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Project 5

BME 7450

Submitted by,

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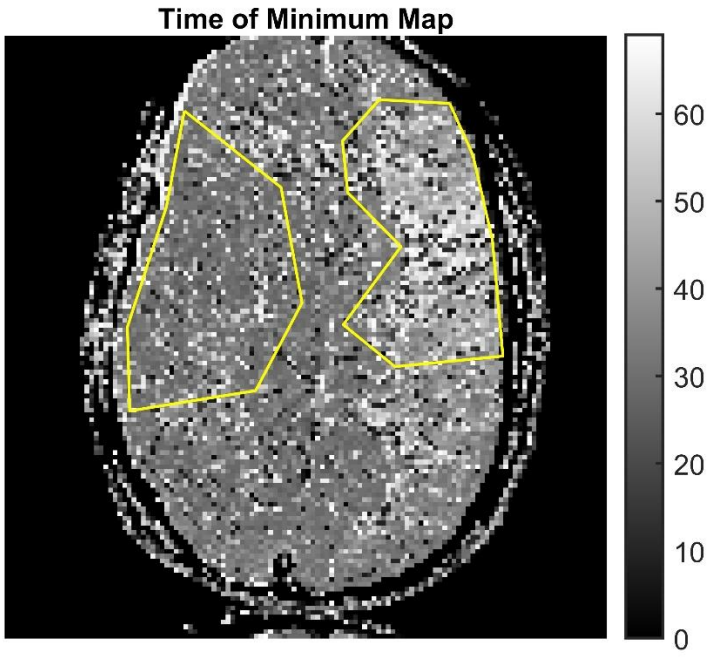
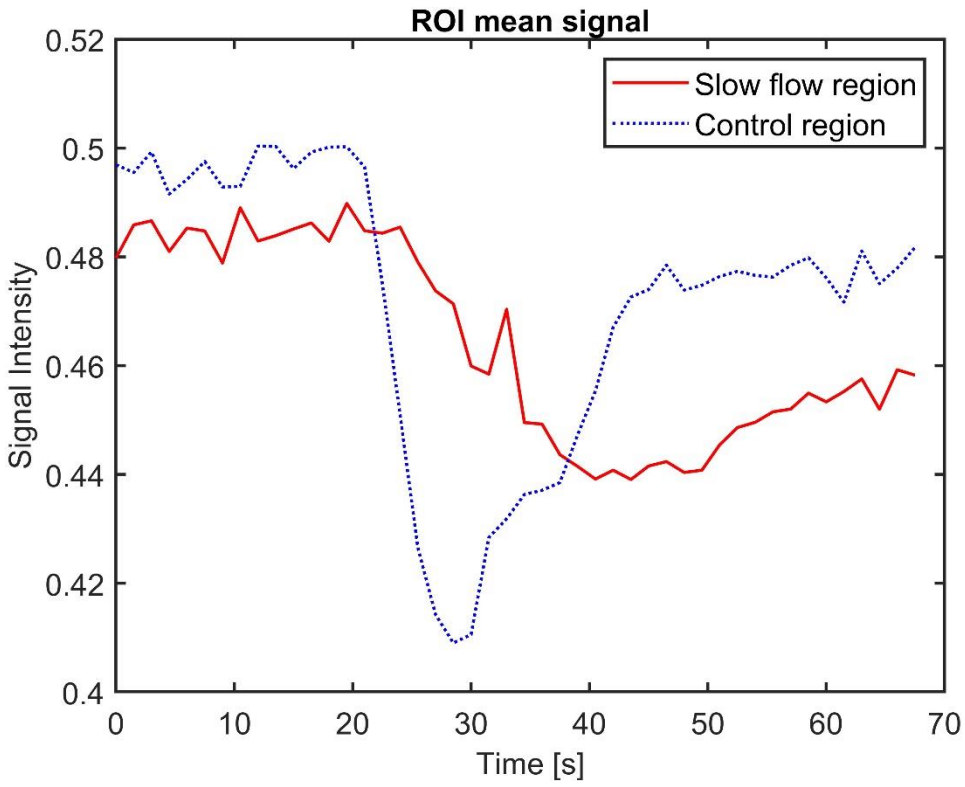
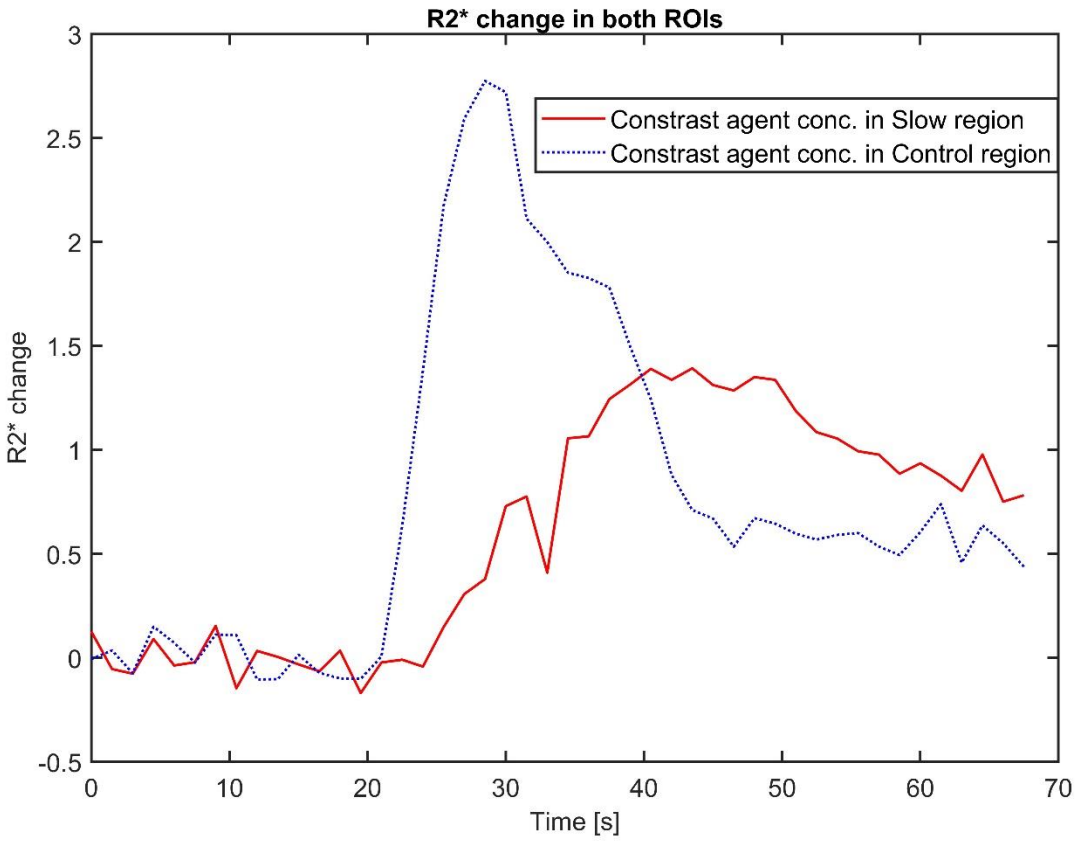
- **Time-of-minimum map with slow and control ROIs:**



- **Plot of signal intensity vs time for both ROIs:**



- **R_2^* change vs time in both ROIs:**



Questions:

1. *How does the R2* curve differ between the two regions (in terms of amplitude, width, and time delay)? What physiological properties might these differences reflect?*

   Answer:

   For control region, $\mathbf{R_2^*}$ changed sharply and drastically compared to the slow region. The change in $\mathbf{R_2^*}$ occurs after a delay and by that time $\mathbf{R_2^*}$ change in control region has already peaked and going down.

   The change in $\mathbf{R_2^*}$ refers to the contrast agent concentration in that region. From the plot, it can be easily devised that contrast agent spread quite quickly and thoroughly compared to the slow region. This implies that there were some obstructions in the slow region that didn't allow the contrast agent to spread out. This can be because of blood clot in the vessels of the slow region which indicates that there might be a stroke in that region.

2. *A stroke is a sudden brain injury caused by impaired blood supply (due to a blood clot blocking a vessel, for example). If the perfusion deficit is severe and prolonged, brain cells die due to hypoxia (insufficient oxygen). How could you use your measurements to evaluate the extent and severity of stroke?*

   Answer:

   By comparing the cerebral blood volume (CBV) in both slow and control, we can have a measure of the severity of stroke. The ratio of slow-flow CBV to control CBV can be the measure which implies how much blood flow occurred in both regions. If the stroke is severe, then this ratio would be smaller and vice-versa.

3. *What is the relative CBV in the slow-flow region? Does this seem low enough to affect a patient?*

   Answer:

   In this project, rCBV was 0.7795. In my opinion, this seems low enough to affect a patient; the supply of contrast agent shows that the delay in blood flow which in this case long enough to have severe effects.

4. *What are some possible sources of error in your measurement? Briefly describe what you could do to improve the accuracy of the relative CBV estimate.*

   Answer:

   Some possible sources of error could be in measuring the area under the $\mathbf{R_2^*}$ change curve, creating the head mask, selection of regions, etc.

   To improve this algorithm's accuracy:

   - have more images with shorter repetition time (tr). This will allow us to estimate the area under curve better.
   - selection of regions can be improved by having images with better resolution.

Matlab Script:

```
clc; close all; clear all;

%loading the data
load('proj5data_qfi.mat');

% Making a movie:
figure
for index = 1:nTimes
    imagesc(squeeze(image_3d(:, :, index)))
    % Set the intensity scale based on the first image:
    if (index == 1)
        cLim_v = get(gca, 'CLim');
    else
        set(gca, 'CLim', cLim_v)
    end
    axis image
    axis off
    colormap(gray)
    title(['Brain Images', num2str(index)])
    drawnow
    mov(index) = getframe;
end
fps = 4; % frames per second.
nReps = 1; % number of repetitions.
movie(mov, nReps, fps)

%creating a head mask
headMask_m = zeros(128, 128);
max_pixel = max(image_3d, [], 'all');
for row=1:128
    for col=1:128
        pixels = squeeze(image_3d(row, col, :));
        if mean(pixels)>=0.1*max_pixel
            headMask_m(row, col) =1;
        end
    end
end
% %displaying the head mask
% imagesc(headMask_m)
% colormap(gray)
% axis image
% axis off
% title("Head Mask")

%creating the time-of-minuimum map
timeOfMin_m = zeros(128, 128);
for row=1:128
    for col= 1:128
        if headMask_m(row, col)==1
            [minimum, I] = min(squeeze(image_3d(row, col, :)));
            timeOfMin_m(row,col) = I*tr;
        end
    end
end
%displaying the time-of-minimum map
imagesc(timeOfMin_m)
```

```
colorbar
colormap(gray)
axis image
axis off
title("Time of Minimum Map")

%selecting slow and control region
[slowRoiMask_m, x1_v, y1_v] = roipoly;
line(x1_v, y1_v,'color', 'y')
hold on
[controlRoiMask_m, x1_v, y1_v] = roipoly;
line(x1_v, y1_v,'color', 'y')
hold off
slowRoiMask_m = slowRoiMask_m .* headMask_m;
controlRoiMask_m = controlRoiMask_m .* headMask_m;

% % displaying the selected region masks
% figure
% imagesc(slowRoiMask_m + controlRoiMask_m)
% colorbar
% colormap(gray)
% axis image
% axis off
% title("Slow and Control ROI Mask")

%taking the mean signal value for each region after introducing the
%contrast agent
slowRoiMean_v = zeros(1, nTimes);
controlRoiMean_v = zeros(1, nTimes);
for timeIndex = 1:nTimes
    image_m = squeeze(image_3d(:, :, timeIndex));
    slowRoi_m = image_m .* slowRoiMask_m;
    controlRoi_m = image_m .* controlRoiMask_m;
    %Enter your own code here to calculate the mean signal intesity, S
    %in each ROI at the current time:
    slowRoiMean_v(timeIndex) = sum(slowRoi_m(:))/sum(slowRoiMask_m(:));
    controlRoiMean_v(timeIndex) = sum(controlRoi_m(:))/sum(controlRoiMask_m(:));
end

%displaying the mean signal intensity, S in selected regions
figure
time_v = tr * (0:(nTimes-1));
plot(time_v, slowRoiMean_v, 'r-', time_v, controlRoiMean_v, 'b:')
title('ROI mean signal')
xlabel('Time [s]')
ylabel('Signal Intensity')
legend('Slow flow region', 'Control region')

%measuring the baseline signal intensity, S0
baselineTime = input('Enter the duration of the baseline (in seconds): ');
baseIndex_v = find(time_v < baselineTime);
slowBaseSignal = mean(slowRoiMean_v(baseIndex_v));
controlBaseSignal = mean(controlRoiMean_v(baseIndex_v));

%calculating R2* change
slowR2_v = -log(slowRoiMean_v/slowBaseSignal)/te;
controlR2_v = -log(controlRoiMean_v/controlBaseSignal)/te;

%displaying R2* change curve w.r.t. time
figure
time_v = tr * (0:(nTimes-1));
```

```
plot(time_v, slowR2_v, 'r-', time_v, controlR2_v, 'b:')
title('R2* change in both ROIs')
ylabel('R2* change')
legend('Constrast agent conc. in Slow region', 'Constrast agent conc. in Control region')

%calculating relative cerebral blood volume
CBV_ratio = trapz(time_v, slowR2_v)/trapz(time_v, controlR2_v)
```