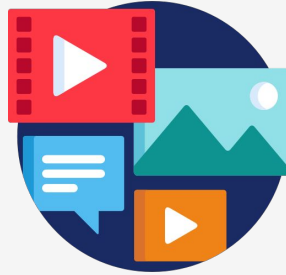


Group Project

Approfondimento Sperimentale

Basi di Dati Multimediali

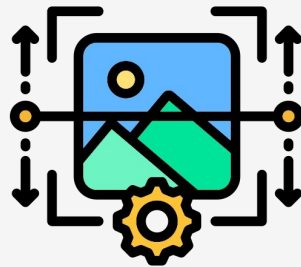


Camoia Andrea
Primicino Linda
Vitturini Davide



UNIVERSITÀ
DI TORINO

Task 1-2





Feature Extraction

- Color Moments
- Histogram of Gradients
- Resnet Layers

Extracted features structure: `<class 'list'>`

Number of objects: 3006

Extracted features keys:

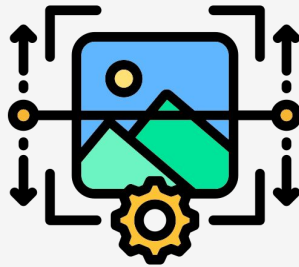
```
dict_keys(['file_path', 'class', 'cm', 'hog', 'avgpool', 'layer3', 'fc'])
```



Feature's Shapes

Feature's Name	Feature's Shape
"file_path"	Variable (String)
"class"	Variable (String)
"cm"	300
"hog"	900
"avgpool"	1024
"layer3"	1024
"fc"	1000

Task 3





Distance and Similarity

Metric distance
Resnet

Metric used: Euclidean for HOG

Similarity: Cosine_similarity_search for ResNet

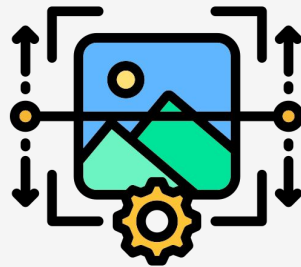
```
result: tabulate(results, headers='keys', tablefmt='psql')
```



Distance and Similarity

image_name	file_path	class	distance_score
brain_tumor_0493.jpg	/workspaces/dbm25/data/Part1/Part1/brain_tumor/brain_tumor_0493.jpg	brain_tumor	7367.01
brain_glioma_0501.jpg	/workspaces/dbm25/data/Part1/Part1/brain_glioma/brain_glioma_0501.jpg	brain_glioma	7296.7
brain_glioma_0137.jpg	/workspaces/dbm25/data/Part1/Part1/brain_glioma/brain_glioma_0137.jpg	brain_glioma	7245.24
brain_glioma_0793.jpg	/workspaces/dbm25/data/Part1/Part1/brain_glioma/brain_glioma_0793.jpg	brain_glioma	7234.57
brain_glioma_0356.jpg	/workspaces/dbm25/data/Part1/Part1/brain_glioma/brain_glioma_0356.jpg	brain_glioma	7119.43
brain_tumor_0021.jpg	/workspaces/dbm25/data/Part1/Part1/brain_tumor/brain_tumor_0021.jpg	brain_tumor	7082.83
brain_menin_0450.jpg	/workspaces/dbm25/data/Part1/Part1/brain_menin/brain_menin_0450.jpg	brain_menin	7022.57
brain_menin_0905.jpg	/workspaces/dbm25/data/Part1/Part1/brain_menin/brain_menin_0905.jpg	brain_menin	6994.54
brain_glioma_0597.jpg	/workspaces/dbm25/data/Part1/Part1/brain_glioma/brain_glioma_0597.jpg	brain_glioma	6993.61
brain_glioma_0662.jpg	/workspaces/dbm25/data/Part1/Part1/brain_glioma/brain_glioma_0662.jpg	brain_glioma	6984.74
brain_tumor_0182.jpg	/workspaces/dbm25/data/Part1/Part1/brain_tumor/brain_tumor_0182.jpg	brain_tumor	6908.79
brain_glioma_0051.jpg	/workspaces/dbm25/data/Part1/Part1/brain_glioma/brain_glioma_0051.jpg	brain_glioma	6897.11
brain_tumor_0615.jpg	/workspaces/dbm25/data/Part1/Part1/brain_tumor/brain_tumor_0615.jpg	brain_tumor	6607.69
brain_glioma_0532.jpg	/workspaces/dbm25/data/Part1/Part1/brain_glioma/brain_glioma_0532.jpg	brain_glioma	6571.41
brain_menin_0937.jpg	/workspaces/dbm25/data/Part1/Part1/brain_menin/brain_menin_0937.jpg	brain_menin	0

Task 4





Task 4

Classification

K-Means

K-Neighbors

K-Neighbors -> Measure: Eclidean

Model: ResNet

Voting + Distance

Feature-Space: Part2

K-Means -> Similarity: Cosine

Model: ResNet



Classification: K-NN

Class	Votes
brain_glioma	34
brain_tumor	11

`image_path= "brain_glioma_1045.jpg"`

`"feature_model="layer3",`

`k=2,`

`measure="euclidean")`

Label:	brain-glioma
Precisione	0.9688
Recall:	0.9394
F1-score:	0.9394

Label:	brain-tumor
Precisione	0.8974
Recall:	1.0000
F1-score:	0.9459



Classification: K-Mean

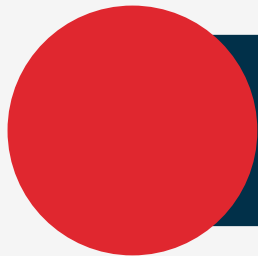
Class	Score
brain_tumor	0.8302
brain_menin	0.7790

`image_path= "brain-tumor-1007.jpg"`

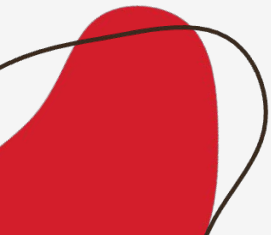
`"feature_model="hog",`

`k=2,`

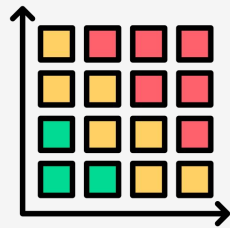
`measure="cosine"`



Title



Task 5





Latent Feature Extraction

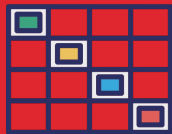
- Singular Value Decomposition (SVD)
- K-Means
- Latent Dirichlet Allocation (LDA)



**Store Latent
Features Values**



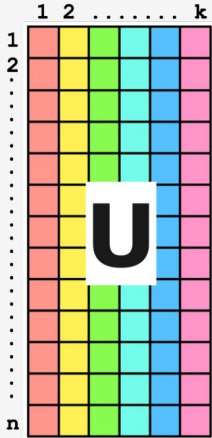
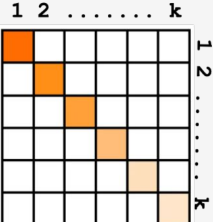
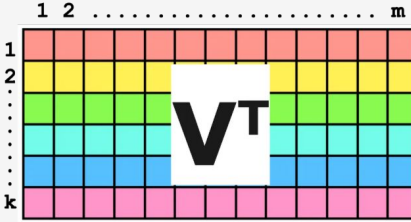
**Weigh Latent
Features**



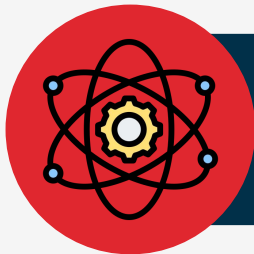
Singular Value Decomposition

- Feature Space Used: HoG

$$D = U \times S \times V^T$$

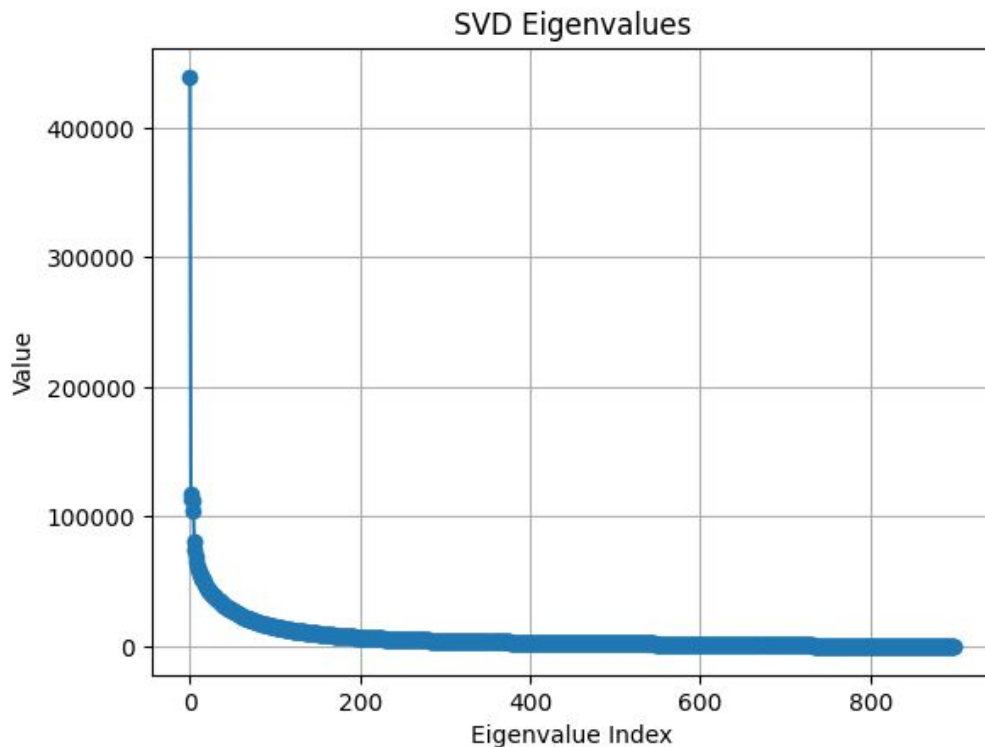
U.shape: (3006, 900) S.shape: (900,) Vt.shape: (900, 900)

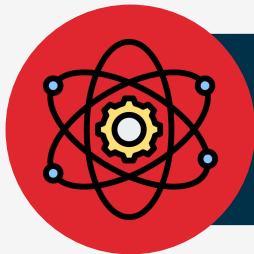


Task 5

Core Matrix

Top-K Latent
Feature Extraction



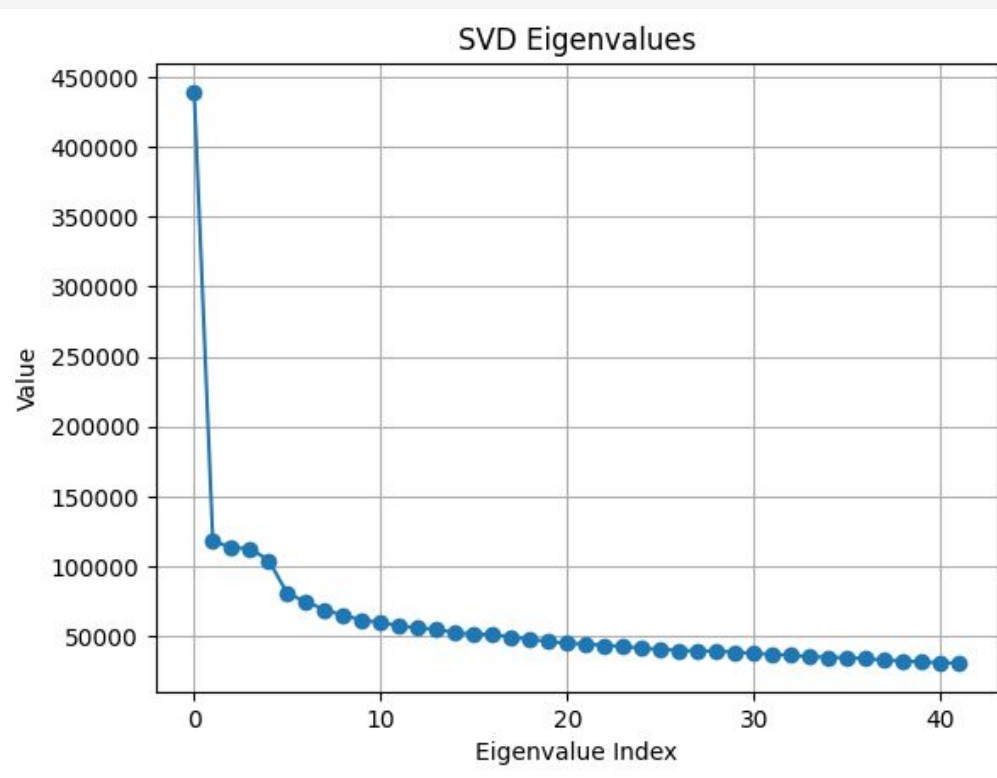


Task 5

Core Matrix

Top-K Latent Feature Extraction

- Elbow Point
Index: 42





Task 5

Feature Weighing

SVD decomposition extracts latent features according to their expressive power.

Weights = Latent Feature Values



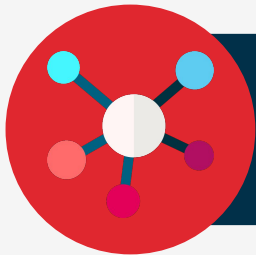
Task 5

Feature Weighing

SVD decomposition extracts latent features according to their expressive power.

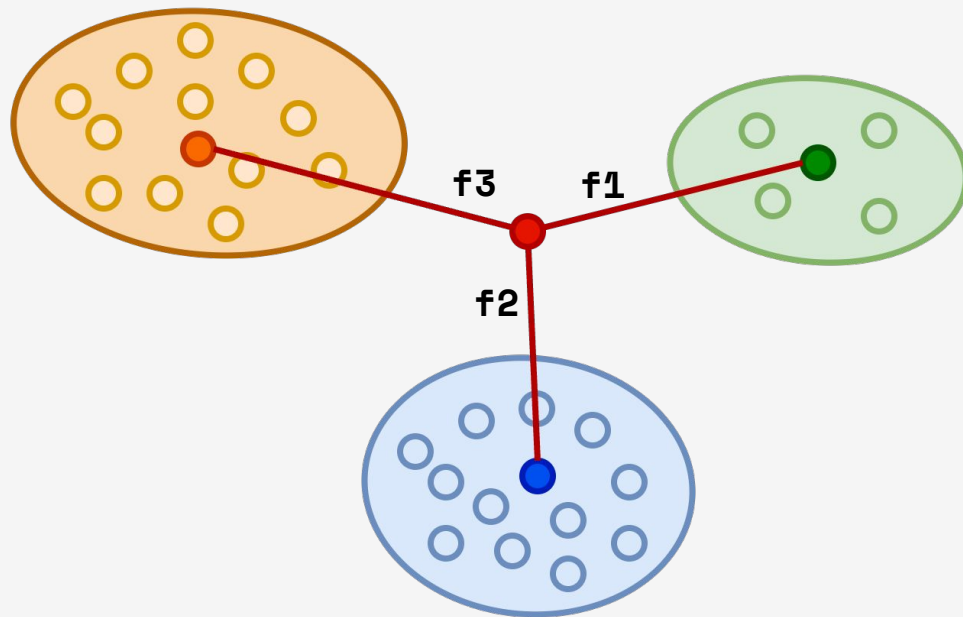
Weights = Latent Feature Values

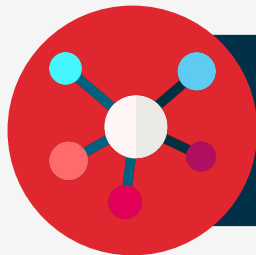
```
[ 'brain_glioma_0051.jpg', [  
    ('Latent Feature 10: ', 0.022267003272862993),  
    ('Latent Feature 31: ', 0.02106213429556215),  
    ('Latent Feature 15: ', 0.018750588877928066),  
    ('Latent Feature 8: ', 0.012947843189133564)  
    ...  
    ...  
]
```



K-Means Decomposition

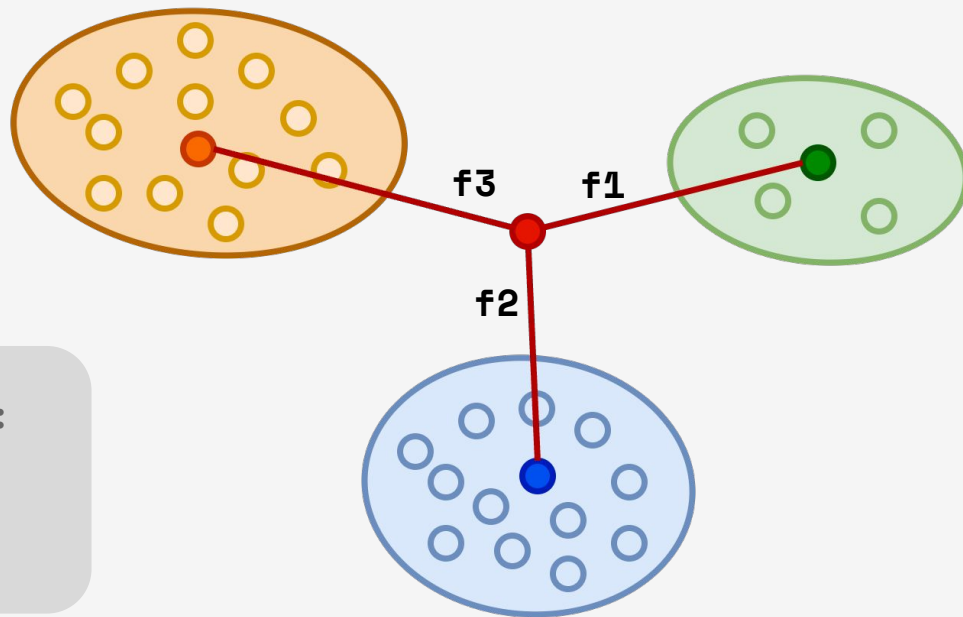
-
- Latent Features:
[f1, f2, f3]



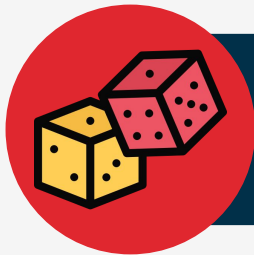


K-Means Decomposition

- Feature Space Used: **layer3**
- Latent Features: $[f1, f2, f3]$



```
'brain_glioma_0051.jpg':  
  [[0.9760344  1.  ]  
   [0.96796572 2.  ]  
   [0.93644494 0.  ]]
```



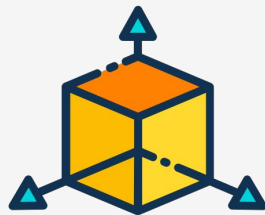
Task 5

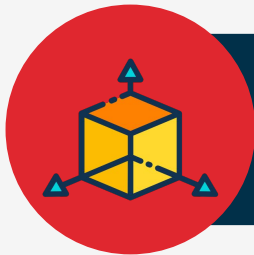
Latent Dirichlet Allocation

- Number of Topic: 5
- Shape of LDA Result: (3006, 5)

```
'brain_glioma_0051.jpg':  
  [0.444327571835563,  
   0.0006674491134033486,  
   0.0006686475889602517,  
   0.0006683056933277641,  
   0.5536680257687456]
```

Task 6



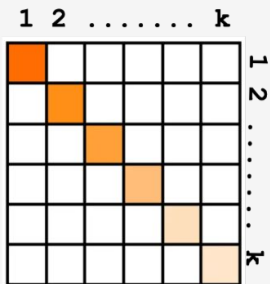


Task 6

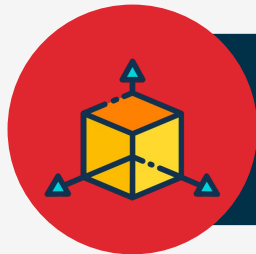
Inherent Dimensionality

- Original Latent Feature Space: (3006, 900)

We obtain the latent features that do not contribute to the representation of objects by calculating the **rank of the Core Matrix S**.



S

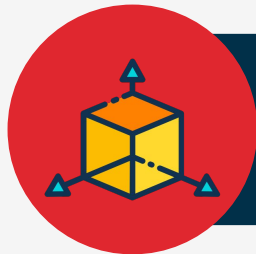


Inherent Dimensionality

- Original Latent Feature Space: (3006, 900)

Inherent Dimensionality for the
entire part one Dataset:

- Matrix rank (inherent dimensionality): 760



Inherent Dimensionality

- Original Latent Feature Space: (3006, 900)

Inherent Dimensionality for each label:

- Brain_Glioma: 760
- Brain_Tumor: 760
- Brain_Menin: 760

These values are calculated from the Core Matrix obtained in each Decomposition on the individual label.

Task 7





Latent Feature Labeling

A representation for each label is obtained by averaging the latent features of the object with that label.

- Similarity Score: **Cosine**
- Feature Model: **HoG**



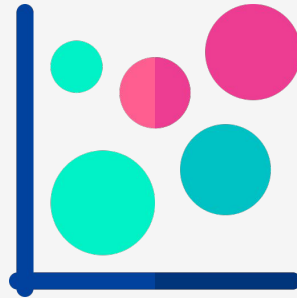
Task 7

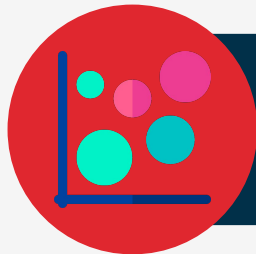
Latent Feature Labeling

Label	Precision	Recall	F1-Score
Brain_Glioma	0.2922	0.2954	0.2938
Brain_Menin	0.3433	0.3423	0.3428
Brain_Tumor	0.2404	0.2385	0.2395

Overall accuracy: 0.2921

Task 8





Clustering

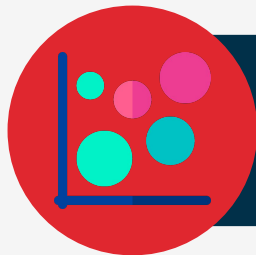
DB-Scan

Using DB-Scan to identify clusters within the same class.

This can be used to identify possible biases or similarities.

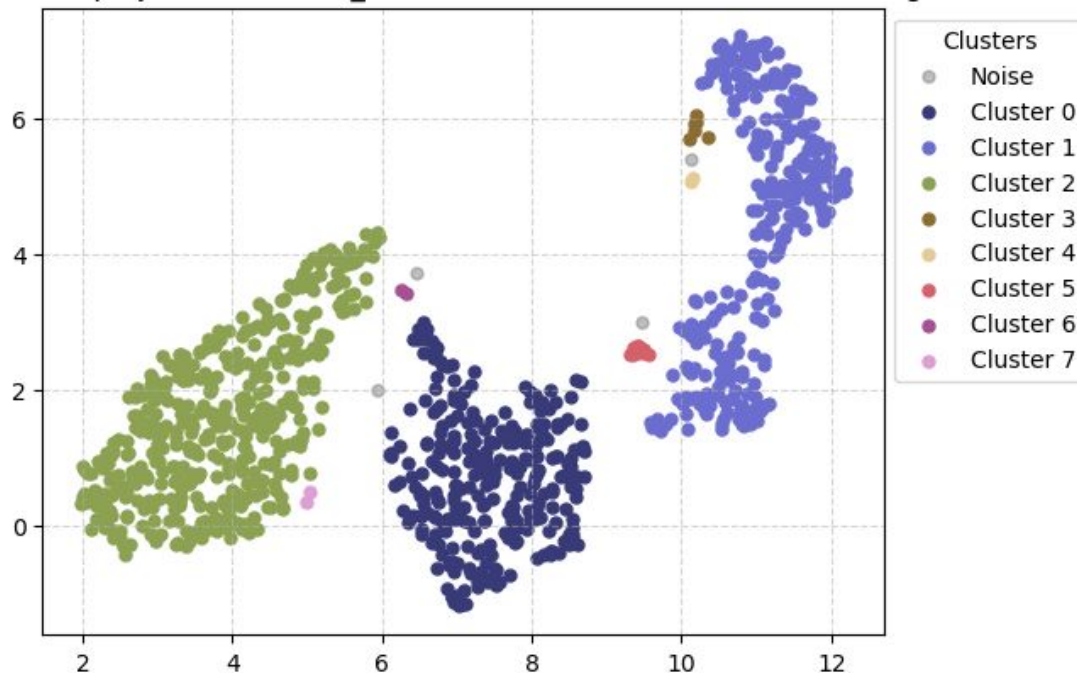
Visualization:

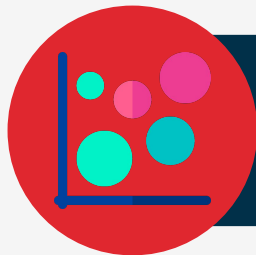
- 2-Dimensional mapping (UMAP)
- Example images of each cluster



Clustering

UMAP projection of brain_menin features with DBSCAN clustering



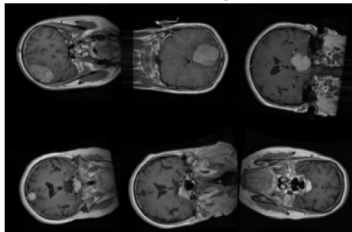


Task 8

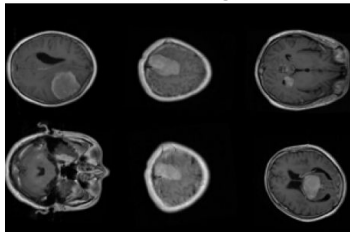
Clustering

Cluster di brain_menin con Thumbnails

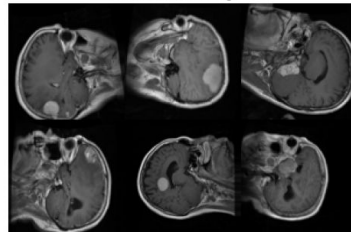
Cluster 0 (6 immagini)



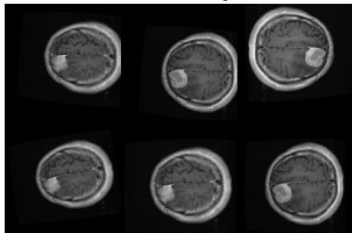
Cluster 1 (6 immagini)



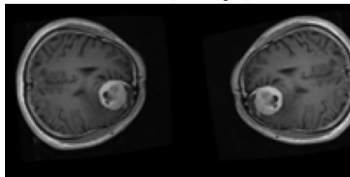
Cluster 2 (6 immagini)



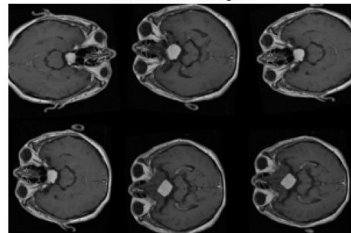
Cluster 3 (6 immagini)



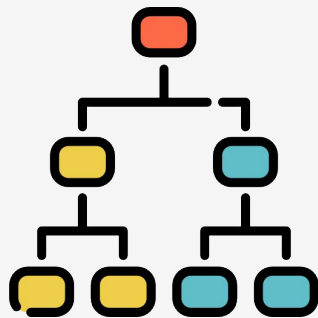
Cluster 4 (2 immagini)

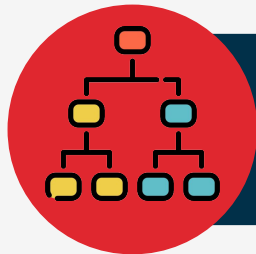


Cluster 5 (6 immagini)



Task 9





Classification

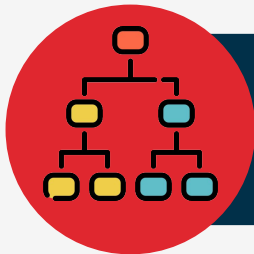
Decision Tree and m-NN Classifiers

Two different classification methods were employed.

Part 1 data was splitted into Train and Test in order to compute metrics.

Decision Tree Hyper-parameters:

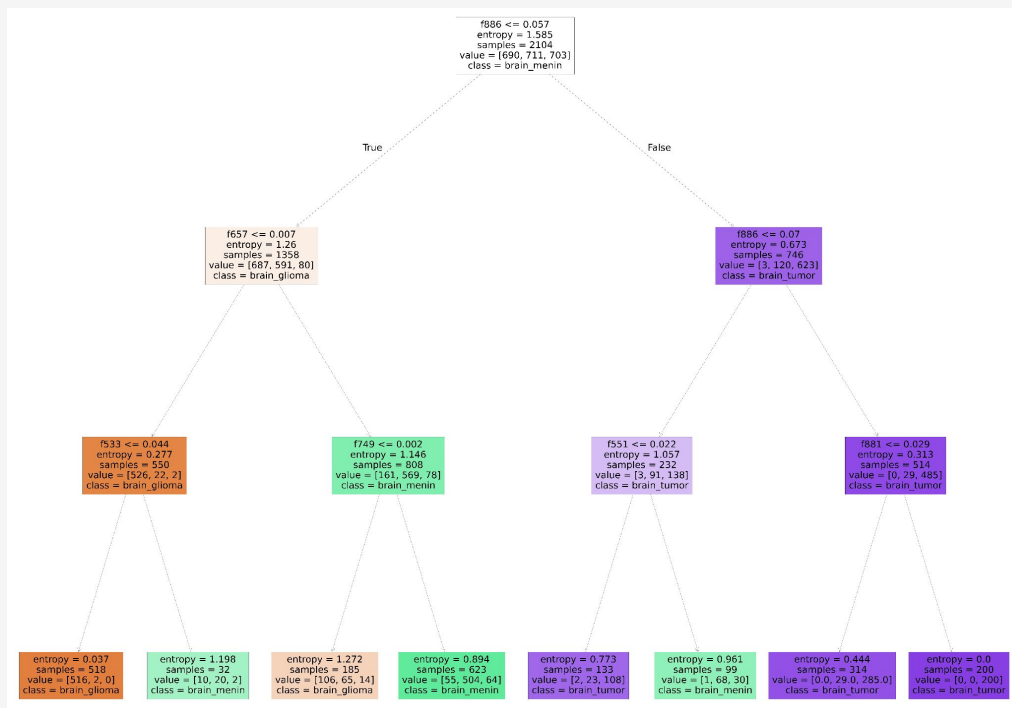
- Tuned with Grid Search
- Leveraged Recall, Precision and F1-score

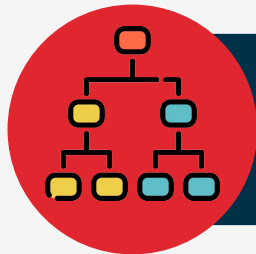


Task 9

Classification

Decision Tree Visualization





Task 9

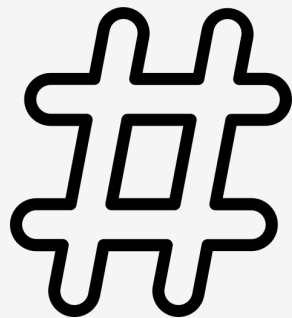
Classification

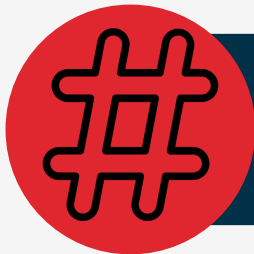
m-NN Classifier: Results

Label	Precision	Recall	F1-score
"brain_glioma"	0.9118	0.9394	0.9254
"brain_menin"	0.8889	0.7742	0.8276
"brain_tumor"	0.8974	0.9722	0.9333

* We selected "layer_3" as feature model and
Euclidean Distance as metric

Task 10



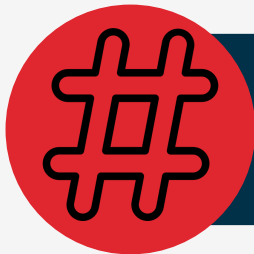


Locality Sensitive Hashing

Indexing technique

Based on Layers (L) and Hashing Functions (h):

- Layers (L) are independent hash tables that increase collision chances for similar items
- Hashing functions (h) are generated via random projections and concatenated per table



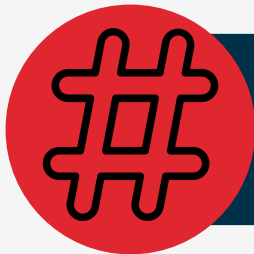
Locality Sensitive Hashing

So for instance...

With $L=2$ and $h=2$ each item (vector) is indexed in 2 different buckets (h) and 2 different tables (L)

```
Indexed vector 0 with hash values: [(1, -2), (2, 0)]  
Indexed vector 1 with hash values: [(1, -1), (1, 0)]  
Indexed vector 2 with hash values: [(1, -1), (2, 1)]
```

...



Locality Sensitive Hashing

Querying indexed data

1. **AND within each table:**
For each L , for each h compute $h(\text{Item})$ and retrieve items matching both.
2. **OR across tables:**
Take the union of items found in each L .
3. **Rank:**
Rerank that union by a given metric.

Group Project

Approfondimento Sperimentale

Thank you for your attention!



*Camoia Andrea
Primicino Linda
Vitturini Davide*



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