REVIEW

in a competition for an academic position

" Professor "

in a professional direction 4.6. Informatics and Computer Sciences " (Computer modeling by CAD systems with application in mechatronics and robotics)",

for the needs of Sofia University "St. Kliment Ohridski ”(SU),

Faculty of Mathematics and Informatics (FMI),

Announced in SG no. 20 of 08.03.2024 and on the websites of FMI and Sofia University

The review was prepared by: Prof. Dr. George Vencislavov Boiadjiev - FMI, Sofia University, 4.5. Mathematics, "Mathematics, theoretical mechanics and robotics", in my capacity as a member of the scientific jury of the competition according to Order № RD-38-203 / 30.04.2024 of the Rector of Sofia University

Only a candidate has submitted documents for participation in the announced competition:

Associated Professor Dr. Ivan Nikolov Chavdarov

Faculty of Mathematics and Informatics, Sofia University “St. Kliment Ohridski ”

I. General description of the presented materials.

1. Details of the application.

The documents submitted by the competition by the candidate comply with the requirements of ZRASRB, PPZRASRB and the Regulations on the terms and conditions for acquiring scientific degrees and holding academic positions at Sofia University "St. Kliment Ohridski ” (PURPNSZADSU).

For participation in the competition the candidate **Associated Professor Dr. Ivan Nikolov Chavdarov** presented a list of a total of 16 titles which are all publications in Bulgarian and foreign scientific journals and scientific forums. Of them, 5 are according to indicator B4: Habilitation work - scientific publications in publications that are referenced and indexed in world-famous databases with scientific information (Web of Science and Scopus), 9 - according to indicator D7: Scientific publications in publications that are referenced and indexed in world-renowned databases with scientific information (Web of Science and Scopus), outside of the habilitation work. Two patents are also presented, one of which is independent, and in the second the candidate is the first author. He has received awards related to his inventive activity, including "Diploma and Golden Statuette - SIB Inventor of 2017."

2. Details of the candidate.

Dr. Ivan Chavdarov graduated from TU-Sofia (1991), majoring in mechanical engineering. There he completed a regular post-graduate specialization in "Robotics" (1992-1993). He was a research assistant at the Bulgarian Academy of Sciences with respectively in the periods (1995-1997 and 1998-2002) - III degree, meanwhile he worked as a specialist mechanic at "Steel Pipes" - EAD, Septemvri. He became a research associate II degree (2004), and in 2006 - a "doctor" in the scientific specialty "Robots and Manipulators" and in the same year he was promoted to a research assistant I degree. He became habilitated in 2008 as a senior research associate II degree (associate professor), approved by the SAC of the Republic of Bulgaria. In 2011, he became an associate professor at the Institute of Systems Engineering and Robotics - BAS, REMIS section, Sofia. In 2015, he held the position of scientific secretary of the Institute of Systems Engineering and Robotics - BAS. From 2017 until now, he is an associate professor at Sofia University "Kliment Ohridski", FMI, Department of Mechatronics, Robotics and Mechanics.

He is a co-author (first author) of a robot design guide. Since 2004, he has been a part-time teacher at the Technical University - Sofia, leading exercises and lectures in the disciplines: "Robot Design and Robotic Systems", "Robotic Technologies and Systems", "Robotics" and "Synthesis, Kinematics and Dynamics of Robots". He managed the "Robo-Academy" project for working with young talents, financed by the BAS. The classes are conducted with students from the Sofia Mathematical High School "Paisiy Hilendarski", the Sofia Vocational High School for Electronics "John Atanasov" and the Vocational High School for Computer Technologies and Systems in the city of Pravets.

His qualifications include professional knowledge and work with AutoCAD, SOLIDWORKS, Mechanical Desktop, Visual LISP, MatLAB, MatCAD, etc.

He participated in more than 10 scientific and scientific applied projects, including international ones (with the University of Stavanger, Norway; Instituto Gerontologico, Matia, Spain, Future and Emerging Technologies under the 7th framework program; project cooperation between the Bulgarian and Russian Academies of Sciences, etc.). He participated in the design of the manipulation system FEEDMAT 1 and FEEDMAT 2 for dosing and filling with molten metal of machines for horizontal casting of aluminum alloys with the manufacturer Bulgarian-German company "SPESIMA" GMBH. He independently designed a robot manipulation system "F3" with 3 independently controlled axes for dosing and charging with molten metal on machines for horizontal pressure casting with the manufacturer of the same company.

He is a member of the Bulgarian Robotics Society. He has two certificates of honor from the Bulgarian Chamber of Commerce and a gold plaque from the Union of Inventors in Bulgaria.

3. General characteristics of the scientific works and achievements of the candidate.

In the publications submitted for participation in the competition, the candidate is the first author in 7 of them, in 2 he is the second author, in 4 articles he is the third author and in 1 article he is the fourth author. No evidence of individual contribution is presented in collective works, so the reviewer assumes that the contributions are equal, although the works where the applicant is the first author suggest his leading participation. But it should be mentioned that the total number of the candidate's scientific publications to date is 100, of which 1 monograph, 2 teaching aids and 8 issued invention patents. Of these, 38 publications are referenced and indexed in Web of Science and Scopus. Of all publications in publications with an impact factor (WoS) there are 13, with an impact rank (SJR, Scopus) there are 24. The articles are cited 149 times. Of these, citations in articles indexed in Web of Science and Scopus are 62, which is impressive.

The achievements (in a professional sense) of the candidate can also include the leadership of 3 national projects that have ended, one of them with the Scientific Research Fund of the Ministry of Education and Science. He participated in the teams of 6 international and national projects.

There is no legally proven plagiarism in the scientific papers submitted at the competition.

4. Characteristics and evaluation of the candidate's teaching activity.

The candidate has extensive teaching experience. He gave lectures and led exercises at FMI and Faculty of Biology of SU in the educational and qualification degrees of bachelor and master (mandatory and elective courses) - lectures on "Mathematics", Faculty of Biology of SU, bachelors; lectures and exercises on: "Kinematics" - FMI, masters; "Robot modeling with a 3D printer" - FMI, masters; "Movement planning in a complex environment" - FMI, masters; "Designing mechanical components of robots with CAD systems" - FMI, masters; "3D modeling, printing and applications in robotics" - FMI, bachelors; "Programming in a CAD environment and applications in robotics" - FMI, bachelors. For the courses, lecture notes are prepared and constantly updated for the students, which are provided to them in the electronic environment "moodle" of the faculty. In the period from 2017 until now, he has conducted training for foreign students under the Erasmus program who visited the FMI of the SU on the basis of bilateral agreements. The courses are on the following topics: "Kinematics", "Planning of motion in complex environment", "Robot modeling using 3D printing technology". The lectures and exercises prepared by him are clear and logical, which helps to better understand the taught material. His auditory employment during all the academic years in which he has been teaching so far always exceeds - and to a considerable extent, the established standards for academic workload, which is evident from the submitted and approved personal reports for the respective semesters. Assoc. Prof. Ivan Chavdarov is the supervisor of the master's theses of five successfully defended diploma students; he supervised two successfully defended doctoral students, and is currently the supervisor of two part-time doctoral students.

5. Content analysis of the candidate's scientific and scientific-applied achievements contained in the materials for participation in the competition.

The candidate's scientific and scientific-applied contributions can generally be grouped into the following topics:

(1) Informatics and Computer Modeling by CAD Systems of Mobile Robots (Research, Control Planning and Modeling of a New Walking Robot Based on the Minimalistic Principle). This subject matter is covered in articles numbered [1] to [5], article [8] and patent 16 according to the attached list.

(2) Informatics and computer modeling of stationary robots. This includes new kinematics methods and algorithms for stationary robots with consideration of joint constraints, as well as types of solutions to the inverse kinematics problem and the presence of obstacles in the work area. This topic is reflected in articles numbered [11], [12], [13] and [14].

(3) Applications of informatics and computer modeling in mechatronics and medicine (CAD modeling of 3D printed robotic humanoid arm; robotic bone drilling). This subject is covered in papers numbered [7], [9], [10] and patent 15.

In the first topic, the following scientific contributions can be highlighted: the creation of a method for optimizing the main dimensions of a walking robot in order to reduce energy losses when moving on flat terrain and overcoming higher obstacles (publications [2], [3] and [4]). A standardized space has been introduced for the basic dimensions of the robot, with a defined area within it where its functioning is possible. An advantage of the proposed normed space-based method is that it is conveniently applied to robots with the same structure but different scale sizes. The proposed approaches for size optimization to reduce energy losses and experimental determination of the momentary center of velocities are applicable to other walking robots. New methods and models have been developed for controlling the gait of a walking robot based on the sensory information combined with its movements (publications [1] and [5]). A walking cycle optimization model and control algorithms for a walking robot named “Big Foot” equipped with various types of sensors were created. Two laws of motion have been proposed and investigated: sinusoidal and polynomial. A method is proposed to combine the control of the motors and the reading of information from sensors located at the base of the robot, which allows it to explore and scan irregularities in the terrain.

Scientific-applied contributions include:

design and creation of a walking robot prototype based on a minimalist principle (publications [2], [3] , [4], patent 16 and project 1). A walking robot with a minimal number of motors was constructed; a CAD model and a prototype were created using a 3D printer. The robot has only two independently driven mechanisms and a small number of moving parts. It moves by walking, turns in place, can go forward or backward from a place, overcomes obstacles and slopes, can climb stairs

according to his size, has some passive adaptability to obstacles. The method for optimizing the main dimensions of a walking robot has been experimentally validated (publications [2], [3] and [4]). The static stability of the "Big Foot" robot and its ability to overcome obstacles were analyzed using simulation CAD software. Simulation and experiments on obstacle overcoming by a 3D printed model of the robot "Big Foot" are presented. The phases of walking and the stages of overcoming an obstacle are described. Theoretical and experimental results are compared. Experiments were performed to overcome a vertical obstacle with the 3D printed model. The results of the experiments are presented graphically, comparing them with a base model. A dimensionless index is introduced to compare the height of the obstacle overcome and the dimensions of the robot. The index allows to objectively comparing the possibilities of overcoming obstacles between different types of mobile robots.

The scientific-applied contributions also include the creation of algorithms and conducting experiments for controlling the movements of a walking robot with the aim of reducing shock loads during its movement on flat terrain and researching irregularities (publication [1], project 4), such as the implementation of the laws of motion is ensured by the use of a PD controller receiving data from encoders and tactile sensors. In addition, an algorithm was created to combine the control of the motors and the reading of information from sensors located at the base of the robot (publication [1]). In publication [8] and projects 2 and 3, the application of the walking robot "Big Foot" in the education and rehabilitation of children with specific needs is presented.

As the main scientific contributions related to the second topic, the creation of a new method for solving the inverse problem of kinematics for robots with an open structure, dividing the solutions by types (publications [11] and [14]), as well as creating of methods and algorithms for robot movement in an obstacle environment taking into account joint constraints and different types of solutions to the inverse kinematics problem (publications [11], [13] and [14]). The algorithm developed in [11] allows finding solutions for a wide range of robots by using a geometric approach representing points in a polar coordinate system. Areas are generated in the working and configuration areas space that are available with different types of solutions. An application of the method for a planar robot with additional degrees of freedom is shown in [14]. In [13], a new obstacle-avoidance motion planning method for planar robots with additional degrees of freedom considering joint constraints is considered. Kinematics is analyzed and different types of inverse kinematic solutions are defined - [11] and [13]. A numerical approach is proposed to find the specific points where the robot can change its solution type in the sense when the robot has to perform a movement that passes through different areas of the workspace. In [14], the zones in the robot's workspace where it can change the orientation of its executive unit without changing its current position, and also the zones where this is impossible, are studied.

The main scientific-applied contributions related to the second topic are characterized by a 3D printed robot prototype with additional degrees of freedom for practical research of the results achieved in the scientific contributions on the second topic, as well as its application in education (publications [11], [12], [13], [14], projects 1 and 4). In [12], a new approach is proposed for deriving the equations of motion and determining the torques of the motors of a robotic arm with an arbitrary number of joints. The proposed approach to obtain the dynamic model in closed form uses graph theory and the principle of orthogonality, which are based on the law of conservation of energy. Furthermore, a program working in CAD environment for solving the inverse problem of kinematics for a robot with additional degrees of freedom (publication [11]) should be mentioned, which uses the graphical capabilities of AutoCAD and presents obstacles, zones and trajectories in the configuration and robot workspace.

The third topic includes the following scientific-applied contributions: creation of a 3D printed humanoid robotic arm built on a modular principle (publications [9], [10] and patent 15); development of an algorithm for determining the main kinematic characteristics of a humanoid hand finger [9]; study of a computer-brain interface with fast setup and minimal learning phase, proposing a new way of decoding signals - [6]; a way to control the feed rate during different stages of the bone drilling process using an orthopedic robot (ODRO) - [7]. A brief description of the listed contributions accordingly includes the following. The first presents an approach to develop mechanical and control systems of a humanoid 3D-printed hand with fingers based on a modular principle. What is new here is creating the 3D printed fingers as a single assembled component and embedding actuators and controls, making it a complete independent unit. This allows the application of the same software for active components to be use in finger modules with different individual sizes and joint limitations. The mechanical and control system of the arm was developed and a working prototype was created. The communication of the modules with the developed software is described and the force each finger can exert during flexion is measured. The second contribution is essentially an algorithm to determine the workspace and the manipulability factor for the fingers. The results are presented graphically. Statistical averages of finger sizes and joint constraints were used. The third is characterized by a new way of decoding the signals. Abrupt changes of current electroencephalographic (EEG) frequency power synchronization or desynchronization are considered. The feasibility of the proposed system has been proven through real experiments. The last contribution specifically represents the synthesis of an algorithm to minimize the time of bone drilling for implant placement; elimination of slippage and bending of the drill bit at the first and second (far) cortex; improving the accuracy of drilling, which ultimately increases the quality of manipulation and patient safety.

6. Critical remarks and recommendations.

I have no critical remarks regarding the peer-reviewed works of the candidate. In them the statement of the task is clearly formulated, the results are summarized as a result of in-depth analysis, proving their completeness.

The exposition is convincing, which shows the good methodological level of the respective publication, and last but not least the quality and completeness of the cited literature, which testifies to the literary awareness of the author.

Further evidence of the lack of critical notes on peer-reviewed papers is the fact that almost all of them have been published in peer-reviewed and indexed international journals and conferences, including impact factor or SJR.

As a recommendation to the candidate, it would be good in his future publications to study in more detail the problems of the dynamics of robots, which is important from the point of view of their control.

7. Personal impressions of the candidate.

I have known Dr. Ivan Chavdarov for almost 17 years. He has always been distinguished by exceptional professionalism in his work, up to pedantry - in the good sense. Always serious and extremely responsible in carrying out his tasks. Has the mindset of an inventor, generates new ideas, but also has the ability to work well in a team.

Dr. Ivan Chavdarov is an established scientist with impressive scientific and applied contributions, which are entirely in the field of robotics. He has extensive teaching experience not only with students, but also with school students, the specificity of which proves his pedagogical skills. He has patents, for which he was awarded with certificates of honor and a gold plaque from the Bulgarian Chamber of Commerce and the Union of the inventors in Bulgaria. His professional qualification fully corresponds to the theme of the announced competition - "(Computer modeling by CAD systems with application in mechatronics and robotics)", respectively and to the needs of the department that announced it.

8. Conclusion on the application.

After getting acquainted with the materials and scientific works presented in the competition and on the basis of the analysis of their significance and the scientific and scientific-applied contributions contained in them, **I confirm** that the scientific achievements meet the requirements of ZRASRB, the Regulations for its application and the respective Regulations of Sofia University "St. Kliment Ohridski" for holding the candidate for the academic position "Professor" in the scientific field and professional direction of the competition.

In particular, the candidate satisfies the minimum national requirements in the professional field and no plagiarism has been established in the scientific papers submitted at the competition.

I give my **positive** assessment to the application.

II. OVERALL CONCLUSION.

Based on the above, **I recommend** the scientific jury to propose to the competent authority for the selection of the Faculty of Mathematics and Informatics at Sofia University "St. Kliment Ohridski" to elect **Associated Professor Dr. Ivan Nikolov Chavdarov** to take the academic position of "Professor" in the professional field **4.6. Informatics and Computer Sciences "(Computer modeling by CAD systems with application in mechatronics and robotics)**".

20.06. 2024

Prepared by the review: Prof. Dr. George Boiadjiev
(academic position, scientific degree, name, surname)