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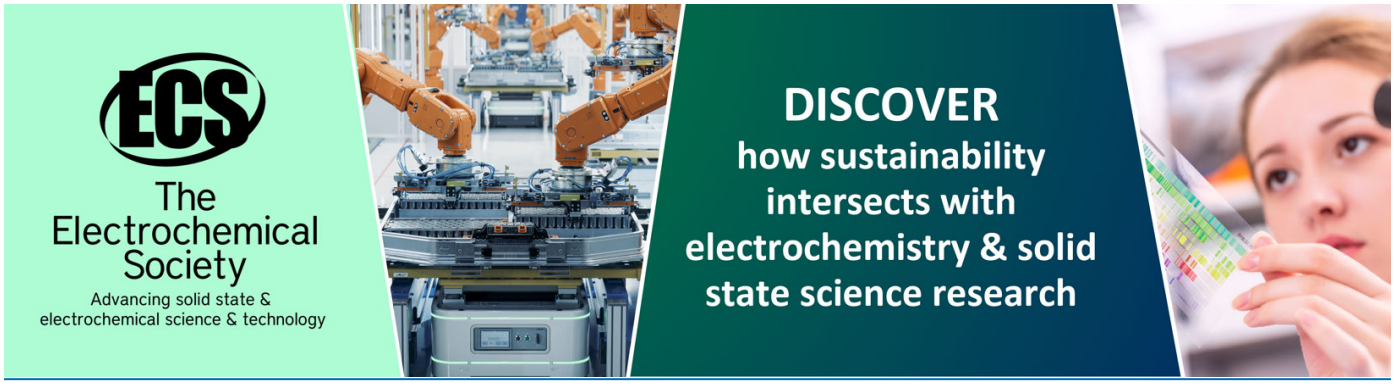

Geometric modelling of building forms using BIM, VR, AR-technology

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Abstract. Modern conditions set new tasks for designers and impose previously not arisen requirements. Along with the design, an important factor is the further presentation of the construction project to the potential consumer. The use of modern VR and AR technologies allows us to bring several advantages to the design that complements the living, real world with digital models. Therefore, there was a need to change the methods of teaching the design for students of construction, considering these factors. *Purpose of research* - to create a complete information model of the building with the help of computer-aided design, as well as the research of the impact of augmented reality technologies on the design conditions and presentation of the project. *Method of research*: observation, comparison, and analysis of the results of research of information and computer technologies, observation, comparison and using the experience of the university. *The article presents* the positive results of creating an information model of the building with the help of graphic programs. Traditional and progressive methods of design, new opportunities of VR and AR-technologies are considered.

1. Introduction

Modelling of building objects, in its essence, is the design of geometric shapes of various surfaces. Creating geometric shapes is a complex engineering task. The development of computer technology has brought in the design of significant reductions in time, labor and other costs. Computer technologies provide fast and accurate engineering tasks. design at all levels. When using three-dimensional space, the final product becomes simpler in perception [1].

Modern conditions set new urgent tasks for designers and impose earlier not arisen requirements, namely: large-scale reconstruction of existing construction objects; fast design of new objects in connection with steady growth of volumes of construction; high saturation of buildings and the infrastructure surrounding them with engineering communications and processing equipment; need of energy-efficient and ecological design taking into account annually increasing requirements to the created objects; the opportunity to continue working with the designed building during its operation and repair; the introduction of the "Smart home" technology in the practice of construction; the increasing need for the demolition and disposal of dilapidated buildings without damage to the existing infrastructure surrounding them; international cooperation in the creation of projects, so that work can be carried out simultaneously in different parts of the world; making the project less costly and more efficient and resilient to crisis in the economy; international cooperation in creating projects so that work can simultaneously be conducted in different parts of the world [2].

Along with the design, an important factor is the further presentation of the construction project to the potential consumer. The use of modern VR (virtual reality) and AR (augmented reality) technologies allows us to bring several advantages of the design that complement the living, real world with digital models [3].

Thus, naturally there was a need to create not just a project of the erected building in the form of drawings, layouts, working documentation, but a model containing all the information about the object that can be in demand during the entire period of its existence – from design, operation, to demolition or reconstruction [4]. This model should be a full-fledged virtual copy of the building with all its "stuffing" and infrastructure. Moreover, all the data about the object should not be easily grouped together, but be the parameters of the model, the correction of which, if necessary, entails automatic change of the entire model. All these issues are solved by a new direction of design, which has recently started to enter– information modeling of buildings and structures, as well as VR and AR technologies [5-7].

2. Materials and methods

2.1. Methods of research

The following methods were used in the research: theoretical (analysis, synthesis, generalization, modeling); diagnostic (questionnaire, testing, method of tasks and tasks); empirical (study of the experience of educational organizations in St. Petersburg Mining University, pedagogical observation); experimental (ascertaining, forming, control experiments); method of graphical representation of the results.

2.2. The experimental base of the research

The pilot survey was conducted of the St. Petersburg mining University.

3. Results

Computer modeling is one of the effective ways to study and design complex systems, such as buildings and structures. Creating virtual models is a simpler and more convenient means of modern technology, because you can use computational experiments [8-10]. Real experiments are not always financially profitable or impossible due to unpredictable results. Information modeling is to conduct computational experiments using a computer, the purpose of which is to analyze, interpret and compare the simulation results with the real actions of the object under study. Unlike traditional computer-aided design systems, the result of building information modeling is usually an object-oriented digital model of both the entire object and the process of its construction [11-13].

Design of buildings with the help of information and computer modeling involves, first of all, the collection and integrated processing in the design process of all architectural, engineering, technological and other information about the building with all its relationships and dependencies-the building and everything related to it are considered as a single, integral object.

Fundamental design decisions are still made by people, and the computer performs only the technical function of information processing and analysis. This approach to the design of objects is called information modeling of buildings or, abbreviated, BIM (Building information Modeling) [14].

Work was carried out to create an information model of the building. There were two groups of students. One of them developed the project of the building in traditional ways, the other – with the help of modern information technologies. The time spent, efforts, results obtained and perception of the final project by "consumer experts (customers)"–the third group of students were compared.

Work on the creation of an information model of the building was carried out in three stages. First, the primary design elements were developed that correspond to both building products (floor slabs, doors, windows, etc.) and equipment elements (heating and lighting devices, elevators, etc.) and everything that is directly related to the building, but is made outside the framework of the construction site and during the construction of the object is not divided into parts. The second stage is

the modeling of everything that is created on the construction site. It is foundations, walls, roofs, curtain walls, etc. Thus, information modeling of buildings initially involves understanding how to build a building, how to equip it and how to live and work in it. The division into stages (the first and the second) when creating an information model of the structure is conditional - you can, for example, insert windows into the simulated object, and then change them, and the project will appear already modified windows. At the third stage, a virtual model of the building was created.

By combining all the design stages, we get the opportunity to accelerate the development of projects, thanks to inter relations of individual design stages. Communication "architect"-"designer"-"designer"-"engineer for the design of communication systems"-"designer" etc., occurs almost at the "non-stop". For example, when making any changes to the project at any stage of its development, a colleague can observe this and, if necessary, adjust.

At the heart of the creation of augmented reality is a special software and special devices that support the function of augmented reality, namely the overlay created graphic objects on the broadcast image of reality. Augmented reality environment has properties combining virtual and real and interaction in real time [15-17].

As a tool to support the visualization process using VR (virtual reality) and AR (augmented reality) augmented reality technologies, you can use the software package, which consists of the following modules. The first is an application that is installed on a portable device. The application requires a device with camera support, network access, and the ability to install the application. It can be phones, smartphones, tablets, laptops, personal computers.

The second is a software module for working with databases and QR-codes (adding new objects, deleting, generating QR-code, printing a marker). It should be noted that any free service is used for generation. The QR code carries a coded identifier that corresponds to a specific operation.

Thus, a virtual 3D information model of the building was created, which allows to feel "inside" the building in real time and to consider all its elements in detail (Figure 1, 2). On the creation of the project in traditional ways was spent much more labor, time effort. Moreover, the result was not sufficiently informative for the consumer.

Figure 1. Creating an augmented reality home.

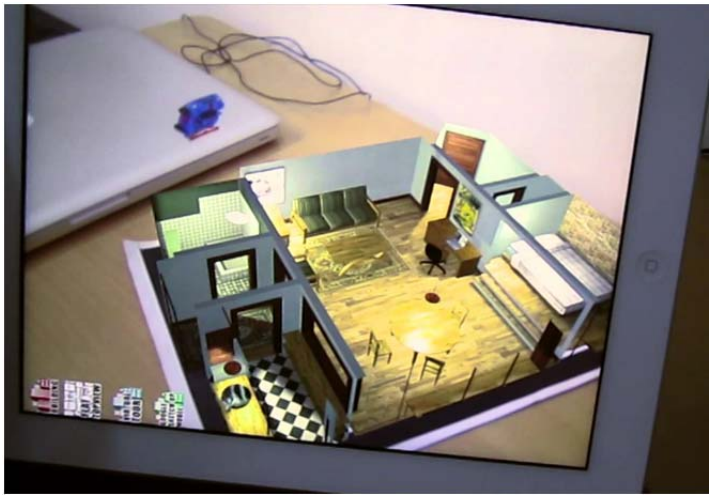

Figure 2. Virtual information project at home.

4. Discussion

The third group of students-experts assessed the degree of perception of the project. According to the General opinion, the information model of the building created with the help of modern computer technologies allows to perceive the construction as an integral object. Moreover, from the point of view of the consumer, such a presentation is more intuitive and understandable to the ordinary man in the street, which is often difficult to understand the drawings.

The main advantage of AR-technologies is the minimum need for additional resources, i.e., unlike VR-technologies, which require mandatory availability of additional equipment for visualization, such as virtual reality glasses or VR-helmets, augmented reality objects can be viewed in space from the screens of conventional smartphones or tablets, which are now almost every person [18].

Having developed several 3d models in AR programs, at the first meeting it will be possible to demonstrate possible design projects and immediately begin a detailed discussion. Some cards with bindings and tablet can greatly simplify the operational issues and to expedite the discussion, because augmented reality is able to reproduce human imagination in the real world. While this development is a novelty in the construction market, it will stand out among competitors at minimal cost. It is also easy to use augmented reality already in place of future work to clarify some points about the position of the house on the land.

The design of the land plot, at the initial stage of construction, is greatly simplified due to the visibility and the ability to work online. Augmented reality technologies allow you to track the stages of construction, comparing the object under construction with the finished project. So, people who are far from construction have an easy way to control the process of construction of buildings on their own.

At the stage of finishing, augmented reality technologies will be simply irreplaceable, as they will not only speed up the construction time, but also reduce the risk of errors and discontent due to misunderstanding between the customer and the developer.

Thus, the prospect of using BIM, VR, AR-technologies in construction promises many advantages over the current ubiquitous methods of construction [19-20]. Augmented reality is useful at all stages of construction: at the design stage-to visualize the future of the building and optimize the work of all engineers through remote access to drawings and plans; directly during construction-allows you to carefully consider each stage, which will reduce the number of possible inaccuracies and makes it possible to edit drawings more quickly; at the last stages - allows the customer to control the flow of work on the interior and exterior, reducing the time of work, and as close as possible to implement the plan. AR-technologies optimize the working process and contribute to the savings necessary for the implementation of projects.

Moreover, modern graphics systems allow not only to design, but also to manipulate the created object, modify it, resorting to various materials of various structures, textures, using a wide palette of

colors, artificially set the conditions and circumstances, up to the extreme, which may be the object of design. Simulating, thus, different life situations, the designer can clearly see the advantages and disadvantages of the project, having the opportunity to implement it, to correct the shortcomings, eliminating the possibility of fatal errors after the construction of the object. Moreover, the productivity of the designer-Builder increases, because by increasing the number of options for the future project at the initial stage of design, eventually, the most qualitative and reliable object will be obtained. This is especially true for unique, complex, expensive objects.

5. Conclusion

Building information modeling is a process based on the use of intelligent 3D models. With this technology, specialists in the design of architectural elements, engineering systems and building structures can more effectively plan, design, build and operate buildings and infrastructure.

One of the significant advantages of such a system – operational control by engineers, and this will be interested in the client himself, who will be able, comparing the digital image with the real picture, to track the work.

Secondly, the human factor is practically excluded, the chances of any inaccuracy, error are reduced to zero, since the whole team always has special guides in the form of visual prompts with schemes or sequence of actions.

Thirdly, the project is quite plastic, that is, if necessary, you can always make amendments to the program and notify the construction team with the help of gadgets. Thus, the modernization of the construction process in accordance with the standards of the 21st century improves quality at a lower time.

Here you can also add such creative tasks as the arrangement of the local area, interior decoration and design of rooms. Three-dimensional visualization will help to fully implement the compositional design of the construction project under construction.

According to the information model created at the preparatory stages, builders will be able to navigate in complex engineering systems that are typical for large buildings and structures. It is particularly relevant to the possibility of timely synchronization of all amendments to the project, as well as communication between employees on the construction site to solve any actual situations by videoconference in real time on the job. In addition, such facilities are already sufficiently equipped with high-quality equipment, so it remains only to Supplement them with special labels.

Since the inception of the idea, augmented reality will accompany engineers, simplifying their work. For example, when creating a drawing of a future object, it is possible to upload the drawing to online services and make corrections to the project remotely. Autodesk already has such a platform (Appendix A360). The application allows you to upload files with drawings of future buildings directly to the browser, as well as to connect other persons to view the files, which allows engineers to coordinate their work and make amendments to the project from different points of the Earth.

Thus, modern graphic systems allow not only to design, but also to manipulate the created object, to modify it, resorting to various materials of various structure, texture, using a wide palette of colors, to artificially set the conditions and circumstances, up to the extreme, which may be the object of design. Simulating, thus, different life situations, the designer can clearly see the advantages and disadvantages of the project, having the opportunity to implement it, to correct the shortcomings, eliminating the possibility of fatal errors after the construction of the object. Moreover, the productivity of the designer-Builder increases, because by increasing the number of options for the future project at the initial stage of design, eventually, the most qualitative and reliable object will be obtained. This is especially true for unique, complex, expensive objects [21,22].

Based on the research work on the building information model university students, it can be argued: augmented reality will improve the technology of construction of buildings. It is an integral part of the marketing campaign of construction firms and will become information tool for solving various engineering problems at all stages of construction. With a universal model for the construction of any objects should be divided according to scale, since this determines the important features of the

interaction between the customer and the contracting organization and structures. Augmented reality is today, and the need to train a new generation of students is obvious modern computer technology in the design of buildings and structures.

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