



**[Master's thesis]**

[Name]

**[Title of thesis]**

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# 1 Introduction

## Introduction

### 1.1 Background

There are volumetric and microstructural changes in the brain linked to a covid infection, which may result from neuroinflammation and the degeneration of axons [1, 2]. Brian volume changes could also be induced by the lockdown [3].

## 2 Methods

### Methods

#### 2.1 Patient Matching

Following procedure was applied to match the patients:

1. Include patients if at least 2 scans, acquired on different dates with:

$$L_{\text{scan}}(\text{scan}_i, \text{scan}_j) = L_{\text{scan},(i,j)} < d_{\min}, \quad (1)$$

are present for the patient. The distance  $L_{\text{scan},(i,j)}$  between scan  $i$  and scan  $j$ ,  $i \neq j$ , is defined as follows

$$L_{\text{scan},(i,j)} = 2L_{\text{res},(i,j)} + L_{\text{scanner},(i,j)} + L_{B_0,(i,j)}. \quad (2)$$

The first term measures the difference in resolution:

$$L_{\text{res},(i,j)} = \frac{1}{|R|} \sum_{r \in R} \left( \frac{r_i - r_j}{\sigma_r} \right)^2, \quad (3)$$

where are the resolution parameters:  $R = \{N_{\text{rows}}, N_{\text{columns}}, N_{\text{slices}}, \Delta d_{\text{rows}}, \Delta d_{\text{columns}}, d_{\text{slice}}\}$  is the number of resolution parameters. The second term is 1 if the manufacturer model name is different and 0 else. The last term defines the difference in the magnetic field strength  $B_0$ .

$$L_{B_0,(i,j)} = \left( \frac{B_{0,i} - B_{0,j}}{\sigma_{B_0}} \right)^2, \quad (4)$$

2. Patient which are included in 1. are now matched for demographics, comorbidities and minimal difference in the number of days between two scans.

The metric to measure the distance between patients  $k$  and  $l$  is given by:

$$L_{\text{pat},(k,l)} = 2L_{\text{EHR},(k,l)} + DD_{\text{min},(k,l)}, \quad (5)$$

where the first term includes patient age, sex and comorbidities and is computed as:

$$L_{\text{EHR},(k,l)} = \left(\frac{a_k - a_l}{\sigma_a}\right)^2 \cdot w_a + \left(\frac{b_k - b_l}{\sigma_b}\right)^2 \cdot w_b + (s_k - s_l)^2 \cdot w_s + \sum_{c \in C} (c_k - c_l)^2 \cdot w_c \quad (6)$$

the second term is the minimal difference of time periods between two scans performed on patients  $k$  and  $l$ . It is computed as follows:

- For patient  $k$  and a pair of scans  $(i, j)$  that are close enough according to 1. compute  $\Delta t_{(i,j,k)} = \text{abs}\left(\text{days}(\text{date}_i - \text{date}_j)\right)$ .  
Using this compute the minimal distance:

$$DD_{\text{min},(k,l)} = \min_{(i,j),(m,n)} \left( \frac{\Delta t_{(i,j,k)} - \Delta t_{(m,n,l)}}{\sigma_{\Delta t}} \right)^2 \quad (7)$$

To match the patients we select the age on the date of the first scan, if the patients has 2 scans, else we select the median age computed over all the scans, excluding the last one.

### 3 [Title 1]

#### 3.1 [Title 2]

## References

- [1] Yiping Lu, Xuanxuan Li, Daoying Geng, Nan Mei, Pu-Yeh Wu, Chu-Chung Huang, Tianye Jia, Yajing Zhao, Dongdong Wang, Anling Xiao, et al. Cerebral micro-structural changes in covid-19 patients—an mri-based 3-month follow-up study. *EClinicalMedicine*, 25:100484, 2020.
- [2] Elkhonon Goldberg, Kenneth Podell, Daniel K Sodickson, and Els Fieremans. The brain after covid-19: Compensatory neurogenesis or persistent neuroinflammation? *EClinicalMedicine*, 31, 2021.
- [3] Tom Salomon, Adi Cohen, Daniel Barazany, Gal Ben-Zvi, Rotem Botvinik-Nezer, Rani Gera, Shiran Oren, Dana Roll, Gal Rozic, Anastasia Saliy, et al. Brain volumetric changes in the general population following the covid-19 outbreak and lockdown. *NeuroImage*, 239:118311, 2021.