I. IDENTIFICATION DATA

Thesis name:	**Neural networks using for handwritten numbers recognition**
Author's name:	**Dina Latypova**
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Computer Science
Thesis reviewer:	Associate professor Makletsov Sergey Vladislavovich, Ph.D
Reviewer's department:	Kazan Federal University, N.I. Lobachevsky Institute of Mathematics and Mechanics, Department of Theory of Functions and Approximations

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **challenging**

Evaluation of thesis difficulty of assignment.

The thesis deals with the problem of pattern recognition using a hierarchical neural network. This task is very popular. The work uses a recurrent neural network – Hopfield neural network, that is close to the work of the brain's memory. The Kohonen neural network is also used, which is an auxiliary stage. The cluster analysis carried out in this work can answer some questions related to errors in pattern recognition by neural networks. All research points to the difficulty of this task.

Satisfaction of assignment **fulfilled**

Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.

The author explores the problem of image recognition using neural networks. In this paper, we studied neural networks, which are currently widely used. A hierarchical neural network was constructed, consisting of the Kohonen neural network and the Hopfield neural network. The author also proposed two methods for determining the similarity of two images. These methods are used in the Hopfield neural network. The work of neural networks is analyzed and compared. A program with a convenient graphical interface was also developed. Based on the results of the Kohonen neural network, a cluster analysis was performed. Its results explain errors in pattern recognition by neural networks. Also the training of the Kohonen neural network was parallelized using CUDA and OpenMP technology. The thesis as a whole is performed at a high level, although some aspects are not properly discussed.

Method of conception **correct**

Assess that student has chosen correct approach or solution methods.

Existing approaches to the solving the problem were analyzed. A mathematical method for the proposed model is comprehensively described and correct.

Technical level **A - excellent.**

Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

The author has conducted a large study of existing technologies and approaches to solve this problem. The author correctly used the acquired skills.

Formal and language level, scope of thesis **B - very good.**

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

The dissertation is well designed and organized. A large number of images and tables make the results clearer. But some sentences are too long and this makes it difficult to perceive this information
in the text.

Selection of sources, citation correctness **B - very good.**

Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.

The sources are selected correctly and quoted correctly. Some of the sources are recent, which is very good for this work. But sources that are not recent are also used, which is not good for machine learning, since it is a rapidly changing field

Additional commentary and evaluation

Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.

Judging by results, the task was completely solved. Performance evaluation of the proposed algorithm showed good results. Testing algorithms on different data sets has shown the universality of the algorithms

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.

The thesis, in its content, corresponds to the chosen topic and tasks. However, some questions are remained open:

1. How can you improve neural networks for pattern recognition?

2. How can large cluster intersections be avoided?

I evaluate handed thesis with classification grade **A - excellent.**

Date: **22.5.2019**   Signature: