Generative Deep Learning: A Course Introduction

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Generative Deep Learning 2021/2022

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Sapienza
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1 About This Course

Course Description
Syllabus
News of Edition 2022
Lectures and Seminars
Exam Assessment

General information

- Credits: 3 CFU (18 hours)
- Scientific sector: ING-IND/31
- Course language: English
- Offered programs: PhD Course in Information and Communication Technology (ICT)
- Course webpage: danilocomminiello.site.uniroma1.it/teaching/gdl
- Classroom page: Download slides, videolectures, Python notebooks, homeworks and additional material. Access code: **rg2mczw**. Participants are invited to register here.
- Office hours: in-presence/remote meeting by appointment.
- Contact: danilo.comminiello@uniroma1.it

Course description

This course deals with **generative deep learning**, which is one of the most promising paradigms of the modern "artificial intelligence".

Generative models aim at learning the true data distribution and generating new data points by leveraging the capabilities of deep neural networks.

We study the foundations and the main models of generative deep learning, including *variational autoencoders* and *generative adversarial networks*, among others.

The course also discusses some ICT applications that benefit from generative deep learning.

Application examples are addressed by using TensorFlow. Fields of application can be agreed with the teacher on the basis of the own PhD research topics.

Prerequisites and background

This course requires basic knowledge of:

- machine learning
- linear algebra
- probability theory and stochastic processes
- optimization
- Python

Anyway, additional material can be provided, even on request, to fill some gaps.

Syllabus

- **Introduction to Generative Deep Learning**
  - Generative modeling and deep neural networks.
- **Generative Autoregressive and Flow-Based Models**
  - Autoregressive models and generative autoregressive models, normalizing flows.
- **Variational Autoencoders**
  - Autoencoders, variational inference, deep VAE architectures.
- **Generative Adversarial Networks**
  - Generator and critic, training GANs, main GAN models.
- **Energy-Based and Diffusion Models**
  - Energy based models with latent variables, diffusion and score-based models.
- **Applications**
  - Music generation, image style transfer, text generation, video generation, anomaly detection, data augmentation, inverse problems solution, medical imaging.

Course material

Classroom:

- Lecture slides, papers, notebooks and supplementary material will be provided on the Classroom page (access code: rg2mczw).

GitHub:

- On the GitHub repository of the course you can find course notebooks, additional material and project notebooks.

Main textbooks:

- Jakub M. Tomczak, "Deep Generative Modeling", Springer, 2022.
- Kevin P. Murphy, "Probabilistic Machine Learning: Advanced Topics", The MIT Press, 2022.
- David Foster, "Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play", O'Reilly Media, Inc., June 2019.

TensorFlow Faculty Award

The course of Generative Deep Learning has been awarded the **TensorFlow Faculty Award 2021** from Google in support of the development of new teaching courses on emerging machine learning topics that also promote diversity initiatives aimed at widening access to machine learning education.

To this end, this edition of the course also features some extra initiatives:

- Invited seminars by world-expert researches in generative deep learning;
- Possibility to agree research projects including more students from different PhD programs under the supervision of a tutor;
- GitHub repository containing tutorial notebooks on the main generative models in TensorFlow;
- Additional material and tutorials from Google TensorFlow.

Invited seminars

This edition includes 3 amazing webinars from world-experts in generative deep learning.

- Chitwan Saharia, Google Brain
  One of the authors of Imagen, Palette, and other astonishing generative methods from Google Brain.

- Antoine Caillon, IRCAM
  The author of RAVE, a generative model for neural audio synthesis.

- Yang Song, Stanford University
  The world expert on score-based generative models.

Class schedule

The course is held in June 2022 with the following schedule:

- Monday, June 6 10:00–13:00
- Tuesday, June 7 10:00–13:00
- Monday, June 13 10:00–13:00
- Tuesday, June 14 10:00–13:00
- Monday, June 20 10:00–13:00
- Tuesday, June 21 10:00–13:00

The course is held in hybrid modality:

- In-person: DIET Reading Room, DIET Dept., II floor, Via Eudossiana 18
- Online: via Zoom at this link.

Exam assessment and grade evaluation

Small project assignment on one of the course topics.

Students are required to deliver a commented notebook on a chosen problem.

New: for those interested, it is possible to organize study groups that may include students from different PhD programs supervised by a tutor for advanced research projects (i.e., potentially publishable).

Topics can be agreed on the basis of your own interests and your PhD research program.

2 Setting Up Your Environment

Python Setting

Python setting

In this course, we will use Python and some basic libraries.

Lab session notebooks can be run by using Jupyter.

You can install Python through the Anaconda distribution, which also includes Jupyter and most of the basic libraries used in this course.

You can also install TensorFlow following the instructions on the website.

Alternatively to Anaconda, you can run all notebooks by using the Google Colaboratory service.

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