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SMAGRINET

POWERING SMART GRID
EXPERTISE IN EUROPE

his project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 837626

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Manual for

ARTIFICIAL INTELLIGENCE IN SMART GRID MODULE

PROGRAMME
H2020

CONTRACT NUMBER
837626

DURATION
30 Months

START
April 2019

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Main Contributor(s)

Name	Organisation
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1. Introduction

Based on the material prepared for the blended programme the trainers manual for the short-term programmes have been developed under the SMAGRINET project. The methodological manual package includes support for the trainers for the up-take of the capacity building programme (module).
These manuals are available as online resources for the enrolled universities and representatives and are easily accessible for the Trainers and universities that have joined the SAMGRINET HUB.

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2. Objective of the module

2.1.1. Learning outcomes

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

2.1.2. Aims as a lecturer

1. Motivate students to understand the value of AI for the high penetration of renewable energy sources.
2. Make them understand the fast development of digital technology and cloud computing.
3. Motivate them to try their hand in exploiting extensive measurement campaigns and permanent monitoring (smart meters).
4. Ease the stress of engaging the exponential growth of data (“Big data”).
5. Make them understand that a novel framework and techniques (AI) to excavate useful information in fast and comprehensive way are required in the future workforce.
6. Provide them with new vision to perceive and Teaching material.

2.1.3. Lecture register

1. What is AI and why AI?
2. Data representation, exploration and visualisation
3. Linear models
4. Nonlinear models
5. Deep learning
6. Generalisation issues, model assessment and selection
7. Unsupervised learning
8. Applications of AI and conventional technologies:
    - Demand management, load forecast, power prediction, yield
    - optimisation
    - Consumer and consumption insights, virtual agents, predictive
    - maintenance
    - Participation in energy markets
    - SCADA/EMS systems
    - Cyber security, power system protection

2.1.4. Types of materials and methods used in the lecture

10 lecture files will be provided to you after the completion of traind-the-trainer program and contractual agreements between the SMAGRINET consortium and the faculty of your University.

- Oral examination forms 40% of the grade.

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A project

- Projects concern application of AI technologies. You will do projects in groups of two students.
- Results: Written report & oral presentation (40%)

Seminars (1 each student)

- Each student has to give a seminar (15 mins). Seminars will
- be on applications, typically based on research papers.
- Material is provided by the course responsible.
- Evaluation (20%)
- SMAGRINET can provide assistance but the final material is provided by the course representative.

The course consists of lectures, project, and seminars. The course is of 6.0 p split into 2.5 p for lectures, 2.5 for projects, and 1.0 hp for seminars.

In addition to lectures, the recommended text books including web based materials are available in the indexes of lectures.
You may also use the vídeos from the SMAGRINET Youtube channel or other vídeo recordings if they are available and help with the illustration of the material.

2.1.5. Timeframe or preparation

Six Months Prior

- Familiarise the module or course goals and re-determine course content.
- Begin reviewing your arsenal of possible supportive material such as:
  - The latest EU policy summaries of new directives.
  - Relevant material regarding your national trends and comparative material with the EU.

THREE MONTHS PRIOR

- Begin to develop course schedule and syllabus.
- If you have had prior experience re-evaluate your teaching methods and tools at your disposal (excel, CAD and others)
- Determine the dates when you will evaluate student learning: you're your assignments and exams accordingly.
- Organise updated text(s) and other materials, including films, videos.
- If planning to use instructional technology or multimedia equipment, reserve a classroom that has all the necessary components.
- If possible for seminars – contact guest speakers.
- If possible - arrange field trips and other activities

One Month Prior

- Refine the course syllabus for the concrete semester (might have moved).
- Seek training or consult with SMAGRINET on the possible developments the on how to use updated instructions or other related topics.

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DURING AND AFTER

- Take a few, brief notes after every class session; these notes will remind you of what went well and what you would like to change after the course has concluded for next year.
- Review student evaluations.
- Refine the course design, responding to student evaluations and reflecting on your own evaluation of the course.

2.2. Guidance for the Teacher related to the lectures

2.2.1. Lecture material

What is AI, Data representation, exploration

Format of the course (lectures, seminars, projects, examination), goals, content, literature [1, 2, 3], short introduction into artificial intelligence (AI), why AI is taking off now, data representation, data mapping from high to low-dimensional spaces, visualization.

Linear and nonlinear models

Linear models: Formal description of classification and regression tasks, assumptions, notations, linear regression, error function, ridge regression, gradient descent, Bayes rule, linear Gaussian classier, training a linear classier by gradient descent.

Nonlinear models: assumptions, polynomial models, kernel regression, quadratic Gaussian classier, k-NN classier, multi-layer perceptron (MLP), support vector machine (SVM), decision trees, random forests.

Deep learning

What is deep learning: learning hierarchical representations, topology of deep convolutional neural networks, some related theory, deep autoencoders.

Generalisation, model assessment and selection

Model family, model bias and model variance, bias and variance trade, estimating the generalization error, cross-validation, K-fold cross-validation, model comparison and selection, controlling overting, early stopping, regularization, committees, growing & pruning, variable selection, dropout.

Unsupervised learning

Definitions and tasks, clustering, K-means clustering, fuzzy C-means clustering, mapping from high- to low-dimensional spaces, auto-encoder,

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self-organizing maps (SOM), multidimensional scaling (MDS), deep auto-encoder.

Applications: demand management, load and power prediction

Demand management, demand response methodology, dynamic pricing, load forecast, day-ahead load forecast, day-ahead prediction of power generated by solar power plant, yield optimisation. The lecture is based on the following articles [4, 5, 6, 7, 8].

Applications: consumer insights, predictive maintenance, virtual agents, 2h Smart meters, consumption insights - single household perspective, incentive-based demand response, predictive maintenance { power consumption anomaly detection, virtual agents { electricity-theft detection. The lecture is based on the following articles [9, 10, 11, 12].

Applications: participation in energy markets

Wind power plant participation in energy pool market: approach and framework, optimization under uncertainty, objective function, results; Participation in frequency containment reserve market: tasks and operations, data exploration, extracted features, results. The lecture is based on the following articles [13, 14].

Applications: SCADA/EMS, cyber security, power system protection

What is SCADA/EMS?, using SCADA data for solar power forecasting, smart building EMS example, cyber security, power system protection: detecting false data injection attacks, detecting disturbances and cyber-attacks, intrusion detection in SCADA. The lecture is based on the following articles [15, 16, 17, 18, 19].

2.2.2. Seminars

Presenting articles

Students are expected to present scientic articles in the area of machine learningbased techniques used in smart grids. Each student has to give a seminar (about 15 mins). Material for the seminars is provided by the course responsible. Students may choose an article from the topic they are interested in.
You may also suggest an article outside the set of articles provided by the course responsible.
Students are expected to prepare 12-15 slides for the presentation.
When reading and presenting a paper, students may focus on the:
objectives, methods, results, conclusions and scientific contribution.
Other machine learning techniques than the ones discussed at the lectures may be included in the articles. To understand these techniques better it might be necessary to follow up reference articles.

One of the key aspects when presenting an article is to keep within the

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time you have been assigned to talk. The seminar leader will inform you about the time constraints.

Questions from students for other students

To accumulate material for discussion students are expected to formulate at least one question for each of at least two articles, different from the one They themselves as a participants are going to present at their seminar. The questions are to be emailed to you as the seminar leader before the seminar starts.

2.2.3. Kinds of projects

You will do projects in groups of two students. Each group shall do a classification or regression project. However, other kinds of projects are possible, solving some optimisation task, for example. Discuss this issue with course responsible at the beginning of the course.

The project will be performed in MATLAB, other tools can be used aswell. Results are to be presented in a report and orally for the class. Below given is a list of steps usually taken when accomplishing a typical classication or regression project.

After a few weeks from the course start a project seminar will be arranged. During the seminar students will be asked to give a short presentation of project results achieved so far. The detailed project material is explained in the teaching material.

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3. Teaching model

3.1.1. Teaching with the lectures method

The SMAGRINET lectures are an immensely effective tool for your classroom as they have been previously piloted in the classroom, allowing you as an instructor to provide an overarching theme with pre-organizes material in an illuminating and interesting way.
You as the instructor must take care, however, to shape the lecture for the specific audience of students who will hear it and to encourage those students to take an active and immediate part in learning the module.

CREATE A COMFORTABLE, NON-THREATENING ENVIRONMENT.

Introduce yourself and explain your interests in the topic on the first day. Encourage questions from the outset. For example, require each student to submit a question about the course during the first day or week. Students can submit these questions via an online discussion forum, such as that which is available on Moodle.

REVIEW AND PRACTICE THE LECTURE BEFORE CLASS BEGINS.

After writing the lecture, leave at least 30 minutes before your class to organize your thoughts and gather any material you need. Practicing the lecture will help you identify points where you will want to slow the pace, pause, or offer a summary or a question.
.
Make sure your tech works
If you do not have an assigned classroom or have had prior bad experience with projectors at your assigned classroom, especially regarding connecting them – make sure that you have somebody at hand or you are there early enough to get the nuisance of connection problems out of your way.

If you have chosen to do your lectures online – makes sure that you send the invitation of the digital online class with a 15 minute spare time prior to the agreed start time of the lecture. This allows for students to get into the lobby of the online platform that you are using and they are able to work out their audio-visual problems that might occur. This gives you vital time to make sure that your own microphone is working and your presentations are ready to be presented.

INTERACT WITH YOUR STUDENTS.

Arrive to class early, especially on the first day, and greet students who are already in the room. Students will feel more comfortable asking you questions and will feel more engaged in the topic of the course if they have an opportunity to interact with you in this way. If time does not permit for students to approach you for questions before or after the lecture, encourage them to see you during office hours.
The more an instructor interacts with the students during a lecture, the more active the learning will be. The judicious use of questions throughout a class session can move the lecture forward, engage the students, increase the use of higher-order thinking processes, and make the lecture more interesting.

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3.1.2. Suggestions

PREPARING

- Create a comfortable, non-threatening environment.
- Organize the lecture like a good speech.
- Prepare notes that will serve as a “road map” rather than a script to be read verbatim.
- If you are team-teaching, talk with co-instructors or TAs often to ensure coherence among lectures, discussions sessions, and office hours.
- Review and practice the lecture before class begins.
- If you plan to use tech for your lectures – make sure they work

DURING THE LECTURE

- Interact with your students.
- Provide students a clear sense of the day’s topics and their relation to the course as a whole.
- Show passion for the subject.
- Focus on communicating with your audience: speak clearly; move around the room, and use gestures to engage student attention.
- When asking questions, do not be afraid of silence.
- Demonstrate respect for, and interest in, student ideas and questions.

10 COMMON MISTAKES TO AVOID

- Trying to cover too much material in one class session.
- Not including opportunities for questions or active learning.
- Waiting until the last two minutes of class to ask and answer questions.
- Answering your own questions or asking more than one question at once.
- Assuming students are learning the material if they are not asking questions.
- Assuming that students will identify and understand the important points of each lecture.
- Reading your notes or the content of your slides when using slide-ware such as PowerPoint.
- Not looking at the students when you are lecturing; looking only at your notes or the chalkboard.

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4. Grading and feedback

You should diligently follow the grading criteria, procedures, and policies developed by SMAGRINET. In addition, you should keep in mind that you will be on the “front line” for student questions and concerns about grading. Therefore, it is essential that you communicate early and often with the course instructor about all aspects of the grading process, so that you can answer questions and concerns that are likely to be posed by students.

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5. General approach to teaching

It has been taken into account that the need to add some readings and classroom discussions help students understand their vital role in the learning process.

nN order to avoid problems with attendances, uncompleted reading assignments, and student focus on grades rather than learning it is important to make sure that students recognize the value of what they are learning.

One of the safest ways of connecting and providing insight to students is to reference each topic back to The Green Deal. The Green Deal provides the course for the EUs economy and at the end of the day it will directly affect the industry, society and the environment physically around the students.

5.1.1. The Green Deal

The European Green Deal provides an action plan to:

- boost the efficient use of resources by moving to a clean, circular economy
- restore biodiversity and cut pollution

The plan outlines investments needed and financing tools available. It explains how to ensure a just and inclusive transition.

The EU aims to be climate neutral in 2050. It has been proposed at the European Climate Law level to turn this political commitment into a legal obligation.

Reaching this target will require action by all sectors **which your students will be fulfilling** and play a part in the following years to come:

- **investing in environmentally-friendly technologies**
- **supporting industry to innovate**
- **rolling out cleaner, cheaper and healthier forms of private and public transport**
- **decarbonising the energy sector**
- **ensuring buildings are more energy efficient**
- **working with international partners to improve global environmental standards**

- The EU will also provide financial support and technical assistance to help those that are most affected by the move towards the green economy. This is called the Just Transition Mechanism. It will help mobilise at least €100 billion over the period 2021-2027 in the most affected regions.

All in all, the Green Deal asks your students to be bold and take action as they are educated and if they are educated, they should know that if they understand the flow of the future in the energy and environmental sector they will have a bright future.

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6. Motivation of the students

Some students worry about grades; others need to satisfy a course prerequisite. Still others want to learn and explore ideas. In fact, many students are probably motivated to learn and to succeed by a combination of intrinsic and extrinsic elements. The key for us as teachers is to understand what we can do to build students' motivation to learn in our classroom, and to nurture the intrinsic motivation that will guide future learning.

Teachers often assume that, because they are"teaching," students must be learning. Students assume that, because they have read their textand memorized facts, they have learned something.

We know that students respond positively to three elements in most classes:

· A well-organized course;

· A teacher who is enthusiastic about the material and about teaching;

· A teacher who shows he or she cares about the students and their learning.

Communicate high but attainable expectations and goals. Most students want to be challenged and feel that they are directing their energies toward a worthwhile experience.

This means that they will work to achieve challenging goals if they view the goals as within their reach. True, some students are motivated by the fear of the daunting "killer test," but you will lose more students than you gain, and those you gain will not retain their motivation outside of the classroom.

6.1.1. Motivation during your module

Create a learning community in your classroom

Interaction, particularly with peers, is an important motivator for many students. There are several easy steps you can take to create an environment where students see themselves as part of a community of learners rather than as isolated individuals.

Things maybe looked upon from different point of views

Reward success publicly. This does not need to be an elaborate effort. Thank students for their comments, compliment good points by saying "good point," and refer back to individual students for their contributions when you can.

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Share exemplary work with students

Copy, distribute (without names and with permission) and discuss outstanding research papers or assignments. This helps students see your standards and it recognizes students who do outstanding work.

Use collaborative/cooperative learning groups

Students respond to interaction with their peers. Putting students in groups can therefore promote their learning.

Know your students and their interests

If you know who your students are and what they are involved in, you can adjust your class to connect with their interests. This can help them see the relevance of the material and motivate them to engage in class.

Some students can't be motivated

When you feel this way (and you will), it is important to remember that, for students, our course is one small component of their lives (Luce, 1990).

They are taking other courses, making friends, participating in activities, working to pay their way through school, and even taking care of families. In short, they are leading complex lives that affect how much energy and attention they can give to our classroom.

There is a limit to just how much we can actually motivate students. But it is also important not to stop trying because you may find that they actually will appreciate the efforts you have made.

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6.1.2. Simple tips to keep in mind

There are simple solutions for quickly motivating and supporting students during the modules:

1. State clearly and explicitly what students need to do to receive an "A" in your course.
2. Get to class early and talk with your students about what they are doing in school, what they hope to learn, and what they are really enjoying.
3. Find simple ways (a comment to the class, a remark to a student after class, an e-mail) to recognize student contributions and excellent work.
4. Give students examples of ways in which class concepts relate to "real world" matters.

6.1.3. Lecturer suggestions during class sessions

Arrive early, start on time, and end on time.

Showing your respect for everyone's time will encourage your students to do the same. Arriving at the classroom early will allow you not only to set up for class but also to talk with students informally. This informal interaction will help you establish a rapport with your students, which will in turn help them feel confident to participate in class and to ask for help when they need it.

INTERACT WITH STUDENTS; INCLUDE OPPORTUNITIES FOR ACTIVE LEARNING.

Demonstrate from the first class that you are interested in what students are thinking. Include plenty of opportunities for students to ask and answer questions. While a lecture course will provide fewer opportunities for interaction than a discussion course, you will find that students will be able to learn and retain more material if you pause every 15-20 minutes to ask questions or to ask students to apply a theory, solve a problem, or discuss a debated point.

SHOW PASSION FOR THE SUBJECT AND FOR YOUR STUDENTS' LEARNING.

One of the most effective ways to inspire your students to learn is to show that you are truly interested in, and excited about, the course content and their learning.

BE FLEXIBLE.

Be prepared to have good days and bad days in the classroom. If you are not getting good results teaching in a particular way, try something new. For example, if the students in your discussion or recitation section are extremely quiet, break them up into smaller groups to solve a problem or answer a set of questions.

IF STUDENTS APPEAR BORED, INCLUDE MORE OPPORTUNITIES FOR ACTIVE LEARNING.

Pause in the middle of class to have students ask and answer questions, provide examples, or solve problems. Do not assume that students look bored because they know the material and then decide to speed up your pace; it may be instead

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that they are having trouble understanding what you are presenting to them. It may also be that they are sleep-deprived, as college students often are.

IF YOU DO NOT KNOW THE ANSWER TO A QUESTION, SAY SO.

Tell the students that you will find an answer, and then get back to them. Present the answerto the entire group during the next class; do not let the matter drop. You do not need to be allknowing to maintain your credibility. One way to lose it, in fact, is to bluff by giving an answer of which you are unsure and that students may later find out to be untrue. Model intellectual curiosity and honesty. Your enthusiasm to learn something new will inspire your students to follow your example.

WHEN ASKING QUESTIONS, DO NOT BE AFRAID OF SILENCE.

Often, silence means that students are thinking. Do not give in to the temptation to end the silence by answering your own questions, which will only convince students that if they wait long enough, they will not have to think because you will supply the answers for them. Wait 5-10 seconds for an answer. If, at that point, you are getting blank stares and quizzical expressions, rephrase your question. (For additional questioning strategies, see Asking

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