

June 21-25, 2004

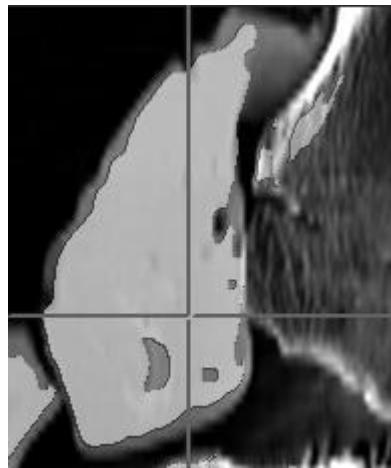
A program is developed to facilitate the use of ITK in image processing. This program includes the following features

1. Allow choosing which filter / segmentation / registration method to apply to the loaded image at runtime
2. Allow adding filter / segmentation / registration method to the programs with ease. The readers and writers are shared among all the filters, and other basic functionalities (discussed below) are shared.
3. Allow all filters to make use of ranged parameter. This means that we can define a range for each parameter required for a filter, and the filter will iteratively produce output images that are in the parameter space.
4. Auto-generate file name based on the sequence of filters (and the parameters) being applied.
5. Facilitate the use of ITK filters for research purposes in the future

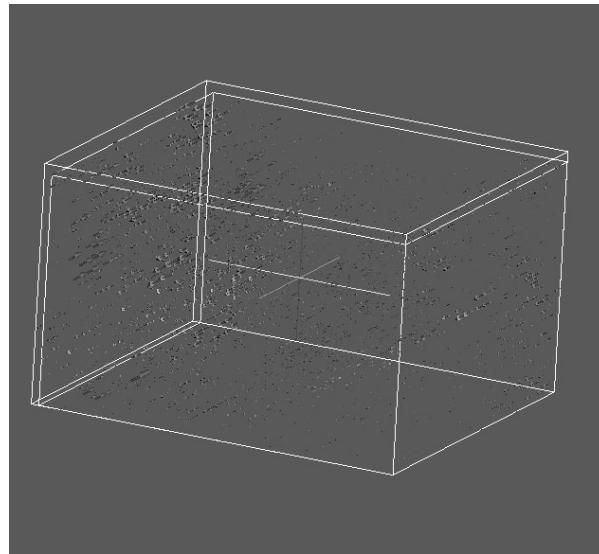
[Source Code](#)

[Binary for Win32](#)

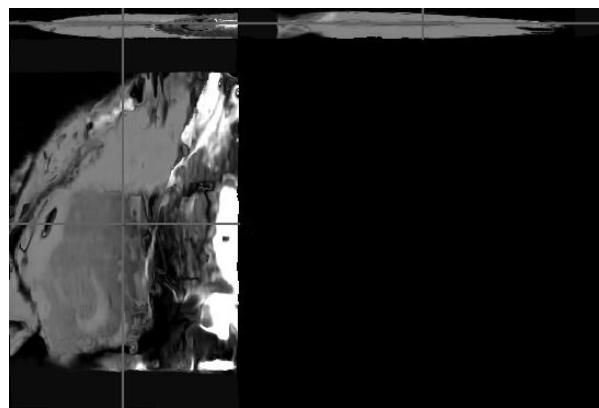
Some of the results produced:



Apply neighbourhood filter



Applying Demon Deformation registration. (Deformation field)



Applying Demon Deformation registration. (Resulting Image)

June 17-18, 2004

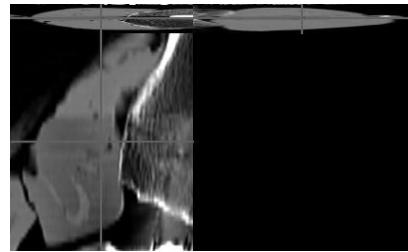
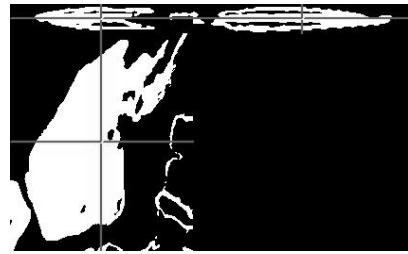
-Attempting to fix/investigate various issues:

1) Not able to use binary masks

-seems like applying a binary mask of all 1's is not the same as having no binary mask.. bug it seems.

2) Improving segmentation on cropped images

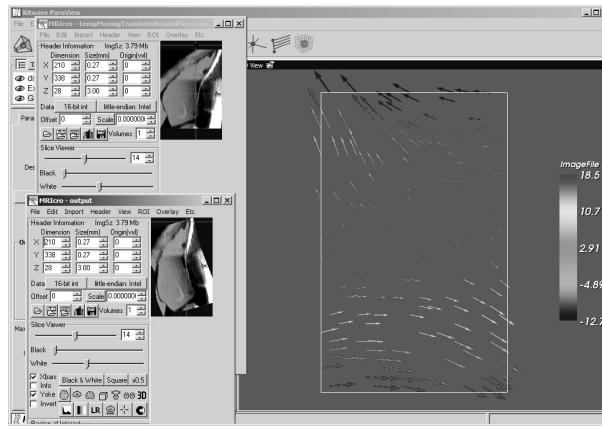
Hybrid approach with FuzzyConnect + CannyLevelSet



June 16, 2004

-Source code Snapshot developed calculating the displacement field...

It produces the following results (which seems to be right?):



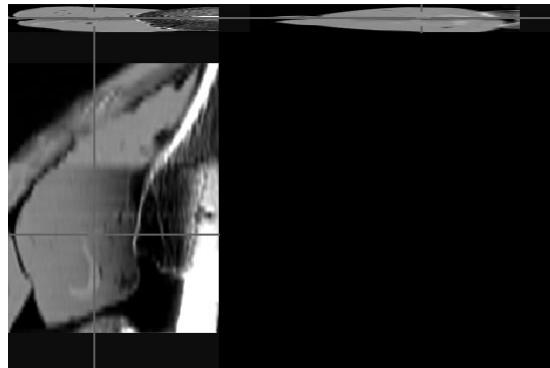
Displacement Vectors that generate the above diagram

June 15, 2004

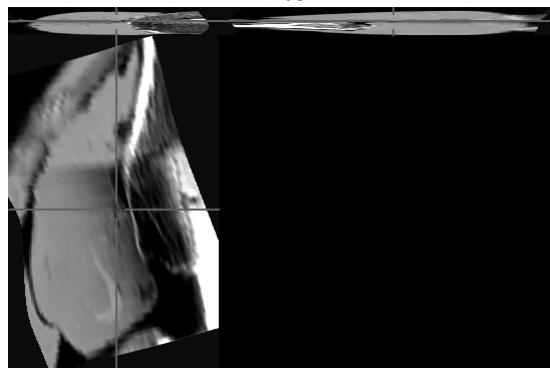
-Updated Source code developed for thin plate spline...

It only applies the transformation based on the landmarks I manually defined. For future reference: [landmarks.txt](#)

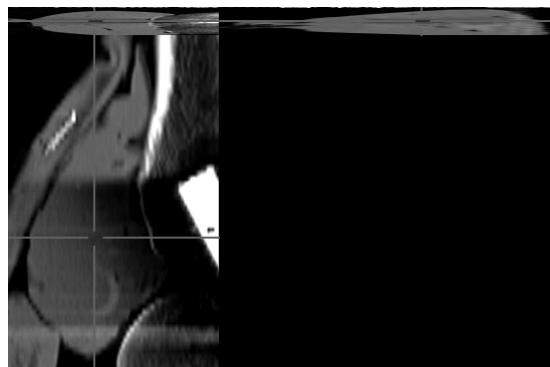
The code deforms the ModelFlex image:



into



...in an attempt to make it look like the ModelExtend image:



-Going to incorporate the code into the registration framework ([Source Code](#) being developed)

June 14, 2004

-Source code being developed for thin plate spline...

June 11, 2004

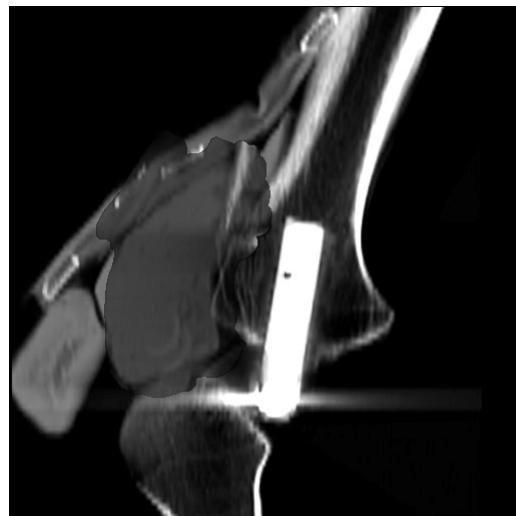
- No error in attempting to register a cropped image (without mask ... affine transformation)
- Also no error in attempting to register a cropped image (with a Fixed Image Mask... affine transformation)
- Applying a binary mask to the moving image (even with all 1's) would return error (all points mapped outside image blah), suggesting there's really something wrong with the mask (when applied to moving image). The sample only applies mask to fixed image.
- Moving on to nonlinear registration.

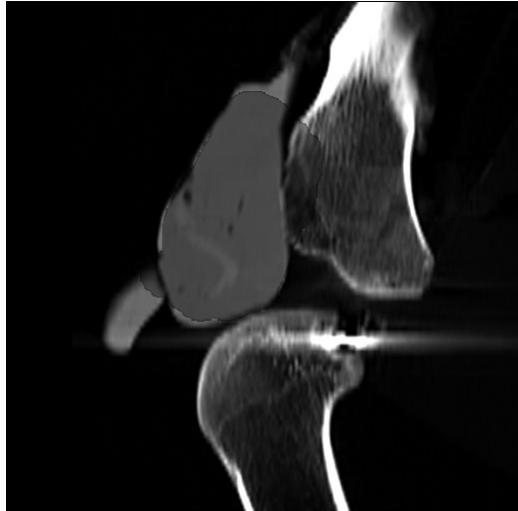
June 10, 2004

Source Code Updated

Command line parameters: modelExtends.hdr modelFlex.hdr
dilatedModelExtendsBestResults.hdr dilatedModelFlexBestResults.hdr output.hdr difference.hdr

- Fixed centroid step. Now shows more plausible results (It was file naming problem, writing to the wrong file)
- Tried exchanging the moving and fixed image (i.e. using Extends as fixed and Flex as moving the first time, and then using Flex as fixed and Extends as moving the second time). Both of them return no solution (Attempted to translate manually first, and then use the translated image and mask as input. Also attempted to use the parameters from centroid step as initial parameters to registration.).
- Attempting to iterate all the different initial values by brute force.
- Here are the results from the centroid step (Top: Flex as fixed, Extends as moving. Bottom: Extends as fixed, Flex as moving)





-Full Image volumes are uploaded to /cs/guests/vwchu/myfiles/share/temp

June 6, 2004

Registration with mask + CenterTransformInitializer Code

-Noticed that before registration, the scale of each pixel in each direction should be the same. ResampleFilter should be used. The resulting image is 150MB each, and running the code using those images require a lot of memory.

-The example used in software guide for centroid principle axis translation uses Rigid2DTransformation class as the transform. However, there is no Rigid3DTransformation. A related class, CenteredEuler3DTransform, is tried, but later discovered that it is not fully implemented.

-CenterAffineTransform is used as a substitute. (Not sure if it is compatible with **CenterTransformInitializer**)

-Code currently does not run on linux box (matrix with values equals 'nan' and the process is killed)

-Binary mask image need to be rescale such that all the pixel values goes from 0 to 1. (If it's 0 and 255, then even though **and** is applied other than **multiplication**, the result would still overflow <ITK implementation problem>)

-Attempted to adjust the step size, etc to a very small value. However, running the code would still return no solution.

June 5, 2004

-Spatial Objects can now be created out of binary images. It works in the general sense. However, if we restrict the transformation to translation and using the dilated segmentation results as the mask, then no solution is found for registration. Time to move on to other registration methods...

June 2, 2004

-Although there are still room for improvement in segmenting real data, the improved results for model data is quite satisfactory and I think it can be used as masks for registration. Working on linear registrations now.

June 1, 2004

-Attempt to obtain better segmentation results by trying various seed points / smoothing values. Only Model Flex has improved. The following are the best image in each of the four new data sets:

(top, from left: Model Extend, Model Flex; bottom, from left: Real Extend, Real Flex)



May 31, 2004

-Organize all the Source Code produced/used (some are original, and some are from the software guide) in the past month and upload to dogwood.

-Ran Hello World Registratin Example

-Obtained improved fast marching results by setting multiple seeds, and seeds at different locations. Updates has been made to the screen shots on May 28.

-Organized all the results (obtained by feeding fastmarch algorithm with different parameteres) from segmentation and comparison into jpeg format (15.5MB).

May 28, 2004

-Comparing Results (Source Code)

For the purpose of evaluating how good the segmentation is, we need a reference image where we know the segmentation is correct. For each of the four data sets, I extracted the middle slice and manually segment (through eyeballing and following the roughly aligned demarkated images from the medical doctors) the fat from that slice using photoshop.

The top left image in each of the following thumbnails is the one with the best match (only the middle slice is compared. All the other slices are ignored). The score in front of the file names indicate how many pixels are different.

Real Knee Extension (Fastmarching)



Real Knee Flex (Fastmarching)



Updated on March 31

Model Knee Extension (Fastmarching)



Model Knee Flexion (Fastmarching)



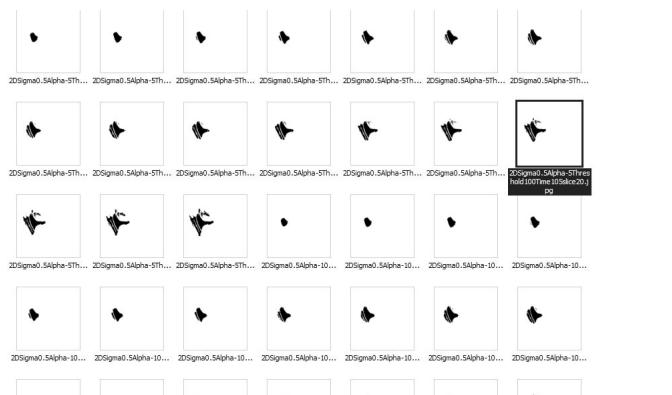
Updated on March 31

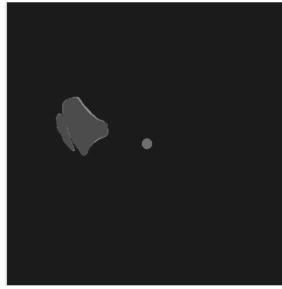
May 25-27, 2004 (Updated!)
-Fast Marching ([Source Code](#)) Results on various inputs:

1) Model Knee (Extends) Data

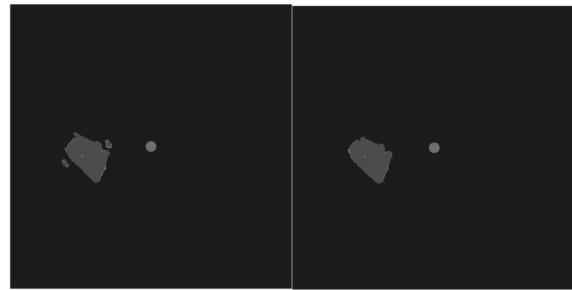


2) Real Knee (Extends) Data





3) Erosion and Dilation is re-applied on the Real Knee Flex data and obtained the following:



4) Model Knee Flex Data

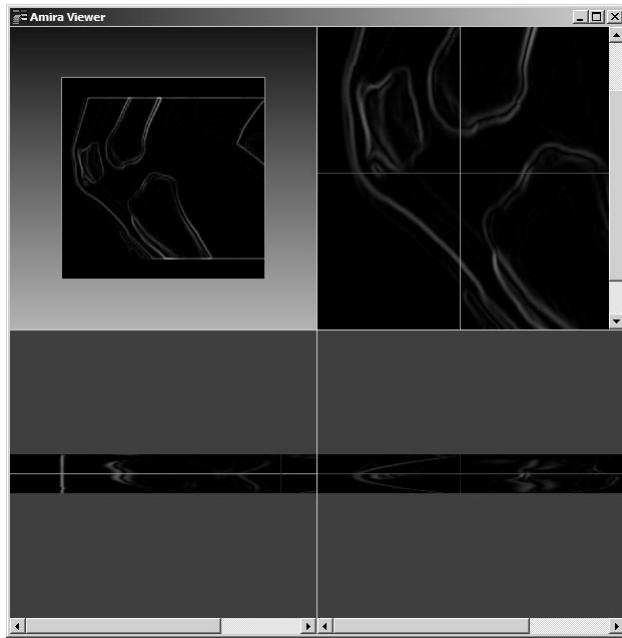


-Finished reading the chapter on Registration in Software Guide.

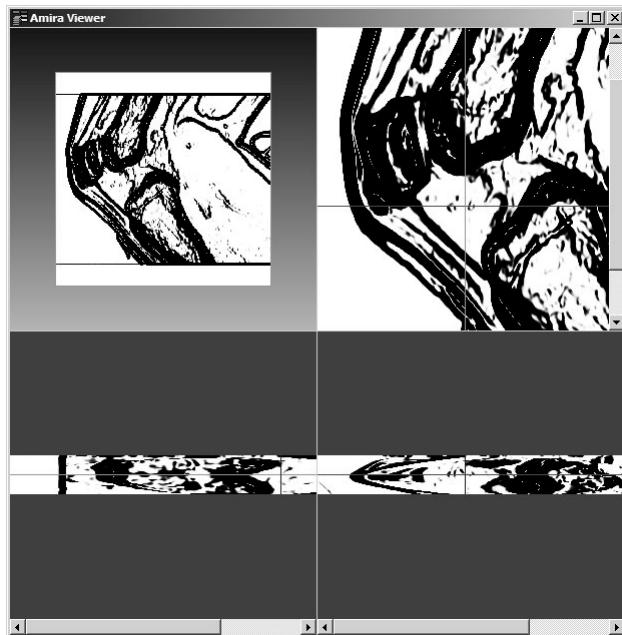
May 21, 2004

-Erosion and dilation on the knee 3D volume would take 2:30 hour.

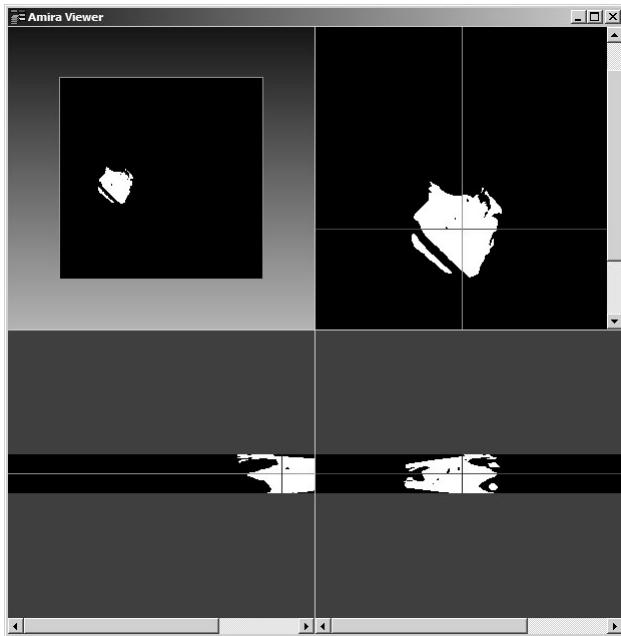
Results from applying various filters and segmentation techniques to the flex knee image:



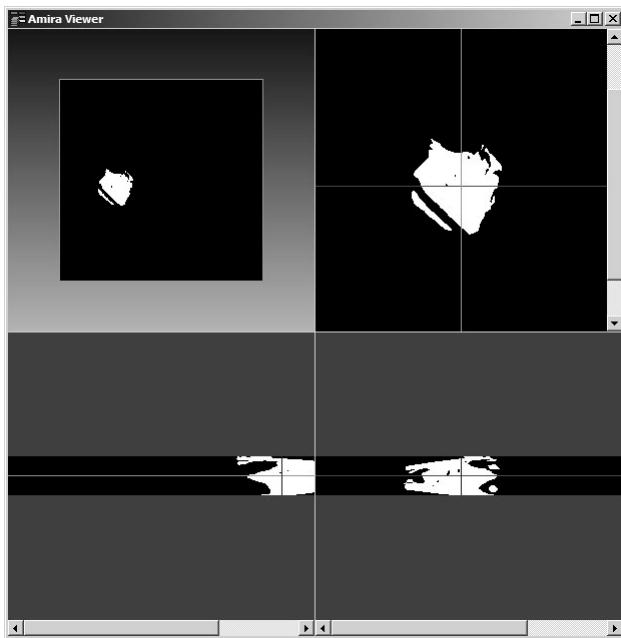
In an attempt to better isolate the fat pad, gradient magnitude filter is first used. This parameter of sigma 0.5 seems to give the best results (Sigma controls how much noise to ignore). The outlines of the bones show high contrasts, however, the fat pad does not.



Luckily, with alpha and beta carefully set (alpha and beta are parameters to adjust the input range window for the sigmoid filter), the outline of the fat pad can be amplified. (Alpha = -5, Beta = 30)



Fastmarching algorithm is then applied. The optimal parameter seems to be with threshold equals to 55 and timeThreshold = 60.



Attempt to apply dilation (radius 6) and erosion (radius 7) on the result I got from fastmarching. It ran for hours with little improvement. (Update: This is because an incorrect target value was set. The correct parameter should be dilateFilter->setvalue(255))

May 19-20, 2004

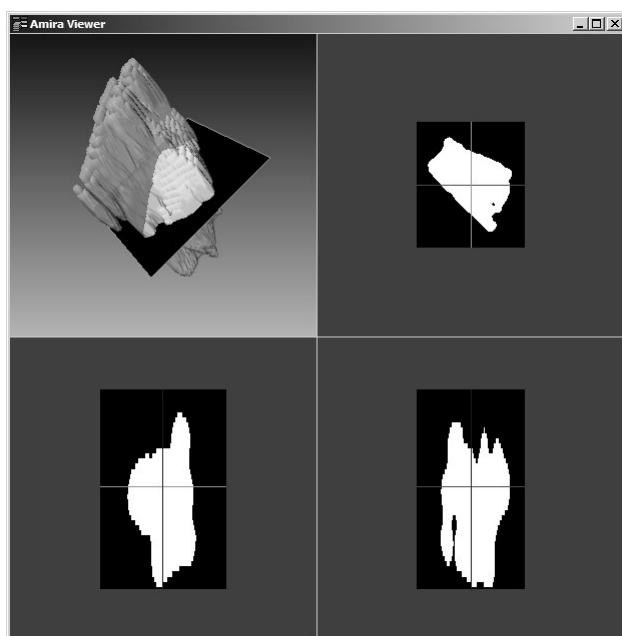
-Installed ccmake/ITK on **glacier** (Linux box). As expected, running ITK programs do not occasionally return segmentation fault. Although the program is not executed at a lightning speed, it can be a resource we can use.

Results from applying various filters and segmentation techniques to the flex knee image:

Erosion then dilation on

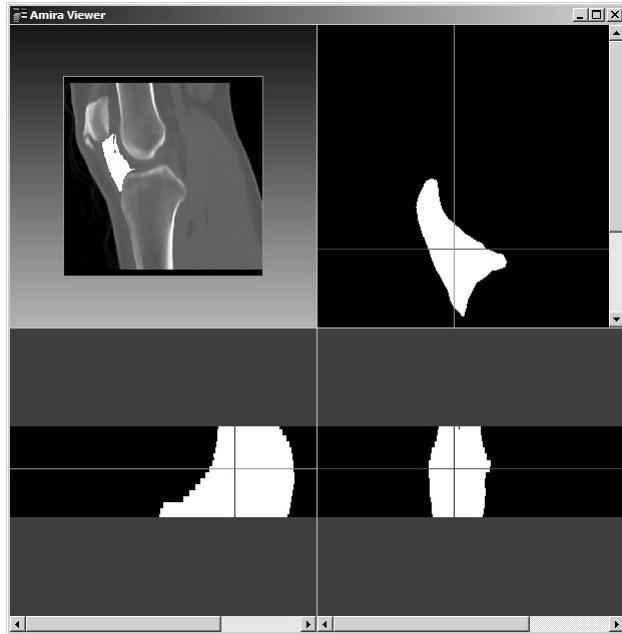


results in the following. The following shows erosion of radius 5 and dilation of radius 4.

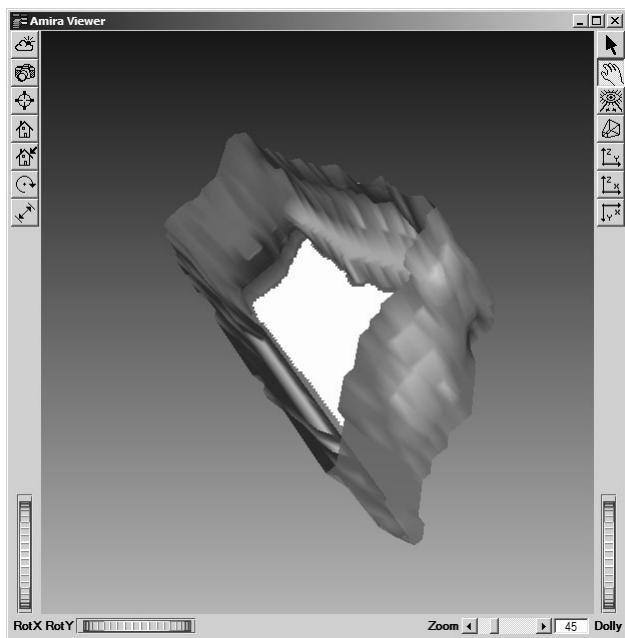


This parameter combination is used as determined through trial and error. If the erosion radius is set lower than 5, the extraneous portion of the segmented image would not go away.

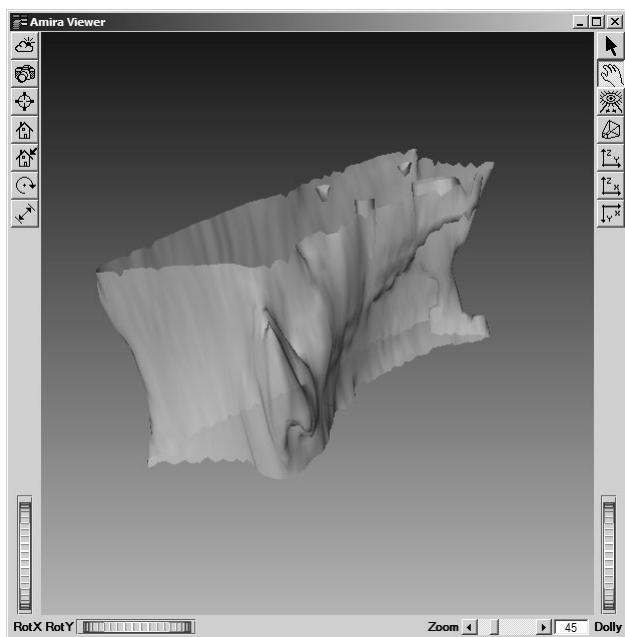
Through trial and error of parameters and filtration techniques, the following segmentation for knee extension is obtained by first smoothing with anisotropic curvature filter and then followed by confidence connected. The process is aided by manual extraction of the "relevant" slices from the 3D volume



With the two preliminary models of Flex and Extension, I did a preliminary comparison using Amira just to visualize current standing:



Fat pad during Flexation



Fat pad during Extension

May 17-18, 2004

- Installed Amira on Windows (Expiry date: May 24)
- Investigating the use of level segmentation techniques: Fast March, Shape Detection.
- Devising method to assist in the time consuming task of determining the various parameters of filters and segmentaiton methods: still at trial and error stage. Should write loops and then output extracted slices with various parameters. Problem: Takes too long.

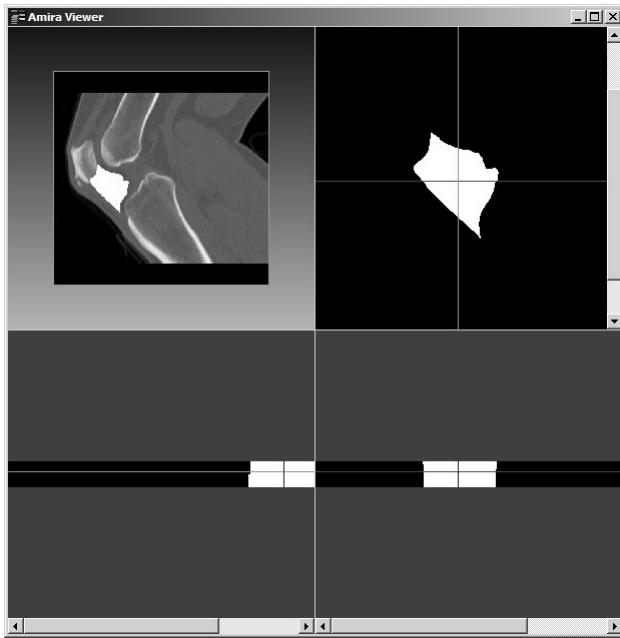
-Attempting to run on Nexus returns error 139. Appears that program has core-dumped
PBS Job Id: 20918.nexus.nic.ualberta.ca
Job Name: extractFatMulti
Execution terminated
Exit_status=139
resources_used.cpupercent=611
resources_used.cput=01:01:32
resources_used.mem=133280kb
resources_used.vmem=143232kb
resources_used.walltime=00:31:00

Results from applying various filters and segmentation techniques to the flex knee image:

Original Image:

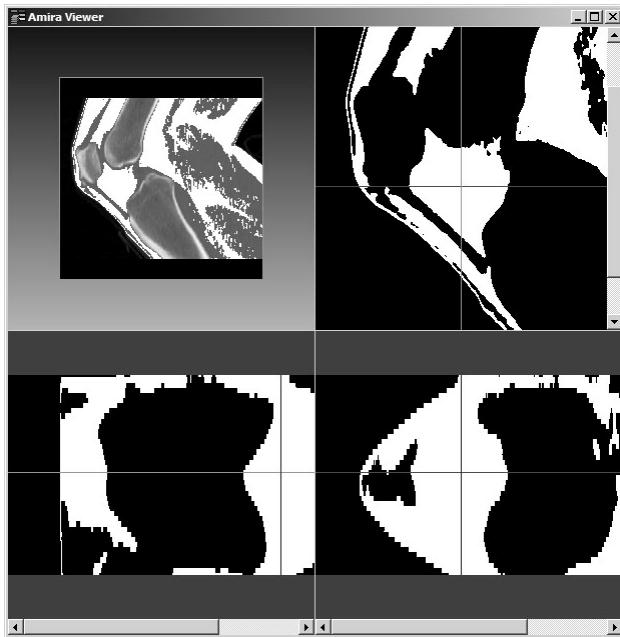


Preliminary Results from several days ago (now properly aligned in Amira):



The following are screenshots showcase the several techniques (with the best possible parameters) and the respective results:

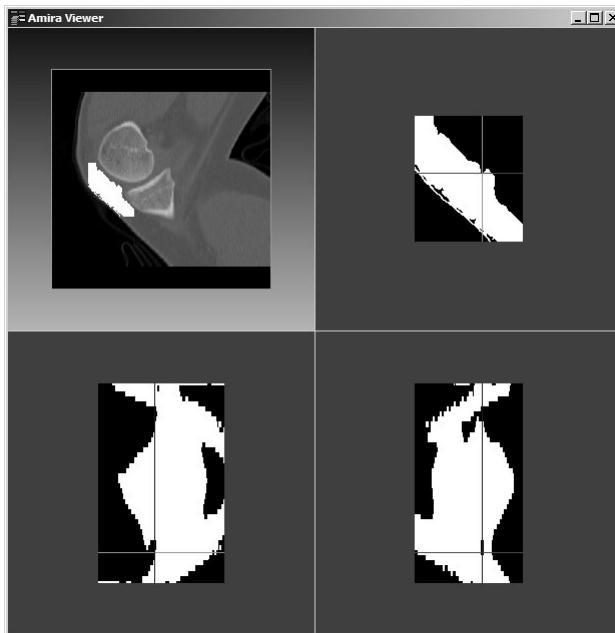
IsolatedConnected Filter cannot be used to isolate the fat area. An attempt to subtract the extra area will cause nothing to be segmented. This suggests that there is no upper threshold that can be set to separate the desired fat area from the other extraneous areas that is also segmented in the picture:



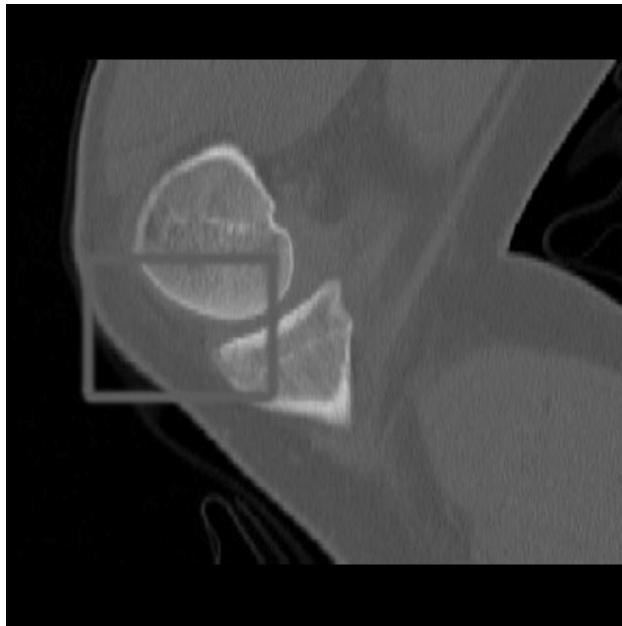
Confidence connected segmentation filter seems to offer better result by manually isolating the area to look at (i.e. just include the region where there is the fat we want). If we do not manually isolate the area first, we get the same problem as we saw previously from isolatedConnected:



In all cases, it seems apparent that the problem area locates in slice 6, where it is not apparent where the fat is (barely noticeable by eye). Various filtering/segmentation techniques will produce the following results: (the white region is where the algorithms think the fat should be)

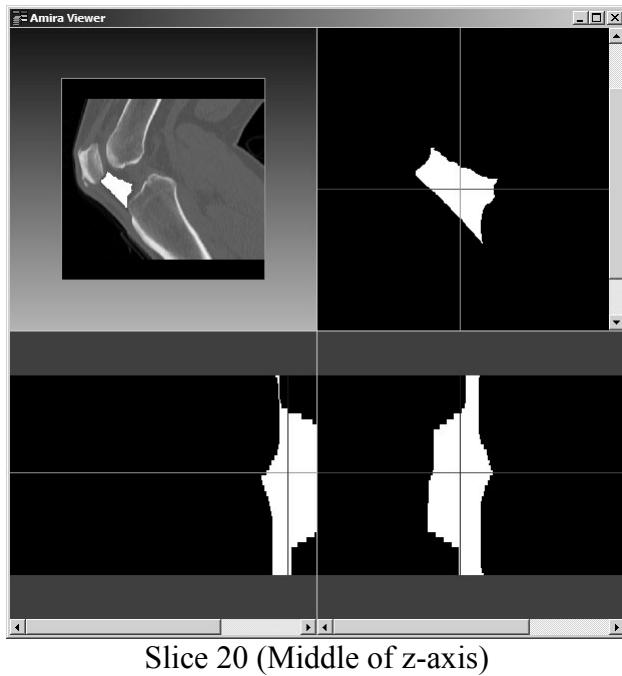


A much larger area than desired is segmented

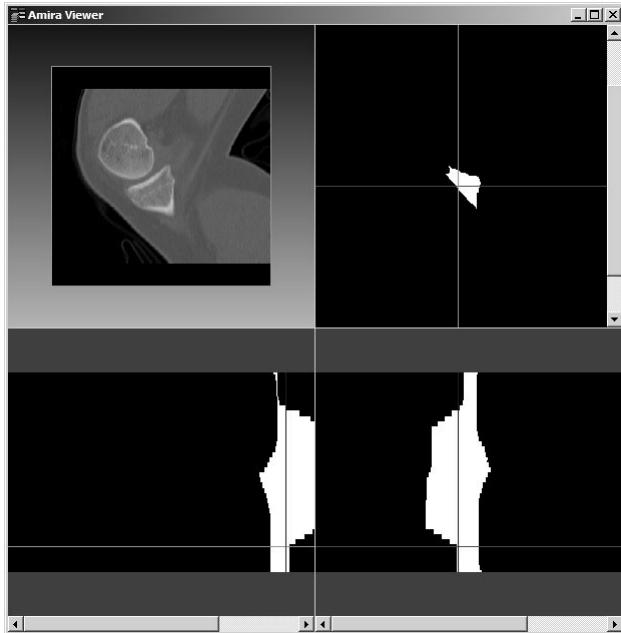


Problematic region is highlighted in red box

Using information obtained from confidenceConnected, I attempt to tweak the results using neighbourhoodConnected. This time without specifying the region manually ahead of time:



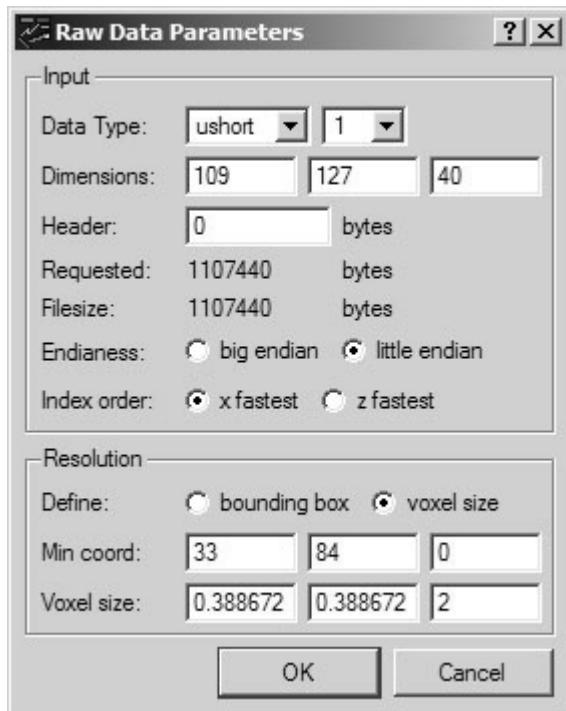
Slice 20 (Middle of z-axis)



(Slide 6)

There is now no extraneous area. However, the segmented area of the desired fat also shrinks.

For future reference (self-note), parameters used for Amira:



May 15, 2004

-Filtering using ITK often produces segmentation fault after running for an hour or so when it's run on nexus/westgrid. No problem running on dogwood(SunOS). Wasted hours on this for the last couple days. Nothing online addresses this problem. Need help.

-qsub does not necessarily always run faster (depends on status?) => CurvatureAnsio takes 20 minutes to run on 1.8GHz machine by 40 minutes to run on Nexus (with and without qsub).

May 14, 2004

-cmake and ITK toolkit were installed successfully on nexus.

(Running **make** in interactive mode causes disk quota exceeded. But using qsub, the problem was somehow bypassed)

-Smoothing filters on 512x512x40 volume would take, on average, an hour to run.

-qsub can request/reserve to use more than one CPU for multi-threaded programs...

-**globus-url-copy** does not work well with getting files from internet (even worse than **wget**) (possibly because incorrect parameters are set? ... not worth the time to investigate)

May 13, 2004

-Amira can be used to

-Certificate doesn't work with vizserver (i.e. vizserver is not grid-enabled as of today)

-**globus-url-copy** operates at 25MB/s.

```
blackhole.westgrid.ca : blackhole - SSH Secure Shell
[File Edit New Window Help]
[Back Forward Stop Reload Home Stop All Stop This Tab Stop All Tabs]
[Quick Connect Profiles]

error: a system call failed (No such file or directory)
[vwchu@blackhole data]$4 pwd
/home/vwchu
[vwchu@blackhole data]$4 globus-url-copy file:/home/vwchu/testbed.tar gsiftp://ne
xus/scratch/vwchu/testbed.tar
error: a system call failed (No such file or directory)
[vwchu@blackhole data]$4 globus-url-copy file:/home/vwchu/data/testbed.tar gsiftp
://nexus/scratch/vwchu/testbed.tar
[vwchu@blackhole data]$4 globus-url-copy file:/home/vwchu/data/testbed.tar gsiftp
://nexus/scratch/vwchu/testbed.tar -vb
ERROR: too many url strings specified
Syntax: globus-url-copy [-help | -usage] [-version[s]] [-vb] [-dbg] [-b | -s]
[-x <subject>] [-d <object>] [-ss <subject>]
[-top-bs <size>] [-bs <size>] [-p <parallelism>
[-l <localfile>]
[sourceURL destURL]
Use -help to display full usage
[vwchu@blackhole data]$4 globus-url-copy -vb file:/home/vwchu/data/testbed.tar gs
iftp://nexus/scratch/vwchu/testbed.tar
924844032 bytes   23155.32 KB/sec avg    22341.81 KB/sec inst
[vwchu@blackhole data]$4
```

e.g.

%ssh blackhole.westgrid.ca

%globus-url-copy file:/home/vwchu/data/ITKTestBed/ extractFat/binary/extractFat
gsiftp://nexus/scratch/vwchu/test

would copy extractFat on blackhole to nexus.

(equivalent to

scp vwchu@blackhole.westgrid.ca:

/home/vwchu/data/ITKTestBed/ extractFat/binary/extractFat
vwchu@nexus.westgrid.ca:scratch/vwchu/test)

-More information about grid tools at [westgrid website](#)

-Source code for extracting fat would work on SunOS as well, but not on vizserver. No search result from google regarding this matter. Smoothing example code included in the ITK toolkit suffers the same problem as well.

-Attempted to run the compiled binary on nexus instead of vizserver, it also runs with segmentation fault/bus error. **qsub** with computation expensive job does seem to be faster.
-libstdc++ is required on Nexus. On IRIX, the runtime linker looks for **so** files in environment variable **LD_LIBRARY_PATH**

(e.g.

LD_LIBRARY_PATH=/usr/local/Globus/lib:
/usr/global/express6.2/lib/sg6:
/scratch/vwchu/binary)

May 12, 2004

-Using NeighbourConnectedFilter and CurvatureFlowImageFilter to isolate fat tissues. Had trouble setting up appropriate value of threshold and seed index. **Paraview** remaps coordinate system causing confusion. Paraview uses measurements in real world (as calculated from mhd header file for raw files). **Color map** is used, and has to be reset when new image files are read.
-Same source code does not run on unix (segmentation fault) debugging...

-slicer

/ensc/IMAGE/opt/slicer2-linux-x86/slicer2-linux-x86

-DICOM data

/home/ghassan/data/NYUknee

May 11, 2004

-vizserver was down in the morning. Continue with software guide reading (filters, etc)

May 10, 2004

-Experiment with various filters. Reading software guide.
-vizserver was down for an hour in the morning

May 9, 2004

-Error compiling program that uses ITK. Missing .so. Has to manually **ln -s**. Same problem in windows (missing dll)
-Exception would be thrown at runtime (error message not clear) when the image is set at the wrong dimension

May 7, 2004

-Installation problem on westgrid is fixed by doing a clean install (new **tar** does not replace truncated files)
-Experimenting with imageReader and imageWriter from ITK.

May 6, 2004

-Continue reading various documentations from ccmake and ITK
-Attempting to install ITK on westgrid. Compilation error. (stdlib++ problem //suggestion: **ar** and **ranlib**)
-**tar** is different on Sun and Linux

- Access to Nexus is lost after attempting to transfer files from dogwood to nexus using **scp**.
- Installed sgi client for viewing stuff from vizserver (sort of like X-Win stuff to me)

May 5, 2004

- Continue reading various documentations from ccmake and ITK
- Installing ccmake and ITK on dogwood. Experiment with westgrid. Able to connect to nexus and lattice
- Obtained account from westgrid and css in the afternoon

May 4, 2004

- Following up with various individuals for accounts
- Continue reading various documentations from ccmake and ITK
- Obtained account from westgrid and css in the afternoon
- Installing ccmake and ITK on Windows. Compiled and ran "Hello World" application

May 3, 2004

- Waiting for account from css and westgrid
- Reading various documentations from ccmake and ITK
- Reading descriptions from westgrid