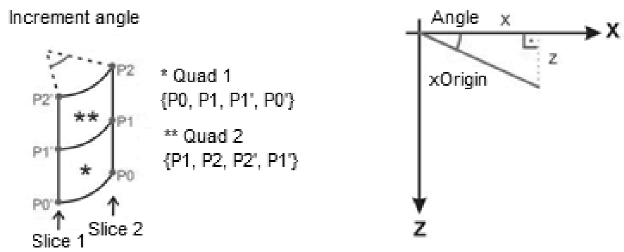

Figure 2. (a) building two quads and (b) getting the new values of x and z

The new values of x and z are given by:

$$x = xOrigin \times \cos(angle) \qquad z = xOrigin \times \sin(angle)$$

After running all these processing steps, finally the solid geometry is generated, as can be seen in the Figure 3 and Figure 4 below:

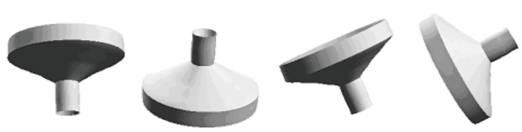

Figure 3. Visualization of the 3D funnel generated

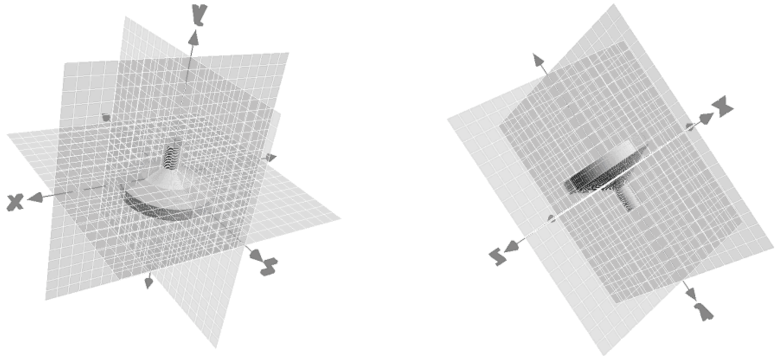

Figure 4. Visualization of the 3D funnel generated on a cartesian plane.

4. CONCLUSION

Actually, there is a big discussion about the information technologies and new educational relationships. It is time for a general evaluation of the progress of education: education mediated by technology. This pedagogical approach requires a new posture from the teacher and student, and implies a new way of organizing the pedagogical work.

In the classroom can be observed the great difficulty found by the learners in obtaining a satisfactory progress to issues related to mathematics. In Brazil, this difficulty is due, in great part, the insufficient preparation in elementary mathematics that the students arrive to college. In addition, many students return to school after a long period far away from the educational environment, which naturally makes them forget the content and do not follow the lessons in a reasonable manner.

Therefore, the tool developed proves that the augmented reality together the virtual reality combines features and attributes that makes it a powerful tool to support the teacher, enabling simulations, practices or even experience situations, fundamental to the understanding of a knowledge or a knowledge model that is being built. The pre-set goals as proposal for this work were achieved. The tool is able to reproduce accurately any solid by revolution, from the coordinates of the points marked by the user, providing the system user a safe interaction, without training, since him can bring to your real environment virtual objects, incrementing and increasing his vision of the real world.

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