Institut
québécois
d'intelligence
artificielle

Mila

Block 1 - Humanware project

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HumanWare

Over 25 years of service to people with vision loss

Recognized for its capacity to innovate
(Digital reading systems, talking book players, handheld talking GPS)

A worldwide network of distributors
(North America, Europe & Australasia)

150 employees making independence possible
(15% of our employees are also our clients)

#1 worldwide in blindness service

Products supporting over 25 languages
(including the Braille script)

Products available in more than 45 countries

Drummondville, Canada
Head Office
Operations Canada & USA

Rushden, Angleterre
Operations Europe,
Middle East & Africa

Longueuil, Canada
Marketing & R&D

Sydney, Australia
Operations Australasia

Humanware project

- **Task:** Detection of text in natural scenes, with its location and the ability to guide the user to get the full text (alignment) so that the text is interpretable by a recognition engine.

- **Use case:** Detection of house numbers, text on a bus stop sign, or text on a storefront (name, product details, opening hours, ...)

- **Constraints:** Execution time, online vs. offline, memory usage (in the case of a mobile application), etc.

Focus on door number detection

668

- Help blind persons find their way around
- Make sure that's the right house
- (Long term) Facilitate micronavigation

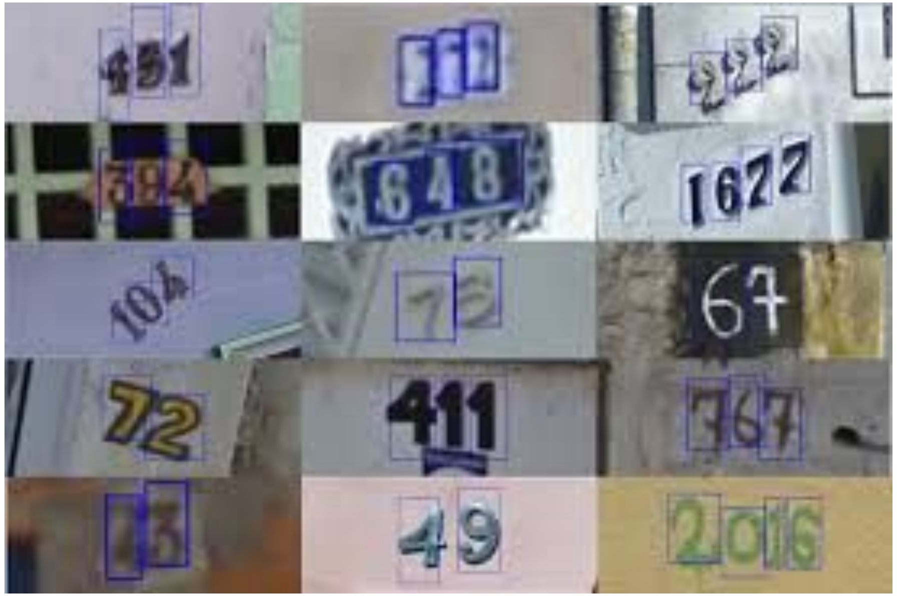
Data

The Street View House Numbers (SVHN) Dataset:

- Open-source
- ~200k street numbers
- bounding boxes and class labels for individual digits, giving about 600k digits total

Limitation:

- zoom on the numbers, lack of background
- no negative examples (i.e. no images without numbers)



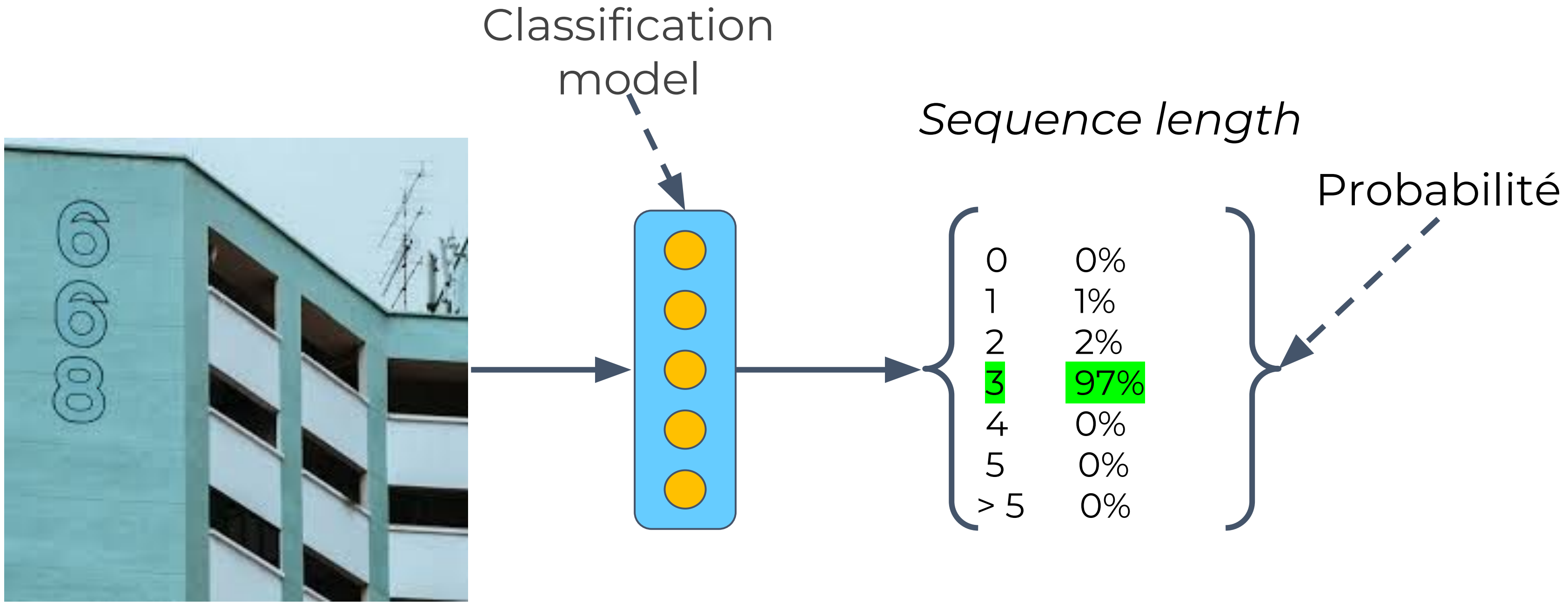
[Yuval Netzer, Tao Wang, Adam Coates, Alessandro Bissacco, Bo Wu, Andrew Y. Ng Reading Digits in Natural Images with Unsupervised Feature Learning NIPS Workshop on Deep Learning and Unsupervised Feature Learning 2011.]

Ongoing data collection

In house dataset

- Aim to be open-source
- Video of street views (case studies defined with the users)
- No ground truth bounding boxes available
- Centroid of the door numbers and sequence label
- The collection started
- You can help!

Sequence length classification



0	0%
1	1%
2	2%
3	97%
4	0%
5	0%
> 5	0%

Block 1 instructions / expected timeline

	Week 2 - 2019/01/14	Week 3 - 2019/01/21	Week 4 - 2019/01/28	Week 5 - 2019/02/04
Tasks / Homework	• Literature review of available datasets • Read the Goodfellow et al. 2013 article	• Code the data loader for SVHN as in Goodfellow et al. 2013 • Implement data visualization functions	• Train a CNN for the classification of the sequence length	• Write a short report summarizing the work, and results • (Peer-) Review of other teams' code
Objectives / Deliverables	• Justify the choice of using the SVHN dataset and to collect an in-house dataset	• SVHN data loader	• CNN for the classification of the sequence length	• Produce documented code and report summarizing the experimental work • Provide model for blind test set evaluation • Complete the peer code review

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Deadlines

- Each team needs to provide the deliverable (report + code + best model) corresponding to a block at the latest on Friday noon (12:00pm) of the last week of the block.

- Any block deliverable that is provided past Friday noon (12:00pm) of the last week of a block will automatically get 0% for the peer evaluation.

Deadlines

- Any block deliverable that is provided past Tuesday 11:59pm following the last week of a block will automatically get 0% for the UdeM evaluation.

- Peer evaluation must be completed by Monday 11:59pm following the last week of a block.

Evaluation for Block 1

25% of the final score

- 10% Code review [5% of averaged peer evaluation + 5% UdeM]
- 12% Report evaluation [UdeM]
- 3% Model performance evaluation on blind test set [UdeM]

Code review - Peer evaluation

- **10% of the final score** [5% of average peer evaluation + 5% UdeM]
- Random assignation of code reviews
- The code provided by a team will be evaluated by at **least 2 other teams**

Code quality (peer evaluation + UdeM evaluation)	8
Coherent and modular code/file organization (e.g. data processing, model definition, model training, model inference are in different files/modules; no code duplication)	
Code respects the PEP8 standard	
Comments are relevant (see article)	
Proper management of input arguments in the training script (see argparse, python fire, configparser)	
Proper utilization of GitHub (e.g. branching, relevant commits and messages, usage of pull request)	
Meaningful variable and function names	
Executable scripts with a “main” function (see article)	
Reproducible experiments (e.g. seed)	

Report Evaluation

Introduction	2
Introduction to the project	
Brief introduction to the methods that will be used in the report	
Methodology	6
Description of the algorithms and the experiments (including hyperparameter fine tuning (if appropriate), etc.)	
Data description and data selection (train/valid/test, number of samples, shape/structure of data points)	
Results and discussion	6
Presentation of results (tables, figures, etc.)	
Discussion of results	
Conclusion	2
Recommendation for next steps	
Summary of project state (what was done, what needs to be done)	
Quality of the report	2
Report format (title with team member names, clear sections, flow between sections, figures and tables titled, axes titled, etc.)	
Report is short and to the point (5-7 pages including references, font size 11)	

- **12% of the final score**
- 5-7 pages
    - Including figures, tables, and references
- Single column
- Font size 11
- Use the NeurIPS LaTeX format

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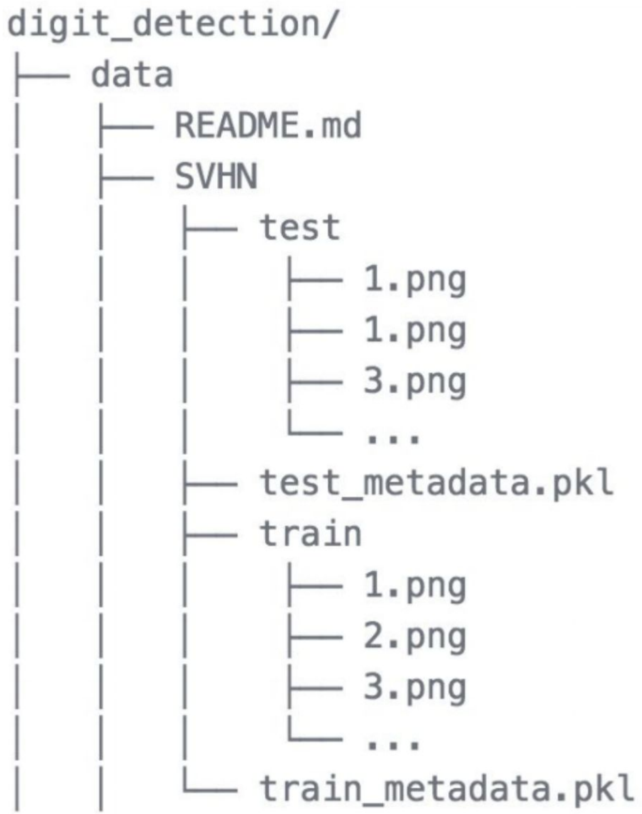
Blind Test Set Evaluation

- **3% of the final score**.
- If the best model provided by a team crashes or provides results that are statistically worse than those of the baseline model provided by the TAs, the team gets 0%.
- Otherwise, if the best model provided by a team is statistically equivalent to the baseline model, the team gets 1%.
- Otherwise, if the best model provided by a team is statistically better than the baseline model:
    - The team gets 3% if the model is the best performing one or is statistically equivalent to the best performing model provided by another team.
    - Otherwise, the team gets 2%.

Code execution - Blind test set evaluation

- The **test set** will be structured identically to the **train set.**
- You will not have access to the **test set** and we will be executing your code on the **test set** ourselves.
- We will provide explicit instructions and examples for you to enhance an evaluation skeleton script that will be provided to you. You will need to complete this script. We reserve the right to give 0 if we cannot execute your code.
- **If you use the test set labels for predictions, you will get 0. We will audit your code.**

- Tips: **do not shuffle the test set**. Predictions should be made sequentially, according to their indexed order in **test_metadata.pkl**



```
digit_detection/
├── data
│   ├── README.md
│   ├── SVHN
│   │   ├── test
│   │   │   ├── 1.png
│   │   │   ├── 1.png
│   │   │   ├── 3.png
│   │   │   └── ...
│   │   ├── test_metadata.pkl
│   │   ├── train
│   │   │   ├── 1.png
│   │   │   ├── 2.png
│   │   │   ├── 3.png
│   │   │   └── ...
│   │   └── train_metadata.pkl
```

Literature review

Tasks / Homeworks

- Literature review of the available datasets
- Read the [Goodfellow et al. 2013]() article

Objectives / Deliverables

- Justify the choice of using the SVHN dataset and to collect an in house dataset

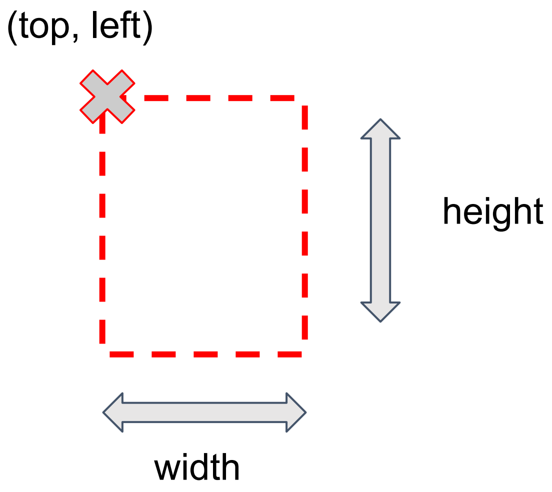
Tips:

- Use search engines like google scholar, arXiv, ...
- Define what are the desirable characteristics of the corpus you need (e.g., publicly available, representative of the task, large in size, etc.)

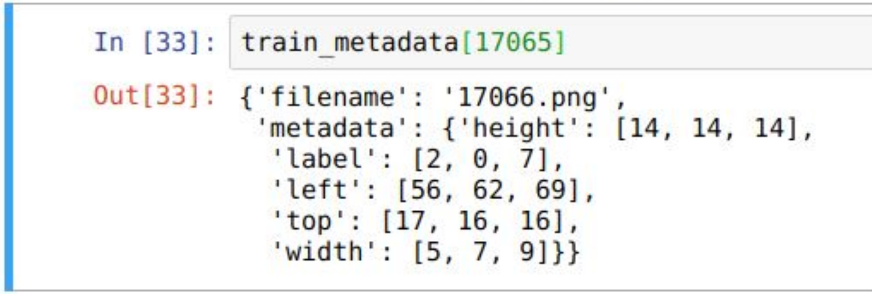
Data preparation

- Data provided directly by the Mila team.
- Based on the original data found in SVHN
- Only use the data provided by Mila as we keep the test set blind. **Do not pick up the official test set available online. We reserve the right to reject a model if we have valid reasons to believe that the test set was used to build/refine the model.**
- We have formatted the original bounding box data so that it can easily be imported in python through pickle files
- Follow the instructions of Goodfellow et al. 2013 for the data preprocessing and data loader construction

Data preparation

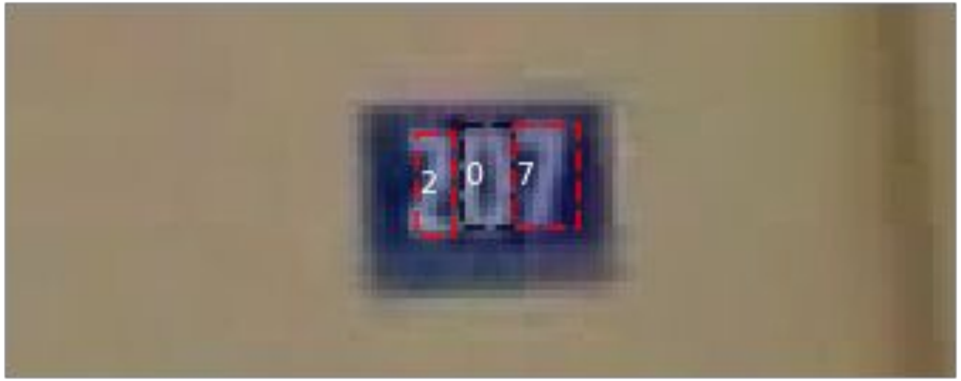


```
with open('train_metadata.pkl', 'rb') as f:
    train_metadata = pickle.load(f)
```

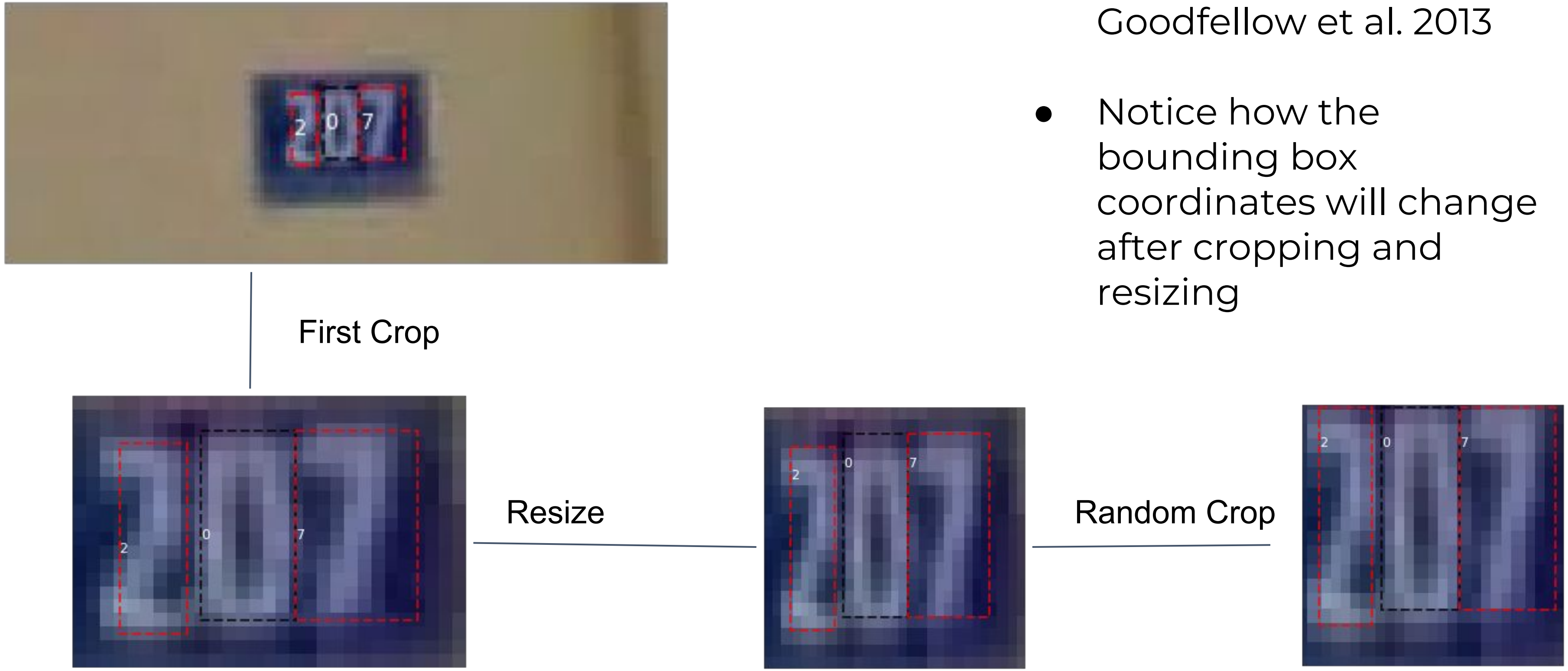


```
In [33]: train_metadata[17065]

Out[33]: {'filename': '17066.png',
          'metadata': {'height': [14, 14, 14],
           'label': [2, 0, 7],
           'left': [56, 62, 69],
           'top': [17, 16, 16],
           'width': [5, 7, 9]}}
```



Data preparation

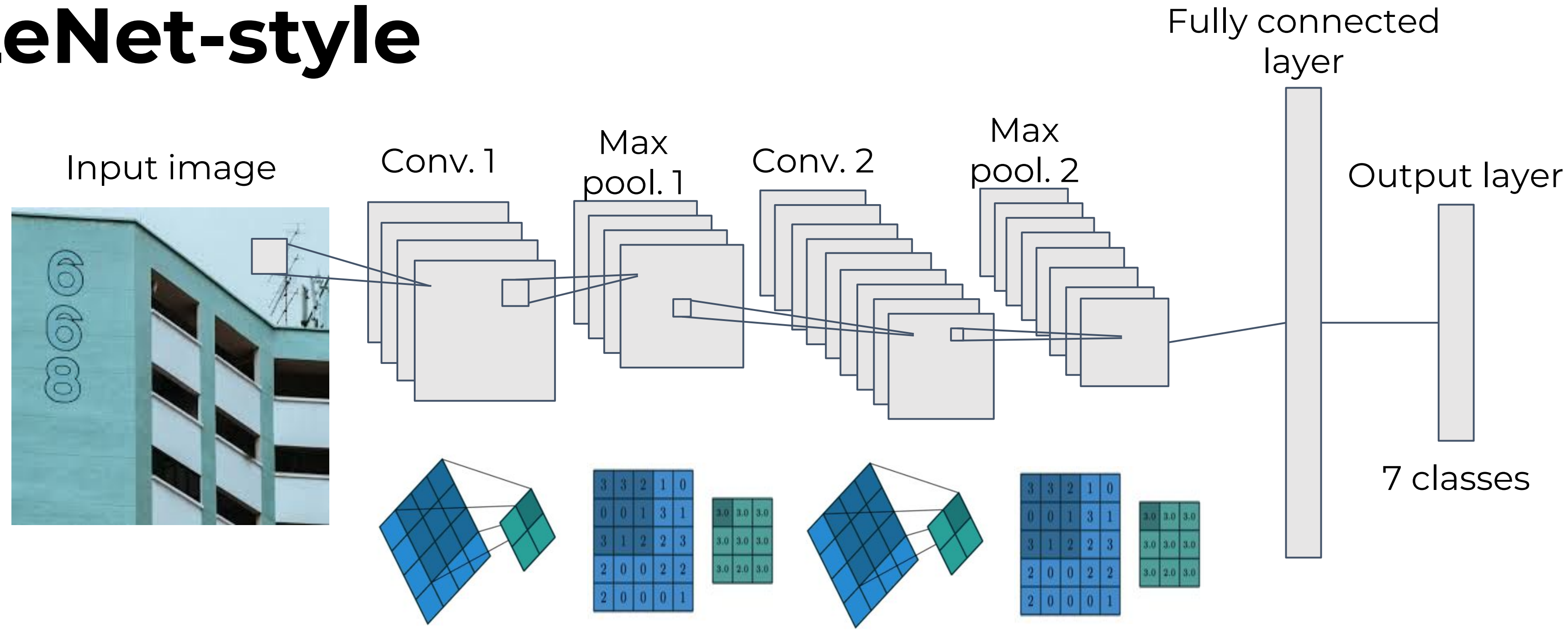


- Data processing pipeline as explained in Goodfellow et al. 2013
- Notice how the bounding box coordinates will change after cropping and resizing

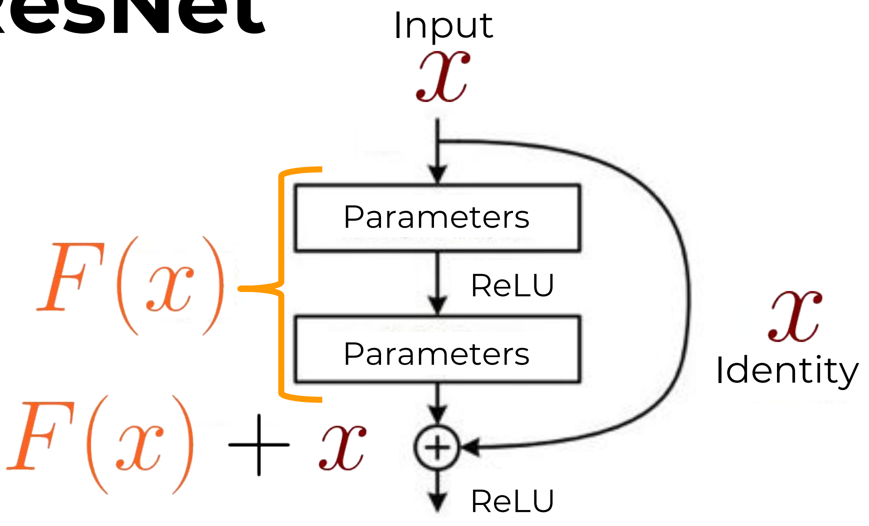
Data preparation - To keep in mind

- Data preparation is dependent on the data set
- Consider standardizing the data
- Data augmentation can be (but is not always) useful
- Data difficulties / challenges:
  - Images and objects of different sizes
  - Adversarial examples
  - Partially visible objects
  - Similar / “confusable” classes
  - Bounding boxes need to be properly updated when doing some data transformations
  - Few or no examples for some of the classes in the training set
  - …

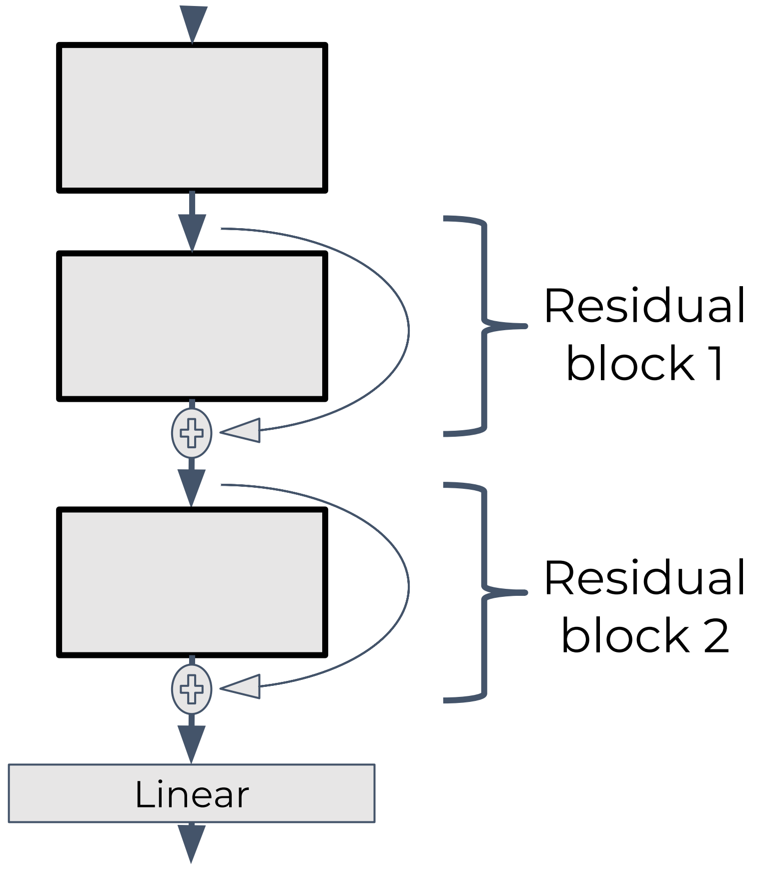
Model example: LeNet-style



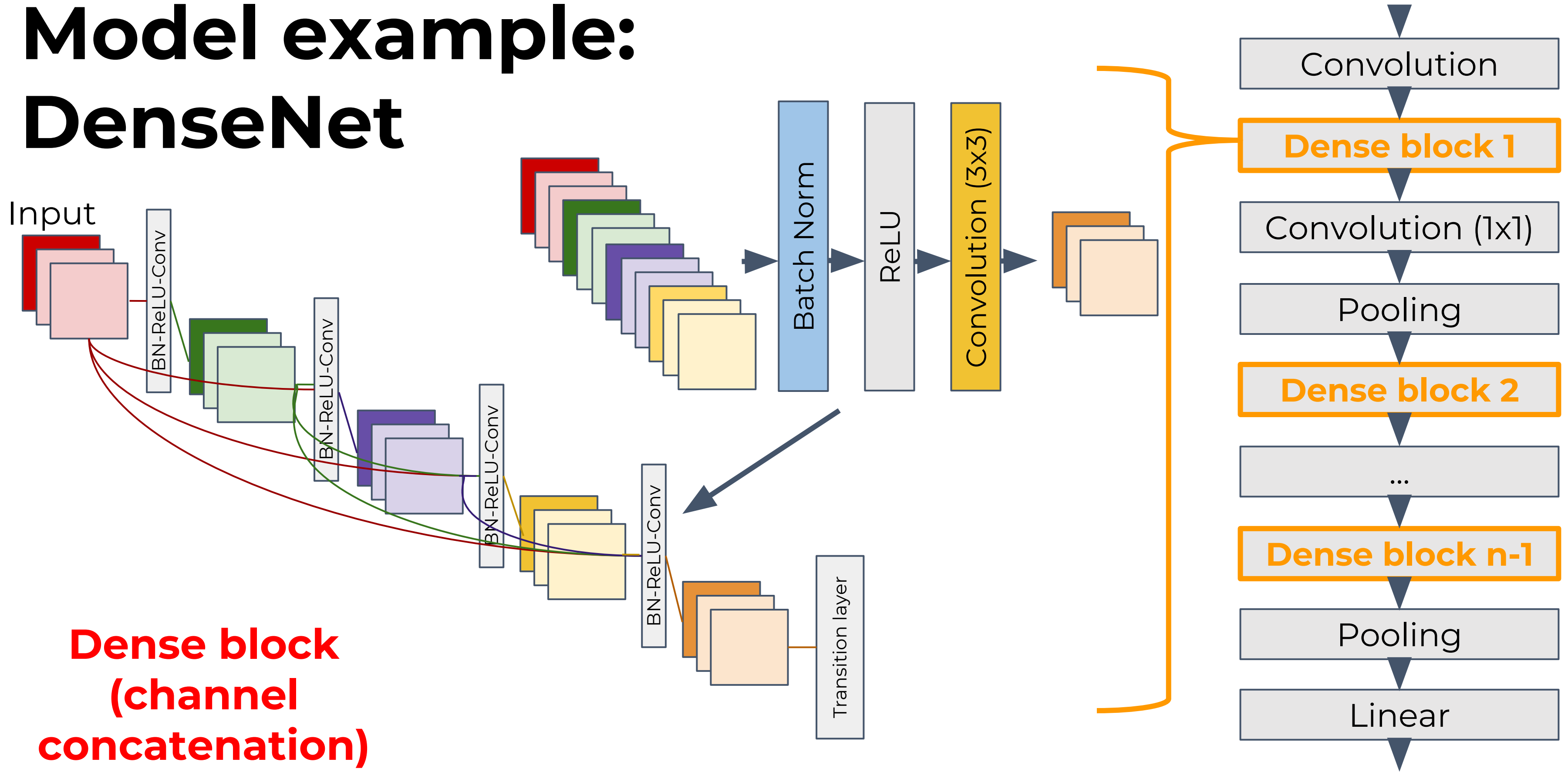
Model example: ResNet



Residual block (element-wise addition)



Model example: DenseNet



Dense block (channel concatenation)

Other examples :

- AlexNet (2012) : http://www.cs.toronto.edu/~fritz/absps/imagenet.pdf
- VGG (2014) :

  https://arxiv.org/abs/1409.1556
- Inception (2014) :

  https://arxiv.org/abs/1409.4842
- ...

Implementation example

Very often the code already exists!

```
import torchvision.models as models
import torch.nn as nn

# ResNet
resnet18 = models.resnet18(pretrained=False)
resnet34 = models.resnet34(pretrained=False)
resnet50 = models.resnet50(pretrained=False)
resnet101 = models.resnet101(pretrained=False)
resnet105 = models.resnet152(pretrained=False)

# DenseNet
densenet121 = models.densenet121(pretrained=False)
densenet169 = models.densenet169(pretrained=False)
densenet161 = models.densenet161(pretrained=False)
densenet201 = models.densenet201(pretrained=False)

model = models.resnet18(pretrained=True)
num_ftrs = model.fc.in_features
num_classes = 447
model.fc = nn.Linear(num_ftrs, num_classes)
```

Think about redefining the output layer!

Official evaluation metric

- Sequence length accuracy (for block 1)
  - # correct sequence length predictions / total # sequences

Informative evaluation metrics

- Accuracy, precision, recall, … per class
- etc.

Examples of other scores / metrics

- Accuracy = (TP + TN) / (TP + FP + FN + TN)
- Precision = TP / (TP + FP)
- Recall = TP / (TP + FN)
- F1-score = 2 * (precision * recall) / (precision + recall)

Where

- TP = true positives
- TN = true negatives
- FP = false positives
- FN = false negatives

Examples of loss functions

- Binary cross entropy = $-clog(p) - (1-c)log(1-p)$

Where

  - c = gold truth label (0 or 1)
  - p = predicted probability for label 1

- Cross entropy = $-\sum_j c_{i,j}log(p_{i,j})$

Where

- $c_{i,j}$ = gold truth for example i / class j
- $p_{i,j}$ = predicted probability for example i / class j

Scores

- Accuracy

```
import torch

_, predicted = torch.max(outputs.data, 1)
total = labels.size(0)
correct = torch.sum(predicted == labels.data)
accuracy  = 100 * correct / total
```

- F1-score

```
from sklearn.metrics import (
     accuracy_score, f1_score)

accuracy = accuracy_score(labels, predicted)
f1 = f1_score(labels, predicted,
average='macro')
```

Loss function

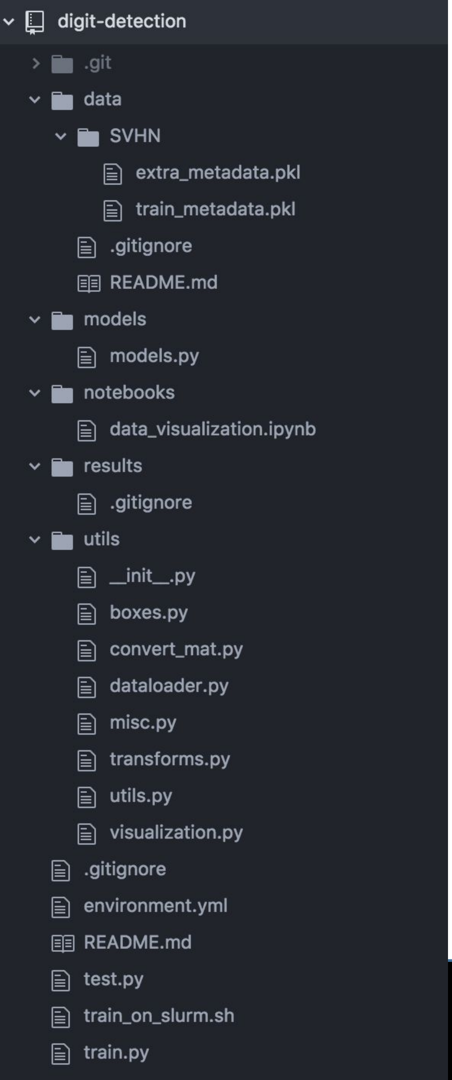
- Binary cross entropy

```
import torch.nn as nn

criterion = nn.BCELoss()
loss = criterion(outputs, labels)
running_loss = loss.data[0]
```

- Cross entropy

```
criterion = nn.CrossEntropyLoss()
```



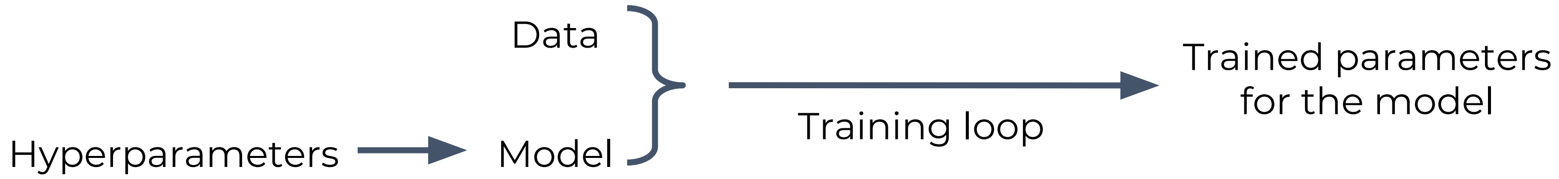
```
digit-detection
  .git
  data
    SVHN
      extra_metadata.pkl
      train_metadata.pkl
    .gitignore
    README.md
  models
    models.py
  notebooks
    data_visualization.ipynb
  results
    .gitignore
  utils
    __init__.py
    boxes.py
    convert_mat.py
    dataloader.py
    misc.py
    transforms.py
    utils.py
    visualization.py
  .gitignore
  environment.yml
  README.md
  test.py
  train_on_slurm.sh
  train.py
```

How the code should be organized

- Have separate folders: config, data, models, notebooks, results, trainer, utils …
- In each folder, separate the code into several files to simplify reading
- Use meaningful names for your directories and files
- Avoid code duplication => use object-oriented programming (e.g. parent and child classes)

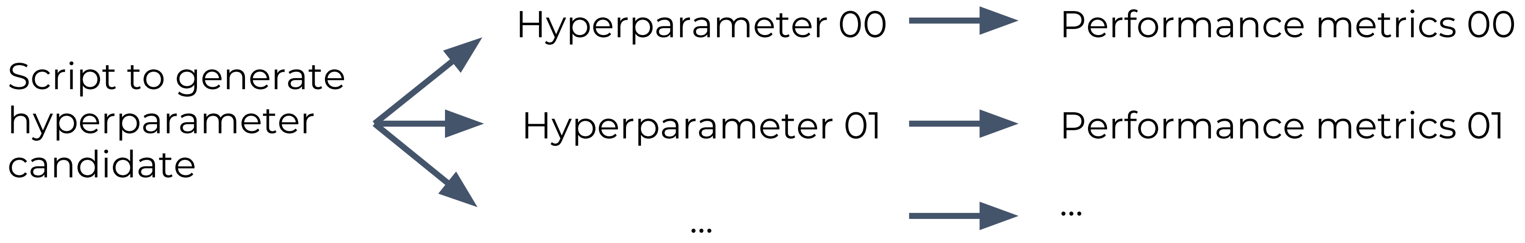
Running a Deep Learning experiment

- Training diagram for a model instance



Running a Deep Learning experiment

- Exploration of hyperparameters to obtain the best model



Each experiment must produce enough logs to:

• diagnose errors and suspicious behaviour

• allow the selection of a set of hyperparameters that is considered the best to generalize to new data

Implementation - To keep in mind (1)

General advice

- See what other people are doing and use it as inspiration.

- Develop your own style from this.

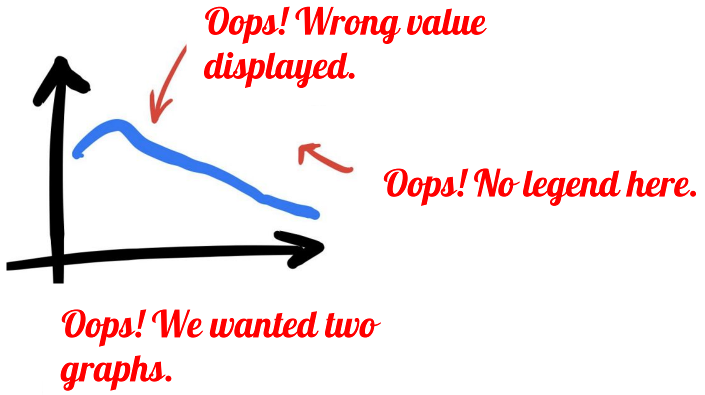
Implementation of a deep learning model

- Reuse as much as possible models already available online. Search for "model zoo".

- Sometimes we even want to use (or start from) a pre-trained model. Search for "pretrained model" or "pretrained model weights".

Implementation - To keep in mind (2)

- When you run several large-scale experiments, you must store the data necessary to generate graphs / figures in case you need to modify / update them.

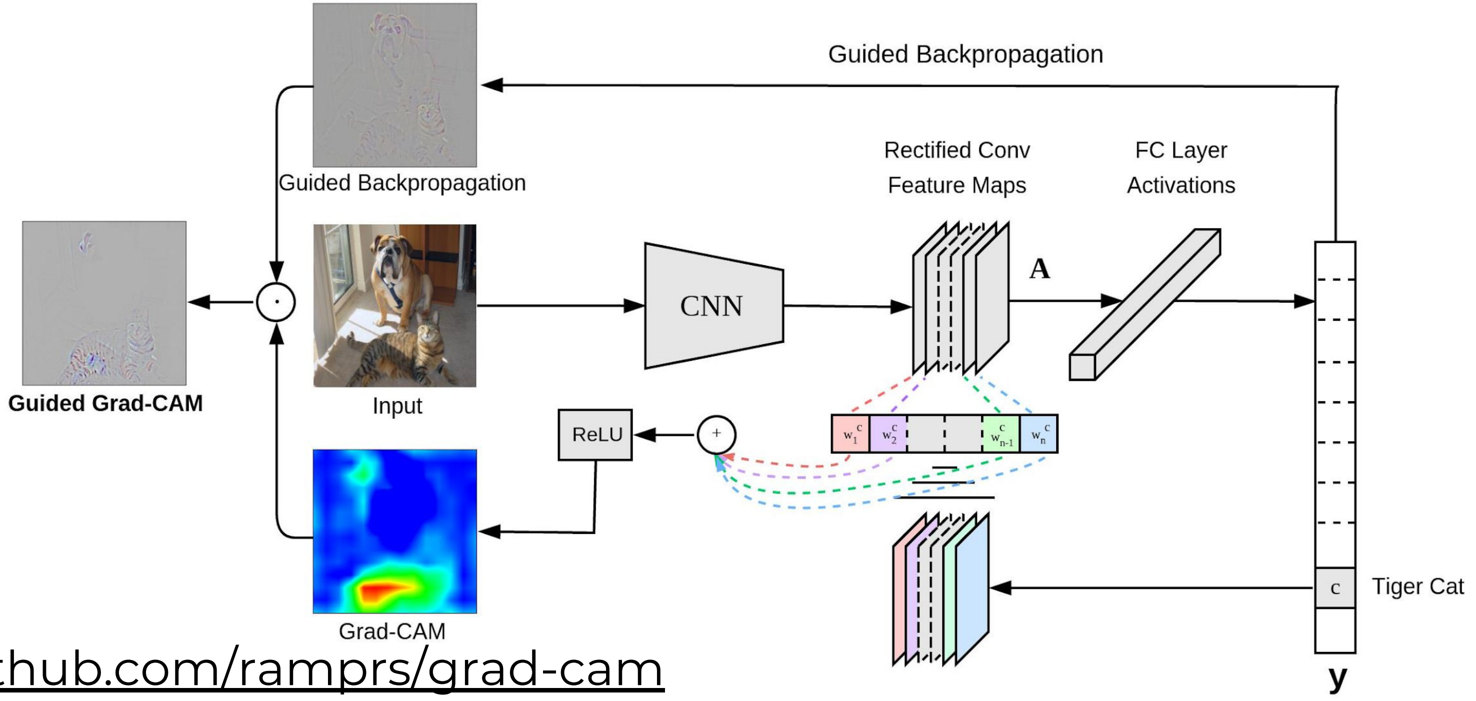


- An experiment that can be interrupted in the middle and then restarted without being affected by the interruption is much easier to manage.

To go further....

Grad-CAM: Why did you say that? Visual Explanations from Deep Networks via Gradient-based Localization

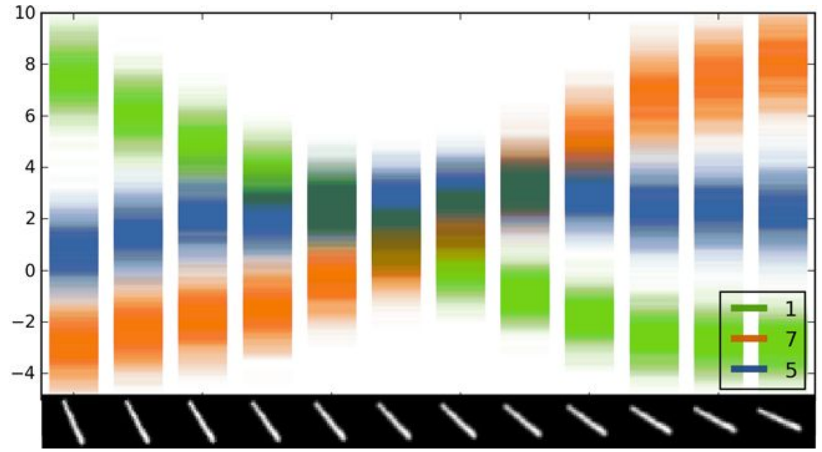
Selvaraju et al. 2017 - https://arxiv.org/abs/1610.02391



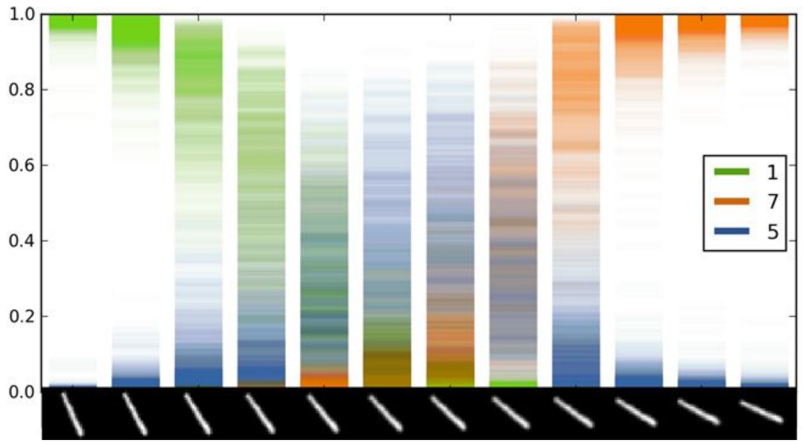
https://github.com/ramprs/grad-cam

What My Deep Model Doesn't Know...

Yarin Gal 2015 : http://mlg.eng.cam.ac.uk/yarin/blog_3d801aa532c1ce.html



Softmax input scatter



Softmax output scatter

A scatter of **100 forward passes** of the softmax input and output for **Monte Carlo dropout** LeNet. On the X axis is a rotated image of the digit 1. The input is classified as digit 5 for images 6-7, even though **model uncertainty** is extremely large.