Music Computer Technologies: Approaches of Classification

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***Abstract*— The purpose of this work is to continue the research presented by the authors, which raises the problem of classification of MCT. We consider the principles of classification in science and identify the best ones for solving the research problem. It is proposed to distinguish four major groups based on the functioning of technology: pedagogical (training, educational); analyzing (research); aimed at preserving (collecting, saving) and transmitting (communication) knowledge about music, creative (performing and composing). The ways to consider the prospects for further solving the stated problem in terms of a more fractional division of the selected groups are suggested.**

***Keywords*— Classification of terms and concepts, functional method**, **functioning of technologies, music computer technologies (MCT), scientific typology**.

I. Introduction

The purpose of this work is to continue the research presented by the authors [1-4 etc.], which raises the problem of classification of MCT. Currently, the vast majority of new music products are created and recorded using MCT. Traditional music and music of academic genres, recorded and broadcast on the basis of the use of MCT, computer music, music and computer training programs and technologies are becoming one of the most important components of modern musical culture. Classification of MCT seems to be one of the complex and necessary methods of cognition of this area. The author emphasizes the possibility of different approaches to typologization and classification in science and considers the classification of MCT proposed in this article as one of the options.

The purpose of this work is to continue the research presented by the authors [3- 6, etc.], in which the problem of classification of music and computer technologies is raised. Previously, we conducted a review of research, considered the principles of classification in science and identified the optimal ones for solving the research tasks; four large groups were identified based on the functioning of the MCT: pedagogical (teaching, educational) [7-12]; analyzing (research) [13-16]; aimed at preserving (collective, saving) [17-19] and broadcasting (communication) knowledge about music [20; 21]; creative (performing and composing) [22; 23], including in the field of inclusion [24; 25]. In this study, a more complete description and fractional division of the selected groups are proposed.

Relevance. The relevance of the issues considered in the article is connected with the need to systematize the accumulated theoretical knowledge and practical materials in the field of MCT by various researchers and practitioners for their further comprehension, holistic coverage and hierarchy. The analyzed problem is related to the consideration of various methods of classification and the proposal of one of them, which, at this stage, cannot be comprehensive. The authors are aware that the proposed classification does not cover all the problems associated with MCT and represents one of the possible options, choosing a functional method as a basis. The terminological apparatus of the MCT is constantly being discussed and updated in the scientific community due to the fact that many musicians, scientists are only included in the field of research considered in the article, which explains the need for this work in the field of classification and typology as one of the methods of cognition of modern science.

Practical significance. The classification proposed in this paper is aimed at generalizing the varieties of MCT in the perspective of their functioning in musical culture and will contribute to the development of the process of scientific understanding of modern phenomena in composing, musical performance, research work of music and computer laboratories, as well as in the educational space, in the development of teaching materials, which can be based on the proposed aspects of the work.

Methodology. In our opinion, the proposed classification of MCTs reflects their place and functioning in modern culture. In the proposed classification, we believe that it is an adequate basis for the features of the functioning of the MCT and classify the MCT according to the type of functional tasks, i.e. how (for what) these technologies function. In our previous work, we proposed four large groups. In the process of research work in this direction, the scale and ambiguity of solving the task of compiling a unified classification of the MCT became quite obvious. It seems impossible to have a rigid and unambiguous classification of MCTs in view of their huge diversity and unexplored in full. MCT continues to develop rapidly in step

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with the times, musical instruments are constantly being improved, new software and hardware are being created.

In addition, we will highlight the multitasking and multifunctionality of the MCTs themselves, which makes their unification and classification more complicated: the same technology can be attributed to different groups of the classification we have proposed, differing precisely in the task of application, that is, the type of functioning. That is why the functional feature at the present stage of the study seems to us to be one of the most adequate, and the functional method (based on a scientific analysis of the features of functioning) is the most productive and meets the objectives of the study.

Classification of MCT

MUSIC COMPUTER TECHNOLOGIES (MCT)			
Pedagogical MCT	Preserving and communicative MCT	Analyzing MCT	Creative MCT

We propose to divide each of the four selected groups into three subgroups that are universal for each group: software, hardware and mixed MCTs, which in turn will be divided more fractionally:

PEDAGOGICAL MCT		
Software: -sequencers -music editors (notators)	Hardware: - EMI (electronic musical instruments) - recording studio hardware	Mixed: -recording studios -digital workstations -mixing MCT with acoustic sound
PRESERVING AND COMMUNICATIVE MCT		
Software: -sequencers -music editors	Hardware: - EMI (electronic musical instruments) -recording studio hardware	Mixed: - recording studios -digital workstations -mixing of MCT with acoustic sound
ANALYZING MCT		
Software: -sequencers -music editors	Hardware: - EMI (electronic musical instruments) -recording studio hardware	Mixed: - recording studios -digital workstations -mixing of MCT with acoustic sound
CREATIVE MCT		
Software: -sequencers -music editors	Hardware: - EMI (electronic musical instruments) -recording studio hardware	Mixed: - recording studios -digital workstations

Examples of determining the place of the MCT in the proposed classification:

1. The Steinberg Subase sequencer is used by the composer to create a music computer composition from embedded preset samples, tracks and other data of the sequencer itself, without making changes to them:

the MCT function is a composer;

MCT group – creative;

subgroup – software MCT (sequencer).

Further, we can also distinguish a smaller subgroup - software MCTs used without changing program data.

2. When working with the sequencer, the composer records and downloads, as well as creatively uses his author's (user) data in combination with pre–installed ones:

the MCT function is composer;

MCT group – creative;

the subgroup is software MCT (sequencer).

Next, we can distinguish a subgroup - software MCTs used with the introduction of a personal element.

3. The resulting finished composition is played to the public:

the MCT – broadcasting function;

MCT group – preserving and communicative MCT;

subgroup – software, hardware, or mixed MCT (depending on how the composition is played).

All computer technologies, one way or another related to the transmission (communication) of musical information – "communicating or broadcasting MCT" – in the broadest sense include any sound recording and sound reproducing computer technologies. In a narrower sense, we will classify all types of sequencers, audio editors, etc. into this category.

4. The resulting finished composition is reproduced to the public for educational purposes:

the MCT function is broadcasting;

MCT group – pedagogical;

subgroup – software, hardware or mixed MCT (depending on how the composition is played).

5. Work is underway with the student on mastering an electronic keyboard instrument (synthesizer):

the MCT function is educational;

MCT group – pedagogical;

The subgroup is hardware MCT (including EMI - electronic musical instruments).

6. Work is underway with the student to master the sequencer as an installed PC program or online sequencer:

the MCT function is a training;

MCT group – pedagogical;

the subgroup is software MCT (sequencer).

7. Work is underway with the student to master the MuseScor notator:

the MCT function is educational;

MCT group – pedagogical;

the subgroup is software MCT (notator).

8. The composer uses the Sibelius notator to compose the score:

the MCT function is compositional;

MCT group – creative;

the subgroup is software MCT (notator).

9. The composer uses the Sibelius notator to sound the score he created:

the MCT function is broadcasting;

MCT group – preserving and communicative MCT;

the subgroup is software MCT (notator).

In the music computer laboratory, musical notes are deciphered with the help of MCT:

the function of MCT is research;

MCT group – analyzing (research) MCT;

subgroup – software or hardware MCTs (depending on how the recording is analyzed).

Analyzing (research) MCT contribute, for example, to the establishment of the belonging of musical fragments to certain types; the establishment of the authorship of musical works; the restoration of lost fragments of musical works. "With the development of music programming technologies in a broad and narrow understanding of this process, a new objective method of studying creativity <...> has emerged – modeling (reproduction or imitation of several sides of the studied objects or processes). At the same time, it is possible not only to imitate already known compositions, but also, most importantly, to create new musical structures, various elements of the musical fabric" [26, p. 2659]. Currently, MCT plays a huge role in deciphering musical folklore, both in the field and preserved only in recordings of samples of musical creativity. MCT allows you to process and annotate the collected material.

11. In the music and computer laboratory, the affiliation of musical fragments to certain types is established with the help of the MCT:

the MCT function is research;

MCT group – analyzing (research) MCT;

subgroup – software or hardware MCTs (depending on how the music fragment is analyzed).

One of the modern functions of the MCT aimed at preservation and cataloging (collective, saving) is the encoding and storage of information, the formation and functioning of the "intonation dictionary" (Sichra), the "synesthetic fund" (Galeev), [see. about this: 27, p. 149], creation of an automated catalog of musical folklore (Goshovsky, Grabalova) [see. about this: 27, p. 150], "intellectual system for cataloging and analyzing music of the peoples of the world" (Aliyeva, Gorbunova, & Mezentseva) [1; 17; 18; 21]. One of the most important tasks of the MCT, which performs a collective and conservation function, is the cataloging, classification, systematization and digitization of musical materials of traditional music.

12. The composer models various elements of the musical fabric with the help of the MCT:

the MCT function is the composer's;

MCT group – creative MCT;

a subgroup is software or hardware MCTs (depending on how the simulation takes place, most often software).

13. A piece of music is performed that is completely reproduced from the "memory" in the recording:

the MCT – broadcasting function;

MCT group – preserving and communicative MCT;

subgroup – software or hardware MCTs (depending on how the playback takes place).

Here we can note the special phenomenon of the performer of musical works created with the help of MCT. With the advent of MKT, the approach to performance is being rethought: the performance can now be completely reproducible from the "memory" of the recording or in combination with an acoustic performance or completely acoustic. If a piece of music is played from "memory" in a recording in combination with an acoustic performance, then it is possible (and necessary) to classify it differently:

the MCT function is performing;

MCT group – creative MCT;

subgroup – mixed MCT (mixing MCT with acoustic sound).

A special phenomenon is born: the interaction of the composer and performer with the MCT. Since the mid-90s of the 20th century, from the moment when computers became able to fully process sound information in real time, new methods of interactive user interaction with the musical model have appeared, new views on the musical computer as a musician's instrument have been formed ([15; 16; 29].

In the group "Creative MCT" it is obvious that already within the group there is a division into subgroups: "Performing MKT" and "Composer MCT". However, we deliberately combined these categories into one group, believing that it is within the framework of music and computer creativity that the functions of a composer and a performer are often mixed. In addition, the composer often becomes not only a performer, but also a computer arranger, sound engineer, creator of new timbres, musical acoustics, etc.; MCT, thus, become an integral part of the modern creative and performing process. The very principle of execution is also changing.

Examples can be continued. Most researchers are absolutely right here: "no technique, no method or algorithm can replace creative thought, melodies and dialectics of its development. On the contrary, the method, elevated to dogma, fetters the imagination of a talented artist, composer and creates the illusion of ease of composition. Therefore, both the researcher and the composer should remember that mathematical methods are just a means of solving problems that significantly reduce labor intensity and only in some cases give fundamentally new results" [29, p. 99].

II. Research review

There are two main aspects regarding the terminological apparatus in the field of music computer technologies:

1. Actually the definition of MCT;

2. Terms and concepts from the field of MCT.

Actually, the definition of "music computer technologies" has already become established and successfully formulated in 2002 by one of the authors of the article (I. Gorbunova); a more detailed description of the phenomenon of MCT and, accordingly, the terminological apparatus associated with this definition was described in [5]. It was developed the concept of “Music Computer Technologies in Education” and created the Education and Methods Laboratory *Music Computer Technologies* at the Herzen State Pedagogical University of Russia. In the context of this approach, MCTs are defined as an *interdisciplinary field of professional activity associated with the creation and use of specialized musical software and hardware, requiring knowledge and skills both in the music field and in the field of computer science* [3].

These technologies are considered as an innovative phenomenon of modern culture and education, in particular,

MCT are evaluated as corresponding to the following educational principles: scientific, visibility, activity, consistency and consistency, individualization of learning (for example, see in more detailed in the work [32]).

In addition, in modern research, the term "music computer technologies" is recognized as optimal for international use-it is close in spelling and sound for the largest number of other languages. Based on the painstaking analysis carried out by the authors in the article [4], and highlighted in the study the most widely used lexemes for the phenomenon of "music computer technologies" in various languages of the world, as well as in the perspective of our consideration, it is noted that "the terminological apparatus that is used in the music and computer direction of music education (given a certain degree of freedom in the use of terms by authors to refer to technologies), is formed, to a certain extent, not only based on the authority of any authors, but also due to the publication activity of a number of scientists and editorial teams" [4, p. 175].

Researchers present arguments for the approval of the term "music and computer technologies" as an international one and analyze the sum of connotations that the terms from the list have: "music technology", "music computer technologies", "digital music technology", "computer-based technology", "music teaching via technology". In the works of other researches, the problems of functioning of cloud-oriented technologies that are similar in meaning and their implementation in creativity and education are raised [33; 34]; MCT and transformation of the socio-cultural paradigm of performing on musical instruments, including electronic musical instruments (EMI) [23; 35].

We will consider the second aspect of studying the terminological apparatus - the creation of a generalized classification of terms and concepts from the field of MCT, which would reflect their place and functioning in contemporary culture.

III. Conclusion

In fact, all the numerous variants of computer technology (in the broadest sense of the term), as well as software, computer musical developments designed for recording, listening, creating, editing music, saving and transferring data are used in all points of our proposed classification, but perform different functions. After all, they are all intended for professional activities related to the creation and use of specialized musical software and hardware. For example, the understanding of music computer technologies as a contemporary means of preserving and transmitting cultures allows us to single out a separate group in our proposed classification. However, the same MCT will function in other groups, but in a different capacity. Electronic musical instruments in all their varieties can function in each of the points of our classification for one purpose or another. A new culture of transmission of knowledge in a digital educational environment also becomes possible with the help of technologies of any other group of our classification, etc.

Hence the prospect of further research emerges: the continuation of the classification of MCT. Each group we have identified needs a more detailed division. The prospect of further work seems to us very important, since any classification reveals the logical-conceptual structure of the subject area in all its diversity.

A contemporary composer and performer opens up new opportunities for creativity: a notator (music editor), allows you to hear the full score in the process of composing or arranging it (even if not in the "live" sound of acoustic instruments, but in the "digital", but this listening makes it possible to immediately cover and present the orchestral/ ensemble sound, including a number with vocal and synthesized timbres in the performance that the composer intended; the process of selecting a part from the created score is facilitated both for listening (solo or in an ensemble) and for physical allocation to electronic or paper media; a number of musical computer techniques help reduce the complexity of some processes, for example, when composing canons, polyphonic works (a kind of saving of creative energy), the creation of musical works with specified sound characteristics, creating sound fragments of a given character, etc. "Today, composers have a rich range of necessary software and hardware at their fingertips, allowing them to quickly switch from one necessary element to another. The user-friendly interface, professionally oriented user interface makes it possible to fully focus on the purely creative process, completely without being distracted by technological issues" [29, p. 75].

It becomes possible to create musical compositions using "computer modeling of elements of musical creativity" (I. Gorbunova, V. Belichenko, S. Chibirev) [3; 4; 29]. The issues of modeling creative processes with the help of MCT, approaches to modeling musical text have been studied in the works of a number of scientists, among which we note the works [19; 26; 30; 31]. The composer has the opportunity to directly influence the process of creating an algorithmic composition: "<...> change individual data, algorithms, invade various elements of the algorithmic compositional structure. He uses a musical computer as an instrument with a wide palette of artistic and aesthetic possibilities for creating an image and expressing musical thought" [29, p. 75].

As an integral part of the creativity of a modern musician of the digital era, MCT is considered by modern researchers. Once again, we focus on the fact that all the numerous variants of computer technology (in the broadest sense of this concept), as well as software, computer musical developments designed for recording, listening, creating, editing music, saving and transmitting data are used in all groups of the classification proposed by us, but perform different functions.

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She was on a number of business trips abroad, among them working trip to the USA (1999); lecturing and giving research and practice seminars in Hungury (2003, 2005, 2015, 2017, 2019), Belarus (1999-2022); business trip to the UK (2016, 2019); business trip to Ireland (2019), etc. Work experience; 1990 – 2010 - Associate Professor, Professor of the Department of Information Technology of the Herzen State Pedagogical University of Russia, St. Petersburg; 2010 - present - Full Professor of the Department of Digital Education, Institute Information Technology and Technological Education of the Herzen State Pedagogical University of Russia, St. Petersburg; 2002 – present – Head and Chief Researcher of the Education and Methods Laboratory *Music Computer Technologies* of the Herzen State Pedagogical University of Russia, St. Petersburg. She has more than 400 scientific publications, among them are monographs: *Music Computer Technologies: Historical-Theoretical and Practical Aspects* (2007) and *Music Computer Technologies: The Problem of Modeling the Process of Musical Creativity*, compiled with participation of S. V. Chibirev (2012), *Musical Synthesizers (2018)*; course books: *Information Technology in Music*, vol. 1 – 4: vol. 1, *Architectonics of musical sound* (2009), vol. 2, *Musical Synthesizers* (2010), vol. 3, *Musical Computer* (2011), *Music, Mathematics and Computer Science*, vol. 4, compiled with participation of M. S. Zalivadny (2013), *Musical Sound Engineering*, compiled with participation of M.I. Karpets, G.G. Belov (2020). Her research activities include such directions as: MCT in professional music education (as a means to expand creative opportunities); MCT in general musical education (as one of the means of education); MCT as a means of rehabilitation of people with disabilities; MCT as the new direction in preparation of specialists of humanitarian and technological profile; MCT in the field of digital arts; MCT in information technology, psychoacoustics and musical acoustics; system of training arrangements and the art of performing skills on electronic musical instruments. Her circle of interests also includes the problems of interrelation of natural and technical sciences and humanities, as well as the possibilities of applying the results of such interrelation for the purposes of music education and upbringing. She also takes part in working out the specialized software for computer music devices and in application of this software in pedagogical processes. Her developments and researches also belong to the field of musical pedagogics and musicology, musical informatics, computer modeling of processes of musical creativity, timbre programming, art of performing skills and arrangement on electronic musical instruments, creative work in the field of computer music, mathematical methods in musicology.

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