ELEC-E8739 - AI in Health Technologies D

Final Examination

10.00 - 14.00, December 14th, 2020

Requirements

1. Answer at least 5 out of 6 Questions. The best 5 answers will be taken into account.
2. You can write using LaTeX, text editor, write by hand and then scan or take an image, etc.
3. Submit your solution to the MyCourses exam page by 14.00. You cannot submit after that so take it into account and submit your work in time.
4. No aid from literature (books, lecture notes etc.) or peers.

Question 1

Shortly answer (1-3 lines) on the following questions:

1.1 What is the convolutional kernel?

1.2 What is the activation function and what is its role in neural networks?

1.3 What is data augmentation?

1.4 What is regularization?

1.5 What is embedding in language models?

Question 2

Different types of neural networks have some prior functional form encoded into them, such that the output of each layer is (approximately) invariant or equivariant to some transformation of the input. These are called symmetries. Common symmetries are translational symmetry, rotational symmetry, mirroring symmetry, permutation symmetry, scaling symmetry, etc.

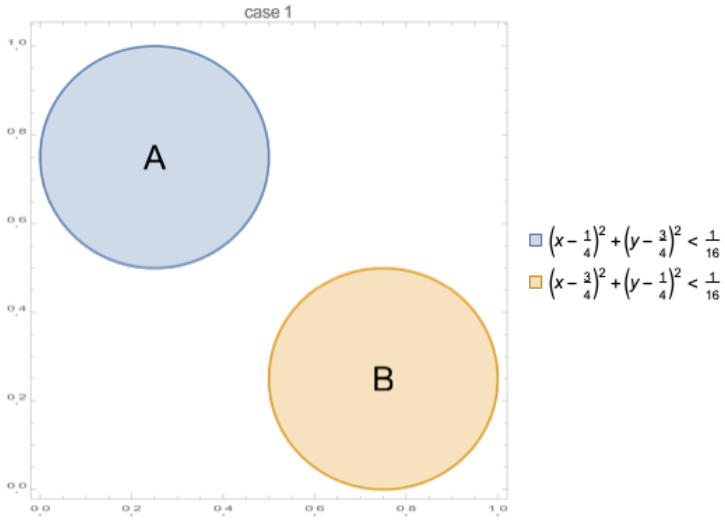
2.1 What are the symmetries preserved in convolutional neural networks and why?

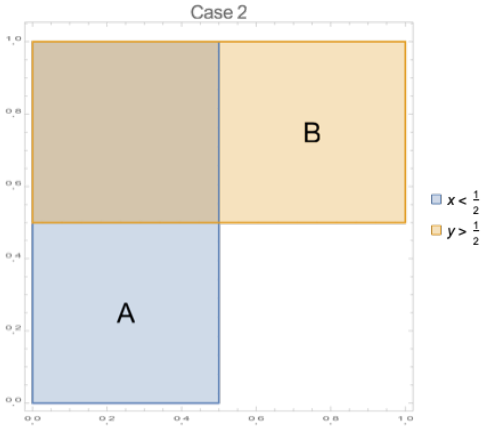
2.2 What are the symmetries preserved in recurrent neural networks and why?

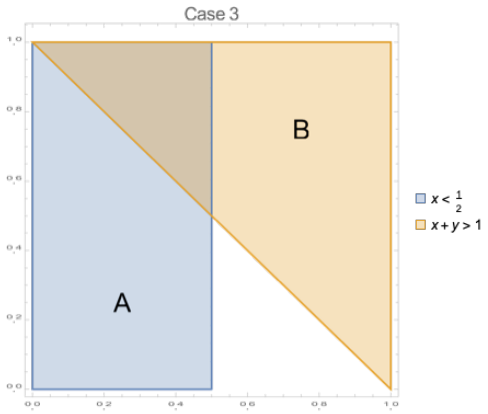
2.3 What are the symmetries preserved in transformer neural networks and why?

Question 3

3.1 For each of the following three illustrations write down if A and B are independent events. The sample space is the unit square $R = \{(x, y) \mid 0 \le x \le 1, 0 \le y \le 1\}$.







3.2 What is the joint entropy $S(X, Y) = -\sum_{x\in\{A,notA\}} \sum_{y\in\{B,notB\}} \mathbb{P}(x, y) \log(\mathbb{P}(x, y))$ in each of the three cases?

3.3 Which case (1, 2, or 3) has the maximum entropy i.e the one where the feature A gives minimal information about the feature B?

3.4 Are the features A and B independent, when the joint entropy is largest?

3.5 If you keep the feature A (annotation) fixed and modify B (neural network output), when would the joint entropy be at its minimum?

Hint: $\lim_{x\to 0} x \log(x) \to 0$.

Question 4

Read setups below and figure out possible problems with at least three of them. The best answers would be taken into account.

4.1 Selecting a random set of people alive today as training set to predict the onset of cancer from their past health records.

4.2 Taking a set of x-ray images from hospital records and dividing them randomly to train and test sets.

4.3 In order to prove the drug effectiveness against melanoma, planning to test 2000 potential medical drugs on 10000 volunteers (only one drug is given to each group of five people).

4.4 Using treatment effectiveness dataset from country with paid medical care for neural network training.

Question 5

Answer at least two sub-questions. Better answers would be taken into account.

5.1 Explain how one can study embarrassing topics by randomizing the query. (Hint. You can use throwing a coin to randomize the query)

5.2 For performance evaluation, could you explain what is the ROC and the PR curve, and what are the differences between them?

5.3 Fβ scores.

- When should you use F1 score instead of Accuracy?
- When should you use F2 score?

$$F\beta = (1+\beta^2)\frac{precision \cdot recall}{(\beta^2 \cdot precision) + recall}, \beta = 1,2,..,N \tag{1}$$

Question 6

Write an essay on the following subject: You are part of a machine learning group which has been given access to a hospital database. The task for your group is to develop a CNN which can predict if there is a tumour in an x-ray image of the chest. You are given a set of images and a file with the annotation for each image (tumour present vs. not) and a patient ID to identify from which patient each image is.

Describe how you set up the experiment from the beginning to the end, where your goal is to have a results which you could publish in a paper. On each step, describe some common problems which might occur and explain how you will try to solve them.