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REVIEW

by competition for the occupation of an academic position "Ass. Professor" in the section "Sensors and measuring technologies in robotics and mechatronics" in professional direction 5.2. "Electrical engineering, electronics and automation", scientific specialty "Additive and inhomogeneous structures in sensors". The competition was announced in the "State Gazette", no. 64 of 30.07.2024

candidate: Martin Lachezarov Ralchev, Eng. Ph.D.

Reviewer: Prof. Dr. Eng. Nikola Vichev Kolev, Doctor of Sciences, member of the Jury, according to Order No. 81/01.10.2024 of the Director of the Institute of Robotics at the BAS.

1. General and biographical data

The candidate for the competition, Dr. Martin Ralchev, was born in 1995 and completed a bachelor's and master's course in electrical engineering at the Faculty of Electrical Engineering of the Technical University - Sofia. He works as a Assistant at the Institute of Robotics at the BAS. He was immediately enrolled in part-time doctoral studies at the Institute under the supervision of Prof. Dr. Eng. Sia Lozanova. Dr. Ralchev defended his dissertation on "Emission and sensory registration of microparticles in inhomogeneous structures under uniaxial deformations" and received the educational and scientific degree "doctor".

Over the years, Dr. Ralchev has been honored with a number of awards for his active participation in scientific projects of the institute, among them the EUREKA Foundation award for young scientist-inventor for the year 2023, the BAS award for the youngest scientist under 30 years old, a diploma of "Lachezar Tsotsorkov" foundation for a young entrepreneur .

Dr. Ralchev has 4 recognized invention patents and 4 published patent applications.

His total work experience in the specialty is 5 years, having qualified in: sensors and technologies, robotics and mechatronics, intelligent sensor-information architectures and electrical measuring instruments and technologies. There are participations in 3 scientific and educational projects under the line of the National Competence Center "QUAZAR"on "Quantum communication and intelligent systems for security and risk management" and "Personalized medicine and robotic surgery" and under the line of Euro QCI with a total value of BGN 57 million.

2. General description of the presented materials

The candidate in the competition for the academic position "Associate Professor" Dr. Ralchev submitted the following materials: an application to the Director of Research:

resume; copies of diploma for the educational and scientific degree "Doctor", certificate of internship; list of systematized 10 publications with the qualities of a monographic work, lists of scientific works in specialized scientific publications; separate copies of the scientific publications for participation in the competition; author reference for citations of his works; author reference for scientific and scientific-applied contributions; certificate of participation in scientific and educational projects; certificate of patents and certificate of compliance of the applicant's materials with the minimum requirements for candidates for the academic position of "Associate Professor", according to the Appendix from the PUZAD of the BAS.

3. General characteristics of the candidate's scientific research and applied scientific activity

The candidate in the competition, Dr. Ralchev, worked in the field of micro-sensorics and intelligent sensor-information systems.

He has submitted for review 33 scientific papers outside of dissertation publications. He has presented 10 publications with the qualities of a monographic work on the topic "Additive sensor systems with application in electrical engineering".

The achieved results and scientific contributions in these scientific publications are the result of Dr. Ralchev's work in three major research projects with European funding, implemented by a team of the Institute of Robotics with the participation of the candidate in the competition. The development and application of computer-based and robotic technologies in industry, medicine and biology determine their increasingly widespread application. These technologies not only transform manufacturing, but play a key role in advancing measurement and analysis methods. Improving accuracy is essential to increasing the efficiency of process systems. One example of such refinement is harmonic spectrum filtering, which is applied to improve current sensor measurements. These additive technologies allow for more precise signal processing to correct the harmonic distortions they contain. Thus, a significant increase in accuracy and data quality is achieved, which is essential for the reliable operation of sensor systems in their various applications. In recent years, the harmonic spectrum filtering method has been successfully applied in a number of scientific and engineering projects, an example of which is the harmonic spectrum analysis of current sensors, resulting in significant improvements in accuracy and reliability. In addition, rotational flow modulation was applied, which further expanded the control and optimization capabilities of these systems. This includes remote monitoring of load transformer switching processes based on acoustic measurement, which is a new monitoring solution. The development of additive sensors (multisensors) for simultaneous and independent

measurement of the three components of the magnetic field provides new opportunities for a more detailed and precise study of magnetic phenomena in electrotechnical devices. Magnetic flux patterns in 3D-printed atmospheric CO2 absorption devices have also been refined, thereby increasing their efficiency. One of the key results in this field is the development of a device for measuring the mobility of current carriers in semiconductors, which is widely used in modern microelectronics and materials science. In addition, the new class of 2D and 3D vector magnetometers based on the Hall effect provide opportunities to study the structure of magnetic fields and their influence on various materials. Other innovations such as paired Hall sensor, magnetotransistor sensor transducers, magnetic navigation systems in robotic surgery, etc. also contribute to raising measurement technologies to a higher level based on additive sensing phenomena. The idea described above defines the possibilities for achieving new scientific and applied scientific results, systematized in the form of publications with monograph qualities.

Separately, Dr. Ralchev has presented a list of 23 scientific works outside the 10 publications, of which 16 are registered in the world databases and a list of 4 invention patents and 4 published patent applications. The results of the scientific works other than those with the qualities of a monograph are in the field of inhomogeneous sensor structures and have been achieved in the work on European projects implemented in the National Competence Center and on the Bulgarian National Plan for Quantum Communication Infrastructure at the Institute of Robotics. The methodical and engineering solutions are patented as inventions, as the proposed innovations allow the creation of new structures of means of control, as well as for early detection of the folding of tectonic plates and the dynamics of faults, the displacement of rock massifs, etc. The action of particle generation in inhomogeneous systems is easily automated for robotic systems with artificial intelligence elements and the protection of critical infrastructure sites. These studies are aimed at predicting earthquake processes. For the purposes of magnetic field metrology, new inhomogeneous sensor systems and technologies have been developed and investigated, which expand the possibilities of measuring magnetic and electrical characteristics in complex conditions. Practically oriented examples are research related to the application of bipolar transistors and related to information about inhomogeneous and highly divergent magnetic fields, as well as Hall microsensors for determining the in-plane X and Y components of the magnetic vector. Based on them, original modulator systems containing multi-purpose permanent magnets were constructed. The used Hall elements are suitable for multidimensional magnetometry, as their sensitivity increases sharply at cryogenic temperatures. The action of particle generation in

inhomogeneous systems is easily automated for robotic systems with artificial intelligence elements and the protection of critical infrastructure sites. The scientific and applied results of these developments can be summarized and cover and build upon various aspects of electrical engineering, robotics and measurement technologies, with each category including purpose-specific publications. Implemented in electrical engineering are IoT technologies for remote monitoring and control of various electrical parameters. A characteristic example is the study of electrical discharges in real time, which significantly increases the efficiency and reliability of metrology in such complex and inhomogeneous systems.

Dr. Ralchev's scientific works have been published in magazines: "Compte Rendus de l, ,Academie", in the scientific editions of international conferences "Proceedings of the IEEE and Electronics" and others. In the list of citations according to the procedure, 28 citations of the candidate's publications by scientists from the country and abroad (China, Germany, Austria, Russia, Brazil, India, etc.) are noted.

The complex nature of the developments with which Dr. Ralchev participated in the competition forced him to work in a team, and therefore his works and patents are collective.

The scientometric report on the candidate's activities in the competition shows that with a minimum requirement of 400 points for an associate professor at the BAS, Dr. Ralchev has exceeded the required minimum points for all positions (a total of 1027.8 points).

The review of the documents of the candidate, Dr. Ralchev, shows that the procedural and legal requirements arising from the ZRASRB (Art. 29, para. 1), the Regulations thereto (Art. 60) and the Regulations on the terms and conditions for occupying academic positions at the Institute of Robotics at the BAS have been fulfilled.

4. Basic scientific and scientific-applied contributions

I will present in a systematized manner the candidate's contributions to the competition, which are of a scientific and scientific-applied nature.

First, the contributing elements of the scientific works that are included in the list of scientific works with the qualities of a monographic work will be examined and evaluated. All 10 scientific papers are in scientific journals with an Impact factor or Scopus, referenced and indexed in the global rating system.

1. An additive method for filtering the harmonic spectrum of current sensors has been developed, which significantly improves the accuracy of measurements by identifying and correcting harmonic distortions. (publications: B4-1, B4-2 and B4-3);

2. A new technology has been proposed for creating a prototype of rotary flux-modulator systems, which allows an accelerated process of design, testing and

implementation of new systems for controlling electric motors and generators, significantly shortening the time for innovative solutions in electrical engineering. (publication: B4-4, G7-14, G7-15 and G7-16);

3. A system for remote monitoring of transformer switching processes has been created, based on additive acoustic sensors, which technology allows to monitor the state of transformers in real time, increasing the reliability of power distribution networks and reducing the risk of malfunctions and accidents. (publication: B4-5);

4. An additive silicon sensor (multisensor) was created, measuring simultaneously and independently the three components (XYZ) of the magnetic field, and this component increases the accuracy when studying magnetic fields with complex topology, which is important for the optimization of many electromagnetic applications. (pub.: B4-6);

5. A model was developed and tested for the simulation of fluid flow in 3D printing devices for CO2 absorption, which leads to the optimization of additive systems and significantly reduces carbon emissions. (publication: B4-7);

6. Innovative Hall methods for measuring the mobility of current carriers in semiconductor wafers for the purposes of microelectronics based on three-contact Hall elements have been created and verified, which improves control capabilities in the semiconductor industry. (publications: B4-8, B4-9 and B4-10);

The scientific and applied contributions in the publications under indicators "G7" and "G8" cover various aspects of robotics and measurement technologies, as follows:.

1. Methods for measuring and analyzing electrical discharges have been developed, based on which they are proposed for monitoring electrical discharges using acoustic spectra in inhomogeneous systems. The acoustic spectrum of electric arcs is analyzed and their use for estimating the power of the electric discharge is proposed. (publications: G7-1, 3, 4, 5, 10);

2. Sensor systems and devices for the purposes of magnetic field metrology have been improved, and new inhomogeneous sensor systems and technologies have been developed that expand the possibilities of measuring magnetic and electrical characteristics, and on their basis, original modulator systems containing permanent magnets with multifunctional purpose. (publications: G7-2, G8-2, 3, 4, 5);

3. IoT technologies have been implemented in electrical engineering for remote monitoring and control of various electrical parameters, achieved with the integration of IoT technologies in measurement systems. (publications:G7-4, G8-1);

4. Methods for control and optimization of processes in 3D printing have been developed and tested, the mechanisms of thread feeding and solidification of the body materials have been analyzed, and gas diffusion monitoring cameras have been developed. (publications: G7-6, 7, 8, 12, 13);

5. New sensor methods and devices for registering seismic activity have been proposed, and this class of devices is based on the experimentally established regularity in inhomogeneous systems - rocks and concrete, resulting in the generation of micro- and nano-particles under the influence of high uniaxial deformations. (publications: G7-9, 11; G8-2, 3, 4, 6, 7);

5. Significance of contributions for science and practice

The significance of the created sensors, methods and devices is indisputable, because completed technical developments are offered, some of which have been approved for patents and implemented in practice in fulfillment of scientific projects and contracts.

The works of the candidate in the competition are prepared qualitatively, with a broad literary justification, an analytical part and a conclusion.

6Critical notes and recommendations

1. The author reference for contributions with publications and patents is verbose.

2. I recommend that Dr. Ralchev prepare and publish a monograph based on the accepted developments, so that they find wider recognition.

7. Personal impressions and opinion of the reviewer

I know Dr. Ralchev from my participation as a reviewer in the defense of his dissertation. I was impressed by the thorough knowledge of the processes he had researched to prove his theses.

I positively assess the results of Dr. Ralchev's developments, included in the scientific publications and patents with which the candidate participated in the competition, as well as the knowledge and experience gained at the Institute of Robotics at the BAS.

I note that the candidate in the competition has not proven plagiarism in scientific works in accordance with the statutory procedure (Art. 24, para. 5 of the ZRASRB).

I have no publications in common with Dr. Ralchev and I am not a person related to him in the sense of paragraph 1, item 5 of the Supplementary Regulations of the ZRASRB.

CONCLUSION

Based on familiarization with the competition materials presented by the candidate in the competition (biography, scientific works, patents, participation in projects and contracts, their significance, the scientific and scientific-applied

contributions contained in them), I find it reasonable to give a positive assessment and to propose to the Scientific Jury to make a positive decision on the election of Dr. Eng. Martin Lachezarov Ralchev as an associate professor, and to propose to the Scientific Council of the Institute of Robotics that he be elected to the academic position of "associate professor" by professional direction 5.2. "Electrical engineering, electronics and automation", scientific specialty "Adaptive and inhomogeneous structures in sensors" in the section "Sensors and measuring technologies in robotics and mechatronics".

Sofia
20.10.2024

Reviewer: Prof. Dr. Eng. Nikola V. Kolev, Dr. Sci