


Erasmus+ SkoPS

< D0.1: Fundamental Machine Learning Course Outline and Description >

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1	13.12.2021	Initial draft	Mahnaz Mirhaj
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Contributors

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1 Introduction

Machine Learning (ML) is the science of teaching machines (computers) to learn from data and derive valuable information from data without from A to Z commands. With a massive amount of data being generated and accessible, Machine Learning can serve in different areas from improving businesses' profit to saving lives by being used to medical extents. Therefore, ML is a hot topic and learning it is becoming a must for everyone.

1.1 Abstract

The Fundamental of Machine Learning course is arranged in 7 chapters aiming to help students enhance their knowledge and skills in the most updated Algorithms and techniques of ML. The course covers the technical, theoretical, and practical parts of ML. This course offers different types of activities and media to assist students to understand ML and employ its strategies in different areas.

1.2 Purpose of the document

The purpose of this document is to have an outline for the Fundamental of Machine Learning course. In this file, the general structure of the Fundamental of Machine Learning course is described and determined. This file includes description, materials, activities, objective, contents, prerequisites, references, assessment methods of the Fundamental of ML course.

1.3 Relation to other deliverables

The Fundamental Machine Learning course is in relation to Big Data Management course and Python programming for IoT and data science course.

2 Template

Course Plan Template			
Course ID and Title:	Fundamental Machine Learning		
Course Duration:	6 Weeks	Course ECTS:	
Leading Organization:	PTX		
Course Media:	Video, Text File, Jupyter Notebook		
Laboratory (Yes/No)	Yes		
Course Description:			
<p>This course provides a broad introduction to modern, approved, and most favorable Machine Learning (ML) approaches, their obstacles, and ways of tackling them. It helps you empower computers to learn and discover relationships on data. During this course, you will learn how to create ML models and modify their parameters by applying ML Algorithms to some given data to reach an objective. Furthermore, you will not only learn what the theoretical ideas behind Machine Learning Algorithms are, but also gain hands-on experience by implementing these algorithms on real-world problems.</p> <p>For the theoretical part, we plan to address the Basics of ML, Supervised and Unsupervised learning algorithms and methods, ML challenges, and ways of dealing with them. Moreover, This course covers computational learning theory which gives you mathematical insights, enabling you to conduct novel and innovative approaches for evaluating ML Algorithms. To present these topics, PowerPoint slides mixed with some further video tutorials from the web are offered. In addition, to educate you practically we have designed many virtual laboratories and hands-on projects that concentrate on applications of ML. Real-world problems are presented with given datasets and you are asked to design a model for learning with ML techniques. Finally, you should analyze your results and outputs.</p> <p>This course is designed with a practical perspective for everyone with or without previous knowledge of Machine Learning. Whether you want to enhance your comprehension or escalate your critical thinking and problem-solving skills in the field of Machine Learning, this course would be an asset for you. Although you can use the course content if you are studying Computer Science, Mathematics, or any other related fields in bachelor or master degree or if you just want to learn ML technologies on a self-learning basis, you should be familiar with linear algebra, statistics, and Python Programming.</p> <p>Students and participants of this course are expected to learn the basics of ML, theoretical concepts and algorithms of ML, ML obstacles, and how to design ML models. This leads them to be able to apply these techniques to master ML problems and initiate novel models and strategies on their own after finishing the course.</p> <p>To escalate the outcome of the course, it evaluates and conducts a diverse range of materials and media including, video lectures, reading materials, quizzes, and Jupyter Notebooks.</p>			
Course Materials and Equipment (Prerequisite)			

To use this material you need to be familiar with statistics and Linear Algebra. Also, you should have basic knowledge of Python programming. For executing hands-on projects, you should have access to the Anaconda environment or Google Colab.

Teaching and Learning Activities:

1-Video Lectures: Presenting Concepts, Algorithms, and Mathematics as the basis of Machine Learning methods.

2-Reading Materials (Slides)

3-Virtual lab Projects (assignments):

3.1-Problem representation: representation of a (real-world) problem.

3.2-Hands-on (Python) experience: executing Machine Learning method on the problem, analyzing results.

4-Quiz: to ensure understanding of students, after each chapter, a few questions (objective questions or short answer questions) are designed based on the content of the materials.

Course activities:

This course contains different types of activities which are listed below:

1)Reading the materials: for each chapter students are required to read the materials (slides) and get an intuition of the chapter, leading to understanding the content of the chapter.

2)Watching video lectures: students are expected to watch all the video lectures after reading the materials to better understand the content.

3)participating in quizzes: students should take part in quizzes and assess their understanding.

4)completing the laboratories: students should apply their acquired knowledge to build ML models using ML algorithms and strategies.

Course Objectives:

The Fundamental Machine Learning course's main objective is to give students the foundational education to understand the Machine Learning Methods and gain practice applying them. Thus, they can use these techniques to new problems or even initiate innovative approaches and algorithms for Machine Learning.

A summary of the course objectives are listed below:

- 1- Learning the basics of ML
- 2- Learning the theories behind ML, its concepts, and algorithms
- 3- Learning the obstacles of ML algorithms and overcoming them
- 4- Bulding ML models, evaluating them, and analysing results

Course Summary:

The Fundamental Machine Learning course is divided into 7 main chapters. Each of them is subdivided into modern approaches and algorithms, containing both theory and hands-on practices of Machine Learning.

Through this course students broaden their knowledge and skills in the following areas:

- 1- Basics of ML
- 2- Supervised Learning and different methods of it
- 3- Unsupervised Learning and its different methods
- 4- Obstacles of ML and ways of dealing with them
- 5- Evaluating and Comparing ML Models and Algorithms
- 6- Implementing Machine Learning techniques on different data and analyzing the results

Table of Contents:

WEEK 1, INTRODUCING MACHINE LEARNING AND 2 METHODS OF SUPERVISED LEARNING:

1- Introduction of Machine Learning

- 1.1 - History of Machine Learning
- 1.2 - What is Machine Learning

2- Supervised Learning

- 2.1- What is Supervised Learning
- 2.2- Linear Regression
- 2.3- Classification
 - 2.3.1- Logistic Regression
- 2.4- Quiz

WEEK 2, PRESENTING ML OBSTACLES AND DIFFERENT WAYS OF ADDRESSING THEM:

3- Problem of over/undertraining

- 3.1- Underfitting/ Overfitting
- 3.2- Regularization
- 3.3- Cross-validation
- 3.4- Lab 1/ Implementing Linear/Logistic Regression
- 3.5- Quiz

WEEK 3, PRESENTING NEURAL NETWORKS AND THEIR LEARNING METHODS:

4- Neural Networks

- 4.1- Biological Motivation
- 4.2- Perceptron
- 4.3- Multilayer Perceptron
- 4.4- Learning
- 4.5- Lab 2/ Implementing Multilayer Perceptron from scratch
- 4.6- Quiz

WEEK 4, PRESENTING KERNEL METHODS:

5- Kernel Methods

- 5.1- Maximum Margin Classifiers
- 5.2- Support Vector Machines (SVM)
- 5.3- Lab 2/ Implementing SVM

5.4- Quiz

WEEK 5, INTRODUCES UNSUPERVISED LEARNING, ITS DIFFERENT ALGORITHMS, AND ITS PERFORMANCE EVALUATION:

6- Unsupervised Learning6.1- *What is Unsupervised Learning*6.2- *Clustering*6.3- *K-means*6.4- *Performance Measurement of Unsupervised Learning*6.5- *Lab 4/ Implementing k-means*6.6- *Quiz*

WEEK 6, PRESENTING COMPUTATIONAL LEARNING THEORY AND MODEL EVALUATION METHODS:

7- Model Evaluation7.1- *Comparing Machine Learning Models*7.2- *Computational Learning Theory/ Probably Approximately Correct (PAC) Model of Learning*7.3- *Finite Concept Classes and Infinite Concept Classes (VC dimension)*7.4- *Model Evaluation*7.5- *Quiz***Laboratory Description and Equipment:**

Python is a programming language and is becoming more and more popular for Machine Learning every day. It is used widely for running Machine Learning experiments. We will be using Python with Jupyter Notebook for this course. The purpose of virtual labs is to gain practical experience executing ML techniques on different datasets and implementing its algorithms.

To complete the assignments while you do not need to be an expert in programming, it is necessary to know some basics.

Course References:

Hastie, Trevor, Robert, Tibshirani and J. H. Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*. New York: Springer, 2009.

Tom Mitchell. *Machine Learning*. McGraw-Hill Science/Engineering/Math, 1997.

Christopher M. Bishop. *Pattern Recognition and Machine Learning*. Springer, 2006.

Evaluation and Assessment Methods:

Assessments take a variety of forms including Quizzes after each module (objective questions and short answer questions) or Implementation of a Machine Learning technique on a real-world problem. Students must take 80% of the quizzes and complete the hands-on projects to successfully finish the course.

The tasks lead to the production of the intellectual output and the applied methodology.

There are four main steps, leading to the production of the intellectual output and the applied methodology:

1-Tasks

The Fundamentals of Machine Learning course tasks are listed below:

- 1- Studying all the course references by the organization in charge (PTX).
- 2- Extracting information from the References based on the arranged content of the course.
- 3- Organizing and preparing slides, reading materials, and quizzes.
- 4- Developing video lectures.
- 5- Designing virtual laboratories (choosing appropriate Datasets and conducting codes with Jupyter Notebooks)

2-Review and Feedback

All other partners will be asked to review the course materials and give feedback. This leads to enhancing the functionality of the course, improving its outcomes.

3-Fine-tuning

The responsible partner (PTX) should take the feedback into account and ameliorate the course materials.

4-Publishing

After the approval of the course by all partners, it will be published and is available for everyone online.

3 Course Contents