

OPINION

by **Prof. Evdokia Nikolaeva Sotirova, PhD,**
Burgas State University "Prof. Dr. Assen Zlatarov"

on a dissertation submitted for the award of the scientific degree
Doctor of Sciences (D.Sc.)

Title: **Metaheuristic Algorithms for Nonlinear Dynamic System Identification**

in Higher Education Area 4. Natural Sciences, Mathematics and Informatics,

Professional Field 4.6. Informatics and Computer Science,

Author: **Prof. Olympia Nikolaeva Roeva, PhD, Eng.**

1. General presentation of the procedure and the candidate

This opinion has been prepared pursuant to Order No. RD-560 of 5 June 2026, issued by the Director of the Institute of Biophysics and Biomedical Engineering (IBPhBME), Bulgarian Academy of Sciences (BAS), Prof. Tanya Pencheva, appointing the members of the Scientific Jury for the procedure for the defence of the dissertation entitled "Metaheuristic Algorithms for Nonlinear Dynamic System Identification", submitted by Prof. Olympia Nikolaeva Roeva, PhD, Eng., for the award of the scientific degree "Doctor of Sciences (D.Sc.)" in Higher Education Area 4. Natural Sciences, Mathematics and Informatics, Professional Field 4.6. Informatics and Computer Science. The dissertation was discussed and approved for defence at an extended scientific seminar of the "Bioinformatics and Mathematical Modelling" Department of IBPhBME-BAS held on 28 April 2026.

The materials submitted by Prof. Olympia Nikolaeva Roeva, PhD, Eng., are carefully organized and comply with the Regulations for the Implementation of the Act on the Development of the Academic Staff in the Republic of Bulgaria at IBPhBME-BAS.

2. General characteristics and relevance of the dissertation

The dissertation is focused on the study, development, and application of metaheuristic and hybrid metaheuristic algorithms for the identification of nonlinear dynamic systems, with applications to bioprocess modelling and control. Given the limitations of classical methods in solving complex, nonlinear, and multimodal optimization problems, I consider the topic to be highly relevant. Prof. Roeva investigates the possibilities for combining different metaheuristic algorithms in order to obtain more stable and efficient solutions. The proposed algorithms have been validated in the parameter identification of nonlinear models and in the tuning of PID controllers. This demonstrates that the work has not only scientific but also practical relevance.

3. Evaluation of the scientific content, methodology, and achieved results

The dissertation investigates ten metaheuristic algorithms and provides a comparative analysis of their behaviour and performance. Benchmark functions, real experimental data, statistical methods, and the InterCriteria Analysis method are used to evaluate the results. This allows the proposed approaches to be assessed from different perspectives and provides a sound basis for comparison.

As a result of the conducted research, five hybrid metaheuristic algorithms have been developed: ABC-GA, GA-CSA, ALO-GA, EA-GA, and CEFO. The obtained results demonstrate improvements in accuracy, convergence, and computational efficiency in solving the considered problems. The developed algorithms have been tested both on benchmark problems and in the parameter identification of real bioprocesses and the tuning of PID controllers. I consider the selected methodology appropriate for the stated objectives, while the obtained results are well substantiated and convincingly presented.

4. Main scientific and applied scientific contributions

I agree with the five scientific and two applied scientific contributions of the dissertation summarized on page 234. Among them, I would particularly highlight the development of a generalized theoretical framework for the hybridization of metaheuristic algorithms, the creation of five new hybrid algorithms (EA-GA, ABC-GA, ALO-GA, GA-CSA, and CEFO), and the proven theorem on global convergence in probability. These results demonstrate that the research offers new solutions in the field of hybrid metaheuristic methods.

Also important are the application of the developed approaches to the modelling and control of various bioprocesses and the proposed framework for the evaluation and comparison of metaheuristic algorithms. In this way, the theoretical results have been validated in solving specific nonlinear optimization problems.

I consider the presented contributions to be clearly formulated, supported by the obtained results, and of substantial scientific and applied scientific value.

5. Dissemination and scientific visibility of the results

The results of the dissertation have been presented in **20** scientific publications. Of these, **10** are published in international journals with an impact factor: **5** in Q1, **4** in Q2, and **1** in Q3. Thus, the requirements of the Regulations of IBPhBME-BAS are fulfilled, according to which the candidate must have at least **10** publications with an impact factor related to the dissertation, of which at least **7** must be published in international journals. Prof. Roeva is the first author of **16** of the submitted publications.

One of Prof. Roeva's publications in the journal Mathematics (No. 1 in the submitted list of publications for the award of the scientific degree "Doctor of Sciences") has been included in the Editor's Choice category, which features a limited number of articles considered to be of substantial significance to the respective scientific field.

The publications submitted in connection with the dissertation have not been used in previous procedures for the acquisition of the educational and scientific degree "Doctor" (PhD) or for appointment to the academic positions of "Associate Professor" and "Professor".

The publications have received **295** citations in Scopus, excluding self-citations, and the candidate's *h-index*=**15**. I consider these indicators, together with the presented publication activity, to demonstrate the broad dissemination and scientific recognition of the results of the dissertation.

Prof. Roeva is also actively involved in research projects related to her scientific work. A list of nine projects has been presented, including projects in the fields of bioprocess modelling and control, InterCriteria Analysis, and knowledge extraction from data. In two of these projects, she served as scientific supervisor of a young researcher. She is currently also participating in the project "Centre of Excellence in Informatics and Information and Communication Technologies". This project activity further supports my positive assessment of the candidate's scientific work.

6. Critical remarks and recommendations

I have no substantial critical remarks.

I would recommend that Prof. Roeva extend the application of the developed hybrid algorithms to a broader class of nonlinear dynamic systems and to higher-dimensional problems. It would also be interesting to develop adaptive mechanisms for automatic tuning of the algorithm parameters depending on the problem being solved.

7. Compliance with the requirements for the scientific degree “Doctor of Sciences”

I consider the dissertation to fully comply with the requirements for the award of the scientific degree “Doctor of Sciences”. It presents theoretical generalizations and solutions to significant scientific and applied scientific problems related to the development and application of hybrid metaheuristic algorithms. The obtained results are original in nature and represent a substantial contribution to the investigated field.

The dissertation abstract accurately reflects the structure, main results, and contributions of the dissertation.

The submitted materials demonstrate that Prof. Roeva meets the minimum national requirements and the specific requirements of IBPhBME-BAS for the award of the scientific degree “Doctor of Sciences”.

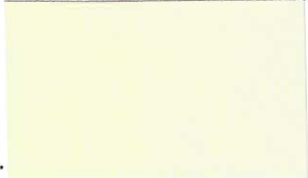
8. Conclusion

My overall assessment of the dissertation, the dissertation abstract, the publications, and the scientific activity of Prof. Olympia Nikolaeva Roeva, PhD, Eng., is entirely positive. The presented results are the outcome of thorough and consistent scientific work and constitute significant original scientific and applied scientific contributions. They demonstrate the candidate’s scientific maturity and her ability to formulate and solve complex problems in the investigated field.

The dissertation fully complies with the requirements of the Act on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its implementation, as well as the Regulations for the Implementation of the Act on the Development of the Academic Staff in the Republic of Bulgaria at IBPhBME-BAS.

This gives me sufficient grounds to confidently recommend that the esteemed members of the Scientific Jury award Prof. Olympia Nikolaeva Roeva, PhD, Eng., the scientific degree “Doctor of Sciences” in Higher Education Area 4. Natural Sciences, Mathematics and Informatics, Professional Field 4.6. Informatics and Computer Science.

16.08.2026

Prepared by: 

(Prof. Evdokia Sotirova)