REVIEW

regarding the "Professor" competition in 5. "Technical Sciences", Professional Field 5.2 "Electrical Engineering, Electronics and Automation"
Scientific Specialty "Biomedical Engineering and Technologies",
Announced in the State Gazette, No. 102/23.12.2022,
for the needs of Faculty "Public Health",
Medical University "Prof. Dr. Paraskev Stoyanov", Varna
Candidate: Assoc. Prof. Eng. Kristina Stanimirova Bliznakova, PhD

Member of the Scientific Jury: Prof. Eng. Teodora Ivanova Bakardjieva, PhD
Varna Free University "Chernorizets Hrabar"
Computer Science Department
Professor in 4.6 "Informatics and Computer Science"

The present review was prepared on the basis of: (1) Documents received through a competition announced by MU "Prof. Dr. Paraskev Stoyanov" (SG, No. 102 of 23.12.2022 and on the website of the MU), (2) Order of the Rector of the Medical University to determine the composition of the scientific jury (No.: P-109-143 /23.02.2023) and (3) Minutes of the first meeting of the scientific jury held on 03.06.2023.

1. General overview of the presented materials and biographical data

From the submitted documents, it can be seen that Assoc. Prof. Eng. Kristina Bliznakova completed her master's Degree in 1996 at the Technical University-Varna, specailty "Electronic Technology and Microelectronics". In 1998, he completed a second master's degree in "Biomedical Technologies" at the University of Patras, Greece. She is currently completing his third master's degree in "Medical Radiation Physics and Technology" at the University of Plovdiv. She received her doctorate at the University of Patras, which was subsequently recognized at TU-Varna in 5.3 "Communication and Computer Engineering". She was appointed as an "Associate Professor" at TU-Varna in 2016, and since 2019 she has been an "Associate Professor" at the Medical University - Varna.

In the competition, the candidate submitted an Academic Reference for the publications, citations and scientific profiles:

Indicator A: 50 points (min. 50)
Indicator C: 143.84 points (min. 100)
Indicator G: 229.28 points (min. 200)
Indicator D: 170 points (min. 100)
Indicator E: 688 points (min. 200)

This includes:

• to cover the minimum scientometric indicators in **Group A**, a diploma for awarding "doctor" degree on the topic "Research, development and application of a software platform for modeling and simulations of X-ray images" is presented.

• to cover the minimum scientometric indicators in **Group C**, **11** peer-reviewed scientific publications in English, indexed in the international SCOPUS database, were selected, with **6** in **Q1, 4 in Q2, and 1 in Q4**;

• a total of **27** peer-reviewed scientific publications (26 in English, 1 in Bulgarian) and a published book chapter were selected to cover the minimum scientometric indicators in **Group G**, of which **16** are indexed in the international SCOPUS database;

• **5** scientific peer-reviewed publications indexed by SCOPUS are shown beyond the minimum requirements;
• to cover the minimum scientometric indicators in **Group D**, a reference was provided for **17** citations, entirely in scientific publications, referenced and indexed in databases with scientific information;
• to cover the minimum scientometric indicators in **Group E**, **8** research projects have been selected, 4 of which are under the leadership of Prof. Bliznakova.
The complete list of participations in national and international scientific and educational projects includes: 18 participations in national projects, 10 participations in international projects and 6 own projects.
Assoc. Prof. Bliznakova has a total of 147 reports in international and 38 reports in national scientific forums, and for the purposes of this competition, the results of scientific research are presented in 98 reports at scientific forums. She participated in the organization of 14 specialized workshops and seminars.
In the reference, scientometric indicators for occupying the academic position "associate professor" and acquiring the "doctor" degree are presented and implemented.

2. General characteristics of the candidate's scientific research and pedagogical activities

Assoc. Prof. Kristina Bliznakova is a good example of a university teacher, and her teaching activity can be divided into three periods. After completing her doctorate at the University of Patras, she led two master's courses from 2009 to 2012 at that university as well as at the National Technical University of Athens. Subsequently, he taught at the Technical University-Varna from 2013 to 2019, being a leading lecturer in the "Bachelor" and "Master" courses in "Discrete Structures", "Logic and Automata", "Basic Programming II" and "C Programming /C++/C#", "Electronic Circuit Analysis and Synthesis", "Computer Simulation in Electronics", "Biomedical Signal Processing" and "Object Oriented Programming Part 1". The third period in the teaching career of Associate Professor Bliznakova began with her admission to the Department of "Medical Equipment, Electronic and Information Technologies in HealthCare" at the Faculty of Public Health of the Medical University-Varna. She is a leading lecturer of bachelors and masters in the disciplines: "Radiological physics", "X-ray technology and other imaging techniques", "Programming in C++", "Programming", "Introduction to C/C++ programming" and "Applied Simulation Products in Health and Healthcare" and is part of the teaching teams of the disciplines "Digital Technologies for Health" and "Innovations and Technologies in Healthcare". Since 2015, Assoc. Prof. Bliznakova has been a lecturer within the European Training and Education for Medical Physics Experts Network and in Postgraduate Studies, and also develops editorial and reviewer activities.
In teaching, she shows precision, persistence and consistency.

3. Essence of the candidate's scientific achievements

Assoc. Prof. Kristina Bliznakova has published 141 scientific works up to the moment of the competition, of which 116 (107) are visible in Scopus (Web of Science), which have been cited

1062 (845) times according to Scopus (Web of Science). Her Hirsch index is 19 (17) according to Scopus (Web of Science).

Since 2000, she has been working on an extremely important and socially significant topic - computer modeling and simulations in the field of mammary gland imaging. Her main research activity is aimed at the improvement of the radiological computer model of the mammary gland and its application in the validation of two methods of obtaining X-ray images of the breast: digital mammography and tomosynthesis. It should be emphasized that the developed model is one of the three most famous computer models in the world: Predrag Bakic's model from 2002, Kristina Bliznakova's model from 2003 and Christian Graf's model from 2016. As a result of the accumulated expertise the candidate won a European scholarship "Marie Curie" and deepened her scientific research by expanding the direction of development: modeling and simulations of existing and new methods for screening and diagnosis of the mammary gland. With the development of a model of a new technology for mammary screening based on X-ray phase contrast of biological tissue models marks the next peak in his scientific career by developing computer models and a simulation platform for in-line phase contrast, a prerequisite for the establishment of a research laboratory on "Computer simulations in medicine" and the approval of the first Bulgarian Twinning project "MAXIMA: Three dimensional breast cancer models for x-ray imaging research", as well as a habilitation at the Technical University-Varna.

After 2016, the scientific achievements of the candidate are shaped in the direction of modeling, simulations and experimental testing and optimization of existing and new methods for screening and diagnosis of the mammary gland, and the results of each developed model and the corresponding simulation are validated, tested and optimized with experimental work, on specific prototype X-ray setups. In order to achieve higher accuracy and precision of research results, in the process of testing and optimizing the new methods, new more realistic models of the mammary gland and tumor formations have been developed, both in computer and in physical version. It is important to note that the experiments are carried out using 3D printers based on stereolithography technology (SLA-stereolithography) and those based on modeling with deposition of melted material (FDM - Fused Deposition Modelling).

Currently, the nature of the candidate's research is determined by three priorities:

New models and simulation platforms of breast screening and diagnostic methods: tomography, phase-contrast mammography and tomography;

New methods for the realization of computer and physical models of the mammary gland, intended for virtual clinical research, practical validation and testing of proposed methods of screening and diagnosis based on X-rays;

New methods for computer and physical models of mammary tumor lesions, including the study of the properties of materials for the production of these models, intended for virtual clinical studies, practical validation and testing of proposed methods of screening and diagnosis based on X-rays.

Publications from group B4 (11 articles in journals) are closely related to these three priorities and can be referred to two main issues: "New models and prototypes of methods and related techniques for screening and diagnosis of the mammary gland" and "Mammary models and tumor formations". The first research topic includes four directions: 3 D mammography with tomosynthesis, Computed tomography, Phase-contrast tomosynthesis in "in line" mode and Phase-contrast mammography with grids.

In the developments on the first research topic, as a result of experimental measurements, the creation of a modified algorithm for the implementation of mammary gland tomosynthesis, which can be used in clinical conditions with digital mammograms characterized by partial isocentric rotation, is shown. The second direction "Computed Tomography" the candidate developed together with the researchers at the University of Naples, using the BreastSimulator. The software package is the basis for the development of a new innovative software platform for virtual clinical studies that includes advanced anthropomorphic models of the mammary gland. The proposed method can be easily customized for a given system. New imaging techniques and methods associated with three-dimensional mammography add the necessary 3D information. Their optimization for mammary gland diagnostics in terms of scan geometry, X-ray source and detector parameters, reconstruction algorithm are best realized in Virtual Clinical Studies, for which anatomically and radiologically realistic computer and physical breast models are required.

The second research topic "Mammary gland models and tumor formations" includes three directions: Materials suitable for mammary gland phantoms, Computer models of the mammary gland and Physical models of the mammary gland. A method for determining the X-ray characteristics of candidate materials for breast tissue substitutes is proposed, and this method is based on monochromatic radiation passing through objects made of these materials. The linear absorption coefficient and refractive index of the materials for the different energies were evaluated for the first time. The method of least squares was used to determine the linear and mass attenuation coefficients of X-rays of a given energy for each material studied. The contribution is in the publication of data on 3D printing materials for use by other researchers, as well as established materials, including 3D printing, suitable for creating anthropomorphic radiological phantoms. It has been demonstrated for the first time that ABS (Acrylonitrile butadiene styrene) combined with resin-based materials is a good combination to realize a phantom suitable for phase-contrast studies, ABS being a good surrogate for adipose tissue, while resins well approximate phase glandular tissue effects. These experimentally obtained data are a powerful tool in the hands of biomedical engineers to create new physical anthropomorphic models of the mammary gland to design, test and optimize new diagnostic imaging methods. The region-growing algorithm for tumor segmentation from patient breast images obtained with clinical computed tomography and tomosynthesis was precisely validated by three radiologists: two from Bulgaria and one from Belgium. A MATLAB software tool was developed to support the implementation of the algorithm for a given patient image set. These newly generated entities are stored in the specialized MAXIMA database. Ready-

made models are widely used by researchers working in this field to test new methods and related techniques for breast screening and diagnosis, with or without compression. A completely new mathematical model has been introduced for the diffuse and irregularly shaped tumor entities and a new method has been proposed to create anatomically realistic computer models of the mammary gland by tissue segmentation from patient images of lesion-free breasts in collaboration with researchers from the University of Naples and San Diego, USA. The results of the application of the developed algorithm on 150 high-resolution patient images obtained on a specialized computed tomograph are described. As a result, the world's largest database of breast phantoms characterized by anatomical realism has been created.

4. Applicant Contributions

The scientific works of Assoc Prof. Kristina Bliznakova, as mentioned above, relate to two main issues: "New methods for computer modeling of the mammary gland" and "New methods for creating physical models (phantoms) of the mammary gland and tumor formations ' and within their frameworks the candidate's scientific, scientific-applied and applied contributions are developed.

I accept as:

Scientific contributions:

• development of a new method for creating an anthropomorphic computer model of a mammary gland for radiological purposes;

• creation of new methods for obtaining computer models of tumor formations with irregular shape and density, based on tomosynthesis and computer tomography of the breast and based on mathematical description;

• development of a new method for studying X-ray refractive indices of materials for 3D printing for the purpose of preparing physical models of the mammary gland for phase-contrast diagnostics;

• creation of a new algorithm for the implementation of mammary gland tomosynthesis;

• introducing a new technique for lung diagnostics using a dark field.

Scientific and applied contributions:

• construction of a new classification of anthropomorphic computer models of the mammary gland and tumor formations;

• increasing the research and innovation capacity of researchers from Bulgaria in the field of computer modeling of mammary gland tumors;

• creation of a new computer approach for researching the available 3D materials for the production of a four-component anthropomorphic mammary gland phantom;

• determining suitable materials for 3D printing to create anthropomorphic radiological phantoms;

• development of a new method based on an ink-jet printer for creating a physical radiological model of a mammary gland;

• creation of new physical radiological mammary phantoms without lesions created with 3D printers;

• development of a new method for printing 3D lesions for applications related to mammary gland imaging;

• development of new and validated methods for creating a physical radiological phantom of a mammary gland from patient images obtained with a specialized computer or magnetic resonance tomograph;

• creation of new methods and related techniques for phase-contrast mammary gland tomosynthesis;

• development of software platforms for virtual clinical research of new methods and related technologies for diagnosis and screening of the mammary gland;

• creation of a software platform for feature extraction from medical images.

Applied Contributions:

• creation of a unique database with models of mammary gland tumor formations with irregular shape and density;

• development of a methodology for printing physical radiological breast phantoms;

• building a web-based platform to support the subjective evaluation of research results related to mammary gland imaging;

• application of a new method and prototype of a device to support research on phase-contrast image diagnostics;

• design, implementation and use of an innovative stroke software platform;

• development of a model for the implementation of research projects during a pandemic;

• introduction of new, attractive methods for conducting training in the field of X-ray technology.

I believe that a measure of the high quality and original nature of the obtained results is the high impact factor of the journals in which the works were published (mainly in Q1 and Q2), the high number of citations in a relatively short time and the successful international projects under European grant schemes.

5. Significance of contributions for science and practice

At the Medical University-Varna, a lot of international projects were won and financed with the participation of Assoc. Prof. Bliznakova, which had a beneficial impact on the scientific achievements of the University and on the development of new interdisciplinary scientific trends. The projects are mainly under international grant schemes - H2020, FP7 EURATOM and Marie Curie Grants, as well as under national programs - National Innovation Fund, Scientific Research Fund, OP "Innovations and Competitiveness" and Fund "Science". The funds raised for projects managed by the candidate are over BGN 2 million.

Assoc. Prof. Bliznakova has a published patent application to the Bulgarian Patent Office: "Method and device for creating inhomogeneous anthropomorphic physical models suitable for X-ray

imaging" 111540/25.07.2013, as well as a recognized patent application from the Patent Office of the Republic of Greece: System and method of material identification and visualization using multi energy x-ray imaging, Published: 05.05.2016.

The impact of Assoc. Prof. Bliznakova's research is clearly evident from her achievements and the recognition she receives. This is evidenced by the presented documents for numerous prestigious awards. She has been awarded two "Varna" Awards of the Municipality of Varna, the "Pythagoras" Award of the Ministry of Education and Science, "Most successful coordinator of a project under the HORIZON 2020 program", 1st place in the contest of the "Marie Skłodowska-Curie Activities" (Marie Skłodowska -Curie Actions-MSCA) 2017 in the category "Contribution to a Better Society" and others.

6. Notes and recommendations

The documentation for the competition and the publications are presented according to the requirements and I have no comments on the works presented. I strongly recommend Assoc. Prof. Bliznakova to continue to attract young and motivated scientists to whom she can pass on her rich research experience.

7. Personal impressions of the reviewer about the candidate

I know Assoc. Prof. Christina Bliznakova in her capacity as a teacher at the Medical University, Varna. I have excellent impressions of her personal qualities as an enterprising teacher who applies innovative teaching methods that spark students' interest. She has many great merits for the development and implementation of numerous international scientific and technical projects that raise the prestige of the University.

CONCLUSION

The thorough review of the scientific works submitted for the procedure, the fundamental and scientific-applied contributions contained in them, their international significance, as well as the project activity, present the candidate as an established researcher in the field of biomedical engineering and technology. Assoc. Prof. Bliznakova's scientific assets exceed the minimum national requirements for holding the academic position of "Professor". The candidate is a distinguished scientist, a very good researcher and manager in science, as evidenced by the numerous scientific projects and publications.

In view of the above, I strongly recommend that the academic position of "Professor" be awarded to Assoc. Prof. Kristina Stanimirova Bliznakova in Professional Field 5.2 "Electrical Engineering, Electronics and Automation", specialty "Biomedical Engineering and Technologies" for the needs of Medical University-Varna.

11/04/2023

Reviewer: .....

(Prof. Eng. Teodora Bakardjieva, PhD)