

**МЕТОДОЛОГІЯ,
ІСТОРИОГРАФІЯ ТА ДЖЕРЕЛЮЗНАВСТВО**

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**THE PROBLEM OF VIRTUAL MODELING
OF HISTORICAL PROCESSES IN MODERN SCIENCE**

The rapid improvement of computer technologies, as a result of the digitalization of all spheres of human life, the priority of virtual technologies have led to a change in the value attitudes of society, the emergence of information / computer technologies in first place in the sphere of consumption. In such conditions, the methodology of scientific research is also changing, in the field of which modeling is of the greatest importance. Moreover, speaking of the latter, one should take into account the fact of the influence of social virtualization, which affects the spread of computer modeling.

A separate place in the field of computer modeling, or more importantly, virtual modeling, is the application of its technology in the humanities. In this case, we are talking about modeling historical events, social processes. This scientific direction in modern science is on the stage of active development, so we cannot note a large number of studies. This circumstance is also explained by the fact that the same procedure for using virtual technologies requires a separate methodology, technology, and finally, the use of the latest computer technology. Such scientists as A. Bakhtizin, L. Borodkin (2012; 2020), D. Zherybyatyev (2007), I. Zhurbin (2012), V. Kelton & A. Low (2004), V. Makarov (2016), A. Pribovovich (2008), draw attention to the fact that with the current development of information technologies, the historian is given the opportunity to apply modern computer technologies in historical modeling.

D. Zherybyat'ev (2007) calls virtual modeling a new form of presentation of historical material (p. 259). The scientist notes that at present the technologies of 3-dimensional modeling are going through a new stage of

formation as a method of research and processing of historical material, having made a way from arbitrary reconstruction of 3-dimensional models to professional data processing by a team of scientists and researchers of humanitarian and technical specialties, ultimately count, and the result of labor itself acquires a different status - the status of historical research (Ibid, p. 262). All such studies, 3D reconstruction, have a common goal – the preservation and popularization of cultural heritage (Ibid, p. 263).

I. Zhurbin (2012), studying the use of computer modeling in historical research, noted the wide scope of its application in this scientific field. Namely, computer modeling of historical processes and phenomena is used to study various aspects of the economic and political development of society, socio-demographic processes, as well as to study the historical development of individual regions and states.

In this sense, L. Borodkin (2020) notes the versatility of virtual modeling in projects of virtual reconstruction of historical urban landscapes and lost objects of historical urban development. The capabilities of 3D modeling methods, virtual and augmented reality (VR / AR), GIS technologies are considered by scientists as new tasks of historical urban studies (p. 49).

Interesting in this case is the approach of A. Priborovich (2008), who, while exploring the modeling of historical processes using the example of computer games, sees their main advantage in the fact that they clearly demonstrate causal relationships and allow tracing changes in the modeled process depending on the initial data and the influence of random factors (p. 426).

Based on the above-mentioned aspects of relevance, the degree of research of the issue, the purpose of the article is to determine the problem of virtual modeling in modern science, analyze the main conceptual issues related to this scientific field.

When considering virtual modeling, first of all, you should pay attention to the fact that it was formed on the basis of computer and simulation modeling, which are based on mathematical modeling, which, in fact, preceded their formation. The latter led to the emergence of such an interdisciplinary direction as cliodynamics at the turn of the 20th – 21st centuries, the purpose of which, according to A. Listov, is to process information and identify similar coincidences in the future. Cliodynamics is an interdisciplinary field of research that combines the approaches of historical macrosociology, theoretical history, mathematical modeling of long-term social processes, the construction and use of historical databases, studies of social evolution, historical demography.

It is important here that, as A. Priborovich (2008) notes, since about the 70s of the twentieth century, scientists have been engaged in modeling, including computer, historical processes in order to reconstruct them and study the problem of variability of historical development, modeling is also used in educational purposes – to understand the patterns of historical processes and

the influence of random factors on their development and outcome. In computer modeling of historical events, an important point is the choice of a model of historical research, as well as an algorithm for variables and equations that will be implemented in the research (p. 426).

In this case, it is important to take into account the fact that modeling in history means an attempt to reproduce, by description or formalization, an analogue of a research procedure or historical reality. Formalization consists in constructing a system of signs and indicators that characterize the main essential features of a historical phenomenon or process (Жеребятъев, 2007, p. 259). Many modernized scholars note the complexity of this work. Namely, S. Malkov (2013) points to the multiparametry, dynamic instability of social processes, their multilevel and different scale, the weak formalizability of many parameters (such as "social activity", "conformism", etc.), the need to take into account socio-psychological factors (such as the ratio of personal and group interests, peculiarities of individual and national psychology when making decisions, etc.), poor predictability of the "human factor". The scientist notes that the main problem in the study and modeling of social systems (SS) is the danger of "drowning" in details, concentrating on secondary issues, missing the main thing, and incorrectly prioritizing the defining parameters and processes. To avoid this danger, it is necessary to move from the general to the particular, from studying the most general laws of the evolution of such systems to studying the features of their dynamics in specific conditions.

In addition to the noted criteria for the complexity of modeling historical processes, the issue of the source study base of the event should also be taken into account. We are talking about the study of the early periods of history (archaeological cultures, the functioning of which is not reflected in written sources), the only objective source of information is a set of material remains – artifacts and structures recorded during excavations of ancient settlements and burial sites. The limited initial data determines significant problems in modeling archaeological cultures: lack of a priori information about the cause-and-effect relationships between various elements and subsystems in ancient societies (lack of written sources); incompleteness of the initial data (not all archaeological sites were identified by specialists, many archaeological sites were destroyed during late technogenic and anthropogenic activities, natural disasters); heterogeneity and weak structuring of the initial data, limited opportunities for their formalization (each category of archaeological objects requires its own system of description, the need to take into account qualitative and quantitative characteristics) (Журбин, 2012, p. 65).

We can say that this is why simulation modeling (based on computer technologies) has become a convenient form of creating a historical model in the form of a simple imitation or imitation game. The construction of such models is based on the principle of approximate reproduction of the process under study; elementary phenomena constituting it are imitated while

maintaining their logical structure and sequence of flow in time. Simulation models aim to reconstruct missing or incomplete source data (Бородкин, 2020, p. 50).

A special place among this type of simulation is agent modeling, the development of which is directly determined by the increasing computing power of modern computers, allows you to model a system of almost any complexity with a large number of interacting objects without resorting to their aggregation (Окорокова, 2018, p. 81). An example of this type are the so-called agent-oriented models (AOM). The basic idea underlying AOM is to build a computing tool that is a set of agents with a certain set of properties and allows you to simulate real phenomena. Agents in AOM can be humans (as well as other living organisms), robots, cars, and other moving objects; immovable objects; a set of similar objects. That is, the agents in the AOM can be any objects that are observed in real life, but the main task of their accounting in the model is their correct specification. A common feature of all AOM and at the same time their main difference from the models of other classes is the presence in them of a large number of interacting agents.

Among foreign developments in the field of AOM construction using supercomputer technologies, scientists distinguish the following:

- FuturICT – an unprecedented interdisciplinary project to model the technological, social and economic systems of the world, launched in 2012. Its implementation period is 10 years. The use of the latest achievements in the field of natural and social sciences will allow to develop a system for monitoring the state of the global socio-economic system of the world, with which it is possible to predict, among other things. The platform proposed by the project participants includes three components: Planetary Nervous System, Living Earth Simulator, and Global Participatory Platform.

- Large-scale AOM of the European economy – EurACE, or Europe ACE (Agent-Based Computational Economics – Agent-Oriented Computational Economics), which was launched in September 2006. Using the developed model, a number of experiments were conducted to study the labor market.

- Full-scale distributed Agent model of epidemics. Under the leadership of D. Epstein and D. Parker at the Center for Social and Economic Dynamics at the Brookings Institution (Center on Social and Economic Dynamics at Brookings) was built one of the largest AOM, which includes data on the entire US population – the US National Model.

- Simulation on a supercomputer of medieval military operations, which is part of the project "Medieval Warfare on the Grid" (MWGrid). Alternatively, representatives of the School of Computer Science, University of Birmingham, the Institute of Archeology and Antiquity, University of Birmingham, and the Department of History at Princeton University in the United States. History, Princeton University) consider the agent-oriented

approach as a tool for detailed reproduction of the studied events (Макаров, 2016, p. 254).

L. Borodkin (2012), among the vicious examples of the use of virtual modeling, gives an example of the virtual modeling of the Colosseum. As the scientist notes, for a long time archaeologists could not identify the purpose of individual parts of the walls, presumably used for fastenings supporting the awning. The complex structure, consisting of 240 pillars supporting a gigantic material (awning), left behind only traces and individual fixings in the walls of the ancient structure. There were several variants of Colosseum tents proposed by researchers; the most plausible were two hypotheses put forward by historians and architects. According to one of them, it was assumed that the structure of the awning worked on the basis of large wooden posts-masts, on which the fabric was stretched (similar to sails). The second hypothesis was a completely different idea of the structure of the awning, relying on the use of rope nets to support the dome, when the rope nets were pulled out of the central ring.

Building a virtual model of the Colosseum with two awning systems and simulating the effects of lighting throughout the day through a computer experiment allowed researchers to test the functionality of hypotheses in science about its design and appearance, which was impossible without the use of computer programs within the framework of the traditional approach. Thus, in the course of a computer experiment, the researchers selected the architects' hypothesis as withstanding criticism from a technical point of view (Бородкин, 2012, p. 53).

His remarks on paleoanthropology are also interesting. The use of three-dimensional technologies by paleoanthropologists, laser scanners, have revolutionized the field of human paleontology and physical anthropology, initiating what is usually called "virtual paleoanthropology". As an example of this historical branch, the scientist points to the project of the British Museum in 2004 to build a three-dimensional model of the ancient Egyptian mummy of the priest Nesperenub, buried in Thebes about 2800 years ago, at the turn of the VIII–VII centuries. BC. During the digitization of the model, carried out on the basis of specialized software Silicon Graphics, one and a half thousand slices (layers) of the mummy were obtained, which were subsequently "glued" into a single model. Thanks to this digitization, it became possible to carry out a multidimensional computer analysis of parts of the mummy, layers of tissue, various related objects (for example, amulets, glass fragments, etc.) without damaging the object under study (Ibid, p. 54).

The above fully explains the effectiveness of virtual modeling of historical events, which has many more advantages than those that existed previously. The main distinguishing feature of the BP model is the illusion created by the user of his presence in a computer-simulated environment, called remote presence (Цветков, 2016, p. 35). In some of the BP models, users take a changing perspective and see objects from different vantage

points – as if they were moving inside the model. If the user has more receptive (immersed) input devices, such as digital gloves and virtual helmets, then the model is provided with the necessary amount of information to properly respond to user actions such as turning the head or even moving eyes.

Virtual modeling creates new models for correlating representations with objective reality. This is the scale of space, the scale of time, the treatment of time, the simulation of unreal situations. The emergence of information models of large information capacity has led to the recognition first of practice, and then the theory of the status of virtuality as an equal ontology. The effect of cognitive activity in virtual modeling is that virtual models and virtual information situations are created, various real situations of human existence and the surrounding reality are sketched. Virtual models sometimes do not even have the status of essence, become builders of new spatial forms on the basis of real spatial relations (Окорокова, 2018, p. 84).

Thus, the analysis of the problem of virtual modeling primarily indicates its extraordinary relevance in modern science. This is largely due to the fact that speaking about modeling often implies mathematical modeling, and about modeling in the humanities, reasoning began to acquire a controversial character only from the end of the twentieth century. It is for this reason that cliodynamics arose, which at an interdisciplinary level allows you to create a modeled object of a particular era.

Secondly, the virtual modeling of historical processes, as we saw, is actively developing, spreading at the same time to the sphere of computer games, which also effectively allows testing the model. It is important to take into account the fact that the modeling of historical events is a process that requires the availability of sources (and we are talking about both written and material), understanding the nonlinearity of the historical process. Society here acts as a complex system, the modeling of which requires colossal work to study the smallest details of the way of life, the worldview of a person of a particular era. It is about using additional software and hardware.

In addition, virtual modeling aimed at visualizing the model object has a number of advantages, which are expressed in the ability to create a more or less plausible imitation of an event, has a pronounced property of interactivity, information content, the ability to change the nature of the process or the result of an event, unlimited in time and space.

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Окорочова В. В. Проблема віртуального моделювання історичних процесів в сучасній науці

Стаття присвячена дослідженню проблеми віртуального моделювання історичних подій, процесів. Відзначається, що моделювання соціальних та історичних процесів стало розроблятися як метод дослідження суспільства лише з 70-80-тих років ХХ століття. На зламі ХХ–ХХІ століть виникає такий міждисциплінарний напрям як кліодинаміка, присвячений моделюванню історичних процесів на основі математичних методів. Поява даного наукового напрямку показує, що тема моделювання історичних процесів ґрунтується на методології математичного моделювання.

У статті окрему увагу прикуто до віртуалізації сучасного суспільства як фактору удосконалення методу моделювання. Основними засобами тут стають комп'ютерні технології, що набагато спрощує технологію моделювання. В якості прикладу, наводяться АОМ (агент-орієнтовані моделі), як метод імітації та візуалізації об'єктів, явищ.

Ключові слова: агент-орієнтовані моделі, віртуальне моделювання, імітаційне моделювання, кліодинаміка.

Окорокова В. В. Проблема моделирования исторических процессов в современной науке

Статья посвящена исследованию проблемы виртуального моделирования исторических событий, процессов. Отмечается, что моделирование социальных и исторических процессов стало разрабатываться как метод исследования общества лишь с 70-80-тых годов XX века. На рубеже XX – XXI века возникает такое междисциплинарное направление как клиодинамика, посвященная моделированию исторических процессов на основе математических методов. Появление данного научного направления показывает, что тема моделирования исторических процессов основывается на методологии математического моделирования.

В статье отдельное внимание обращается на виртуализацию современного общества как фактор в усовершенствовании метода моделирования. Основными средствами становятся компьютерные технологии, что намного упрощает технологию моделирования. В качестве примера, приводятся АОМ (агент-ориентированные модели), как метод имитации и визуализации объектов, явлений.

Ключевые слова: агент-ориентированные модели, виртуальное моделирование, имитационное моделирование, клиодинамика.

Okorokova V. V. The problem of virtual modeling of historical processes in modern science

The article is devoted to the study of the problem of virtual modeling of historical events and processes. It is noted that the modeling of social and historical processes began to be developed as a method for studying society only from the 70s-80s of the XX century. At the turn of the XX - XXI century, such an interdisciplinary direction as cliodynamics, devoted to the modeling of historical processes based on mathematical methods, appeared. The emergence of this scientific direction shows that the topic of modeling historical processes is based on the methodology of mathematical modeling.

The article draws special attention to the virtualization of modern society as a factor in improving the modeling method. Computer technologies are becoming the main means, which greatly simplifies the modeling technology. Problems in creating a model of historical processes are noted, which is associated with a source study basis, the use of additional technologies, and it is also necessary to take into account the complexity, irreversibility, nonlinearity of the historical process itself. Also, as an example, ABM (agent-based models) are given, as an example of imitation and visualization of objects, phenomena. Among the individual characteristics of virtual modeling, the author identifies the ability to create a plausible imitation

of an event, interactivity, information content, the ability to change / correct the intended nature of the process or the result of an event, unlimited time and space. This is the advantage of virtual modeling as a method of modern reconstruction of historical events, especially those that do not have accurate data, are debatable. Moreover, the article points out that this type of modeling has already embraced even those historical sciences that were more problematic in this regard (archeology, paleontology).

Key words: agent-based models, virtual modeling, modeling, cliodynamics.

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