

```

%% Clear workspace and close figures
clear; close all; clc;

%% Read the images
% Contrast image (live_new) is the reference image.
live = imread('live_new.tif');
% Mask image (mask_new) is the floating image.
mask = imread('mask_new.tif');

% Convert to grayscale if necessary
if size(live,3) == 3
    live = rgb2gray(live);
end
if size(mask,3) == 3
    mask = rgb2gray(mask);
end

% Convert images to double precision for processing
live = im2double(live);
mask = im2double(mask);

%% Compute the Subtracted Image WITHOUT Registration
% Always subtract the mask from the live image (live - mask) so that the vessels
% appear dark.
diffBefore = live - mask;

```

1- Iteration array=[5000 400 200], Accumulated Field Smoothing (AFS)= 30

```

%% Perform Non-Rigid Registration
numIterations = [5000, 400, 200];
% numIterations = [50, 20, 5];
AFS = 30;

[~, maskReg] = imregdemons(mask, live, numIterations, 'AccumulatedFieldSmoothing',
AFS);

%% Compute the Subtracted Image WITH Registration
diffAfter = live - maskReg;

%% Display the Evaluation Figures
% The evaluation includes:
% 1. The original live (contrast) image (reference)
% 2. The original mask image (floating)
% 3. The subtracted image BEFORE registration (live - mask)
% 4. The subtracted image AFTER registration (live - registered mask)
figure('Name','DSA Registration Evaluation','NumberTitle','off');

subplot(2,2,1);
imshow(live, []);

```

```

title('Live Image (Contrast - Reference)');

subplot(2,2,2);
imshow(mask, []);
title('Mask Image (Floating)');

subplot(2,2,3);
imshow(diffBefore, []);
title('Subtraction Before Registration');

subplot(2,2,4);
imshow(diffAfter, []);
title('Subtraction After Registration');

sgtitle('DSA Registration Evaluation: Live - Mask');

```

DSA Registration Evaluation: Live - Mask

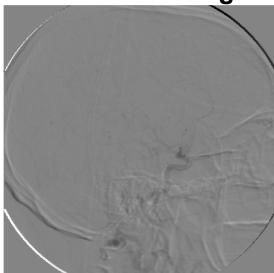
Live Image (Contrast - Reference)



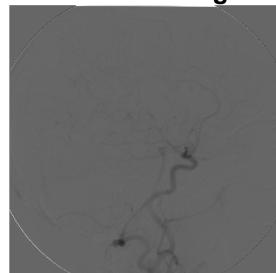
Mask Image (Floating)



Subtraction Before Registration



Subtraction After Registration



```

% Save the Output Images
imwrite(live, 'live_new.png');
imwrite(mask, 'mask_new.png');
imwrite(mat2gray(diffBefore), 'diff_before_registration.png');
imwrite(mat2gray(diffAfter), 'diff_after_registration.png');
imwrite(mat2gray(maskReg), 'mask_registered.png');

```

Displacement matrix

```
% Now extract the displacement field as the first output
```

```

[dispField, maskReg] = imregdemons(mask, live, numIterations,
'AccumulatedFieldSmoothing', AFS);

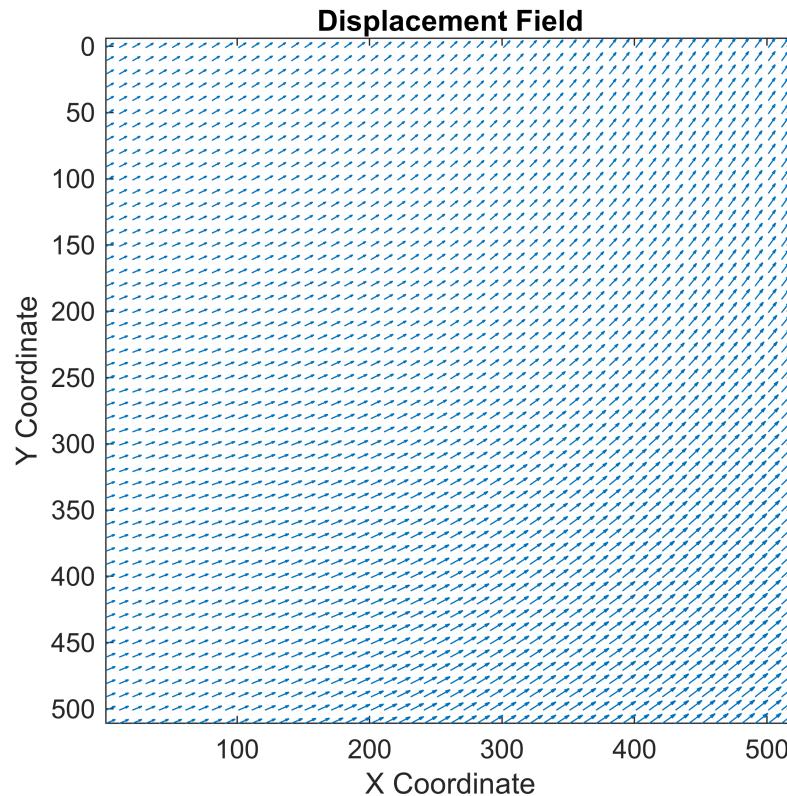
[rows, cols, ~] = size(dispField);

% Create a grid of coordinates corresponding to the displacement field
[X, Y] = meshgrid(1:cols, 1:rows);

subsample = 10;
Xsub = X(1:subsample:end, 1:subsample:end);
Ysub = Y(1:subsample:end, 1:subsample:end);
u = dispField(1:subsample:end, 1:subsample:end, 1); % x-component
v = dispField(1:subsample:end, 1:subsample:end, 2); % y-component

% Create the quiver plot
figure;
quiver(Xsub, Ysub, u, v, 'AutoScale', 'on');
title('Displacement Field');
xlabel('X Coordinate');
ylabel('Y Coordinate');
axis image; % Keep aspect ratio
set(gca, 'YDir','reverse'); % Optional: reverse y-axis if image coordinates are used

```



2- Iteration array=[5000 400 200], Accumulated Field Smoothing (AFS)= 3

```
% Perform Non-Rigid Registration
```

```

numIterations = [5000, 400, 200];
% numIterations = [50, 20, 5];
AFS = 3;

[~, maskReg] = imregdemons(mask, live, numIterations, 'AccumulatedFieldSmoothing',
AFS);

%% Compute the Subtracted Image WITH Registration
diffAfter = live - maskReg;

figure('Name','DSA Registration Evaluation','NumberTitle','off');

subplot(2,2,1);
imshow(live, []);
title('Live Image (Contrast - Reference)');

subplot(2,2,2);
imshow(mask, []);
title('Mask Image (Floating)');

subplot(2,2,3);
imshow(diffBefore, []);
title('Subtraction Before Registration');

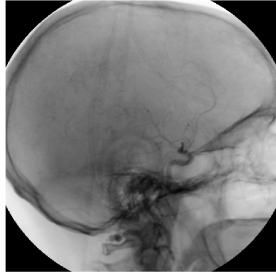
subplot(2,2,4);
imshow(diffAfter, []);
title('Subtraction After Registration');

sgtitle('DSA Registration Evaluation: Live - Mask');

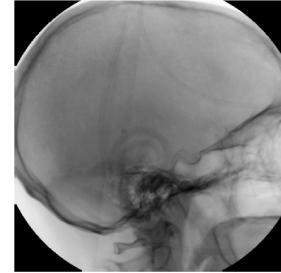
```

DSA Registration Evaluation: Live - Mask

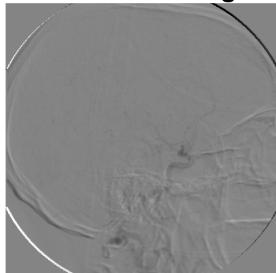
Live Image (Contrast - Reference)



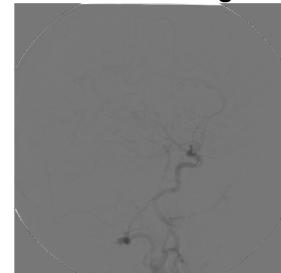
Mask Image (Floating)



Subtraction Before Registration



Subtraction After Registration



```
% Save the Output Images
imwrite(live, 'live_new.png');
imwrite(mask, 'mask_new.png');
imwrite(mat2gray(diffBefore), 'diff_before_registration.png');
imwrite(mat2gray(diffAfter), 'diff_after_registration.png');
imwrite(mat2gray(maskReg), 'mask_registered.png');
```

matrix

```
% Now extract the displacement field as the first output
[dispField, maskReg] = imregdemons(mask, live, numIterations,
'AccumulatedFieldSmoothing', AFS);

% Visualize the Displacement Field Using a Quiver Plot

% Get the size of the displacement field (assumed MxNx2)
[rows, cols, ~] = size(dispField);

% Create a grid of coordinates corresponding to the displacement field
[X, Y] = meshgrid(1:cols, 1:rows);

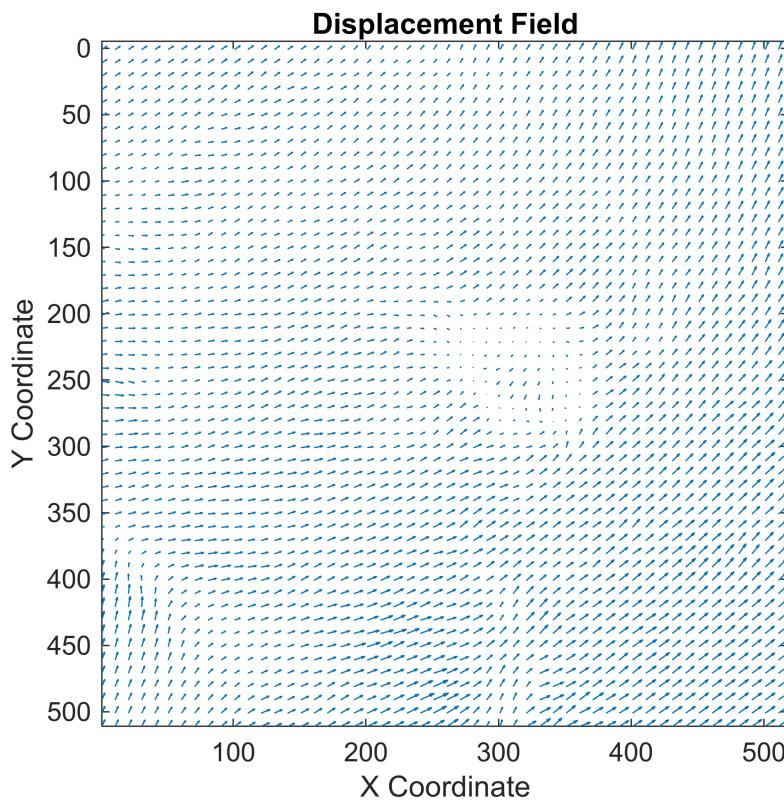
subsample = 10;
Xsub = X(1:subsample:end, 1:subsample:end);
```

```

Ysub = Y(1:subsample:end, 1:subsample:end);
u = dispField(1:subsample:end, 1:subsample:end, 1); % x-component
v = dispField(1:subsample:end, 1:subsample:end, 2); % y-component

% Create the quiver plot
figure;
quiver(Xsub, Ysub, u, v, 'AutoScale', 'on');
title('Displacement Field');
xlabel('X Coordinate');
ylabel('Y Coordinate');
axis image; % Keep aspect ratio
set(gca, 'YDir', 'reverse'); % Optional: reverse y-axis if image coordinates are used

```



3- Iteration array=[50 20 5], Accumulated Field Smoothing (AFS)= 30

```

%% Perform Non-Rigid Registration
numIterations = [50, 20, 5]

numIterations = 1×3
50     20      5

AFS = 30;

[~, maskReg] = imregdemons(mask, live, numIterations, 'AccumulatedFieldSmoothing',
AFS);

```

```

%% Compute the Subtracted Image WITH Registration
diffAfter = live - maskReg;

figure('Name','DSA Registration Evaluation','NumberTitle','off');

subplot(2,2,1);
imshow(live, []);
title('Live Image (Contrast - Reference)');

subplot(2,2,2);
imshow(mask, []);
title('Mask Image (Floating)');

subplot(2,2,3);
imshow(diffBefore, []);
title('Subtraction Before Registration');

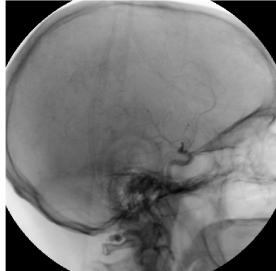
subplot(2,2,4);
imshow(diffAfter, []);
title('Subtraction After Registration');

sgtitle('DSA Registration Evaluation: Live - Mask');

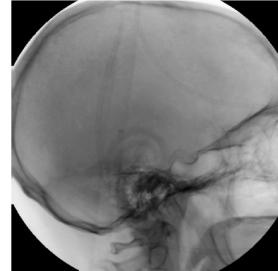
```

DSA Registration Evaluation: Live - Mask

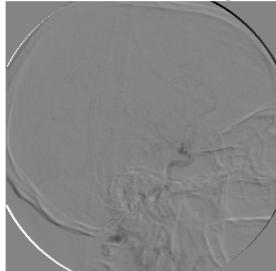
Live Image (Contrast - Reference)



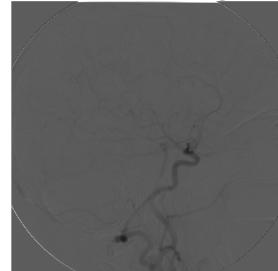
Mask Image (Floating)



Subtraction Before Registration



Subtraction After Registration



```

%% Save the Output Images

```

```
% Since subtraction images might have negative values, we use mat2gray to scale
them to [0,1]
imwrite(live, 'live_new.png');
imwrite(mask, 'mask_new.png');
imwrite(mat2gray(diffBefore), 'diff_before_registration.png');
imwrite(mat2gray(diffAfter), 'diff_after_registration.png');
imwrite(mat2gray(maskReg), 'mask_registered.png');
```

matrix

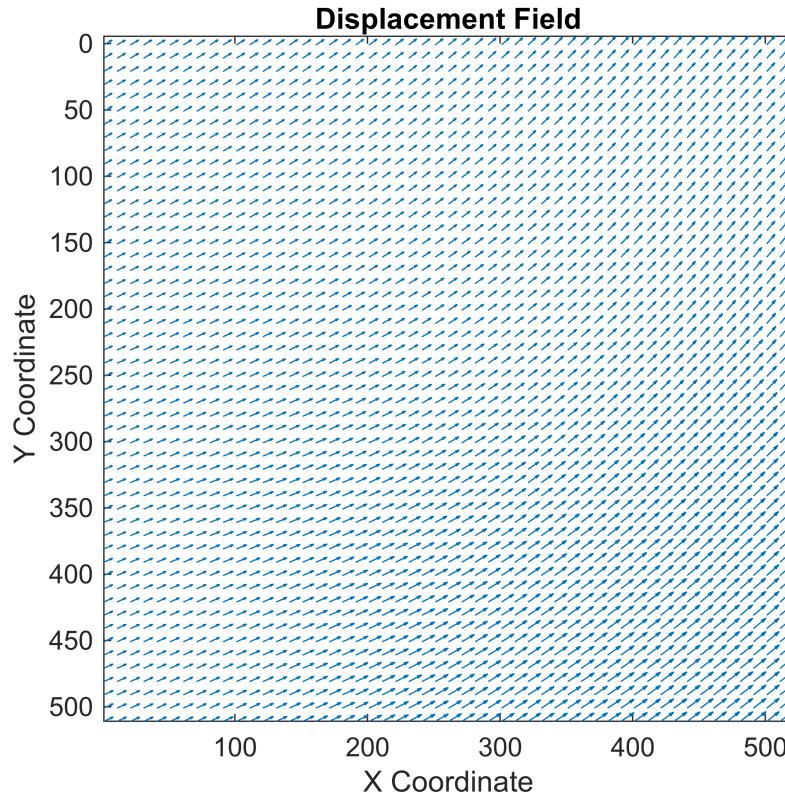
```
% Now extract the displacement field as the first output
[dispField, maskReg] = imregdemons(mask, live, numIterations,
'AccumulatedFieldSmoothing', AFS);

[rows, cols, ~] = size(dispField);

% Create a grid of coordinates corresponding to the displacement field
[X, Y] = meshgrid(1:cols, 1:rows);

subsample = 10;
Xsub = X(1:subsample:end, 1:subsample:end);
Ysub = Y(1:subsample:end, 1:subsample:end);
u = dispField(1:subsample:end, 1:subsample:end, 1); % x-component
v = dispField(1:subsample:end, 1:subsample:end, 2); % y-component

% Create the quiver plot
figure;
quiver(Xsub, Ysub, u, v, 'AutoScale', 'on');
title('Displacement Field');
xlabel('X Coordinate');
ylabel('Y Coordinate');
axis image; % Keep aspect ratio
set(gca, 'YDir','reverse'); % Optional: reverse y-axis if image coordinates are
used
```



4- Iteration array=[50 20 5], Accumulated Field Smoothing (AFS)= 3

```
%> Perform Non-Rigid Registration
numIterations = [50, 20, 5]

numIterations = 1x3
 50      20      5

AFS = 3;

[~, maskReg] = imregdemons(mask, live, numIterations, 'AccumulatedFieldSmoothing',
AFS);

%> Compute the Subtracted Image WITH Registration
diffAfter = live - maskReg;

figure('Name','DSA Registration Evaluation','NumberTitle','off');

subplot(2,2,1);
imshow(live, []);
title('Live Image (Contrast - Reference)');

subplot(2,2,2);
imshow(mask, []);
```

```

title('Mask Image (Floating)');

subplot(2,2,3);
imshow(diffBefore, []);
title('Subtraction Before Registration');

subplot(2,2,4);
imshow(diffAfter, []);
title('Subtraction After Registration');

sgtitle('DSA Registration Evaluation: Live - Mask');

```

DSA Registration Evaluation: Live - Mask

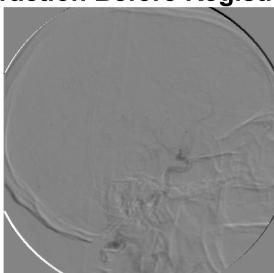
Live Image (Contrast - Reference)



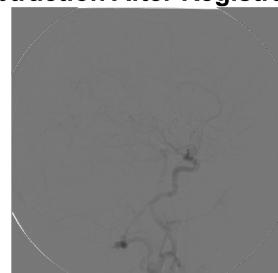
Mask Image (Floating)



Subtraction Before Registration



Subtraction After Registration



```

%% Save the Output Images
% Since subtraction images might have negative values, we use mat2gray to scale
% them to [0,1]
imwrite(live, 'live_new.png');
imwrite(mask, 'mask_new.png');
imwrite(mat2gray(diffBefore), 'diff_before_registration.png');
imwrite(mat2gray(diffAfter), 'diff_after_registration.png');
imwrite(mat2gray(maskReg), 'mask_registered.png');

```

matix

```

% Now extract the displacement field as the first output
[dispField, maskReg] = imregdemons(mask, live, numIterations,
'AccumulatedFieldSmoothing', AFS);

```

```

[rows, cols, ~] = size(dispField);

% Create a grid of coordinates corresponding to the displacement field
[X, Y] = meshgrid(1:cols, 1:rows);

subsample = 10;
Xsub = X(1:subsample:end, 1:subsample:end);
Ysub = Y(1:subsample:end, 1:subsample:end);
u = dispField(1:subsample:end, 1:subsample:end, 1); % x-component
v = dispField(1:subsample:end, 1:subsample:end, 2); % y-component

% Create the quiver plot
figure;
quiver(Xsub, Ysub, u, v, 'AutoScale', 'on');
title('Displacement Field');
xlabel('X Coordinate');
ylabel('Y Coordinate');
axis image; % Keep aspect ratio
set(gca, 'YDir', 'reverse'); % Optional: reverse y-axis if image coordinates are used

```

