



National Research University Higher School of Economics
Programme for a Candidate of Science's Degree Examination in Specialization
1.2.1 «Artificial Intelligence and Machine Learning»

National Research University Higher School of Economics

Approved at meeting of
Academic Committee of
Doctoral School
of Computer Science

Approved

by Academic Director, Doctoral
School of Computer Science,
Alyona Zarodnyuk

**Programme for a Candidate of Science's Degree
Examination in Specialization
1.2.1. Artificial Intelligence and Machine Learning**



1. Field of Application and Regulatory Links

This programme has been developed in line with the programme minimum for the candidate of science's degree examination for specialization 1.2.1 "Artificial Intelligence and Machine Learning", as well as the Passport for specialization 1.2.1 "Artificial Intelligence and Machine Learning".

2. Structure of a Candidate of Science's Degree Examination

Testing format;

The examination will be held verbally.

Duration of examination:

no more than one hour

Structure of examination:

The exam is conducted in the form of a conversation in a free form on the selected examinees two items of the program from part 3 of this Program and on the topic of the dissertation research of the examinee. During this discussion, board members will pose questions.

Equipment requirements:

For face-to-face examinations, the examinee shall not require any special equipment.

If an examination is held remotely, the examination must have the right equipment, allowing them to connect to the examination process remotely, as well as a camera, microphone, online access and a device with a graphic editor, allowing them to make written comments at the request of the examination board.

Assessment of knowledge (grading):

Each of the two questions on the examination card shall be graded by the board on a 10-point scale (0-10). An answer on a topic of dissertation research shall also be graded on a 10-point scale (0-10). An overall grade for the examination on the 10-point scale (0-10) shall be set as the average arithmetic median of the three grades. Rounding off shall be arithmetic.

Criteria for grading each question on examination card	Total grade
Answer is complete, without any errors; excellent knowledge of the subject	10
Answer is complete, but with minor errors; excellent knowledge of subject	8-9
Answer is complete but features errors; good knowledge of subject	6-7



Answer is incomplete, and has errors; satisfactory knowledge of the subject	4-5
Answer is incomplete, and has significant errors	1-3
No answer provided	0

Presentation grading criteria	Total grade
Statement of research question is correct and clear	0-2
Purpose and objectives of research are correct and clear	0-2
Examinee demonstrated knowledge of the topic of their dissertation research (e.g., literature, methods, outcomes).	0-6

The final grade will be issued on a five-point scale (from “unsatisfactory” to “excellent”) as per the following conversion scale:

- “Excellent” — 8-10 (on a 10-point scale);
- “Good” — 6-7 (on a 10-point scale);
- “Satisfactory” — 4-5 (on a 10-point scale);
- “Unsatisfactory” — 0-3 (on a 10-point scale);

3. Content

1. Machine learning

Training simple machine learning algorithms to solve classification and regression problems. Classifiers. Quality metrics. Ensemble learning. Cluster analysis. Methods of visualization of multidimensional data in problems of clustering and classification.

2. Data mining.

Methods and algorithms for statistical modeling. Method of principal components and factor analysis. Support vector machine. Principal component analysis.

3. Deep learning

Multilayer neural network. Backpropagation. Convolutional neural networks. Recurrent neural networks. Modeling serial data using recurrent neural networks. Generative Neural Network Models for Synthesizing New Data: Architectures and Methods of Learning Reinforcement learning for decision making in complex environments.



4. Computer vision

Image recognition. Classical methods. Motion analysis. Image recovery. 3D reconstruction. Methods and applications.

5. Analysis and recognition of signals. Visualization in data analysis.

Speech recognition. Time series. Models, methods and algorithms. Computer graphics and virtual reality.

6. Automatic text processing

Main problems. Semantic processing of natural language texts. Methods of analysis of natural language texts. NLP technology. The word summation model. Transformation of words into feature vectors. Building vectors of words based on word2vec. Assessing the importance of words. Clearing text data. Isolation of lexemes. Dynamic Algorithms. Topic modeling with latent Dirichlet placement. Classification and clustering of natural language texts. Dictionaries of n-grams. Sentiment analysis of the text. Lemmatization.

7. Artificial intelligence

Knowledge representation methods. The logic of statements. Rules of inference. First order logic. Forward chain and reverse chain of deductive reasoning. Differences between reverse and forward chain. Reasoning in artificial intelligence. Inductive and deductive reasoning.

4. Presentation on topic of dissertation research

For the discussion of the dissertation topic, the examinee must prepare a presentation (in pptx or pdf format) on their research topic.

The presentation should consist of seven to 10 slides and include the following information:

1. Tasks to be completed;
2. Purpose of analysis;
3. Short bibliographic overview of topic;
4. Applicable methods;
5. Results (generated and forecast), which shall be presented for defence.

References

- [1] Zhou Zhihua. Ensemble Methods: Foundations and Algorithms. — Chapman and Hall/CRC, 2012.
- [2] Robert Schapire, Yoav Freund. Boosting: Foundations and Algorithms. — MIT, 2012.
- [3] Dana H. Ballard; Christopher M. Brown (1982). *Computer Vision*. Prentice Hall.
- [4] Goodfellow I and Bengio Y and Courville A. Deep Learning. —MIT Press, 2016.
- [5] Bloomfield, P. (1976). *Fourier analysis of time series: An introduction*. New York: Wiley.
- [6] Kantz, Holger; Thomas, Schreiber (2004). *Nonlinear Time Series Analysis*. London: Cambridge University Press.
- [7] Сотник, С. Л. Проектирование систем искусственного интеллекта : учебное пособие/ С. Л. Сотник. — 3-е изд. — Москва : ИнтернетУниверситет Информационных Технологий (ИНТУИТ), Ай Пи Ар Медиа, 2021. — 228 с.
- [8] Boolos, George; Burgess, John; Jeffrey, Richard C. (2007). *Computability and logic*. Cambridge: Cambridge University Press.
- [9] Bergmann, Merrie (2008). *An introduction to many-valued and fuzzy logic: semantics, algebras, and derivation systems*. Cambridge University Press.
- [10] Ronald J. Brachman, Hector J. Levesque Knowledge Representation and Reasoning, Morgan Kaufmann, 2004
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