

July 23, 2004

-More updates to paper

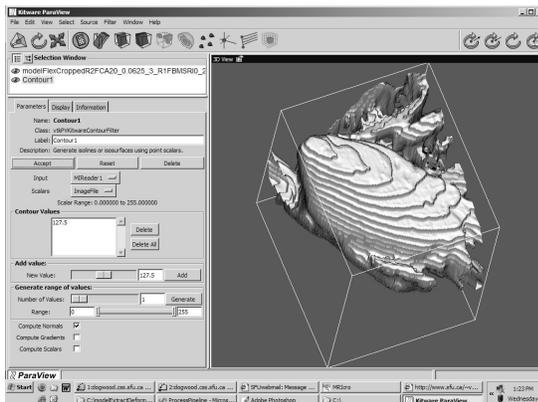
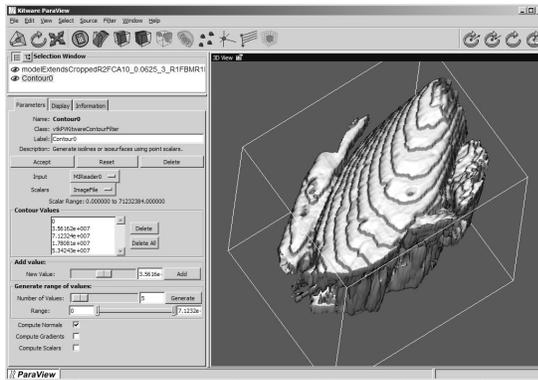
July 22, 2004

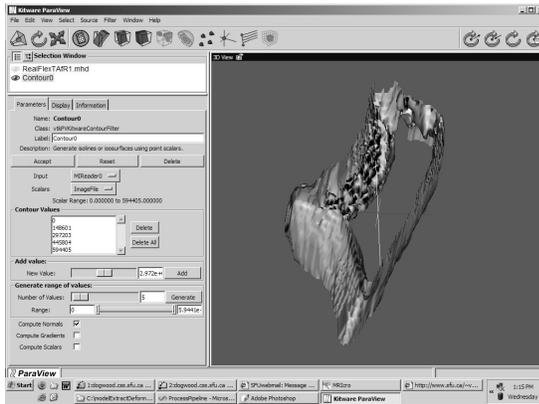
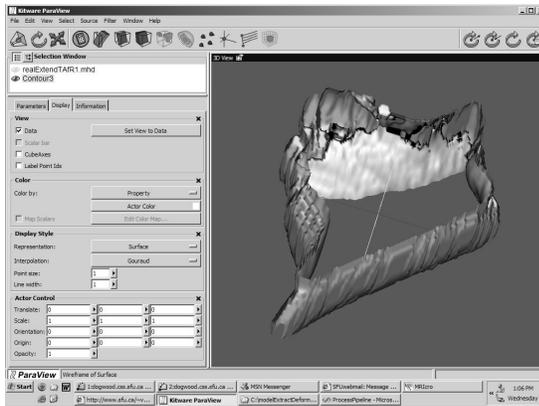
-I find editing with LaTeX is really inefficient if the paper has many images. Gotta miss Word's drag and drop.

Updated LaTeX [Source](#). [Output pdf](#).

July 21, 2004

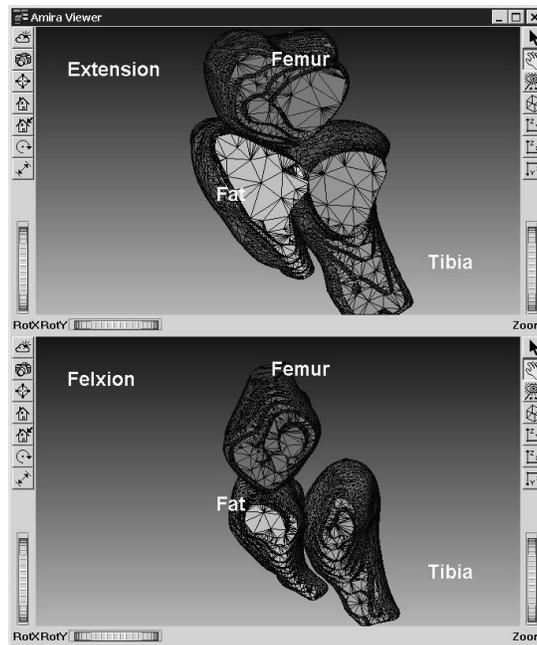
-Converted LaTeX [Source](#). [Output pdf](#).

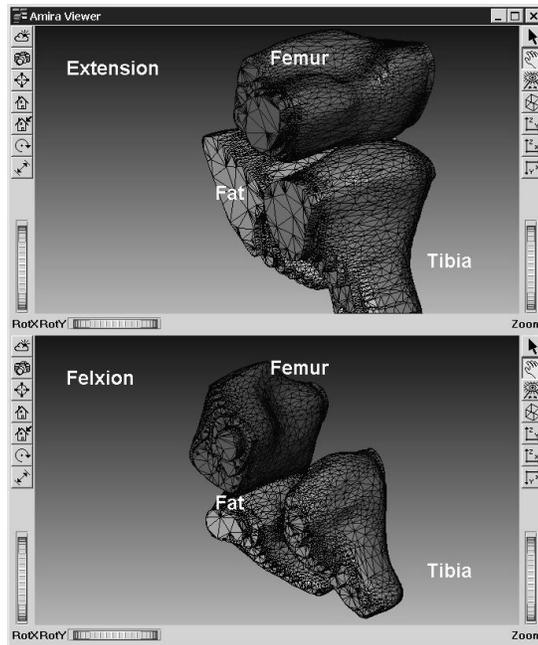




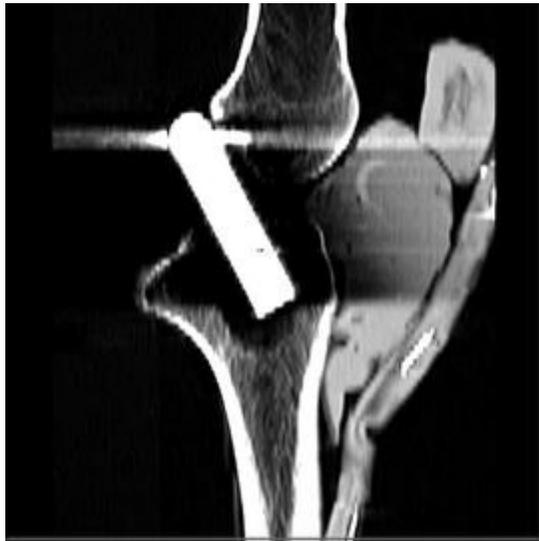
July 20, 2004

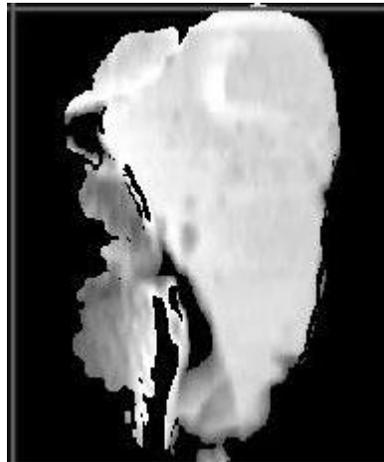
-Images intended to be used for paper:



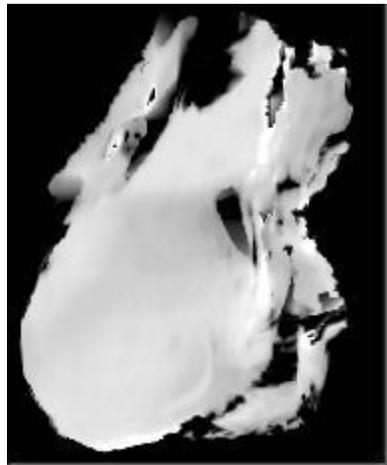






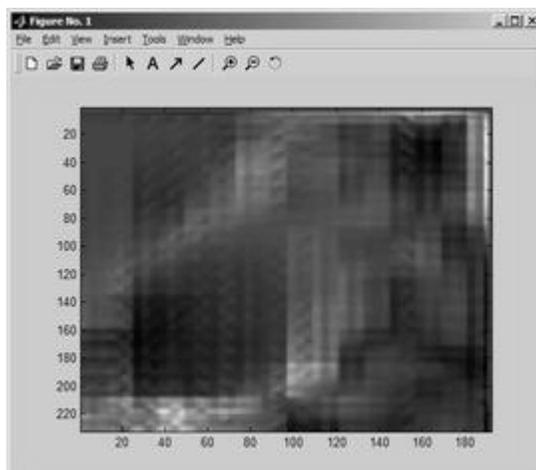
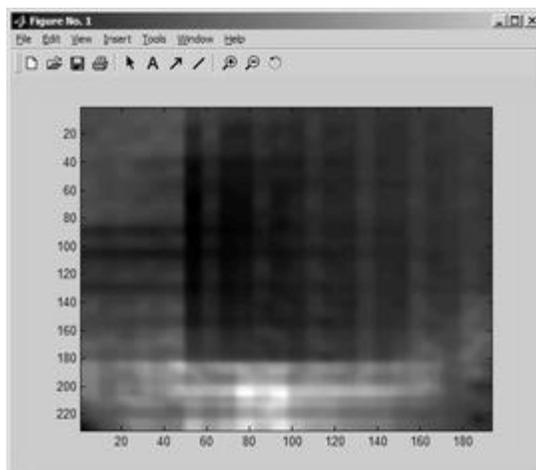


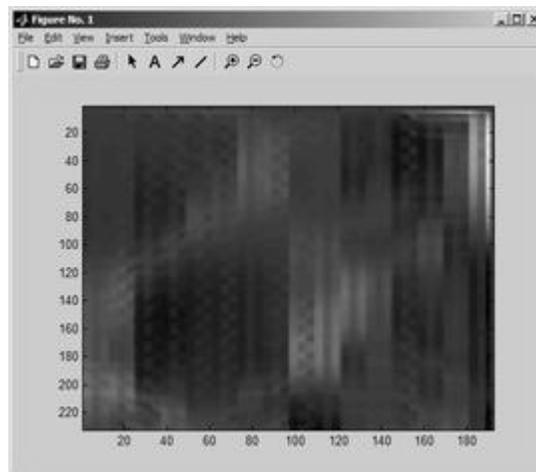
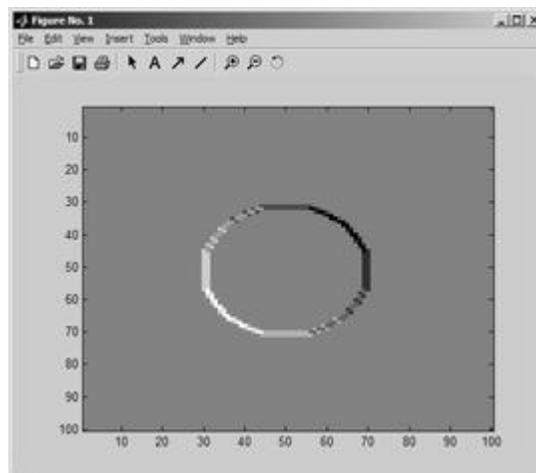
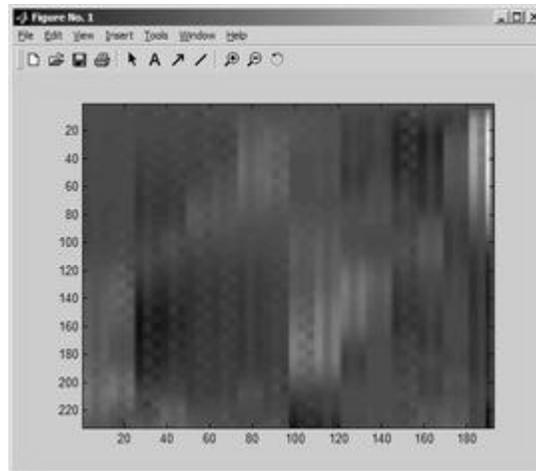


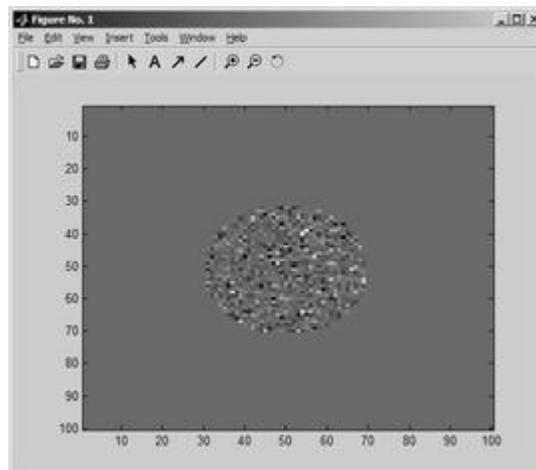
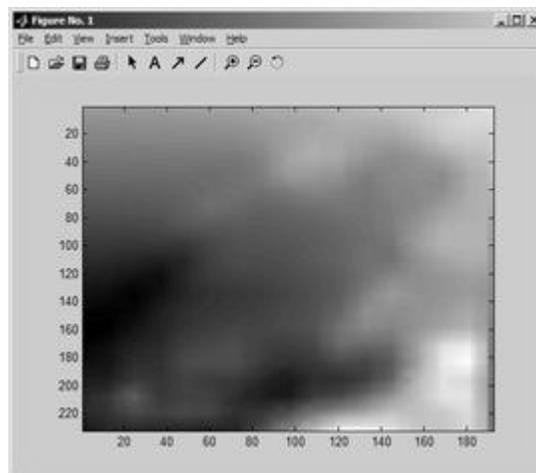
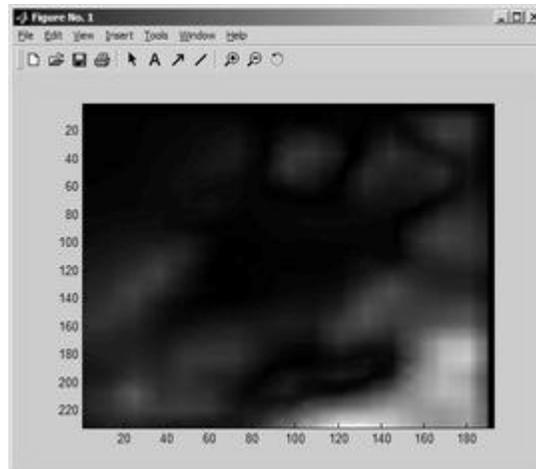




-Miscellaneous Images from discussion:





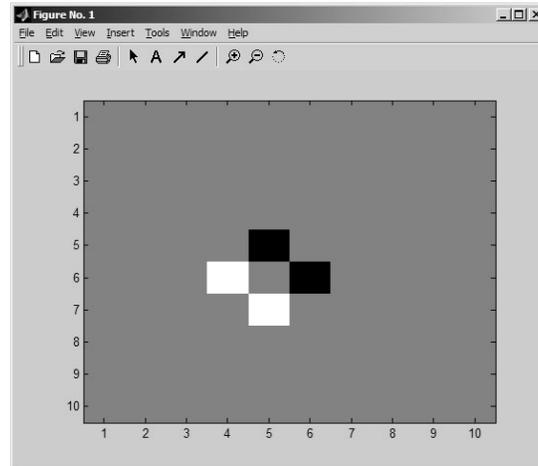


July 19, 2004 Afternoon

-Toy Matlab Example:

1) Code

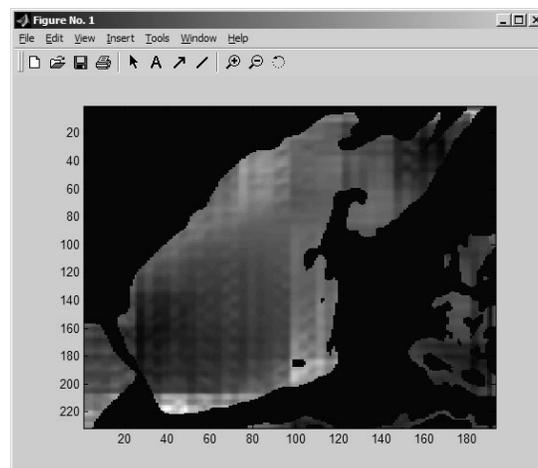
## 2) Text Output showing the values

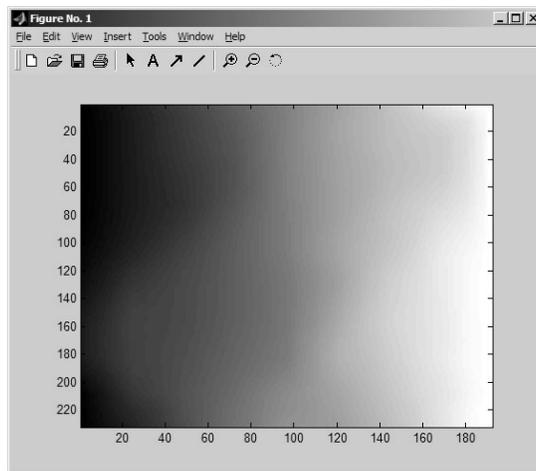
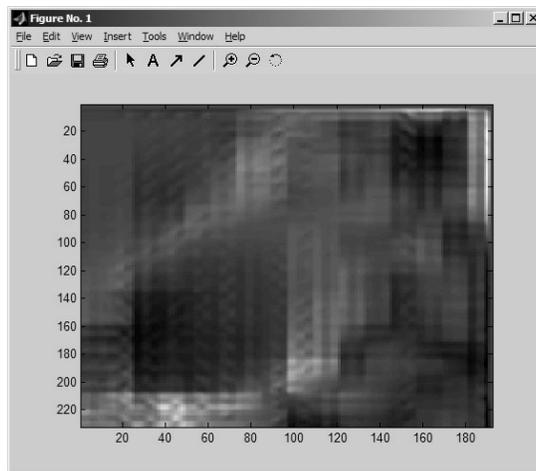
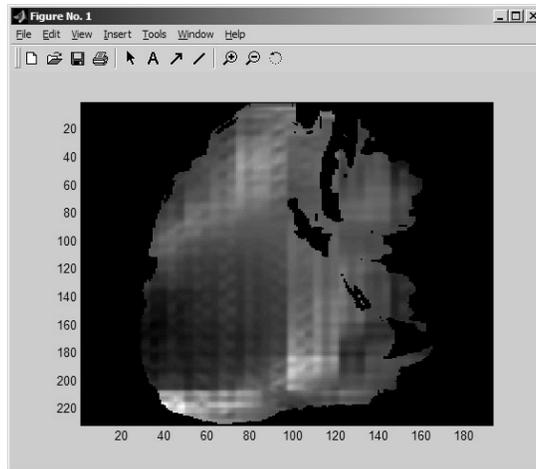


=> From geometry, we know the change should be 0.25 sq.unit, which matches the text output from Matlab. However, the point at which the displacement vector is nonzero actually shows no change in volume, but affect the points around it (how to interpret this?). This may be responsible for the texture pattern we see.

-Also, the  $dF/dx$  and  $dF/dy$  are swapped as a fix. (Source Code)

-Images obtained with the latest code (based on model data):



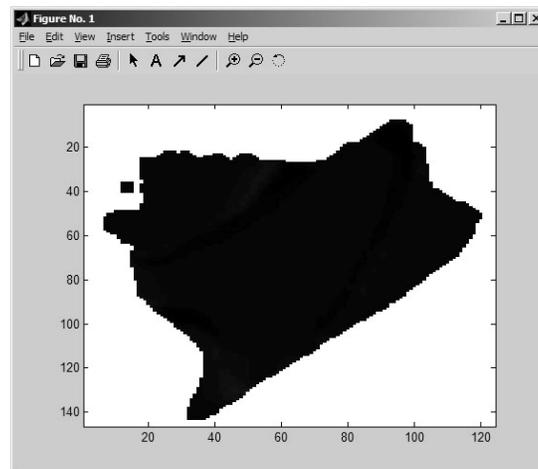
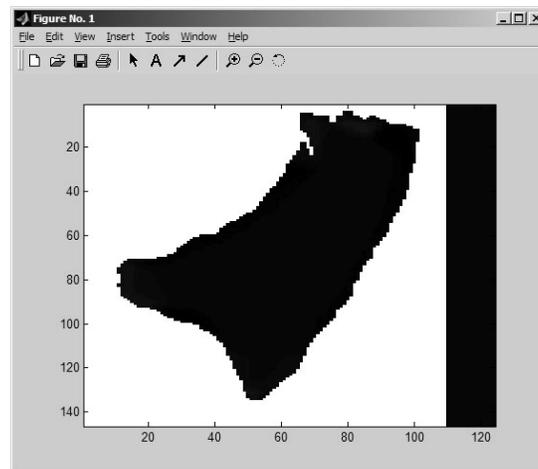


July 18, 2004

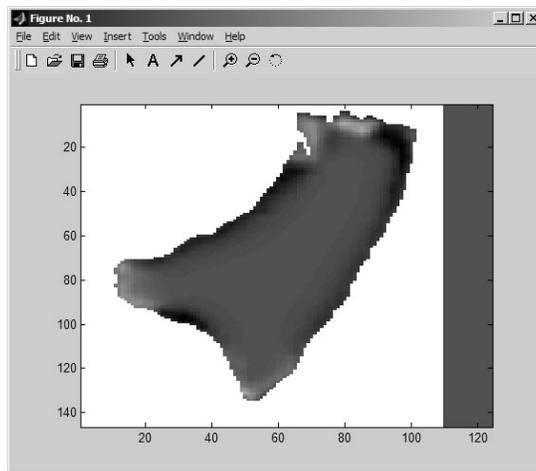
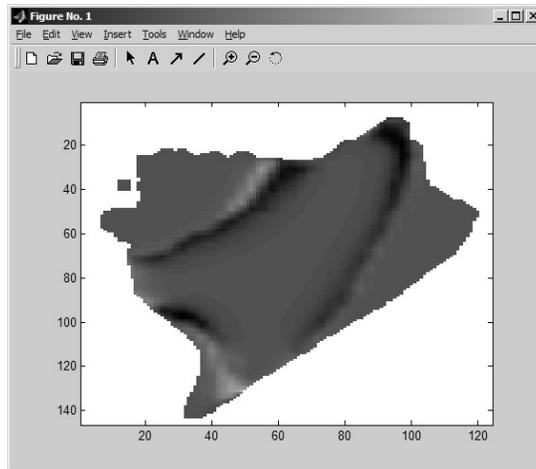
-Indeed, the values of the displacement images produced by FEM increased by 10 times when the spacing in the original images are increased by 10 times.

=Volume Change Images. Note: I set the number of iteration in the FEM registration process to 1, so that I can manipulate and contrast the effect of increasing the spacing easily. All 4 of the following images are local volume change output. Only difference between the last two and the first two are the spacing in the input images.

Before changing the spacing: The volume change is not as noticeable, but this is the correct one. Zoom in can see the difference in the greyscale.

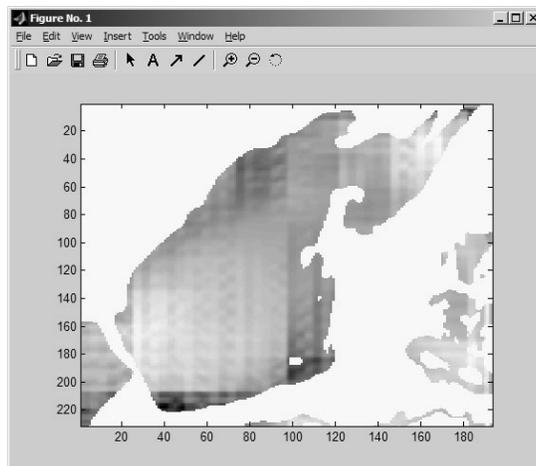


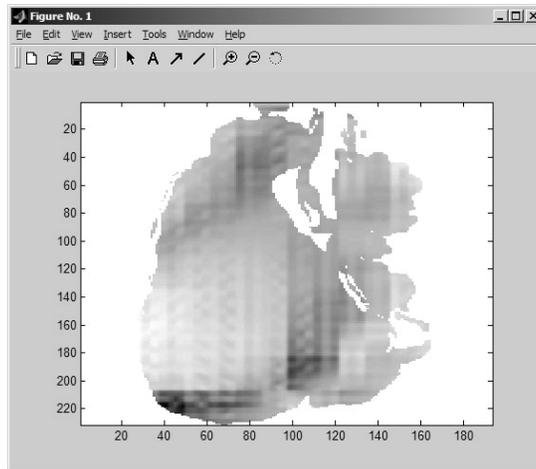
After changing the spacing: The amount of volume change happens to be amplified and becomes more visible in the local volume change output.



-localvolumechangecode to reflect the fact that the generated  $F\{i\}$  should be multiplied the corresponding spacing to change it into real units. Text output showing how spacing impacts the localvolumechange value calculated.

Using Model Data that have gone through successful registration:



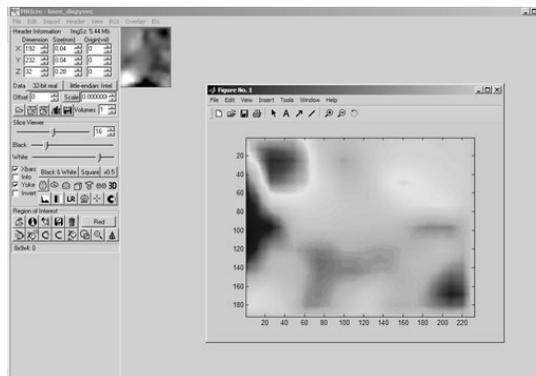
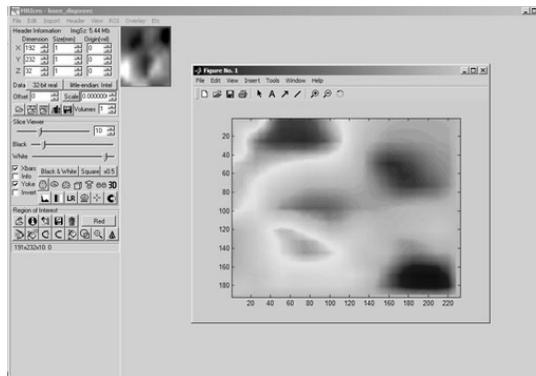


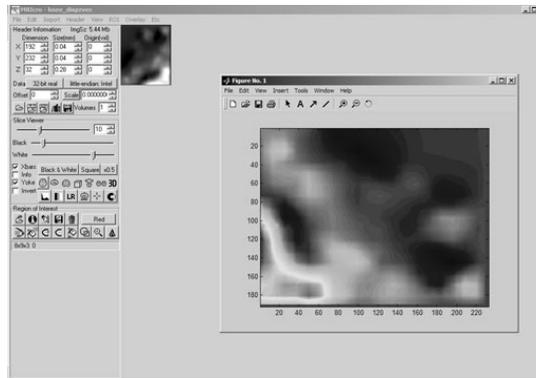
July 17, 2004

-Image volumes from which the images are extracted from. Updated source code so that it generates those img files. hdr files are then created using createheader from AIRA.

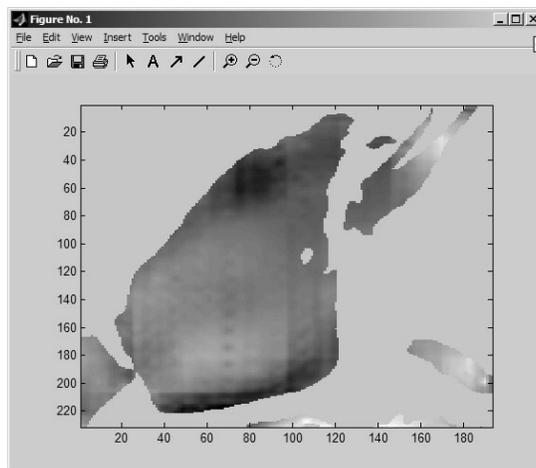
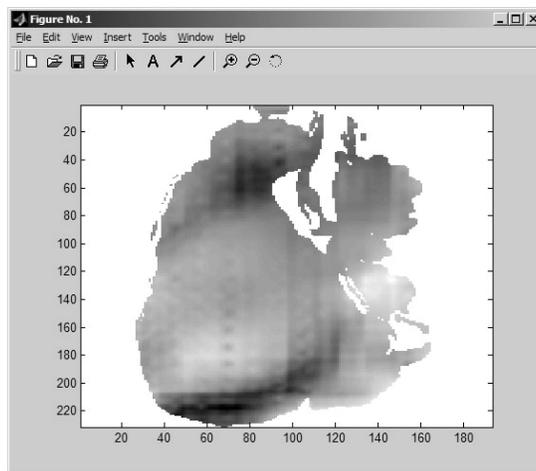
July 16, 2004

-Matlab difference vectors display (Difference Vectors are generated from FEM)





=Modified source code that reads deformation field component analyze files and original images and generate local volume change diagrams:



July 13-14, 2004

FEM

-Apply registration methods to masked real images. These masked images are more accurate

than the ones before.

-Result from FEM for real data. This is Real Extend data attempting to match Real Flex data.

Parameter: 15e4 15e4 100. As good as it gets, as any increase or decrease of the value causes the image to become heavily distorted. (Full Parameter File)

-Attempted to use landmark, but get segmentation fault. Not sure the reason - attempted using empty landmark file, still s.f. Using the sample landmark file from example, it also s.f. Not sure why. Will try with sample data.

Thin Plate Spline

-Result from Thin Plate Spline for real data. Not perfect. But if I add more landmarks, unexpected bulges would appear. Maybe it's just an artifact that the difference between the extend and flex images are too huge. This is Real Flex data attempting to match Real Extend data.

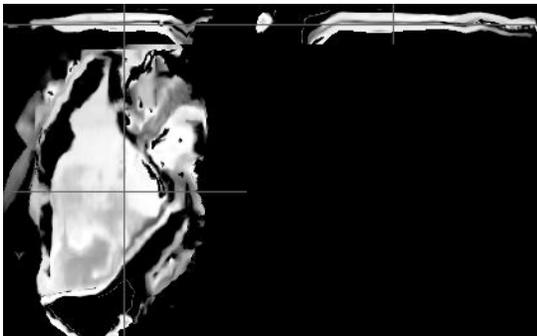
July 12, 2004

-Matching Model Extends to Model Flex obtains the following results using FEM, which I think it's quite good: Image volume

July 10, 2004

-B-Spline program ended with exception but because the code triggers a return, I didn't get the message before the windows closed :( I am switching back to use the original grid size - not sure if it's the grid size that's causing the problem or because I use the masked image.

-Funny how no matter what I use for second level in FEM registration (except using the same elasticity and capacity as the first level), the image becomes so squished:

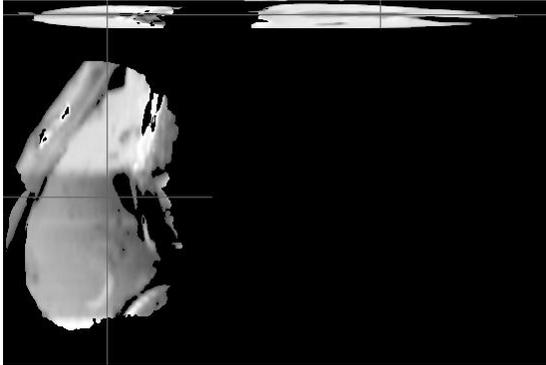


July 9, 2004

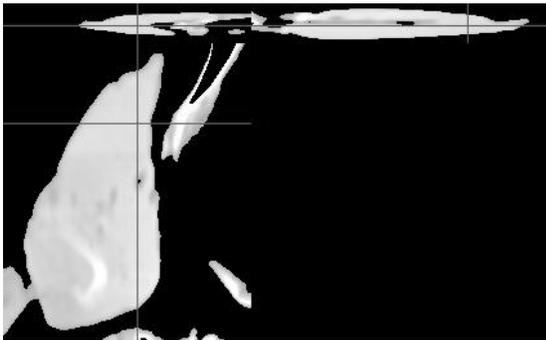
-Trying to do two things:

1. B-Spline. Takes a long time so while it's running, trying to tune the parameters for FEM.

For both FEM and B-Spline, I now use the masked images. Did some more segmentation, seems like this is "as good as it can get" with ITK segmentation for our model images.

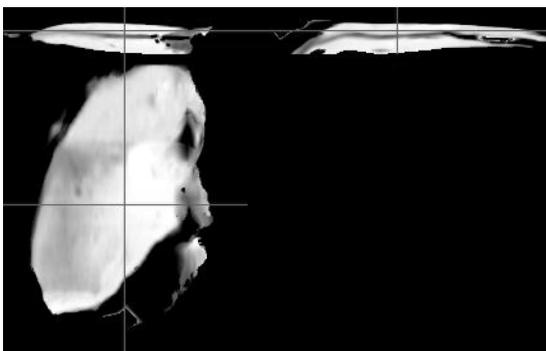


Produced by applying confidence connected, masked the original based on the segmentation. And then, apply fastmarching on the masked image, and then produce this final masked image.



2. FEM

Tuning tuning more tuning. So far this is the "best" obtained. This is trying to match the image immediately above.



July 8, 2004

1. Turns out the link to the FEM paper (in which ITK FEM is based on) is a dead link

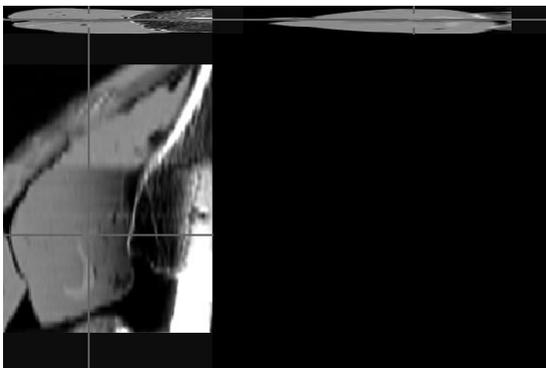
2. E-mailed the group about B-Spline stiffness of each node. Turns out the parameters are the deformation vector of each node (flatten out). You can set the spacing of each grid node. It seems like there are no easy way to adjust the stiffness (i.e. cap the maximum deformation vector for the node - I suppose you can, manually changing the values of the vector at each iteration... )

3. Someone asked already about setting the landmarks for B-Spline. I was thinking this might help limit the "fluidity" of the transform. However, there are no easy ways to set the landmarks. Would apply Thin Plate spline with landmark and then use that output as the input to B-Spline transform a good idea?

4. Attempted FEM with the model knee images. But no matter what elasticity, density x capacity value I use, there are little (close to no change) to the fixed image... I don't see density x capacity mentioned anywhere other than in ITK's sample parameter file (and the email I previously sent you the link to). Maybe those images are too complex? Right now I am attempting to use the masked images.

July 6, 2004

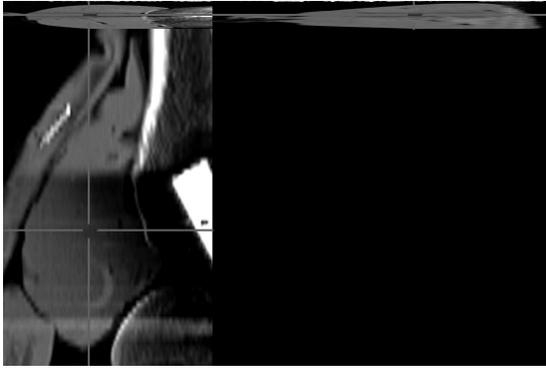
B-Spline:



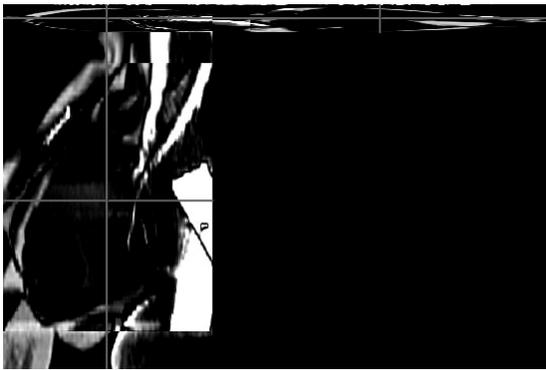
becomes



in an attempt to match this:



Difference before registration:



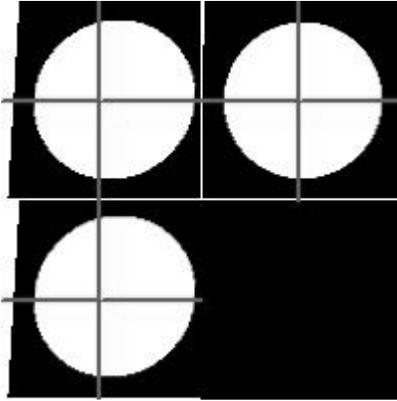
Difference after registration:



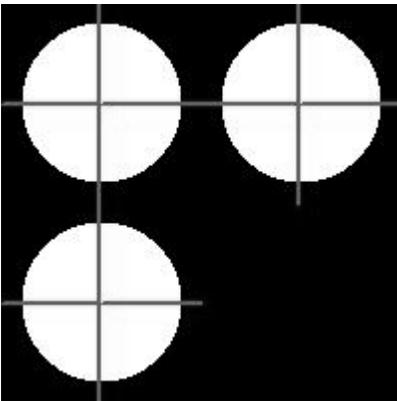
July 5, 2004

Something finally works. The only significant change is having a much higher "Density x Capacity Value" in the first level. The image is almost registered correctly even in the lowest resolution level in the image pyramid.

Easier Input



becomes



with the following parameters:

4 % Number of levels in the multi-res pyramid (1 = single-res)

4 % Highest level to use in the pyramid

8 8 8 % Scaling at lowest level of pyramid

4 4 4 4 % Number of pixels per element

1.e5 5.e4 5.e3 1.e3 % Elasticity (E)

1.e10 5.e9 5.e8 1.e8 % Density x capacity (RhoC)

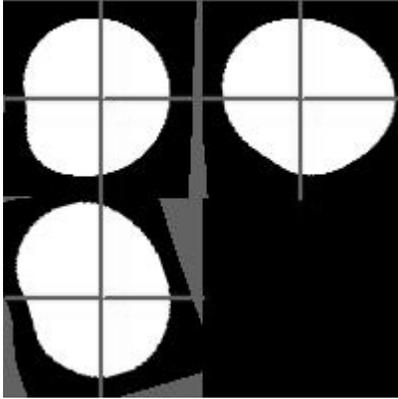
1 1 1 1 % Image energy scaling (gamma)

4 4 4 4 % NumberOfIntegrationPoints

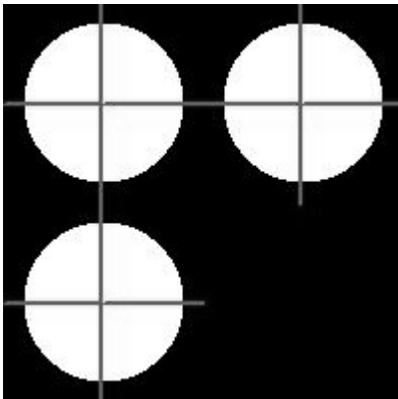
2 2 2 2 % WidthOfMetricRegion

30 30 10 5 % MaximumIterations

Harder Input



becomes



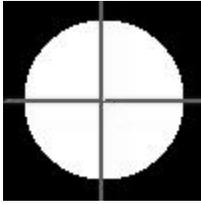
with parameters:

4 % Number of levels in the multi-res pyramid (1 = single-res)  
4 % Highest level to use in the pyramid  
8 8 8 % Scaling at lowest level of pyramid  
4 4 4 4 % Number of pixels per element  
1.e5 5.e4 5.e3 1.e3 % Elasticity (E)  
1.e10 5.e9 5.e8 1.e8 % Density x capacity (RhoC)  
1 1 1 1 % Image energy scaling (gamma)  
4 4 4 4 % NumberOfIntegrationPoints  
2 2 2 2 % WidthOfMetricRegion  
30 20 10 5 % MaximumIterations

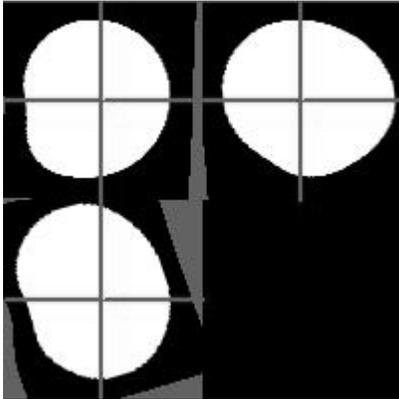
One thing that is weird is even though the final image now looks like a sphere, the energy value displayed remains high.

June 28-July 2, 2004

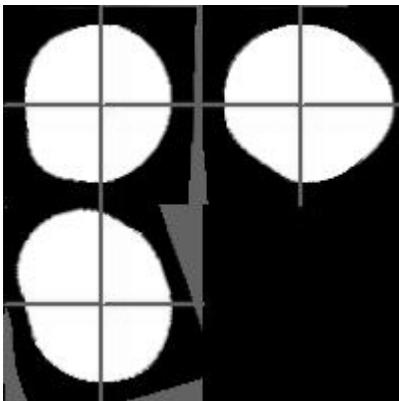
I hope the naming of the images are self-explanatory. Basically I created a sphere



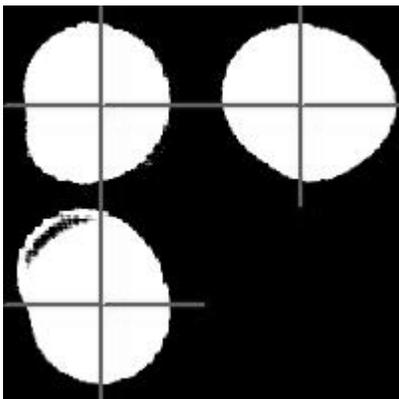
,and then I apply thin spline to it to get this



(3-axis view). Then I feed it into Demon, I get

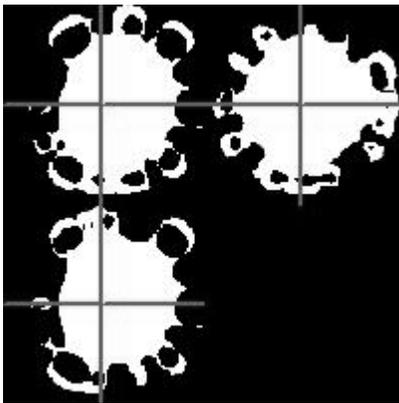
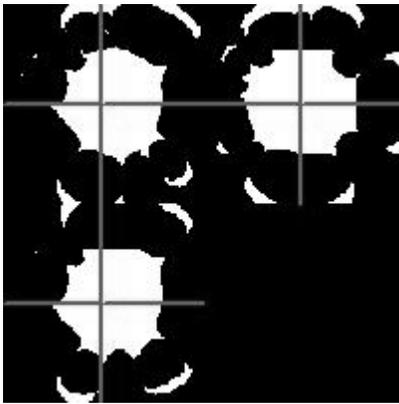


. Then I feed it into FEM with default parameters, and I get this:

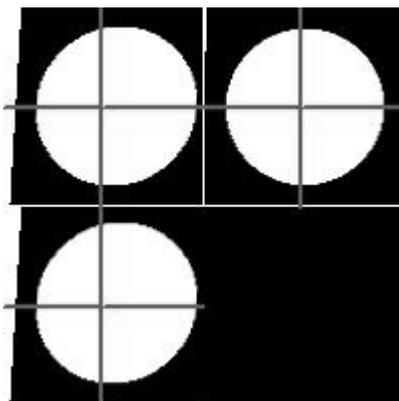


I tried couple hours to adjust the elasticity based on the energy-change, and work with different resolution of the images in the image pyramid (which is based on a smaller part of the original image, rather than scaling). For the lower resolution images, I try to adjust different elasticity, and density ratio of the material, but the energy remains high. In other words, I wasn't successful

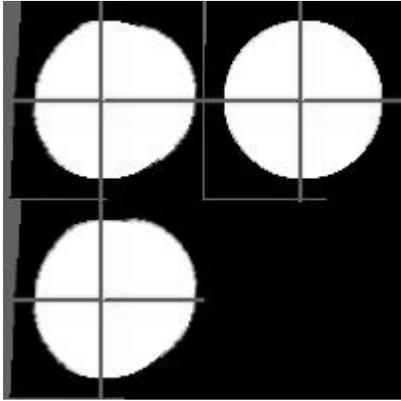
in registering even the lower resolutions of the images. Anyway, if I continue to register regardless of the failure in registering lower resolution of the images, I get these ridiculous output:



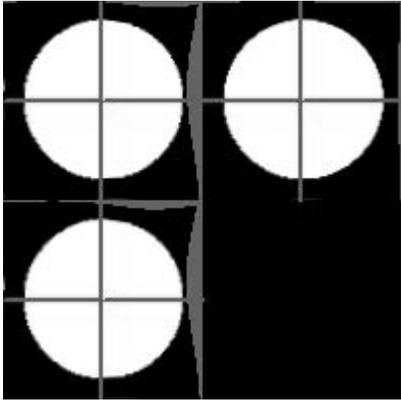
In despair, I try to use a simpler output. So I generate another image with less change to the sphere:



With demon, the result is pretty much the same as the original with only slight changes if you overlap the two and see. The number of iteration seems to make very little difference:



Alas, registering with B-spline seems to give pretty good results. This is the final output, which is similarly to what we are matching to:



However, it takes terribly long to get results. This took 5 hours, and now I am running B-spline against the knee images. It has been running for 1 day, and it is still running