To the International Recognition of the System of Azerbaijani Modes: Aspects of Studying and Learning with Using Music Computer Technologies

Imina G. Alieva and Irina B. Gorbunova

***Abstract*—** Acoustic measurements related to the pitch intonation of Azerbaijani music (both traditional and compositional), with the study of their microintonation schemes, as well as the timbre characteristics of Azerbaijani folk instruments have so far remained out of the field of view of researchers and have not been the subject of special study. The article deals with issues related to the intonation system of Azerbaijani frets, with their existence in contemporary musical culture, cites the field of cognitive musicology, which allows us to present the intonation system of Azerbaijani frets in the form of a cognitive structure, which has significant prospects for their implementation in the field of contemporary musical research with the involvement of music computer technologies. A particularly important aspect is associated with an adequate representation of the range of problems under consideration in the system of contemporary musical education, which is also possible and very productive when using modern music computer technologies**.**

***Keywords*—** ethnomusicology, fuzzy logic, knowledge base, music computer technologies**.**

I. Introduction

Azerbaijani modes, genetically related to the musical systems of the peoples of the East, occupy its own noticeable place in the multicolored palette of modal systems. Uzeyir Hajibeyli (U. Gadzhibekov, U. Hajibeyov) the founder of Azerbaijani composer school pointed out that Azerbaijani modes in their richness and diversity are worthy of great attention, and their harmonious "living system" makes it possible "to bring something new to the common cause of the world musical art" [1].

U. Hajibeyli figuratively wrote that the musical culture of the people of the Middle East reached its flourish in 14th century and had proudly raised as a twelve-columned, six-towered "structure" (dastghah) from the height of which one could view all four cardinal directions: from Andalusia to China and from Africa to the Caucasus. Due to the socio-economic and political changes that took place towards the end of the 14th century, fatal cracks appeared in this magnificent musical "structure" which eventually led to the fact that its columns and towers fell apart and it collapsed. The peoples of the Middle East used the valuable rubble of collapsed "palace of music" and along with their own "mode building material" built their own "musical temple" in the style specific to each nation [2]. These valuable rubble served as "mode building material" for the construction of a musical temple also and Azerbaijani music.

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II. Intonation System of Azerbaijani Modes: Musicological Aspects of the Studying

In modern musical culture, Azerbaijani modes manifest themselves in both traditional and European genres. Existing in their simultaneity in the not-too-distant time space as a living evolving system, they represent a unique opportunity to explore the life of these modes at various stages of development and follow the evolution of musical thinking from ancient oriental monody (mugham) to contemporary composing practices.

The modal system of Azerbaijani traditional music contains more than 80 modes involved with mugham — the main genre of Azerbaijani professional music of oral tradition. The scales of these modes and their tuning are reflected in the scale of a tar, an Azerbaijani folk instrument, with an octave divided into 17 non-temperament tones [3].

This tuning system is appropriate for Azerbaijani professional folk music. It can be described as an unequally tempered scale, in which the semitones, tones and intervals are available in several variants and differ from 12-degree equally tempered one. In Azerbaijani traditional music the modes whose scales seemed to be identical, may differ in sounding and have different names, since the mode and the key of mugham are determined in regard to tar. As F. Chelebiyev noted, if mugham changes its place, i.e. a key, it will certainly acquire a new name, because the key is crucial in Azerbaijani mugham. The same mugham passage sounds differently in different keys. Accordingly, the term "transposition" in conventional meaning

of this word cannot be applied to mugham art [4].

On the other hand, when U. Hajibeyli founded the modern theory of Azerbaijani modes he distinguished only 7 main modes to use them in the composers' creativity. He gave these modes the names of the most popular Azerbaijani mughams: rast, shur, segah, shushtar, chargah, bayati-shiraz, humayun, and he adopted European notation and twelve-tone equal temperament for the scales of these modes [2]. For notation, U. Hajibeyli chose the frets of a tar with the tunings that are closest to 12-tone equal temperament, while retaining the rest for mugham performance [5].

The zone nature of musical hearing [6] existing not only in performance, but also in the perception of pitch, allows accepting minor deviations of pitch. When we compare intervals of Azerbaijani modes with the Garbuzov' zones of melodic intervals, we can see that all the intervals of Azerbaijani modes including mugham intervals (made up of mugham frets) are correlated with the Garbuzov' zones. It means that European notation, and 12-tone equal temperament are applicable to Azerbaijani modes [7].

The functional relationship of the degrees of modes are more informative than their exact tuning which usually is the fundamental basis for the study of modal harmonies and their classification. This conclusion allows to distinguish macro-intonation schemata of modes (related to the functional relationships) and micro-intonation schemata (associated with the nuances of traditional performance and in-zone intonations). These are macro-intonation schemata that allow to recognize Azerbaijani modes in European genres under the 12-tone equal temperament, while their micro-intonation schemata preserves the authenticity tuning in Azerbaijani traditional music.

Meanwhile comprehension of the modal system of Eastern music is a difficult problem for the musicians whose ear is training only on the basis of major and minor, in Eastern music such musicians hear only some general oriental intonations. The problem becomes doubly complicated if modes are represented not only in traditional but also in the European genres — as we face it in Azerbaijani musical culture. Analizing Hajibeyli's opera *Keroglu* Marina Frolova-Walker is forced to admit: "What we hear is the minor subdominant in a major key plus the alternation of tonic major-minor, another cliche of exoticism. While it is possible that a native Azerbaijani might detect in Keroglu national characteristics, westerners are unlikely to share this perception" [8].

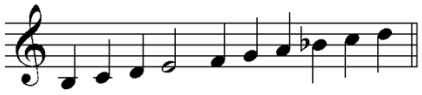
Rast, *segah*, *chargah* modes are equally interpreted by the European ear as *major*, *bayati-shiraz*, *shur*, *shushtar*, *humayun* — as *minor*. It is not only the individual problem of a musician — one can see here the global problem of understanding of *otherness'* culture, the general problem of cognition, the problem of methodology.

Ear training on the basis of major and minor scales, triads and arpeggios develops resistant mode stereotypes, gives a sense of modal structure and ensures confident recognition of mode. However, learned patterns of major and minor do not form the basis for understanding of Azerbaijani modal structures. The structure and logic of Azerbaijani modes differ a lot from the major-minor system, and those who study Azerbaijani music face many phenomena unfamiliar to the European ear [9].

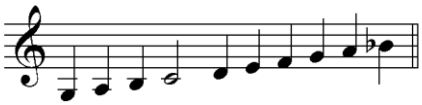
In major and minor scales the sense of mode arises from a unilateral sequential step by step movement from tonic to tonic within a single octave, both up and down.

Unlike major and minor, the number of steps of the scale is not seven. According to Uzeyir Hajibeyli's theory [2], modes in Azerbaijani music contain from 8, like in mode shushtar, to 11 steps, like in mode chahargah.

The tonic of Azerbaijani modes is in the middle of the scale. For example, segah mode with tonic E [2]:



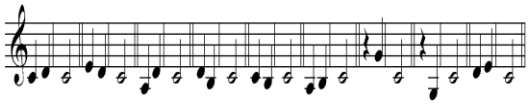
Modes and scales in Azerbaijani folk music are non-octave. One and the same sound in different octaves hold different positions and functions differently. It can be represented in the neighboring octaves by different sounds, for example, h and b1 in rast mode with tonic C [2]:



Augmented second cannot be viewed as a mode-indicator, as it may occur in different cases: either in independent modes or as a result of the creation of chromatic scale.

One of the main features of Azerbaijani modes is that study of their scales is not enough for their aural perception. The scale of Azerbaijani mode when it sounds separately does not allow hearing and experiencing the personality of mode. Cadences play important role for certain distinguishing a mode in Azerbaijani music.

Examples of mode cadences of the six main Azerbaycani modes (*rast, shur, segah, shushtar, chahargah, bayati-shiraz*) were provided by U. Hajibeyli in his treatise *Principles of Azerbaijani national music* [2]. Examples of full cadences of rast mode with tonic *C*:



Study of the Azerbaijani modes traditionally involves education of modal hearing through students' memory development and enrichment of their thesaurus, i.e. accumulation of melodic modal impressions and their fixation in the consciousness. This is a long process involving the assimilation of a sufficiently large number of musical examples.

For studying Azerbaijani modes and developing modal hearing on this basis the models of seven main modes and the *Practical Guide* were created [5]. The author of the guide provides a set of short modal improvisations for teaching aural perception of modes rast, shur, segah, shushtar, chahargah,

bayati-shiraz, humayun (Fig. 1).

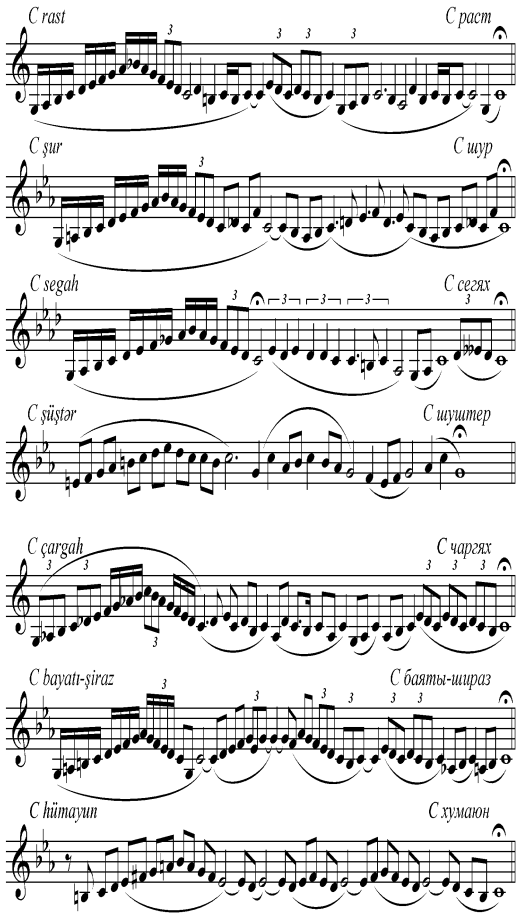


Fig. 1. Models of modes rast, shur, segah, shushtar, chahargah, bayati-shiraz, humayun

The mode models contain necessary and sufficient information needed to identify the mode. These models unify the most typical intonation and metro-rhythmical features of each mode (including the scale and the various options of cadences), in this way, helping to determine the mode in the musical composition. They reflect the regularity of modes of Azerbaijani music; they are laconic, rhythmically defined and easily remembered because of the emotional coloring. On the basis of the modes models, the Practical digital guide for the study Azerbaijani modes was also developed.

The modes models and musical examples were recorded using the multifunctional music notation editor Finale that allows you to type both musical and alphabetic text, and is supported by MIDI keyboards. The recorded models and musical examples are saved both in the graphic .tiff format and in the .mus format, which allows you to listen to the musical text (standard notation was using). To determine the mode of a musical example, it is enough to choose from the group of models with the corresponding tonic the one that is intonationally suitable for the analyzed musical excerpt.

The guide consists of the following sections: Introduction, Modes Models,

Learning, Testing, Appendix.

Introduction. This is a theoretical part that gives an idea of a contempopary manifestation of Azerbaijani modes both in European and traditional janres. This section provides insight into modal system of Azerbaijani music, scales and tuning in traditional janres. The technique of teaching aural perception of seven main Azerbaijani modes on the basis of models is also proposed.

Modes Models. The proposed modes models are grouped according to the principle of the same tonic and are arranged in chromatic order from each tone of the 12-step chromatic scale. With such a grouping, it is easier to distinguish the distinctive intonation features of each mode, which also helps to determine the mode in a piece of music.

Learning. In this section about 80 musical examples systematized by modes — *rast*, *shur*, *segah*, *shushtar*, *chargah*, *bayati-shiraz*, *humayun* — are given. Every example is accompanied by a model in a relevant mode and tonality. For the developing of musical ear, it is recommended to song and perform each example accompanying it by the appropriate model of mode (see fig. 2 and 3).

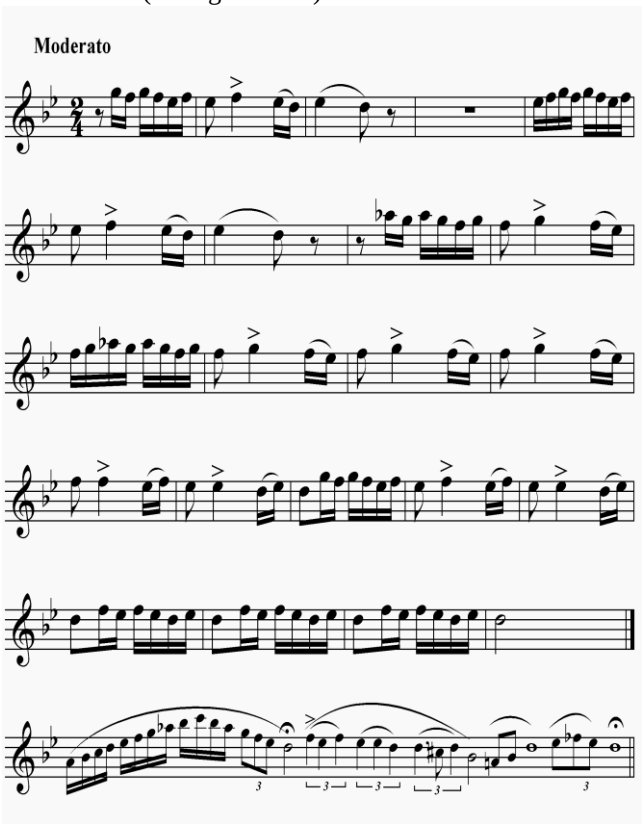


Fig. 2. Overture to opera *Koroglu* of Uzeyir Hajibeyov. First theme (D segah)

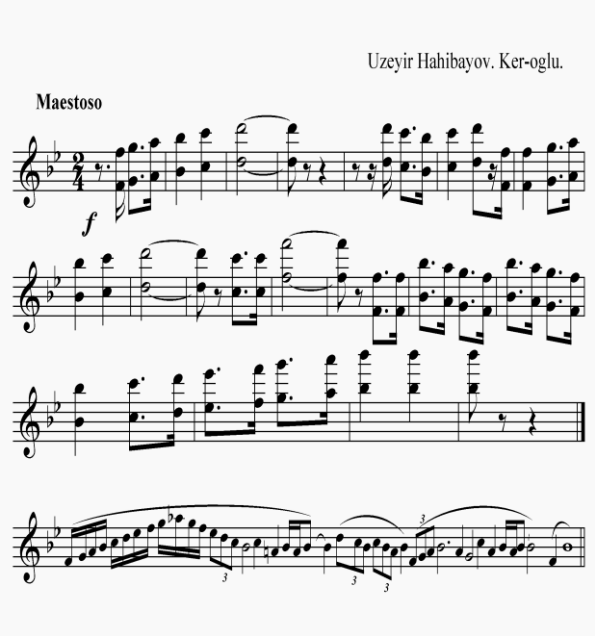


Fig. 3. Overture to opera *Koroglu* of Uzeyir Hajibeyov. Coda (B rast)

III. Aspects of Studying and Learning with Using Music Computer Technologies

Composing experiments on the release of creative imagination, new rules for the organization of sound material and sound forms, new possibilities for creating sound, alternative forms of performing practice, the ratio of vocal-instrumental and computer music, features of studio work - characteristic manifestations of musical culture of the turn of the 20th – 21st centuries, characterizing the general structure of the elements included in the complex model of the semantic space of music, its individual states and subsystems, the functional dependence between the components of the model, the presence of elements of uncertainty in its structure and concrete-figurative content, as well as the reflection of the time parameters of music based on the processes of simultaneity (unification in simultaneity) occurring in musical perception. "The multitude of sound elements forming the musical fabric should merge together into an integral sound and musical form," writes K. Stockhausen [10]. The multidimensional approach to timbre has led to the use of the concepts of "timbre space", "movement in timbre space" (A. Schoenberg) [11]. Listening activity becomes an integral component of such music, since the fabric of the composition is as improvisational as possible, includes random elements. There is a constant search for new ways in musical shaping.

These and many other circumstances were a prerequisite for the formation of a complex field of knowledge and phenomena (musical, informational, technological, artistic, social, cultural, etc.) — music computer technologies (MCT).

In 2002, the education and methods laboratory Music Computer Technologies (EML Music Computer Technologies) was established at the Herzen Russian State Pedagogical University of Russia. EML Music Computer Technologies is a developer of a number of unique, promising areas at the intersection of culture, art, computer science and information technology. The circle of interests of EML employees includes research on the problem of the interrelation of natural, technical and humanitarian sciences, the development of specialized software for computer musical devices and the use of this software in pedagogical processes in order to improve the system of music education and upbringing.

Thus, the most promising areas of application of MCT in the further study and development of a complex model for the semantic space of music are:

- in the field of developing mathematical research methods in musicology - building an intellectual system for cataloging and analyzing music of the peoples of the world with the extraction of musical knowledge in conditions of uncertainty, inaccuracy and partial reliability of information, which, in particular, is reflected in a number of publications prepared jointly with a group of scientists from Azerbaijan [12; 13];
- development of infocommunication technologies and computing systems (knowledge extraction, artificial intelligence systems based on fuzzy sets systems, etc.) to create an accessible, convenient for scientific research and musical creativity, a single, maximally complete (and constantly replenished) catalog of samples of traditional music not only from various regions of Russia, but also from various countries;
- creation of conditions based on the use of MCT (including a technological base) for coordinating the activities of Russian and foreign musicologists-folklorists and ethnomusicologists, psychologists, musical acoustics and engineers in the field of information technology in music and cybernetic ethnomusicology;
- creation of a melody identifier, a virtual sampler, computer music training programs, sequencers, software for the professional activities of a musician based on MCT;
- development of a method for constructing models of difficult-to-formalize subject areas and application of the developed approach to create a model of musical creativity based on the analysis of musical texts, cyclic structuring of statistical data and structural analysis of statistical information, allowing to simulate the creation of texts satisfying previously obtained or manually set parameters;
- development of a Russian software shell that solves many tasks: the use of a domestic sampler for musical and educational purposes, the construction of a number of high-level training programs based on it, professional work with arrangements. Such a tool will expand, in particular, the technical and creative possibilities of teaching children and adults, forming a universal educational and technological model based on the use of MCT;
- construction of a computer model of musical creative work, including synesthetic patterns of music, which allows the analysis and synthesis of musical texts based on the probabilistic parameters of fragments of musical texts (the developed approach can be used in other difficult-to-formalize subject areas;
- creation of a hardware and software complex based on the

use of MCT on the basis of traditional Russian musical culture, music of the peoples of Russia and the world;

- serious and in-depth consideration of issues related to the formation and development of music informatics — a field of knowledge that, on the one hand, studies the specifics of musical activities with the participation of computer technologies, on the other hand, requires the interaction of musicians and specialists in the field of natural and technical sciences. It should be noted that the experience of conducting (in various forms) courses of musical informatics for engineers, programmers, researchers of natural science and technical profile, both domestic and foreign, convinces that musical and theoretical knowledge is necessary for the activities of these categories of specialists in the field of computer science;

- development and research in the field of music pedagogy and musicology, musical informatics, computer modeling of musical creativity processes, timbre programming, performing arts and arrangements on electronic musical instruments, creativity in the field of computer music, mathematical methods in musicology, etc. [14].

The scientists of the EML Music Computer Technologies scientific group are also developing new approaches to the organization of the educational process and conducting classes with a significant reliance on the use of MCT ("Music Computer Technologies in the Digital Age School "), which is implemented in the following main areas: MCT in professional music education (as a means to expand creative opportunities); MCT in general education (as one of the means of teaching); MCT as a means of rehabilitation of people with disabilities; MCT as a new direction in the training of specialists in the humanities and technology profile; MCT in the field of digital arts; MCT in the field of information technology in music, psychoacoustics and musical acoustics, musical and sound-timbral programming; MCT and sound design, sound production; MCT and musical sound engineering; MCT and performance on electronic musical instruments; MCT and computer musical creative work. Developments in these areas of research also contribute to:

- consolidation of the professional community, unification of its leading creative forces in choosing ways to implement the spiritual and moral education of the younger generation, taking into account all the features of the socio-cultural process of modern development of our society;

- assistance in the development of new educational programs in the field of music and, in general, art education, based on the global capabilities of modern information technologies;

- development of existing state educational standards and other new scientific and educational directions.

The synesthetic nature of musical thinking creates prerequisites not only for expanding and enriching the possibilities of music with the participation of computer technologies, but also for its entry into the sphere of other arts (which is convincingly confirmed by the practice of recent decades). It is significant, for example, that based on the experience of using the graphic method of composition ("composing music through drawing") with the participation of computer technology, Ya. Xenakis put forward the idea of educating "broad-profile artists" (in essence, of a synthetic type) with fundamental knowledge in various fields of natural and technical sciences (including computer science), as well as in the field of "theoretical history of music and visual arts." However, this is a topic that requires, due to the scale and complexity of its problems, a separate independent study (see, for example, [15]).

The approach to understanding the musical-historical process as a diachronous-synchronous continuum with the patterns of rhythms of creativity characteristic of it, the study of processes using MCT and computer technologies in general contributes to the expansion of the structure and enriching the diversity of properties of the model [16; 17].

IV. Conclusion

The development of information technologies makes further improvements in the manifestations of the laws of such interaction of music, mathematics, computer science [18], but does not cancel these laws themselves, the understanding of which in their fundamental forms remains necessary. It should also be taken into account that the "actually human" component in this interaction is more stable and does not evolve as rapidly as computer hardware. Meanwhile, as is rightly noted by many, "art itself, whether old or new, is ultimately created for man and his own man." [17, p. 23]. The field of computer science contains a lot of possibilities that have not yet been used (or used to a small extent) by music theory and practice — both with the participation of computer technologies and independently of them.

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Irina B. Gorbunova was born in St. Petersburg (Leningrad), Russia. DipMus, Special Music Higher School of the St. Petersburg State Conservatory named after N.A. Rimsky-Korsakov; BSc in Computer Science: Information Technology, Computer Science and Multimedia, Leningrad State University, Ussurisk State Pedagogical University; MA in Education, the Herzen State Pedagogical University of Russia; PhD in Information Technology and s, the Herzen State Pedagogical University of Russia, St. Petersburg, 1989; Doctor degree: Doctor of Pedagogic Sciences and Information Technology, the Herzen State Pedagogical University of Russia, St. Petersburg, 1999. Dr. Gorbunova, Full Professor, PhD in Sc., Doctor of Pedagogic Sciences, Chief Researcher of the Education and Methods Laboratory *Music Computer Technologies* of the Herzen State Pedagogical University of Russia, St. Petersburg.
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); 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.

Prof. Dr. Gorbunova is Chairman of the Organizing Committee of the International Research and Practical Conference *Contemporary Musical Education*, Chairman of the Organizing Committee of the International Research and Practical Conference *Music Computer Technologies in the System of Contemporary Education*. Dr. Gorbunova is a member of the jury of national and international competitions of musical creative works, including *Bridge of Friendship* (Dortmund, Germany), *Electronic Palette* (St. Petersburg, Russia), *Music and Electronics* (Moscow), *Music of the 21th Century* (Moscow / St. Petersburg), International Festivals and Competitions *Musical Electronics and Multimedia* (Moscow / St. Petersburg), *CLARINE of the 21th Century* (St. Petersburg), *The World of Art without Borders* (St. Petersburg, Russia - Szeged, Hungary), All-Russian Competition of Electroacoustic Music *DEMO* (St. Petersburg). She is a

member of Editorial Boards of international journals: *Music Scholarship* (Web of Science/Scopus), *The World of Science, Culture, Education*, and Electronic Research Journal *Mediamusic*. Prof. Dr. Gorbunova developed the first-ever Bachelor Course "Music Computer Technologies" (2004) and Master Course "Music Computer Technologies in Education" (2006), which is being implemented at educational institutions in various regions of Russia. Prof. Dr. Gorbunova supervises a number of doctoral and post-doctoral students (more than 30) and lectures on “Music Computer Technologies” and “Information Technology in Music”. She supervises research in various directions, among them: theory and history of culture; music art; information system and processes; theory and methodology of professional education; mathematical modelling, calculation methods and program systems; theory and methods of education and upbringing (in the fields of music, informatics, and natural sciences). The research results of Prof. Gorbunova were published in over 400 refereed publications including 48 books and 255 papers in journals and conference proceedings. Awards and honors: 2003 - Gold Medal of the All-Russian Exhibition Centre (former Exhibition of Achievements of the National Economy); 2005 - Silver Medal of the All-Russian Exhibition Centre; 2009 - Gold Medal of the All-Russian Exhibition Centre; 2009 - Diploma of the winner in the nomination «New educational technologies in ICT environment» of the All-Russian creative contest of scientific-technical solutions, educational products and services in the field of informatization of the innovative-educational complex «Music computer technologies in the system of modern education»; 2010 - Grand Prix of International Congress-exhibition «Global Education - Education Without Borders»; 2010 - Diploma of the 11th All-Russian Forum *Educational environment - 2010* for the project «Digital educational resources «Music computer technologies in education» in nomination of «Creative Competition of scientific developments, innovative solutions and programs in the field of higher vocational education» and many others; 2011 - Laureate of the Prize of the Government «For Outstanding Achievements in the Field of Higher and Secondary Professional Education»; 2013 - Honorary Worker of Higher Professional Education of the Russian Federation.