HSNE Demo

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Purpose

This demo illustrates the capabilities of the nptsne HSNE wrapping combined with *nptsne.hsne_analysis* classes for visual analytics support. The demo application is a Qt based GUI for the analysis of multidimensional data. It allows a user to create or load an HSNE hierarchy using the *nptsne.HSne* class and then navigate the HSNE model using the supporting *AnalysisModel* and *Analysis* classes in the *nptsne.hsne_analysis* sub module.

A number of pre-packages demos provide a quick start to the application.

Installing

```
> # Unpack data on linux
> python ../unpack_data.py
> # or unpack data on windows
> python ..\unpack_data.py
> pip install -r requirements.txt
```

Running

```
> python hsnedemo.py
```

Usage

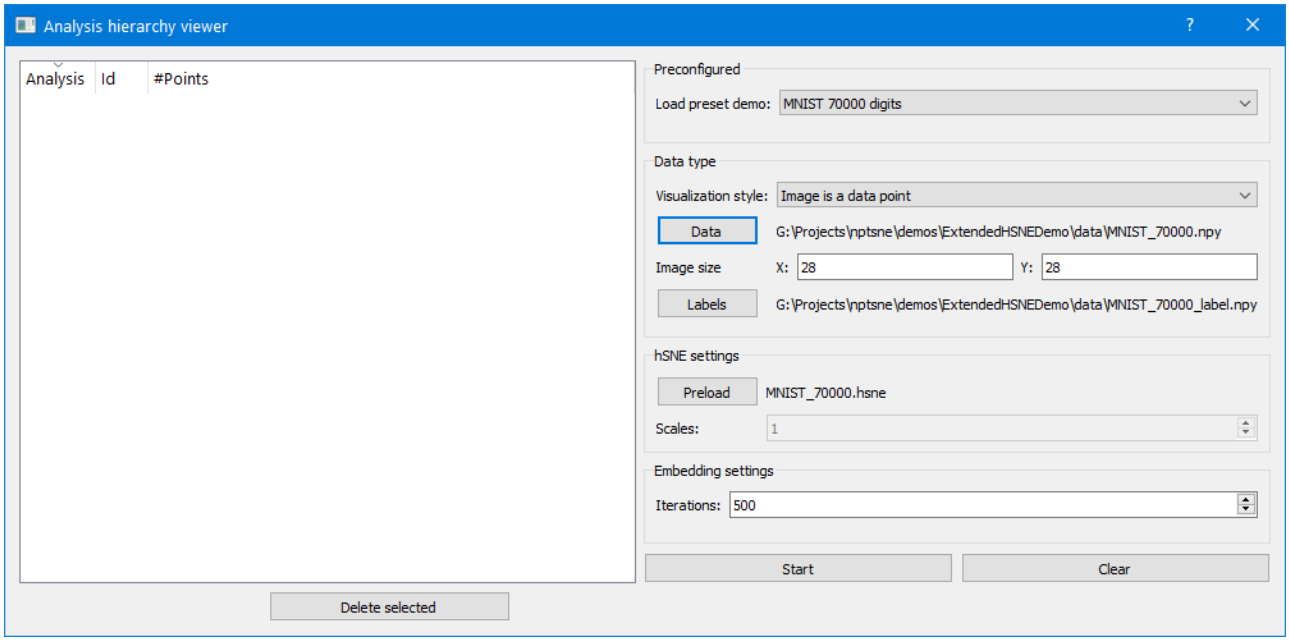
Summary prepackaged data

The demo comes with 3 types of pre-packaged data. If your own data matched one of these types it can be imported in to the demo software. For more information see below.

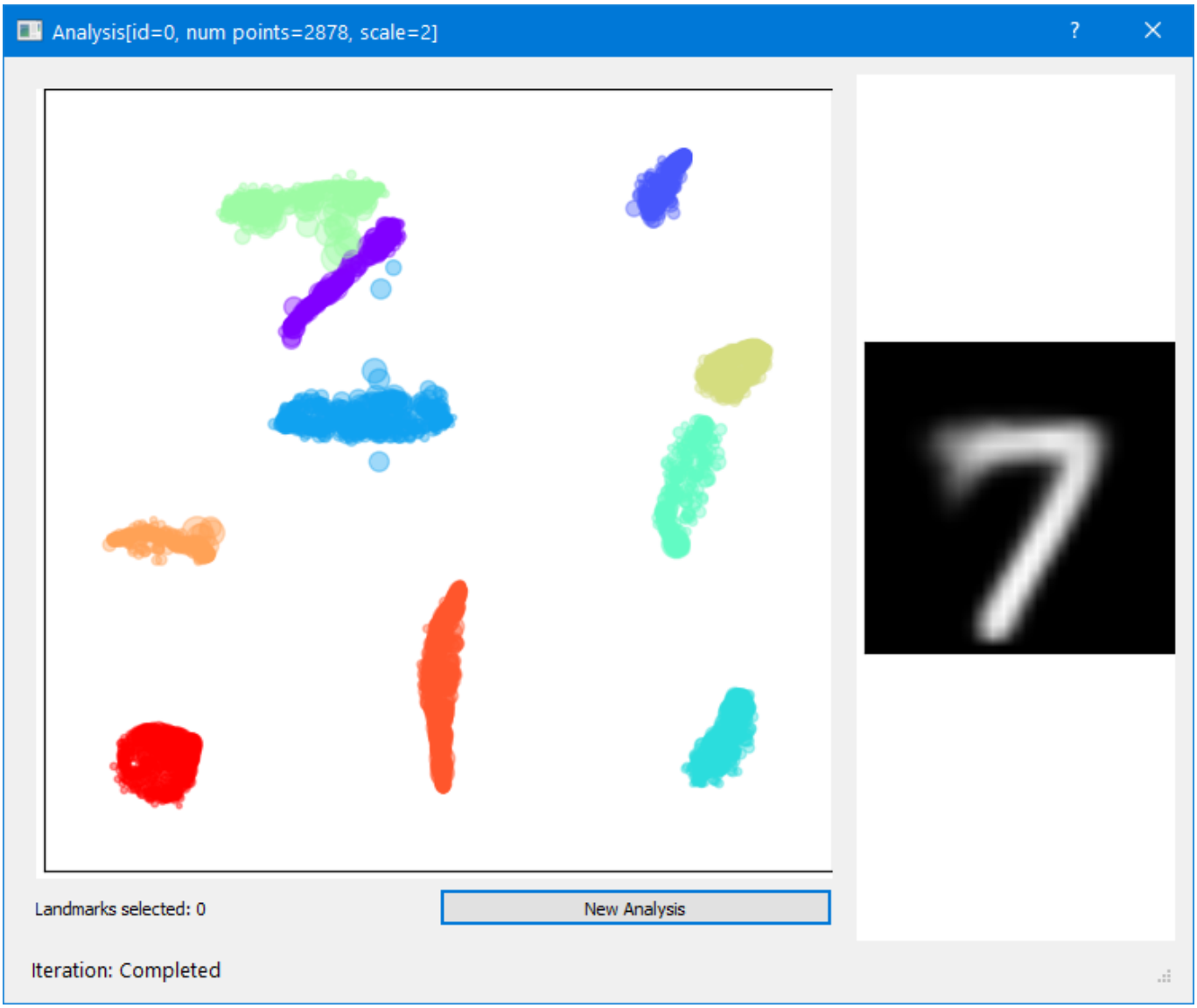
Demo name	Data type	Description
MNIST 70000 digits	Image is data point	MNIST style data
MTG cell data	Point and metadata	Multidimensional points with associated metadata
Hyperspectral sun (512x512)	Hyperspectral image	Each pixel has multiple values
DC Mall (hyperspectral)	Hyperspectral image	Each pixel has multiple values

MNIST: data point is image

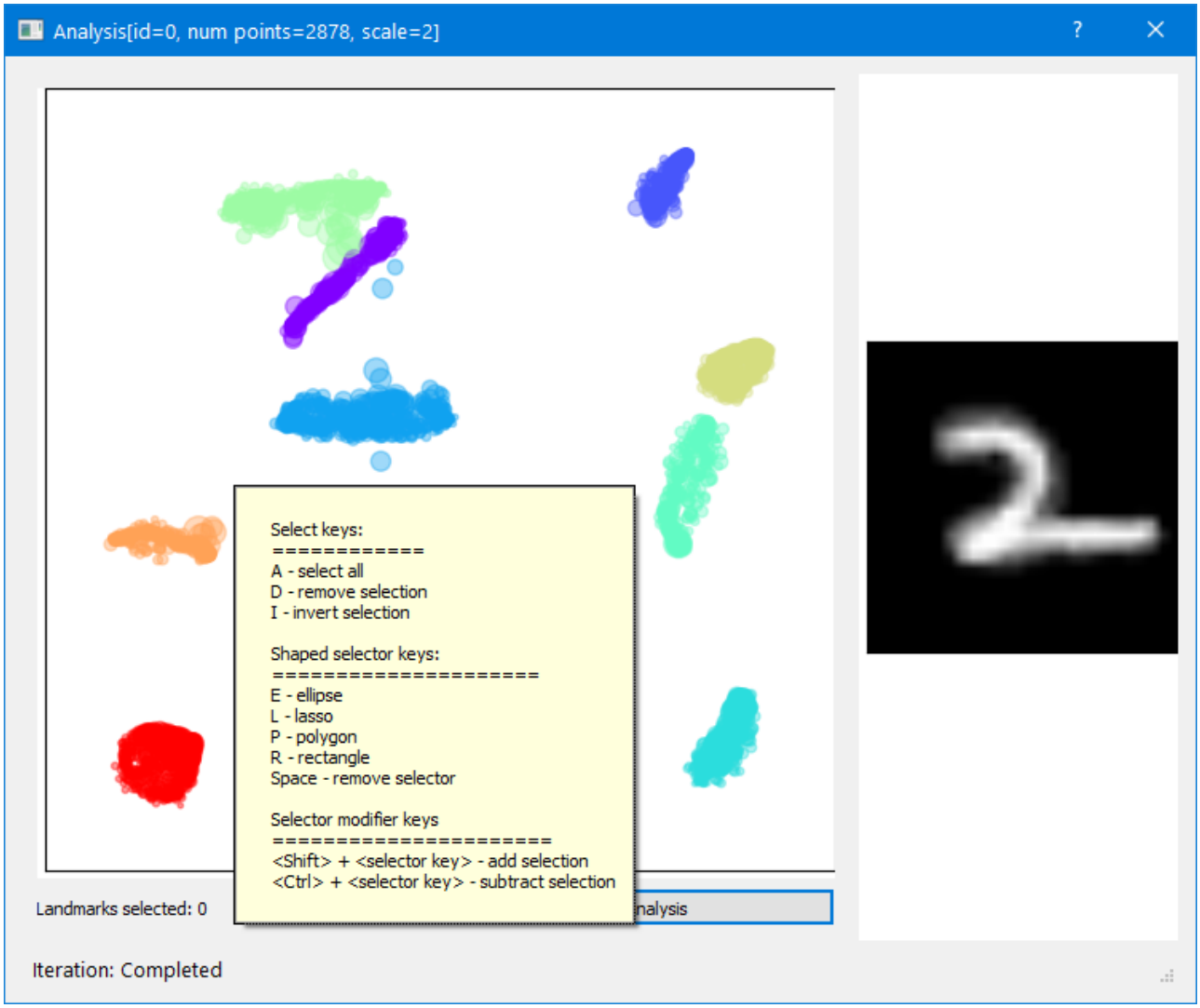
1. Select a **MNIST 70000 digits** from the **Load preset demo** list. The data type and information concerning the demo will be loaded.



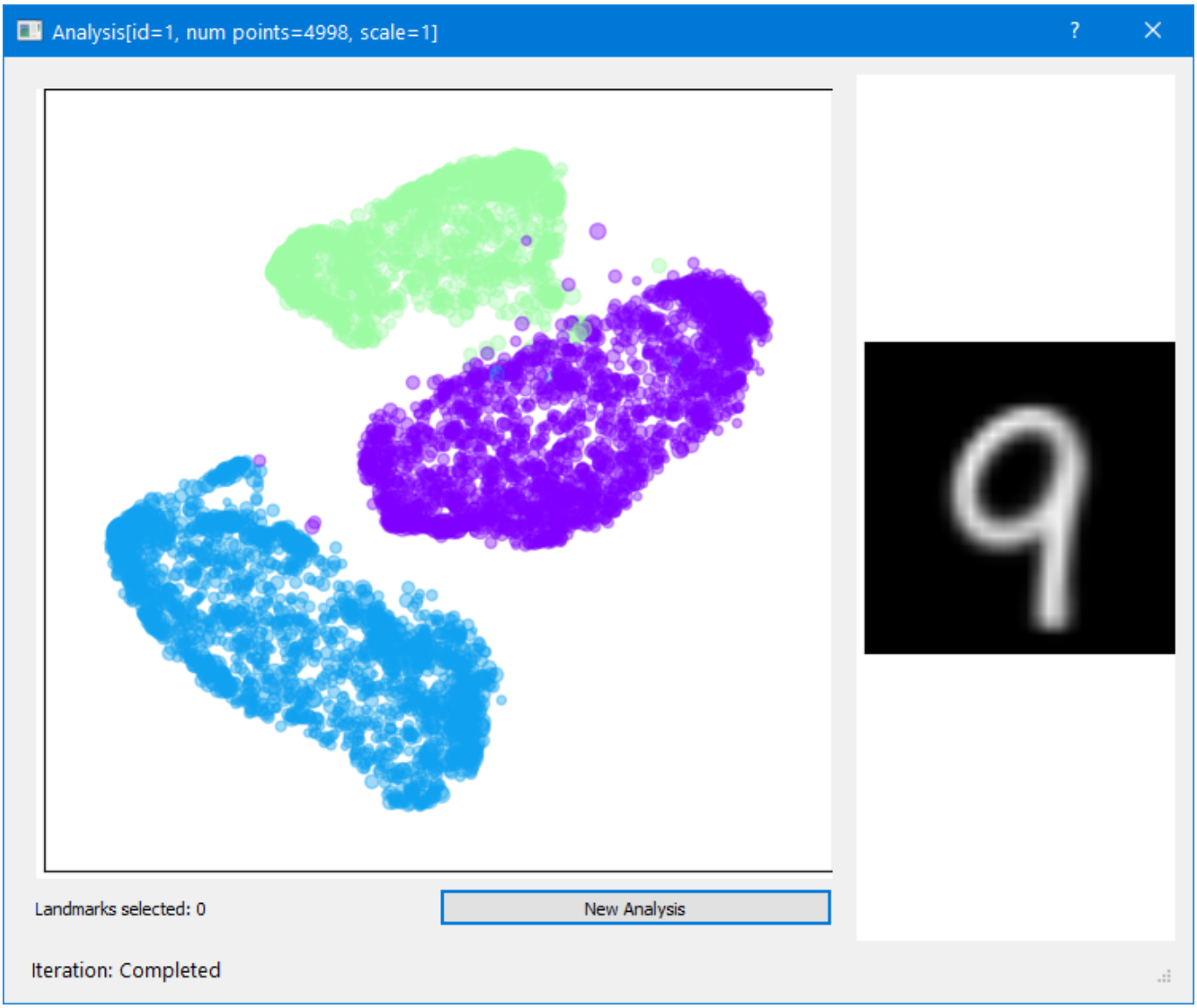
2. Click **Start** and the top-level Analysis embedding will be created.


Analysis[id=0, num points=2878, scale=2]
Landmarks selected: 0
New Analysis
Iteration: Completed

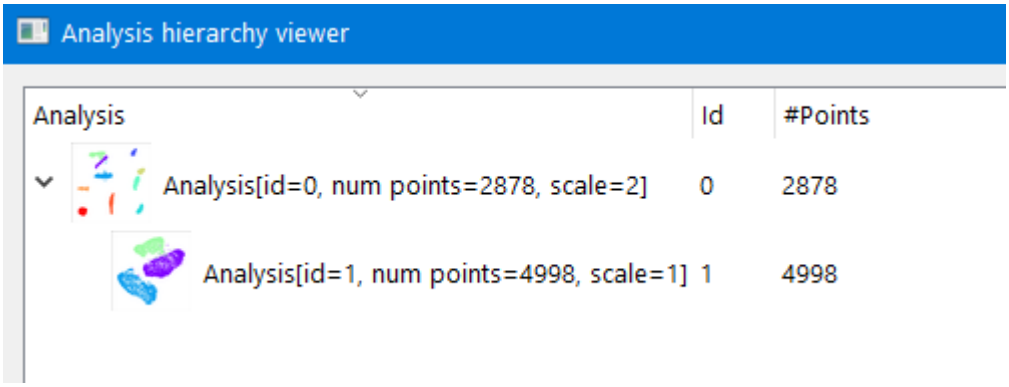
3. Use the select keys to start a selection operation



Then click **New Analysis**. 4. A new embedding is created for the chosen points at a more fine grained HSNE scale.



5. Meanwhile the ModelGui is updated to reflect the hierarchy.



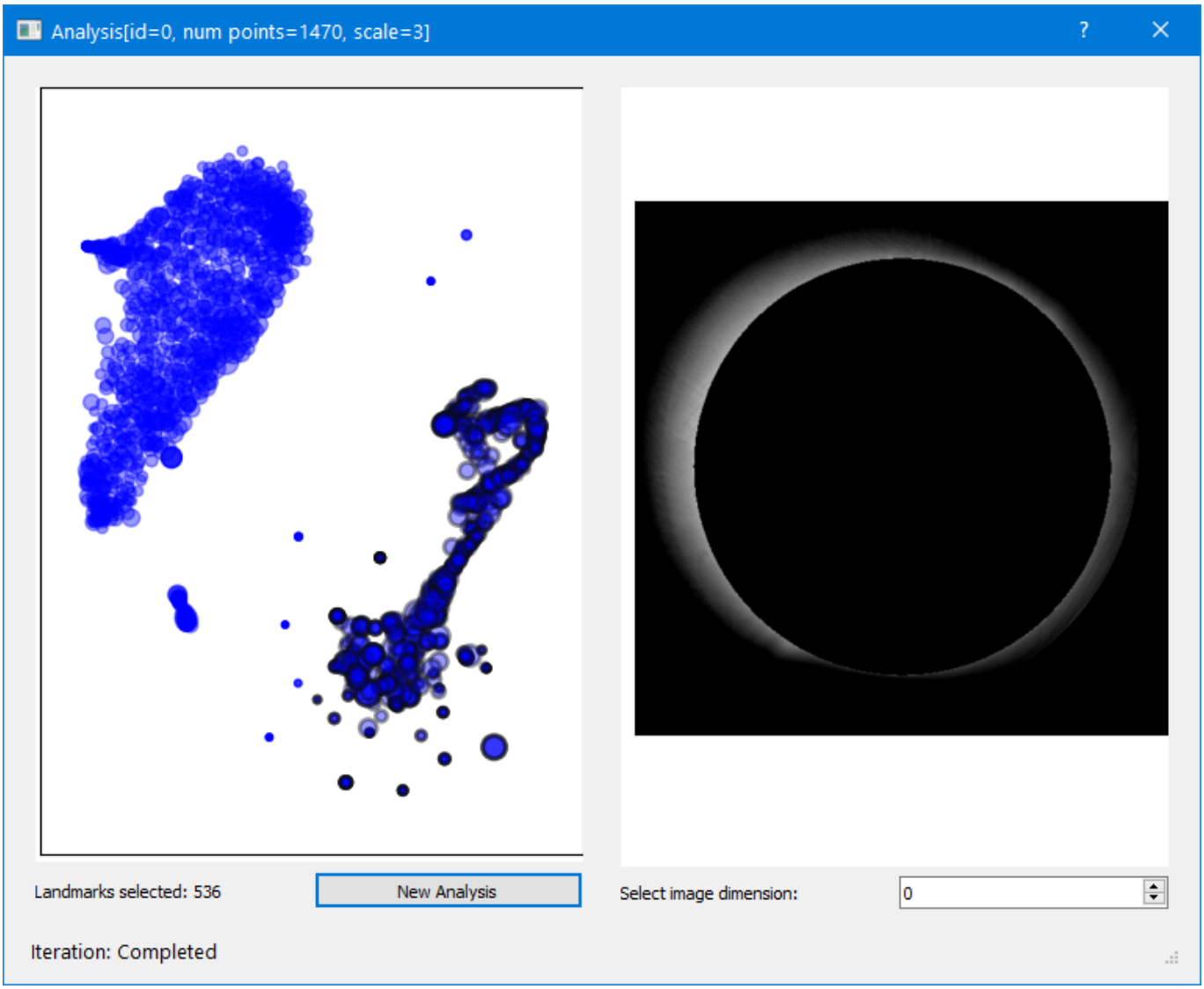
6. Analyses can be brought to the front by clicking in the ModelGui. Once selected in the ModelGui and Analysis and its sub-analyses can be deleted.

Sun: hyperspectral image

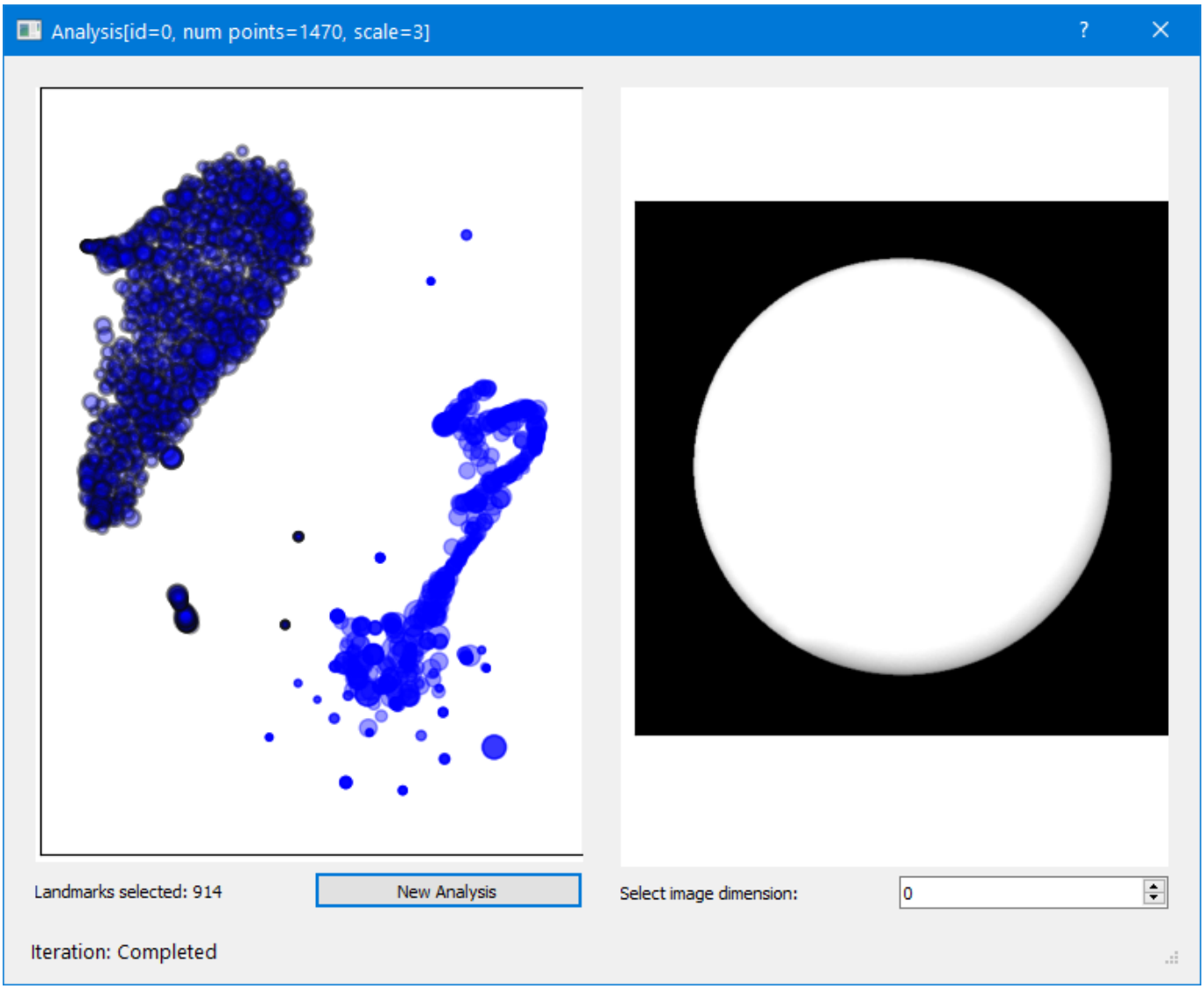
1. Before loading new data restart the program.

2. Load the **Hyperspectral sun (512x512)** data. Two clusters emerge representing

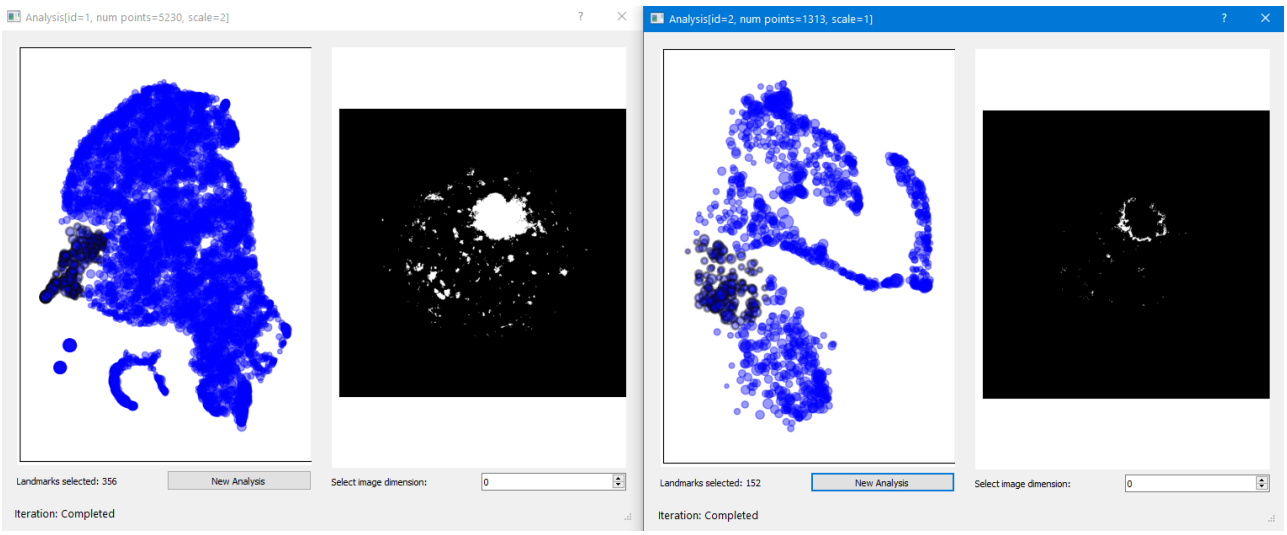
the background pixels (including the corona)



or the photosphere



3. Selecting the photosphere for analysis reveals structure in the cluster allowing us to extract (using lasso selector) and examine details at further sub levels



MTG: point and metadata example

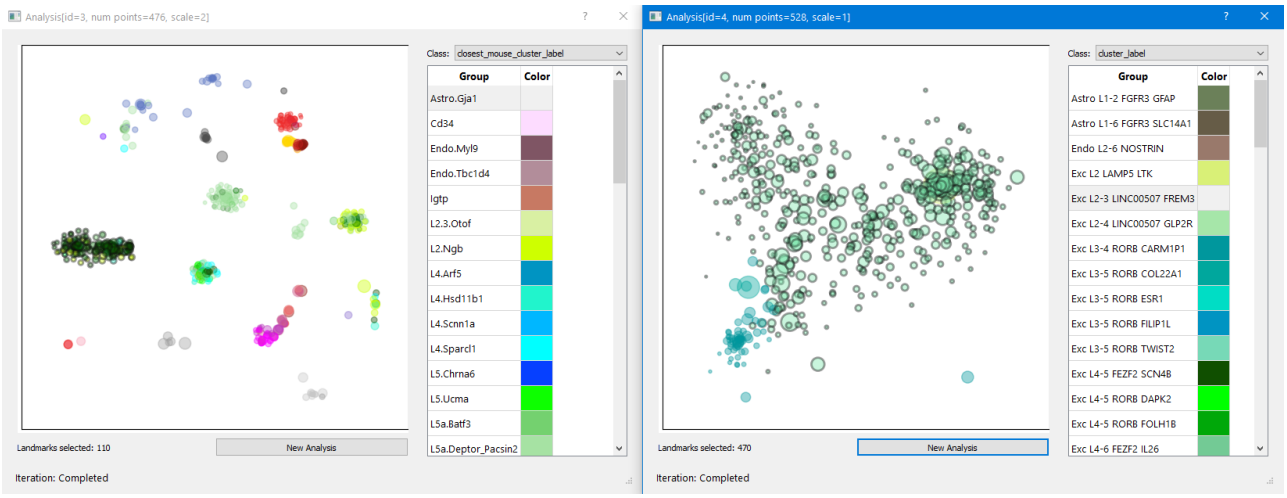
1. Before loading new data restart the program.

2. Load the **MTG cell** data*

3. The analysis immediately reveals multiple well separate clusters some of which have a clear link with cluster labels (select the cluster label in the table - in this case the Exc L3-5 RORB ESR1 cluster label strongle associated with the group below center)

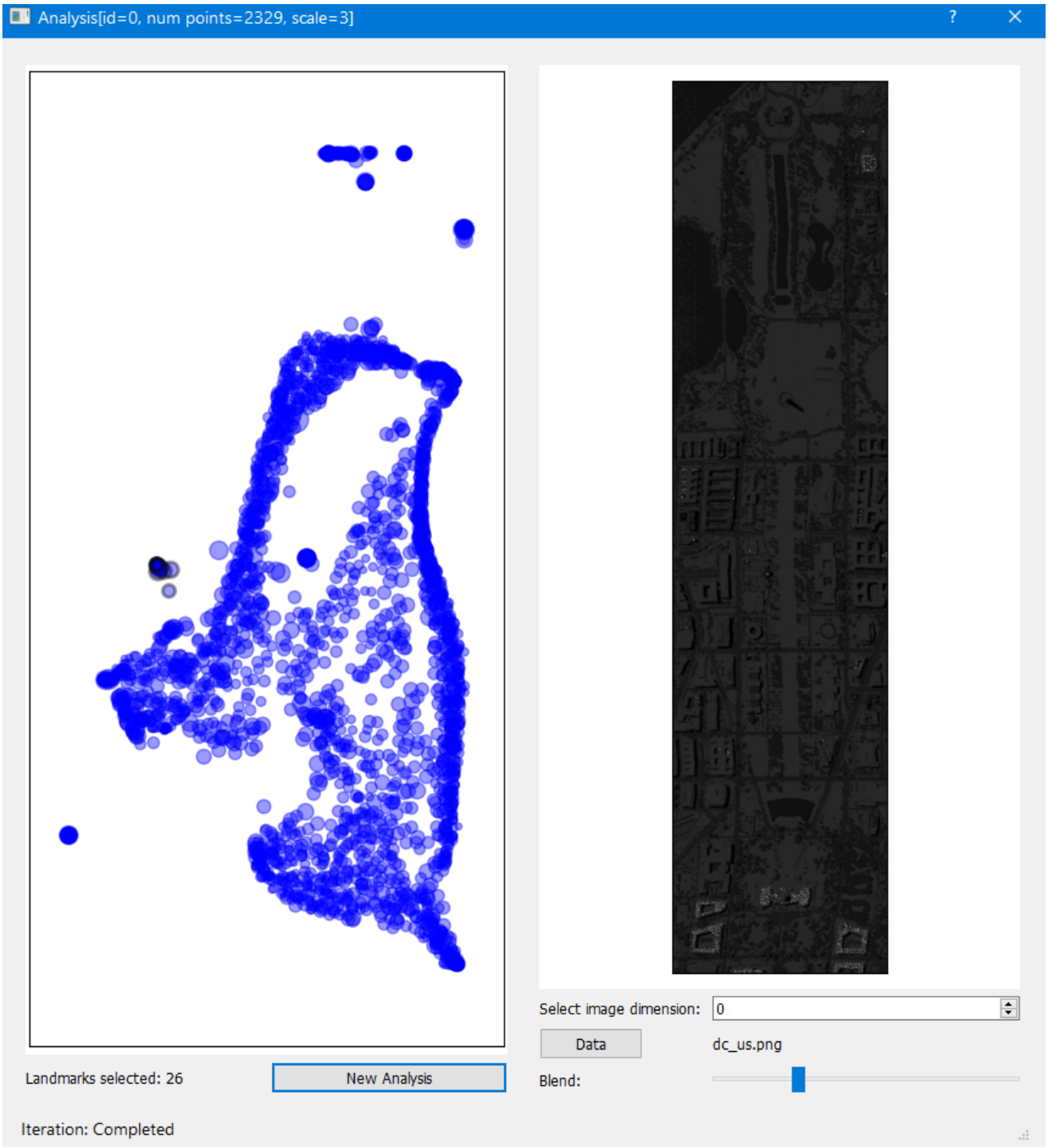
    Selected cluster label

4. Selection of othe label groubs and sub analyses are possible

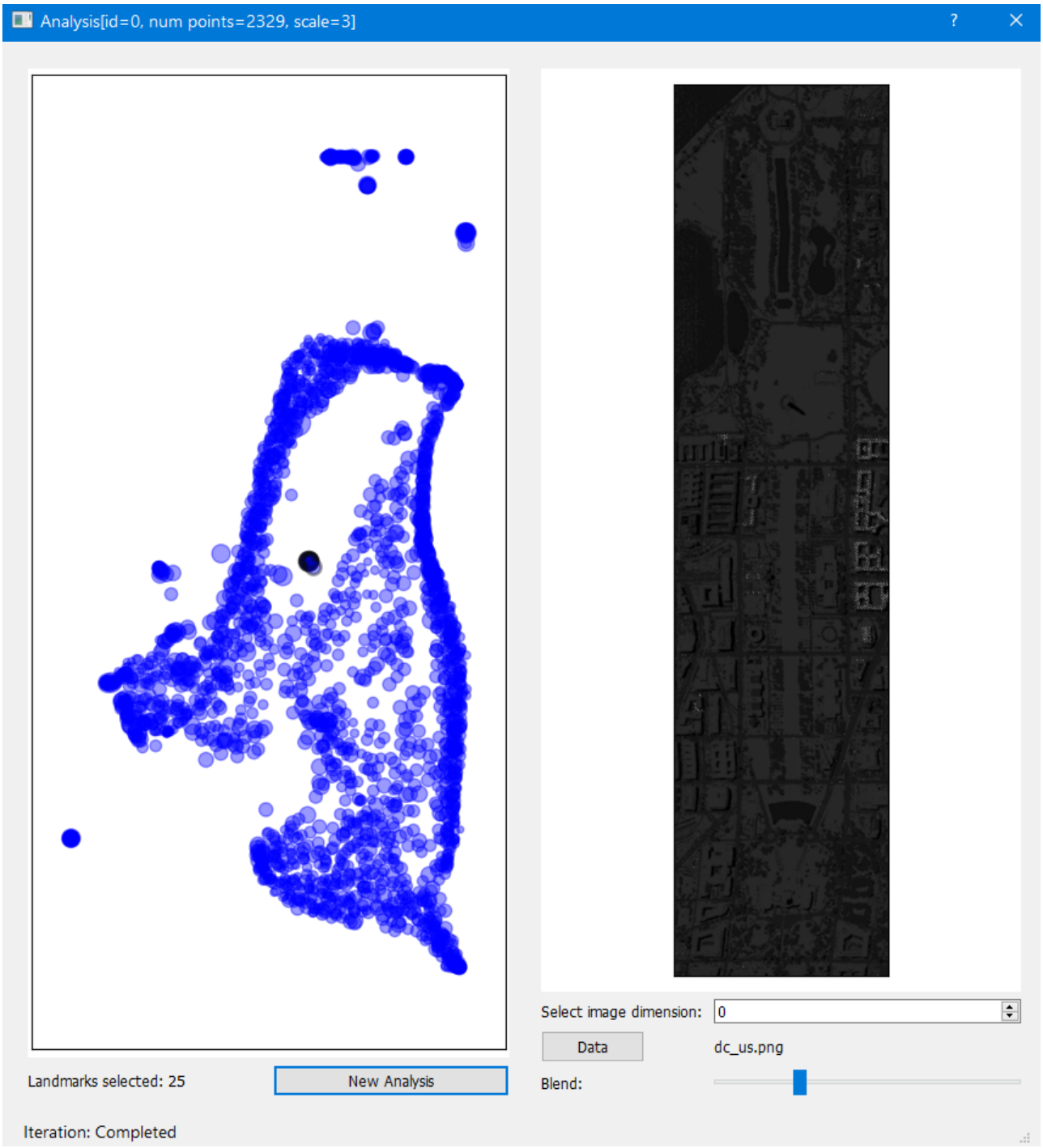


DC Mall: Large hyperspectral example

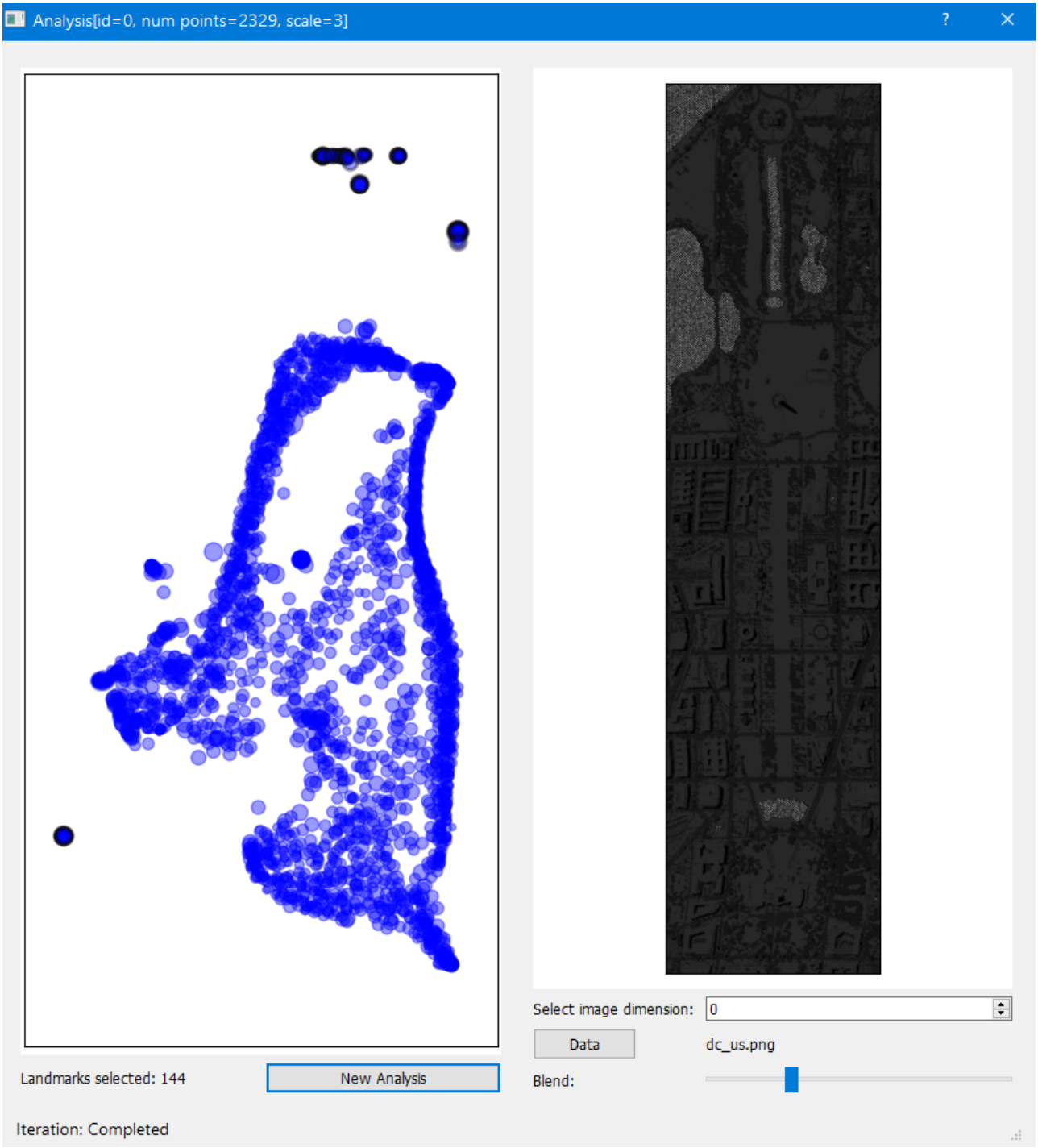
1. Before loading new data restart the program.
2. Load the **DC Mall hyperspectral** data
3. Load the dc_us.png image as background and select a blend level.
4. Moving the cursor over the top level of the HSNE reveals a number of interesting clusters
5. Copper roofs: including the US Capitol (bottom center) and the National Academy of Sciences building (top right)



6. Terracotta tile roofs: including the Herbert C. Hoover building, the US EPA building (right hand side half-way down).



7. Water features. The Lincoln Memorial Reflecting Pool, Potomac River, Tidal inlets and other water features mostly form distinct clusters. All the clusters have been selected here using the add selection feature.



8. Use the blend slider to increase/decrease background visibility to help locate the highlighted areas.

Using your own data

You can load your own data files if they correspond to one of the supported data types. Data must be first converted to a numpy array and then saved using the .npy format (see numpy documentation specifically *numpy.save*)

In detail these types are as follows:

Data types

1. **Image is a data point:**
   Single data file

- npy file - shape = (<number_of_images>, <number_of_pixels>)

2. **Point and metadata**
   Two data files

- npy file for point data - shape = (<number_of_points>, <number_of_dimensions>)
- csv file containing an id followed by pairs of label + color columns

```
id   label0 color0   label1 color1   ---   labelN colorN
.    ...    ...      ...    ...      ---   ...    ...
.    ...    ...      ...    ...      ---   ...    ...
```

3. **Hyper-spectral image**
   Single data file

- npy file - shape = (<number_of_images>, <number_of_pixels>)

Data conversion

For the DC Mall data an offset was applied to the original tiff values to make everything positive and the result was converted to uint32. The 'us' in the filename stands for unsigned.

Loading a precalculated .hsne file

A pre-calculated HSNE model can be saved and read from a file with the **.hsne** extension.

Architecture

For the benefit of developers a short summary of the demo architecture is given here.

There are two main GUI elements:

1. The ModelGui displaying the load controls and the hierarchy of analyses
2. The AnalysisController, one or more dialogs containing the interactive embedding plot widget for an analysis and an associated viewer widget for image or meta-data.

Once data is loaded an initial AnalysisController dialog is displayed for the top level analysis containing all the top scale points.

Software Components

Component	Type	Function
ModelController	Control	Creates the main Qt app and coordinates the creation of an *HSNE* analysis and the navigation of the *nptsne.hsne_analysis.AnalysisModel* and the creation of new *nptsne.hsne_analysis.Analysis* instances. Starts the *ModelGui*

Component	Type	Function
ModelGui	GUI	Displays the hierarchy of *nptsne.hsne_analysis.Analysis* instances in the *AnalysisModel*. Permit deletion of analyses.
AnalysisController	Control & GUI	Controls creation of a new *nptsne.hsne_analysis.Analysis* based on a user selection. Creates an embedding for the *nptsne.hsne_analysis.Analysis*. Starts the *EmbeddingGui* to display the *nptsne.hsne_analysis.Analysis*. Next to the *EmbeddingGui* the appropriate (depending on data type) Viewer GUI is displayed
EmbeddingGui	Widget	Display an interactive scatter plot for the *nptsne.hsne_analysis.Analysis* embedding. Supports multiple selection options: Select brush: *Rectangle:* **R**, *Ellipse:* **E**, *Lasso:* **L**, *Polygon:* **P** *Clear* **<space>** Select function: *Select All:* **A**, *Remove Selection:* **D**, *Invert Selection:* **I** Select modifiers: *Add* **<shift>+<key>**, *Subtract:* **<ctrl>+<key>**
CompositeImageViewer	Widget	View an image based on a user selection in the *EmbeddingGui* where the data represents one image per point (e.g. MNIST)
HyperSpectralImageViewer	Widget	View a hyperspectral image based on selections in the *EmbeddingGui*. For Hyperspectral data.
MetaDataViewer	Widget	Table view of meta data base on user selection in the *EmbeddingGUI*
ConfigClasses	Data	Data containers for application configuration
DemoConfig	Data	The config for this application

Data sources

MNIST Data - retrieved from mnist-orignal.mat (https://github.com/amplab/datascience-sp14/raw/master/lab7/mldata/mnist-original.mat) a Matlab format data file derived from the original Yann LeCun MNIST data base at http://yann.lecun.com/exdb/mnist/

Hyperspectral Solar Images - downloaded from the Solar Dynamics Observatory as in the original Hierarchical Stochastic Neighbor Embedding paper.

MTG cell data - 15603 cell samples from the human middle temporal gyrus with single-nucleus transcriptomes. Data is derived from the complete set at Allen Institute for Brain Science

DC Mall data - downloaded from the Purdue University MultiSpec(c) page. The original 191 band hyperspectral data was created by the Spectral Information Technology Application Center of Virginia.