CS230: Lecture 5
Case Study

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Problem statement: cell segmentation

**Goal**: Determine which parts of a microscope image corresponds to which individual cells.

**Data**: Doctors have collected 100,000 images from microscopes and gave them to you. Images have been taken from three types of microscopes:

<table>
<thead>
<tr>
<th>Type</th>
<th>Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td>50,000 images</td>
</tr>
<tr>
<td>Type B</td>
<td>25,000 images</td>
</tr>
<tr>
<td>Type C</td>
<td>25,000 images</td>
</tr>
</tbody>
</table>

**Question**: The doctors who hired you would like to use your algorithm on images from microscope C. How you would split this dataset into train, dev and test sets?
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Answer:
 i) Split has to be roughly 90,5,5. Not 60,20,20.
 ii) Distribution of dev and test set have to be the same (contain images from C).
 iii) There should be C images in the training as well, more than in the test/dev set.

Question: Can you augment this dataset? If yes, give only 3 distinct methods you would use. If no, explain why (give only 2 reasons).

Answer: Many augmentation methods would work in this case:
 – cropping
 – adding random noise
 – changing contrast, blurring.
 – flip
 – rotate
Architecture and Loss

**Question:**
- What is the mathematical relation between $n_x$ and $n_y$?
- What’s the last activation of your network?
- What loss function should you use?

**Answer:**
i) $n_x = 3 \times n_y$
ii) Sigmoid activation
iii) Summation over all pixel value with cross entropy loss.

$$- \sum_{i=1}^{n_y} (y_i \log(\hat{y_i}) + (1 - y_i)\log(1 - \hat{y_i}))$$
First try: You have coded your neural network (model M1) and have trained it for 1000 epochs. It doesn’t perform well.

Transfer Learning: One of your friends suggested to use transfer learning using another labeled dataset made of 1,000,000 microscope images for skin disease classification (very similar images).

A model (M2) has been trained on this dataset on a 10-class classification. Here is an example of input/output of the model M2.

Question: You perform transfer learning from M2 to M1, what are the new hyperparameters that you’ll have to tune?
**Question**: How can you correct your model and/or dataset to satisfy the doctors’ request?

**Answer**: Modify the dataset in order to label the boundaries between cells. On top of that, change the loss function to give more weight to boundaries or penalize false positives.
**Network modification**

**New goal**: They give you a dataset containing images similar to the previous ones. The difference is that each image is labeled as 0 (there are no cancer cells on the image) or 1 (there are cancer cells on the image). You easily build a state-of-the-art model to classify these images with 99% accuracy. The doctors are astonished and surprised, they ask you to explain your network’s predictions.

**Question**: Given an image classified as 1 (cancer present), how can you figure out based on which cell(s) the model predicted 1?

**Answer**: Gradient of output w.r.t. input X

**Question**: Your model detects cancer on cells (test set) images with 99% accuracy, while a doctor would on average perform 97% accuracy on the same task. Is this possible? Explain.

**Answer**: If the dataset was entirely labeled by this one doctor with 97% accuracy, it is unlikely that the model can perform at 99% accuracy. However if annotated by multiple doctors, the network will learn from these several doctors and be able to outperform the one doctor with 97% accuracy. In this case, a panel composed of the doctors who labeled the data would likely perform at 99% accuracy or higher.
**Network modification**

**New new goal**: To solve your binary classification (presence/absence of cancer cell(s)), you decided to implement the following pipeline.

![Diagram of pipeline: Input image 1 → Cell segmentation → Model A → Binary classifier → Model B → p(cancer)](image)

**Question**:
(i) What are the advantages/disadvantages of this model compared to the previous end-to-end binary classifier?
(ii) If your model doesn’t perform well, how can you find what the problem is?

**Answer**: (i) +: requires less data in general by leveraging human crafted knowledge. Still works if labelled data is not present in both ends. -: might limit the model’s potential performance if the hand-engineered components aren’t optimal. (ii)
Duties for next week

For next Wednesday 10/31, 11am:

**C4M1**
- Quiz: The basics of ConvNets
- Programming Assignment: Convolutional Neural Network - Step by Step
- Programming Assignment: Convolutional Neural Network - Application

**C4M2**
- Quiz: Convolutional models
- Programming Assignment: Keras Tutorial (optional, but highly recommended)
- Programming Assignment: Residual Networks

Midterm, on 11/02: everything up to C4M2 (included), TA sections and next Wednesday’s in-class lecture can be expected.

This Friday (10/26): TA section