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Some Evaluations of Efficiency of Machine Synthesis of Terrain Images Affecting Learning Process Using Simulators for Vehicle Drivers

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***Abstract*— Software appeared in recent years that allows almost anyone to start drawing, does not always meet the requirements for obtaining images of the terrain in the simulators. When synthesizing the visual 3D model of a part of the visualization scene, observed through the window of the simulator's cabin, it is necessary to obtain a model of space in which the observer can train his eye. The quality of this model is to allow a student to acquire professional driving skills. The authors take into account that a student acquires professional skills in driving a real vehicle by driving the model of the vehicle moving in a model of space. When learning using the appropriate simulator, possible deflections maximize the acquisition of so-called "false skills". Studies have shown that there are always false skills when learning on a simulator. This learning for driving a vehicle on a simulator differs from learning driving on a real vehicle. When learning using a real vehicle, false skills are not acquired. The analysis showed that one of the reasons for the appearance of false skills in learning driving a vehicle based on information received from a human visual system are errors in synthesizing a picture on the screen of forming intermediate picture. The article considers some types of errors related to an incorrect display of shadows when synthesizing the 3D models and suggests ways of eliminating them.**

Keywords—decision making, setting management tasks, professional training, new information technologies in solving management and decision-making problems

I. INTRODUCTION

The foreseeable period of human existence shows that there has always been a need to fix the various kinds of information [1]. People invented different ways of fixing information [2]. The most common are texts and images. In fact, these are accordingly analytical and synthetic ways of fixing information [3]. Each of these methods has its advantages and disadvantages.

The analytical method has the following disadvantages, which make it difficult to access information fixed in the texts [4]. This is a huge amount of texts, which is difficult to navigate, and language barriers [5]. On the other hand, the advantage of an analytical way of fixing information is an availability of methods for creating of texts [6]. Almost all modern people are able to read and write.

The synthetic method provides easy access to information [5]. Everyone can get the information fixed in the images [7]. Time of creation of the image and nationality of the creator are not hindrance in understanding of the created image [8]. As a result, images are a means of interethnic and intertemporal communication [9]. But methods of creating images are not available to everybody [10]. How many people are able to create images, in other words, to draw?

II. MATERIALS AND METHODS

Currently not everyone is trained to draw professionally. There are no methods that would allow us to teach any person how to depict a three-dimensional world on the plane [11-13]. Only people with special abilities are trained [14]. Although the need to learn this process does not lose its relevance. The reasons for this need are:

- greater information saturation of images in comparison with texts [5];
- the need to present a holistic studied process or object [15];

the need to operate with geometric information fixed in the images and which all real objects have [16].

All this provided wide application of images in various fields of human activity: engineering, construction, science, art, etc. [17–20].

As a result, there was a contradiction between the growing need of people in images and the inability of any person to create such images [21]. A lot of specialists in the field of computer technologies are working on solving this problem [22]. But their solutions are not always successful [23]. This publication is devoted to criticism of such solutions.

Currently, there are two ways to solve the above problem:

to develop a teaching technology that will teach anyone to draw 3D objects on a plane;

to use software that would allow one to create flat images of three-dimensional objects. And such software is created with an enviable regularity.

Teaching technology has already developed [19,23,24]. It allows one to teach any person to build images that preserve all the geometric information of the source object [18, 23]. A possibility of creating such technologies appeared when the theory of image building was developed, where all laws were stated on the basis of projective multidimensional geometry [24]. But, unfortunately, they are not used widely. To adopt the developed technology, an appropriate level of geometric literacy is required [25]. But the level of geometric literacy has been steadily decreasing recently.

It should be noted that scientific progress has led to the fact that teaching systems [26] and simulators have become widely used for teaching pilots of aircraft, drivers, helmsmen and train drivers [15,27,28,]. The feature of such simulators is an "immersion" of an observer in an artificially generated visually observable virtual space, allowing him to see three-dimensional models training his eye or accurately determining distance to visible models of three-dimensional objects during a movement of a vehicle model in the space in real time with the frame time less than 120 ms [11,29]. This is achieved using one of two known pseudo-volumetric optical systems, allowing the observer to see three-dimensional models with a quality sufficient for training an eye [30]. In the first case, such systems are focused on impact on two components of human vision - accommodation and convergence [15]. In the second case, an optical system is focused on impact on the other component of human vision - binocular disparity [7].

In the first case, an optical system called a collimator is used, which adjusts a person's view of the "gaze into infinity" (Fig.1). This allows one to create glasses-free pseudo-volumetric systems of modeling visually observed images of the terrain around the cabin of the simulator [30]. When they are used on the screen of forming intermediate picture (SFIP) using a computer generator of picture (CGP), based on an information stored in a database, a picture is synthesized based on a location of an observer and a direction of his view in the scene (obtained from a simulator of dynamics) - a two-dimensional projection of a part of the scene of visualization, caught in the visibility pyramid. A synthesized image from one SFIP using optics is delivered to a human visual system, purposefully influencing accommodations and convergence. A major disadvantage of this approach is the presence of a "dead zone" between an eye of an observer and the first model of a three-dimensional object closest to him, regardless of whether such optical devices were designed to observe a model of a terrain for one person, or for a group of observers [7]. With the use of glasses-free indicators modeling 3D images, which previously produced by Penza enterprises, the width of a "dead zone" was evaluated at 80 m. The authors of this article, carrying out research on 3D indicators of different designs, produced by «Video3» Ltd, achieved the result - the distance to the nearest model of a three-dimensional object was 5 m.

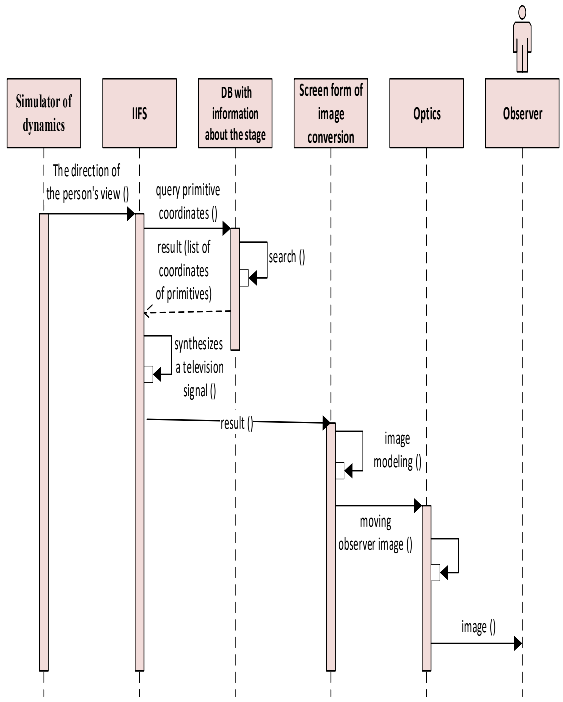

Fig 1. UML sequence diagram of the modeling process of a three-dimensional image in a pseudo-volumetric system with a collimator.

In such systems, disparity glasses are used, delivering to each eye of a person his picture, synthesized taking into account a location of this eye in a world space [13]. At the same time, two pictures are synthesized on two screens of forming intermediate picture, separately for a left eye, and separately for a right eye. Then, with the help of optics, a picture from the screen of forming intermediate picture synthesized for a right eye, purposefully goes into a right eye, and a picture from the screen of forming intermediate picture synthesized for a left eye, purposely goes into the left eye. The advantage of this approach is the absence of a "dead zone", the disadvantage - a significant number of observers should initially learn to see a 3D model (experiments show that after an observer has learned to see such a 3D model, he will always see it).

In all cases, the quality of a resulting 3D picture depends on the quality of a picture synthesized on the SFIP [11]. Any shortcomings that appear at this stage have a negative effect on a visually observable three-dimensional model, which negatively affects the acquisition of orientation experience in space by observer.

III. Results

A creation of flat images is taught in art, technical and construction universities. There, students must master laws of creating various types of flat images. At art universities perspective images are studied. A lot of attention is paid to a creation of shadows. In the rest of the universities, they master mainly an axonometry and a Monge's projection, and the main emphasis is on a Monge's projection, while an axonometry plays a secondary role. Almost no attention is paid to such important section as the creation of shadows. Although it is known that shadows are an additional image that allows one to distinguish a shape of a three-dimensional object depicted on a plane. But in a curriculum this is given very little time, which is also constantly reduced. In addition, people who do not have special training work at the departments of a complex of geometric-graphic disciplines. They find it difficult to assess the seriousness of the problem and find an effective way to solve it [31]. As a result, it is not necessary to speak about qualitative teaching for this process. They rely mostly on the second method. They say there are computer programs, and they will solve all problems that are associated with flat images of three-dimensional objects [3].

At first sight, it seems that this is the case, because any person who wants to create flat images of three-dimensional objects can master computer programs [32]. As a result, a rather large number of such computer programs was created. They can be divided into two groups:

The computer program works like a drawing tool (CorelDRAW, Inkscape).

The computer program makes it possible to compose an image of a complex three-dimensional object, collecting it from simple elements (Autodesk 3ds Max, Cinema 4D, Sketch Up, SDL).

Let us consider the advantages and disadvantages of each of the selected group of computer programs.

To create images using a program that works as a drawing tool, a person must first learn all the laws by which flat images of three-dimensional objects are created. However, such learning, as stated above, is not available to every person.

It would seem that in the second case this problem is solved. Now everyone can create flat images of three-dimensional objects. However, let's see what a level of obtained images is from the example of a flat image of still life, built in 3D MAX (Fig. 2).

Linear image is not objectionable. Another thing is a shadow. It should be noted that shadows are performed on an image in order to reveal a shape of a object and their relative position. Let's see if this is really so.

Images of a jug, dumbbells and balusters, are made in axonometry (Fig. 2). This example is taken from the Internet: the 3D MAX lessons website (www.yandex.ru/images, accessed 10.11.2017). Therefore, a visual aid for students can be considered.

IV. Discussion

Let us consider the correspondence of a location of self and cast shadows to the basic laws.

Law 1. Any point of a contour of self shadow gives a cast shadow.

Judging by the illumination of the lower spherical part of the baluster, a light source should be placed high enough. This position of a light source causes a cast shadow, from the upper spherical part of the baluster to the lower spherical part, which is absent.

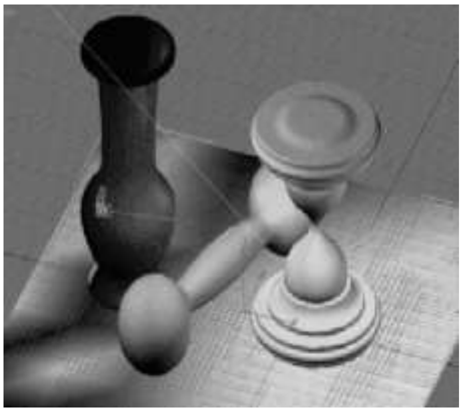

Fig. 2. The image of still life, performed in 3D MAX lessons

The falling shadow from the jug is positioned as if the jug is illuminated from behind, also from left, from front, and from above. Although self shadow on the spherical and cylindrical parts is located as if the jug is illuminated from right. In addition, there is the inner visible surface of the jug illuminated for some reason from left and behind?

Judging by the location of the cast shadow from the dumbbell, it should be located almost at the level of the upper part of the baluster. In this case, its remote part should be raised much higher than the jug. Although the linear image assumes a different arrangement of dumbbells. Where is the dumbbell? At what height does it float above the surface of a table?

The cast shadow behind the jug and the back part of the dumbbell is not clear from what object. If it cast from a dumbbell, then it does not match its illuminated part. If it casts from the jug, then the jug is illuminated also from left, and from front with light sources, which is located low enough. If it casts from the baluster, how did it manage not to cover the illuminated back part of the dumbbell? In addition, where is a falling cast from the baluster? Judging by her absence, the balustrade soared high and there it hovers in cloudless heights. Then how did it (the baluster) manage to give a shadow in the foreground? Is it a mistake?

Law 2. An illuminated part on a cylinder is a strip bounded by its generators. A cast shadow from a lateral surface of the cylinder on a plane is bounded by straight lines and is equal in width to the width of the cylinder.

Judging by the linear representation of the neck of the jug, it is a cylinder. A self shadow of a cylinder must confirm this. However, it shows that this is some other surface. In addition, the cast shadow from the cylindrical part of the jug is too narrow. This does not correspond to the width of the illustrated cylindrical part of the jug. What is a surface of the neck of the jug?

Law 3. Nothing that is in a shadow of an object should be lighter than it is in its illuminated part. Reflections should not be brighter than glares.

Reflections are an illumination of an object by reflected light, so reflections can never be a lighter then illuminated part of an object even if the object has a shiny surface. However, the reflection on the base of the spherical part of the jug, in its brightness, covers the whole of its illuminated part. Probably, the jug has a glossy surface. Then on the illuminated part of it there should be glare, but they are not. This indicates that a surface of the jug is matte. So what to believe: is surface of the jug matte or glossy?

On any sphere, a location of its self shadow obeys the following laws: the brightest illuminated part is the closest to light source. On glossy surfaces, there is usually a glare. It gradually loses its power, passing into a semitone, which also smoothly passes into a shadow. Reflected light illuminates a shadow with a reflection. A semitone is always lighter than a shadow. Then why on the spherical part of the jug on the right there is a dark strip, which by the power of tone is equal to the shadow of this surface? Below on the left under the spherical part of the jug under a shadow, there should be a reflection from a sufficiently light table surface. But it is not! What kind of surface does the jug have?

Law 4. All objects that are closer to a light source have a greater contrast than those that are located further.

The reflection under the top of the baluster is too bright. By the power of tone, one argues with the lighted upper part.

The glare on the spherical back part of the dumbbell should show that this part is closest to a light source. Then the light source should be behind the baluster. In addition, all of its part that turned to an observer should be in a shadow. However, this is not so!

If the light source is above the objects, then the upper part of the baluster is closer to it and should be brighter than the bottom part. But the image is not so.

The ledge of the upper base of the baluster is illuminated from the left, and the spherical part of the lower half is illuminated from the front. If the baluster was illuminated from two sources, then a location of self shadows will be completely different. The question arises: where is this mysterious light source located? Is it on the left, on the right, above, behind the baluster, under the baluster or in front of her, or somewhere else?

In sum, it can be stated that a model image executed in the 3D MAX program distorts the reality. What is a reason? In a program or in an incompetent user? Most likely in that and in the other, importance of computer programs in creating quality images is clearly exaggerated.

Thus, images obtained by the 3D MAX do not preserve all the geometric information of original objects. In other words, they do not correspond to reality. These mistakes can be forgiven if images are only for viewing. Most people do not even realize these mistakes. However, distorted geometric information is perceived on the subconscious level and most often causes an unconscious negative attitude to depicted objects.

Currently, the 3D MAX program is very popular. It is used in the most varied spheres of human activity. For example, in architecture. The inconsistency of an image of reality will prevent a customer from accepting a completed project. Something in it will seem alike, and something does not seem convincing. In addition, if this image is necessary for any simulators? For example, simulators, with a help of which astronauts or car drivers train, they will mislead a trainee as a minimum and can lead in the future to very sad consequences as a maximum. Because a person, accustomed to distortions of reality in an image on which he trains, will be disoriented when faced with reality. Yes, who knows when another situation may arise, in which an unreal image can do much harm?

Teaching computer graphics and programming requires a symbiosis of knowledge of computer technology and the fundamentals of the theory of image building and modeling technologies of an image model perceived by a human visual system as a three-dimensional visually observable object.

V. Conclusions

The paper uses the results obtained during the experiments conducted at «Video3» Ltd:

during implementation of the project "Research and optimization of production technologies of beam splitter plates and spherical mirrors for single-channel and multichannel glasses-free indicators of pseudo-volumetric images with a narrow pupil" (public contract №8009p/8265 of 30.04.2010);

during implementation of initiative projects on the research of pseudo-volumetric indicators and software packages that allow one to synthesize in real time part of a visualization scene for training of an observer orientation in three-dimensional space.

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