3D Modelling of Construction Objects Based on the Integrated AutoCAD System

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Abstract. Wide implementation of computer modeling of three-dimensional construction objects allows us to solve many technical, logistical and design problems. The development of a detailed electronic three-dimensional plan is a valuable virtual base that allows you to create, display and use for engineering purposes models of various types of engineering, telecommunications and computer networks, plan their construction, modernization and replacement. Connecting external databases to the electronic model allows you get a full specification of buildings, networks and any other objects, display a time record of repairs, replacements, etc. In addition, the 3D model allows you to enter the color differentiation of objects, which can give additional information, for example, the allocation of dangerous equipment (fire, explosive, etc.) in red or other color on the three-dimensional plan of the building. AutoCAD was selected to build a 3D model of the branched multi-storey building of one of the buildings of a modern University, which allows you to get accurate 3D models, has the means of obtaining sections and sections, and also provides a fairly realistic visualization. To obtain a 3D model of the University buildings, all the work was divided into the following stages: building two-dimensional electronic plans of each floor; building three-dimensional models of each floor; combining floor models into a common 3D model of the building. Models of buildings were created on separate layers, which makes it easy to turn off a particular layer, and to study the internal structure of buildings. The 3D model has real dimensions and is easily scaled. Engineering networks and other equipment items can be attached to the model elements in the future, and other tasks will also be solved, such as the location of fire-fighting equipment, escape routes, emergency exits, etc. When creating 3D models, we used the color differentiation of objects. We describe a mechanism for programmatically selecting objects by color in the AutoCAD environment, as well as a program that implements this selection mechanism using a data file with sequential access as an external database.

1. Introduction

3D digital models are three-dimensional spatial analogues of real-life objects for various purposes, including construction.

Wide implementation of computer modeling of three-dimensional construction objects (designed, under construction, constructed and reorganized) allows us to solve many technical, logistical and design problems. The development of a detailed electronic three-dimensional plan of the building with realistic dimensions of the premises, facades and surrounding area is a valuable virtual base that allows you to create, display and use for engineering purposes models of various types of engineering,
telecommunications and computer networks, plan their construction, modernization and replacement [1–3 etc.].

Connecting external databases (DB) to the electronic model allows you to easily get a full specification of buildings, networks and any other objects, display a time record of repairs, replacements, etc. In addition, the 3D model allows you to enter the color differentiation of objects, which can give additional information, for example, the allocation of dangerous equipment (fire, explosive, etc.) in red or other color on the three-dimensional plan of the building.

2. Building a real 3D model based on the example of a complex construction structure

Let’s consider the possibility of building a real 3D model on the example of a complex construction structure – a branched multi-storey building of one of the buildings of a modern University. AutoCAD was selected to build a 3D model of the buildings, which allows you to get accurate 3D models, has the means of obtaining sections and sections, and also provides a fairly realistic visualization.

To obtain a 3D model of the University buildings, all the work was divided into the following stages [1]: building two-dimensional electronic plans of each floor; building three-dimensional models of each floor; combining floor models into a common 3D model of the building.

At the first stage, existing drawings of the floors of the building are scanned, if any. In the absence or with poor quality, the necessary natural measurements were taken to supplement the drawings.

AutoCAD created floor plans on top of scanned drawings. At the same time, for repeated fragments (windows, doors, stairs, etc.), the AutoCAD-BLOCK tool was widely used.

The plan of the first floor of the second building of the University is shown in Figure 1.

![Figure 1. Ground floor plan](image)

At the second stage, we use two-dimensional floor plans of the building. Using the REGION command, we transform the closed elements shown in the drawings into a region. Apply the
EXTRUDE command to them to get three-dimensional floors models. To get a complex 3D model of a floor, autocad logical operations are used: join, subtract, and intersect. Figure 2 shows a 3D model of the first floor with the main staircase.

![Figure 2. Ground floor model](image)

At the third stage, we combine the floor models, create interfloor ceilings, the roof, the stairs, model the building facades with relief ledges and combine all the components into a single model. The resulting 3D model of the second university building is shown in Figure 3.

Note that models of buildings were created on separate layers, which makes it easy to turn off a particular layer, and to study the internal structure of buildings.

The 3D model has real dimensions and is easily scaled. Engineering networks and other equipment items can be attached to the model elements in the future, and other tasks will also be solved, such as the location of fire-fighting equipment, escape routes, emergency exits, etc.

When creating 3D models, we used the color differentiation of objects.

Note that in many areas of technical design, including construction, the problem arises of choosing objects according to their schematic representation in the form of nomograms, graphs, structural diagrams, flat drawings, 3-dimensional models, etc.
Separation of objects by color and linking with the color of the necessary information stored in external databases, in many respects makes the design process or the work of another information system, where the connection between the circuit and the data of the circuit objects is required, visual and very convenient. The AutoCAD environment has an almost unlimited range of colors, and many tools that allow you to build almost any scheme and model.

Color differentiation of objects in the general representation scheme can clearly express, for example, the purpose of objects, the materials from which they are made, objects of the same type, etc. You can lay many other most important characteristics for selecting objects.

The remaining characteristics of objects, which are additional descriptions, can be stored in external databases or files, from where they can be extracted by the color code number displayed in the general object scheme.

Consider the mechanism for the programmatic selection of objects by color in the AutoCAD environment. As you know, all information about drawing objects is stored in a graphic database (GDB) in the form of a list consisting of point pairs and coordinate sublists, the first element of which is a DXF code.

The specific color code of the object is contained in a dot pair with a DXF code of 62. The second number in this pair indicates the color of the object. For example, in a point pair (62, 1), 1 means the color is “red”. This number can be extracted using the AutoLISP assoc and cdr functions from the description of the selected object.

It is most convenient to select an object using the mouse in the window of an open AutoCAD drawing using the AutoLISP entsel function.
Let us give an example of a program that implements the specified selection mechanism using a sequential access data file as an external database. We make preliminary comments. The data file must be formed in advance. In it, each object will be represented, for example, by two records, in the first the color code of the object is recorded, in the second and next line, the necessary external data of the object. Let's draw three objects in the drawing: a circle, a segment, a rectangle. Give them the colors sequentially with the following numbers: 1 – red, 2 – yellow, 3 – green. As external information, we write into the file, respectively: “circle”, “segment”, “rectangle”. Listing 1 contains the program text [1].

(Listing 1. The program text)

In the program, external information about the selected object is written to the itog variable using the cond selection function. If it is impossible to identify the object, the message “the object is not included in this color gamut” is displayed. When superimposing object colors, the task is also successfully solved using the VIEWMODE system variable and using the VIEWORDER command. The proposed selection mechanism will be useful for solving many problems.

3. Conclusions
In conclusion, we note that a three-dimensional image that gives a visual effect of volume, perspective, depth of space, formed using computer graphics based on digital graphic information,
filming materials or real graphic plans, has at least two main advantages of three-dimensional models: visibility and information content, necessary during the inspection, modernization or reorganization of the facility.

The visibility of the image provides a correct and clear view of the object of modeling. Visibility is created by the external design of the three-dimensional model, the color scheme, the notation system, the shapes and sizes of the image content elements, its texture and structure, i.e. the visibility of the three-dimensional model is the ability to visually perceive the spatial forms, sizes and placement of the depicted objects. The more detailed the model, the more objects with great details shown on the model.

Informativeness is a property of three-dimensional images determined, first of all, by the presence in the corresponding databases of various technical and spatial characteristics. The maximum informativeness of three-dimensional images means detailed display of the external appearance, spatial position, sizes and shapes of all any essential space elements, as well as the technical and other characteristics of such elements combined into appropriate databases.

References
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