O P I N I O N

On the thesis for obtainment of educational and

Scientific degree „Doctor"

Author of the thesis: **MSc. Alexander Ognianov Marazov**

Thesis title: **Deep Neural Networks for Medical Diagnostics**

Member of the scientific Jury: Prof. Dr. Petia Doycheva Koprinkova-Hristova

I have been appointed as a member of the Scientific Jury by Order No. 911 from 05/28/2024. of the Director of IBFBMI-BAS. I have been presented with all the documents required by the applicant: curriculum vitae according to the European template, a copy of the master's degree diploma, records and certificates of the exams taken according to the study plan, a list and copies of the publications related to the dissertation work, a list of citations, an abstract in Bulgarian and English language and dissertation work.

The dissertation submitted for the acquisition of the educational and scientific degree "doctor" is 162 pages long. It consists of five chapters, the first of which is an overview of the methods used in the dissertation, and the remaining four present the models and methods developed by the doctoral student.

The dissertation work is in a very topical area – application of artificial intelligence methods in medicine, and more specifically for the diagnosis of Alzheimer's disease based on magnetic resonance images of the patients' brains.

The PhD student demonstrates deep knowledge of the state of the problem in four areas: neural networks and in particular convolutional neural networks, intuitionistic fuzzy sets, intercriteria analysis and Alzheimer's disease. The literature review is based on 146 scientific publications, all from the period after 2000, and a large part are from the period after 2020. It is analytical, clearly defining the unsolved problems, with which the PhD student motivates the purpose and tasks of his dissertation work.

The chosen research methodology is logical in its sequence from transfer learning of a convolutional neural network through ensemble classifiers and the application of intuitionistic logic and the intercriteria analysis for aggregation and ordering of the model's solutions.

The contributions are clearly stated and can be briefly summarized as:

A. Theoretical:

- An intuitionistic interpretation of the Kemeny-Young method for ranking options in multi-model voting is developed, and the method developed in this regard for applying threshold values to the degrees of membership and uncertainty increases the accuracy of the classification.

- An approach has been developed to evaluate the solutions of multiple classifiers with the methods of intercriteria analysis.
- An algorithm with reduced complexity and increased speed has been developed for solving the task of intercriteria analysis.

Б. Scientific applications:

- A program implementation of the proposed methods and algorithms has been developed.
- Multiple classifiers of magnetic resonance images have been trained for the diagnosis of Alzheimer's disease stages, and intuitionistic logic and intercriteria analysis methods have been demonstrated to improve diagnostic accuracy.

It makes a particularly good impression that the doctoral student has a vision for future research to upgrade what has already been achieved in his dissertation work.

The PhD student's contributions are of undoubted importance both for science with the developed intuitionistic and intercriteria approaches for the purposes of ensemble classification, and for practice with their application for the diagnosis of Alzheimer's disease.

The doctoral student has submitted a list of 4 publications on the topic of the dissertation work. Two of the publications carry 35 points out of the 30 points required to defend the thesis: one in a journal with an impact factor in Q1 in Web of Science (25 points) and one in a SJR-ranked journal (10 points). The other two publications are in a publication that is included in the National Reference List, but they do not carry points in area 4.6. The PhD student is first author of the SJR-ranked publication and sole author of the two unrefereed publications. With this, he also fulfills the specific requirement of the IBFBMI-BAS Law Implementation Regulations to have 3 publications on the dissertation work, of which at least 1 in an international journal with an impact factor and at least 1 article as the first author. In addition, the PhD student has participated in two international conferences with papers likely to be published. A citation to the first publication is also noted, proving that the work is visible and used by other scholars.

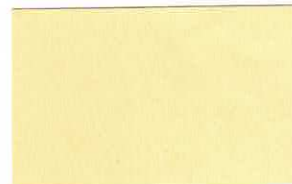The abstract is 39 pages long and sufficiently reflects the main contributing points of the dissertation work.

I have no substantive objections to the PhD work. I have small notes of a technical nature about the translation of some terms and the use of foreign ones, such as inference instead of Bulgarian word; performance instead of presentation, etc., which do not detract from the qualities of the dissertation. I recommend the PhD student to continue to develop in the future in this undoubtedly very current scientific field.

The candidate meets all the requirements of the Law on the Development of the Academic Staff for awarding the educational and scientific degree "Doctor", as well as the specific requirements in the Regulations for the Implementation of the Law of the IBFBMI-BAS. In conclusion, I give a convinced **positive assessment** of the dissertation work.

All this gives me reason to confidently recommend to the members of the respected Scientific Jury to vote for the awarding to **MSc. Alexander Ognyanov Marazov** the educational and scientific degree "**Doctor**" in professional field **4.6. Informatics and computer sciences**, in the scientific specialty "**Informatics**".

Date: 23.08.2024   JURY MEMBER:

(Prof. P. Koprinkova-Hristova)