Visualizing Statistics of Brain Perfusion Data

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(in coop. with Sylvia Glaßer et al.),
MedViz Seminar 2010-10-08
Project Overview

- Next “act” in an on-going cooperation between
  - the Univ. of Magdeburg (group of Prof. Preim)
  - the Univ. of Bergen (myself et al.)
  - others (Arvid, Atle Bjørnerud from Rikshospitalet, …)

- Follow-up research wrt. Steffen Oeltze’s work
  - was here in Bergen, too
  - we worked out an interactive visual analysis approach for medical perfusion data [TVCG 2007, …]
  - defended his PhD this year (magna cum laude!)

- Sylvia’s project (on-going!)
  - own work (best paper of VMV 2009, …)
  - here on brain tumor data from Atle Bjørnerud
Glioblastoma: most common and most aggressive type of primary brain tumor

Tumor Distinction:
- **low-grade** tumors: well-differentiated; not really benign, but still better prognosis for patient
- **high-grade** tumors: undifferentiated; malignant, worse prognosis

example of a high grade glioblastoma (T1 image sequence, image courtesy A. Bjørnerud)
Motivation & Medical Background

- Dynamic susceptibility contrast MRI (DSC-MRI) for perfusion imaging \(\Rightarrow\) physiologic information

**Current focus:**

- **tumor heterogeneity**
  (to differentiate between low-grade and high-grade, if possible)

- **interactive visual analysis**
  based on quantitative and descriptive perfusion parameters (data-near)

T2* image with glioblastoma
(image courtesy: A. Bjørnerud)
Visualization Pipeline

- Integrating
  - **statistical analysis** (correlation analysis, PCA, etc.)
  - **interactive visualization**

- Pre-processing

- Extraction of quantitative & descriptive perfusion params.

- Statistical analysis
  - heterogeneity (based on local correlations)
  - PCA

- Interactive visual expl. & analysis of dataset
Quantitative Perfusion Parameters

Cerebral blood volume (CBV)
- total volume of blood traversing a given region of brain
  [ml of blood per 100 grams of brain tissue]

Cerebral blood flow (CBF)
- volume of blood traversing a given region of brain per unit time
  [ml of blood per 100 gr of brain tissue per minute]

Mean transit time (MTT)
- MTT = CBV / CBF
- average time for blood to traverse between arterial inflow and venous outflow [s]

Derived with NordicICE software

CBF and MTT not yet so much studied in the context of oncologic imaging (even though much used in stroke imaging)
Descriptive Perfusion Parameters

- Derived from the $\Delta R2^*$-Curve, $\Delta R2^*$: relative concentration time curves
- Example of $\Delta R2^*$ dataset with markers and corresponding curves for tumor and brain tissue
Most common descriptive perfusion parameters

- **PE** … maximum value of the curve
- **TTP** … point in time where PE occurs
- **Integral** … the approximated area between curve and baseline
- **Mean Transit Time (MTT)** … the 1st moment of the curve
- **Slope** … steepness of ascending curve during 1st pass
- **Maximum Intensity-Time Ratio (MITR)** … steepness of ascending curve, ratio of PE and TTP
- **DownSlope** … steepness of descending curve during 1st pass

- Reduce no. of params. via correlation analysis
- Trends via principal component analysis (PCA)

Saturated colors indicate high correlation between parameters.
Each principal component represents a trend of the data.
Correlation of **quant. parameters** CBF & CBV

→ first results indicate higher correlation for low-grade tumors

**examples of low-grade tumors**

representative slices of tumor case 009

representative slices of tumor case 050

**examples of high-grade tumors**

representative slices of tumor case 017

representative slices of tumor case 052
**Statistical Analysis – work in progress**

- Visual analysis of the correlation with SimVis
- Starting point: quantitative perfusion parameters of low-grade tumor

3D view of brain (gray) and tumor (color is assigned to integral)

scatterplot of rCBV and rCBF, tumor voxels are highlighted in red

strong correlation between CBF & CBV
Statistical Analysis – work in progress

- Transformation (shear) of scatterplot rCBV–rCBF

3D view of brain (gray) and tumor (color is assigned to integral)

scatterplot of rCBV and rCBF, tumor voxels are highlighted in red
Exclude highly correlated values

A tumor part at the right boundary with high integral values remains → possible indication for high neoangiogenetic activity at boundary.

3D view of brain (gray) and tumor (color is assigned to integral).

Scatterplot of rCBV and rCBF, tumor voxels are highlighted in red.
Example of high-grade tumor, scatterplot of quantitative parameters

3D view of brain (gray) and tumor (color is assigned to integral)

scatterplot of rCBV and rCBF, tumor voxels are highlighted in red
Transformation of scatterplot of rCBV and rCBF

Exclude highly correlated values

3D view of brain (gray) and tumor (color is assigned to integral)

scatterplot of rCBV and rCBF, tumor voxels are highlighted in red
Statistical Analysis – work in progress

- Restrict visualization to a slice

A ring-shaped tumor part with high Integral values remains → bigger areal with high neoangiogenetic activity

3D View of brain (gray) and tumor (color is assigned to Integral)

Scatterplot of rCBV and rCBF, tumor voxels are highlighted in red
Next Steps

- Adaption of the visual analysis to descriptive perfusion parameters and PCA trends
  → model-free approach

- Comparison of all results for low-grade and high-grade tumors to learn about tumor’s heterogeneity

- Additional comparison with longitudinal study involving brain datasets that develop from low-grade into high-grade tumors
Acknowledgements

- Sylvia Glaßer (Univ. of Magdeburg)
- Atle Bjørnerud (Univ. of Oslo, Rikshospitalet)
- Arvid Lundervold and MedViz
- Steffen Oeltze, Bernhard Preim (Univ. of Magdeburg)
- Jonas Waage, Paolo Angelelli, and VisGroup
- Norwegian Research Council and DFG
- SimVis and NordicNeuroLab
- Fraunhofer MeVis
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