Superpixel preprocessing as data reduction in image recognition

Mitan Theodor-Alexandru
Coordonator: Lect. Dr. Benchea Razvan

Outline

In an effort to **reduce computational effort and training time** required for image recognition, clustering delivers a way to “summarise” the data sufficiently, in a way that’s suitable for use with a **simpler neural network** architecture that **trains very rapidly**.

As such, we use a combination of two fundamental machine learning techniques.

Problems addressed

1. CNNs require GPU use or high-powered machines
2. Long training times vs. rapid innovation / testing
3. Complex architectures
4. Per-image testing time can be too high
5. Fixed input size

The Process

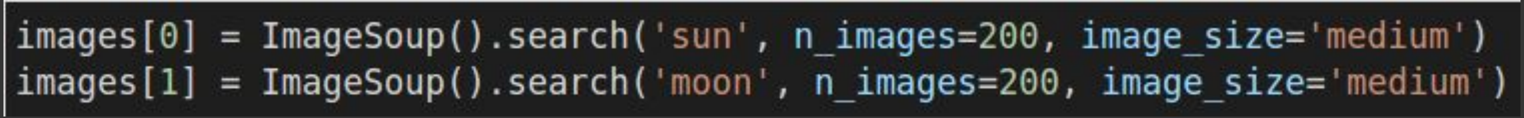
➔ **Acquire images**
CIFAR-10 and ImageSoup scraping.

➔ **Image to XYRGB**
Convert images to a uniform data structure.

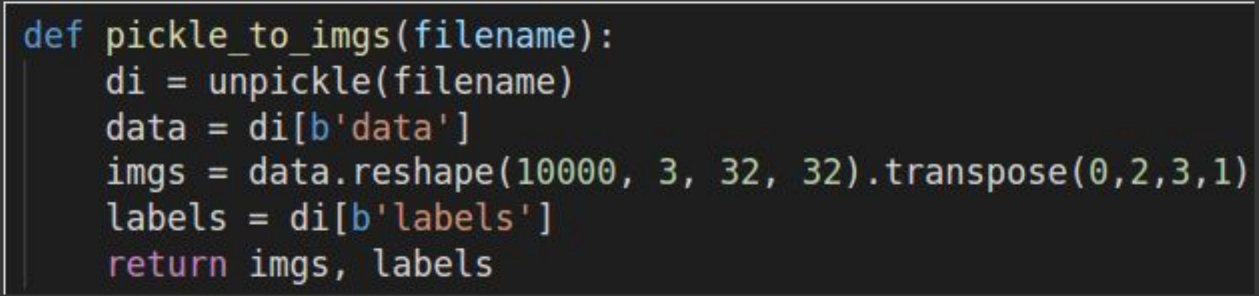
➔ **XYRGB to centroids**
Cluster / segment the data

➔ **Centroids to neural network**
Use the 5-D centroids as input for a neural network that solves the classification problem

1) Acquiring images



```
images[0] = ImageSoup().search('sun', n_images=200, image_size='medium')
images[1] = ImageSoup().search('moon', n_images=200, image_size='medium')
```



```
def pickle_to_imgs(filename):
    di = unpickle(filename)
    data = di[b'data']
    imgs = data.reshape(10000, 3, 32, 32).transpose(0,2,3,1)
    labels = di[b'labels']
    return imgs, labels
```

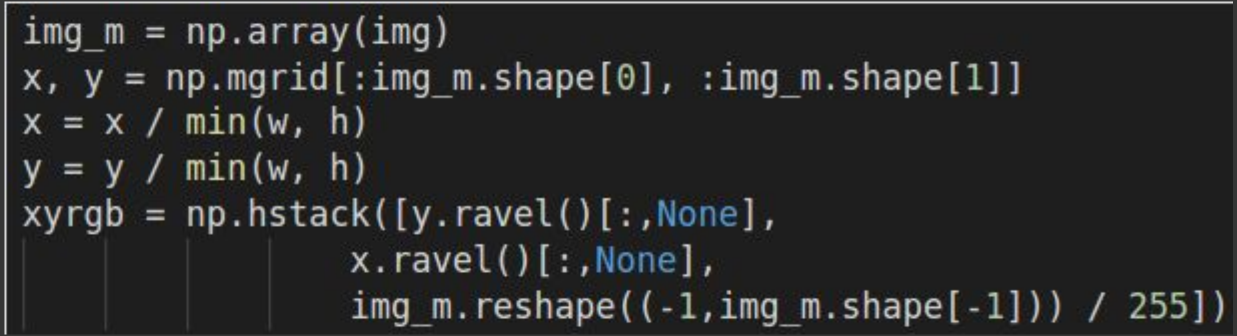
ImageSoup

A simple Python library for quickly scraping images by a certain query

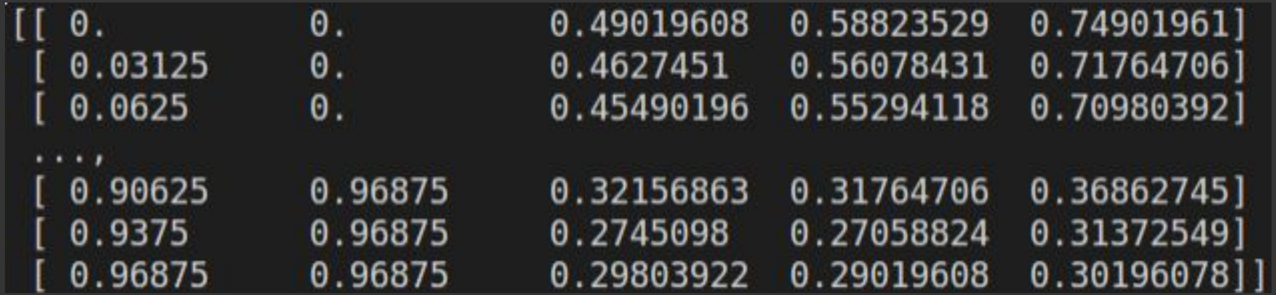
Cifar-10

A classic dataset of 60000 small images.

2) Images to XYRGB



```
img_m = np.array(img)
x, y = np.mgrid[:img_m.shape[0], :img_m.shape[1]]
x = x / min(w, h)
y = y / min(w, h)
xyrgb = np.hstack([y.ravel()[:,None],
                x.ravel()[:,None],
                img_m.reshape((-1,img_m.shape[-1])) / 255])
```



```
[[ 0.          0.          0.49019608  0.58823529  0.74901961]
 [ 0.03125     0.          0.4627451   0.56078431  0.71764706]
 [ 0.0625      0.          0.45490196  0.55294118  0.70980392]
 ...,
 [ 0.90625     0.96875     0.32156863  0.31764706  0.36862745]
 [ 0.9375      0.96875     0.2745098   0.27058824  0.31372549]
 [ 0.96875     0.96875     0.29803922  0.29019608  0.30196078]]
```

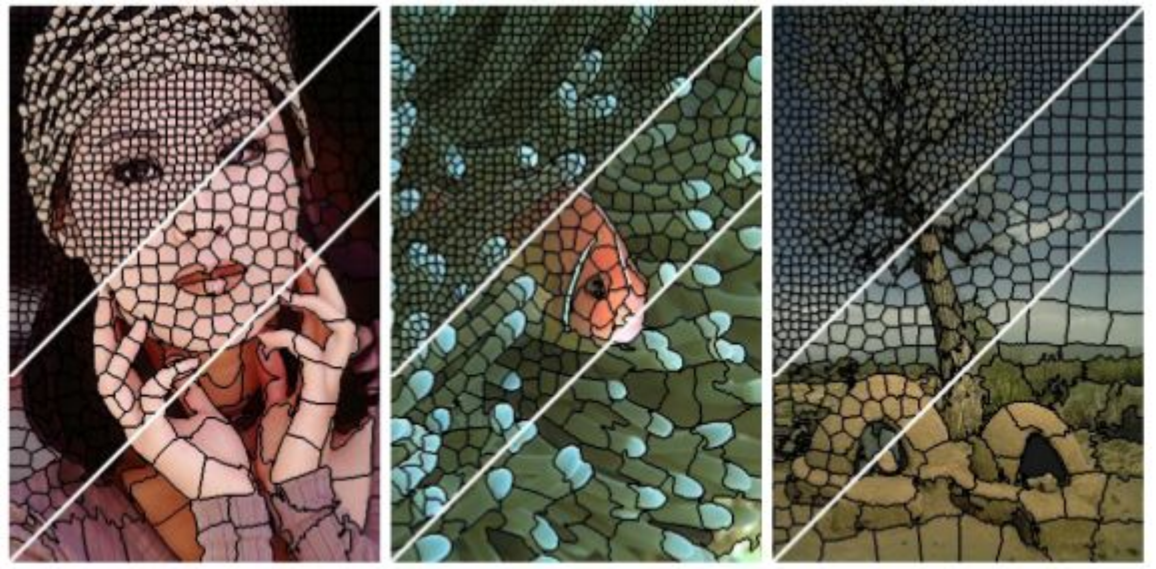
Flattened meshgrid

Each 5-D unit has its coordinates normalised by the shortest side

Normalised RGB

We normalise the RGB components to [0, 1].

3) Superpixels (SLIC)



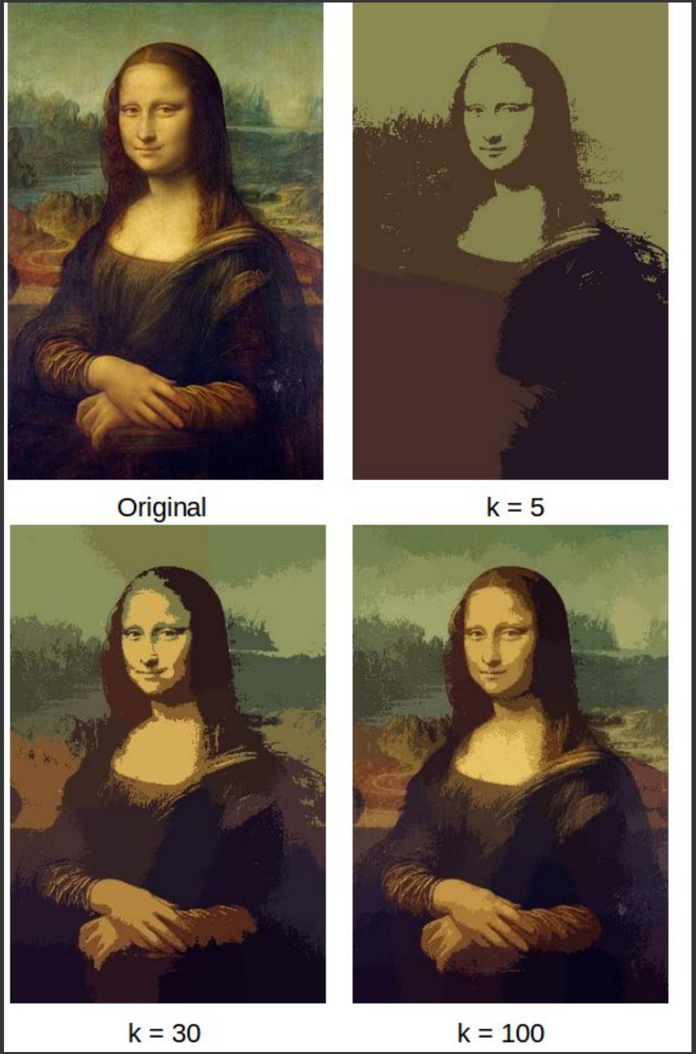
Inspiration: SLIC

SLIC superpixels use a combination of physical and chromatic distance in the La*b* space

3) Superpixels

XYRGB clustering

The simplest model: X, Y, R, G, B are considered similarly, but the first two are "tweaked".



Distance multiplier

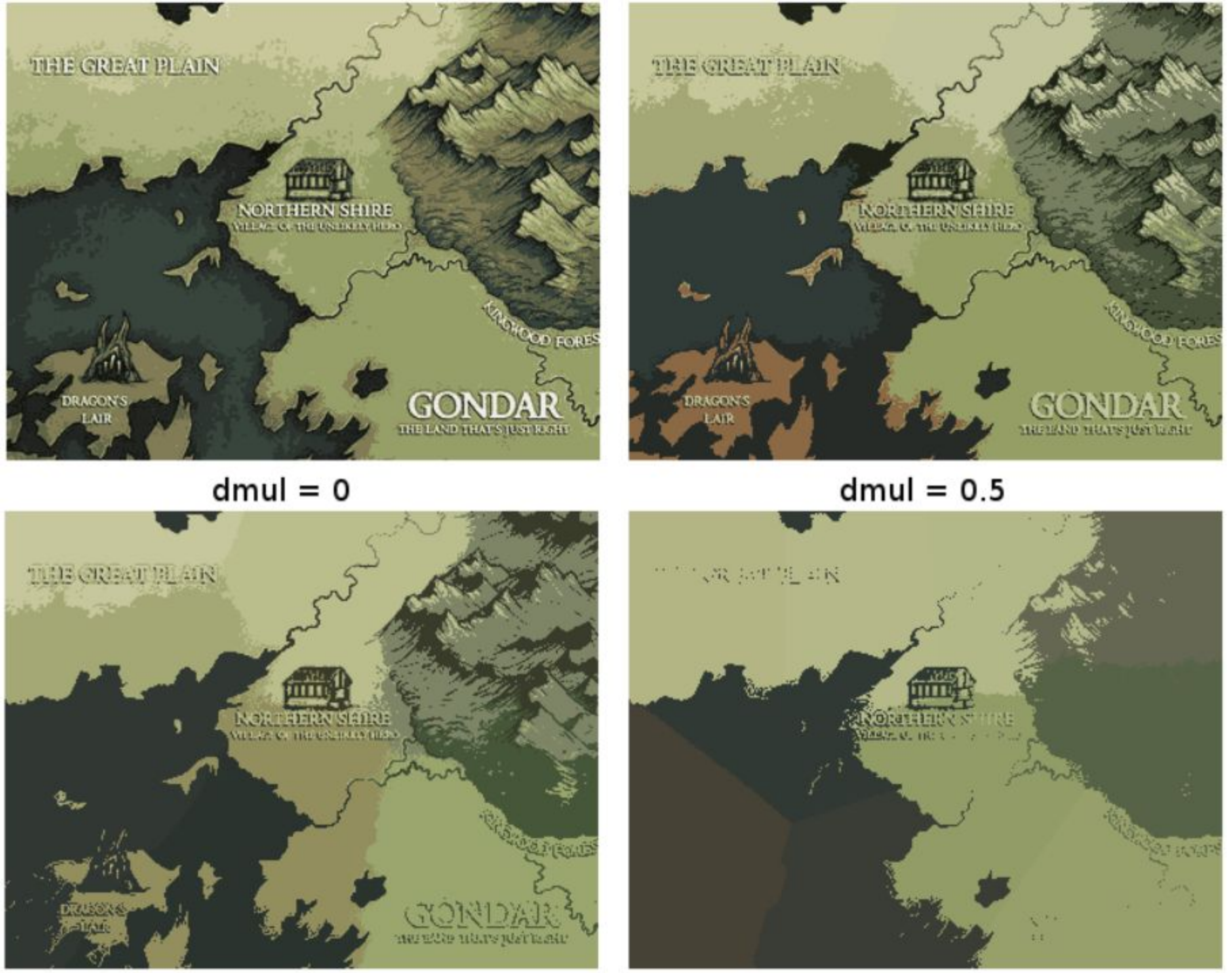
X and Y can be multiplied by a custom parameter for various effects

Low dmul

Colour reduction

High dmul

Equivalent to average-pooling



dmul = 0

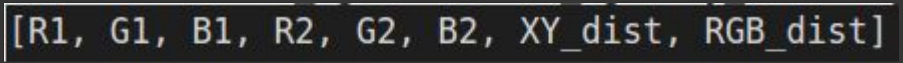
dmul = 0.5

dmul = 1

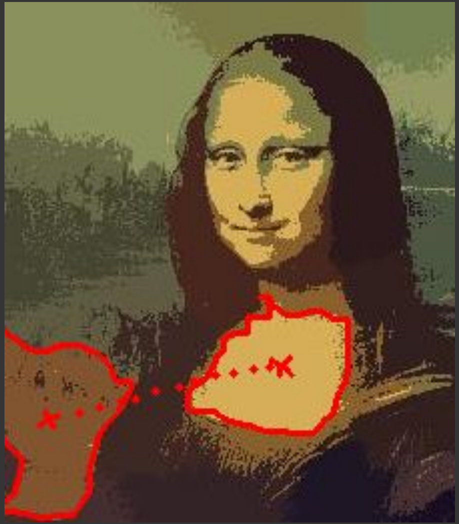
dmul = 2

3) Superpixels to input

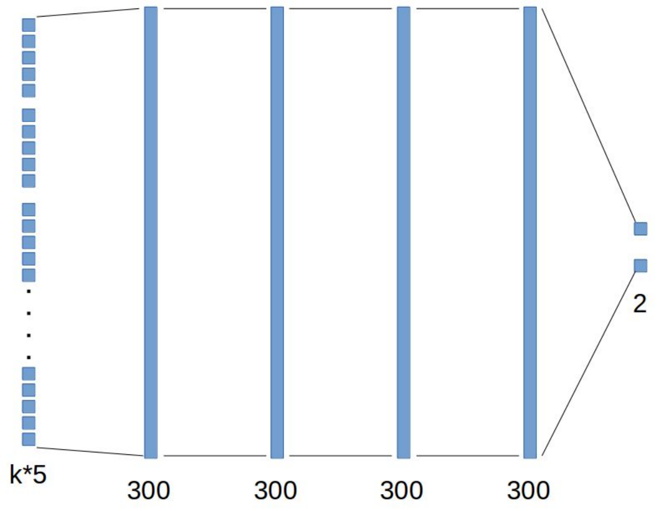
1. “Cellbatch” uses the averages of each superpixel
2. “Relbatch” uses batches of relationships



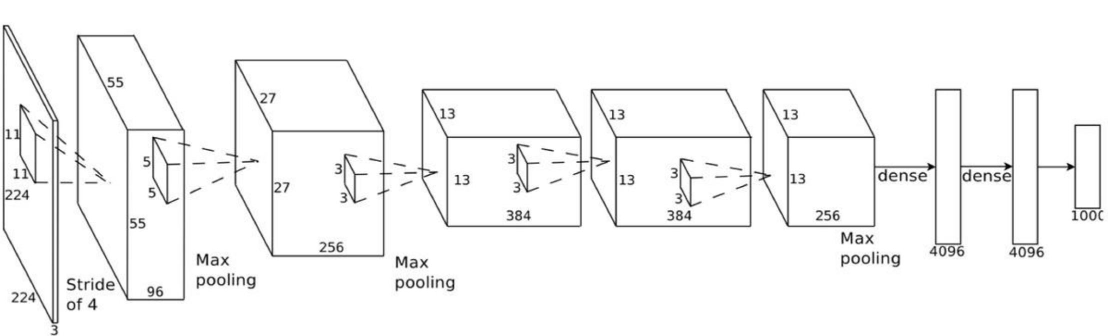
```
[R1, G1, B1, R2, G2, B2, XY_dist, RGB_dist]
```



4) The neural network



Cellbatch



CNN

Rules

1. 30 clusters
2. 20 epochs
3. All images
4. We track accuracy and time
5. Benchmark: flat, fully-connected network

Other parameters

Each algorithm has its own parameters, and they have been tweaked to roughly similar degrees of complexity

Accuracy for “CIFAR-2”

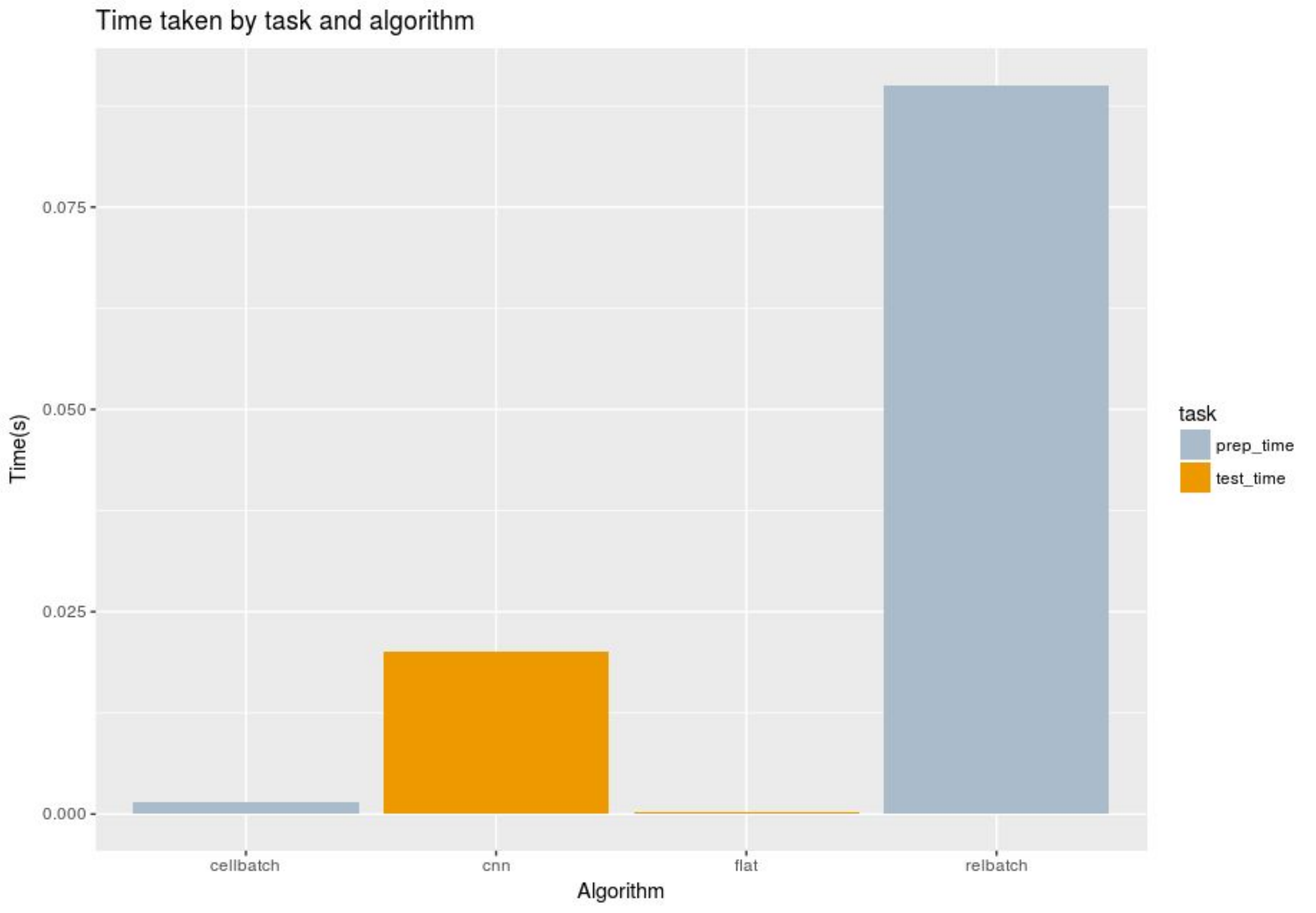
1. Cellbatch: ~85%
2. Relbatch: ~86%
3. Flat: ~50%

Data size

Cellbatch has reduced the input data to under a tenth of its original size.

Relbatch has increased it slightly, depending on number of relationships.

Timing


Time taken by task and algorithm
Time(s)
0.075
0.050
0.025
0.000
cellbatch
cnn
flat
relbatch
Algorithm
task
prep_time
test_time

Further work

- Better use of the superpixels’ immediate neighbourhood
- Cluster analysis on superpixels
- SLIC-like optimisations (limited search space)

Conclusions

- Reasonable accuracy with very fast training times
- Simple architecture
- Flexible input size and type
- Substantial data reduction
- Effort moved to preprocessing, testing is almost instant: can prepare data regardless of network architecture

Ḡif, demos (changing dmul)

Questions