

REVIEW

**under the procedure for acquisition of the educational and scientific degree “Doctor”
of the PhD Thesis titled: „Modeling big data analysis processes using Generalized Nets“
by Prof. Daniela Ananieva Orozova, DCs**

by candidate Petar Rosenov Petrov

In the Scientific field: 5 Engineering sciences

Professional field: 5.3 "Communication and computer technology"

Burgas State University "Prof. Dr. Asen Zlatarov"

The review has been prepared by: **Prof. Daniela Ananieva Orozova, DCs - Trakia University**, as a member of the scientific jury for the defense of this PhD thesis according to Order № № УД-314/14.08.2025 of the Rector of the Burgas State University "Prof. Dr. Asen Zlatarov". The submitted set of materials lacks an abstract in a foreign (English) language.

1. General characteristics of the dissertation thesis and the presented materials

The author of the dissertation is Petar Rosenov Petrov – a Ph.D. student in part-time education at the department “Computer systems and technologies” of the Burgas State University "Prof. Dr. Asen Zlatarov", with supervisors Acad. Prof. Dr. Krasimir T. Atanasov and Assoc. Prof. Dr. Vesselina K. Bureva.

The dissertation work of Petar Rosenov Petrov on the topic "Modeling of processes for big data analysis using Generalized Net" is 148 pages long. The text is structured in an introduction, three chapters, conclusion, contributions, list of publications on the topic. The bibliography covers 138 titles, of which 137 in English and 1 in Bulgarian. The text includes 67 figures and 4 tables. A list of abbreviations is included.

The purpose of the research is defined on page 30 of the dissertation: "to investigate various processes related to big data analysis (Big Data, Data Mining, Data Science) through their modeling using generalized nets and their program implementation, as well as the development of intuitionistic

fuzzy extensions of optimization problems and their implementations". To achieve this goal, five tasks have been set that correspond to the goal and are a good guideline for conducting the research.

The *introduction* presents the relevance of the problem and justifies the need for conducting the research. *Chapter 1* examines the basic concepts and principles related to data mining (Data Mining, Data Science), processing of Big Data, as well as formal models for their representation and analysis. An overview is given of the development of the theory of Generalized Nets, their capabilities and advantages over classical Petri nets. Intuitionistic fuzzy sets with their extensions and indexed matrices as a tool used to represent complex interdependencies between multiple parameters are presented.

Chapter 2 is dedicated to applications of generalized nets and intuitionistic fuzzy evaluations in the field of big data analysis and artificial intelligence, as the theoretical models from the first chapter have been successfully used to solve real-world problems. A Generalized Net (GN) model of a spatial cluster analysis algorithm based on density of noise applications and its applications on a data set related to diabetes is presented. A GN model of the balanced iterative reduction and clustering with hierarchies (BIRCH) method with intuitionistic fuzzy evaluations is considered. Applications of intuitionistic fuzzy evaluations in the waste sorting process and possibilities for extracting knowledge from data in garbage collection and recycling processes, assessing the frequency of user requests, analyzing data on student academic achievements and analyzing data from State Maturity Exams in the secondary education system in Bulgaria are considered. The support vector method is applied to recognize scientific terms and determine keywords in a system for offering educational resources and scientific articles.

In *Chapter 3*, implementations of models with intuitionistic fuzzy logic and algorithms for intelligent data analysis (using Python, MATLAB and C#) are presented. Implementation of algorithms is presented: for solving an intuitionistic fuzzy knapsack problem using indexed matrices for intelligent data analysis; for solving a circular intuitionistic fuzzy knapsack problem; for solving an elliptical intuitionistic fuzzy knapsack problem for decision-making based on economic portfolio data analysis; clustering algorithms DBSCAN and BIRCH on medical data for diabetes and on synthetic data. A classification model for determining belonging to a "scientific term" category using the support vector machine (SVM) method is created and the method is applied to extract key scientific terms from text. Implementation of software systems is presented: for analyzing the academic achievements of students and the results of State Matriculation Exams in the secondary education system of the Republic of Bulgaria.

The conclusion provides a brief summary of the problems raised and the contributions made in the dissertation.

The dissertation explores the possibilities of modeling big data analysis processes through generalized nets, using intuitionistic fuzzy sets and indexed matrices. By integrating these theoretical approaches with applied algorithms for cluster analysis, classification and optimization, a framework for intelligent data analysis under uncertainty is proposed.

2. Short CV and personal impressions of the candidate

Petar Rosenov Petrov is a Master of Science in Software Technologies since 2021 at Burgas State University "Prof. Dr. Asen Zlatarov". He completed his studies as a Bachelor of Science in Software Technologies and Design in 2019 at Plovdiv University "Paisiy Hilendarski". He has been a part-time doctoral student since 2021 at the Department of Computer Systems and Technologies of Burgas State University "Prof. Dr. Asen Zlatarov".

He works as a teacher and deputy director of academic activities at PGEE "K. Fotinov", Burgas and a part-time assistant in databases, information systems and computer security at the Department of "Computer Systems and Technologies" at the University "Prof. Dr. Asen Zlatarov", at the Ministry of Education and Science as a co-author of curricula and national examination programs, trainer at Scalefocus Academy, etc..

He received the professional qualification "Teacher of Mathematics and Informatics" and "Teacher of Vocational Training", V PKS, IV PKS and PPS "Artificial Intelligence in Schools" (III PKS) at TU-Varna.

I do not know the candidate personally. From the published materials and submitted documents, my impressions of Petar Petrov are entirely positive.

3. Content analysis of the scientific and applied achievements of the candidate, contained in the presented PhD thesis and the publications to it, included in the procedure

The contributions have a scientifically and scientifically applied character. I accept the main results and contributions indicated by the Ph.D. student on page 133 of the dissertation, namely:

The scientific contributions are as follows:

- Development of an algorithm with intuitionistic fuzzy scores for data analysis and recommendations for student academic achievements and development of an algorithm with

intuitionistic fuzzy scores for data analysis from State Matriculation Examinations in the secondary education system in Bulgaria.

- Defining intuitionistic fuzzy estimates in the waste sorting process using a robotic arm and for estimating the frequency of user requests.
- Development of algorithms for solving the knapsack problem based on circular and elliptic intuitionistic fuzzy sets.

The scientific and applied contributions are as follows:

- A generalized net model is created to reflect the clustering process of big data using the DBSCAN (Density-Based Spatial Clustering of Applications with Noise) algorithm. The basic concept of DBSCAN is based on recognizing areas with high density of objects, which are considered as clusters, and separating low density objects as noise or anomalies. Compared to other cluster analysis algorithms, DBSCAN does not require the number of clusters to be determined at the beginning. Another valuable quality of the algorithm is that it gives a better distribution of clusters when the data is of odd shape.
- A generalized net model has been created, reflecting the clustering process using the BIRCH method - one of the most effective for processing large data sets. BIRCH is specifically designed to process large volumes of information, minimizing the need to store data in memory. Its main idea is to build a compact summary of the data using a special hierarchical structure called a CF-tree (Clustering Feature Tree), which allows for incremental and dynamic processing of inputs.
- Implementation of a support vector method with intuitionistic fuzzy estimates for recognizing scientific terms and determining keywords in a system for offering educational resources and scientific articles.
- A packet delivery optimization solution based on data analysis and application of the elliptic intuitionistic fuzzy knapsack problem for decision making.

The research carried out in the dissertation requires in-depth knowledge and high practical qualifications, which its author undoubtedly possesses. The doctoral student precisely and clearly argues and presents the main theses in the separate chapters of the dissertation work and the publications to the dissertation.

4. Approbation of the results

The results of the dissertation research are presented in 10 publications in peer-reviewed journals, 8 of which have SJR. All publications are co-authored, and all are in English.

The volume and depth of the publications, reflecting the main aspects of the issues examined in the dissertation, make a good impression.

The presented publications are distributed over time as follows:

Year	2022	2023	2024	2025
Number	1	5	2	2

The works presented go beyond requirements of the Development of Academic Staff Act in the Republic of Bulgaria, the Rules for its Implementation for acquisition by the candidate of educational and scientific degree “Doctor”.

After a detailed review of the scientific works presented, I found that:

a) The scientific works meet the minimum national requirements of the Development of Academic Staff Act in the Republic of Bulgaria for acquiring the educational and scientific degree “Doctor” (Ph.D.) in the scientific field and professional field of the procedure.

b) The results presented by the candidate in the dissertation work and scientific works to it do not repeat such from previous procedures for acquiring a scientific title and academic position.

c) There is no plagiarism proven in the legally established order in the submitted dissertation work and scientific papers under this procedure.

5. Qualities of the abstract

The Bulgarian abstract meets the requirements for an accurate, complete and concise reflection of the dissertation work in terms of volume and content. No abstract in a foreign (English) language has been submitted.

6. Critical notes and recommendations

The content of the dissertation is well structured, the description is accurate and complete, but no prospects for future development of the topic based on the results obtained are formulated.

The following question is addressed to a doctoral student: What characteristics of the data processed by learning management systems link them to the Big Data category?

I recommend that the doctoral student continue his research by expanding the applicability of the results of the dissertation work, such as researching and citing publications by Bulgarian authors in his scientific works.

7. Conclusion

Having become acquainted with the PhD thesis presented in the procedure and the accompanying scientific papers and on the basis of the analysis of their importance and the scientific and applied contributions contained therein, I confirm that the presented PhD thesis and the scientific publications to it, as well as the quality and originality of the results and achievements presented in them, meet the requirements of the ADAS in the Republic of Bulgaria, the Rules for its Implementation for acquisition by the candidate of educational and scientific degree "Doctor" in the Scientific field 5. Engineering sciences, Professional field: 5.3 "Communication and computer technology".

Based on the above, **I recommend** the scientific jury to award **Petar Rosenov Petrov**, the educational and scientific degree "Doctor" in the Professional field: 5.3 "Communication and computer technology".

Date: 8.10.2025

Подпис заличен
Чл.2 от ЗЗЛД
Reviewer: _____
/ Prof. Daniela Orozova, DCs /

**ADASRB - Act on Development of the Academic Staff in the Republic of Bulgaria*