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## GRAPHIC COMPUTER TECHNOLOGIES IN 3D MODELING OF SPECIAL TECHNICAL EQUIPMENT

Received: June 3, 2022 / Revised: July 28, 2022 / Accepted: August 30, 2022

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<https://doi.org/10.23939/>

**Abstract.** The involvement of computer graphics technology is need for the training of specialists in engineering specialties. The concept of the necessary software has been developed, as well as current technical issues have been addressed, in particular, the choice of engine for working with computer graphics. The influence of the main factors on the parameters of rescue equipment is considered, including fire trucks. Special software is given as an example and the work of the developed software is described. Based on the analysis of the model, there can be establish the characteristic data that determine the stability of the rescue vehicle. The developed mocaps of the mobile application allow the analysis of the operation of special equipment.

**Keywords:** engine, software, three-dimensional computer graphics

### Introduction and Problem Statement

In the process of training a mechanical engineer, a future specialist in the field is required to have a thorough knowledge of his field, namely – how this or that equipment and machinery works. In particular, it is important to know the structure and location of its individual components and parts. We took as an example the study of the structure of rescue equipment. The problem is urgent and can be solved with the use of computer technology and specialised software.

It is important for a mechanical engineer to understand the needs, principles and structure of software.

That is why it meets the following criteria:

- logical and clear interface;
- availability and accuracy of instructions for working with software;
- constant updating of the material base by adding new firefighting equipment;
- systematic updating of software to add new functionality and improve the performance of existing ones;
- availability and reliability;
- multiplatform.

When we use multiplatform, it means that the software works independently of the operating system (Windows, Linux, MacOS, Android and others) and platform (personal computer, smartphone, tablet and others). According to them, the software design is customized to the user and the size of the screen, having a flexible design.

Passwords are not used to access and work with the software, it means that any user can access it. At the same time, the software must be debugged to reduce the possibility of errors in the software code, software inhibition, self-shutdown, and must have reliable protection against external interference in the software code.

### **Review of Modern Information Sources on the Subject of the Paper**

The software should be systematically updated to improve its user-friendliness and correct possible errors. At the same time, expanding the functionality and material base simplifies the learning process and makes it more interactive [1].

The interface is clear and easy to use. This is to ensure that the user does not spend a lot of time learning the principles of the software, as well as have access to all software instructions and tips [2-5].

We use Adobe Photoshop software to develop the software concept. The given raster editor completely satisfies all needs for performance of the set task.

Here is an example of the concept of software based on the Android operating system.

### **Main Material Presentation**

The stability of solutions of differential equations of technical systems is determined by the free component of the transition process, the equations of motion of special equipment. We conduct research for the case when the right-hand side of the differential equation, for example, is zero. Instead of a variable parameter for the case of Euclidean  $n$  – measurable space we take its derivative, and its constant value  $A$  we take zero.

Let's fix values of a derivative of a variable parameter:

$$\frac{dy}{dt} = 0. \quad (1)$$

The variety that reflects the solution of such a dependence is parallel to the axis  $O_t$  of the plane  $O_t$  of the line  $y = const$ . As in the case of the formation of hypersurfaces in section 1 of the lowest dimension, the phase space is a two-dimensional plane. Therefore, we write this equality in the form:

$$\frac{d^2y}{dt^2} + \frac{dy}{dt} = 0, \quad (2)$$

and we present it by a system of two first-order differential equations:

$$\begin{aligned} y_1 &= \frac{dy}{dt}; \\ \frac{dy_1}{dt} + y_1 &= 0. \end{aligned} \quad (3)$$

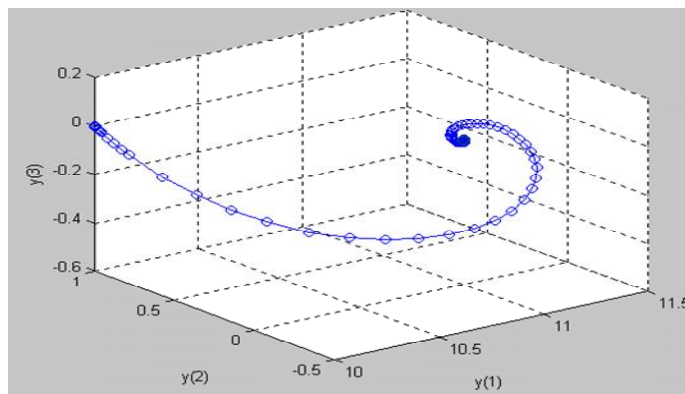
We obtain a one-dimensional manifold – phase trajectory – two-dimensional phase space. We present (2) in the form:

$$\frac{d^3y}{dt^3} + \frac{d^2y}{dt^2} + \frac{dy}{dt} = 0, \quad (4)$$

lowering the order of which we form a system of three equations:

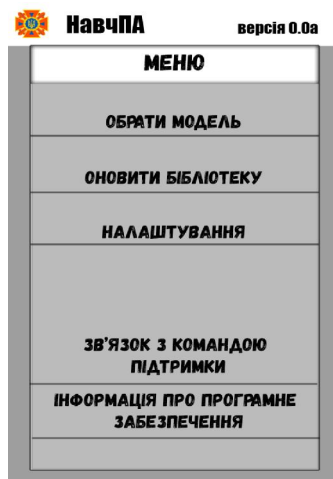
$$\begin{aligned} y_1 &= y, \quad y_2 = \frac{dy}{dt}, \quad y_3 = \frac{d^2y}{dt^2}; \\ \frac{dy_1}{dt} &= y_2, \quad \frac{dy_2}{dt} = y_3, \quad \frac{dy_3}{dt} = -y_3 - y_2. \end{aligned} \quad (5)$$

The system (5) contains four variable parameters  $y_1, y_2, y_3, t$  for which the phase space is three-dimensional. Therefore, the trajectory can be formed immediately in three-dimensional phase space.



**Fig. 1.** Phase three-dimensional space of the system (5)

Note that the above phase portrait is both a visual representation of the phase trajectory of the three-dimensional phase space, the dimensions of which correspond to all three variable parameters (Fig.1). Taking into account the results of our studies of the enveloping phase space of the modeling object, the rationality of using spatial modeling and studies of the three-dimensional plane of projections (Fig. 1), which is built into specialized graphic editors. The proposed algorithm is universal and can be implemented in any system of engineering and illustrative computer graphics. According to this algorithm, our development provides an opportunity to study the situational characteristics of special equipment.



**Fig. 2.1.** Software main menu concept

Given the size of platforms running Android, it's important not to clutter the screen with unnecessary buttons and features. That's why to make it easier, the menu is provided as a drop-down, and will appear when you press or drag the arrow at the bottom of the user's screen.



**Fig. 2.2.** Software main menu concept

A circle with arrows below it is used to rotate the object. When double-pressed, it activates the view mode, during which the model rotates independently around its axis. The user can also rotate using the touch capabilities of the device.



Fig. 3. Circle with arrows to rotate the model



Fig. 4. Extended menu of settings and information

According to Fig.4 we have the following settings:

- Color Mode – The setting that is responsible for the color or black-and-white display of the model.
- Display mode – The parameter that is responsible for displaying the model or displaying the structure (topology grid)
- Light – A setting that turns flashing lights on and off
- Projection mode – A setting that is responsible for displaying an object in perspective mode or in four projection mode (front, top, side, and rear).
- Hints – a setting that turns hints on and off
- Transparency level – a parameter that is responsible for the transparency of the object (set in the range from 0 to 50 %, where 0 % is opaque and 50 % is translucent).

The “Characteristics and information” field contains all the necessary information for the cadet or student related to the object being studied. Computer three-dimensional or spatial graphics play an important role in the work of NavchPA information and graphic software. The work and power of the software will depend on the quality and complexity of the models. That is why the models will be made in three variations:

- low polygonal;
- middle polygonal;
- high poly.

The difference between them is the level of detail and smoothing of the models, as well as the weight of the source files.

Low poly – characterized by the presence of a minimum number of polygons. Each segment of the object has one of two functions – frame or support. The frame function is performed by the segments that define the shape of the model, and the supporting function is performed by the segments that hold the

shape of the model. The set of all segments forms a frame grid or topology grid and divides the object into polygons. According to the rules of topology, polygons can be quadrangular or triangular, the presence of a polygon with more than four points is considered a gross error and needs to be corrected.

The project provides the following functionality:

- Ability to view a wide list of fire and rescue equipment, equipment and fire and rescue equipment;
- Ability to enable and disable the display of individual details of the model;
- Ability to obtain the necessary information about the equipment in text and, in future versions, audio form;
- Ability to communicate with the software support team;
- Ability to switch between color and black and white models;
- Ability to turn on and off the translucent view of the object.

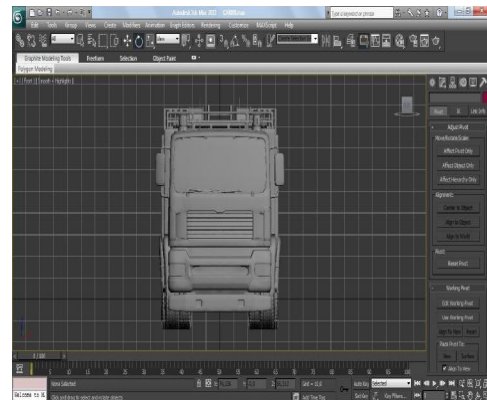
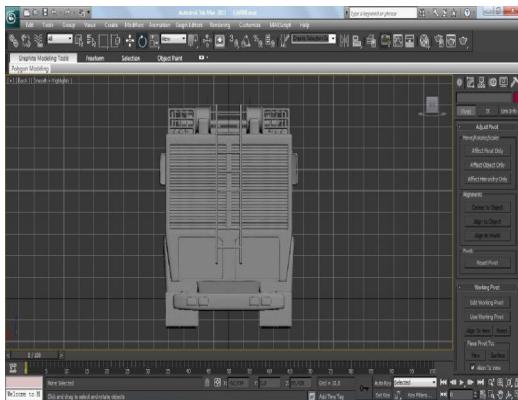
The program provides offline use, it does not require an Internet connection to access the library, but to reduce the weight of the model for Android versions will be simplified, this means that low-polygonal and medium-polygonal models will be used. As a result, it will also reduce the load on the device.

High poly – is characterised by a high level of detail, and therefore a high level of landfills. High-polygonal models based on low-polygonal ones are created by increasing the number of supporting segments. The weight of models made with a large number of polygons significantly exceeds the weight of low-polygonal due to which working with such models requires more power of the engine and hardware, namely – the work platform.

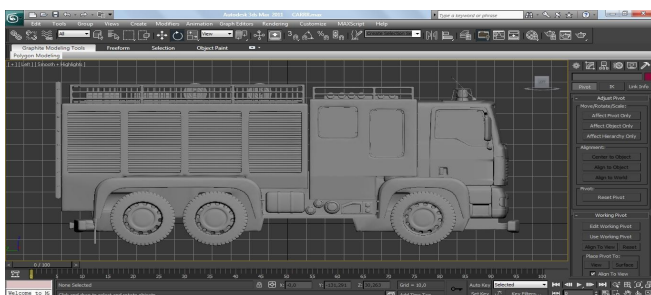
Middle poly – is characterised by the average number of polygons, ie is intermediate between low and high poly models.

When using the software, the use of low-, medium- and high-polygon models will depend on the power of the platform, as well as user settings. That is, in the presence of sufficiently powerful hardware, it is possible to use the maximum detail of objects.

Also, when working with the software, it should also be noted that it will also have a mode of viewing projections, which means that we will be able to view not only the object from all angles in spatial mode.



**Fig. 5.** (a, b) Front and rear projection of a fire truck



**Fig. 6.** Side projection of a fire truck



**Fig. 7.** Picture of a fire truck in perspective

For software development, we reviewed and researched several drivers, but the choice was Unity's Unity Technologies gaming engine.

**Unity** – is a multi-platform tool for developing two- and three-dimensional applications and games running on Windows, OS X. Unity-based applications run on Windows, OS X, Android, Apple iOS, Linux, and gaming consoles Wii, Playstation 3 and XBox 360. Technical characteristics of the engine:

- The game engine is related to the development environment (This means that you can test the software directly during development);
- Scripts in C #, JavaScript and Boo;
- Import of a large number of file formats is supported;
- Built-in network support;
- There is a solution for joint development – Asset Server. It is also possible to use a user-friendly method of version control. For example, it could be SVN or Source Gear.

Given the specifics of the project, it is determined that the prospects for software development and improvement are high. Given the rapid development of technology and the improvement of the educational process, it is necessary to address the issue of integrating the program into the list of training programs for the training of specialists in fire and man-made safety. In addition, along with the improvement of functionality, it is proposed to use the project for other areas as well. As an example we can cite the following areas:

- Labor protection
- Transport technologies
- Architecture.

As already mentioned, in the future the project will be integrated into the initial process of many areas, but in addition the software can be used for work purposes, such as for viewing spatial models of existing projects by architects in real time without waiting for image loading.

### Conclusions

Given the limited material resources of the engineer and rescue unit of the educational institution, we believe that the use of special software is innovative and appropriate. Using it, cadets and students of fire safety will be able to get all the information they need regarding the material support of firefighters.

### Acknowledgements

The research had been performed in the framework of International Project of CRDF Global “Developing software and hardware complex for dynamical authentication of information processing devices in a corporate network for cyber security purposes”, supported by the U.S. Department of State, the Bureau of European and Eurasian Affairs. Grant Agreement: G-202102-67366.

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