ITMO University

Optimization Methods

Course Workload		Assessment form (examination/ graded test/ ungraded test)
ECTS	Hours	
3	108	Ungraded test

The course will introduce students to the most popular modern optimization methods in modeling and machine learning problems. As part of the course, students will learn the theoretical foundations of nonlinear numerical optimization, become familiar with meta-heuristic approaches, and also master practical skills in implementing and studying the effectiveness of optimization algorithms.

Course structure:

1. Modern optimization methods

1.1. Classic optimization methods
1.2. Some problems of classical optimization methods

2. Gradient algorithms and other classical methods

2.1. Machine learning models
2.2. Coordinate descent
2.3. Some gradient optimization problems
2.4. Gradient Descent

3. Evolutionary algorithms and swarm algorithms

3.1. Non-gradient optimization methods
3.2. Monte Carlo method. Simulated Annealing Method
3.3. Population methods. Meta-heuristic algorithms. Population algorithms
3.4. Swarm intelligence methods. Particle swarm method. Ant algorithm
3.5. Algorithms “inspired” by nature

4. Optimize with compute intensive features

4.1. Formulation of a computationally complex optimization problem
4.2. Calibration of computationally complex models. Model sensitivity analysis

4.3. Solving optimization problems with computationally intensive objective functions. Overhauled and intelligent tuning. Estimation of computational complexity. Parallel implementation of evolutionary methods
4.4. Solving practical optimization problems. Pipeline for solving an optimization problem. Optimization in the context of the model life cycle
4.5. Scalar ranking
4.6. Hybrid methods
4.7. Multi-criteria optimization

5. Model tuning using evolutionary algorithms

5.1. Setting up models. Relevance of evolutionary optimization. Problems of evolutionary optimization
5.2. Model tuning using evolutionary algorithms

6. Surrogate Modeling and Robustness

6.1. Surrogate modeling and sustainability
6.2. Kriging for multivariate functions
6.3. Surrogate methods. Application of surrogate methods in optimization
6.4. Stability of ensemble optimization. Kalman filter
6.5. Efficiency of surrogate optimization
6.6. Optimization under uncertainty
6.7. Surrogate evolutionary optimization (SaEA). Dynamic Surrogate Evolutionary Optimization
6.8. Surrogate models
6.9. Introduction to Robust Optimization