SMAGRINET
POWERING SMART GRID
EXPERTISE IN EUROPE

Module I

Artificial Intelligence (AI) in Smart Grids

Module structure, Teaching methods, Intended outcomes, Assessment

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Content of the presentation

1. Structure of the module
2. Main topics of the lectures
3. Project work
4. Seminars
5. Intended learning outcomes
6. Assessment
7. Readings

Structure of the module

1. Lectures (16 h)
2. Project/Practical work (12 h)
3. Seminars (4h)

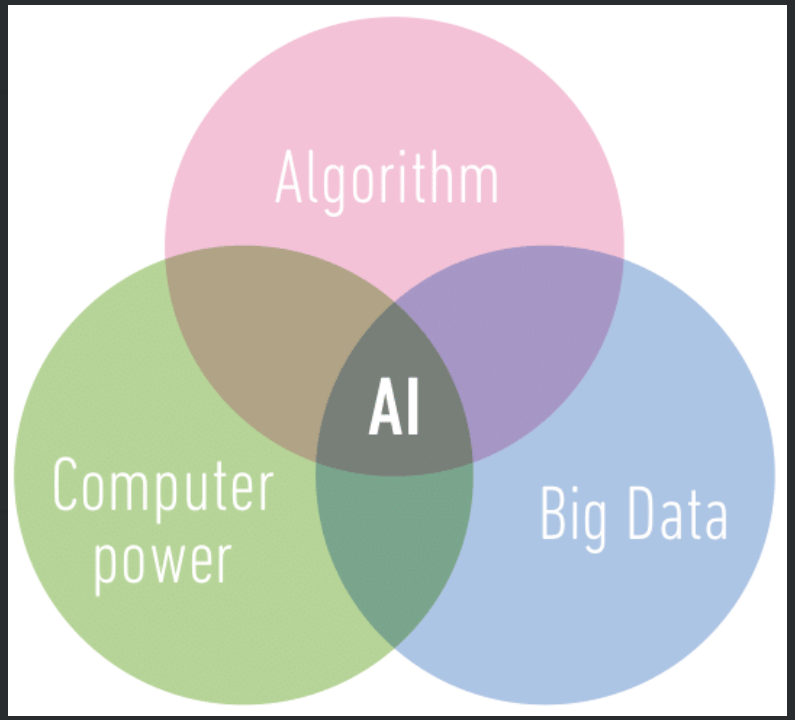
Main topics of the lectures

1. What is AI and why AI is taking off now? (1 h)
2. Data representation, exploration and visualization (1 h)
3. Linear and nonlinear models (2 h)
4. Deep learning (1 h)
5. Generalisation issues in modelling (1 h)
6. Model assessment and selection (1 h)
7. Unsupervised learning (1 h)
8. Applications of AI in smart grids (8 h)

What is AI?

- An AI system should demonstrate at least some of behaviours associated with human intelligence:
  - planning,
  - learning,
  - reasoning,
  - acting in complex environments,
  - …

Why AI is taking off now?



Data representation, exploration and visualization

- Data types: scalar, vector, matrix, image, time series
- Feature extraction
- Data normalization
- Mapping from high to low dimensional spaces

Linear models

- Linear regression models based on
  - pseudo-inverse
  - gradient descent
- Linear classification models
  - Bayes optimal decision rule,
  - Linear Gaussian classifier

Nonlinear models

- Polynomial models
- Kernel regression
- Quadratic Gaussian classifier
- k-NN classifier
- Multilayer perceptron
- Support vector machine
- Decision trees
- Random forests

Deep learning

- The difference between traditional and deep models.
- Topology of deep convolutional neural networks (CNN).
- Examples of CNN.
- Deep autoencoders.

Generalization issues in modelling

- Model family.
- Model complexity.
- Model bias and model variance.
- Model bias & model variance trade-off.
- Controlling over-fitting.

Model assessment and selection

- Model quality greatly depends on the model assessment and selection method
- Estimating generalization error
  - Cross-validation
  - K-fold cross-validation
  - Leave-one-out estimate
  - Bootstrapping
- Model selection
  - Comparing regression models
  - Comparing classification models

Unsupervised learning

- Data clustering
  - k-means clustering
  - Fuzzy C -means clustering
  - …
- Mapping from high- to low-dimensional spaces
  - Self-organizing maps (SOM)
  - Multidimensional scaling
  - Auto-encoder
  - …

Applications of AI in smart grids (8 h)

1. Load and power prediction
2. Energy demand management, balancing power market
3. Consumer and consumption insights
4. Energy trading
5. Energy management systems, yield optimisation
6. Predictive maintenance
7. Cyber security, power system protection

Project/Practical work

Projects

- Projects are done in groups of two students.
- Projects concern application of AI technologies.
- Regression or classification tasks are usually solved within the projects.
- Project results are to be presented for the class.
- A short project report need to be submitted as well.

Practical work

1. Data representation, exploration and visualization (1 h)
2. Linear and nonlinear models (1 h)
3. Generalisation issues in modelling (1 h)
4. Model assessment and selection (1 h)
5. Applications of AI (8 h)

Seminars

1. A set of research articles on AI applications in smart grids is prepared by the course responsible.
2. Each student must select an article and give a seminar (about 15 mins).
3. In addition, each student must formulate at least one question for each of at least two articles, different from the one s/he is going to present.
4. The questions are to be emailed to the seminar leader before the seminar starts.

Intended learning outcomes

- After completion the course, the student:
  - Understands the principles of machine learning and has knowledge of main machine learning methods;
  - Is able to create and validate AI-based models;
  - Can analyze modeling results;
  - Is able to use the models for solving practical tasks arising in smart grids;
  - Can read and comprehend research articles in this area.

Assessment

1. Lectures
   - Oral examination, (40% influence)
1. Project
   - Written report & Oral presentation for the class, (40% influence)
1. Seminars
   - 15-20 min long presentation for the class. Formulation of questions for at least two articles, (20% influence)

Readings

1. Description of the course “AI in smart grids” given at Kaunas University of Technology.
2. The set of articles on AI applications in smart grids.
3. G. James, D. Witten, T. Hastie, R. Tibshirani, An Introduction to Statistical Learning, with Applications in R, 7th Printing, 2017 Edition, Springer, New York, 2017.
4. Hal Daume III, A Course in Machine Learning, 2nd Edition, Self-published, 2017.

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