

## REVIEW

On a competition for the position "Associate Professor"  
in a professional field **5.2 "ELECTRICAL ENGINEERING, ELECTRONICS  
AND AUTOMATICS"**,  
specialty: "Application of the principles and methods of cybernetics in various fields  
of science (biomedicine)"  
published in State Gazette issue 69/16.08.2024  
with a candidate Todor Venkov Stoyanov, Assist. prof., PhD  
Reviewer: Ivo Tsvetanov Iliev, Prof., DSc., Dipl. Eng.

### **1. General characteristics of the presented materials**

The current competition for the academic position of "Professor" has been announced for the needs of the "Processing and Analysis of Biomedical Signals and Data" section at the IBPhBME-BAS. The only candidate who submitted documents and was allowed to participate is Assistant Professor Todor Venkov Stoyanov, Ph.D. The materials presented by him are in accordance with the Regulations for the Scientific Development of the Academic Staff of IBPhBME-BAS and the criteria for occupying the academic position "associate professor". All works are in the scientific field of the announced competition and have not been presented by the candidate in previous competitions for acquiring an educational and scientific degree and holding an academic position. According to the presented data, the total number of points for the scientometric indicators is 524.5 points (indicator A - 50 points, indicator B - 130.5 points, indicator D - 244 points, indicator D - 100 points), with 400 points required, according to the minimum requirements to occupy the academic position of "associate professor" and the regulations for the development of the academic staff of IBPhBME-BAN.

### **2. Education and professional career**

Todor Stoyanov obtained a master's degree in Electronics (specialization "Electronic Medical Device Construction") at the Faculty of Electronic Engineering and Technologies of the Technical University - Sofia. During the period 1999-2002 holds the position of "specialist" at the Central Laboratory of Biomedical Engineering-BAS. From 2002 to 2005 was an assistant at IBPhBME-BAN. Since September 2005, until now, he is assistant professor at the same institute. In 2005 defends a dissertation on the topic "Computer processing and analysis of electrocardiograms" and acquires the educational and scientific degree "Doctor" in the specialty "Automated systems for information processing and management in medicine".

### **3. General description of the presented materials**

In the competition for the academic position "Associate Professor", assistant professor Dr. Todor Stoyanov participated with 36 scientific works, distributed as follows:

- Articles in journals with an impact factor – 8 (total IF = 25.29);

- Articles in publications with SJR rank - 13;
- Articles in other peer-reviewed journals – 15.

From the total number of 36 scientific works, 2 are self-publications, and the remaining 34 are collective works, in 1 of which the candidate is the first author, in 5 the second, and in 5 the last.

The Scopus reference shows the number of citations after 2004 – 222 (without self-citations), of 21 materials and h-index 8.

A list of 6 scientific research projects is attached to the competition materials, of which 2 are international and 4 are financed by the National Scientific Research Fund. One of the international projects is with a leading company in the development of specialized medical equipment – Schiller (Switzerland), which has issued 6 certificates for implemented innovations.

The candidate's works reflect serious research and scientific-applied activity in terms of volume and quality and directly correspond to the scientific specialty of the competition. In the separate thematic areas, the emphasis on the analysis and processing of biomedical signals directly related to cardiac activity, as well as the design and implementation of hardware applications for recording and visualization of electrocardiographic signals, is clearly highlighted.

The candidate has participated in numerous scientific forums, both international and national.

#### **4. Assessment of the implementation of the minimum national requirements of the Law on the development of the academic staff in the Republic of Bulgaria (ZRASRB) for the relevant field and the additional requirements of IBPhBME-BAS**

With regard to the minimum national criteria, according to ZRASPB, Ass. prof. Todor Stoyanov has presented the following scientometric indicators summarized by groups as follows:

Indicator A: 50 points (required 50)

By indicator B: 130.5 points (required 100). Eleven scientific publications equivalent to a habilitation thesis, in issues that are referenced and indexed in world-renowned databases of scientific information (Web of Science, Scopus and/or the specific PN 5.2. Zentralblatt and IEEEXplore) are included.

By indicator D: 244 points (required 200). They are formed by 10 scientific publications in issues that are referenced and indexed in world-renowned databases of scientific information, and 15 in non-refereed peer-reviewed journals or in edited collective volumes.

By indicator D: 100 points (required 50). Points for this indicator are from 10 citations visible in Scopus, where it is evident that the candidate has more than 200 citations.



## **5. General characteristics of the candidate's research activity**

The scientific interests of Dr. Stoyanov, according to the presented scientific works, are focused in the following directions: (1) - Development of devices, including prototypes for registration, calibration and testing of electrocardiographic (ECG) devices; (2) - Development of methods for filtering ECG signals; (3) - Detection of P-waves and segmentation of cardiac cycles; (4) - Detection of cardiac arrhythmias; (5) - Development of software for annotating ECG signals; (6) - Intuitionistic fuzzy sets, intercriteria analysis and generalized networks – theory and applications in medicine.

## **6. Basic scientific and scientific-applied contributions**

*6.1. Scientific and scientific-applied contributions related to synthesis and application of new methods and algorithms for detection, analysis and treatment of life-threatening cardiac arrhythmias.*

Dr. Stoyanov has summarized his claims in this area in the following sections:

- Classification of chamber complexes;
- Analysis of ECG signals for the purposes of automatic external defibrillation;
- Analysis of ECG signals for detection of atrial fibrillation;

The largest in volume, and correspondingly with the most claims for contributions, is the field related to the detection, analysis and treatment of life-threatening cardiac arrhythmias. This is understandable, since the presented activities cover a rather long period of the candidate's career development. The presented results have been validated in 8 publications. This section highlights the applicant's contributions to the development, experimental research and refinement of the Shock Advisory System (SAS). Extremely important are the studies and the obtained results related to the compatibility of SAS with other resuscitation methods, such as indirect heart massage, as well as to eliminate interference from external sources falling within the spectrum of the analyzed ECG signal. All successful solutions are built into a new generation of automatic external defibrillators (AED) FRED EASY by Schiller Medical, France.

The second section covers the candidate's achievements related to the automatic analysis and classification of ventricular complexes and cardiac arrhythmias. The number of relevant publications is 3. The object of synthesis, research and verification are algorithms for the classification of chamber complexes based on morphological parameters. In the majority of studies, an approach of comparing the current form of cardiac contraction with a formed adaptive template, based on different morphological parameters of previous contractions, is applied.

In the third section, including five publications, results related to atrial fibrillation detection are summarized. Various approaches combining automated analysis methods with the use of multi-parameter intercriteria analysis, linear discriminant analysis and connected neural networks have been demonstrated to distinguish atrial fibrillation,



normal sinus rhythm and other types of arrhythmias, as well as to assess the risk of recurrence of atrial fibrillation after cardiac ablation.

The publications [B4.10, Д7.1, Д7.4, Д7.5, Д7.9, Д8.13] can also be referred to the mentioned sections, which present theoretical aspects of intuitionistic fuzzy sets and examples of intercriteria analysis and generalized networks. The applications in medicine are in the detection of non-linear relationships between criteria calculated during the processing of ECG signals for the purpose of detection of cardiac arrhythmias, as well as in creating models for the design and construction of centers for remote medical care.

### *6.2. Scientific and applied contributions related to synthesis and application of new methods for processing and analysis of ECG signals.*

This group includes published studies [G7.3, G8.14] and achieved results aimed at removing electromyographic noises by applying a filter based on the Savitzky–Golay approximation procedure with a dynamically changing cutoff frequency. The filter operates in pseudo-real time with some delay and provides: (1) - a low cut-off frequency (of the order of 14 Hz) in the null-line sections (PQ-, ST- and TP-segments) and low-amplitude P- and T-waves ; (2) - cutoff frequency is in the range of 20-30 Hz for high-amplitude P- and T-waves; and (3) - cutoff frequency above 100 Hz in the area of high-frequency QRS complexes. In this way, good suppression of EMG interference is ensured without affecting the useful components of the ECG signals.

In a series of publications [G7.7, G8.8, G8.11], new approaches for removing network interference in ECG signals are presented. The procedures applying: (1) - adaptive change of the sampling frequency, synchronously with the change of the network frequency, have quite good indicators; (2) - modification of the subtraction procedure using a sampling rate of 128 kHz, i.e. at an odd multiple of the network frequency; (3) - an adaptive filter, responding adequately to the current amplitude and frequency changes of the power line frequency.

From the point of view of the algorithms for automatic detection of rhythm and conduction disorders in cardiac activity, the contribution related to recognizing P-waves in the cardiogram and finding the beginnings and ends of P-waves, QRS-complexes and T-waves can be distinguished. [B4.11].

### *6.3. Applied contributions related to the creation of a new instrumentation and its application for registration, calibration and testing in the field of electrocardiography.*

This group of contributions includes the developed prototype of a 12-channel ECG module with high amplitude resolution (24 bits) and sampling frequency (32 kHz), as well as a prototype and software for recording 2-channel ECG and subsequent analysis of cardiac variability.

A system (DEFIMPULSE Recorder) has been developed to collect a database during and immediately after a defibrillation shock, in order to monitor the patient's condition and optimize the specific settings of the high-voltage pulses. It records high-intensity



voltage and current pulse sequences generated during a defibrillation shock, as well as long-term recording of ECG and high-frequency impedance.

It is known that electrocardiographic devices are one of the most frequently used diagnostic tools in medical practice. As medical devices, they are subject to a number of regulations and medical standards. A mandatory requirement is their periodic inspection and certification of their correct functionality, which is carried out by authorized bodies. Dr. Stoyanov participated in a team that developed a specialized tester for multi-channel ECG devices with a high sampling frequency and amplitude resolution in accordance with the requirements of the IEC 60601-2-47 standard and the international metrological recommendations OIML R 90.

### **7. Applicant's personal contribution**

Considering the publications and my impressions of the candidate's presentation at various scientific forums, I believe that his personal participation is essential in the contributions formulated in this way.

For the most part, the results of the research activity are directly related to the implementation of specific tasks, most often on contractual topics. The proof is the 6 certificates for implemented innovations from the Schiller Company.

### **8. The teaching activity of the candidate**

In the period 2000-2006 Ch. assistant Stoyanov has conducted exercises with masters from the specialty "Biomedical Engineering" at FEET, TU-Sofia. He was the supervisor of 5 graduates at TU-Sofia, FEET.

### **9. Critical comments and recommendations**

I have no significant comments on the submitted materials for participation in the competition. I believe that the contributions could more adequately represent the candidate's achievements if they were systematized and consolidated, bearing in mind the emphasis that unites them - software and hardware applications in the field of electrocardiography. I would also recommend the preparation of a monographic work, together with co-authors and colleagues in the scientific team, who have vast experience and have sufficiently significant achievements in this field.

### **10. Personal impressions and opinion of the reviewer**

I have good impressions of the scientific research activity and academic work of Ch. assistant Todor Stoyanov, for the entire period of his professional development. Over the years, he established himself as a specialist in the field of medical technology, with a marked interest in the development and practical application of innovative approaches and solutions. I can definitely say that together with his colleagues in the Biomedical Signal and Data Processing and Analysis section, they have strengthened the traditions

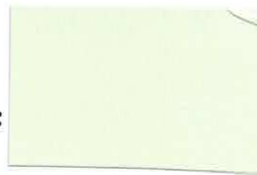
and international authority in the field of electrocardiographic signal analysis and processing. The achievements of this collective led to the creation of a new generation of defibrillators. Part of the research and successful implementations are the personal work of Eng. Todor Stoyanov

## CONCLUSION

The submitted materials for the competition provide an opportunity for an objective and multifaceted assessment of the candidate's qualities. Assist prof. Todor Stoyanov is a highly qualified and erudite specialist with national and international authority. The presented scientific works, in their predominant part, are aimed at solving current problems related to applications of the latest achievements in the field of information and communication technologies in health care. The requirements and criteria laid down in the normative provisions for occupying the academic position of "associate professor" have been fulfilled. This gives me reason to propose Dr. Eng. Todor Stoyanov, to obtain the academic position of "associate professor" in professional direction: 5.2 "ELECTRICAL ENGINEERING, ELECTRONICS AND AUTOMATICS", scientific specialty: "Application of the principles and methods of cybernetics in various fields of science (biomedicine)" for the needs of the section "Processing and analysis of biomedical signals and data" at IBPhBME-BAS.

**15 Nov. 2024**

**Reviewer:**



/Prof. Ivo Iliev, DSc/