

LIVER METASTASIS EARLY DETECTION USING fMRI BASED STATISTICAL MODEL



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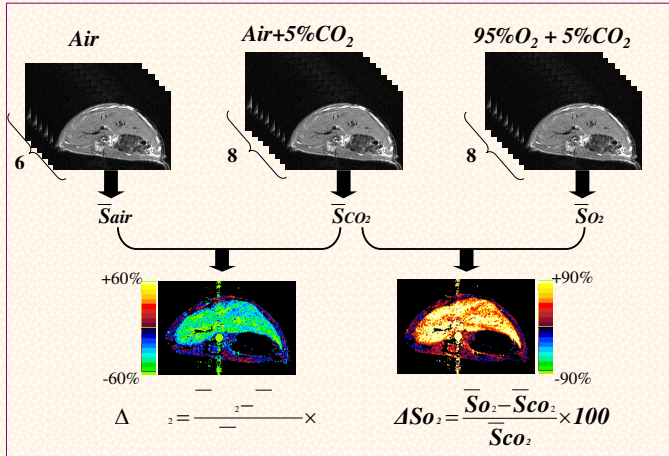
Introduction

Motivation:

- The liver is the most common site of visceral metastases for colorectal carcinoma patients. Hepatic metastases are a frequent clinical complication.
- Despite the availability of a variety of treatments, hepatic metastases are difficult to eradicate because of their late discovery.
- Early and accurate detection of these lesions is recognized as having the potential of improving survival rates and reducing treatment morbidity.

Approach:

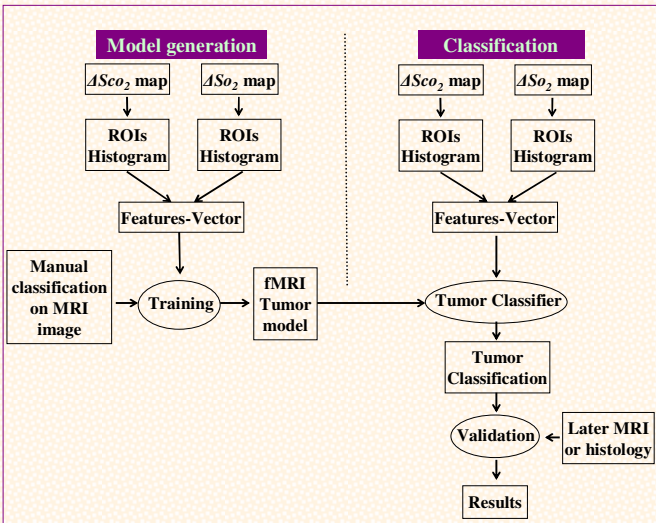
- Use fMRI with hypercapnia and hyperoxia for monitoring changes in liver perfusion and hemodynamics without the need of a contrast agent administration and reduction of the spatial resolution due to the high temporal resolution.
- Automatic detection of colorectal hepatic metastases based on their early hemodynamical changes using Support Vector Machine (SVM) classification on the fMRI-based maps.



MRI Data Analysis. Maps of mean signal intensity (SI) values for each pixel during the different inhaled gases (ΔS_{air} , ΔS_{CO_2} and ΔS_{O_2}) were calculated from 8 repeats for each gas. The percentage of change of fMRI signal intensity induced by hypercapnia (ΔS_{CO_2}) and hyperoxia (ΔS_{O_2}) was calculated using the below equations. Data is presented in color maps as indicated in color-bar.

Method

- Model generation phase** - Train a SVM classifier using healthy and advanced growth phase fMRI-based maps.
- Classification phase** - Classify early growth phase fMRI based maps according to the generated model.

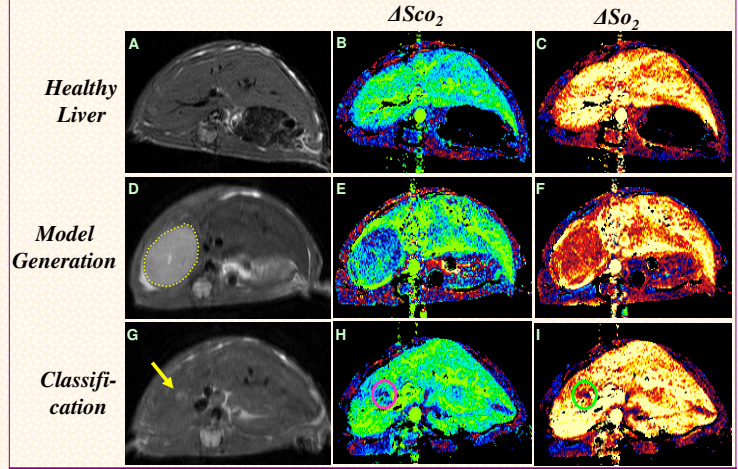


Flow chart of model generation and classification processes.

Method outline:

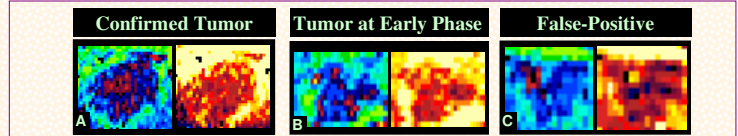
- Manually selected rectangular Regions of Interest (ROI) from the fMRI-based maps.
- Normalized histograms of ΔS maps values used as features-vector for each ROI.
- SVM engine was trained with samples from late growth phase using a generalized Radial Basis Function (RBF) kernel with the Earth Mover's Distance (EMD) as the affinity measure.
- The training samples from the late growth phase classified manually according to the anatomical images.
- New samples from early growth phase classified automatically according to the generated model.
- Automatic classification results compared to late growth phase anatomical MRI images or histology.

Experimental results



Representative T_2W anatomical images (Left), ΔS_{CO_2} maps (Centre) and ΔS_{O_2} maps (Right) of mice livers. Healthy liver (A-C); Confirmed tumor (D, yellow circle) from late phase growth (21 days after cell injection) that was taken for model generation (D-F); Suspected area (G, yellow arrow) from early phase growth (14 days following cell injection) that was taken for classification. Note typical changes in the corresponding ΔS maps (circled area in H,I).

- SVM classifier trained on 64 metastasis samples and 64 healthy samples from the advanced growth phase.
- Leave-One-Out results on the training set: 93.3% accuracy, 94.03% precision, 95.59 recall.
- Test set consists of 32 New, early growth phase, samples classified using this model.
- Classification results on the test set: 84.38% accuracy, 80% precision, 72.73% recall.



Representative samples of ΔS_{CO_2} maps (Left) and ΔS_{O_2} maps (Right) that were included in model generation phase (A) and in classification phase (B, C). (C) A sample of false-positive case.

Future work

- A machine learning approach for the clustering of the fMRI data.
- Human experiments.