Mastering Data Science with Deep Learning

Syllabus

COURSE DESCRIPTION

Mastering Applied Data Science with Deep Learning course combines our Data Science, Project Based Learning, and Deep Learning programs to give students a solid foundation in data science and project experience.

In the Data Science program, you will cover the fundamentals of data science and hone your skills through various projects and assignments. Upon completion, you will compete with your peers in a private Kaggle competition to showcase what you have learned throughout the program.

In Project Based Learning, you will put your knowledge to use by building your own end-to-end machine learning projects from scratch. Deepen your knowledge by solving real-world business problems and learn best practices to implement into your own projects.

The Deep Learning component of the program builds on concepts from the first two modules. It highlights the importance of building deep neural networks and how they can be utilized to solve business challenges.

INSTRUCTORS

Zafer Acar

Email:
zacar@mtu.edu

Office Hours:
By appointments via Zoom

PREWORK

Students will work through a collection of tutorials to be completed prior to the start of Data Science Course. These are meant to cover the basics of Python, so all students can start from a similar base of knowledge to build upon.

TEXTBOOK & COURSE MATERIALS

Grus, J. (2015). *Data Science From Scratch: First Principles with Python* (First ed.). Sebastopol, CA: OReilly Media.

Matthes, E. (2016). *Python Crash Course*. San Francisco, CA: No Starch Press, Incorporated.

DOWNLOADS

Anaconda Python 3 (https://www.anaconda.com)

COURSE SCHEDULE

PreWork

Python 101:

Whether you are familiar with programming or not, our Python PreWork sessions introduce the fundamentals of Python, such as variables, string fundamentals, if-else statements, try & except statements, for loops, while loops, break & continue statements, & lambda functions, as well as certain data types relevant to data science, like lists, tuples, dictionaries, & sets for beginning exposure.
The activities done in these sessions will guide students to moving forward.

Stats 101:

The hands-on portion of statistics in PreWork is to establish an understanding of concepts such as mathematical variables, numerical vs categorical, nominal vs ordinal, interval vs discrete; measurements of statistics, when to use mean, when to consider median, & when to revised to mode; relationship between variables, like correlation & independence; ending with hypothesis testing & p-value, but only to the degree of applying the mindset towards data science. These concepts will be reviewed in Day 2 of the program to ensure student's clarifications are addressed.

Web 101:

An introduction to HTML & CSS is key to future project building & publication of a blog students' write tracking their progress throughout the program. The access of relevant open-source data is available throughout the web for people to utilize. Using the most open-source methods, like HTML & CSS, to grab that information within our Python environments will be introduced in Day 3. Once students are in Project Based Learning, GitHub portfolios are best displayed in themes that students choose & customize with HTML & CSS.

SQL 101:

While some of the tools used in Python will take the place of SQL functions & methods, it is still beneficial to understand the origins of these tools as well as be able to replicate them when applied in future work's expectations. A solid portion of demand in data science jobs ask for big-query experience with SQL, such as: Microsoft SQL & PostgreSQL vs NoSQL, MongoDB &

DynamoDB, which students will learn scenarios to further solidify their application to the business problems.

Applied Labs

Session 1: Introduction to Data Science with Python

In our first class, we will go over some intermediate functions in Python as review & move onto introducing what is the expected mindset of a data scientist versus the traditional viewpoint & how to take full advantage of the program by using the Applied Labs environment. We will encourage students to introduce themselves to each other & gather each other's strengths, along with the instructor's experience to not only grasp the skills & tools a data scientist is expected to know, but know exactly when to use which tools & why through peer & real-life learning. There will also be an introduction to the CRISP-DM data science methodology & chosen framework with the distinctions between the two mindsets of machine learning: supervised learning & unsupervised learning. The session has two miniature projects, Temperature & Christmas, to wrap up Python essentials.

Project 1: Pandas

Session 2: Exploratory Data Analysis

We start by asking the questions that data science can help answer for students to identify the difference between a data analytical question vs a data science question. We further breakdown what are the key checklist items in form of questions that CRISP-DM individual stages require before moving further in the cycle. We again showcase the distinctiveness between supervised learning & unsupervised learning & explain why sometimes supervised learning is the method that most of us will encounter, but unsupervised learning will elaborate more patterns in data than we can ever imagine. We introduce the self-checking mindset of what is considered good data for data science projects: what is good data & how can we detect bad data from good data, & we let the students ponder how we can tackle dirty data. We then give the attributes to help students identify big data from small data through the Four V's. A small review on what are the differences between mathematical variables, numerical vs categorical along with a short case of where statistics are required the most in data science: the data analysis phase. The hands-on portion of the class familiarizes students with NumPy and Pandas and showcasing how to clean, manipulate, and analyze data by applying those concepts. Students will be given the data set for Titanic, a

Kaggle competition known for introductory data science methods & cleaning, practicing data analysis skills on the Titanic dataset with Pandas to get students in the data science mindset of result- oriented, instead of process-oriented.

Project 2: Exploration of Titanic

Session 3: Data Visualizations & Information Analysis

We start off by asking what's the purpose of visualization in data science, broadening on student's experiences with charting & decision making with charts. A review of NumPy functions for generating different types of data is done before a brief introduction to Matplotlib's figure attributes & properties. Instructors will continue with explaining what the most common analysis-based visuals are, such as histograms & scatterplots. An intermediate approach to Titanic is used for exercises with graphing in Matplotlib & analyzing whether the graph is deemed useful or not. We continue with creating a Python based method for web-scraping & introduction to JSON. There are further functions & helpful tips to consider analyzing data with Pandas, such as common Excel functions implemented to insights. The day ends with a project on what happened during the 2012 election & whether the data of polls can give us clues into who was more likely to win. A GitHub repository is expected to be created by the end of this session & students will learn how to create their own blog & begin to publish content.

Project 3: Election Day Results

Session 4: Machine Learning

We will review by explaining the difference between supervised learning and unsupervised learning, asking students why certain scenarios will not be effective for supervised learning. Furthermore, an explanation on the two result-oriented methods of supervised learning, regression & classification are introduced. The day is dedicated to determining a regression problem, immediate analysis to modeling using regression methods, assessing the models, then optimizing for the best results by different metrics. Afterwards, students will work on building one of the regression models introduced, such as linear, polynomial, ridge, lasso, gradient, robust, & an introduction to logistic regression for classification. The day end with a Kaggle based project using regression.

Project 4: Optimizing House Price Predictions

Session 5: Advance Machine Learning

Revisiting the results students derived for their House Pricing project we will give more hints & clues to how to approach the project further. We will then dive into the second supervised learning need: classification algorithms, such as Naïve Bayes, Decision Trees, Random Forest, and other methods based on regression. Students are expected to be able to identify when a certain algorithm should be used based on the data, which methods to use to optimize classification algorithms, what is appropriate for insights & decision making. Students will also learn metrics such as R-squared, MSE & RMSE, & scoring using precision, recall, sensitivity, specificity, accuracy score, AUC, ROC, along with gains & lift charts. The session ends with a Spam Classifier project, which alludes to the processes of Natural Language Processing.

Project 5: Classification of Spam Emails

Session 6: Hack Day

Students will be separated into groups to practice their skills, emphasizing on visualization & modeling with machine learning, with a live Kaggle competition. During this time working with others, students will also be encouraged to identify the gaps in their skills, especially in analysis & modeling, in the project & review as much as possible moving forward to other projects in the continual sessions.

Project 6: Baseline Kaggle Competition

Project Based Learning – Level 1

Project 1: Skill Assessment

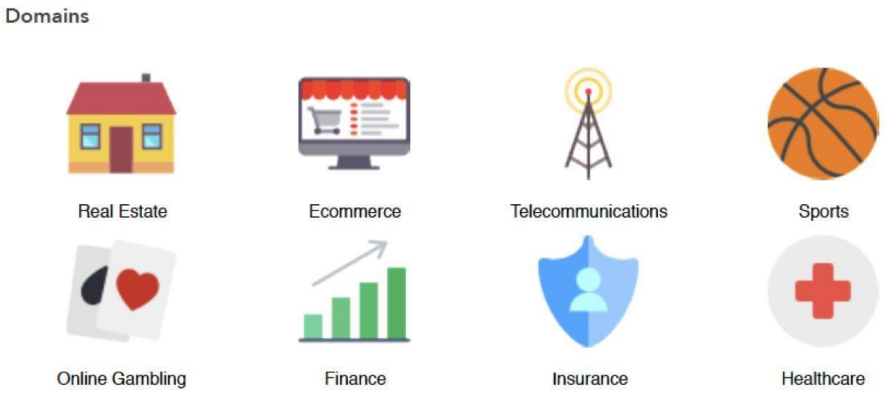
The first project is designed to solidify the skills that are crucial to any data science project. This project will let students understand where they need more review in.

Project 2: End-to-End Development

In this project, students will complete a data science project to the deployment stage; their results will be displayed in a report from an acceptable medium, an app or a webpage.

Project 3: Domain-Specific Project

Students are given the option of choosing a project in a domain from below.



Session 7: Recommender Systems

Students will review machine learning algorithms and be introduced to types of recommender systems, such as collaborative filtering with k-nearest, using either items or users, similar to Amazon's. Then students will start by building their own recommender system with the MovieLens dataset, elaborating on what to consider as the best method for selection & integrating with what viewers of recommender results will use best; understanding dimension reduction with PCA, principal component analysis; explore SVM, support vector machines; and learn A/B Testing with T-Tests and P-Value methods.

Project 7: MovieLens Through Recommendations

Session 8: Natural Language Processing and Sentiment Analysis

Students will explore the Natural Language Toolkit to process and extract text data: learning about tokenization of words & sentences, part-of-speech tagging & stemming with lemmatization for the best analysis of textual data. Students will then start a Natural Language Processing project with Yelp data before we move onto Sentimental Analysis to predict positive versus negative Yelp reviews.

Project 8: Yelp Reviews & the Truth from Customers

Session 9: Big Data with Spark

Students will be introduced to Big Data and data engineering with the Hadoop ecosystem, the MapReduce paradigm, Apache Spark, and the up-and-coming Splunk, where real-time data is represented in a dashboard format for easier assessment. An existing project, such as MovieLens, will be transferred to AWS to expose students to the difference.

Project 9: MovieLens Through Big Data & Splunk

Session 10: Deep Learning and Time Series

Instructors will make sure that student's understanding of unsupervised learning & supervised learning is re-clarified & where does deep learning come in. We will be introducing deep learning through Tensorflow, training neural network, and visualizing what a neural network has learned using TensorFlow Playground. Students will also learn time series, what makes them special, loading and handling time series in Pandas. Students will understand how seasonality affects trends. Projects for this session include handwriting recognition & digital face recognition.

Project 10: Hand-writing Recognition

Session 11: Computer Vision with OpenCV and Hack Project

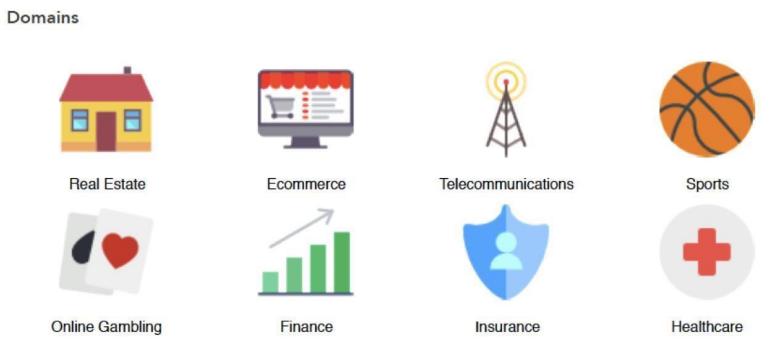
After initial installation, we will expand on the notion why letting computers understand images is harder said than done when compared to the way humans & eyes process images. Then, students will be introduced to computer vision fundamentals using OpenCV to detect faces, people, cars, and other objects, even when images are manipulated in rotations or scaling situations. Projects will use sensors such as student's webcam to create a real-time facial recognition program & object recognition program.

Project 11: Facial Recognition

Session 12: Hack Day

In the last session, we will host a private Kaggle competition amongst the students. Students will be grouped into teams and will showcase their group project at the end of class. Students will be assessed based on their presentation skills, as well as their ability to solve the business problem while utilizing the skills they've developed thus far.

Project 12: Private Kaggle Competition



Project Based Learning – Level 2

Project 1: Skill Assessment

The first project is designed to solidify the skills that are crucial to any data science project. This project will let students understand where they need more review in.

Project 2: End-to-End Development

In this project, students will complete a data science project to the deployment stage; their results will be displayed in a report from an acceptable medium, an app or a webpage.

Project 3: Domain-Specific Project

Students are given the option of choosing a project in a domain from below.

Advance Expertise using Deep Learning

Deep Learning mastering Theano, TensorFlow and Keras libraries

- Develop large models on GPUs cheaply in the cloud
- Crash course in Multilayer Perceptrons
- Develop your first Neural Network with Keras
- Evaluate the performance of Deep Learning Models
- Use Keras Models with Scikit-Learn for General Machine Learning

Advanced Multilayer Perceptrons and Keras

- Save your models for later with Serialization
- Keep the best models during training with Check Pointing
- Understand model behavior during training by Plotting History
- Reduce overfitting with Dropout Regularization
- Lift performance with learning Rate Schedules

Convolutional Neural Networks

- Course in Convolutional Neural Networks
- Project: Object Recognition in Photographs

Recurrent Neural Networks

- Course in Recurrent Neural Networks

Deep Learning for natural language processing

Develop Deep Learning Models with Keras

- Develop a Neural Bag-of-Words Model for Sentiment Analysis
- Develop Word Embeddings with Gensim

Neural Language Modeling

- Develop a Word-Based Neural Language Model
- Neural Image Caption Generation
- Neural Network Models for Caption Generation
- Load and Use a Pre-Trained Object Recognition Model

Machine Translation

- Neural Machine Translation
- Encoder-Decoder Models for Neural Machine Translation
- Configure Encoder-Decoder Models for Machine Translation

Deep Learning for Time Series Forecasting

Taxonomy of Time Series Forecasting Problems

- Develop a Skillful Forecasting Model
- Transform time series to a Supervised Learning Problem

Simple and Classical Forecasting Methods

- Prepare time series data for CNNs and LSTMs

Develop LSTMs for Time Series Forecasting

- Grid search Deep Learning Models for Univariate Forecasting

Project Base Learning – Deep Learning

Business Focus Deep Leaning Level 1 Deployment

- Using Theano, TensorFlow and Keras libraries
- Project 1: Object Recognition in Photographs
- Project 2: Sentiment from Business Reviews Box

Business Focus Deep Leaning Level 2 Deployment

- Deep Learning with Natural Language Processing
- Project 1: Develop a Neural Language Model for Text Generation

- Project 2: Prepare a Photo Caption Dataset for Modeling
- Project 3: Develop a Neural Image Caption Generation Model

Business Focus Deep Leaning Level 3 Deployment

- Deep Learning with Time Series
- Project 1: Explore Household Energy Usage Data
- Project 2: Text Generation with Alice in Wonderland