Image Registration Techniques
Homework 3
Due: Wednesday July 7/29 before class

This homework explores Lectures 9 and 10. Answer each of the following questions clearly. Submit your work at the start of lecture.

You are required to write code using the Insight Toolkit and run the corresponding executable using specific images as input. The material that you should return is composed of your source code and the output images generated from the execution of your program. Include your CMakeLists.txt files along with the source code.

1. (**10 points**) Image Registration Exercise. You will register the two images:

   - Insight/Examples/Data/BrainProtonDensitySlice.png
   - Insight/Examples/Data/BrainProtonDensitySliceShifted13x17y.png

   Using the program: Insight/Examples/Registration/ImageRegistration3.cxx

   This program is described in Section 8.3 of the ItkSoftwareGuide.pdf document. Copy the program in a new empty directory. Create a CMakeLists.txt file for it. Configure the project and build it. Modify the program in order to use different step lengths for the optimizer. Try steps : 1.0, 2.0, 5.0, 10.0 and 20.0 millimeters. You may find it convenient to take the value from the command line so you dont need to recompile the code for each different step length. Something like:

   ```
   optimizer->SetMaximumStepLength( atof( argv[4] ) );
   ```

   Return with you homework the version of the program that registered the images correctly, along with the resampled moving image generated by this program.

2. (**10 points**) Metric Smoothing Exercise. Write a program that will read a 2D image from a file, apply a Gaussian smoothing and save the resulting image into a file. Set sigma = 4.0. Then repeat the execution of the registration process of the previous exercise using the same set of step lengths for the optimizer and compare how many iterations it takes now to converge to the solution. Comment on your observation.

3. (**10 points**) Rigid Registration Exercise. You will register the two images:

   - Insight/Examples/Data/BrainProtonDensitySliceBorder20.png
   - Insight/Examples/Data/BrainProtonDensitySliceRotated10.png

Using the program: Insight/Examples/Registration/ImageRegistration5.cxx

This program is described in Section 8.5 of the ItkSoftwareGuide.pdf document. Copy the program in a new empty directory. Create a CMakeLists.txt file for it. Configure the project and build it. Modify the program in order to use different step lengths and translation-Scales. Comment on your observation.

4. Metric Plotting Exercise. You will compute the value of an image metric for a set of different translations. As fixed and moving image use the following two images:

   - Insight/Examples/Data/BrainT1Slice.png
   - Insight/Examples/Data/BrainProtonDensitySlice.png

   Use a NearestNeighbor interpolator and the Mattes Mutual Information metric.

   (a) Use a translation transform and plot the values of the metric for translations along X going from -20.0mm to +20.0mm every 1.0mm. Set the translation along Y = 0.0mm in all the cases. Report your results as a graph of Metric versus translation in X.

   (b) Testing the effect of changing the interpolator. Plot the same metric now for translations along X from -5.0mm to 5.0mm every 0.1mm. **(NOTE that in this case you are performing sub-pixel displacements.)** Generate the plots for the following three interpolators: Neares Neighbor, Linear, BSpline. Comment on your observations on the effect of the interpolator over the smoothess of the metric function.