AI in Medicine I
WiSe 2022/23

Technical University Munich
Department of Informatics

I31 - AI in Medicine and Healthcare
I32 - Computational Imaging in AI and Medicine

Practical exercise 1 **25. Oct. 2022**

Brain age regression

Submission deadline: 8. Nov. 2022, 11 p.m.

Please submit your solutions (via Moodle).
The corresponding tutorial session is

27. Oct 2022, 4-6 p.m. in lecture hall 5901.EG.051

For questions regarding this exercise sheet, please contact: `sophie.starck@tum.de` or `felix.meissen@tum.de`
For general questions, please contact: `course.aim-lab@med.tum.de`

Code and further instructions on this practical can be found at
`https://github.com/compai-lab/aim-practical-1-brain-age-estimation`

Predicting the age from a brain MRI scan is believed to have diagnostic value in the context of a number of pathologies that cause structural changes and damage to the brain. The objective for the coursework is to implement two different supervised learning approaches for age regression from brain MRI data. A dataset of 652 brain MRIs is provided as well as the corresponding age for each subject. The Jupyter Notebook provided contains some preliminary code you can use and some function prototypes that you are expected to fill in. The deliverables for the submission an archive containing the code proided completed as well as a short report explaining your strategies and choices for each task in this practical.

1. (40%) Task 1 : **Feature-based linear regression using brain structure segmentation**

   The first approach aims to regress the age of a subject from the volumes of brain tissues, including grey matter (GM), white matter (WM), and cerebrospinal fluid (CSF). It is known that with increasing age the ventricles enlarge (filled with CSF), while it is assumed that grey and white matter volume might decrease.

   Different regression techniques should be explored, and it might be beneficial to investigate what the best set of features is for this task.

   (a) (20%) Task 1a : Feature Identification and Calculation

   Implement a function that calculates volume features given the three tissue volumes and the overal brain volume (which can be calculated from the brain masks). You should use this function to construct a big matrix X with a row for each subject and features across the columns.

   (b) (20%) Task 1b : Age regression and cross-validation

   Experiment with different regression methods and evaluate them using cross-validation. At least two different regression methods should be used.

   Hint The $scikit-learn$ library might be of some help.

2. (60%) Task 2 : **Image-based regression using CNNs**

   This second approach aims to build a CNN and regress the age from brain MRIs directly. Here you are expected to train a regression model from scratch, and play around with the hyperparameters.

   (a) (10%) Task 2a : Implement a Dataloader

   The first step here is to implement the Dataloader which will feed the data to your model. Here you will have to fill the blanks in the data_utils.py file. You are expected to load the data correctly and implement preprocessing steps.

   (b) (30%) Task 2b: Implement the model.

   The goal here is to implement a regression model. A good practise here is to start simple and build complexity upon an already working model to improve performance. For this, we provided a structure that you will complete. During this step you will need to complete the __init__, the forward pass, and the loss-function.

   (c) (20%) Task 2c: Training.

   The next step is to train your model. A training function is provided, you should read it and get familiarized with it. Alongside training you are expected to tune your hyperparameters and tweak your model in order to optimize your performance as needed. You should be able to reach a mean average arror of around 8.0.

3. (10%) BONUS: What is the carbon footprint of your model?

   "Ai is a powerful technology and a force for good, but it's important to be conscious of its growing environmental impact. The code carbon project aims to do just that, and I hope that it will inspire the AI community to calculate, disclose and reduce its carbon footprint" - Yoshua Bengio

   The goal of this bonus exercise is to track the carbon footprint of the brain age regression model you implemented. You may use any tool you'd like.

   Hint : You can take a look at these packages: Carbontracker or CodeCarbon