

ECOLE

Experience-based Computation:
Learning to Optimise

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ECOLE - Training Programme

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AM3	Machine Learning: Advanced topics in machine learning, covering several forms of supervised, semi-supervised and unsupervised learning, in both theories and applications.								
AM4	Multiple-Criteria Optimisation and Decision Analysis: Theoretical foundations, algorithms, and application techniques of multi-objective optimisation								
AM5	Advances in Data Mining: Recent developments in data mining for classification, regression and clustering and beyond, dealing with massive data sets. Techniques for distributed data mining (e.g., Hadoop).								
AM6	Evolutionary Algorithms: State-of-the-art in evolutionary computation; including efficient optimisation techniques (i.e., small number of function evaluations)								

* Cells in green: the course is completed by the ESR.

Objective 4.2: Additional knowledge courses to learn other fields which could be useful in the future as natural computation is a multi-disciplinary field. To achieve this objective, seven cross-domain courses were provided. All ESRs have attended the training, writing reports and passed the vivas. The description of each course and the status of whether the ESR has completed the training are given in the table below.

Table. Training Courses in Objective 4.2 and Completion Status

Course	Lead	ESR Number							
		1	2	3	4	5	6	7	8
Applied Statistics	UoB								
Statistical Inference ¹	UoB								
Combinatorial Optimisation ²	UoB								
Nonlinear Programming ³	UoB								
Animal Sensory Systems	Leiden								
Neurobiology and Behaviour	Leiden								
Genetics	UoB & Leiden								

* Cells in green: the course is completed by the ESR.

2. Training Modules in Objective 4.1

¹ Completed as part of "Applied Statistics", AM2 and AM3. Refer to the table of "Topics in AMs".

² Completed as part of AM1. Refer to the table of "Topics in AMs".

³ Completed as part of AM1 and AM4. Refer to the table of "Topics in AMs".

The training details of each core module are described in this section.

AM1 and AM2 took place between January 14th to June 12th, 2019. The training was provided online by the University of Birmingham. Each ESR submitted a report for assessment, followed by a viva that involved questions covering the course content and the report. Prof. Thomas Bäck (Leiden University), Prof. Xin Yao (University of Birmingham), Dr. Zhao Xu (NECLE), Dr. Stefan Menzel (Honda) examined the vivas.

AM3, AM4, AM5 and AM6 took place in the autumn term in 2018 (September to December, 2018). AM3 was provided online by the University of Birmingham. AM4 to AM6 were provided online by Leiden University. Each ESR submitted a report for assessment, followed by a viva that involved questions covering the course content and the report. Prof. Thomas Bäck (Leiden University), Prof. Xin Yao (University of Birmingham), Dr. Zhao Xu (NECLE), Dr. Stefan Menzel (Honda), Dr. Leandro Minku (University of Birmingham) and Prof. Peter Tino (University of Birmingham) examined the vivas.

The topics covered in the AMs are summarized in the table below.

Table. Topics in AMs

Module	Covered Topics
AM1	<ul style="list-style-type: none"> • Randomised algorithms • Optimisation problems and local search • Stochastic local search • Evolutionary algorithms • Constraint handling • Swarm intelligence and particle swarm optimisation • Niching and speciation • Multi-objective optimisation, combinatorial optimisation • Nonlinear/genetic programming
AM2	<ul style="list-style-type: none"> • Linear algebra • Principal components analysis • Statistical analysis • Latent semantic analysis • Self-organizing maps • Page rank • Gaussian mixture models
AM3	<ul style="list-style-type: none"> • Bayesian regression, multivariate regression • Selecting and evaluating models, regularisation • Classification: curse of dimensionality, linear and quadratic discriminant analysis • Unsupervised learning

	<ul style="list-style-type: none"> • Ensemble learning methods
AM4	<ul style="list-style-type: none"> • Mathematical programming and complexity • Multicriteria decision analysis • Orders and pareto dominance • Multicriteria landscape analysis
AM5	<ul style="list-style-type: none"> • Recommender systems • MapReduce • Mining data streams • Similarity search
AM6	<ul style="list-style-type: none"> • Optimisation and evolutionary algorithms basic concepts • Genetic algorithms: theory and applications • Evolution strategies: self-adaptation, theory and applications • Genetic programming

3. Training Courses in Objective 4.2

Courses under Objective 4.2 are served to broaden ESR's horizon such that they are aware of developments in other related areas. The training details of each course are described in this section.

"Applied statistics" was replaced by a purposely designed training course called "Statistical Comparison of Algorithms", which is more tailored to ESRs' research needs in statistics and its use in engineering research and practice. It also covered part of the "Statistical Inference" course. The course was provided as part of the ECOLE workshop and project check meeting during May 20th-22nd, 2019, hosted by the University of Birmingham, and at the ECOLE Summer School hosted by the Leiden University during July 29th-30th, 2019. All ESRs have attended the course with records.

The content of "Animal Sensory Systems" and "Neurobiology and Behaviour" are combined in one large course, called "Cognitive Neuroscience in AI", because this new course is more appropriate and relevant to the ECOLE project than the former ones. It took place between October 23rd, 2020 to March 8th, 2021. The training was provided online by Leiden University. It covered more than the original proposed content, including a wide range of topics in cognitive neuroscience to explain neuronal activity and behaviour of the brain, such as cognatic neuroscience processes, magnetic resonance imaging, taxonomy of brain manipulation methods and motor control and pattern generator using sensors, muscles and neuronal computations. Each ESR submitted a report for assessment, followed by a viva that involved questions covering the course content and the report. Prof. Thomas Bäck (Leiden University) examined the vivas.

The "Genetics" module took place between February 1st to May 14th, 2021. The training was provided online by the University of Birmingham. Each ESR submitted a report for assessment,

followed by a viva that involved questions covering the course content and the report. Prof. Xin Yao (University of Birmingham) and Dr. Shuo Wang (University of Birmingham) examined the vivas.

