

## Exercises 3 – Hopfield And Deep Learning

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### Problem 1: (35)

- (a) Does The synchronous algorithm for Hopfield networks go into an infinite loop? What about sequential algorithm? explain. (10)
- (b) If we run the sequential algorithm starting with one of the target patterns, do we always get the very same pattern back? (10)
- (c) What is the role of pooling layers in a Convolutional Neural Network? (5)
- (d) In a convolution layer, the input consists of 6 feature maps of size  $20 \times 20$ , the output consists of 8 feature maps, and the filters are of size  $5 \times 5$ . The convolution is done with a stride of 2 and zero padding, so the output feature maps are of size  $10 \times 10$ .
  - Determine the number of weights in this convolution layer. (5)
  - Now suppose we made this a fully connected layer, but where the number of input and output units are kept the same as in the network described above. Determine the number of weights in this layer. (5)

### Problem 2: (40)

Design a Convolutional Neural Network using Keras, and train it to classify the given numbers in the first problem of HW2.

- Describe the network's hyperparameters.
- Calculate the Precision, Recall, and F1-Score for the whole dataset and each class individually.
- Plot the error for both train and test dataset during the learning phase.

### Problem 3: (40)

Design a Hopfield Network and train it on the images of the first 10 letters of English alphabet to get a noisy image and correct it. In order to test your model, add noise to X percent of each of the images and then give them to your network. In the end calculate the network's accuracy. Then complete the following table. ( Each cell represents the accuracy of which the network guessed the input letter )

|              | 10% noise | 30% noise | 60% noise |
|--------------|-----------|-----------|-----------|
| Font size 16 |           |           |           |
| Font size 32 |           |           |           |
| Font size 64 |           |           |           |

- The code used for generating images of the first 10 letters of the English alphabet with different font sizes is as follows.

```
from PIL import Image, ImageFont

font_size = 16
font = ImageFont.truetype("Tahoma.ttf", font_size)

for char in "ABCDEFGHIJ":
    im = Image.Image().new(font.getmask(char))
    im.save(char + ".bmp")
```

Please pay attention to the followings:

- This homework has 115 marks. However, the questions marked by a star are considered as bonus questions and it is up to you whether to answer them or not.
- The codes are to be submitted with python and numpy module
- You should send your homework to [iust.ci972@gmail.com](mailto:iust.ci972@gmail.com). You only need to email a zip file named as p3\_94520000\_lastname.zip. The zip file should contain a document to fully explain your code and the answer to other questions, the code itself and images containing your program execution and charts.
- You should submit your homework before Khordad 11 (11:59 pm Khordad 10). You have 3 extra days to submit your homework after the given deadline during this semester. If you exceed your 3 extra days, you will lose 10 percent of your mark by each day.
- Please subscribe to our telegram channel (@CAI972) to get the latest news about your homework.

Good Luck