REVIEW

from
Prof. Dr. Vladimir Monov

on a dissertation for obtaining an educational and scientific degree "Doctor"

Author of the dissertation: **mag. Ivan Ivanov Blagoev**
Dissertation title: "**Methods and tools for data analysis in information systems using time series**"
Field of higher education: **4. "Natural sciences"**
Professional field: **4.6. Informatics and Computer Science**
Scientific specialty: **"Informatics"**
Scientific adviser: **Assoc. Prof. Dr. Tatiana Atanasova**

By Order No. 130 / 27.05.2021 of the Director of IICT-BAS I have been confirmed as a member of the Scientific Jury for conducting the defense of the dissertation. By decision of the Scientific Jury at a meeting held on 03.06.2021 I was appointed reviewer of the dissertation. As a member of the Scientific Jury I have received:

1. Dissertation for acquiring educational and scientific degree "Doctor".
2. Abstracts of the dissertation in Bulgarian and English.
3. Copies in full text of nine publications on the dissertation.
4. Report for the fulfillment of the minimum requirements of IICT for the educational and scientific degree "Doctor".

The evaluation of the dissertation follows the normative requirements for acquiring the educational and scientific degree "Doctor", defined by the Law for development of the academic staff in the Republic of Bulgaria (art. 6, para. 3), the Regulations for application of the law , para 1 and para 2), as well as the Regulations for the specific conditions for acquiring scientific degrees and holding academic positions in the Institute of Information and Communication Technologies (art. 3, para 1, item 1.1).

1. Structure and content of the dissertation.

The dissertation is 125 pages long and consists of an Introduction, 4 chapters, a Conclusion with a summary of the obtained results, and a Bibliography. It Contains 33 figures and 1 table. The list of bibliographic sources consists of 122 titles, including sources from Bulgarian and foreign authors, as well as Internet sites. Data for five citations of three of the dissertation publications are presented. The participation in two research projects during the doctoral studies is noted, guidelines for future research activity are formulated. Appendix 1 to the dissertation is presented with the results of analysis of data collected by a random number generator through specialized software.

According to the requirements, a Declaration of originality of the obtained results is attached to the dissertation.

The dissertation was discussed and proposed for defense at an extended meeting of the section "Modeling and Optimization" of IICT-BAS, held on 18.05.2021.

2. Relevance of the problem developed in the dissertation in scientific and scientific-applied terms

The general goal of the dissertation is aimed at developing methods and software tools for time series analysis and processing of large volumes of data with applications in forecasting financial indicators and improving cryptography and cybersecurity. To achieve this goal, five research tasks are appropriately formulated. Data analysis and time series research allow both descriptive and predictive analysis of a range of activities and events, and can therefore play a key role in industry, business and finance, information security and the planning sectors for future operations. Both internationally and in our country, modern achievements and problems in this field are subject to constant interest and active research, which undoubtedly determines the relevance of the research and the usefulness of the scientific results and practical solutions obtained in the dissertation.

3. Degree of knowledge of the state of the problem and creative interpretation of the bibliographic material

The introduction and the literature review, made in Chapter 1 of the dissertation together with the formulated goal and tasks are presented in 21 pages. The main characteristics of the time series are analyzed and the main objectives in the processing of data obtained from time series are outlined. Special attention is paid to the application of time series in the study of financial instruments with the help of fundamental and technical analysis, as well as the use of artificial neural networks for forecasting purposes. Possibilities for the use of time series to improve cryptography and cybersecurity in information systems are outlined. The literature review and analysis of the current state and current trends in the problem area of the dissertation show in-depth knowledge of the subject and current problems, as well as potential opportunities for their solution. On this basis, the goal and tasks of the dissertation are formulated.

4. Correspondence of the chosen research methodology and the goal and tasks of the dissertation with the achieved contributions

The formulated general goal of the dissertation is to develop new methods and tools for data analysis in information systems using time series. To achieve this goal, the following tasks are formulated.

- To develop a method for analysis and prediction of price movements in the financial field using time series;

• To propose an algorithm for training artificial neural networks in forecasting financial time series;

• To propose solutions for increasing the cryptographic protection in the information systems by applying methods for analysis of time series;

• To conduct experimental research to verify the proposed methods for increasing cryptographic protection in solving problems for increasing cybersecurity.

• To develop program methods for overcoming problems when working with large volumes of data in time series.

The methodology of the research includes refining and improving the accuracy of known methods for forecasting market price movements, using the apparatus of artificial neural networks for modeling and forecasting, evaluation of cryptographic protection algorithms in information systems and increasing cybersecurity through the use of time series. This approach fully corresponds to the general goal and specific tasks of the dissertation. The obtained results show that the doctoral student has successfully used the chosen research methodology in accordance with the formulated goal and the achieved scientific and applied contributions.

5. Characteristics of the dissertation

The dissertation demonstrates knowledge and capabilities for research work of the author in the thematic area of the dissertation. Compared to the previous version of the dissertation presented at the preliminary discussion, it can be noted that the overall content of the dissertation has been improved, taking into account the remarks and recommendations made.

Chapter 1 provides an overview of current research in the field of data analysis, with special attention paid to the case where these data are presented in the form of time series. The need to develop new methods and tools for data analysis in information systems using time series is motivated.

Chapter 2 examines one of the main tools in technical analysis for forecasting price movements known as the Momentum oscillator. A new method has been proposed, integrating the capabilities of Momentum with known statistical methods, which increases the accuracy of forecasting. The chapter also includes application of the apparatus of artificial neural networks for time series prediction, and a hybrid structure and algorithm for neural network training have been developed.

Chapter 3 analyzes standards and algorithms for data encryption in information and communication systems. Based on the conducted research of the quality of random number generators, a method has been developed to increase the cryptographic data protection. The method is applied in an operating server from the technological infrastructure of IICT-BAS which shows the results of tests for cryptographic protection in the implementation of various information services (web-server, e-mail, etc.).

Chapter 4 discusses software approaches for data processing and analysis, with special attention to the approach to statistical and mathematical data processing based

on the programming language R. Software techniques for optimizing computer memory when working with large arrays and limited computer resources.are developed.

The final part of the dissertation summarizes the results obtained and lists the contributions, which are essentially defined as scientific and applied. A plan for future development of the conducted research and the obtained results is also presented.

The dissertation is characterized by an in-depth study of the problems and the use of appropriate methodology for their solution. The numerous experiments and the analysis of the experimental data confirm the correctness of the chosen approach and the applicability of the obtained results.

6. Scientific and scientific-applied contributions of the dissertation

I accept and evaluate positively the scientific-applied contributions, formulated in the dissertation and the abstract. In summary, they can be listed as follows.

1. A hybrid method has been developed, integrating the capabilities of the known Momentum indicator with methods from statistical analysis, which increases the accuracy of forecasting time series from financial data.

2. The apparatus of artificial neural networks for studying financial time series is applied, as a result of which a model based on a three-layer perceptron and an algorithm for neural network training have been developed, providing a higher degree of self-adaptation in network training.

3. A method has been developed to increase cryptographic protection in information systems as a result of research on the quality of random number generators using time series.

4. Software methods have been developed for efficient work with big data by means of the R language.

5. Experimental studies have been conducted in public hosting services, which confirmed the applicability of the proposed method to increase cryptographic data protection and cybersecurity. The method is implemented in the technological infrastructure of IICT-BAS on server systems with public Internet services operating in real conditions.

A good attestation for the results obtained in the dissertation is the fact that they have been used and applied in the work of the National Research Program "Information and Communication Technologies for a Digital Single Market in Science, Education and Security" and the project "Digital and Cyber Sustainable IICT".

7. Assessment of the degree of personal participation of the doctoral student in the contributions

I know the doctoral student personally and I have direct impressions both from his independent work and from the work of the team in which he participates. This gives me reason to believe that the dissertation and its contributions are his personal work, obtained under the direct supervision of his supervisor.

8. Evaluation of the publications on the dissertation

Nine publications on the dissertation topic are presented, of which seven are self-authored and two are co-authored. Seven of the publications are in English and two in Bulgarian. Two of the presented publications are in impact rank editions (Scopus SJR). All publications on the dissertation are in the period 2017-2020 and as a volume and quality they meet the requirements for obtaining the educational and scientific degree "Doctor". With the publications made, the results of the dissertation have become available to our and the international scientific community.

9. Significance of the results of the dissertation work in science and practice

The dissertation includes research and results related to the analysis and application of time series in the development of methods for forecasting financial indicators, improving cryptography and cybersecurity, processing big data sets. Experimental studies have been carried out, illustrating the advantages of the developed methods, the obtained results have been realized in the technological infrastructure of IICT. In general, the dissertation contains contributions of a scientifically applied nature, which relate to the development of new and improvement of existing methods and approaches, as well as the application of useful practical solutions.

10. Assessment of compliance of the abstract with the requirements for its preparation

The abstract is 37 pages long and meets the requirements for its preparation. Its content corresponds to the content of the dissertation and presents exactly the main results in the dissertation. An abstract of the dissertation in English in a volume of 36 pages is also presented.

11. Assessment for fulfillment of the minimum national requirements and the additional requirements under Art. 1a, para 2 of PPZRASRB

According to PPZRASRB for obtaining educational and scientific degree "Doctor" in professional field 4.6 "Informatics and Computer Science", it is required a minimum of 50 points on indicator A and 30 points on group of indicators D. The same number of points is required in the Regulations on specific conditions for acquisition of scientific degrees and holding academic positions at IICT-BAS. From the submitted Report for fulfillment of the requirements for obtaining educational and scientific degree "Doctor" it is evident that the doctoral student fulfills the requirement according to indicator A, and according to indicators from group D he has reported 40 points, which exceeds the required minimum number of points.

12. Opinion, recommendations and remarks

The dissertation is elaborated in detail and represents a completed research work. The doctoral student has carried out an in-depth and systematic study of the problem and has offered original scientific and applied results that fully meet the goal and objectives of the dissertation.

I have no critical remarks on the substance of the dissertation and the results presented. Of an editorial and technical nature, I have the following remarks.

The text of the dissertation uses the term "arbitrary number generator", which is inaccurate and does not correspond to the accepted terminology "random number generator".

The list of bibliographic sources contains omissions or inaccuracies, for example, in some of the titles there is no source of publication or publisher, not everywhere there are pages of publications, the titles of sources [85] and [86] are repeated, etc.

These remarks are not on the essence of the work and do not reduce the value of the contributions of the dissertation.

My recommendation to the doctoral student is to continue the research activity in accordance with the plan for future work outlined in the dissertation, as well as to publish the results in prestigious international journals.

CONCLUSION

I positively evaluate the work done and the results obtained in the dissertation. The dissertation meets all the requirements of ZRASRB, the Regulations for its implementation, as well as the specific conditions for obtaining scientific degrees and holding academic positions at the Institute of Information and Communication Technologies. I strongly suggest to the esteemed Scientific Jury to give to the mag. Ivan Ivanov Blagoev educational and scientific degree "Doctor" in the field of higher education: 4. "Natural Sciences", professional field: 4.6. "Informatics and Computer Science", specialty "Informatics".

Sofia,
June 25, 2021

Reviewer: .....
/ Prof. Dr. V. Monov /