Applying Multivariate Techniques to MRI Scans of Individuals With and Without Alzheimers

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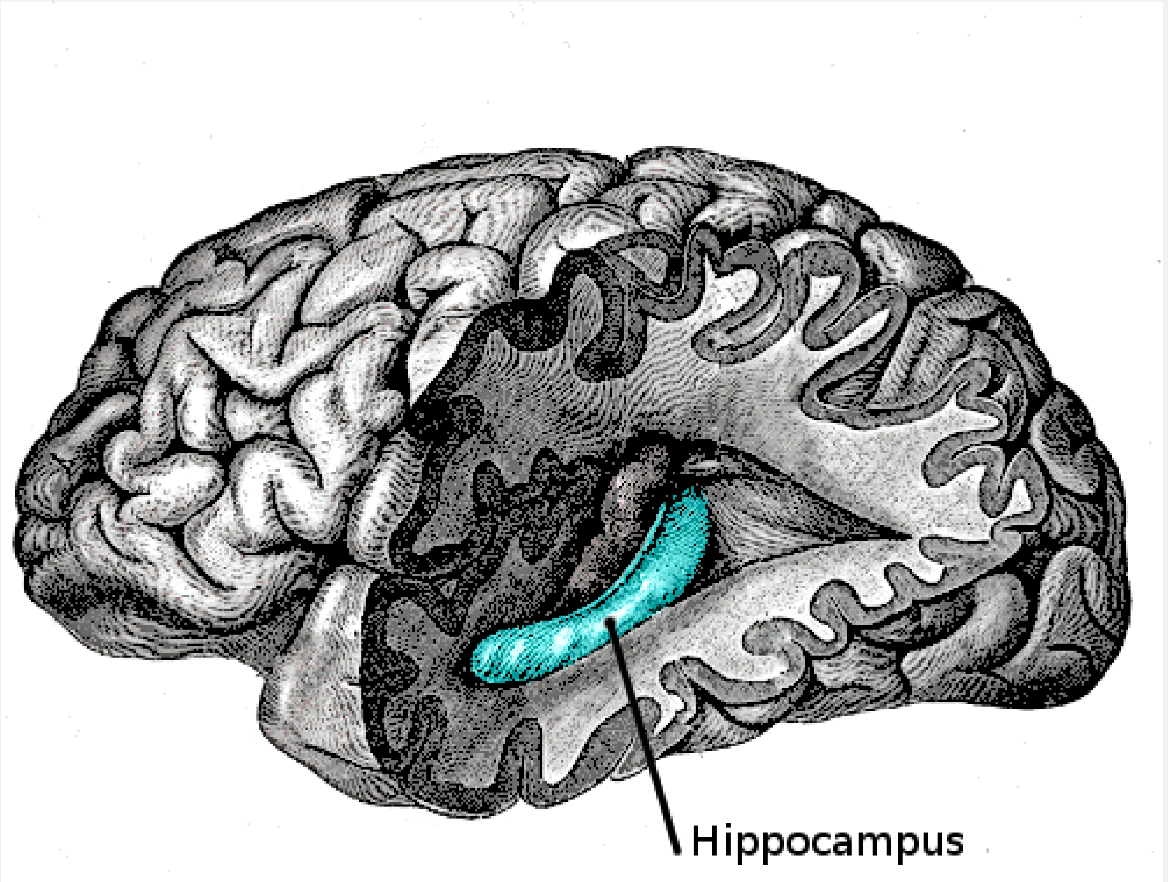
Overview

Introduction

- Neurodegenerative disease
- characterized by damage to the neurons in the brain
  - particularly in hippocampus
  - responsible for talking, walking and thinking
- Significant changes to the brain as it progresses

- Accounts for estimated 60%-80% of all dementia cases
- particularly affects those 65 and over
- incidence rates projected to double by 2050
- early prediction of Alzheimer's allows steps to be taken to minimize or stop progression



Age Range	65-74	75-84	85+
Incidence Rate	0.4%	3.2%	7.6%

Data Description

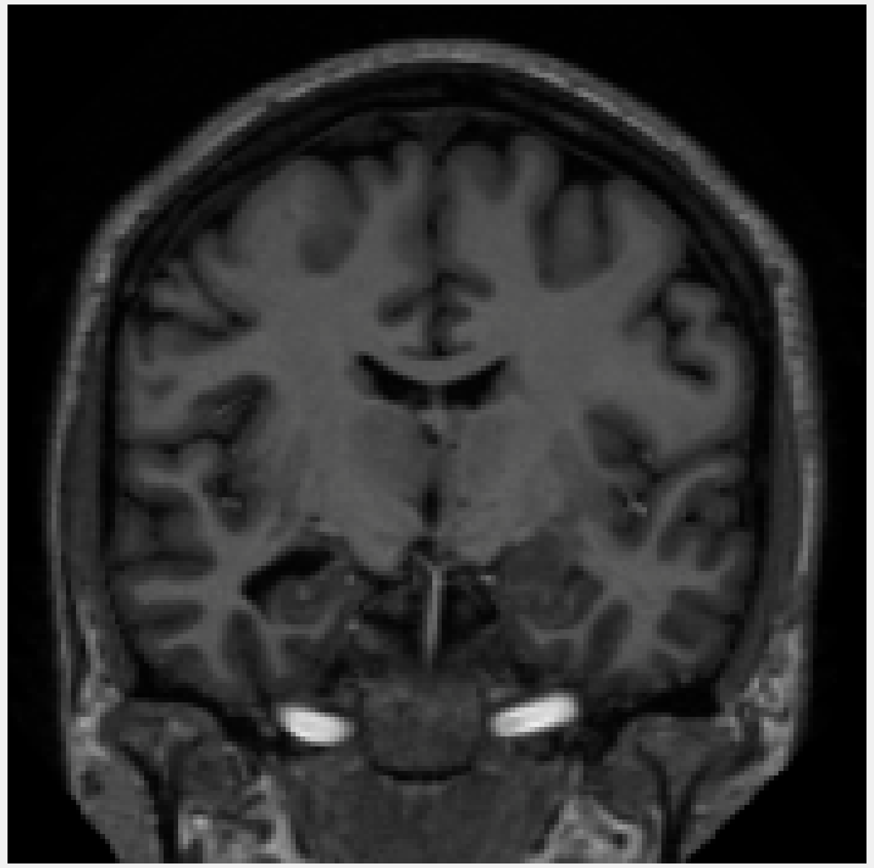
- Dataset comes from OASIS1 Opensource MRI Imaging
  - 400 individuals
  - Clinical Dementia Rating can be: No dementia = 0, mild dementia = 0.5, moderate dementia = 1 and severe dementia = 2
  - Missing observations removed
  - Grouping CDR = 2 with CDR = 1

Table 1: Table of number of indiviuals with different levels of CDR

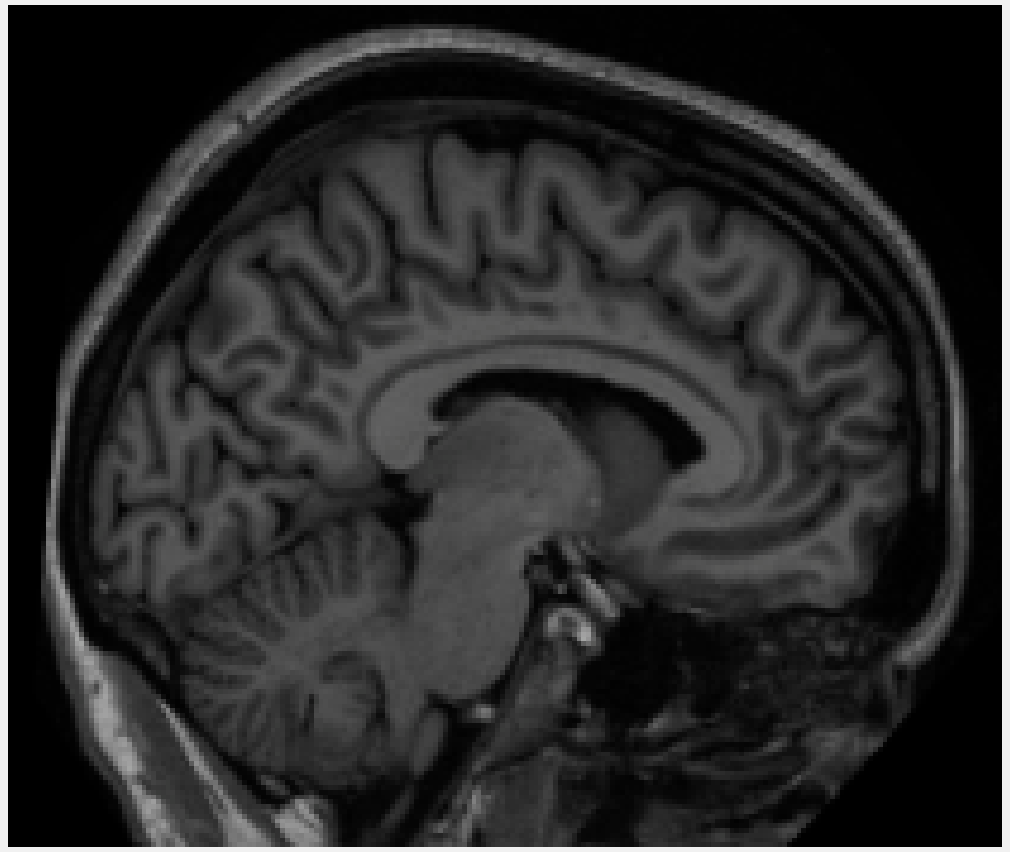
CDR = NA	CDR = 0	CDR = 0.5	CDR = 1	CDR = 2
176	130	67	25	2

Data Given

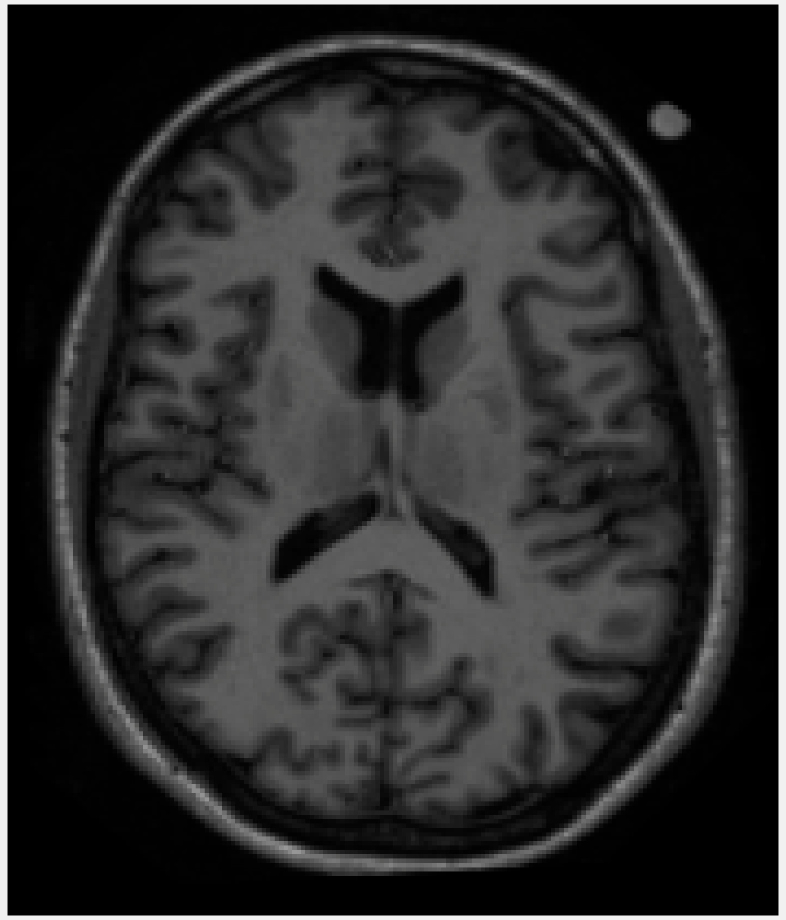
- 1: session ID
- 2: Age of individual
- 3: Male/ Female
- 4: Dominant Hand
- 5: Education Level
- 6: Social Economic Status
- 7: Clinical Dementia Rating
- 8: Mini Mental State Examination
- 9: Total Volume of the Skull
- 10: Normalization Factor
- 11: Total Brain Volume



FRONT SCAN
FOR INDIVIDUAL 58



SIDE SCAN
FOR INDIVIDUAL 58



TOP SCAN
FOR INDIVIDUAL 58

Methodology

- Dimension Reduction

	Pro’s	Con’s
Locally Linear Embedding (LLE)	• Able to keep local structure of brain in lower dimensions • Allows non linear relationships	• Does not keep global structure of brain • very impacted by choice of neighborhood size
Auto Encoder	• Capable of Non-Linear dimension reduction • Especially useful for anomaly detection (reconstruction error will be high) • Flexibility in model design	• Too complex model leads to overfitting • Too simple model leads to not enough variation being explained • Large data requirements
Convolutional Auto Encoder (CAE)	• Filters allow extraction of information from pixels values, e.g. edge detection • Capable of Non-Linear dimension reduction • Flexibility in model design	• Too complex model leads to overfitting • Too simple model leads to not enough variation being explained • Large data requirements

Methodology

- Clustering

	Pro’s	Con’s
K-Means	• Popular due to speed and ability to differentiate brain tissue and diagnose neurodegenerative diseases	• Requires you to predefine number of clusters • Struggles with non-spherical data
Density Based Clustering (DBScan)	• Able to detect arbitrarily shaped clusters • Doesn't need to predefine number of clusters	• Sensitive to epsilon and minimum points chosen • Assumes clusters have similar density

Results From LLE

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	72	28	13
1	44	34	13
2	14	5	1

Table 2: K-Means Clustering with 3 Clusters for LLE on Front MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	69	41	13
1	61	26	14

Table 3: K-Means Clustering with 2 Clusters for LLE on Front MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	52	30	13
1	78	37	14

Table 4: DBScan Clustering for LLE on Front MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	40	23	6
1	20	11	10
2	70	33	11

Table 5: K-Means Clustering with 3 Clusters for LLE on Top MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	80	47	19
1	50	20	8

Table 6: K-Means Clustering with 2 Clusters for LLE on Top MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	59	23	12
1	71	44	15

Table 7: DBScan Clustering for LLE on Top MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	40	27	8
1	59	20	6
2	31	20	13

Table 8: K-Means Clustering with 3 Clusters for LLE on Side MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	101	54	24
1	29	13	3

Table 9: K-Means Clustering with 2 Clusters for LLE on Side MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	75	35	12
1	55	32	15

Table 10: DBScan Clustering for LLE on Side MRI Scans

Results From Auto Encoder

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	41	22	6
1	40	29	6
2	49	16	15

Table 11: K-Means Clustering with 3 Clusters for AutoEncoder on Front MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	75	42	11
1	55	25	16

Table 12: K-Means Clustering with 2 Clusters for AutoEncoder on Front MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	130	67	27

Table 13: DBScan Clustering for AutoEncoder on Front MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	52	29	18
1	68	25	5
2	10	13	4

Table 14: K-Means Clustering with 3 Clusters for AutoEncoder on Top MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	95	41	11
1	35	26	16

Table 15: K-Means Clustering with 2 Clusters for AutoEncoder on Top MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	0	2	0
1	130	65	27

Table 16: DBScan Clustering for AutoEncoder on Top MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	43	28	13
1	72	28	7
2	15	11	7

Table 17: K-Means Clustering with 3 Clusters for AutoEncoder on Side MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	89	37	11
1	41	30	16

Table 18: K-Means Clustering with 2 Clusters for AutoEncoder on Side MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	24	20	7
1	106	47	20

Table 19: DBScan Clustering for AutoEncoder on Side MRI Scans

Results From Convolutional AE

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	63	33	7
1	37	13	6
2	30	21	14

Table 20: K-Means Clustering with 3 Clusters for CAE on Front MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	51	23	8
1	79	44	19

Table 21: K-Means Clustering with 2 Clusters for CAE on Front MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	35	23	12
1	95	44	15

Table 22: DBScan Clustering for CAE on Front MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	72	36	16
1	46	24	11
2	12	7	0

Table 23: K-Means Clustering with 3 Clusters for CAE on Top MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	79	38	20
1	51	29	7

Table 24: K-Means Clustering with 2 Clusters for CAE on Top MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	2	2	0
1	128	65	27

Table 25: DBScan Clustering for CAE on Top MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	55	17	6
1	49	29	9
2	26	21	12

Table 26: K-Means Clustering with 3 Clusters for CAE on Side MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	62	22	6
1	68	45	21

Table 27: K-Means Clustering with 2 Clusters for CAE on Side MRI Scans

Cluster	CDR = 0	CDR = 0.5	CDR = 1
0	130	67	27

Table 28: DBScan Clustering for CAE on Side MRI Scans

Conclusion

- Neither K-Means nor DBScan was able to identify distinct clusters
- DBScan consistently predicted 2 clusters

- Methods in this report unable to confidently detect differences in brain structure for Alzheimer's and Non-Alzheimer's patients.
  - may be due to lack of data
  - may be due to inability to train sufficiently deep models due to processing power restrictions