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FACULTY OF ELECTRICAL ENGINEERING

ETIMA 2021

FIRST INTERNATIONAL CONFERENCE

19-21 OCTOBER, 2021

TECHNICAL SCIENCES APPLIED IN ECONOMY, EDUCATION AND INDUSTRY

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PREFACE

The Faculty of Electrical Engineering at University Goce Delcev (UGD), has organized the International Conference ***Electrical Engineering, Informatics, Machinery and Automation - Technical Sciences applied in Economy, Education and Industry-ETIMA*.**
ETIMA has a goal to gather the scientists, professors, experts and professionals from the field of technical sciences in one place as a forum for exchange of ideas, to strengthen the multidisciplinary research and cooperation and to promote the achievements of technology and its impact on every aspect of living. We hope that this conference will continue to be a venue for presenting the latest research results and developments on the field of technology.
Conference ETIMA was held as online conference where contributed more than sixty colleagues, from six different countries with forty papers.
We would like to express our gratitude to all the colleagues, who contributed to the success of ETIMA'21 by presenting the results of their current research activities and by launching the new ideas through many fruitful discussions.
We invite you and your colleagues also to attend ETIMA Conference in the future. One should believe that next time we will have opportunity to meet each other and exchange ideas, scientific knowledge and useful information in direct contact, as well as to enjoy the social events together.

The Organizing Committee of the Conference

ПРЕДГОВОР

Меѓународната конференција ***Електротехника, Технологија, Информатика, Машинство и Автоматика-технички науки во служба на економија, образование и индустрија-ЕТИМА*** е организирана од страна на Електротехничкиот факултет при Универзитетот Гоце Делчев.
ЕТИМА има за цел да ги собере на едно место научниците, професорите, експертите и професионалците од полето на техничките науки и да представува форум за размена на идеи, да го зајканува мултидисциплинарното истражување и соработка и да ги промовира технолошките достигнувања и нивното влијание врз секој аспект од живеењето. Се надеваме дека оваа конференција ќе продолжи да биде настан на кој ќе се презентираат најновите резултати од истражувањата и развојот на полето на технологијата.
Конференцијата ЕТИМА се одржа online и на неа дадоа свој допринос повеќе од шеесет автори од шест различни земји со четириесет труда.
Сакаме да ја искажеме нашата благодарност до сите колеги кои допринесоа за успехот на ЕТИМА'21 со презентирање на резултати од нивните тековни истражувања и со лансирање на нови идеи преку многу плодни дискусии.

Ве покануваме Вие и Вашите колеги да земете учество на ЕТИМА и во иднина. Веруваме дека следниот пат ќе имаме можност да се сретнеме, да разменime идеи, знаење и корисни информации во директен контакт, но исто така да уживаме заедно и во друштвените настани.

Организационен одбор на конференцијата

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DEVELOPMENT OF COMPUTER SOFTWARE FOR CREATING CHOREOGRAPHY

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Abstract
This paper is based on research into the connection between computers and the process of documenting and creating choreography as part of the performing arts. The possibilities for creating a software program that will digitize the creation of choreographic record and will go a step further, a program that will be able to create works based on those digital records and will support the artistic expression in the creation process, ie. will enablethe creation of software for the articulation of artistic expression. To develop such a program that will have the functionality to create computer-generated choreography.

Key words
Computer-generated choreography, dance, contemporary dance, software, digitalize

Introduction

The paper is based on research into the use of digitalization in the performing arts, namely, theart of dance, as well as the possibility of programming software to create computer-generated choreography, with a focus on contemporary dance, its justification and use in a broader sense.Given the huge development of technology, especially in the field of computer science and technology, the question arose as to how to make a program for computer-generated choreography, which will support the creation process and what will be its justification in termsof creating works of art by artists ‘live’ (in-person), or the beginning of a process in which choreography can be created through software, which belongs to the field of artificial intelligence.

Research shows that initial attempts in this direction are based on the need to create digital records of choreographic works, given that in contemporary dance, there is no official vocabulary, as in the classical ballet technique, but each choreographer creates their own vocabulary. Throughout the history of the development of contemporary dance in the 20th century, attempts have been made to create an effective system for recording choreographic works, but the results are complicated writing systems, such as Labanotation (considered one of the most successful systems), then notation systems by Benesh, and Eshkol-Wachman. Thedevelopment of technology provides an opportunity to create digital records and a number of artists and computer engineers are beginning to research in that direction. Exploring the historical development of this issue, we came to specific projects and programs that connect computers and choreography, at the beginning of the second half of the 20th century. During this period, the term 'computer-generated choreography' is formulated, and the development oftechnology directly affects the digitization and documentation of works of art. We are interestedin how this process of computer-generated choreography can help in the creation of choreography, whether and how these programs will help in digitalization and technology in the educational process in the field of dance; determining the need for the art processes to keepup with and follow technological progress; studying the way of creating art programs and the impact that those programs will have on real-world situations, ie. their

use and justification. The paper explores the possibility of creating software for the articulation of artistic expression,based on a particular existing language for notation of dance (Labanotation).

Literature review

The history of the development of the performing arts, especially contemporary dance, has beenlinked to the development of technology since the early 20th century, when Loie Fuller and herinnovations in the use of light and light effects on stage appeared as she danced. The art of dance has developed extremely fast in the last years of the 20th century and the beginning of the 21st century and in its development, it introduces technological elements, which enrich thestage space and visualization of the works that are performed. Sometime in the middle of the 20th century, the first articles appeared in which computers were connected with choreography,and later through the development of this process the term 'computer-generated choreography'was developed, which means a technique for using algorithms to create a choreographic text, ie. dance / choreography. The process began with the work of American dancer and professor Jeanne Beaman [1] in 1964, when with the help of computer scientist Paul LeVasseur she created the work "Random Dances" [2]. Her ventures are considered pioneering in terms of connecting computers and choreography. In 1966, Michael Noll [3], for the Philadelphia Art Alliance, wrote a paper titled "Choreography and Computers" (published in Dance Magazine in 1967), in which he spoke about the use of computers in the direction of writing and notationof choreography, i.e. how a computer program could recognize and transcribe the movements,leaving a permanent record of the choreography / choreographic text (dance notation typewriter). Noll assumes that if the traditional way of creating choreography is avoided, the time for rehearsing the choreographic text would be better used and the process of creation in the studio would be used to the maximum. He imagines that the choreographer has in front of him a "tool" ("digital computer with some form of visual display") through which he will createand write the choreography, which he will then only transmit to the dancers. Between 1968- 1974, Francisco Sagasti [4] and William Page attempted an interaction between dance and computers, i.e. worked on a program to "create and stage a computer-generated choreography for multiple dancers" [5]. Their work, on the one hand, is based on the need to use technologyin creating dance sequences, which would bring the technology closer to the artists, but, on theother hand, to point out the fact that technology and computers cannot take the living artistic creations, no matter how sophisticated the software that will produce the program.

The first world-famous choreographer to connect computers to the process of creating choreography was Merce Cunningham. He used the "LifeForms" program to determine the position of dancers on stage and in 1991 created the first computer-generated choreography "Trackers", which he then staged. Cunningham also used "Dance Forms", the successor to "LifeForms", to create the "CRWDSPCR" choreography. This work remained on the company's repertoire until 1999.

The process of computer creation of choreography develops in parallel with the development of computer technology itself, algorithms, and neural network systems. Attempts and interest in combining technologies and computer advances in the programming of choreographic text sentences are increasingly appearing on the world stage. Most significant are the work of computer scientist Thomas W. Calvert from the eighties of the 20th century, the Choreology Project of the University of Sydney, based on Benesh notation [6], then the work of Robert John Lansdown [7], whose experiments were based on understanding the possibilities of creating computer-generated choreography / dance with the help of "various procedural techniques for generation" and "established notations for scoring". He realizes that in order to create a sophisticated program that will at least produce a choreographic text close to the workof a human choreographer, a remarkably sophisticated program needs to be created. Therefore,he, in a way, "limits" the program, in order to set only the basic movements of the dance sequences, "the peaks, not the complete movement", i.e. makes a framework, in which it allowschoreographers to insert their ideas. Brazilian choreographer Analivia Cordeiro works on creating a computer program that uses computers and television to design and perform dance. According to her "by selecting components and establishing formal relationships between them,the choreographer structures an interactive dance-TV system. In this way he creates the algorithm which will generate the choreography he imagined". The computer program devisedby Cordeiro generated a set of instructions for the dancer, the cameramen, and the TV director,with the dancer using his or her individual expression to define additional elements, such as muscular effort and fluidity of movement, that remained unspecified by the computer program.[8]

Considering that this paper aims to help develop software for creating choreography in the fieldof contemporary dance, special attention was drawn to the work of the Ohio State University, which in collaboration with world-renowned choreographer William Forsythe, through the Advanced Computing Center for the Arts and Design (ACCAD). They create the "SynchronousObjects" project, which seeks to answer certain questions, such as "What are the organizing structures behind a piece of choreography? How can these be made visible using interactive screen-based media? And what is the best way to communicate them?" [9]. Forsythe is makingan effort to create digital platforms for storing choreographies, such as "Improvisation Technologies: A Tool for the Analytical Dance Eye", then "Synchronous Objects", and"Motion Bank", a research platform for creating and researching online digital scores in collaboration with guest choreographers.

Over the past twenty years, there appear authors who want to link computer-generated choreography to artistic dance expression, such as the project of Wayne McGregor, a world-renowned choreographer from the UK, and his collaboration with Google Arts & Culture Lab,followed by Luka Crnkovic-Friis and Louise Crnkovic. Friis in their paper "Generative Choreography using Deep Learning" and others.

Development of computer software for creating choreography

The creation of a choreographic work can be defined as a complicated mental and artistic process, which is related to the conditionality of several elements needed to achieve the goal - dancer / body, space, choreographic thought / idea and process of the work itself, ie. creation of movements in continuity, which would create a composition of movements, which will grow into a reflection of the choreographic thought, ie. a process of creating a choreographic text. The original choreographic text is autochthonous and is part of the stylistic expression and poetics of each artist separately. In order to create a choreography with artistic expression, the choreographer works in a space in which he or she is together with the dancers (bodies) who are instruments in the creation of the choreographic text, which revives the choreographic thought.

To develop such a program that will have the functionality to create choreography, means to

digitalize the idea and the process of creating choreographic text. If we want to make a sophisticated computer program, which will initially write, i.e. document the process of creatingdance sequences, and for that we take as a basis Labanotation, which through a complicated system of symbols, makes records for a certain choreography, it is necessary to get acquaintedwith the kinetic theories of dance by Rudolf Laban. In his system for the description of humanmovement, called "Laban movement analysis (LMA)"), Laban defines four basic categories, through which he makes his analysis of the movements: Body, Form, Strength and Space (Categories, according to the LMA, are capitalized). Laban, in his theories, gives an interpretation of the relations of the four categories: Body, Form, Strength and Space. He explains the connections and conditionality of these four basic categories, which are at the heartof dance, as well as their sub-categories and relations. At the same time, Laban creates a codified system for recording movements, Labanotation, which consists of symbols and is quitecomplicated, but can be taken as a basis on which to create the computer program.

All previously known tools / software programs for computer-generated choreography are based on the creation of formations and eventual positioning of bodies in space. Therefore, it can be said that if we look at the Laban Motion Analysis (LMA), as well as the categories Laban analyzes in his kinetic theories, the hitherto known types of computer programs for computer- generated choreography deal with the relationship between Body and Space. In order to achieve a real process of creating computer-generated choreography it is necessary to initially develop software that will cover the following categories individually: Body, Form and Strength. Then it will be possible to develop software that will generate the relationships between the categories, which, more precisely, will be able to obtain 'original' movements, which will be combined in the creation process.

Until we succeed in producing software programs that will break down and support the categories according to Laban, their subcategories and relationships in a software program, it is almost impossible to talk about the process of creation with computer-generated choreography which will reflect the real-world process of creating choreography.

Initially, it is necessary to create a digital model of the human Body (bodies). An example is a physical body, which will be connected to the computer body through sensors: Alter-body [10] of the original. In this way it will be possible to copy the movements and 'write them down' in the algorithm of movements, which we would divide into basic (basic), definite (individual) and interactive (duet). We will call this vocabulary of movements the Global Digital Vocabulary of HighAlterBodies.

Library of basic movements

To clarify the process of creating the Global Digital Vocabulary, we will say that the software for the development of motions of the AlterBody, if based on LMA, should rely on biokinetics and the way the body moves. The program should initially be 'fed' by the Library of basic movements, which will consist of the well-known, specific movements of the Body category.

To complete the process of creating this library, an algorithm should be developed, in which

the categories - Body, Effort and Shape, and their sub-categories will be inserted, as well as defining the movements that contain the interactive reactions between these categories and sub- categories.
Effort has four subcategories (effort factors) - Space, Weight, Time and Flow, each of which has two opposite polarities (Effort elements); Direct/Indirect; Strong/Light; Sudden/Sustained; Bound/Free.
Shape has three Modes of Shape Change: Shape Flow, Directional & Carving.
Effort has a model of Action drive which includes Space, Weight, and Time with the combinations, named Float, Punch (Thrust), Glide, Slash, Dab, Wring, Flick, and Press.
These elements should be projected for each body segment separately.
The program created for the AlterBody will be able, we assume, to support 'real' human movement in dancing with greater credibility. Then, a program for the interaction between Space and the AlterBody should be developed, i.e. the ways of interaction of these two categories should be predicted. In combination with the software for AlterBody (with a completely generated Library of basic movements) and Space (with generated basic directions of movements), it will be possible to complete the movement of the computer-generated
AlterBody, which will be able to fulfill the tasks of creating certain movements through space, which would be closest to the terms dance and choreography. The program should define a basic digitized vocabulary of movements, supported by the categories and their software, which will represent the database of elements to be worked with.

Particular movements

In order to realize the idea of complementing computer-generated choreography, with artistic expression, during further development, we need to create a prototype of an upgraded model of AlterBody with artificial intelligence, which we will call HighAlterBody. This model should have a program that combines, designs, and upgrades elements from the basic digitized vocabulary with individual interpretation and sequencing. Given that when creating live choreographic text (in-person), there is an interactive reaction between the choreographer and the dancers, which greatly facilitates the creation itself, such software should have a tool (brain), which will consist of algorithms and neural networks, with which it will be able to program the necessary interaction. Technology will help us feed this system, through programs that use neural networks and sensory interactions, as tools to support movements, according to certain human examples. Thereby, a library of special-defined-individual movements will be created, which will serve for further development of the HighAlterBody model.

Duet movements

This part of creating the program will be the most complex, because it means the interaction of two HighAlterBodies. Each HighAlterBody will need to be able to maintain individuality and not produce symmetrically-synchronized movements, but individually-segmented movements, which will perform in interactive harmony. This duet movement will be programmed as an algorithm for connecting segmented and precisely defined parts of two HighAlterBodies.
The process of motion detection will again have to be combined with 'feeding' by simulating duet movements of real human bodies, recognizing and segmenting them. This phase can be developed when the first two phases of creating the Global Digital Vocabulary of HighAlterBodies to support the process of creating a choreographic text are fully formed.

The development of artificial intelligence will be crucial to finish this program, which will help create a model for the creation of mutual dance, which includes not only forms and formations throughout space, but ways of functioning that are transversal, three-dimensional and special.

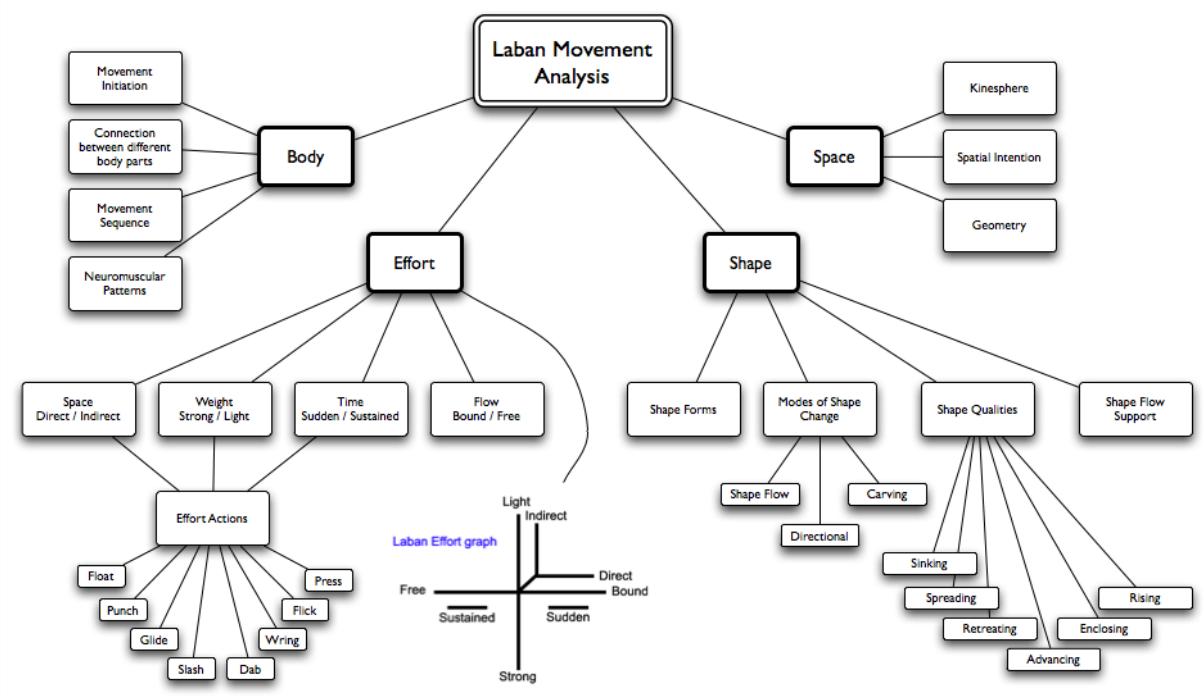

Fig. 1 Key parameters of Laban Movement Analyses
Source: Debaig, Clemence, *Using Laban Movement Analysis to create a framework of interactions*;https://medium.com/@demzou.art

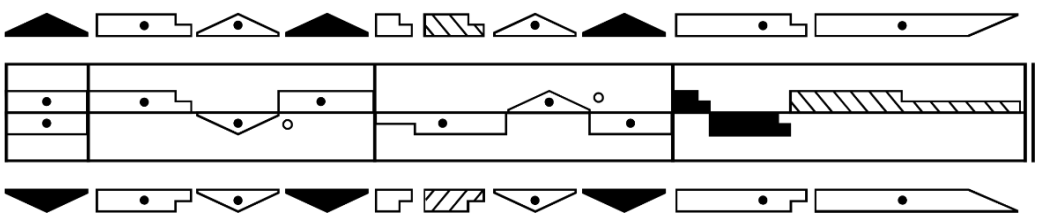

Fig. 2 Labanotation, example, graphic score
Source: https://commons.wikimedia.org/wiki/File:Labanotation.svg

Conclusions

For the past 60 years, the development of computer-generated choreography programs has grown exponentially. The beginning is inspired, above all, by the desire to document and write down existing choreographies, ie. facilitating that process. With the development of computer technology and advances in software development, achievements are being accelerated. Today we have programs which are supported by artificial intelligence, which support the movement, which through sensors and holograms create an interaction of artificial AlterBodies and physically present bodies.
The original idea was to create a tool that would help shorten the creation process in the studio, thus saving time and resources, a tool that would allow the choreographer to try out certain
situations and experiment, without involving other participants and to work more effectively in a studio, 'live' (in-person). Now, that idea has been developed to a much higher level, as state- of-the-art programs are used to determine motion and create body avatars that move and reproduce computer-generated motion. By creating the Global Digital Vocabulary of HighAlterBodies program, the development of computer-generated choreography will be elevated one level higher. Creating a dance is still a thought, but we are approaching the moment when a program will be created that can upgrade itself and 'think'.
Here, we can ask ourselves the question of the ethical justification of the development of such technology and its use, as well as the replacement of people with their digital AlterBody and HighAlterBody counterparts. The dilemma is philosophical, we wonder if such programs can completely replace the creativity that is born through the interaction of two living beings - the choreographer and the dancer. The 'artistic' dimension will be difficult to achieve until artificial intelligence reaches the peak of its development. This advancement of technology will completely change the understanding of Man and his environment, will develop and technologically overcome the social, anthropological segments of the social order. Dance, since ancient Greek times, is considered a free (perhaps the oldest) art. It was originally associated with the term 'expressive art', as opposed to 'constructive art', a term that Nietzsche [11] later defined as 'Dionysian' and 'Apollonian' art. It is a dualism that has permeated the definitions of artistic categories for centuries. Dance is considered a part of the fine arts, which has a universal language, with strong individual features. When talking about the future of dance and choreography and their connection to technology, as well as the development of computer programs, the advantage that dance has as a free, expressive, Dionysian art, becomes an obstacle, which in the future, through technology will have to be determined through the 'dose' of constructiveness it carries, which takes away expression, the main individual feature of contemporary dance and contemporary dance choreography. What started out as a need for a 'tool' to help document choreographic performances can take precedence and develop into a process that will completely replace the existing notion of artistic values and needs. The development of technology is unstoppable and necessary in many segments of modern life, because it facilitates and simplifies the daily process of existence. However, there is a dose of doubt, simply, here, today, we are not sure how technology will succeed in replacing the process of interaction between two human beings and the individuality of their expression in contemporary dance. And, the question is, if that succeeds, what will happen to Man and his creativity, what will happen to art?

References

[1] Jeanne Hays Beaman (1919 – 2020) was an American pioneer of computational choreography, creating the piece Random Dances in 1964 by using an IBM 7070 computer to select and order movement instructions from three lists. Her 1965 article, "Computer Dance", was widely cited by later practitioners, as was a 1968 exhibition of her process at the Institute of Contemporary Arts in London. In her early career she studied with Martha Graham and danced with the San Francisco Ballet; she was also Professor Emeritus at the University of Pittsburgh, where she taught from 1961-74.

[2] J. Beaman, “Computer Dance: Implications of the Dance,” Impulse: The Annual of Contemporary Dance, 1965, 27–28.

[3] A. Michael Noll (born 1939) is an American engineer, and professor emeritus at the Annenberg School for Communication and Journalism at the University of South
California. He was a very early pioneer in digital computer art and 3D animation and tactile communication.

[4] FRANCISCO SAGASTI is a professor at the Pacıfico Business School of the Universidad del Pacıfico and a senior researcher emeritus at FORO Nacional Internacional, Lima, Peru.

[5] Francisco Sagasti and William Page, “Computer Choreography: An Experiment on the Interaction between Dance and the Computer,” Computer Studies in the Humanities and Verbal Behavior 3 (January 1970): 46–49. This short-lived academic journal, printed by Mouton & Co. in The Hague, saw the publication of five volumes between 1968 and 1974.

[6] Benesh Movement Notation (BMN), also known as Benesh notation or choreology, is a dance notation system used to document dance and other types of human movement. Invented by Joan & Rudolf Benesh in the late 1940s, the system uses abstract symbols based on figurative representations of the human body. It is used in choreography & physical therapy and by the Royal Academy of Dance (UK) to teach ballet.

[7] Robert John Lansdown (1929 – 1999) was a British computer graphics pioneer.

[8] Analivia Cordeiro, “The Programming Choreographer,” Computer Graphics and Art Magazine (February 1977): 29, http://analivia.com.br/analivia-cordeiro- theprogramming-choreographer/.

[9] 60. Steve Sucato, “The Science Inside a Dance: What Can Choreography Do for Scientific Research? William Forsythe and Ohio State University Team Up to Find Out,” Dance Magazine, May 2009, 50.

[10] In the text below, when describing the software program, we will use this term to denote the end-product that we want to get.

[11] Friedrich Nietzsche, Die Geburt der Tragödie aus dem Geiste der Musik,
Publisher E. W. Fritzsch, 1872.