ARIS PROJECT

AI SKILLS FOR ICT PROFESSIONALS

(O2-T1_a)

Definition of ARIS learning units

BT

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Acronyms and abbreviations

AI	Artificial Intelligence
ARIS	Artificial Intelligence Skills For ICT Professionals
DL	Deep Learning
E-CF	European e-Competence Framework
EU	European Union
EQF	European Qualification Framework
ICT	Information and Communications Technology
I-VET	Initial Vocational Education and Training
M. Sc.	Masters of Science
MOOC	Massive Open Online Course
ML	Machine Learning
NN	Neural Network
OER	Open Educational Resources
VET	Vocational Education and Training

1 Introduction

The second intellectual output of the ARIS project includes tasks which help to define the specifications (i.e. learning outcomes) for the ARIS course curriculum. Accordingly, we have carried out a field research and a desk research which the results were published in the following documents:

- **ARIS_O1-T4_a1_ Analysis of evidence (field research)_2020_01_12.docx**[1]
- **ARIS_O1-T4_a2_ Analysis of evidence (desk research)_2020_02_13.docx**[2]

The first document provides the analysis of the results of the online questionnaires (field research), while the second document provides the analysis of the results of the skill matching between AI skill demand and AI skill supply (desk research). Based on this research learning outcomes were defined and published in the following document:

- **ARIS_O1-T4_b_Definition of ARIS Learning Outcomes_2020_04_26.docx**

The above document provides a comprehensive report of learning outcomes which are "statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and competences". It also gives some guidelines on how to prepare corresponding learning lessons.

This report provides the definition of ARIS learning lessons. It is based on the results of the abovementioned deliverables. It represents the outcome of the O2-T1_a deliverable, namely "ARIS Learning Units Report" (O2-T1-a). The report is structured as follows:

[1] https://freedcamp.com/ARIS_partnership_COV/ARIS__Artificial_J91/files/versions/8017345
[2] https://freedcamp.com/ARIS_partnership_COV/ARIS__Artificial_J91/files/versions/8289990

- **Section 2**. Reviews the Learning Outcomes structured into 4 units
- **Section 3.** Makes some global consideration on the Course Structure
- **Section 4**. Presents the Learning Lessons of each unit.

2 ARIS Learning outcomes

Previous ARIS tasks have structured the course learning outcomes in 4 Units as follows:

- **Learning Unit 1**: Foundations of Artificial Intelligence
- **Learning Unit 2**: Machine Learning
- **Learning Unit 3**: Neural Networks and Deep Learning for vision
- **Learning Unit 4**: Deep learning for Natural Language Processing and Big Data analysis

The learning outcomes of each module are specified hereafter, in Table 1 to 4, in terms of knowledge, skills and competences. These correspond to statements of what ICT professionals should know, understand and be able to do upon the completion of the ARIS course.

Table 1: ARIS Unit 1 learning outcomes

Learning Unit 1	**Foundations of Artificial Intelligence**		
Learning outcomes correspond to EQF Level 4	Defines the essential AI characteristics. Addresses the fundamental features of AI applications.		
	Knowledge	**Skills**	**Competence**
	Knows / Aware of: - Definitions of Artificial Intelligence - Main topics and areas of Artificial Intelligence - Methods for problem solving using search algorithms - Methods for knowledge representation using logic and probabilistic formalisms - Methods for Machine Learning - Applications of Artificial Intelligence - Ethical implications of AI	Able to: - Explain the scope of AI differentiating applications from methods and techniques - Identify a potential application of AI and critically chose the AI sub-field that may be applied - Provide examples of problems that must be addressed with deterministic or probabilistic AI methods - Differentiate the knowledge representation, learning and reasoning components in a given AI system. - Explain the ethical implications of an AI deployment and anticipate the ethical dilemmas that may have to be addressed.	Capable to: - Give an account of the main methods used in AI solutions and the main areas where AI has been successful - Autonomously explain the benefits and risks of AI solutions in terms of performance, accuracy - Examine a suitable real-world problem and abstract its elements to suit one of the AI paradigms

Table 2: ARIS Unit 2 learning outcomes

Learning Unit 2	Machine Learning		
Learning outcomes correspond to EQF Level 4	Defines the foundations for Machine Learning. Teaches how to select the right ML model and to implement it in a given domain.		
	Knowledge	**Skills**	**Competence**
	Knows / Aware of: - Typology of Machine learning problems (supervised vs unsupervised, classification vs regression) - Theoretical principles of Machine Learning - Data transformation and visualization - Principles and methods of linear ML for classification and regression problems - Principles and methods of nonlinear ML for classification and regression problems - Principles and methods of unsupervised ML - Evaluation of Machine Learning models - Languages and resources for ML	Able to: - Provide examples of the different ML types of problems - Identify the ML component in a software system - Communicate the potential of ML methods critically telling advantages and disadvantages with respect more traditional approaches - For a given problem, formalize requirements of a ML solution, collect the set of methods that may be applied and critically design a plan to test and evaluate the different alternatives - Identify languages and other resources for specific ML applications - Recognize the relevant data by choosing the right visualizations and the right transformation from raw noisy data. - Design a plan for testing a ML solution, evaluate its performance and validate its accuracy.	Capable to: - Evaluate the feasibility of implementing a suitable ML algorithm in a novel domain - Provide expertise on a detailed plan to gather the right data, develop the right algorithm taking advantage of existing resources and conducting a suitable validation. - Examine a given problem, identify the component that may be formalized as a ML task and recognize the appropriate typology that is more suitable

Table 3: ARIS Unit 3 learning outcomes

Learning Unit 3	**Neural Networks and Deep Learning for Vision**		
Learning outcomes correspond to EQF Level 4	Provides the knowledge, skills, and competence to apply big data analysis to large datasets and deep learning to Natural Language Problems.		
	Knowledge	**Skills**	**Competence**
	Knows / Aware of: - Brain origin and elements of neural networks: neurons, architectures (feedforward, recurrent) with linear algebra - Perceptrons and supervised learning: gradient-descent learning, batch learning (Python) - Multi-Layer Perceptrons and supervised DL for regression and classification - Deep learning architectures for image processing: Convolutional NN - Keras applications for object recognition - A use-case application for object localisation	Able to: - Code a neuron activation, sigmoid/ReLU, and NN spreading - Code and train a perceptron from scratch to solve a basic classification problem (AND/OR) - Implement a deep NN with Keras - Implement a convolutional NN with Keras - Solve problems of object recognition with a NN and Keras - Solve problems of object localisation with NN and Keras	Capable to: - Classify different types of problems where different types of NN and DL are applicable. - Plan the features of the chosen models to solve a specific problem with NN/DL. - Select and prepare data to face a specific problem with NN and DL. - Use suitable resources to implement specific NN and DN solutions for a given problem. - Improve models iteratively (meta-parameters, overfitting/bias, performance), and make decisions on data, to face a given problem.

Table 4: ARIS Unit 4 learning outcomes

Learning Unit 4	Deep Learning for Natural Language Processing and Big Data Analysis		
Learning outcomes correspond to EQF Level 4	Provides the knowledge, skills, and competence to apply deep learning to Natural Language Problems and Big Data analysis to large datasets.		
	Knowledge	**Skills**	**Competence**
	Knows / Aware of: - Deep learning architectures for natural language processing: text embeddings - Deep NN for Natural Language Processing - Deep learning for sentiment analysis - Big data: problems, core techniques, and introduction to Hadoop - Big data: Hadoop and Spark for data processing - Big data: main analytics, visualisation and applications	Able to: - Implement methods and techniques for text embedding - Develop and test NN for Natural Language Processing - Develop and test NN for sentiment analysis - Recognise different big data problems and choose the techniques for their solution - Perform analytics of large datasets with Hadoop and Spark - Collect, clean, store, manipulate, analyse and visualise large datasets	Capable of: - Frame and solve problems that can be solved with NLP techniques - Apply suitable methodologies and libraries for NLP applications of different types - Apply sentiment analysis to real problems - Frame and solve problems that can be solved with big-data techniques - Apply suitable methodologies and libraries for big data analysis to large databases of different types

3 General Concerns on the Course Structure

It is impossible for a course of such depth to be completely self-contained. Artificial Intelligence is a field within Computer Science, so it requires some programming skills. An AI practitioner may have to use libraries and even modify code. In ARIS we stick to the Python programming language because some of the most popular resources are based on it. Although ARIS is being designed as a very practical course we consider that some algorithms must be presented algebraically because only then they are communicated and analyzed with certain precision. It is unlikely that an ICT professional will implement the algorithms from scratch, but we consider that it is important that a practitioner knows the essentials. Finally, the *value/quality* of some outputs must be characterized in terms of probability because only then managers may use them properly in Decision Making.
From our analysis, we have identified three topics that the learner must have basic knowledge of before starting the ARIS course. They are:

1. Programming with Python
2. Linear Algebra
3. Probability Theory

Most learners will already have this background from their previous studies and they will not have any problem following the ARIS course. However, other learners may have diverse backgrounds and they may need to review these topics. The course will include links to recommended resources that students can check in case they need to. The linked resources will be mainly in English, but the topics are so general that it will not be hard to find similar resources in any of the languages covered by the course.

As a guideline, each one of the units is assumed to have a workload of 12 hours for a prototypical student. Units are broken into lessons, each lesson having a set of lecture notes, slides, and self-contained examples (use cases).

For the purpose of evaluation, each lesson also contains some Questions & Answers and Multiple Choice Quizzes.

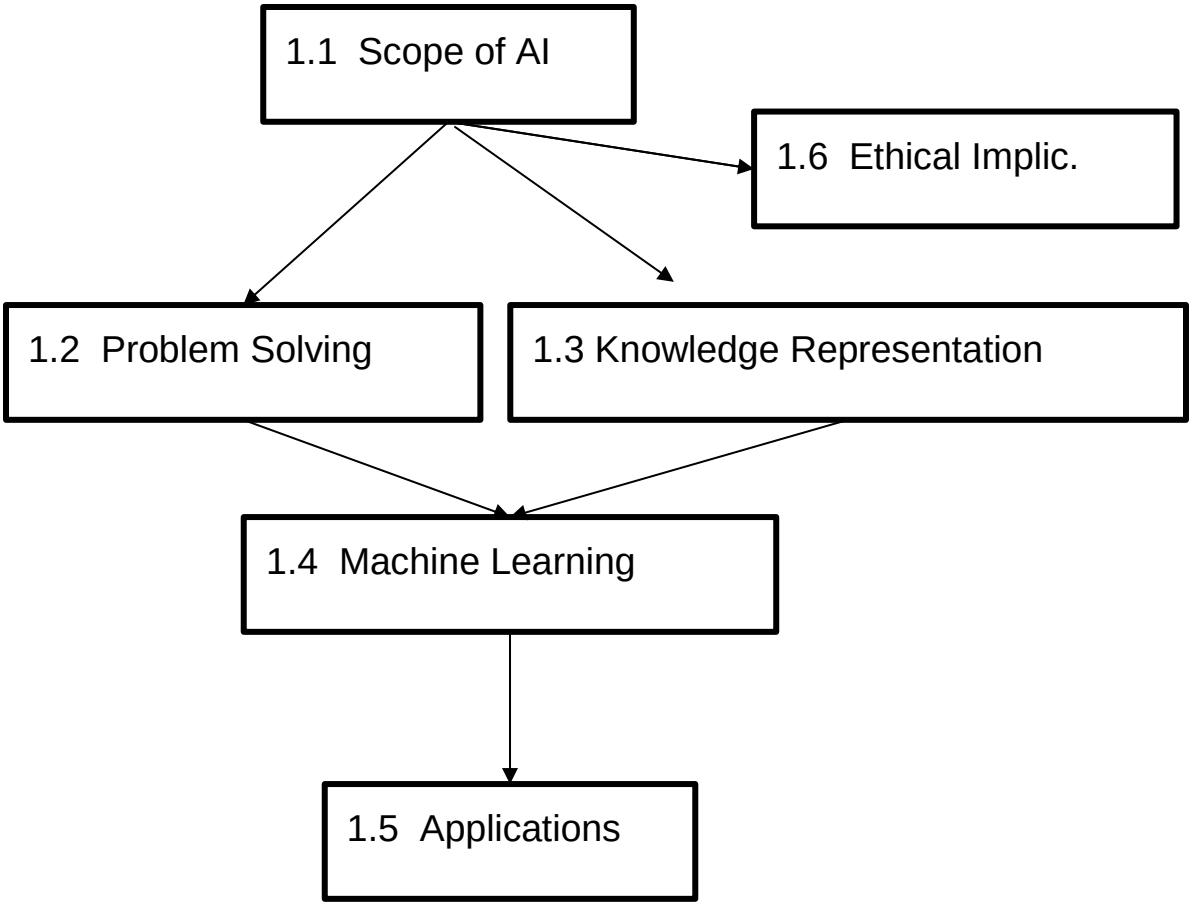
All learning material will be made available in all the languages of the partnership. That is: French, Italian, Spanish, Greek and Lituanian.

4 Formulation of learning units in lessons

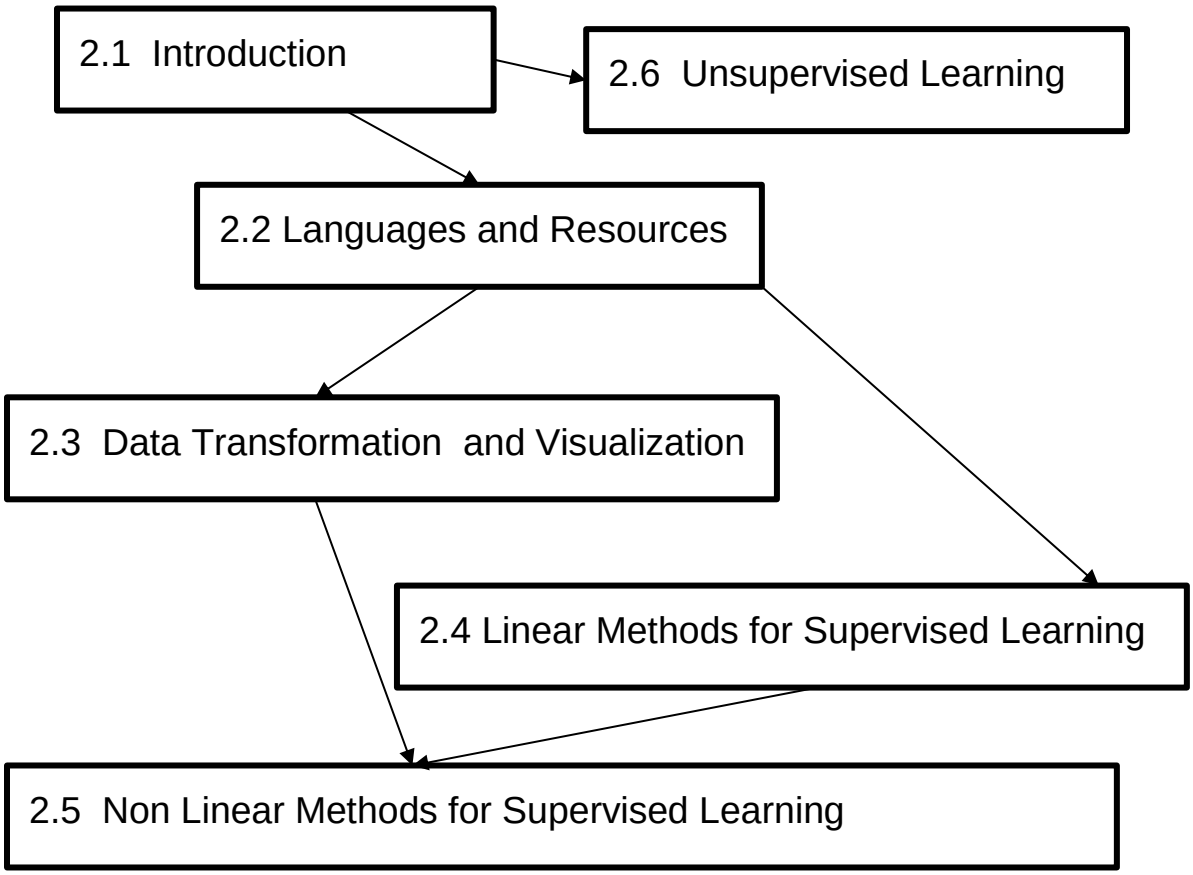
The ARIS lessons lay the ground for the development of ARIS training and assessment material. The learning training and assessment material should be specified in intellectual output 2, according to the project application form. A lesson should include the following items: a title, the learning unit of which the lesson is part of, the list of topics of the learning unit content, prerequisites, learning materials, planned duration of the lesson and references.
Training materials will be created and if suitable reused to support learning on the technical components and practical applications, such as lecture notes, slide presentations, case studies, FAQs, and audio-visual aids.
Assessment of learning outcomes means methods and processes used to establish the extent to which a learner has in fact attained particular knowledge, skills and competences. In order to determine whether the learner has acquired the proposed knowledge, skills and competences and to provide learners with the opportunity to evaluate the extent to which they have attained the desirable knowledge and skills, assessment materials for each learning unit will be developed.

The four learning units in which learning outcomes have been structured constitute a natural founding ground for learning units. Each learning unit has been divided into a set of coherent lessons. The following figure gives a graphical view of the global structure. After that, each lesson is specified.

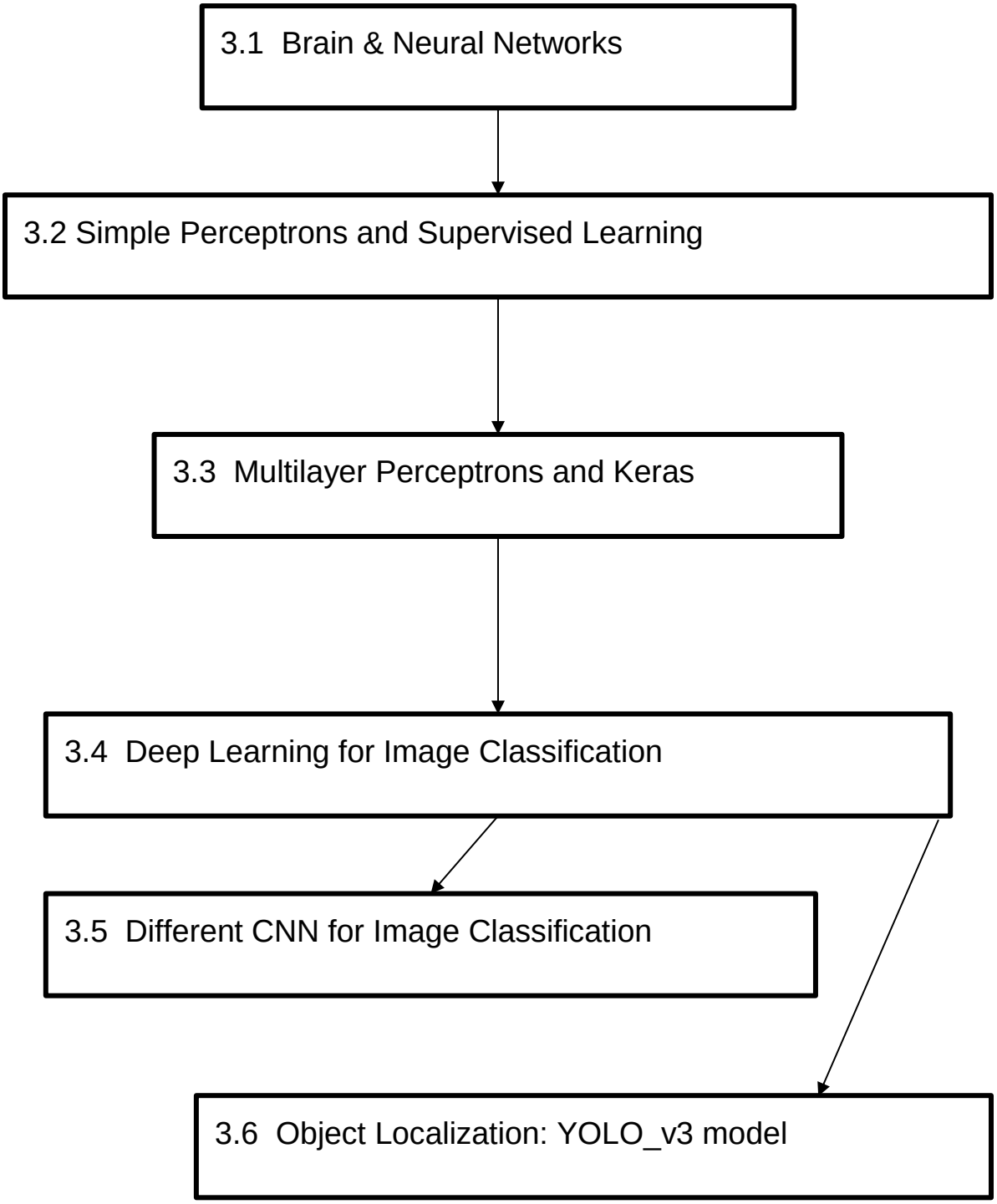
Unit 1: Foundations of Artificial Intelligence



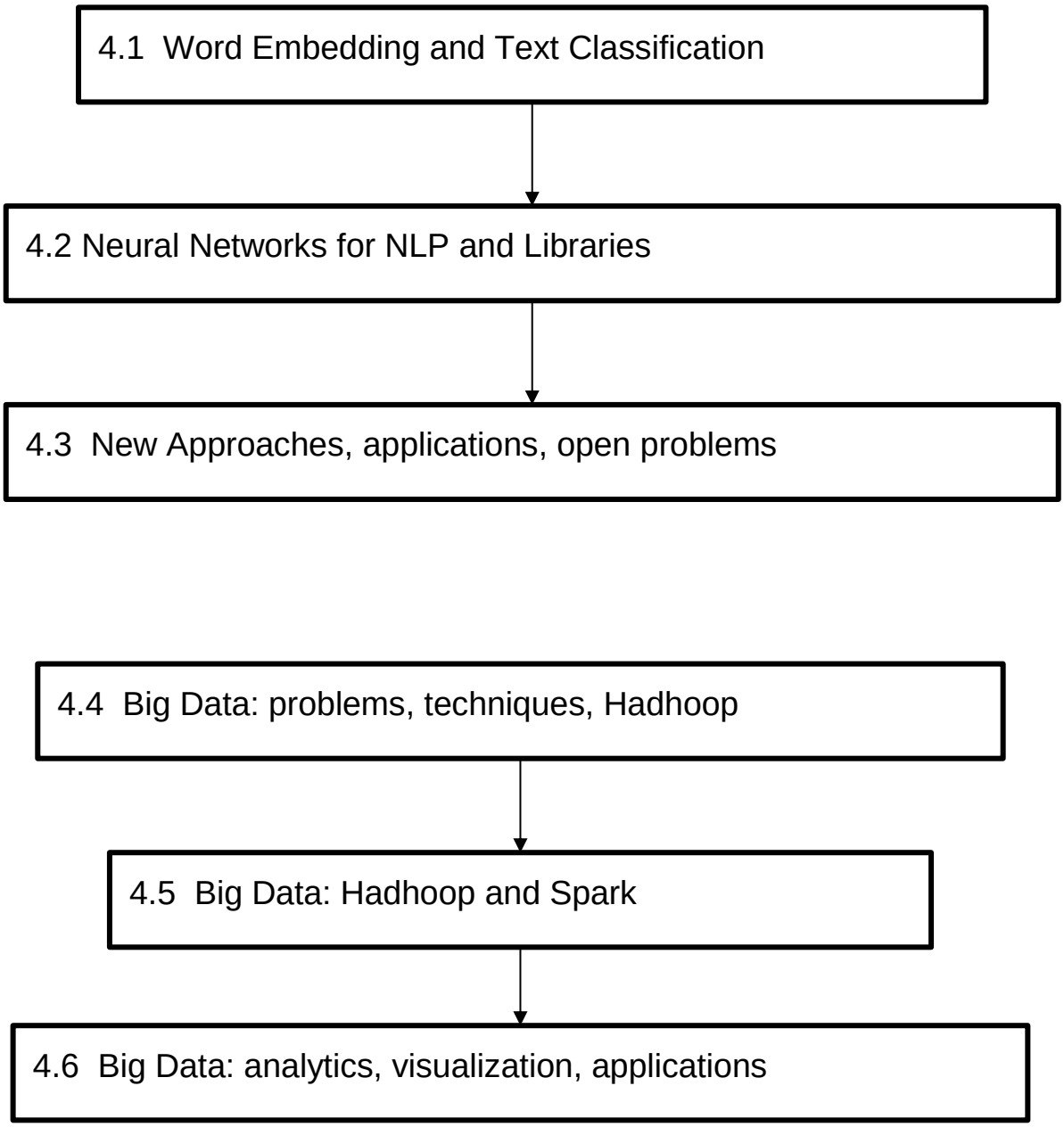
Unit 2: Introduction to Machine Learning



Unit 3: Neural Networks and Deep Learning for Vision



Unit 4: Deep Learning for Natural Language Processing and Big Data Analysis



3.1 Learning Unit 1: Foundations of Artificial Intelligence

Table 5: ARIS Lesson 1.1 - Scope of AI

Lesson title: Scope of AI
Part of learning unit 1 – Foundations of Artificial Intelligence
Lesson objectives
- Give a global overview of what is AI and where it can be applied - Learn about different applications of the field of AI
Topics / Content
This lesson is comprised of the following parts: - Part 1: Foundations of AI - Part 2: Main topics of AI
Prerequisites
- No prerequisites are needed
Learning materials
Presentation slides and lecture notes: 20 Slides/2-3+ pages of Lecture Notes Case studies: 1-2 case studies Assessment material: Multiple choice questions: 5-10 Questions answers: 5-10 Practical Exercises: 1-2
Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case

studies: 1.5h - Learner personal work: 0.5h
References
1. **Artificial intelligence: a modern approach** - Russell, S.J.; Norvig, P, Prentice Hall, 2010. ISBN: 9781292153964 2. **Artificial intelligence: a new synthesis** - Nilsson, N.J, Morgan Kaufmann Publishers , 1998. ISBN: 1558604677 3. **Artificial intelligence: structures and strategies for complex problem solving** - Luger, G.F, Pearson Education : Addison Wesley, 2009. ISBN: 9780321545893

Table 5: ARIS lesson 1.2

Lesson title: Problem solving with search algorithms
Part of learning unit 1 – Foundations of Artificial Intelligence
Lesson objectives
- Understand problems as a search space, and problem solving as search algorithms - Understanding of the elements of a search algorithm: states, actions, heuristics - Types of search problems and algorithms: heuristic search, local search, constraint satisfaction
Topics / Content
This lesson is comprised of the following parts: - Part 1: Automatic problem solving and state space - Part 2: Methods for heuristic search - Part 3: Methods for local search

- Part 4: Constraint Satisfaction Problems

Prerequisites

- Lesson 1.1

Learning materials

Presentation slides and lecture notes: 20 Slides/2-3+ pages of Lecture Notes

Case studies: 1-2 case studies

Assessment material:

Multiple choice questions: 5-10

Questions answers: 5-10

Practical Exercises: 1-2

Planned duration of the lesson

- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h

- Learner personal work: 0.5h

References

1. **Artificial intelligence: a modern approach** - Russell, S.J.; Norvig, P, Prentice-Hall, 2010. ISBN: 9781292153964
2. **Artificial intelligence: a new synthesis** - Nilsson, N.J, Morgan Kaufmann Publishers , 1998. ISBN: 1558604677
3. **Artificial intelligence: structures and strategies for complex problem solving** - Luger, G.F, Pearson Education : Addison Wesley, 2009. ISBN: 9780321545893
4. **Heuristic Search: Theory and Applications** - Edelkamp, S.; Schrödl, S., Elsevier, 2012. ISBN 978-0-12-372512-7

Table 5: ARIS lesson 1.3

Lesson title: 1.3 - Knowledge Representation
Part of learning unit 1 – Foundations of Artificial Intelligence
Lesson objectives
- Understand the need for knowledge representation on AI problems and the different kinds of knowledge that are needed - Understand knowledge representation based on logic formalisms - Understand knowledge representation based on probabilistic formalisms
Topics / Content
This lesson is comprised of the following parts: - Part 1: Representation of factual knowledge - Formal logic - Part 2: Representation of procedural knowledge - Production rules - Part 3: Representation of uncertainty - Bayesian networks
Prerequisites
- Lesson 1.1
Learning materials
Presentation slides and lecture notes: 20 Slides/2-3+ pages of Lecture Notes Case studies: 1-2 case studies Assessment material: Multiple choice questions: 5-10 Questions answers: 5-10 Practical Exercises: 1-2

Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h
References
1. **Artificial intelligence: a modern approach** - Russell, S.J.; Norvig, P, Prentice-Hall, 2010. ISBN: 9781292153964 2. **Artificial intelligence: a new synthesis** - Nilsson, N.J, Morgan Kaufmann Publishers, 1998. ISBN: 1558604677 3. **Artificial intelligence: structures and strategies for complex problem solving** - Luger, G.F, Pearson Education : Addison Wesley, 2009. ISBN: 9780321545893

Table 5: Lesson 1.4

Lesson title: 1.4 - Machine Learning
Part of learning unit 1 – Foundations of Artificial Intelligence
Lesson unit objectives
- Understand the methods for learning and detecting patterns from data - Understand basic methods for supervised learning
Topics / Content
This lesson is comprised of the following parts: - Part 1: Areas of machine learning - Part 2: Methods for supervised learning: decision trees and naive bayes
Prerequisites
- Lesson 1.2, lesson 1.3
Learning materials
Presentation slides and lecture notes: 20 Slides/5-10 pages of Lecture Notes Case studies: 1-2 case studies Assessment material: Multiple choice questions: 5-10 Questions answers: 5-10 Practical Exercises: 1-2 All learning materials will be available in English and in the partnership languages (FR, NL, IT, ES, GR, LT).
Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h

- Learner personal work: 0.5h
References 1. **Introduction to machine learning -** Alpaydin, E, The MIT Press, 2014. ISBN: 9780262028189 2. **The elements of statistical learning: data mining, inference, and prediction** - Hastie, T.; Tibshirani, R.; Friedman, J, Springer, 2009. ISBN: 9780387848570 3. **The hundred-page machine learning book**. Andriy Burkov, 2019. ISBN: 978-1999579500 4. **Artificial intelligence: a modern approach** - Russell, S.J.; Norvig, P, Prentice-Hall, 2010. ISBN: 9781292153964 5. **Artificial intelligence: a new synthesis** - Nilsson, N.J, Morgan Kaufmann Publishers, 1998. ISBN: 1558604677

Table 5: Lesson 1.5

Lesson title: 1.5 - Artificial Intelligence Applications
Part of learning unit 1 – Foundations of Artificial Intelligence
Lesson unit objectives
- Recognize the elements of AI in an application - Know the main languages used in AI development
Topics / Content
This lesson is comprised of the following parts: - Part 3: Applications of AI - Part 4: Languages and resources for developing AI applications
Prerequisites
- Lesson 1.2, lesson 1.3, lesson 1.4
Learning materials

Presentation slides and lecture notes: 20 Slides/2-3+ pages of Lecture Notes

Case studies: 1-2 case studies

Assessment material:

Multiple choice questions: 5-10

Questions answers: 5-10

Practical Exercises: 1-2

All learning materials will be available in English and in the partnership languages (FR, NL, IT, ES, GR, LT).

Planned duration of the lesson

- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h

- Learner personal work: 0.5h

References

6. **Introduction to machine learning -** Alpaydin, E, The MIT Press, 2014. ISBN: 9780262028189
7. **The elements of statistical learning: data mining, inference, and prediction** - Hastie, T.; Tibshirani, R.; Friedman, J, Springer, 2009. ISBN: 9780387848570
8. **The hundred-page machine learning book**. Andriy Burkov, 2019. ISBN: 978-1999579500
9. **Artificial intelligence: a modern approach** - Russell, S.J.; Norvig, P, Prentice-Hall, 2010. ISBN: 9781292153964
10. **Artificial intelligence: a new synthesis** - Nilsson, N.J, Morgan Kaufmann Publishers, 1998. ISBN: 1558604677

Table 5: ARIS lesson 1.5

Lesson title: 1.5 - Ethical implications of AI
Part of learning unit 1 – Foundations of Artificial Intelligence
Lesson objectives
- Understand the ethical implications of deploying AI systems
Topics / Content
This lesson is comprised of the following parts: - Part 1: Surveillance Capitalism - Part 2: Algorithmic fairness - Part 3: Overoptimism
Prerequisites
- Lesson 1.1
Learning materials
Presentation slides and lecture notes: 20 Slides/2-3+ pages of Lecture Notes Case studies: 1-2 case studies Assessment material: Multiple choice questions: 5-10 Questions answers: 5-10 Practical Exercises: 1-2
Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h

References

1. Machine Bias (https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing)
2. Explainer: what is surveillance capitalism and how it shapes our economy (https://theconversation.com/explainer-what-is-surveillance-capitalism-and-how-does-it-shape-our-economy-119158)
3. Its 2020: where are our self-driving cars? (https://www.vox.com/future-perfect/2020/2/14/21063487/self-driving-cars-autonomous-vehicles-waymo-cruise-uber)
4. Barcelona Declaration for the proper development and usage of Artificial Intelligence (https://www.semanticscholar.org/paper/The-Barcelona-declaration-for-the-proper-and-usage-Steels-M%C3%A1ntaras/e24f9dce0134b7c162bf14b70a262969e62a4acb)

3.2 Learning Unit 2: Introduction to Machine Learning

Table 5: ARIS lesson 2.1

Lesson title: 2.1 - Introduction to Machine Learning
Part of learning unit 2 – Machine Learning
Lesson objectives
- Understand the different types of ML problems and its theoretical principles
Topics / Content
This lesson is comprised of the following parts: - Part 1: Different types of ML problems (supervised vs unsupervised, classification vs regression) - Part 2: Theoretical principles - Part 3: Evaluation of ML models
Prerequisites
- Basic Probability Theory - Basic Linear Algebra
Learning materials
Presentation slides and lecture notes: 20 Slides/2-3+ pages of Lecture Notes Case studies: 1-2 case studies Assessment material: Multiple choice questions: 5-10 Questions answers: 5-10 Practical Exercises: 1-2
Planned duration of the lesson

- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h
References
1. **Introduction to machine learning -** Alpaydin, E, The MIT Press, 2014. ISBN: 9780262028189 2. **The elements of statistical learning: data mining, inference, and prediction** - Hastie, T.; Tibshirani, R.; Friedman, J, Springer, 2009. ISBN: 9780387848570 3. **The hundred-page machine learning book**. Andriy Burkov, 2019. ISBN: 978-1999579500 4. **Understanding Machine Learning: From Theory to Algorithms -** Shalev-Shwartz, S.; Ben-david, S., Cambridge University Press, 2014. ISBN: 9781107057135 5. **Mathematics for Machine Learning** Deisenroth, M. P.; Faisal, A.; Soon Ong, C.; Cambridge University Press, 2020

Table 5: ARIS lesson 2.6

Learning lesson: 2.2 - Languages and Resources for ML
Part of learning unit 2 – Machine Learning
Lesson objectives
- Have a broad view of the different languages and resources available for ML
Topics / Content
This lesson is comprised of the following parts: - Python: main libraries for supervised and unsupervised learning (scikit-learn, numpy, pandas, matplotlib, seaborn, statsmodels)
Prerequisites
- Lesson 2.1

- Basic Knowledge of Python
Learning materials
Presentation slides and lecture notes: 20 Slides/2-3+ pages of Lecture Notes Case studies: 1-2 case studies Assessment material: Multiple choice questions: 5-10 Questions answers: 5-10 Practical Exercises: 1-2
Planned duration of the lesson unit
- Average duration for reading the lecture notes and slide presentations: 1.5h - Learner personal work: 0.5h
References
1. **Machine Learning in Python : Essential Techniques for Predictive Analysis -** Bowles, M., John Wiley & Sons, 2015. **ISBN:** 978-1119559962 2. **The hundred-page machine learning book**. Andriy Burkov, 2019. ISBN: 978-1999579500 3. ***Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems***. Aurélien, G., O'Reilly Media, 2019. ISBN: 978-1492032649

Table 5: ARIS lesson 2.3

Lesson title: 2.3 - Data Transformation and Visualization
Part of learning unit 2 – Machine Learning
Lesson objectives

- Understand the different algorithms for data transformation and visualization.

Topics / Content

This lesson is comprised of the following parts:

- Part 1: Unsupervised Linear transformation and visualization (PCA,MDS)

- Part 2: Unsupervised non-linear transformation and visualization (t-SNE, LLE)

Prerequisites

- Lessons 2.1, 2.2

- Basic Probability Theory

- Basic Linear Algebra

- Basic knowledge of python language

Learning materials

Presentation slides and lecture notes: 20 Slides/2-3+ pages of Lecture Notes

Case studies: 1-2 case studies

Assessment material:

Multiple choice questions: 5-10

Questions answers: 5-10

Practical Exercises: 1-2

Planned duration of the lesson

- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h

- Learner personal work: 0.5h

References

1. **Pattern recognition and machine learning** - Bishop, C.M, Springer, 2006. ISBN: 0387310738
2. **The elements of statistical learning: data mining, inference, and**

prediction - Hastie, T.; Tibshirani, R.; Friedman, J, Springer, 2009. ISBN: 9780387848570

3. **The hundred-page machine learning book**. Andriy Burkov, 2019. ISBN: 978-1999579500
4. **Understanding Machine Learning: From Theory to Algorithms -** Shalev-Shwartz, S.; Ben-david, S., Cambridge University Press, 2014. ISBN: 9781107057135
5. **Mathematics for Machine Learning** Deisenroth, M. P.; Faisal, A.; Soon Ong, C.; Cambridge University Press, 2020.

Table 5: ARIS lesson 2.4

Lesson title: 2.4 - Linear Methods for Supervised Machine Learning
Part of learning unit 2 – Machine Learning
Lesson objectives
- Understand the different linear algorithms for ML for classification and regression
Topics / Content
This lesson is comprised of the following parts: - Part 1: Linear regression and regularization - Part 2: Decision trees - Part 3: K-nearest neighbor - Part 4: Naive bayes
Prerequisites
- Lesson 2.1, 2.2 - Basic Probability Theory - Basic Linear Algebra - Basic knowledge of python language

Learning materials
Presentation slides and lecture notes: 10 Slides/2-3+ pages of Lecture Notes Case studies: 2 Assessment material: Multiple choice questions: 10 Short response questions: 5 case studies and application scenarios analysis: 1
Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h
References
1. **Machine learning: a probabilistic perspective -** Murphy, K.P, MIT Press , 2012. ISBN: 9780262018029 2. **Pattern recognition and machine learning** - Bishop, C.M, Springer, 2006. ISBN: 0387310738 3. **The elements of statistical learning: data mining, inference, and prediction** - Hastie, T.; Tibshirani, R.; Friedman, J, Springer, 2009. ISBN: 9780387848570 4. **The hundred-page machine learning book**. Andriy Burkov, 2019. ISBN: 978-1999579500 5. **Understanding Machine Learning: From Theory to Algorithms -** Shalev-Shwartz, S.; Ben-david, S., Cambridge University Press, 2014. ISBN: 9781107057135 6. **Mathematics for Machine Learning** Deisenroth, M. P.; Faisal, A.; Soon Ong, C.; Cambridge University Press, 2020.

Table 5: ARIS lesson 2.5

Lesson title: 2.5 - Non Linear Methods for Supervised Machine Learning

Part of learning unit 2 – Machine Learning
Lesson objectives
- Learn the different non-linear algorithms for classification and regression
Topics / Content
This lesson is comprised of the following parts: - Part 1: Support Vector Machines and Kernels - Part 2: Neural Networks: Perceptron and Multi-layer Perceptron - Part 3: Ensembles: Bagging and Boosting for Decision Trees
Prerequisites
- Lesson 2.1, 2.2, 2.4 - Basic Probability Theory - Basic Linear Algebra - Basic knowledge of python language
Learning materials
Presentation slides and lecture notes: 20 Slides/2-3+ pages of Lecture Notes Case studies: 1-2 case studies Assessment material: Multiple choice questions: 5-10 Questions answers: 5-10 Practical Exercises: 1-2
Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h

References
1. **Kernel methods for pattern analysis.** Shawe-Taylor, J.;Cristianini, N. Cambridge university press, 2004. ISBN: 978-0521813976 2. **Neural networks for pattern recognition**. Bishop, C. M. Oxford university press, 1995. **ISBN-13:** 978-0198538646 3. **Pattern classification using ensemble methods**. Vol. 75. Rokach, L. World Scientific, 2010. **ISBN:** 978-9811201950 4. **The hundred-page machine learning book**. Andriy Burkov, 2019. ISBN: 978-1999579500 5. **Pattern recognition and machine learning** - Bishop, C.M, Springer, 2006. ISBN: 0387310738 6. **The elements of statistical learning: data mining, inference, and prediction** - Hastie, T.; Tibshirani, R.; Friedman, J, Springer, 2009. ISBN: 9780387848570 7. **Understanding Machine Learning: From Theory to Algorithms -** Shalev-Shwartz, S.; Ben-david, S., Cambridge University Press, 2014. ISBN: 9781107057135 8. **Mathematics for Machine Learning** Deisenroth, M. P.; Faisal, A.; Soon Ong, C.; Cambridge University Press, 2020.

Table 5: ARIS lesson 2.6

Learning lesson: 2.6 - Unsupervised Learning
Part of learning unit 2 – Machine Learning
Lesson objectives
- Learn the basic algorithms for unsupervised learning
Topics / Content
This lesson is comprised of the following parts: - Part 1: Hierarchical Clustering - Part 2: Model based unsupervised learning: k-means and gaussian mixture models
Prerequisites

- Basic Probability Theory

- Basic Linear Algebra

- Basic knowledge of python language

Learning materials

Presentation slides and lecture notes: 20 Slides/2-3+ pages of Lecture Notes

Case studies: 1-2 case studies

Assessment material:

Multiple choice questions: 5-10

Questions answers: 5-10

Practical Exercises: 1-2

Planned duration of the lesson

- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h

- Learner personal work: 0.5h

References

1. **Algorithms for clustering data**. Jain, A. K., and Dubes, R. C. Prentice-Hall, Inc., 1988. **ISBN-13:** 978-0130222787
2. **Pattern recognition and machine learning** - Bishop, C.M, Springer, 2006. ISBN: 0387310738
3. **The elements of statistical learning: data mining, inference, and prediction** - Hastie, T.; Tibshirani, R.; Friedman, J, Springer, 2009. ISBN: 9780387848570
4. **The hundred-page machine learning book**. Andriy Burkov, 2019. ISBN: 978-1999579500
5. **Mathematics for Machine Learning** Deisenroth, M. P.; Faisal, A.; Soon Ong, C.; Cambridge University Press, 2020.

3.3 Learning Unit 3: Neural networks and deep learning for vision

Table 5: ARIS Lesson 3.1 - Brain origin and element of neural network

Lesson title: Brain origin and element of neural network
Part of learning unit 3 –Neural networks and deep learning for vision
Lesson objectives
- Give a global overview of the brain origin of artificial neural networks and the elements that constitutes them
Topics / Content
This lesson is comprised of the following parts: - Part 1: The brain origin of artificial neural networks - Part 2: Element of artificial neural networks and linear algebra
Prerequisites
- Basic Linear Algebra - Basic knowledge of Python language
Learning materials
Presentation slides and lecture notes: 10 Slides/10 pages of Lecture Notes Case studies: 2 case studies Assessment material: Multiple choice questions: 10 Short response questions: 5 Case studies and application scenarios analysis: 1
Planned duration of the lesson

- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h
References
1. **Artificial intelligence: a modern approach** - Russell, S.J.; Norvig, P, Prentice Hall, 2010. ISBN: 9781292153964 2. **Artificial intelligence: a new synthesis** - Nilsson, N.J, Morgan Kaufmann Publishers , 1998. ISBN: 1558604677 3. **Artificial intelligence: structures and strategies for complex problem solving** - Luger, G.F, Pearson Education : Addison Wesley, 2009. ISBN: 9780321545893

Table 5: ARIS Lesson 3.2 - Simple Perceptrons and supervised learning

Lesson title: Simple perceptrons and supervised learning
Part of learning unit 3 –Neural networks and deep learning for vision
Lesson objectives
- Learn the simplest artificial neural network architecture, the perceptron, and and the rules behind its operation
Topics / Content
This lesson is comprised of the following parts: - Part 1: Simple perceptron architecture - Part 2: Supervised learning mechanism
Prerequisites
- Lesson 3.1 - Basic Linear Algebra

- Basic knowledge of Python language
Learning materials
Presentation slides and lecture notes: 10 Slides/10 pages of Lecture Notes Case studies: 2 case studies Assessment material: Multiple choice questions: 10 Short response questions: 5 Case studies and application scenarios analysis: 1
Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h
References
1. **Artificial intelligence: a modern approach** - Russell, S.J.; Norvig, P, Prentice Hall, 2010. ISBN: 9781292153964 2. **Artificial intelligence: a new synthesis** - Nilsson, N.J, Morgan Kaufmann Publishers , 1998. ISBN: 1558604677 3. **Artificial intelligence: structures and strategies for complex problem solving** - Luger, G.F, Pearson Education : Addison Wesley, 2009. ISBN: 9780321545893

Table 5: ARIS Lesson 3.3 - Multilayer perceptrons and keras, a python library for deep learning

Lesson title: Multilayer perceptrons and keras, a python library for deep learning
Part of learning unit 3 –Neural networks and deep learning for vision
Lesson objectives

- Learn how to build a multilayer perceptron using keras, an high level python library.

Topics / Content

This lesson is comprised of the following parts:

- Part 1: Multilayer perceptron architecture and functioning

- Part 2: Keras, an high level python library for deep neural network

Prerequisites

- Lesson 3.1, 3.2

- Basic Linear Algebra

- Basic knowledge of Python language

Learning materials

Presentation slides and lecture notes: 10 Slides/10 pages of Lecture Notes

Case studies: 2 case studies

Assessment material:

Multiple choice questions: 10

Short response questions: 5

Case studies and application scenarios analysis: 1

Planned duration of the lesson

- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h

- Learner personal work: 0.5h

References

1. **Deep learning** - Goodfellow, I. ; Bengio, I.; Courville, A., MIT press, 2016. ISBN: 0262035618

Table 5: ARIS Lesson 3.4 - Deep learning for image classification: Convolutional Neural Network

Lesson title: Deep learning for image classification: Convolutional Neural Network (CNN)
Part of learning unit 3 –Neural networks and deep learning for vision
Lesson objectives
- Learn the architecture and functioning of convolutional neural networks (CNN) and how implement a homemade CNN using keras for image classification
Topics / Content
This lesson is comprised of the following parts: - Part 1: Convolutional Neural Network architecture and functioning - Part 2: Implement a Convolutional Neural Network using keras for image classification
Prerequisites
- Lesson 3.1, 3.2, 3.3 - Basic Linear Algebra - Basic knowledge of Python language
Learning materials
Presentation slides and lecture notes: 10 Slides/10 pages of Lecture Notes Case studies: 2 case studies Assessment material: Multiple choice questions: 10 Short response questions: 5 Case studies and application scenarios analysis: 1

Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h
References
1. **Artificial intelligence: a modern approach** - Russell, S.J.; Norvig, P, Prentice Hall, 2010. ISBN: 9781292153964 2. **Artificial intelligence: a new synthesis** - Nilsson, N.J, Morgan Kaufmann Publishers , 1998. ISBN: 1558604677 3. **Artificial intelligence: structures and strategies for complex problem solving** - Luger, G.F, Pearson Education : Addison Wesley, 2009. ISBN: 9780321545893

Table 5: ARIS Lesson 3.5 - Different CNN for image classification: keras built-in applications

Lesson title: Different CNN for image classification: keras built-in applications
Part of learning unit 3 –Neural networks and deep learning for vision
Lesson objectives
- Learn how to use keras built-in models for image classification with different keras built-in datasets
Topics / Content
This lesson is comprised of the following parts: - Part 1: Keras applications module - Part 2: Keras datasets module
Prerequisites
- Lesson 3.1, 3.2, 3.2, 3.4

- Basic Linear Algebra - Basic knowledge of Python language
Learning materials
Presentation slides and lecture notes: 10 Slides/10 pages of Lecture Notes Case studies: 2 case studies Assessment material: Multiple choice questions: 10 Short response questions: 5 Case studies and application scenarios analysis: 1
Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h
References
1. **Artificial intelligence: a modern approach** - Russell, S.J.; Norvig, P, Prentice Hall, 2010. ISBN: 9781292153964 2. **Artificial intelligence: a new synthesis** - Nilsson, N.J, Morgan Kaufmann Publishers , 1998. ISBN: 1558604677 3. **Artificial intelligence: structures and strategies for complex problem solving** - Luger, G.F, Pearson Education : Addison Wesley, 2009. ISBN: 9780321545893

Table 5: ARIS Lesson 3.6 - Object localization: YOLO model and Keras implementation

Lesson title: Object localization: YOLO_V3 model and Keras implementation
Part of learning unit 3 –Neural networks and deep learning for vision

Lesson objectives

- Learn how to locate objects in images with YOLO model using keras

Topics / Content

This lesson is comprised of the following parts:

- Part 1: An explanation of YOLO model

- Part 2: Keras implementation of YOLO model

Prerequisites

- Lesson 3.1, 3.2, 3.2, 3.4

- Basic Linear Algebra

- Basic knowledge of Python language

Learning materials

Presentation slides and lecture notes: 10 Slides/10 pages of Lecture Notes

Case studies: 2 case studies

Assessment material:

Multiple choice questions: 10

Short response questions: 5

Case studies and application scenarios analysis: 1

Planned duration of the lesson

- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h

- Learner personal work: 0.5h

References

1. **Artificial intelligence: a modern approach** - Russell, S.J.; Norvig, P, Prentice Hall, 2010. ISBN: 9781292153964
2. **Artificial intelligence: a new synthesis** - Nilsson, N.J, Morgan

Kaufmann Publishers , 1998. ISBN: 1558604677
3. **Artificial intelligence: structures and strategies for complex problem solving** - Luger, G.F, Pearson Education : Addison Wesley, 2009. ISBN: 9780321545893

3.3 Learning Unit 4: Deep learning for Natural Language Processing, and Big Data analysis

Table 5: ARIS Lesson 4.1 - Word Embeddings and Text Classification

Lesson title: Word Embeddings and Text Classification
Part of learning unit 4 – Big data analysis and deep learning for natural language processing
Lesson objectives
- Getting an overview of the main approaches of NPL; understanding what the Embeddings is, how to use it, how to make a text classifier.
Topics / Content
This lesson is comprised of the following parts: - Part 1: Background - Part 2: Word Embeddings - Part 3: Preprocessing - Part 4: Text classification
Prerequisites
- Basic Linear Algebra - Basic knowledge of Python language
Learning materials
Presentation slides and lecture notes: 15 Slides/10 pages of Lecture Notes

Case studies: 2 case studies Assessment material: Multiple choice questions: 10 Short response questions: 5 Case studies and application scenarios analysis: 1
Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h
References
1. **Speech and Language Processing, 2nd Edition** - Jurafsky, D.; Martin, J. H., Prentice Hall, 2008. ISBN-10: 9780131873216 2. **Deep Learning with Python** - Chollet, F., Manning Pubns Co, 2017. ISBN-10: 9781617294433 3. **Natural Language Processing with Python** - Bird, S.; Klein E.; Loper E., O'Reilly Media, 2009. ISBN-10: 0596516495

Table 5: ARIS Lesson 4.2 - Neural networks for NLP and libraries

Lesson title: Neural networks for NLP and libraries
Part of learning unit 4 – Big data analysis and deep learning for natural language processing
Lesson objectives
- Know the characteristics of the main layers used in NLP and how to implement them with the most used libraries; - Introduction to Attention Mechanism, Reinforcement Learning and Unsupervised Learning
Topics / Content

This lesson is comprised of the following parts:

- Part 1: Scikit-learn, Keras and Tensorflow libraries
- Part 2: Convolutional Neural Network
- Part 3: Recurrent Neural Network
- Part 4: RNN Variants (LSTM, GRU)
- Part 5: Attention Mechanism
- Part 6: Reinforcement Learning
- Part 7: Unsupervised Learning

Prerequisites

- Lesson 4.1
- Basic Linear Algebra
- Basic knowledge of Python language

Learning materials

Presentation slides and lecture notes: 10 Slides/10 pages of Lecture Notes

Case studies: 2 case studies

Assessment material:

Multiple choice questions: 10

Short response questions: 5

Case studies and application scenarios analysis: 1

Planned duration of the lesson

- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h
- Learner personal work: 0.5h

References

1. **Natural Language Processing with Python** - Bird, S.; Klein E.; Loper E., O'Reilly Media, 2009. ISBN-10: 0596516495
2. **Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems** - Géron, A., O'Reilly & Associates Inc, 2019. ISBN-10: 1492032646

Table 5: ARIS Lesson 4.3 - New approaches, applications, open problems

Lesson title: New approaches, applications, open problems
Part of learning unit 4 – Big data analysis and deep learning for natural language processing
Lesson objectives
- Understand how the latest approaches to NLP work; - Learn about the different applications of these technologies and the still open problems
Topics / Content
This lesson is comprised of the following parts: - Part 1: Character-Based Neural Language Model - Part 2: Transformers, BERT and ELMo - Part 3: Natural language processing applications - Part 4: Open problems
Prerequisites
- Lessons 4.1 and 4.2 - Basic Linear Algebra - Basic knowledge of Python language
Learning materials

Presentation slides and lecture notes: 10 Slides/10 pages of Lecture Notes Case studies: 2 case studies Assessment material: Multiple choice questions: 10 Short response questions: 5 Case studies and application scenarios analysis: 1
Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h
References
1. **Applied Text Analysis with Python: Enabling Language-Aware Data Products with Machine Learning** - Bengfort, B.; Bilbro, R.; Ojeda, T., O'Reilly Media, 2018. ISBN-10: 1491963042 2. **Deep Learning for Natural Language Processing** - Brownlee, J. 3. **Attention is all you need** - Vaswani, A.; Shazeer, N.; Parmar, N.; Uszkoreit, J.; Jones, L.; Gomez, A. N.; Kaiser, Ł.; Polosukhin, I., In Advances in neural information processing systems. 5998–6008, 2017. 4. https://github.com/google-research/bert 5. **BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding** - Devlin, J.; Chang, M.; Lee, K.; Toutanova, K., CoRR abs/1810.04805 (2018). URL: http://arxiv.org/abs/1810.04805 6. https://github.com/slowbreathing/Deep-Breathe

Table 5: ARIS Lesson 4.4 - Big data: problems, core techniques, and introduction to Hadhoop

Lesson title: Big data: problems, core techniques, and introduction to Hadhoop
Part of learning unit 4 – Big data analysis and deep learning for natural language processing

Lesson objectives
- Understanding big data problems and major solutions strategies; introduction and initial learning of the Hadoop ecosystem.
Topics / Content
This lesson is comprised of the following parts: - Part 1: Big data: problems and definitions, and core techniques of solution - Part 2: Big data processing platforms and tools, and introduction to the Hadoop ecosystem - Part 3: Big data collection, integration and storage, queries
Prerequisites
- Lessons 3.1, 3.2 - Basic Linear Algebra - Basic knowledge of Python language
Learning materials
Presentation slides and lecture notes: 10 Slides/10 pages of Lecture Notes Case studies: 2 case studies Assessment material: Multiple choice questions: 10 Short response questions: 5 Case studies and application scenarios analysis: 1
Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h

References
1. **Data Analytics Made Accessible.** Anil Maheshwari (2020). (Kindle). 2. **Hadoop For Dummies**. Dirk deRoos (2014). Wiley, New York. ISBN: 978-1-118-60755-8. 3. **Hadoop: The Definitive Guide**. Tom White (2015). O'Reilly, Yard CA. Fourth edition. ISBN: 978-1-491-90168-7. 4. **High Performance Spark: Best Practices for Scaling and Optimizing Apache Spark**. Holden Karau, Rachel Warren (2017). O'Reilly, Sebastopol, CA. ISBN: 978-1-491-94320-5.

Table 5: ARIS Lesson 4.5 - Big data: Hadhoop and Spark for data processing

Lesson title: Big data: Hadhoop and Spark for data processing
Part of learning unit 4 – Big data analysis and deep learning for natural language processing
Lesson objectives
- Understanding and learning to use some of the Hadoop ecosystem components more in depth, and learning Spark basic functionalities.
Topics / Content
This lesson is comprised of the following parts: - Part 1: Hadoop ecosystem more in depth: HDFS, MapReduce, YARN, HBase, Hive, Pig, Sqoop, Zookeeper, Flume, Oozie. - Part 2: Introduction Spark: main functions for data treatment and processing - Part 3: Hadoop and Spark collection/integration/storage/processing techniques for data processing
Prerequisites
- Lessons 3.1, 3.2, 4.4 - Basic Linear Algebra - Basic knowledge of Python language

Learning materials
Presentation slides and lecture notes: 10 Slides/10 pages of Lecture Notes Case studies: 2 case studies Assessment material: Multiple choice questions: 10 Short response questions: 5 Case studies and application scenarios analysis: 1
Planned duration of the lesson
- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h - Learner personal work: 0.5h
References
1. **Data Analytics Made Accessible.** Anil Maheshwari (2020). (Kindle) 2. **Hadoop For Dummies**. Dirk deRoos (2014). Wiley, New York. ISBN: 978-1-118-60755-8. 3. **Hadoop: The Definitive Guide**. Tom White (2015). O'Reilly, Yard CA. Fourth edition. ISBN: 978-1-491-90168-7. 4. **High Performance Spark: Best Practices for Scaling and Optimizing Apache Spark**. Holden Karau, Rachel Warren (2017). O'Reilly, Sebastopol, CA. ISBN: 978-1-491-94320-5.

Table 5: ARIS Lesson 4.6 - Big data: main analytics, visualisation and applications

Lesson title: Big data: main analytics, visualisation and applications
Part of learning unit 4 – Big data analysis and deep learning for natural language processing
Lesson objectives
- Understand different real applications and their techniques that involve big

data

Topics / Content

This lesson is comprised of the following parts:

- Part 1: Big data: predictive and other analytics

- Part 2: Big data: visualisation

- Part 3: Big data: application perspectives in analytics, retail, marketing, hospitality, consumer good, defense, etc.

Prerequisites

- Lessons 3.1, 3.2, 4.4, 4.5

- Basic Linear Algebra

- Basic knowledge of Python language

Learning materials

Presentation slides and lecture notes: 10 Slides/10 pages of Lecture Notes

Case studies: 2 case studies

Assessment material:

Multiple choice questions: 10

Short response questions: 5

Case studies and application scenarios analysis: 1

Planned duration of the lesson

- Average duration for reading the lecture notes, slide presentations and case studies: 1.5h

- Learner personal work: 0.5h

References

1. **Data Analytics Made Accessible.** Anil Maheshwari (2020). (Kindle)
2. **Hadoop For Dummies**. Dirk deRoos (2014). Wiley, New York. ISBN:

978-1-118-60755-8.

3. **Hadoop: The Definitive Guide**. Tom White (2015). O'Reilly, Yard CA. Fourth edition. ISBN: 978-1-491-90168-7.
4. **High Performance Spark: Best Practices for Scaling and Optimizing Apache Spark**. Holden Karau, Rachel Warren (2017). O'Reilly, Sebastopol, CA. ISBN: 978-1-491-94320-5.

References

[1] The European Qualifications Framework, https://ec.europa.eu/ploteus/search/site?f%5B0%5D=im_field_entity_type%3A97
and http://www.cedefop.europa.eu/en/events-and-projects/projects/european-qualifications-framework-eqf

[2] CEDEFOP (2017). Defining, writing and applying learning outcomes - A European handbook, Luxembourg: Publications Office of the European Union, http://www.cedefop.europa.eu/en/publications-and-resources/publications/4156

[3] The European e-Competence Framework (e-CF) - A common European framework for ICT Professionals in all industry sectors, http://www.ecompetences.eu/