# Assignment 4 group 1

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## Exercise 1

Transfer learning can be used when you want to train a neural network for a certain task B but do not have a lot of data available for this task. However, you do have another task A for which you have more data and from which the low level features can be useful for learning task B. It is important that task A and task B have the same input. It does not make sense to pre-train a neural network on a database that is significantly smaller than the database for the task you want the model to perform. You can train a model for task B by taking a 'pre-trained' model that has been trained for task A, replace the output layer by randomly initialized weights and then finetune the weights of the layers. ImageNet has 1.2 million images, whereas Patch-CAMELYON has 327.680. ImageNet has a significantly larger image database. Therefore it makes sense to do transfer learning from ImageNet to the Patch-CAMELYON dataset. However, due to the large differences between the ImageNet and the Patch-CAMELYON datasets it is important that not only the output layer is replaced, but that the weights of a number of hidden layers are finetuned as well.

## Exercise 2

In this exercise, 3 models are compared. The first one is a transfer model (model 1) where the model weights are initialized using the ImageNet weights. With other words, pre-training of the model on ImageNet is performed. The second model (model 2) is a model with random initialization. The third model (model 3) is a convolutional neural network model. This model consists of two convolutional layers that are each followed by a max pooling layer, and finally by a fully connected layer with 64 neurons. A kernel size of 3x3 is used for the convolutional layer, and a pool size of 4x4 for the max pooling layer.

The layers in all models use ReLu activaiton, which exception of the output layers. Here sigmoid activation is used.

For the evaluation of the model performance, the validation and training accuracy were used. This was done since the used dataset did not contain a labelled test set.

When looking at the training set, the accuracy was highest for model 1 (0.9158), followed by model 3 (0.8477) and model 2 (0.8393). When looking at the validation set, the accuracy was highest for model 3 (0.86), followed by model 1 (0.6913) and model 2 (0.5163).

Since the validation dataset was not used for training of the model but only for model selection, the validation accuracy can be seen as the best metric to evaluate model performance in the absence of test accuracy. From the validation accuracy, we can conclude that the convolutional neural network model performs much better than the transfer model and the randomly initialized model. Moreover, the transfer model has higher performance that the model with randomly initialized weights.

Looking at the accuracy plot (Figure 1.), it seems to be the case that model 1 has overtrained on the training set. The validation accuracy is highest after 6 epochs (0.865) and then decreases to 0.6913 after 9 epochs. Furthermore, the validation accuracy of model 3 does not increase. It's final value (0.5163) is actually lower than it's starting value (0.535).

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Figure 1: The accuracy curves of the training and validation set for model 1, 2 and 3 of exercise 2.

## Exercise 3

The Dropout layer sets input units to 0 randomly. The inputs that are not set to 0, are scaled up so that the sum over all inputs is unchanged. Adding a Dropout layer to the neural network helps prevents overfitting (*Dropout Layer*, n.d.). However, applying dropout to a neural network typically increases the training time (Ko et al., 2017).

When running transfer.py without the dropout layer, the computational time was 29 minutes and 12 seconds. While the computational time with dropout layer was 19 minutes and 16 seconds (Figure 2:). This contradiction with the literature stated earlier can be a result of running more other programs while running spyder during the training of the model without the dropout layer than during the training of the model with dropout layer.

The accuracies of the training set with dropout layer and without dropout layer are 0.9139 and 0.9206 respectively. The accuracies of the validation set with dropout layer and without dropout layer are 0.8575 and 0.7936 (Figure 2). To conclude, the dropout layer in these models does not affect the accuracy of the training set significantly. However, it does affect the accuracy of the validation set, since this is significantly higher for the model with dropout layer than for the model without dropout layer. This corresponds to the found literature that the dropout layer helps preventing overfitting.

Chart

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Figure 2: The accuracy curves of the training and validation set of the tranfer model with dropout layer and without dropout layer.

## References

*Dropout layer*. (n.d.). https://keras.io/api/layers/regularization\_layers/dropout/

Ko, B., Kim, H.-G., & Choi, H.-J. (2017). Controlled dropout: A different dropout for improving training speed on deep neural network. *2017 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*, 972–977. https://doi.org/10.1109/SMC.2017.8122736