Appendix 1

MINISTRY OF EDUCATION AND SCIENCE OF THE RUSSIAN FEDERATION
NATIONAL RESEARCH
TOMSK STATE UNIVERSITY

Institute of Applied Mathematics and Computer Science

APPROVE:
Director
_____A. V. Zamyatin

Evaluation materials of the current control and intermediate certification in the discipline
(Evaluation tools by discipline)

Neural networks - II

in the major of training

01.04.02 Applied mathematics and informatics

Direction (profile) of training:
Big Data and Data Science

Tomsk-2024

ET was implemented:
Candidate of Physics and Mathematics Sciences, Associate Professor,
Associate Professor of the Department
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Reviewer:
cand. tech. Sciences,
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Evaluation tools were approved at a meeting of the educational and methodological commission ofthe Institute of Applied Mathematics and Computer Science (EMC IAMCS).

Protocol dated 20.05.2024 № 1

Chairman of the EMC IAMCS,
Dr. tech. Sciences, Professor — S.P. Sushchenko

Evaluation tools (ET) are an element of the system for assessing the formation of competencies among students in general or at a certain stage of its formation.

The ET is developed in accordance with the work program (WP) of the discipline .

1. Competencies and training outcomes, obtained upon the discipline mastery

Competence	**Competence indicator**	**Code and name of planned training outcomes that characterize the stages of competency formation**	**Criteria for evaluating training outcomes**			
			Excellent	Good	Satisfactorily	unsatisfactory
UK-1. Able to carry out a critical analysis of problem situations based on a systematic approach, develop an action strategy	IUK-1.1 Identifies a problem situation, on the basis of a systematic approach, carries out its multifactorial analysis and diagnostics.	OP-1.1.1. The student will be able to: - find and use sources of additional information to improve the level of general and professional knowledge; - to select and process information on the chosen research topic; correctly quote and make references to the sources used in written works; - be able to apply natural science and mathematical knowledge for the application of neural network technology in the field of scientific and engineering problems.	90-100 points	70-89 points	50-69 points	0-49 points
	IUK-1.2 Carries out the search, selection and systematization of information to determine alternative options for strategic solutions in a problem situation.					
	IUK-1.3 Suggests and justifies the strategy of action, taking into account the limitations, risks and possible consequences.					

OPK-3. Able to develop mathematical models and analyze them when solving problems in the field of professional activity	IOPC-3.3 Develops and analyzes new mathematical models for solving applied problems of professional activity in the field of applied mathematics and informatics	OP-3.3.1. - be able to choose the topology of a neural network for solving an applied problem. OP-3.3.2. The student will be able to: - develop and issue a program code in accordance with the established requirements; - to form a training data set for machine learning of a neural network model; - develop a test data set to test the operation of the created software application; - to accelerate the process of machine learning for a specific computer architecture; - to conduct computer experiments on training and testing the developed neural network model; - to adapt the neural network model for practical application based on computer experiments; - to compare the obtained results with known domestic and foreign analogues.	The theoretical content of the course was mastered completely, without gaps the necessary practical skills of working with the mastered material were formed, all the training tasks provided for by the training program were completed, the quality of their implementation was estimated by a number of points close to the maximum.	The theoretical content of the course has been mastered completely, without gaps, some practical skills in working with the mastered material are not sufficiently formed, all the training tasks provided for by the training program have been completed, the quality of none of them has been assessed with a minimum number of points, some types of tasks have been completed with errors.	The theoretical content of the course has been partially mastered, but the gaps are not significant, the necessary practical skills for working with the mastered material are basically formed, most of the training tasks provided for by the training program have been completed, some of the completed tasks may contain errors	The theoretical content of the course has not been mastered, the necessary practical work skills have not been formed, the completed training tasks contain gross errors, additional independent work on the course material will not lead to a significant improvement in the quality of the training tasks.
PC-6. Able to manage the receipt, storage, transmission, processing	IPK-6.1 Monitors and evaluates the performance of big data processing	OP-6.1.1 The student will: - Know the principles of planning and				

of big data	IPK-6.2 Uses methods and tools for receiving, storing, transmitting, processing big data IPK-6.3 Develops proposals to improve the performance of big data processing	organizing analytical work using neural network technologies OP-6.1.2 The student will be able to: - Conduct analytical research and develop applications using neural network technologies in accordance with customer requirements OP-6.2.1 The student will be able to: - Prepare data for analytical work on the study of big data using neural networks OP-6.2.2. The student will be able to: - be able to develop algorithms for neural network processing of big data. OP-6.3.1 The student will be able to: - Carry out procedures for identifying, forming and coordinating requirements for the results of analytical work using neural network technologies				

2. Stages of competency formation and types of evaluation tools

No.	Stages of competency formation (discipline sections)	Code and name of training outcomes	Type of evaluation tool (tests, assignments, cases, questions, etc.)
1.	Sections 1. Optimization in training neural networks Performing laboratory work No. 1. "Building a Neural Network Regressor"	RD 1 The student will be able to apply natural science and mathematical knowledge for using neural network technologies in the field of scientific and engineering problems.	Survey in the classroom, preparation for laboratory classes, public defense of laboratory work No. 1.
2	2. Convolutional networks. Performing laboratory work No. 2. " Designing a Convolutional Neural Network "	RD 2 The student will have the ability to develop implementation tools using neural network technologies	Survey in the classroom, preparation for laboratory classes, public defense of laboratory work No. 2.
3.	3. Modeling of sequences: recurrent and recursive networks. Performing laboratory work No. 3. " Designing a Recurrent Neural Network "	RD 2 The student will have the ability to develop implementation tools using neural network technologies	Survey in the classroom, preparation for laboratory classes, public defense of laboratory work No. 3.
	4. Practical methodology. five. Applications. Laboratory work №4. " Research of architectures and optimizers of a neural network - a classifier to improve its efficient operation "	RD 2 The student will have the ability to develop implementation tools using neural network technologies	Survey in the classroom, preparation for laboratory classes, public defense of laboratory work No. 4

3. Typical control tasks or other materials necessary for the assessment of educational training outcomes

3.1. Typical tasks for conducting ongoing monitoring of progress in the discipline

Laboratory work No. 1 " Building a neural network regressor **"**

The purpose of the work is to write a program in Python and R that builds and trains feed-forward neural networks that solve the regression problem (samples received from the teacher), it is required to select a non-redundant network architecture that works with an acceptable error level and visualize the process of model training. The results of the work should be included in the report.

Lab #2 " Designing a Convolutional Neural Network **"**

The purpose of the work is to write a program in Python and R that builds and trains an image classifier using convolutional neural networks (samples received from a teacher), it is required to select a non-redundant network architecture that works with an acceptable error level and visualize the process of model training. The results of the work should be included in the report.

Laboratory work No. 3 " Designing a recurrent neural network **"**

The purpose of the work is to write a Python program that builds and trains a model for

predicting future values based on time sequence data (the sample was received from the teacher), it is required to select the architecture of a recurrent neural network that works with an acceptable error level and visualize the process of training models and bring quality metrics . The results of the work should be included in the report.

Laboratory work No. 4 " Research of architectures and optimizers of a neural network - a classifier to increase its efficient operation **"**

The purpose of the work is to explore in Python and R languages methods for tuning parameters and hyperparameters of neural networks using different optimizers, enumeration of architectures for solving problems of multiclass, binary classification, as well as regression for samples provided by the teacher. The results of the work should be included in the report.

3.2. Typical tasks for conducting intermediate certification in the discipline

1. Optimization in training neural networks. How does learning differ from pure optimization. Minimization of empirical risk. Surrogate loss functions and early stopping. Batch and mini-batch algorithms.
2. Problems of optimization of neural networks. Bad conditioning. local minima. Plateaus, saddle points and other flat areas. Cliffs and steeply rising gradients. Long term dependencies. Inaccurate gradients. Poor correspondence between local and global structures. Theoretical optimization limits.
3. Basic algorithms. Stochastic gradient descent. impulse method. Nesterov's method.
4. Parameter initialization strategies.
5. Algorithms with adaptive learning rate. Ad Grad. RMSProp. Adam. Choosing the right optimization algorithm.
6. Approximate methods of the second order. Newton's method. Conjugate gradient method. BFGS algorithm.
7. Optimization strategies and metaalgorithms. Batch normalization. Coordinate descent. Pole's averaging. Pre-training with a teacher. Model design for ease of optimization. Methods of continuation and training according to the plan.
8. Convolutional networks. Convolution operation. Motivation. Pooling.
9. Convolution and pooling as an infinitely strong prior distribution. Variants of the basic convolution function.
10. structured output. Data types.
11. Efficient convolution algorithms. Random signs and unsupervised signs.
12. Neurobiological foundations of convolutional networks. Convolutional networks and the history of deep learning.
13. Sequence modeling: recurrent and recursive networks. Calculation graph unrolling.
14. Recurrent neural networks. Forcing the teacher and the network with recursion at the output. Gradient calculation in a recurrent neural network. Recurrent networks as directed graphical models. Modeling context-specific sequences using RNNs.
15. Bidirectional RNS.
16. Encoder-decoder or sequence-to-sequence architectures.
17. Deep recurrent networks.
18. Recursive neural networks.

19. The problem of long-term dependencies.
20. Neural echo networks.
21. Leaky blocks and other multi-timescale strategies. Adding direct links through time. Leaky blocks and a spectrum of different time scales. Removing links.
22. Long short-term memory and other gated RNNs. Long short term memory. Other valve RNS.
23. Optimization in the context of long-term dependencies. clipping gradients. Regularization to push the information flow.
24. explicit memory.
25. Practical methodology. Quality indicators.
26. Selecting the default base model.
27. Do I need to collect additional data?
28. Choice of hyperparameters. Manual tuning of hyperparameters. Algorithms for automatic optimization of hyperparameters. Grid search. Random search. Model-based hyperparameter optimization.
29. Debugging strategies.
30. Example: multiple digit recognition.
31. Applications. Large scale training for neural networks. Implementations on fast CPUs. GPU implementations. Large scale distributed implementations. Model compression. dynamic structure. Specialized hardware implementations of neural networks.
32. Computer vision. Preprocessing.
33. Speech recognition. Processing of natural languages. N-grams. Neural language models. Multidimensional outputs. Combining neural language models with n-grams. Neural machine translation. History reference.
34. Other applications. recommender systems. Representation of knowledge, reasoning and answering questions.

4. Methodological materials that determine the procedures for evaluating educational training outcomes

4.1. Methodological materials for assessing the current control of progress in the discipline.

The current control of the discipline is carried out by monitoring attendance, performing laboratory work, tests on lecture material, doing homework and is recorded in the form of a control point at least once a semester.

4.2. Methodological materials for conducting intermediate certification in the discipline.

The results of the test are determined by the marks "excellent", "good", "satisfactory", "unsatisfactory".

The final assessment of the student's knowledge in the discipline is carried out according to a 100-point system and includes:

- 60% of the result obtained in the test;
- 40% of the results of the current academic performance.

The formula for calculating the final grade:

$$F = 0{,}4\,\frac{P_1+P_2}{2} + 0{,}6\,T \qquad (1)$$

where, P1, P2 are the digital equivalents of the first and second control points, respectively; T - the digital equivalent of the assessment in the test.

The points scored during the current control are taken into account during the intermediate certification. The grades "excellent", "good", "satisfactory", "unsatisfactory" are given with the number of points scored: 90-100, 70-89, 50-69 and 0-49, respectively.