Lab 13: "Fully Convolutional Networks for Image Segmentation"

Julio Nicolás Reyes Torres
jn.reyes10@uniandes.edu.co

Juan David Triana
jd.triana@uniandes.edu.co

Computer Vision
Biomedical Engineering
Universidad de los Andes
2019

1. Description

In this lab are presented two architectures of *fully convolutional networks* for image segmentation over Pascal VOC database. In figure (1) is showed an example of a ground-truth provided by Pascal VOC. The implementation is based on the article "Fully Convolutional Networks for Semantic Segmentation" by Long et al, which is a FCN end-to-end for pixelwise prediction and from supervised pre-training. [1]

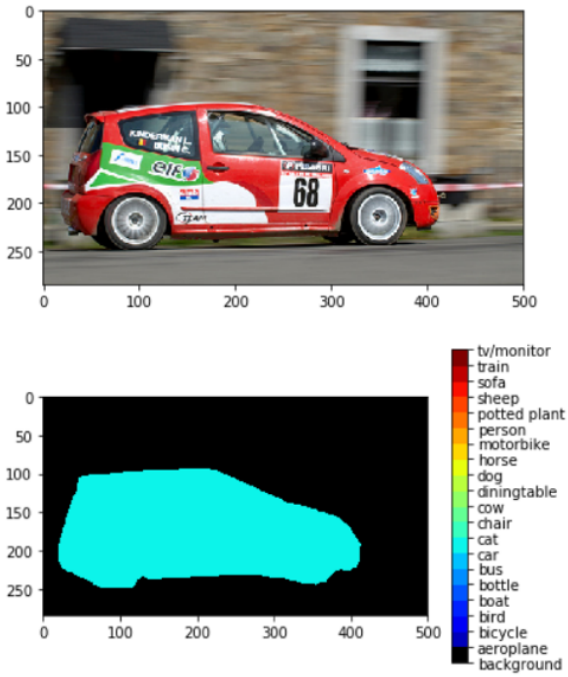


Figura 1: Example of image Ground-truth.

2. Architecture FCN 32s

1. Layer 1
    - (64,3,500,375) 3x3Convolution
    - (64,64,500,375) 3x3Convolution
    - (64,64,500,375) 2x2MaxPool
2. Layer 2
    - (64,128,225,188) 3x3Convolution
    - (128,128,225,188) 3x3Convolution
    - (128,128,225,188) 2x2MaxPool
3. Layer 3
    - (128,254,112,94) 3x3Convolution
    - (254,254,112,94) 3x3Convolution
    - (254,254,112,94) 2x2MaxPool
4. Layer 4
    - (254,512,56,47) 3x3Convolution
    - (512,512,56,47) 3x3Convolution
    - (512,512,56,47) 2x2MaxPool
5. Layer 5
    - (512,512,28,24) 3x3Convolution
    - (512,512,28,24) 3x3Convolution
    - (512,512,28,24) 2x2MaxPool
6. FC1
    - (512,4096,16,12) 3x3Convolution
7. FC2
    - (4096,4096,16,12) 3x3Convolution
    - (4096,21,16,12) 1x1Convolution
    - 32 stride upsample

As it is seen on the architecture, the main focus of the segmentation task comes with the implementation of a 32 stride upsample. This means that all of the categories will be expanded from the final map to the initial size of the image, since it was downsampled 5 times or by $2^5 = 32$.

2.1. Results

First we implemented a training process with VGG-16 pretrained weights. After a series of iterations, the following image describes segmentation of the algorithm over a validation set.

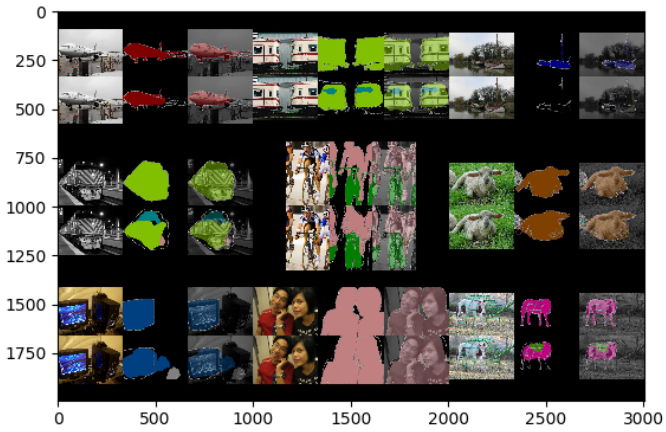
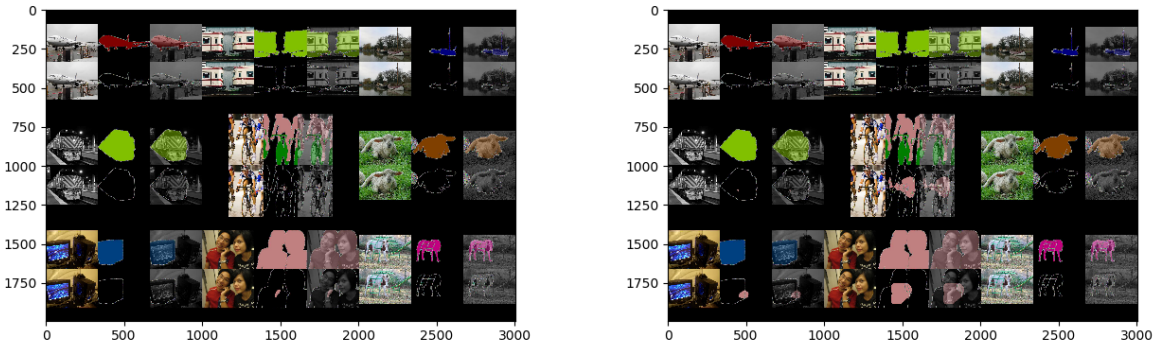


Figura 2: 32s with VGG pretrained weights (1 epoch).

Afterwards, a training process with no fine-tuning was implemented, as follows:

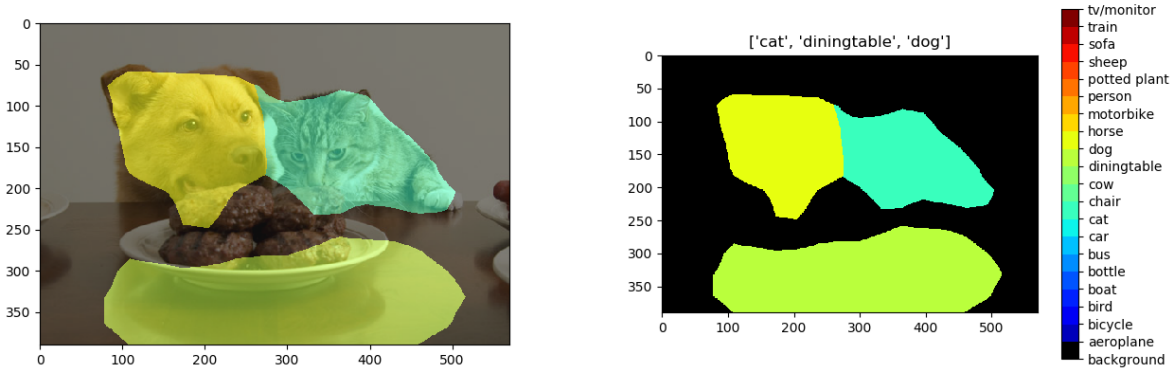


(a) Epoch 1

(b) Epoch 2

Figura 3: 32s Training with no VGG pretrain.

Finally an implementation of the 32sFCN was made for images in the wild:



(a) Image segmentation

(b) Class segmentation

Figura 4: Image in the wild test of FCN 32s

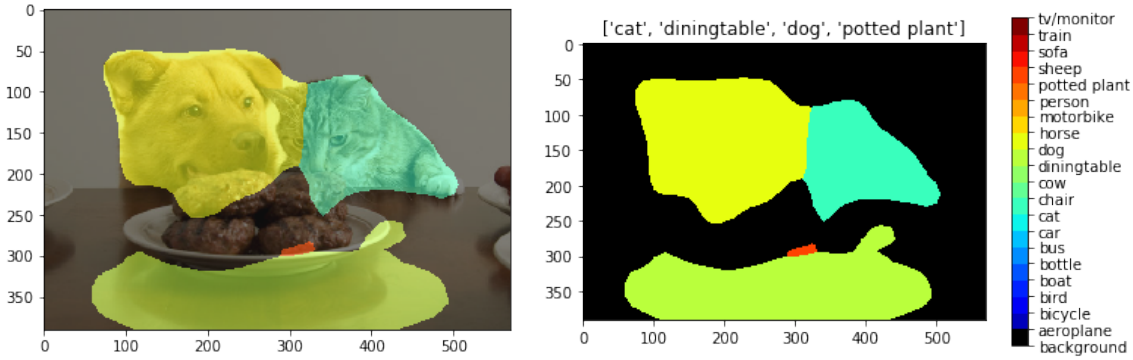
2.2. Discussion

As it was seen on the results, finetuning is very useful and effective on segmentation tasks when it comes to small amounts of iterations. This is shown on figure 2 where an accurate segmentation is visualized on every single image on the first epoch of the algorithm. This is contrary to the results shown on figure 4, where a poor recognition of the object area was found on each image on epoch number 2.

3. Architecture 16s

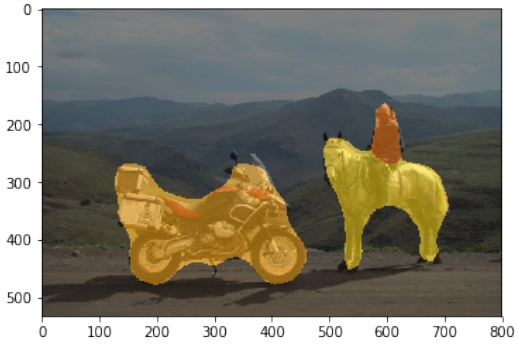
3.1. Results of segmentation

The "fully convolutional net (FCN)" implemented for segmentation combines layers of the feature hierarchy and refines the spatial precision of the output [1]. The main difference on this architecture is to extract more information from "32x prediction" and use it to recover details that represent a better segmentation. The results of train the net "16s architecture" are presented following:

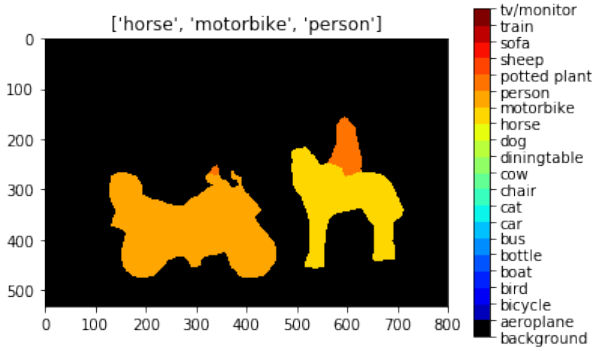


(a) Test image # 1 segmented

(b) Segmentation for image 1



(c) Test image # 3 segmented



(d) Segmentation for image 3

Figura 5: **Segmentation with architecture 16s.** Image (a) Test image # 1, the image (b) shows the segmentation done for image (a). Image (c) is the test image # 3 and (d) its the corresponding segmentation.

3.2. Discussion

Figure (5) presents two final results of images segmented by FCN. Figure (a) shows a set of objects very clustered and partially represented, it is a difficult case, figure (b) is the segmentation. It is observed the objects are segmented and identify, however, the results are not the best. the contour is not totally segmented and an extra object (potted plant) is identify.

Otherwise, the test image in (c) and its segmentation (d) is the example of a good representation. The three objects are well identify (horse, motorbike, person) and very well segmented, the contours represents accuracy the edges of the objects.

4. Conclusions

- The segmentation model presented with “architecture 16s” presents a better result than “32s model”, in figures (5) and (4) are presented its segmentations respectively. This result is logical because the fully convolutional net (FCN) with architecture 16s for segmentation combines the previous layer of the feature hierarchy and refines the spatial precision of the output.

- “Fully convolutional networks” represents a complete solution to obtain quality and accuracy in segmentation problems, specially the architecture with multi-resolution layer combinations, improves the learning and speed up the models.

Referencias

[1] Long, J., Shelhamer, E., and Darrell, T., “Fully Convolutional Networks for Semantic Segmentation,” Tech. Rep. [Online]. Available: https://people.eecs.berkeley.edu/{~}jonlong/long{_}shelhamer{_}fcn.pdf