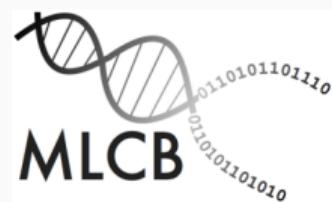


Uncovering the saliency of local topological features for Alzheimer's disease characterisation

Philip Hartout

December 31, 2020

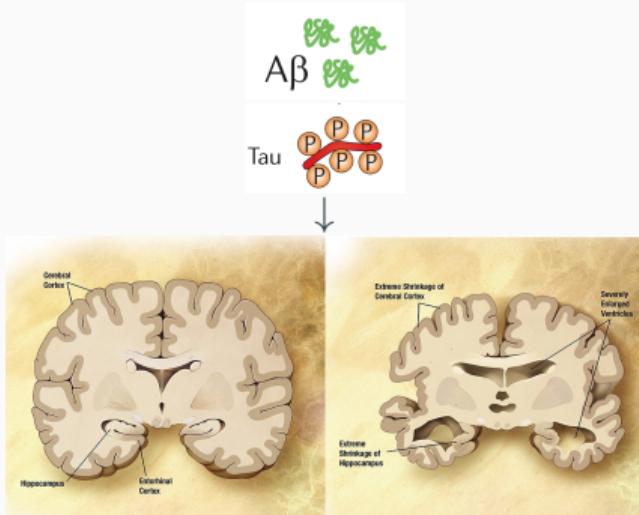


DBSSE

ETH zürich

Alzheimer's disease:

- Nearly 40 million people live with AD
- Cost in US alone \$ 2 trillion by 2030
- Among leading causes of death in EU



Images adapted from Ittner et al and Wikipedia

Topology:

- Concerned with “properties of a geometric object that are preserved under **continuous deformations**, such as [...] crumpling.”
- Recently, *persistent homology* has emerged as a way to quantify the shape of data.
- **How can we apply persistent homology to quantify changes in shape due to Alzheimer's disease?**

Topology in AD - Research Avenues

1. **Classification**
2. Subtype identification
3. Progression & forecasting

Determining the patch of interest

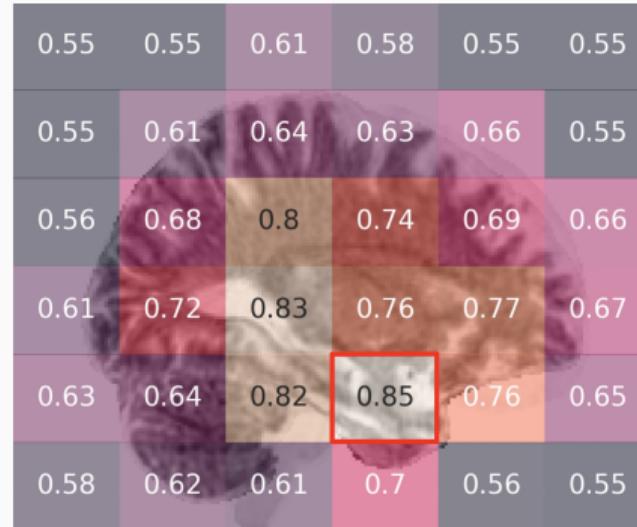


Figure 2: The patch with the highest accuracy was selected. Results from Brüningk, Sarah C et al
<https://arxiv.org/abs/2011.06531>

Obtaining topological features from sMRI data

- We use the T1-weighting value (fat ≈ 1 ; water ≈ 0) to compute topological features
- Filtration of point clouds:

Figure 3: Point cloud filtration. Adapted from giotto-ai.github.io/gtda-docs/

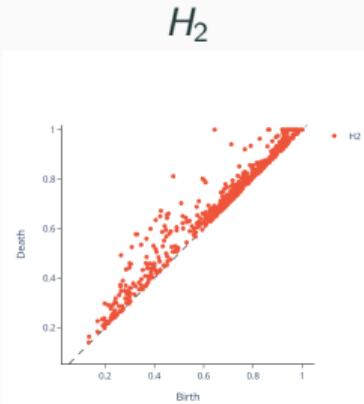
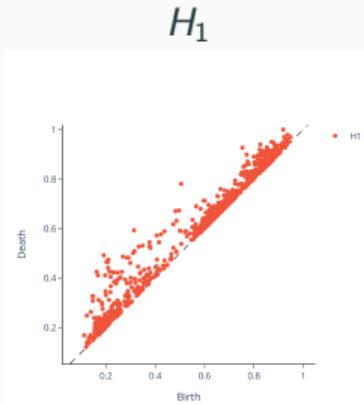
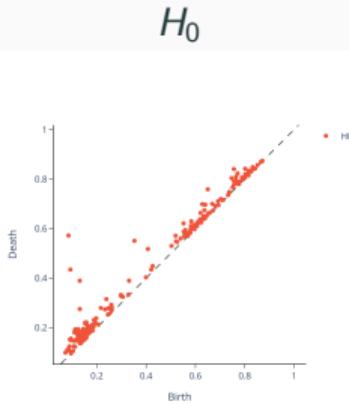
Obtaining topological features from sMRI data

- We use the T1-weighting value (fat ≈ 1 ; water ≈ 0) to compute topological features
- Filtration of cubical complexes to examine the connected components, cycles, and voids.

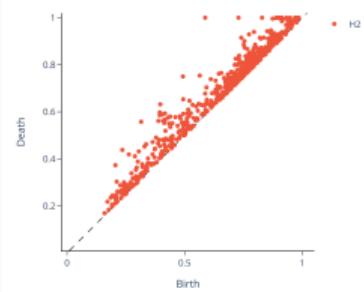
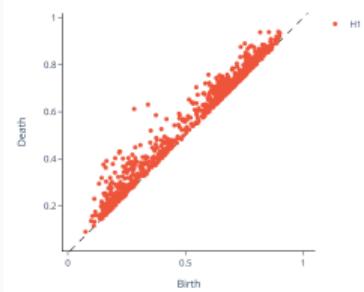
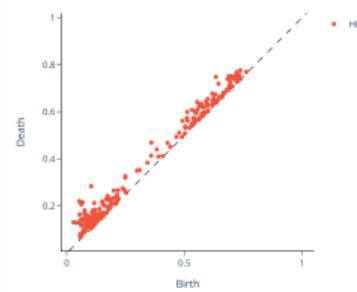
Figure 4: Cubical complex filtration. Adapted from Bastian Rieck <https://youtu.be/4mBcwy1t0J4>

I - Persistent homology

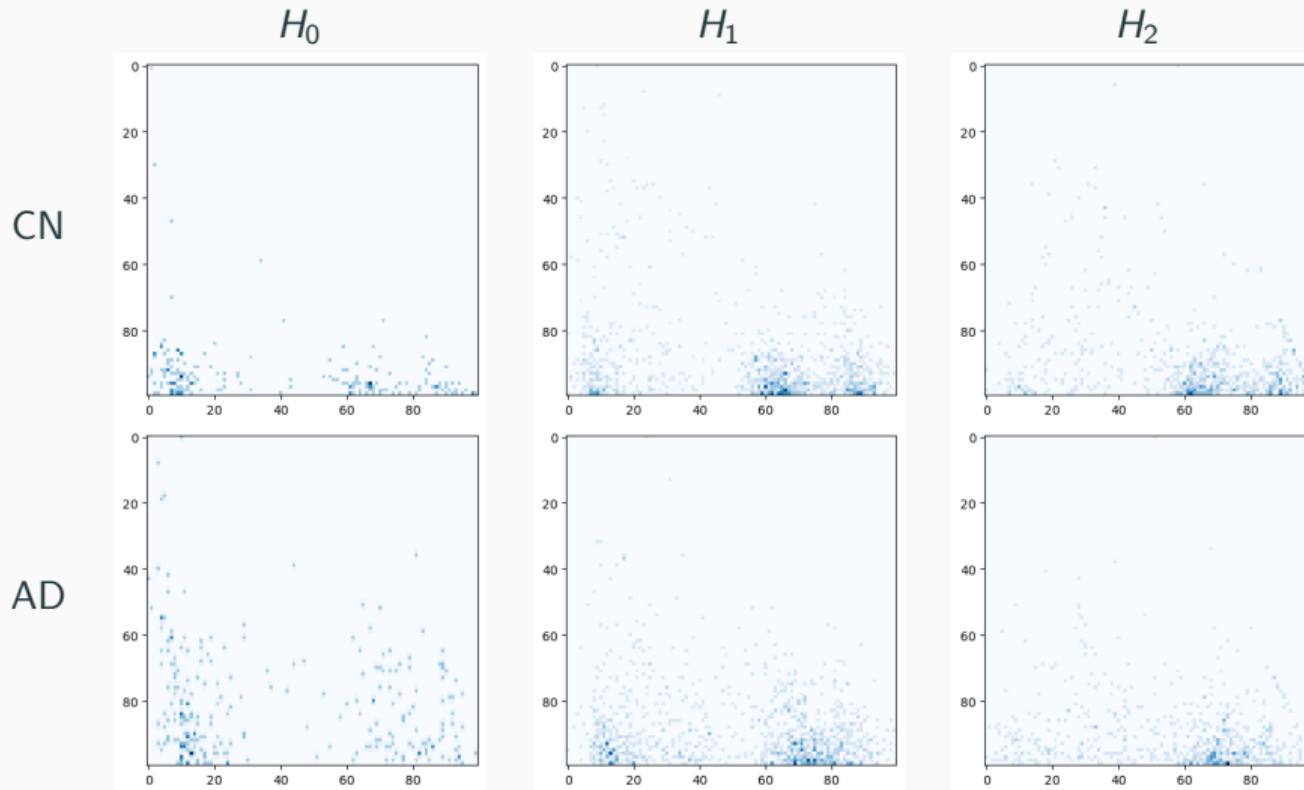
CN



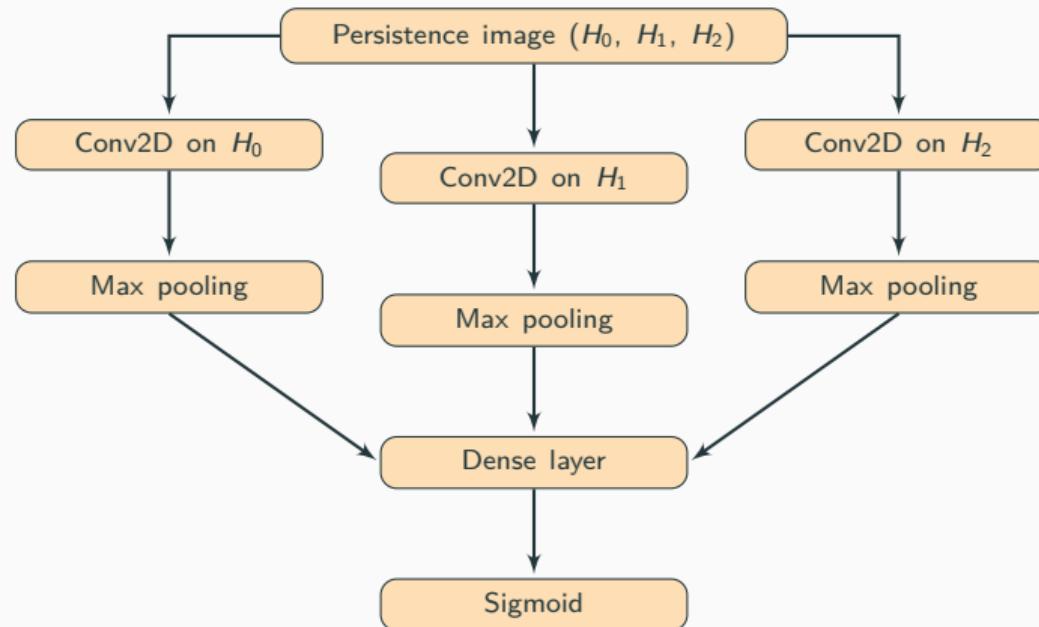
AD



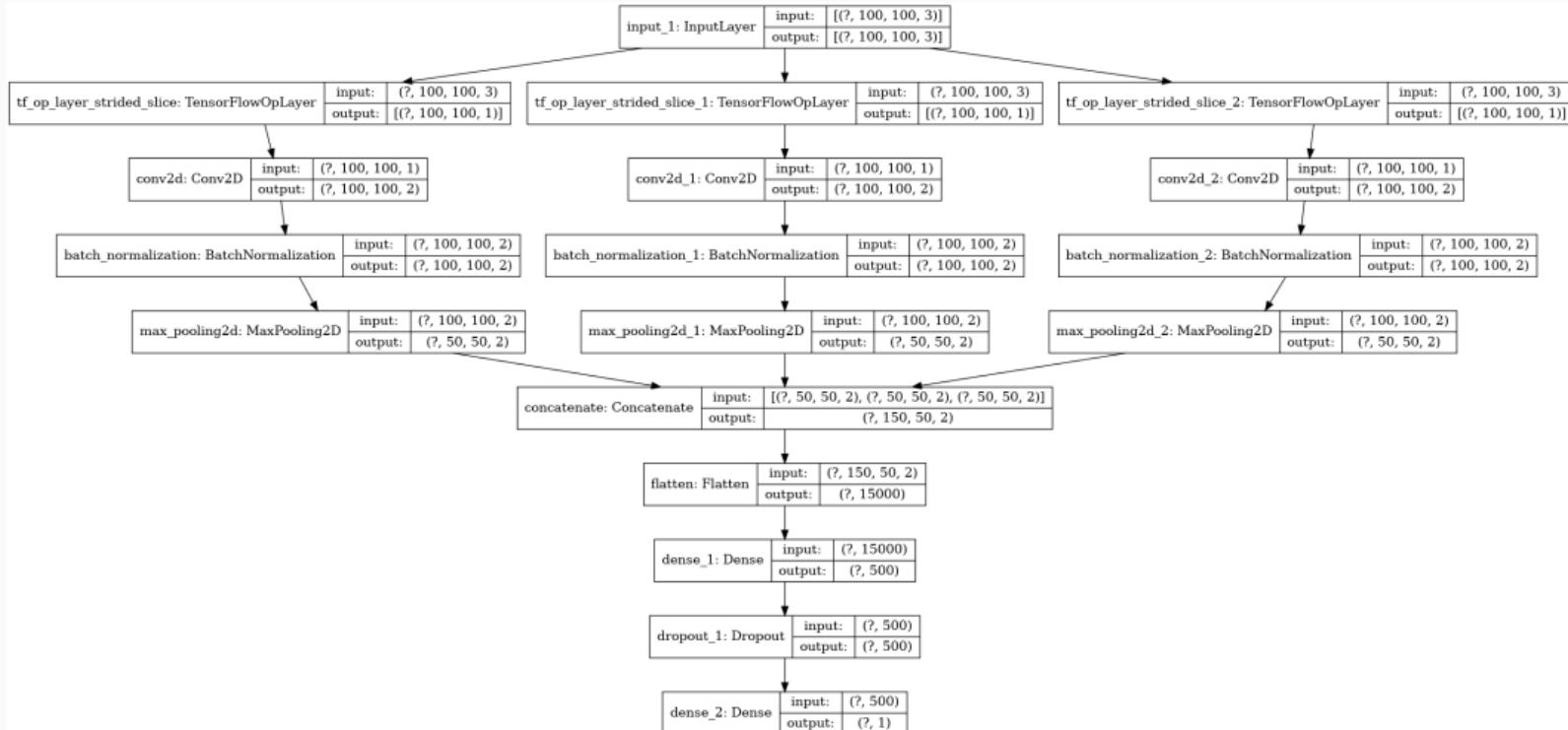
I - Classification - Persistence Images



I - Classification - Network architecture



I - Classification - Network architecture



Methodological considerations

- 4 fold CV, 3 inits. Stratified for age, diagnoses and patients spread over folds.
- Same settings as in Brüningk, Sarah C *et al* <https://arxiv.org/abs/2011.06531>

I - Classification - Performance

	Local Global	PI	3D Conv	PI
Validation accuracy		0.79 ± 0.02	0.85 ± 0.06	0.76 ± 0.02
Precision		0.81 ± 0.04	0.87 ± 0.04	0.74 ± 0.02
Recall		0.81 ± 0.02	0.87 ± 0.08	0.88 ± 0.08
AUC		0.85 ± 0.03	0.89 ± 0.05	0.78 ± 0.02

Table 1: Performance metrics of the different models trained on the same data.

Metrics from Brüningk, Sarah C *et al* <https://arxiv.org/abs/2011.06531>.

→ Local 3D Conv training takes 15 minutes on a **server GPU**.

→ Local PI training time is 2 minutes on a **laptop CPU**.

Persistent homology produces **highly salient compressed** features for AD characterization.

Limitations & Outlook

Limitations:

- Using **raw** images is **better**, but more **expensive**.
- Does not take atrophy from **other regions** into account

Future directions:

- Can persistent homology be used to diagnose **prodromal** forms of AD?
- Use a similar approach for **subtype identification**.

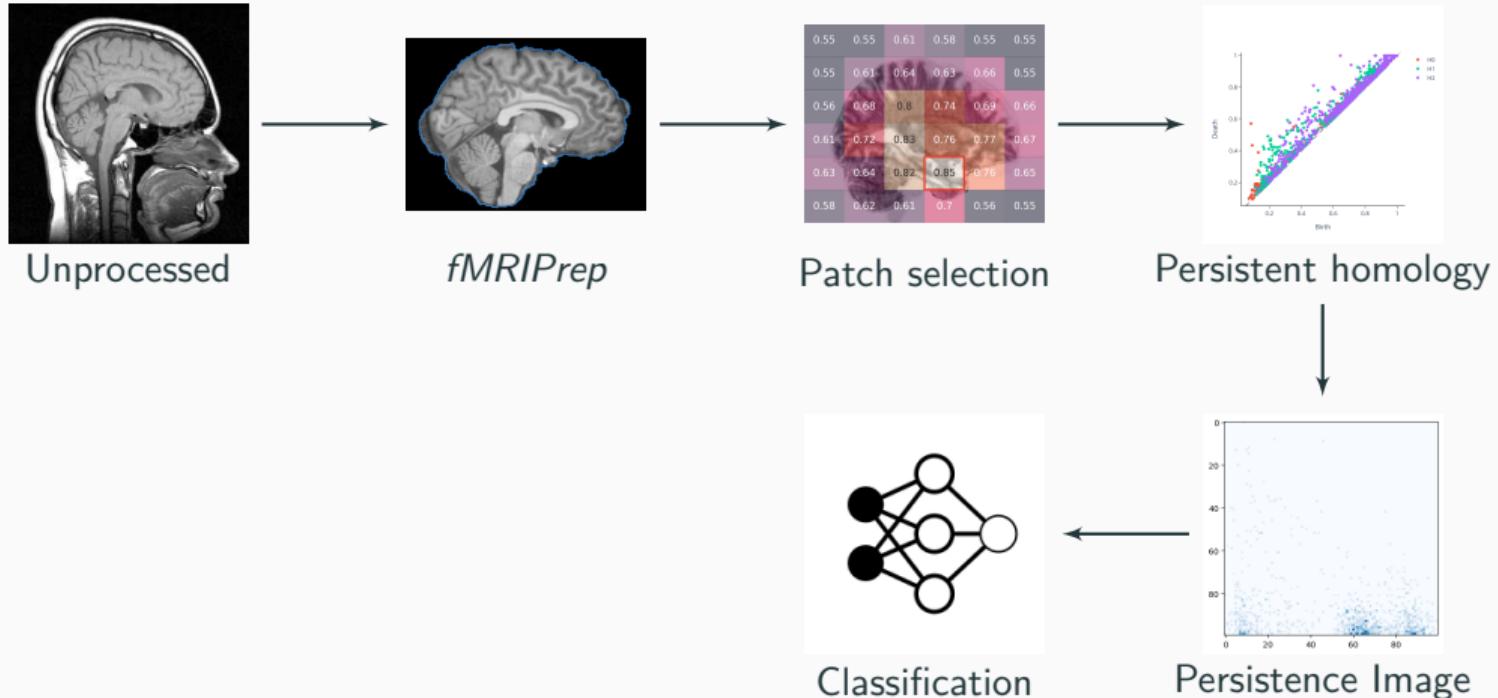
Thanks!

GitHub repository of the project (currently available upon request)

`github.com/pjhartout/TDA_ADNI_MLCB`

With thanks to Bastian Rieck for the supervision and Sarah Brueningk, Felix Hensel, Catherine Jutzeler, Merel Kuijs and Louis Lukas for insightful discussions, code, and data & Karsten Borgwardt for providing the research setting.

Questions?



Images adapted from Wikimedia, slicer.org, and Sachin Modgekar