

Deep learning

0. Introduction

Clément Gorin

clement.gorin@univ-paris1.fr

Harbin Institute of Technology, Shenzhen

August 2024

Introduction

There is a growing interest among applied economists in using machine learning models for applied economic analysis

- Accurate forecasting of economic and time-series variables (Moritz and Zimmermann 2016)
- Non-parametric tools for estimation (Belloni et al. 2012) and inference (Athey and Imbens 2016)
- Modelling of previously inaccessible data for economic analysis (Mueller et al. 2021; Combes et al. 2023)

Neural networks represents the best performing approach to image and language modelling (LeCun et al. 2015)

- Mapping high-dimensional data structure into lower dimensional representations (Bengio et al. 2013)
- Latent representations encode large amounts of information, disentangling sources of variation
- Powerful numerical properties e.g. locally generalisable, distributed, hierarchical, disentangled

This course introduces neural networks with a language and approach familiar to economists

1. Provides a comprehensive understanding of neural networks models and their optimisation
2. Introduces some of the most capable supervised approaches to images and language modelling
3. Articulate intuition and formalisation, with a focus on effective implementations using TensorFlow

1. Neural networks

Lecture: Predictive modelling, Regularisation, Neural networks, Backpropagation

Application: Simple example using TensorFlow

2. Image modelling

Lecture: Image data, Image processing, Convolutional networks, Representations

Application: Image classification or Image segmentation or Image localisation

3. Language modelling

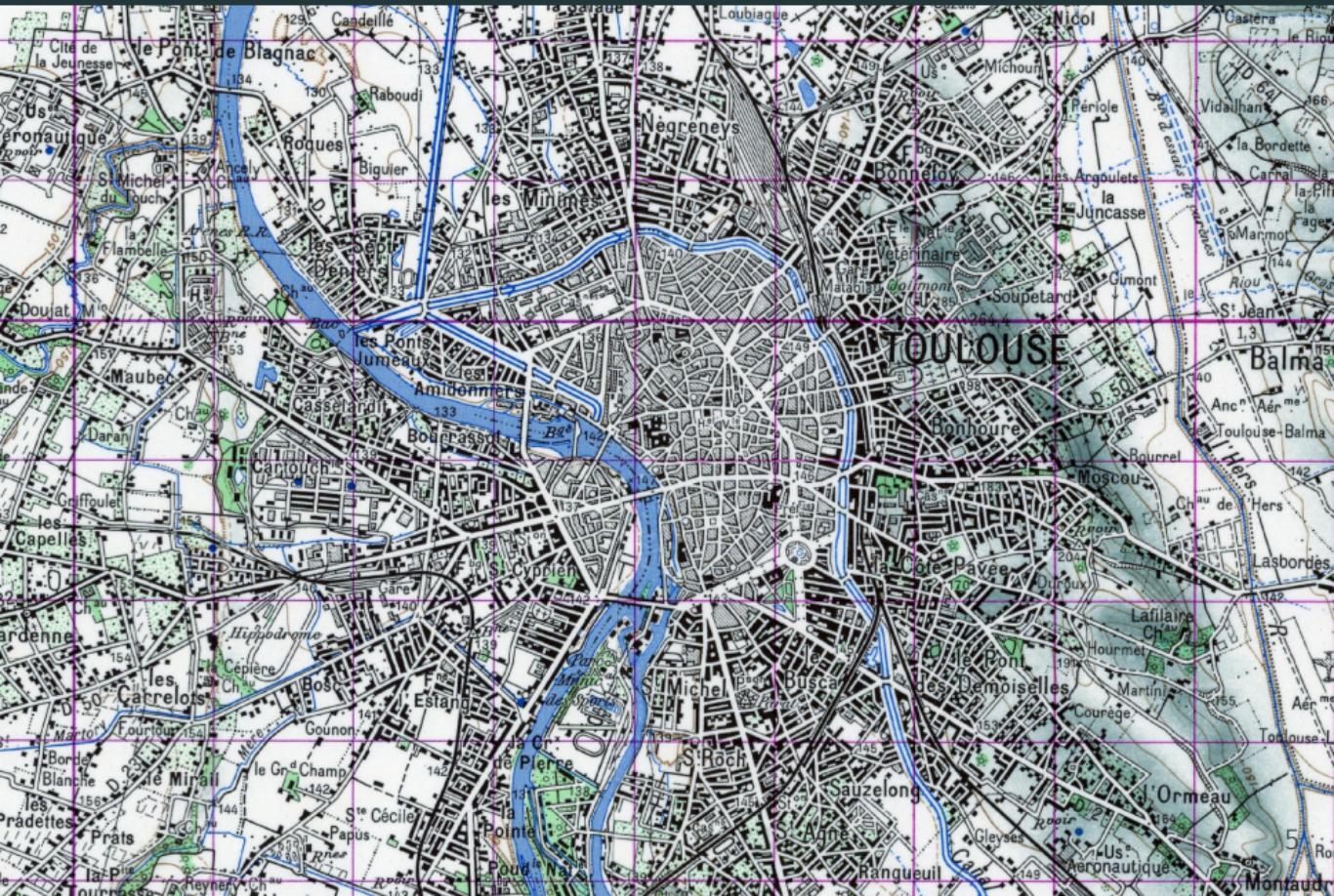
Lecture: Text data, Embeddings networks, Recurrent networks, Transformers

Application: Sentiment analysis

Examples

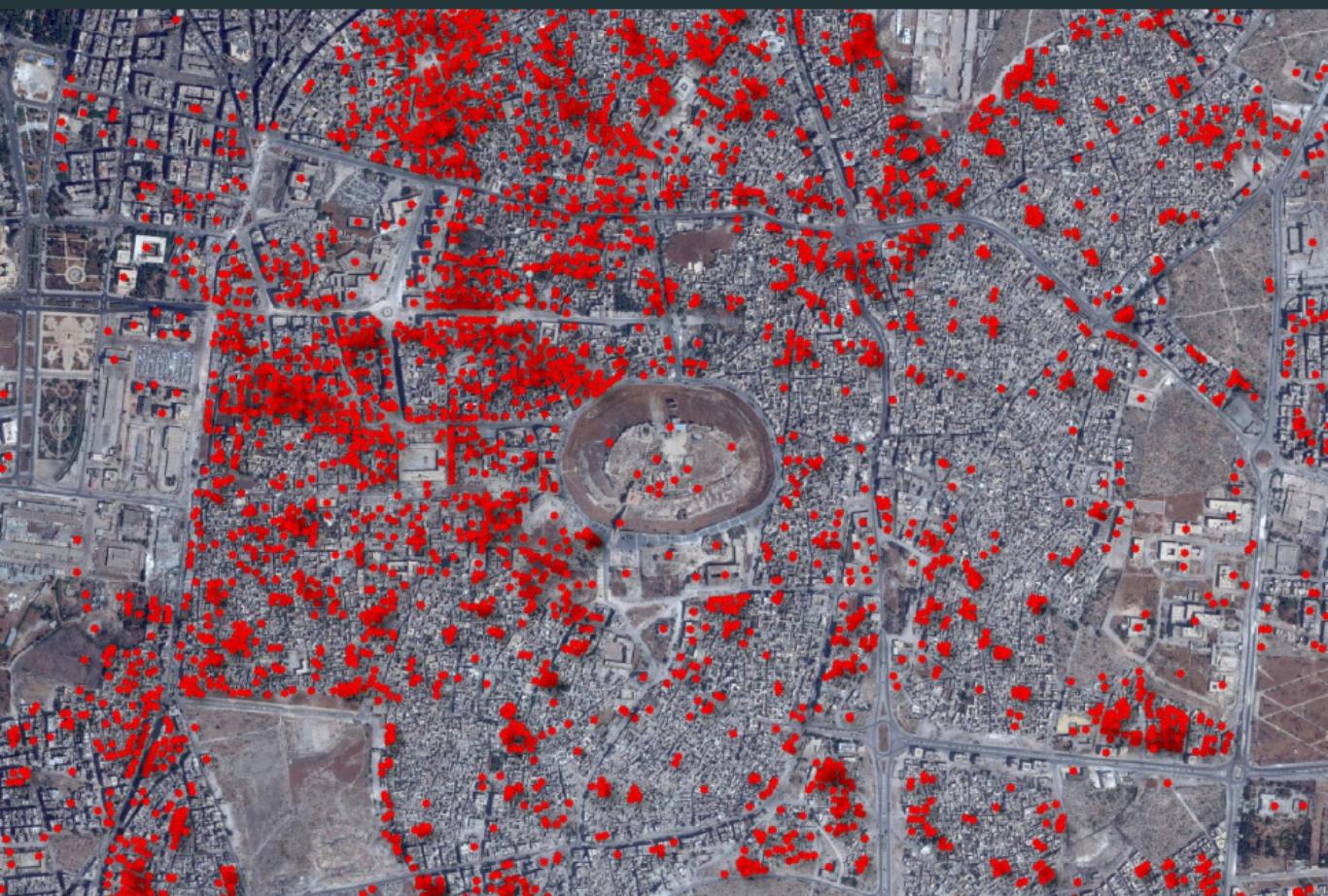
Examples

Historical maps



Examples

Satellite images



Examples

Nightlight data



Examples

Street view



Examples

Written documents

58 Saturday The first part of the day showers of rain & some snow. The Mill and Father Carl Clare & Father Lind & Strong gate AM sent the 2 Uplanders at Bay. Several Indians at the house. Self and Man seriously employed.

59 Sunday Cloudy and much snow this morning. Strong gate spent the day in telegraph. Some Captain Cabiling and family on the plantation and got very driving hard.

60 Monday Clare, Cleason & Father Lind Marshall light snow self and man employed signing for trucks at the saw mill the late factory was signed up 4000 of bricks stinkhouse and granaries. 3M came back Wilson and two of the hunters gave them 3 kinds of tobacco & drink and sent them to the tent.

61 employed at Harvey's AM to the Indians of 4th day have 11.4000 and sent them 12.00

62 Wednesday Wood cutting leather 12.00
yesterday the man employed building Martin's self employed at Harvey's Cork & Martins

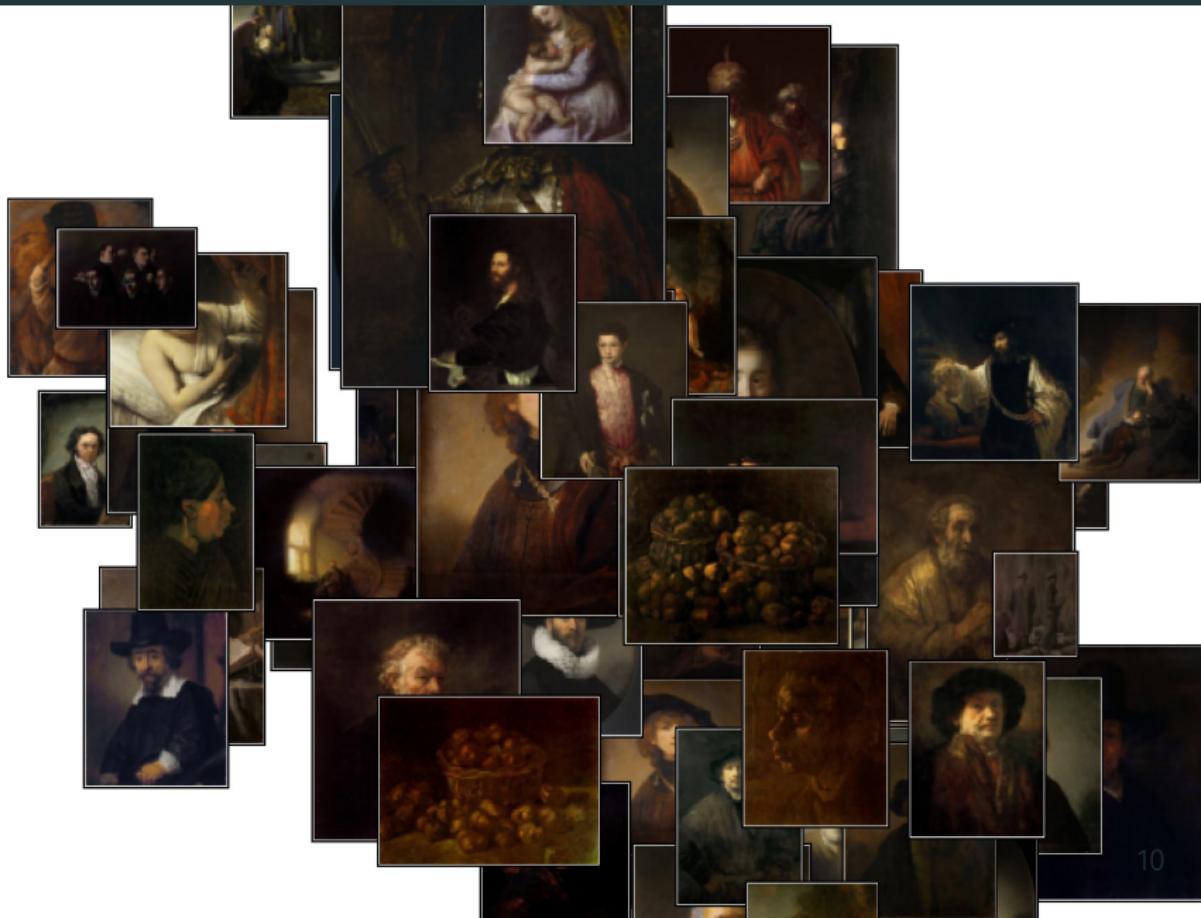
63 Thursday AM 20th leather 12.00 18 employed no 11th & Martins and 2 babbitts all for Friday

64 Friday the most part having houses of brick made from 1500 & employed at Harvey's Cork and bought the houses

65 Saturday The first Mill part with rain fine and little employe to yesterday AM same 2 Indians in the trap and Cork 5000 brought 4 lots of fish bait and boards for the fish and let them have 11.4000 and sent away 9 pairs to the house to back dinner \$2 00 4.30

Examples

Visual arts



Details

Learning material

- The repository github.com/goclem/deeplearning contains lectures, coding exercises, data, papers
- Files are updated right before every session so make sure to download the latest version in class

Computer resources

- Individual computer with administrator rights and a working internet connection
- [Google Colab](#) or [Anaconda](#) / [Miniconda](#) Python 3.12, with a development environment e.g. [VSCode](#), [PyCharm](#)

For a local installation, create a separate virtual environment for the course, which you can remove afterwards

- For tensorflow, decide whether you want the CPU or GPU optimised version (recommended for project)
- For GPU support, follow the [Cuda](#) (NVDIA) or [Metal](#) (M-chip) instructions for your operating system

```
1 conda create -n deeplearning
2 conda activate deeplearning
3 conda install -c conda-forge -y matplotlib pandas [...]
```

- Hastie, Trevor, Robert Tibshirani, and Jerome Friedman (2009). *The elements of statistical learning*. Springer.
- Nielsen, Michael A. (2015). *Neural networks and deep learning*. Determination Press.
- Goodfellow, Ian, Yoshua Bengio, and Aaron Courville (2016). *Deep Learning*. MIT Press.
- Zhang, Aston et al. (2023). *Dive into Deep Learning*.
<https://D2L.ai>. Cambridge University Press.

- Breiman, Leo (2001). “Statistical modeling: The two cultures”. In: *Statistical Science* 16.3, pp. 199–231.
- LeCun, Yann, Yoshua Bengio, and Geoffrey Hinton (2015). “Deep learning”. In: *Nature* 521, pp. 436–444.
- Mullainathan, Sendhil and Jann Spiess (2017). “Machine learning: An applied econometric approach”. In: *Journal of Economic Perspectives* 31.2, pp. 87–106.
- Chollet, Francois (2019). “On the Measure of Intelligence”. In: *CoRR* abs/1911.01547.
- Gentzkow, Matthew, Bryan Kelly, and Matt Taddy (2019). “Text as data”. In: *Journal of Economic Literature* 57.3, pp. 535–574.

- Lones, Michael A. (2021). “How to avoid machine learning pitfalls: A guide for academic researchers”. In: *CoRR* abs/2108.02497.

Specific references are provided in class

Thank you for your attention!