Assignment 5
Monomodal Registration

CS 473/673: Medical Image Processing

Due 4:00pm Thursday 17 March 2016

1. [8 marks] **Least-Squares Registration**
   Implement an iterative least-squares registration method using fixed-point iteration. Your function should be called `RigidRegLS`, and should work for 2D or 3D rigid-body registration. Each iteration should approximate the rigid-body transformation using a linear model, and solve the linear least-squares problem to find the optimal motion parameters for that linear model. The prototype for the function is

   ```
   function p = RigidRegLS(f, g, m0)
   ```

   where `f` and `g` are the images (or volumes) to be registered, and `m0` is the vector of motion parameters for the initial guess (see the function's help file for more information). The returned set of motion parameters, `p`, are those that move `f` into register with `g`. The motion parameters should be a 1×6 array in the same format as the input for the `p2m` function. Rotations are about the image centre. This function should call the `MyDerivative` function from assignment 4. You will also find `MyAffine` useful. For building the A matrix (that holds the partial derivatives of the image with respect to the motion parameters), you will also find the Matlab function `reshape` helpful. You can also turn any array `f` into a 1D column vector in Matlab using the notation `f(:)`. All resampling should be done using either linear or cubic interpolation.

   For this iterative optimization technique, stop the iteration if the change in each motion parameter is less (in absolute value) than 0.001, or if it reaches 20 iterations (whichever comes first).

   Your solution must use the "trick" in which you linearize the transformation of `g`, and compute it only once.

   You can test your registration function using the supplied `test_ls_reg.m` script, but your method should work for other situations as well. In particular, your method should work for rotations and translations of up to 5 degrees or pixels.

2. [6 marks] **Graduate Question**
   If you are registered in CS673, you must also answer this question.

   Write a non-rigid registration function called `NonrigidReg` with the prototype

   ```
   function p = NonrigidReg(f, g, p0)
   ```

   where `f` and `g` are, as in the questions above, two images (2D is sufficient), and `p0` is an initial guess for the transform parameters. Your function should non-rigidly register `f` to `g`, and return the spatial transform parameters in `p`. You may assume that the two images are from the same modality, so that corresponding pixels should have the same intensity once the images are properly registered. For this question, you should use `MyDeform` – either your own version, or the one supplied. The meaning of the argument `p` is determined by the function `MyDeform`. Your registration function should use either gradient-descent or fixed-point iteration to minimize the SSD cost function.

To test your method, create a Matlab script that demonstrates your method. The script (called `test_nonrigid_reg.m`) should read in one of the images used in class and deform it slightly using some chosen parameters. The script should call your `NonrigidReg` function to register the original image to the deformed image, and produce parameters close to those used to produce the deformed image.

What do I submit?
Your submission should consist of the following files:

1. `RigidRegLS.m`
2. `NonrigidReg.m`, `MyDeform.m` and `test_nonrigid_reg.m` if you are registered for CS 673

Place these files in a directory, zip up the directory, and submit the zip file to the Drop Box.