O P I N I O N

by Prof. Dr. Dimitar Karastoyanov, IICT-BAS

of dissertation for awarding the educational and scientific degree "Doctor"
on **"Forecasting time series with artificial neural networks"**
in the field of higher education 5. "Technical sciences"
professional field 5.3. "Communication and computer equipment"
doctoral program "Communication Networks and Systems"
author: Petar Rosenov Tomov
scientific supervisor: Prof. Dr. Vladimir Monov

1. Relevance of the problem

Neural networks have become very popular in recent decades. In particular, they are used in the description and analysis of types of time series, often through directed weight graphs and layers. Among the used technologies, the role of ICT is significant. The topic of the dissertation is actual. The doctoral student demonstrates knowledge of the state of the problem and cites global approaches and solutions.
The aim of the dissertation is to propose hybrid algorithms for accelerating training in artificial neural networks of the multilayer perceptron type for the purposes of time series forecasting. There is a correspondence between the set goal and tasks, the chosen research methodology and the stated contributions.

2. General characteristics of the dissertation

The dissertation consists of 157 pages, structured in an introduction, 4 chapters, conclusion, contributions, list of publications, bibliography and 1 appendix. 134 literature sources were used.
The first chapter provides an overview, analysis and systematization of various algorithms for training artificial neural networks. Opportunities for training of artificial neural networks are presented.
In the second chapter the algorithms for the training of artificial neural networks of the multilayer perceptron type are studied. Modifications of some of the algorithms that are applicable in time series forecasting are proposed.
The third chapter presents a software architecture and offers an object-oriented model, relational model, communication protocols and graphical user interface.
The fourth chapter describes the performed experiments and the obtained results. Performance and error were analyzed.

3. Characteristics and evaluation of the contributions in the dissertation

The research in the dissertation is focused on algorithms for training artificial neural networks of the multilayer perceptron type. The doctoral student has managed to analyze, summarize and integrate modern information and communication technologies required for software

implementation of the proposed hybrid algorithms. There is a correspondence of the chosen research methodology with the set goal and tasks of the dissertation. I believe that the doctoral student has successfully coped with the goals and objectives of the dissertation and I appreciate the positive results and contributions as mostly scientific-applied.

4. Publications on the topic of the dissertation

The dissertation is based on 11 scientific publications, of which 3 are in journals and 8 are from conference proceedings. 2 of the publications are independent, and in another 6 the doctoral student is in first place. This gives me reason to conclude that most are prepared by the doctoral student.

5. Use of the obtained results

The obtained results could be used in artificial neural networks for control of autonomous systems, forecasting the presence and workload of employees, when conducting a population census, etc ..

6. Critical remarks and recommendations

The dissertation contains minor syntactic, grammatical and technical errors, as well as numbering errors.
The inaccuracies do not diminish the contributions of the dissertation, but the author should be more precise in publishing his future results.

7. Conclusion

The dissertation meets the conditions of ZRASRB, PPZRASRB and the Regulations for the specific conditions in IICT-BAS. The dissertation contains scientific and applied results of an innovative nature, which I appreciate. The candidate demonstrates the ability for independent research. **I strongly recommend to the Honored Scientific Jury to award the educational and scientific degree "Doctor" to Petar Rosenov Tomov in the field of higher education 5. Technical sciences, professional field 5.3. Communication and computer engineering, in the doctoral program "Computer Networks and Systems".**

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