Contents


```
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% BIOE404
% 10-22-2014

clc, clear all, close all % boilerplate

% Intialize Data from Table - each row is a new marker, column (1) = i coordinates, etc.
preMarkers = [0, 0; 0.98, -0.02; -0.01, 1.01; 0.97, 1.02; 0, 0; 0.97, 0.03; -0.04, 1.03; 0.97,
 1.02];
postMarkers = [-0.07, -0.05; 1.03, -0.04; -0.05, 1.09; 1.04, 1.08; 0.02, 0.04; 0.95, 0.12; 0.0
9, 0.95; 1.06, 0.97];
```

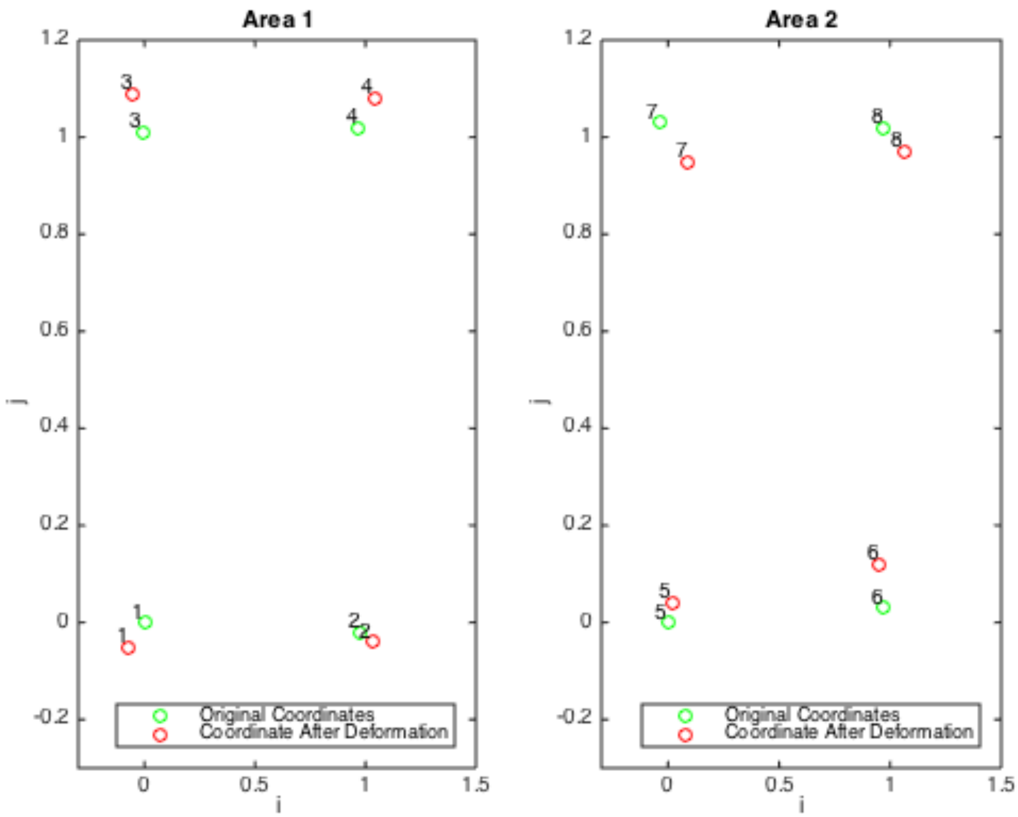
a) Plot points for before and after deformation

```
% Indicate number of each spot
labels = cellstr( num2str([1:4]') );
labels2 = cellstr( num2str([5:8]') );

% Plot the first area
figure(1), subplot(1, 2, 1)
plot(preMarkers(1:4,1), preMarkers(1:4,2), 'go'), hold on
plot(postMarkers(1:4, 1), postMarkers(1:4, 2), 'ro')
% Label the points from 1->4
text(preMarkers(1:4,1), preMarkers(1:4,2), labels, 'VerticalAlignment','bottom', 'HorizontalAl
ignment','right')
text(postMarkers(1:4,1), postMarkers(1:4,2), labels, 'VerticalAlignment','bottom', 'Horizontal
Alignment','right')
legend('Original Coordinates', 'Coordinate After Deformation', 'Location','SouthEast'), title(
'Area 1'), xlabel('i'),  ylabel('j'), axis([-0.3, 1.5, -0.3, 1.2]) , hold off
hold off

% Plot the second area
subplot(1, 2, 2)
plot(preMarkers(5:8,1), preMarkers(5:8,2), 'go'), hold on
plot(postMarkers(5:8, 1), postMarkers(5:8, 2), 'ro')
% Label the points from 5->8
text(preMarkers(5:8,1), preMarkers(5:8,2), labels2, 'VerticalAlignment','bottom', 'HorizontalA
lignment','right')
text(postMarkers(5:8,1), postMarkers(5:8,2), labels2, 'VerticalAlignment','bottom', 'Horizonta
lAlignment','right')
legend('Original Coordinates', 'Coordinate After Deformation', 'Location','SouthEast'), title(
'Area 2'), xlabel('i'),  ylabel('j'), axis([-0.3, 1.5, -0.3, 1.2]) , hold off
hold off
```

```
% Intialize Marker Table of initial point, final point, and displacement
markerTable = zeros(8, 6);
for i = 1:8
  for j = 1:2
    markerTable(i,j) = preMarkers(i, j);
    markerTable(i, j+2) = postMarkers(i,j);
    % Find the displacement in columns 5 and 6 of markerTable
    markerTable(i, j+3) = postMarkers(i,1) - preMarkers(i, 1);
    markerTable(i, j+4) = postMarkers(i,2) - preMarkers(i, 2);
  end
end
% markerTable % for testing
```



b) find the four displacement gradients, âˆ‚u/âˆ‚x0

point 1-2, 3-4, 5-6, 7-8 for âˆ‚u/âˆ‚x0i

```
for areaAnalysis = 0:4:4
  sumiMark = 0; sumjMark = 0;
  for i = 2:2:4
    sumiMark = sumiMark + ((markerTable(i+areaAnalysis, 5) - markerTable(i-1+areaAnalysis, 5))
/(markerTable(i+areaAnalysis, 1) - markerTable(i-1+areaAnalysis, 1)));
    sumjMark = sumjMark + ((markerTable(i+areaAnalysis, 6) - markerTable(i-1+areaAnalysis, 6))
/(markerTable(i+areaAnalysis, 1) - markerTable(i-1+areaAnalysis, 1)));
  end
  duidxi(areaAnalysis/4+1) = (1/2)*sumiMark;
  dujdxi(areaAnalysis/4+1) = (1/2)*sumjMark;
```

```
  % 1-3, 2-4, 5-7, 6-8 to calculate â^,u/â^,x0j
  sumiMark = 0; sumjMark = 0;
  for i = 3:1:4
    sumiMark = sumiMark + ((markerTable(i+areaAnalysis, 5) - markerTable(i-2+areaAnalysis, 5))
/(markerTable(i+areaAnalysis, 2) - markerTable(i-2+areaAnalysis, 2)));
    sumjMark = sumjMark + ((markerTable(i+areaAnalysis, 6) - markerTable(i-2+areaAnalysis, 6))
/(markerTable(i+areaAnalysis, 2) - markerTable(i-2+areaAnalysis, 2)));
  end
  duidxj(areaAnalysis/4+1) = (1/2)*sumiMark;
  dujdxj(areaAnalysis/4+1) = (1/2)*sumjMark;
end

% Print answers
disp([' In order of: ' 'Area 1' ' then Area 2'])

duidxi
dujdxi
duidxj
dujdxj
```

```
 In order of: Area 1 then Area 2

duidxi =

    0.1173   -0.0404


dujdxi =

    0.0051    0.0406


duidxj =

    0.0245    0.1090


dujdxj =

    0.1028   -0.1290
```

c) Utilize these displacement gradients to compute the Lagrangian strain tensor, E, and the infinitessimal strain tensor, Îµ,for each quadrant.

```
for areaAnalysis = 1:2
  Eii(areaAnalysis) = (1/2)*(2*duidxi(areaAnalysis) + duidxi(areaAnalysis)^2 + duidxj(areaAnal
ysis)^2);
  Eij(areaAnalysis) = (1/2)*(duidxj(areaAnalysis) + dujdxi(areaAnalysis) + duidxj(areaAnalysis
)*duidxi(areaAnalysis) + dujdxi(areaAnalysis)*dujdxj(areaAnalysis));
  Eji(areaAnalysis) = (1/2)*(duidxj(areaAnalysis) + dujdxi(areaAnalysis) + duidxj(areaAnalysis
)*duidxi(areaAnalysis) + dujdxi(areaAnalysis)*dujdxj(areaAnalysis));
  Ejj(areaAnalysis) = (1/2)*(2*dujdxj(areaAnalysis) + dujdxi(areaAnalysis)^2 + dujdxj(areaAnal
```

```
ysis)^2);


  eii(areaAnalysis) = (1/2)*(2*duidxi(areaAnalysis));
  eij(areaAnalysis) = (1/2)*(duidxj(areaAnalysis) + dujdxi(areaAnalysis));
  eji(areaAnalysis) = (1/2)*(duidxj(areaAnalysis) + dujdxi(areaAnalysis));
  ejj(areaAnalysis) = (1/2)*(2*dujdxj(areaAnalysis));
end

% Lagrangian
EareaOne = [Eii(1), Eij(1); Eji(1), Ejj(1)]
% Infinitesimal
eareaOne = [eii(1), eij(1); eji(1), ejj(1)]


EareaTwo = [Eii(2), Eij(2); Eji(2), Ejj(2)]
eareaTwo = [eii(2), eij(2); eji(2), ejj(2)]
```

```
EareaOne =

    0.1245    0.0165
    0.0165    0.1081


eareaOne =

    0.1173    0.0148
    0.0148    0.1028


EareaTwo =

   -0.0337    0.0700
    0.0700   -0.1198


eareaTwo =

   -0.0404    0.0748
    0.0748   -0.1290
```

d) Which strain tensor, Lagrangian or infinitesimal, is more appropriate for describing this deformation?

```
disp('Lagrangian tensor analysis works best for large strains where the squared term represent
s a similar magnitude value of the summation, whereas the infinitesimal strain is best for min
uscule strains such as those in cells of tissue. In this case the strain is great enough to wa
rrant the more specific analysis of the Lagrangian strain tensor as the infinitesimal strain t
ensor deviates greater than 1% from the Lagrangian calculation')
```

```
Lagrangian tensor analysis works best for large strains where the squared term represents a si
```

```
milar magnitude value of the summation, whereas the infinitesimal strain is best for minuscule
 strains such as those in cells of tissue. In this case the strain is great enough to warrant
the more specific analysis of the Lagrangian strain tensor as the infinitesimal strain tensor
deviates greater than 1% from the Lagrangian calculation
```

e) Do the two areas indicate that there is homogeneous deformation across the tissue?

```
disp('There is non-homogeneous deformation as indicated by the variation in the duidxi, dujdxi
, duidxj, and dujdxj terms for both areas')
```

```
There is non-homogeneous deformation as indicated by the variation in the duidxi, dujdxi, duid
xj, and dujdxj terms for both areas
```

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