This Readme describes how to use the Facial Nucleus Registration scripts.

The Package contains the following folders:

1. Test Inputs: This folder contains the following test files
   1. Contours of Facial Nucleus as an Amira spatial graph file.
   2. Locations of whisker motor neurons from a retrograde tracer injection experiment (where tracer was injected into C3 whisker muscle) as an Amira Landmark file.
2. Test Outputs: This folder contains the output files produced by **facialNucleusRegistration.m** which are as follows.
   1. Canonical Axes (with X Axis: Lateral-Medial, Y: Rostral-Caudal and Z: Ventral-Dorsal) as Amira spatial graph files.
   2. Coordinates of cells and FN contours centered at the centroid of the FN contours as an Amira landmark file.
   3. Coordinates of the surface points of the ellipsoid that has been fit to the FN contours (as Amira landmark file) along with its principal axes - X’, Y’, Z’ - whose lengths are equal to their respective radii (as Amira spatial graph file).
   4. Coordinates of the registered cells and FN ellipsoid surface points, which have been registered to the average facial nucleus; written as an Amira landmark file in the facial nucleus local coordinate system (i.e. X’ – Lateral-Medial Axis, Y’: Rostral-Caudal and Z’: Ventral-Dorsal).
   5. Coordinates of the registered cells and FN ellipsoid surface points, which have been registered to the average facial nucleus; written as an Amira landmark file in the canonical coordinate system; along with the principal axes of the average facial nucleus reference frame.
   6. Center, principal axes extent and principal axes orientation of the FN ellipsoid as a csv file.
   7. Centroid, principal axes extent and principal axes orientation of the registered cells as a csv file.
3. Scripts: Scripts are organized into 2 folders.
   1. RegistrationScripts: This folder contains the following registration routines.
      1. facialNucleusRegistration.m: This is the **main registration** script and it calls relevant routines to perform the following. 1) Reads FN contours and cell locations to be registered from Amira. 2) Registers these to the average FN reference frame. 3) Writes the registered FN along with axes, registered cells and related stats.
      2. fitEllipsoid.m: This routine fits an ellipsoid to the FN contours using linear least squares method and returns the center, radii and principal axes along with the surface points of the FN ellipsoid.
      3. RigidTransformation.m: This routine translates inputs to given center; then rotates the given points to the axes provided as inputs; and then scales the inputs to the scaling factor given as input parameter.
   2. IOScripts: This folder contains Matlab routines that read and write files in Amira format as well as write csv files with FN ellipsoid and registered cell information.
      1. readLandmarkFileAmira.m: This routine converts the 3D coordinates from Amira Landmark file format to an Nx3 matrix where N is the number of points.
      2. readPtsSpatialGraphAmira.m: This routine converts the 3D coordinates from Amira SpatialGraph file format to an Nx3 matrix
      3. writeLandmarkFileAmira .m: This routine writes the given list of 3D coordinates as an Amira Landmark file.
      4. writeSpatialGraphLineAmira.m: This routine writes the given list of points as an Amira spatial graph file.
      5. writeRegisteredCellStats.m: This routine takes registered cell coordinates as input and writes a csv file with the following information. Number of cells, Volume of the convex hull occupied by the cells, distance from FN center, centroid coordinates, principal axes extents and directions (in degrees).
      6. writeFNEllipsoidStats.m: This routine takes FN surface coordinates as input and writes a csv file with the following information: centroid coordinates, extents and directions of principal component axes, volume covered by the FN ellipsoid.

The following table summarizes the registration process while running the script facialNucleusRegistration.m. It indicates the sequence of operations involved as well as routines called for each operation along with their Inputs and outputs.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| # | Operation | Script name | Inputs | Outputs |
|  |  |  |  |  |
| 1. | Read the Facial Nucleus contours. | readPtsSpatialGraphAmira.m | FN contours file path | FN contours as an Nx3 data matrix |
|  | Read the Locations of the cells that need to be registered. | readLandmarkFileAmira.m | Cell file path | Cell Coordinates as an Nx3 data matrix |
|  | Approximate the FN contours by an Ellipsoid and get its center, direction and extent of principal axes. | fitEllipsoid.m | FN contours as an Nx3 data matrix | Surface coordinates of the ellipsoid fit (Nx3), Center, Radii, Orientation of principal axes. |
|  | Perform rigid transformation to register cells to Average FN reference frame by centering, rotating and scaling. | rigidTransformation.m | Coordinates of points to be transformed (Nx3), Center for translation (1x3), Axes of rotation as 3 column vectors (3x3), scaling factor | Centered (Nx3), Rotated (Nx3), Scaled (Nx3) coordinates. |
|  | Write the axes of the FN ellipsoid and Average FN ellipsoid (X’, Y’, Z’) as a spatial graph. | writeSpatialGraphLineAmira.m | Starting point of the line (1x3), Ending point of the line (1x3). | Line between given points as a spatial graph file. |
|  | Write the surface points of the FN ellipsoid and cell locations as a Landmark file. | writeLandmarkFileAmira.m | List of 3D coordinates of the points to be written (Nx3) | 3D coordinates of the points as a Landmark file. |
|  | Write centroid coordinates; extents and directions of principal component axes; and volume covered by the FN ellipsoid. | writeFNEllipsoidStats.m | Path of the file to be written, Surface points of the FN ellipsoid (Nx3), extent and orientation of the principal axes. | Input parameters written as a csv file. |
|  | Write centroid coordinates; extents and directions of principal component axes; and volume covered by the registered cells. | writeRegisteredCellStats.m | Path of the file to be written, Registered cell coordinates (Nx3). | Centroid coordinates, Extents and directions of principal component axes, Volume covered by the registered cells written as a csv file. |

**Note**: To reproduce results presented in the ‘TestOutputs’ folder perform the following:

* Download the FNRegistrationScripts.zip and unzip it.
* Start Matlab and add the unzipped ‘FNRegistrationScripts’ folder and its subfolders to Matlab active path as follows:
  + In the Matlab file browser enter the path for unzipped folder ‘FNRegistrationScripts’.
  + Now ‘FNRegistrationScripts’ folder will appear in the ‘Current Folder’ window of Matlab.
  + Right click on ‘FNRegistrationScripts’ and select ‘Add to Path’ from the drop down menu; then click ‘selected folders and subfolders’ option.
* Make sure the output folder ‘TestOutputs’ is writable by unchecking the read only option.
* Run the registration script located: ‘FNRegistrationScripts\Scripts\RegistrationScripts \facialNucleusRegistration.m file.
* Now, output folder must contain the results same as in the shipped ‘TestOutputs’ folder.
* In order to provide your own input, change the input and output paths at the beginning of facialNucleusRegistration.m file and run the script.