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Project 4

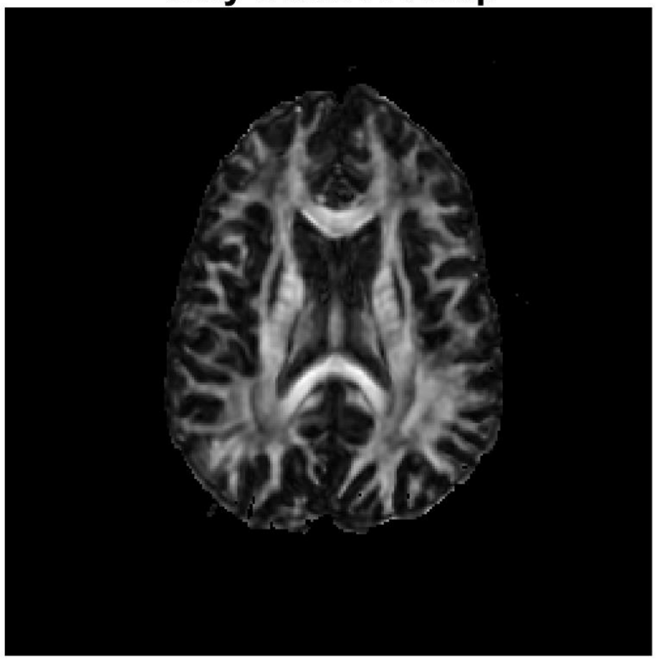
BME 7450

Submitted by,
Rana Mozumder
DEPARTMENT OF BME, VANDERBILT UNIVERSITY

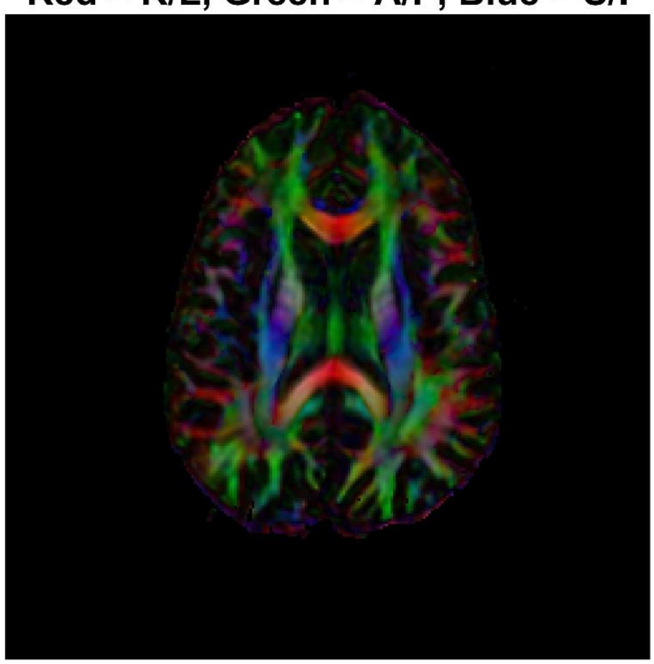
VANDERBILT UNIVERSITY

Gray-scale and color-coded FA maps

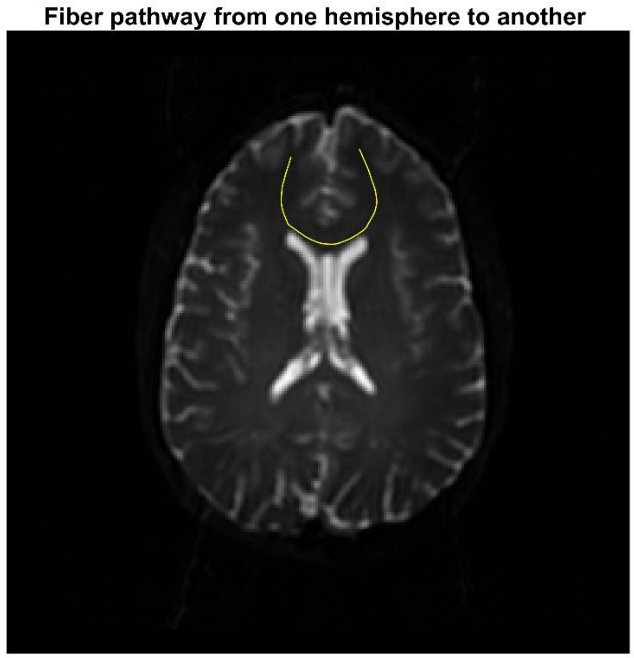
Gray-scale FA Map



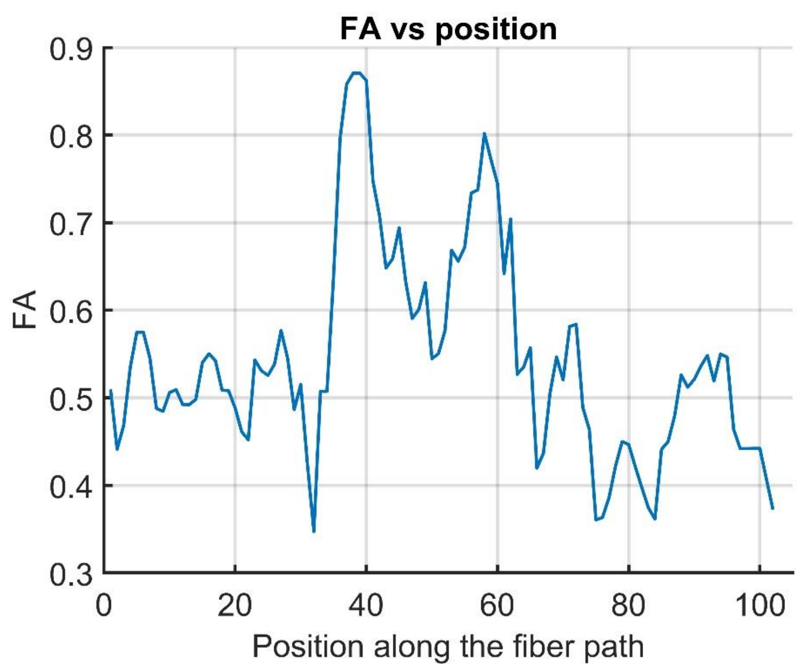
Red = R/L, Green = A/P, Blue = S/I



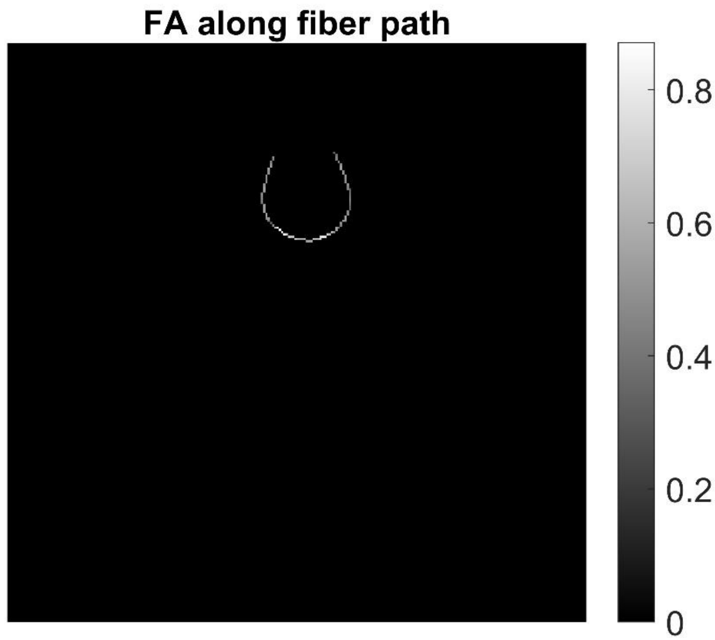
Fiber path connecting gray matter regions in the two hemispheres



Plot of FA vs position



Plotting FA in the pixels of the fiber

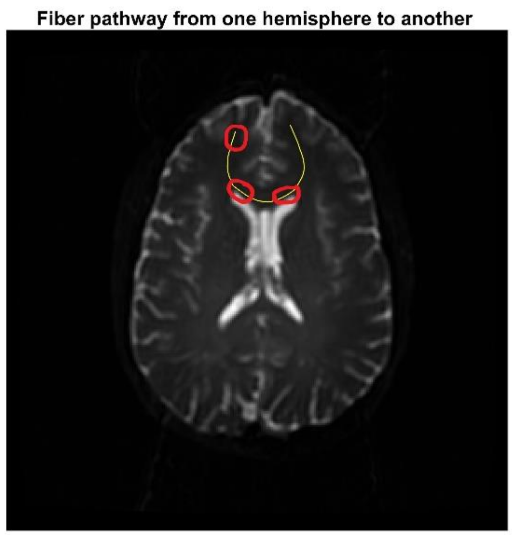


Questions

1. ***How accurate do you think your fiber path is? If there are points where the path took a wrong turn, indicate these on your figure.***

   Answer:

   I think the path is pretty accurate, even if there are wrong turns, they'll be very subtle. I attach the fiber path with region marked where I think it went slightly wrong.

2. ***Can you think of simple ways to improve the tracking algorithm? If so, briefly describe them.***

   Answer:

   Some ways to improve the algorithm can be:

   a. We can use a moving average filter to smoothen the sharp edges of the tracked fiber.
   b. Taking a thin slice parallel to the fiber we want to track.
   c. Using image with better resolution.
   d. Using more points to create vector to measure cosine of angle.
   e. Varying the parameters to better the breaking condition within the while loop.

3. ***What is the total length of the fiber path (the path that you show in your report)? The width of each pixel is 1 mm.***

   Answer:

   There were 102 pixels in the fiber the code tracked. Since is each pixel has 1mm width, the fiber path would be 102mm long.

4. ***What tissue properties might account for the variation of FA along the fiber?***

Answer:

The variations of FA along the fiber are due to the orientation of fibers in that region. The more oriented fibers results in less discrepancies in the FA map. Besides in the selected slice of the brain, may be fibers oriented in other direction can overlap with the one we were tracking. This can also lead to variations in FA.

Matlab Script

```matlab
load('proj4data.mat');
%displaying the original image
figure
imagesc(anat_m);
colormap(gray)

%creating a mask
mask_m = (anat_m>0.07*max(anat_m(:)));
figure
imagesc(mask_m)
colormap(gray)

%creating the FA matrix
fa_m = zeros(256, 256);
for row=1:256
    for col = 1:256
        if mask_m(row,col)==1
            lambda1 = eigValues_3d(row,col,1);
            lambda2 = eigValues_3d(row,col,2);
            lambda3 = eigValues_3d(row,col,3);
            lambda_bar = (lambda1 + lambda2 + lambda3)/3;
            numerator = (lambda1-lambda_bar)^2+(lambda2-lambda_bar)^2 ...
                +(lambda3-lambda_bar)^2;
            denominator = (lambda1)^2+(lambda2)^2+(lambda3)^2;
            fa_m(row, col) = sqrt(1.5*numerator/denominator);
        end
    end
end
%displaying the gray-scale FA map
figure
imagesc(fa_m)
colormap(gray)

% Display color-coded FA map:
red_m = fa_m .* abs(fastDiffVector_3d(:, :, 1));
green_m = fa_m .* abs(fastDiffVector_3d(:, :, 2));
blue_m = fa_m .* abs(fastDiffVector_3d(:, :, 3));
color_3d = cat(3, red_m, green_m, blue_m);
figure
imagesc(color_3d)
axis image
axis off
title('Red = R/L, Green = A/P, Blue = S/I')

%To define the seed point
figure
imagesc(anat_m)
axis image
```

```
colormap(gray)
hold on
disp('Define seed point...')
[x0, y0] = ginput(1);
hold on

x = x0;
y = y0;
x_v = x;
y_v = y;
stepFlag = 1;
cosAngle = 1;
stepSize = 1;
prevStep = [x_v,y_v];

while (stepFlag == 1)
    % To find the fast diffusion direction at the nearest
    % integer values of x and y:

    fast_v =
squeeze(fastDiffVector_3d(round(y_v(end)),round(x_v(end)),1:2));

    % Break out of the while loop if the in-plane component of the
    % vector is too small:
    if (sum(fast_v.^2) < 0.5)
        disp('In-plane component of fast_v is too small')
        break
    end
    % To calculate cosAngle, the cosine of the angle between the previous
step and
    % fast_v. If cosAngle is negative, reverse the direction of fast_v
    if length(x_v) > 1
        cosAngle = dot(prevStep,fast_v)/(norm(prevStep)*norm(fast_v));
        if cosAngle < 0
            fast_v = -fast_v;
        end
    end

    % Stepping a distance stepSize in the direction of fast_v
    % (i.e., update x_v and y_v):
    x = x+stepSize*fast_v(1);
    y = y+stepSize*fast_v(2);
    x_v = [x_v x];
    y_v = [y_v y];

    % line segment to the image to show the current step:
    line([x_v(end-1),x_v(end)],[y_v(end-1),y(end)], 'color', 'y')
    drawnow
    prevStep = fast_v;
    % setting stepFlag = 0 if abs(cosAngle) is too small:
```

```
    if abs(cosAngle)<0.5
        stepFlag = 0;
    end
    % End of while loop:
end
hold on
%OPPOSITE DIRECTION:

x2 = x0;
y2 = y0;
x2_v = x0;
y2_v = y0;
stepFlag = 1;
cosAngle2 = 1;
stepSize = 1;
prevStep2 = [x2_v,y2_v];
while(stepFlag == 1)

    fast2_v = -
squeeze(fastDiffVector_3d(round(y2_v(end)),round(x2_v(end)),1:2));

    if (sum(fast2_v.^2) < 0.5)
        disp('In-plane component of fast_v is too small')
        break
    end

    if length(x2_v) > 1
        cosAngle2 =
dot(prevStep2,fast2_v)/(norm(prevStep2)*norm(fast2_v));
        if cosAngle2 < 0
            fast2_v = -fast2_v;
        end
    end

    x2 = x2+stepSize*fast2_v(1);
    y2 = y2+stepSize*fast2_v(2);
    x2_v = [x2_v x2];
    y2_v = [y2_v y2];
    line([x2_v(end-1),x2_v(end)],[y2_v(end-1),y2(end)], 'color', 'y')
    drawnow
    prevStep2 = fast2_v;

    if abs(cosAngle2) < 0.5
        stepFlag = 0;
    end
end
hold off

%creating FA vector and matrix along the fiber path
fa = zeros(256, 256);
```

```matlab
X = round([flip(x_v, 2), x2_v(1, 2:end)]);
Y = round([flip(y_v, 2), y2_v(1, 2:end)]);
for i=1:length(X)
    lambda1 = eigValues_3d(Y(1, i),X(1, i),1);
    lambda2 = eigValues_3d(Y(1, i),X(1, i),2);
    lambda3 = eigValues_3d(Y(1, i),X(1, i),3);
    lambda_bar = (lambda1 + lambda2 + lambda3)/3;
    numerator = (lambda1-lambda_bar)^2+(lambda2-lambda_bar)^2 ...
        +(lambda3-lambda_bar)^2;
    denominator = (lambda1)^2+(lambda2)^2+(lambda3)^2;
    fa_v(i) = sqrt(1.5*numerator/denominator);
    fa(Y(i),X(i))=fa_v(i);
end

%plotting FA vector vs position
figure
plot(1:length(X), fa_v)

%displaying the FA matrix
figure
imagesc(fa)
axis image
colormap(gray)
axis off
title("FA along fiber path")
colorbar
```