Automated Pupil Data Recosntruction using DL

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RECHERCHE EN IMAGERIE OCULAIRE

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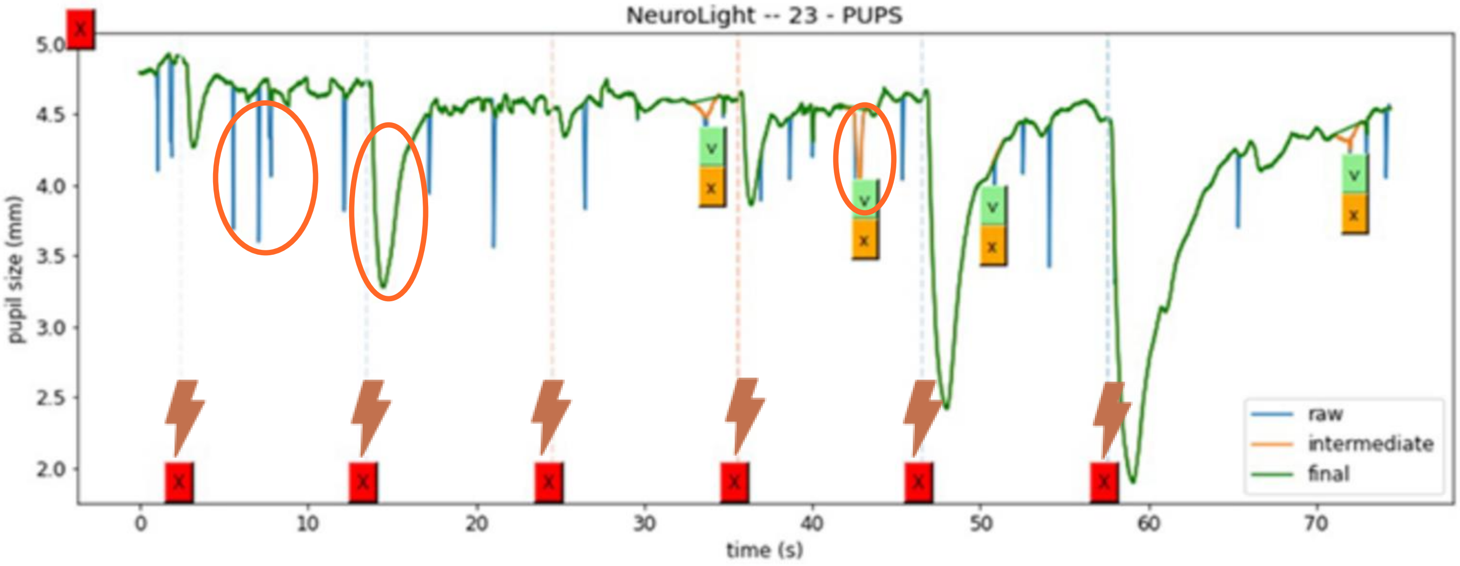
Pupil reactions are indicative of brain diseases and emotional states

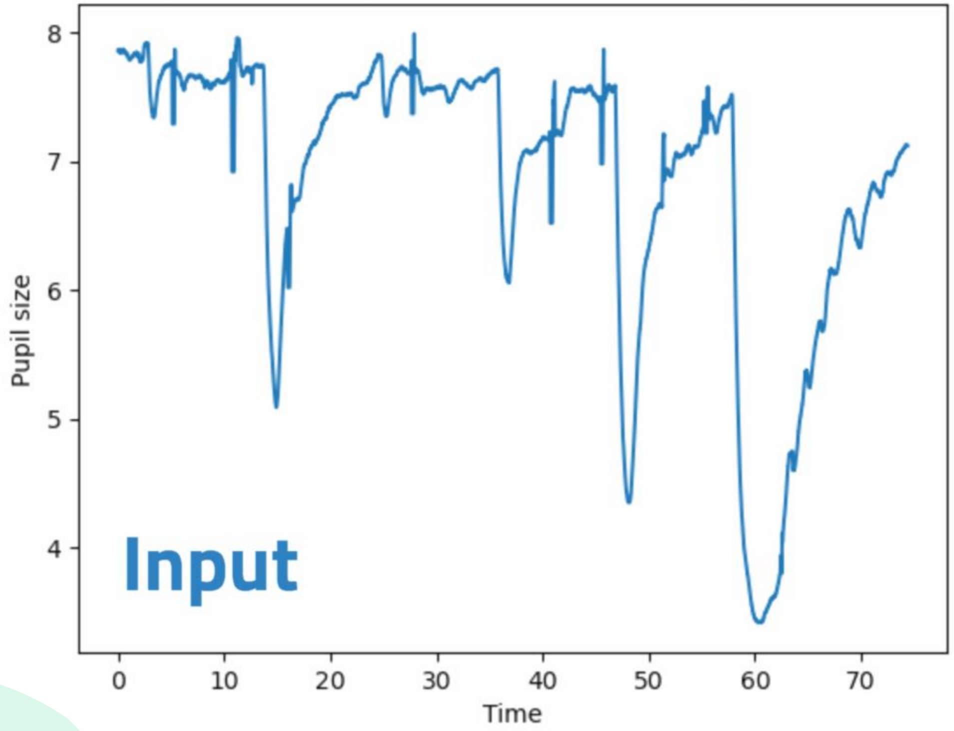
- Pupil reactions are needed to regulate the amount of light reaching the retina
- Pupil diameter changes
  → Two smooth muscles
- Pupil reactions can be used to
  → Evaluate retinal integrity
  → Evaluate rod and cone activity
  → Evaluate a subject’s psychological state

Today, analysis of pupil reactions still requires lengthy human intervention (semi-automated)



Our project aims to fully automate pupil data analysis

By training a Deep Learning model to detect and remove signal artifacts.



To reach our aim, we planned and then implemented the following steps

01 Data understaning and background research

02 Data preparation and cleaning

03 Plotting and intermediate graphical representation

Intermediate presentation

04 Research different Deep Learning models

05 Models training

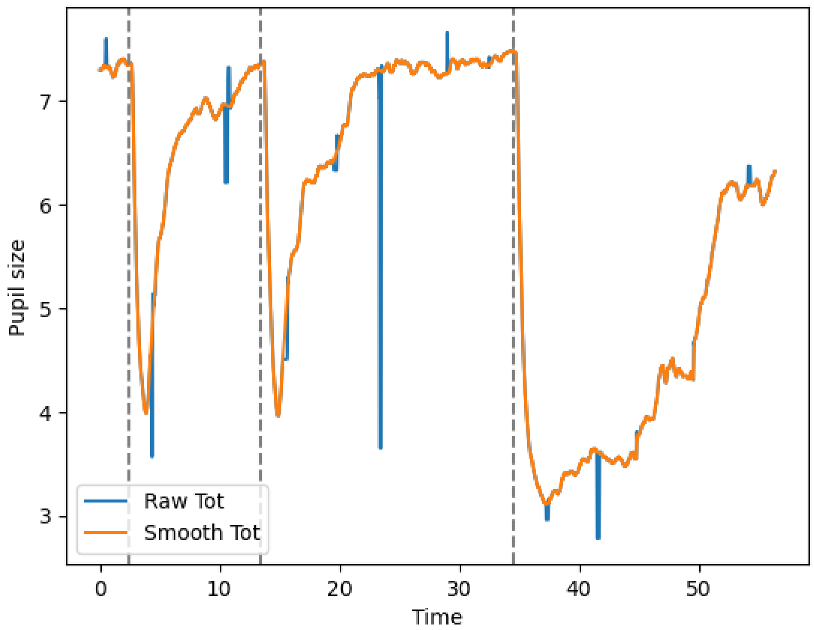
06 Grid search to find the best suitable model and parameters

07 Graphical representations and **final presentation**

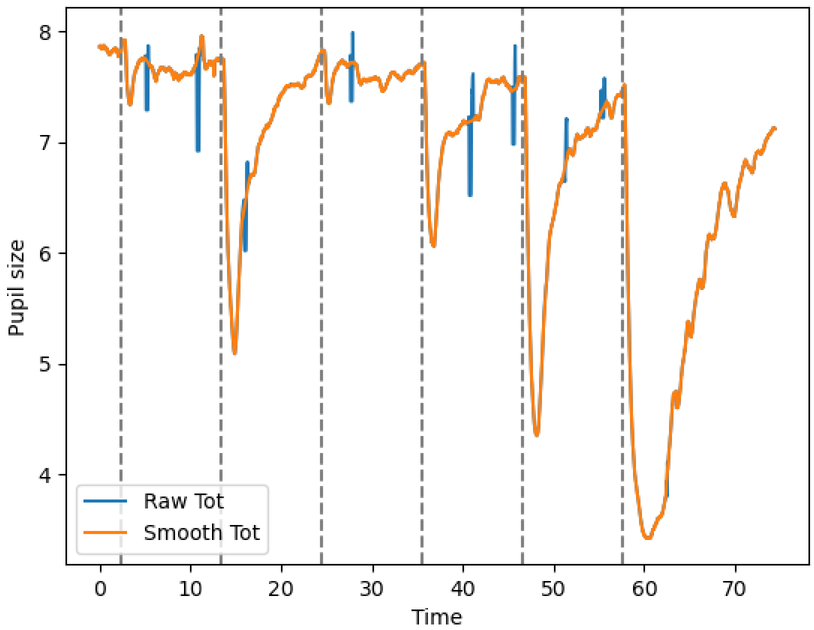
We started with data preparation and plotting

The input required data preparation and cleaning in order to obtain intermediate graphical representation

High intensity



Low intensity



We familiarized ourselves with Deep Learning

Definition

- Modeled after the human brain's structure and function
- Advanced machine learning technique
  - Neural networks with **many layers**
- **Analyze and interpret** large amounts of data to make predictions

How it works

- Training with **large dataset** through layers
  - Pattern recognition
- Superior performance compared to classical ML
- **High computational power** needed

We tested several Deep Learning models

CNN

Convolutional Neural Network

Spatial patterns → Image recognition

Applied in 1D

RNN

Recurrent Neural Network

Suited for sequential data → Time series

Importance of previous output in the serie

LSTM

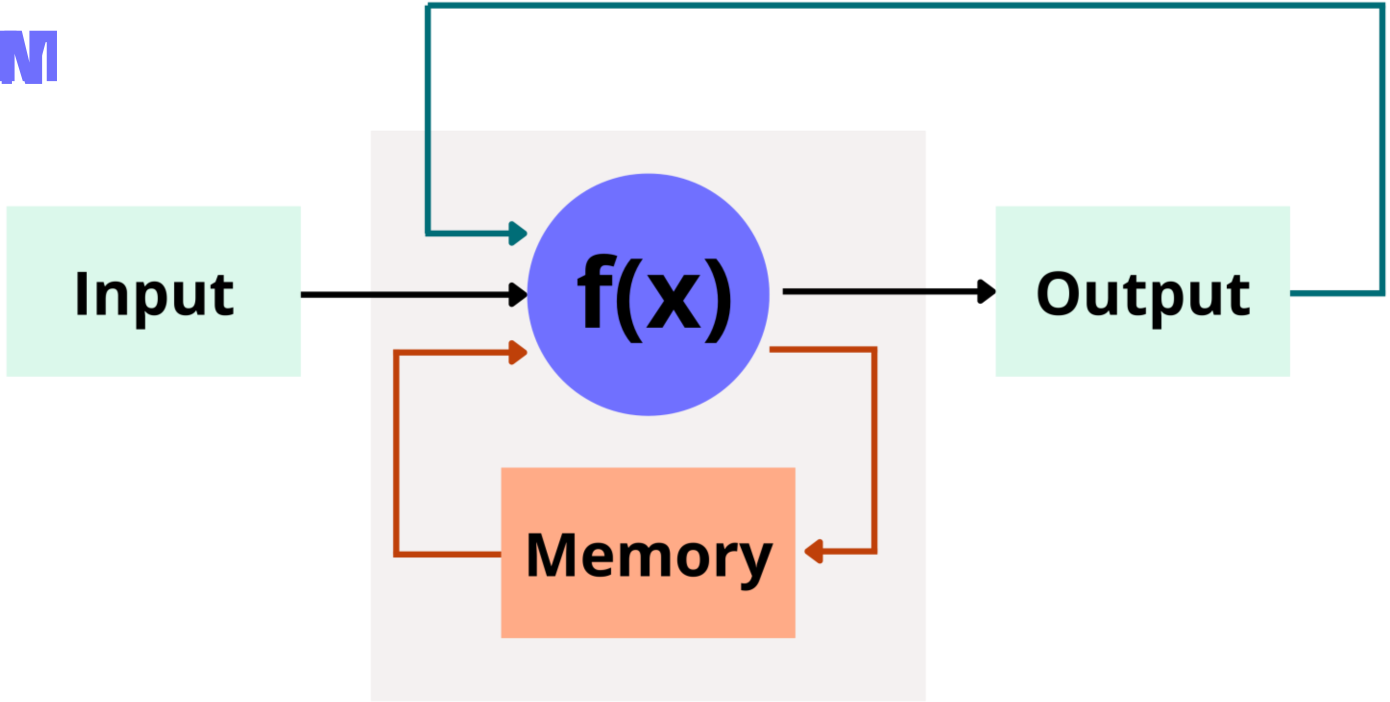
Long Short Term Memory

Evolving gates memory

Overcome the exploding/vanishing gradient problem

… But how are these models built?

LSTM
RNN



We automatically optimized several hyper-parameters by means of a grid search

Sequence length

Number of raw data → Prediction of clean data

Activation function

Selection filter

Optimizer

Weight assignment director

Learning rate

Rate of update of weights

Dropout rate

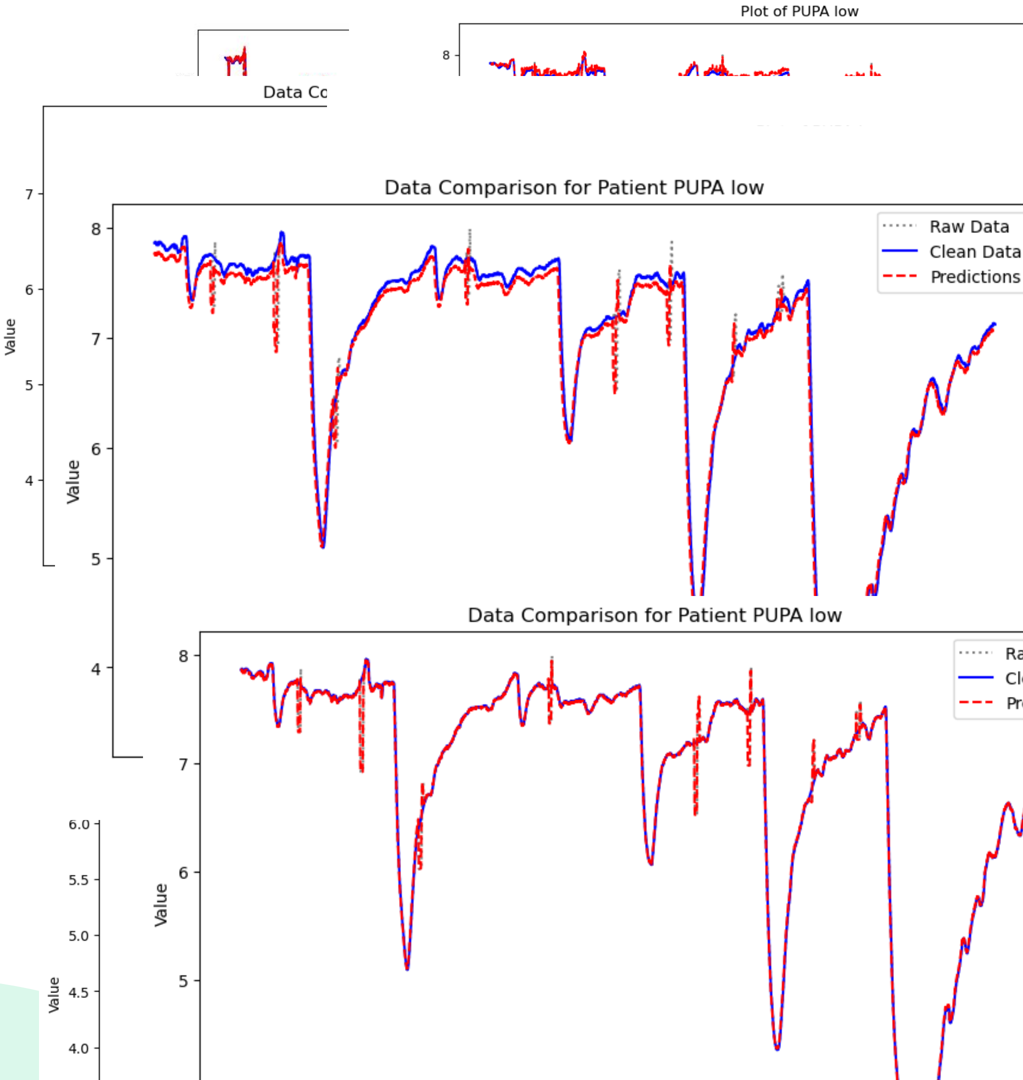
Overfitting prevention

Epoch

Number of training rounds

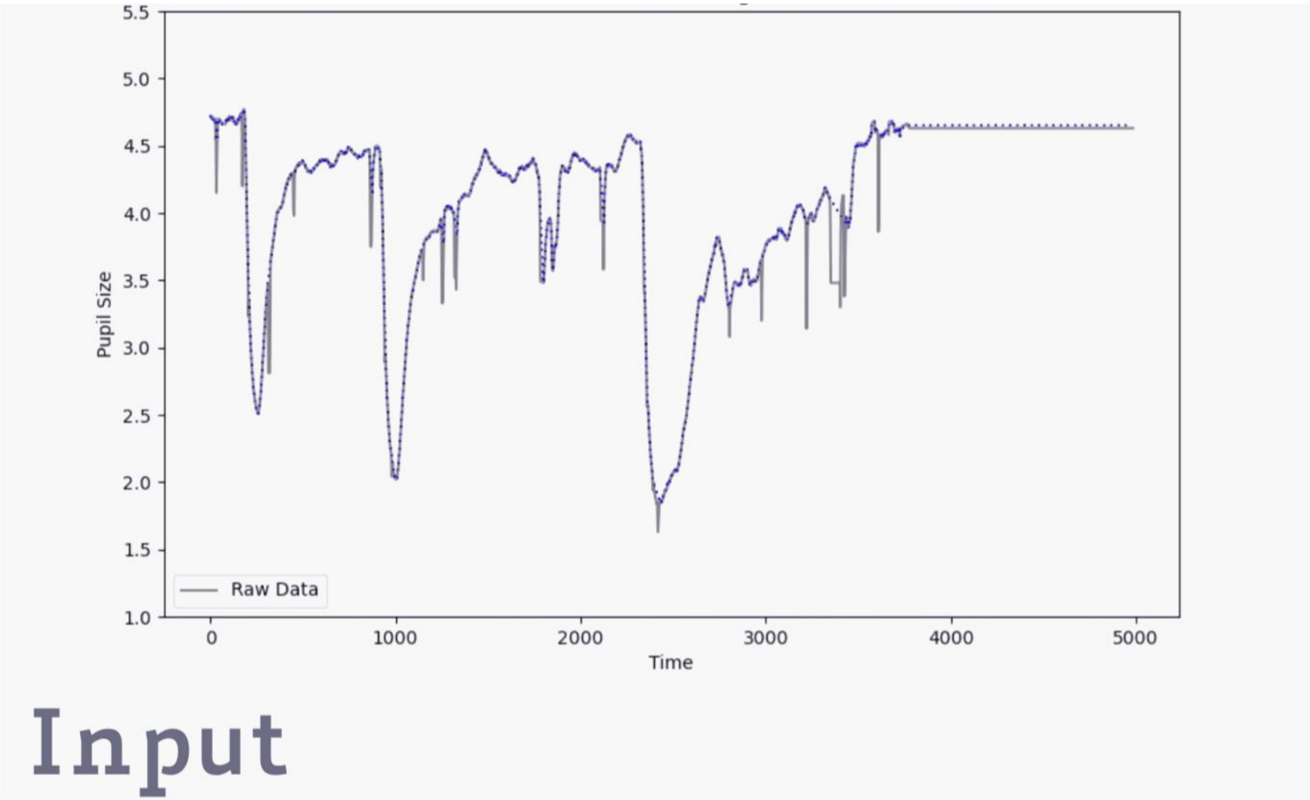
192

Total number of models that we explored in order to find the best one

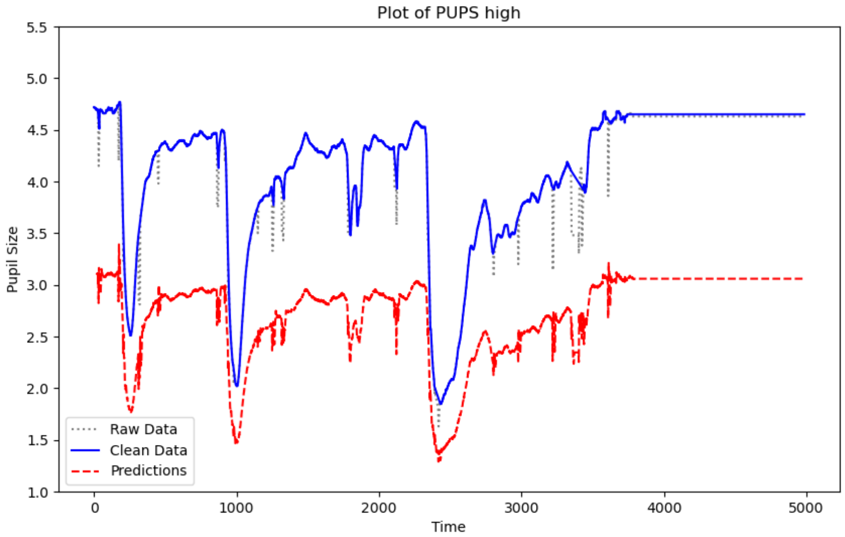


We obtained impressive results

by combining model selection with hyper-parameters optimization



Our WORST Model



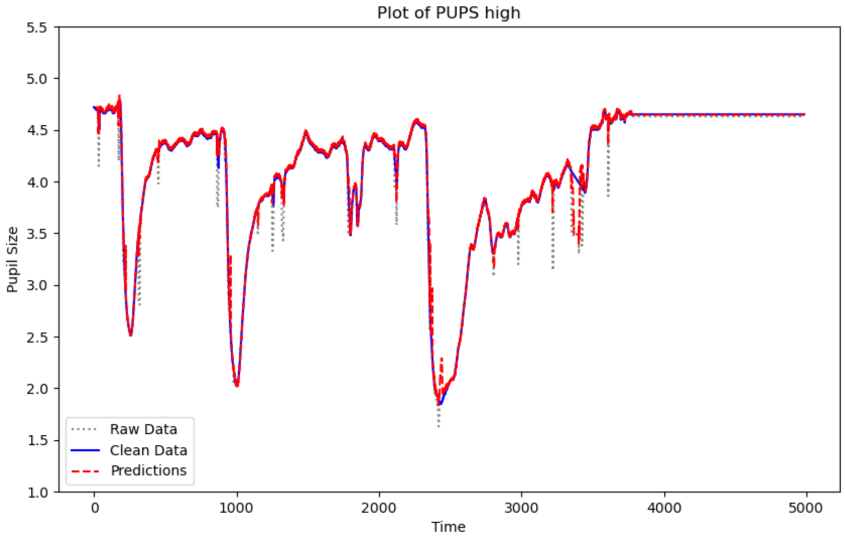
Totally shifted

Model probably overfitted

Learning rate & number of epochs are too high for such a simple model

Model	Seq length	Epochs	Activation function	Optimizer	Learning rate	Dropout rate	MSE
CNN	20	50	tanh	RMSprop	0.01	0.5	6.091

Our BEST Model



More adapted model to our specific case

Remembers previous data in the sequence → Makes better predictions

Model	Seq length	Epochs	Activation function	Optimizer	Learning rate	Dropout rate	MSE
LSTM	20	50	tanh	Adam	0.001	0.5	0.004

We encountered multiple challenges and were able to tackled them, learning valuable lessons

DL knowledge gaps

- **No previous knowledge** of DL
- A ton of **research** to find models and make them work
    - We learned a LOT

Hardware

- High computational capacity required
    - **Time consuming** computations
- Separation of the problem into **smaller parts** → Backup at different checkpoints
- Optimization

Our findings could be extended in four main possible future directions

DL pupil reconstruction project

1. Pre trained LSTM model
2. Increase the epochs of training
3. Implementing a Transformer algorithm
4. Changing output to binary

Three pieces of constructive feedback on the course

Inclusion of courses

Testing and putting into practice the notions learnt during all the module courses (many mini projects) would be interesting

Access to UNIL hardware

Providing access to computer servers with more computing capacity would have been beneficial

Great course

Very stimulating and challenging, we learned how to:

- ✓ Manage of python environments
- ✓ Implement DL models
- ✓ Grid search hyperparameters optimization

Thanks!

Do you have any questions?

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