Combined Radiology and Pathology Classification of Brain Tumors

Rozpoznanie guza mózgu na podstawie obrazu radiologicznego i patologicznego

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Outline

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Motivation & Pathology-based classification

FIGURE – Information regarding the 2015 MICCAI (Munich, Germany) challenge

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Definitions

Cancer

- Cancer occurs when abnormal cells grow out of control

Brain tumor

- Benign or Malignant
- Over time, a low-grade tumor can become a high-grade tumor
- Brain tumors are classified as grade I, grade II, or grade III, or grade IV

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Brain tumor - Survival rate (5 years or more)

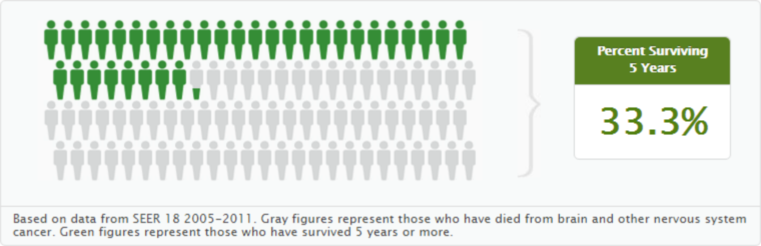

FIGURE – Based on data from SEER 18 2005-2011, cancer.gov

Brain tumor - Survival by stage

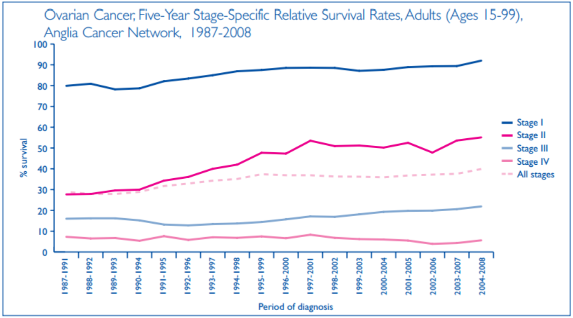

FIGURE – Ovarian cancer, Five-year stage-specific relative survival rates, adults (ages 15-99), Anglia Cancer Network, 1987-2008

Brain tumor - Diagnosis process

- General Practitioner
  - Neurologist
    - MR or CT - Radiologists
      - (tumor confirmed)
        - Neurosurgeon
          - Benign
            - Pathologist
              - (final diagnosis)
          - Malignant
            - 2 Pathologists
              - (final diagnosis)
      - (clear image)

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Diagnosis problems

Problems

- Diverse shapes, sizes and appearances of tumors
- Relies on histopathologic examination (biopsy examination)
- Waiting for tests and to start treatment
- Radiology imaging is used only to establish location, size and whether it is benign and malignant tumor

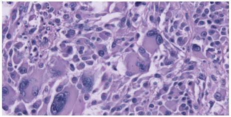

FIGURE – Glioblastoma cells

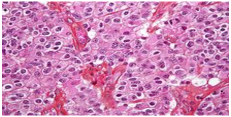

FIGURE – Oligodendroglioma cells

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Diagnosis problems

Problems

- Diverse shapes, sizes and appearances of tumors
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Targets in the UK

No more than 2 months wait between the date the hospital receives an urgent GP referral for suspected cancer and starting treatment

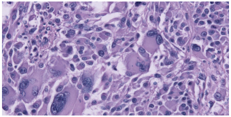

FIGURE – Glioblastoma cells

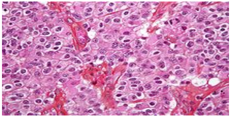

FIGURE – Oligodendroglioma cells

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Aims & Limitations

Aims

- Research & build a segmentation mechanism for the MRI scans (ROI selection)
- Research & build a classifier based on the segmented radiological images
- (if possible) Combine the Pathology-based classification with radiology-based classifier

Limitations

- Limited access to the MRI samples with the diadnosis provided by the doctor
- Conservative environment - only non-black box models

Related work

Brain tumor segmentation

- The topic of brain segmentation is relatively popular thanks to BraTS challenge
- Several supervised and unsupervised algorithms were proposed
  - Random Decision Forest that classifies voxels
  - Fuzzy C-means clustering
  - Mean Shift and K-means clustering

Brain tumor classification

- Slightly less popular subject (current diagnosis fully rely on histopathology imaging)
- Feature extraction
  - Extraction of structure information
  - Feature selection
- GLCM (Gray-Level Co-occurrence Matrix)

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Influential articles

- Joana Festa and Sérgio Pereira and José António Mariz and Nuno Sousa and Carlos A. Silva
  Automatic Brain Tumor Segmentation of Multi-sequence MR images using Random Decision Forests
  Proceedings of NCI-MICCAI BRATS 2013, Nagoya, Japan, 2013
- Nitish Zulpe and Vrushsen Pawar
  GLCM Textural Features for Brain Tumor
  International Journal of Computer Science, 2012
- Hassan Khotanlou, Olivier Colliot, and Isabelle Bloch
  Automatic brain tumor segmentation using symmetry analysis and deformable models
  Nationale Superieure des Telecommunications, 2007

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Brain tumor - Modified diagnosis process

General Practitioner

Neurologist

MR or CT - Radiologists **& piece of software**

(tumor confirmed **& partial diagnosis**) (clear image)

Neurosurgeon

Benign | Malignant

Pathologist | 2 Pathologists

(final diagnosis) | (final diagnosis)

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Data set

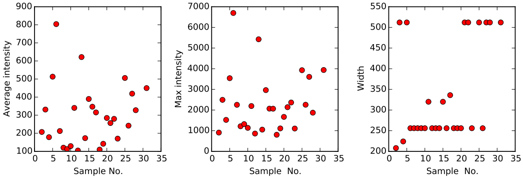

FIGURE – Plots of different attributes of the data set

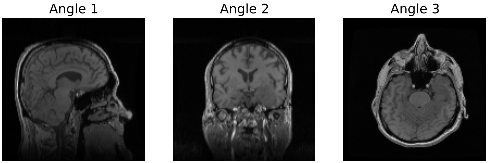

FIGURE – Viewing angles of MRI scan

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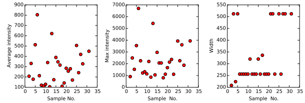
Data set

Summary

- 27 cases with lower grade glioma tumors
- 13 of them with Oligodendroglioma and 14 with Astrocytoma
- Each case has 3 or 4 MRI scans (T1, T1C, FLAIR, and T2)
- Provided samples were taken using different hardware



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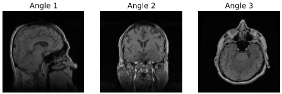

FIGURE – Viewing angles of MRI scan

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Pre-processing

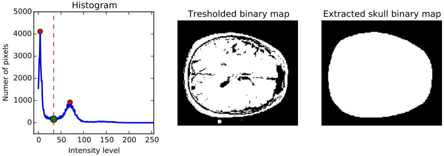

FIGURE – Process of skull extraction

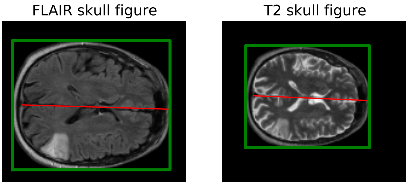

FIGURE – Skulls properties in FLAIR and T2

Pre-processing

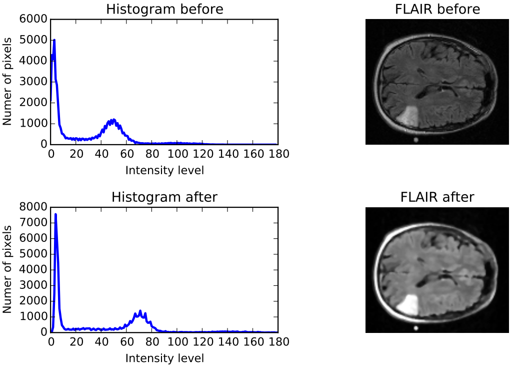

FIGURE – Median filter effect on image histogram

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Segmentation - K-Means

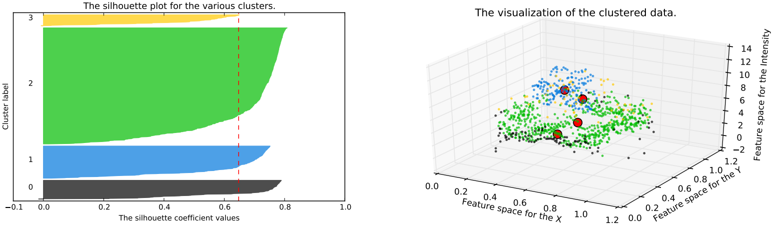

FIGURE – Silhouette analysis for K-Means(k=5)

Segmentation - Symmetry analysis

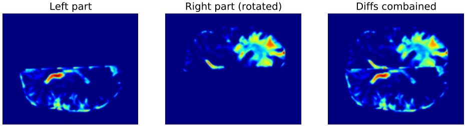

FIGURE – Diffs of hemispheres subtraction

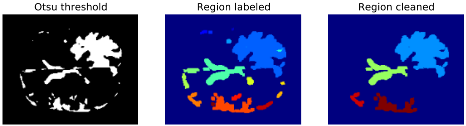

FIGURE – Labeled regions extraction

Segmentation - Combined

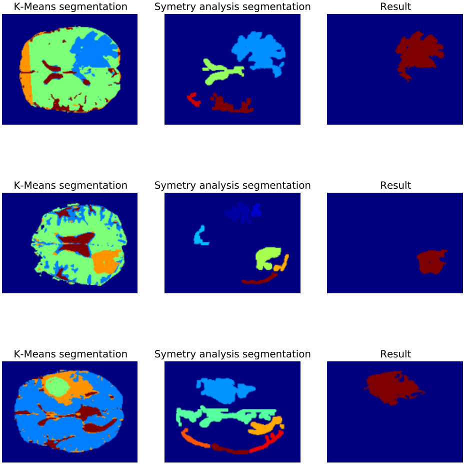

FIGURE – Segmentation with results

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Segmentation - Alternatives

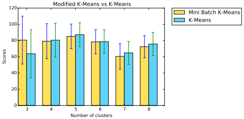

FIGURE – Mini K-Means

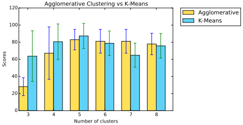

FIGURE – Agglomerative clustering

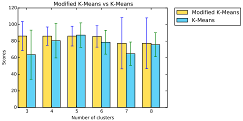

FIGURE – K-Means with position

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Classification

Tested methods

- Feature extraction & evaluation
- Texture features extraction with Gray-Level Co-Occurrence Matrix
- Texture features extraction with Local Binary Pattern

Classification algorithms

- SVM (Support vector machine)
- Gaussian Naive Bayes
- Logistic Regression
- Random Forest

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Classification - Feature extraction & evaluation

Selected features (out of 59)

- Tumor volume (in mm^3)
- Tumor position (x,y,z) calculated from the middle of the brain
- Metrics intensity of tumor area
- 8 bins of intensity histogram

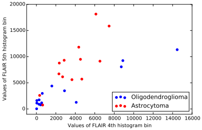

FIGURE – Selected features extracted from data set

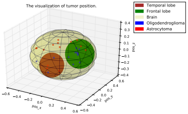

FIGURE – Tumor positional features

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Classification - Texture features extraction with GLCM & LBP

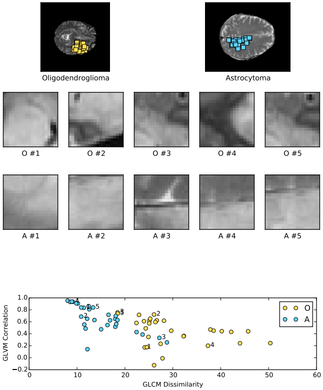

FIGURE – Co-occurence matrix features for Oligodendroglioma and Astrocytoma

Radiology imaging

Tumor segmentation	
METHOD	BEST SCORE
Mini Batch K-Means (5 clusters)	89.027% (std : 5.408)
K-Means (5 clusters)	88.168% (std : 5.264)
K-Means with position (5 clusters)	86.026% (std : 5.282)
Agglomerative Clustering	88.956% (std : 10.632)

Cancer classification	
METHOD	BEST SCORE
Random Forest Classifier	87.000% (std : 12.991)
Logistic Regression	81.297% (std : 5.744)
Logistic Regression (texture)	68.285% (std : 0.082)

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Combined Radiology and Pathology

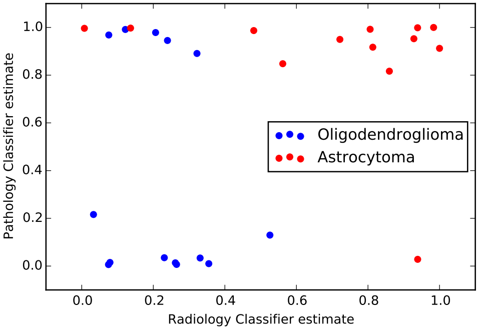

FIGURE – Comparison of Pathology and Radiology results (average estimations of Oligodendroglioma cancer for each sample)

Results

Conclusion

- Random Forest classifier validated with k-fold cross validation had average accuracy of 87.0%
- Pre-processing of the input data is a hand-crafted process, that had to be performed
- K-Means had the best score out of Mini Batch K-Means, K-Means with modified input vector (with position), and Agglomerative clustering

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