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3D OBJECTS CREATION APPROACHES

In this paper are discussed the application of 3D technologies, which are reflected in various areas of life, such as education, science, engineering and entertainment industry. The use of 3D technology in the educational process can significantly increase its efficiency by bringing the virtual computer environment closer to the real three-dimensional world. But for now the use of augmented reality in teaching is only gaining momentum. Many applications are still quite primitive, but developers are actively working on their refinement, increasing the amount of educational content, improving quality. It is not entirely clear what the basic steps of 3D modeling are for importing a model into augmented reality. Today there are a large number of areas of application of 3D models. The question is whether it is possible to use a single algorithm for all models and which. The aim of this work is to increase the level of use of 3D technologies in the educational process for an effective and external interactive way of providing information. In the course of the work the methods of creating 3D content for different areas of application such as game industry, 3D visualization, 3D printing, AR projects, holographic fans, preliminary assessment of technical properties of the product and etc were considered. Data analysis has been shown that for each area of application 3d content has its own requirements and features. This information was identified and presented in the form of a comparative table. Based on the analysis of modern methods of developing 3D content for different applications, it was proposed to combine the requirements for creating 3D models of individual areas. Based on the proposed combination, a small experiment was performed. 3D model of the character for the children audio-encyclopedic stories educational application was designed. The obtained models were also integrated in the augmented reality environment. After analyzing the relevant indicators, we concluded that the requirements for 3D content in these areas are the same. The paper also structured the main stages for creating 3D models of different applications, which in turn brings clarity and clarity to the process of developing 3D content for further import into AR training projects.

Key words: 3D model, AR projects, 3D technologies, educational process, augmented reality

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ПІДХІД ЩОДО СТВОРЕННЯ 3D-ОБ'ЄКТІВ ДЛЯ ІМПОРТУ ЇХ У AR ПРОЕКТИ

В данній статті розглядається питання застосування 3D-технологій, які знаходять своє відображення в різноманітних сферах житедіяльносі, наприклад таких як: освіта, наука, техніка та індустрія розваг. Використання 3D технологій в освітньому процесі дозволяє суттєво підвищити його ефективність завдяки наближенню віртуального комп'ютерного середовища до реального тривимірного світу. Але, поки що використання доповненої реальності в навчанні тільки набирає обертів. Багато додатків залишаються досить примітивними, але розробники активно працюють над їх доопрацюванням, збільшенням кількості освітнього контенту, підвищенням якості. Актуальною постає задача швидкого та якісного алгоритму створення 3D контенту для подальшого імпорту його у AR навчальні проекти. Не зовсім зрозуміло, які основні етапи 3D моделювання необхідні для імпорту моделі у доповнену реальність. Сьогодні існує велика кількість сфер застосування 3D моделей. Виникає питання чи можна використовувати один єдиний алгоритм для усіх моделей та який. Метою роботи є підвищення рівня використання 3D технологій в освітньому процесі для ефективного і наочного інтерактивного способу подачі інформації. В ході роботи були розглянуті методики створення 3D контенту для деяких розпоширених сфер застосування таких як: ігрова індустрія, 3D візуалізація, 3D друк, AR проекти, голографічні вентилятори, попередня оцінка технічних властивостей виробу та ін. Аналіз даних показав, що для кожної сфери застосування 3D контент має свої вимоги та особливості. Зазначена інформація представлена в статті у вигляді порівняльної таблиці. На основі аналізу сучасних методів розробки 3D контенту для різних сфер застосування було запропоновано обєднати вимоги до створення 3D моделей окремих сфер. Спираючись на запропоноване поєднання був прведений невеликий екперимент. Було створено 3D модель персонажу освітнього додатку аудіо енциклопедичних історій для дітей. Також було здійсненно інтегрування отриманої моделі в середовище доповненої реальності. Проаналізувавши відповідні показники прийшли до висновку, що вимоги для 3D контенту зазначених сфер однакові. В роботі також структурізували основні етапи для створення 3D моделей різних сфер застосування, що в свою чергу вносить ясність та чіткість в процес розробки 3D контенту для подальшого імпорту його у AR навчальні проекти.

Ключові слова:3D модель, AR проекти, 3D технології, освітній процес, доповнена реальність

Introduction

Modern technologies introduce many useful features and capabilities that greatly simplify life, make it brighter and more comfortable. It's a well-known fact that everyone perceives the world in three-dimensional projection and technology allows you to discover the full potential of perception, thanks to 3D design. Today, the applications of 3D technologies are reflected in various fields such as education, science, engineering and entertainment industry. The use of 3D technology in the educational process can significantly increase its efficiency by bringing the virtual computing environment closer to the real three-dimensional world. Many educational institutions already use augmented reality in laboratory work in physics and chemistry, practical classes in astronomy, history and other fields of science. The principle of clarity works much more effectively than the old methods - learning from textbooks, viewing images, videos, and more. This is, firstly, more interesting, and secondly, gives a much better idea of things, processes and events. But for now, the use of augmented reality in teaching is only gaining

momentum. Many web-applications are still quite primitive, but developers are actively working on their refinement, increasing the amount of educational content, improving quality. One of the basic points of 3D technologies is to improve the process of 3D modeling. This is the cornerstone of all three-dimensional techniques. So, the task of fast and high-quality algorithm for creating 3D content for further import in AR training projects has been urgent.

Related works

3D model is a three-dimensional digital image of the required object, real or imaginary. 3D-models are created in special software for 3D-modeling. The functionality of such programs may differ slightly. For example, there are programs focused on the design of 3D engineering models, there is software directly for modeling organic objects, as well as applications for 3D visualization and animation. In fact, the software does not have a strict classification, but most applications contain certain functions aimed at performing specific tasks. Depending on the specific objectives, the requirements for 3D modeling may differ. That is, in the development of computer games, some laws of construction of 3D models are applied, which may not be needed when creating 3D models for 3D printing. The application of 3D modeling has many areas, the main of which are listed below [8]:

- development of computer games;
- as one of the stages of 3D-visualization;
- for preliminary assessment of technical properties of the designed product;
- in the preparation of samples for 3D printing;
- 3D objects for import them into AR projects and etc.

Let's pay attention to how 3D models differ for different areas of application, what are the requirements for 3D objects in the relevant practical areas, what are the main stages of creating 3D elements. Can we use one approach for all models or there will be some differences?

First direction, which we will describe, is game industry. Creating bright characters is one of the main tasks of game developers. Let's look at the main steps of creation cycle and the basic requirements of 3D models for computer games. Each 3D developer has their own style and methods of work. Therefore, there is no single plan for creating a character. There are no strict rules that must be followed, because it is an individual process. But there are steps to keep in mind if you need to create a crafted and full-fledged character [1, 2, 7]. The main steps of character creation cycle:

- concept of the character;
- low poly model;
- high poly model;
- retopology of the model;
- efficiency of the model;
- UV mapping and texturing;
- baking cards;
- setup;
- animation;
- render.

In addition to performing the main steps of a model creation, you must also fulfill the basic requirement for the characters of computer games - a certain number of polygons. Highly detailed objects put a heavy load on computer equipment. It is necessary to try not to use polygons more than it is necessary, and also it is necessary to reduce quantity of seams on the UV card and rigid edges which double tops. Of course, with the development of technology, the number of polygons in the objects will increase, but today a 3D character for a computer game must have from 20,000 to 80,000 polygons on average [9, 3].

The next area of application of 3D objects is 3D visualization. 3D visualization of objects aims to obtain high-quality 3D images of an object [5]. 3D visualization can be performed for a product (designed or actually existing), a design object or just a three-dimensional element used as part of a composition. In 3D visualization of objects an important role is played lighting, materials (properties of visualized 3D surfaces), composition of the scene, which most advantageously emphasizes the feature of the visualized 3D model. Therefore, the number of polygons does not play any role in this case. The model will assume a static position and for this reason it should be noted that there is no need to detail the part of the object that will not be visible in the scene.

Another well-known area of application of 3D content is a preliminary assessment of the technical properties of the designed product**.** For example, in dentistry perform three-dimensional reconstruction of tomography images [10]. For 3D reconstructions, 3D objects must match the original and be created with high accuracy. The number of landfills does not matter. The most important requirement is that the actual shape and proportions of the original object correspond exactly.

Another area of practical application of 3D models is the preparation of the 3D content for 3D printing. It is known that a prerequisite for 3D printing is the presence of a 3D model, according to which the printer will grow a three-dimensional object. However, not all models are suitable for 3D printing. Before you start creating a model for 3D printing, it is important to understand what material you want to print the product from. Each material has its own

individual features for 3D modeling - the maximum and minimum dimensions of the model, wall thickness, distance between moving parts, etc. [4].

If we will discuss AR projects direction, we will see that there are 8 most common steps involved in producing a remarkable 3D asset creation [11]. They are namely:

- Concept and Storyboards
- 3D Modelling
- Texturing
- Rigging
- Animation
- Lighting
- Camera Setting
- Rendering

Purpose

To increase the level of use of 3D technologies for an effective and visual interactive way of presenting information in the educational process.

Proposed technique

For more pictorial analyses we had been decided to collect all general 3D object creation steps and additional fitches in one line of table 1. In other way the table 1 consist different area of practical application of 3D model. So now we can analyze, which of 3D object creation steps is necessary for every area of practical application. Based on related works for every area we had put pluses for all necessary steps of creations and mines for all unnecessary steps. The term Efficiency means the removal of hidden elements of the model that the viewer will not be able to see and that will not affect the appearance or operation of the model.

Table 1

Comparative table of 3D content

Areas of 3D models application	Concept	modeling	Retopology	Efficiency	UV mapping and texturing	baking cards	rigging	animation	Camera setting	render	light ing	High accuracy of similarity to the original	Influence of material on the model quality	Max. and min. model dimensions, wall thickness, distance between movements. parts	Compatible formats
Game industry	+	+	+	+	+	+	+	+	+	+	+	-	-	-	+
3D visualization	+	+	-	-	+	+	_	_		+	+	-	-	-	-
3D printing	+	+	-	-	_	_	_	_		_	-	+	+	+	+
AR projects	+	+	-	-	+	_	+	+	+	+	+	-	-	-	+
Hholographic fans	+	+	-	-	+	_	+	+	+	+	+	-	-	-	+
Preliminary assessment of technical properties of the product	+	+	-	-		_	-	-	_	_	-	+	+	-	-

By this table 1 we can say, that 3D models of game industry, AR projects and Holographic fans applications have the same requirements accept requirements as low poly model, retopology and baking cards. The next part of work we had been trying to find out how impotent the last requirements for AR projects and Holographic fans applications and can we combine this three areas?

For this reason 3D objects for the visualization by augmented reality had been made. The character is a girl Kalina, who will tell children interesting stories in audio encyclopedic children application. The design of this character was performed by with retopology and without it.

The first step was to create a character concept based on an existing audio release script. The main character is Kalyna - a 5-year-old Ukrainian girl, who learns about nature, interesting places and features of Ukraine and Europe. The main goal was to show her as a smart, cheerful, inquisitive girl with a bit of a boyish character, with epic clothes, in a cartoon style. Character concept is presented in Figure 1.

Fig. 1. Character concept

Next step of the process was modeling of a low-poly model using the software package Z-Brush. After this, there was made retopology to reduce the volume of the model and to improve performance in the AR environment. To do this, the polygonal mesh of the model was worked out in detail, taking into account that the structure of the polygons corresponded to the anatomical structure of a person. Note that the high polygonal model had 364,000 polygons, and after retopology, the model had been already numbered 3,182 polygons.

Then we dealt with the efficiency of the model. Checked the integrity of the model, the direction of the normals of all polygons, checked all polygons for planarity. Also part of increasing the efficiency of the model was the removal the part of the body that is hidden behind the dress.

The step of working with textures began with the UV mapping. To make the checker material look correct, the complex elements that appeared after the automatic mapping of the model were untangled and corrected. To give the low poly models all the details of the high polygon model: highlights, volume, deep shadows, etc. hand-drawn textures were created and cards were baked.

The model was imported into an augmented reality mobile application. No Artifacts were found during testing. The loading speed of the high poly model into augmented reality was 9.3 seconds, but the loading speed of the model, which was made taking into account retopology and baking cards, was 2.5 seconds (Fsg.2a,b).

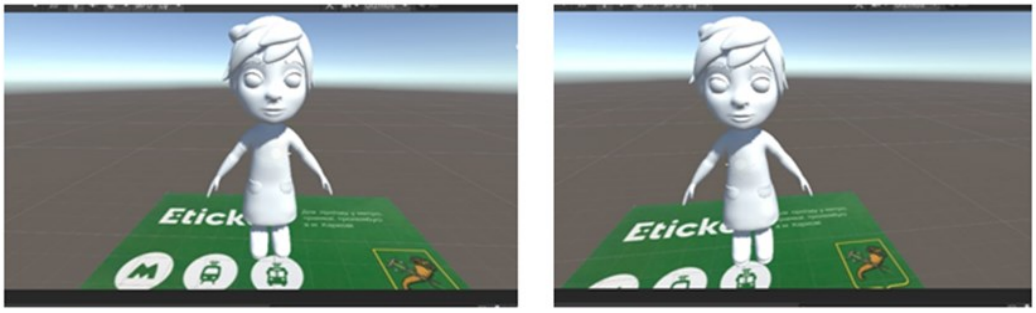

Fig. 2. The loading speed of the model

Figure 3 shows the model, which is presented in augmented reality based on a marker. Marker is electronic ticket.

Fig. 3. The model is in augmented reality Results

As a result of research we can say that the retopology and baking cards requirement for 3D model for AR projects application are very useful and desirable. It is logical to assume that retopology requirement will be also useful for 3D model of Holographic fans applications. Fulfilling this requirement 3D content will be faster download. By this reason we can unite requirements for 3D models of three areas of application: game industry, AR projects, holographic fans. Picture 4 clearly shows requirements for 3D model of all above areas of application which we had been discussing during our work.

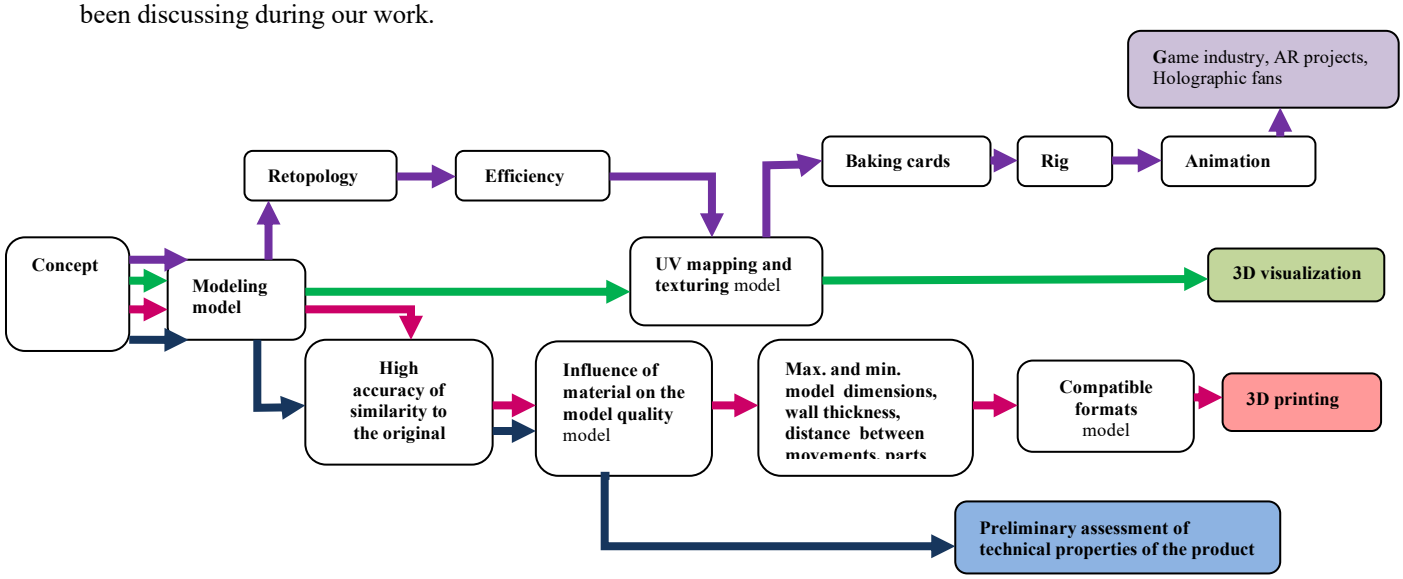

Fig. 4. Main steps for creation 3D model of the different area of appliocation

Conclusions

The paper focuses on the application of 3D models in various fields. The following four major industries were identified, such as the entertainment industry, medicine, industry, and education. The results of the study showed that for each area of application 3D content has its own requirements and features. Analyzing all requirements for 3D models for all above fields we had come to conclusion that requirements for content of game industry, AR projects and holographic fans application are almost the same, but not wholly the same. In this paper we had decided to investigate this question more detail. 3D model of the character has been created and its integration into the augmented reality environment was successful. The loading speed of the 3D model, which was imported in AR training project with taking into account retopology and baking cards, was faster. And we had come to the conclusion that requirements for 3D models of game industry, AR projects and holographic fans application are wholly the same. All 3D models which will be use for animation have to necessarily have retopology and baking cards step, what will be increase speed of their downloading or speed of movements or speed of their visualization.

The paper also structured the main stages for creating 3D models of different applications, which in turn brings clarity and clarity to the process of developing 3D content for further import into AR training projects.

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