

STATEMENT

regarding the competition for the academic position "Assoc. Prof. (docent)" in scientific field "5. Technical sciences", professional direction "5.2. Electrical engineering, electronics and automation", announced for the needs of the Institute of Biophysics and Biomedical Engineering (IBBE) at the Bulgarian Academy of Sciences (BAS) in State Gazette no. 69 of 16.08.2024, with candidate Dr. Todor Venkov Stoyanov, Assist. Prof. in the Department "Processing and analysis of biomedical signals and data", IBBE-BAS

Reviewer: Prof. Dr. Vasil Nikolov Kolev, Institute of Neurobiology, BAS

The competition for the academic position "associate professor" in the professional domain "Electrical engineering, electronics and automation" has been announced for the needs of the Department of "Processing and analysis of biomedical signals and data" at IBBE-BAS. The only candidate in the competition is Dr. Eng. Todor Stoyanov from the same department.

The review of the documents clearly shows that the procedures for disclosing and announcing the competition have been followed appropriately. The documents also have been prepared according to the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria, with the regulations for its application being published in the Official State Gazette, along with the subsequent regulations for its application from BAS and IBBE.

The total number of Dr. Todor Stoyanov's scientific publications submitted for the competition is 36, 8 of which are in journals with an impact factor, 13 – in journals with SJR rank, 15 – in other peer-reviewed journals. The appearance of publications in renowned international journals such as Medical and Biological Engineering and Computing, Physiological Measurement, Advances in Intelligent Systems and Computing, etc. is to be specifically emphasized. Evidence for over 300 citations of scientific works is also presented. For about 15 years, Dr. Stoyanov has participated in two international projects and 4 projects supported by the National Research Fund. Six innovation certificates from the company Schiller AG, Switzerland are presented. The candidate manifests teaching activities, encompassing the management of practical exercise sessions and the preparation of graduates from the Technical University - Sofia. The scientific activity of Dr. Stoyanov is reflected in the achieved high h-factor = 8 (calculated according to the Scopus).

The scientific and applied activities of the candidate essentially contribute to the field of biomedical engineering, which makes his achievements particularly significant and impressive. With regard to contribution to the theoretical domain, the development of methods and principles for recording heart activity in humans, as well as the study of intuitionistic fuzzy sets are to be particularly noted. Within the applied practical domain, the developments of specialized devices for recording and analyzing ECG signals and the development of specialized software merit consideration. All research and development issues are clinically oriented, which reinforces the importance of Dr. Stoyanov's scientific achievements in fundamental and applied science.

The candidate's contributions are the result of his activities in several scientific and applied areas and can be summarized as follows:

1. Development of prototype devices for recording, calibrating and testing ECG signals.

Particularly important is the development allowing the recording of ECG signals with high resolution, which was implemented as a prototype and a supporting software. No less important is the development of a device for recording ECG signals during intervention with high-voltage electrical impulses, e.g. during defibrillation. An important contribution is also the development of test devices and a new benchmark for checking digital electrocardiographs.

2. Development of methods for filtering ECG signals.

Low-pass filtering of ECG signals as a tool for cleaning physiological artifacts (e.g., EMG artifacts) is of particular importance for correct registration. The candidate's contribution is in the development and implementation of a specific filter allowing artifact suppression without affecting the useful components of the ECG signal.

When registering ECG signals it is also important to filter out mains interference (50-60 Hz). To this end, the candidate's contributions are in the development and implementation of adaptive methods for real-time mains interference suppression.

3. Detection of P-waves and segmentation of cardiac cycles.

Algorithms were developed and neural network models were investigated for segmentation of averaged P-QRS-T segments. The candidate substantially contributes to achieving high accuracy of P-wave detection.

4. Detection of cardiac arrhythmias.

Analysis and classification of ventricular complexes are particularly important for the development of methods and devices applied to completely characterize ECG signals. The candidate's activity aimed at the development of algorithms for the classification of ventricular complexes based on morphological parameters in normal ECG signals and in the presence of extrasystoles.

A special place in the research presented by Dr. Stoyanov is occupied by the analysis of ECG signals for the purposes of automatic external defibrillation. Here, there are several relevant contributions: the impact of electromagnetic disturbances on the performance of an algorithm for the detection of life-threatening arrhythmias has been studied in detail, which validates its application in the development of automatic external defibrillators of the Schiller AG company; the analysis of the same algorithm shows that it can be used successfully in the study of children; approaches have been developed to detect life-threatening arrhythmias based on short ECG segments; a high-accuracy defibrillation decision-making system has been developed; an algorithm for detection of cardiac rhythms requiring an immediate defibrillation shock during chest compression has been validated. All this research has found application in the development of automatic external defibrillators by the Schiller AG company.

The candidate's developments regarding the analysis of ECG signals for the detection of atrial fibrillation also represent an important line of scientific contribution. The developed

algorithm demonstrates high accuracy and allows its application in medical equipment construction.

A significant contribution has also been made to the development of methods for analyzing ECG signals to assess the degree of damage to the heart muscle, a matter of extreme theoretical and clinical importance.

5. Development of software for annotating ECG signals.

The candidate's software can be used to annotate large ECG databases, without limitation of the number of channels or the duration of recordings. Schiller Medical certified this software.

6. Research on intuitionistic fuzzy sets, intercriteria analysis and generalized networks – theory and applications in medicine.

The scientific contributions in this direction of research are both fundamental and applied. Among the fundamental ones, the extension of the theory of intuitionistic fuzzy networks can be highlighted, and among the applied ones - the discovery of non-linear relationships between criteria obtained in the analysis of ECG signals to detect cardiac arrhythmia and create models for the implementation of centers for remote medical care.

At the end of the presented extended reference, the candidate's plans for future work are described. The expressed intention to continue previous developments by using new methods for digital processing of biomedical signals, as well as to apply new theoretical developments based on deep and convolutional neural networks, is impressive.

Conclusion

The scientific activity of Assist. Prof. Dr. Todor Stoyanov is significant and is focused on investigating the characteristics of ECG signals oriented to the application in medical devices. The presented scientific works and developments characterize Dr. Stoyanov as a highly erudite professional and researcher. The high scientific qualities of the candidate are evidenced by the values of scientific indicators evaluating his research. Based on all of the above, I strongly recommend the scientific jury to choose Assist. Prof. Dr. Todor Stoyanov for the academic position "Associate Professor (Docent)" at the Institute of Biophysics and Biomedical Engineering - BAS.

21.11.2024

Reviewer:

