Testing of Img Utils (Data Engineering & Exploration)

Michael Janus, May/June 2018

Goal of this notebook is to test and validate the functions in **imgutils**, which functions as the infrastructure for the data engineering and exploration. For most functions, there are test-functions in **imgutils_test**, which also show how to use the functions together.

1. Import the used modules, including the one with test functions:

In [1]:
```
import warnings
warnings.filterwarnings("ignore", category=DeprecationWarning)

import matplotlib

import imgutils
import imgutils_test as tst
```

In [2]:
```
# Re-run this cell if you altered imgutils or imgutils_test
import importlib
importlib.reload(imgutils)
importlib.reload(tst)
```

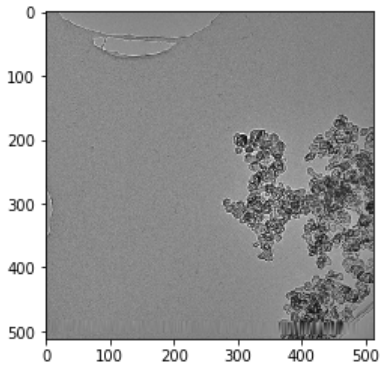
Out[2]:
```
<module 'imgutils_test' from 'C:\\JADS\\SW\\Grad Proj\\realxtals1\\sources\\imgutils_test.py'>
```

2. Test the basic image IO and display

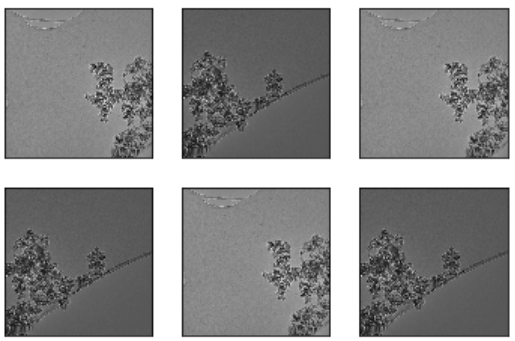
In [3]:
```
tst.test_scanimgdir()
```

```
<bound method NDFrame.head of          filename
0  testimage1.tif
1  testimage2.tif>
```

In [4]:
```
tst.test_loadandshowimg()
```



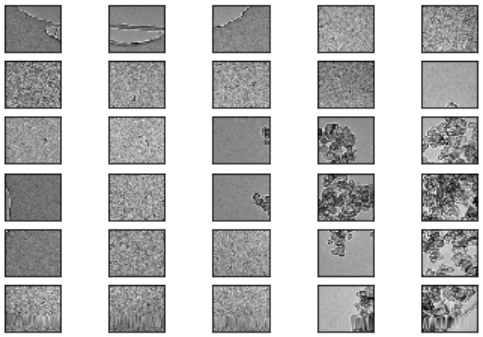
In [5]:
```
tst.test_loadandshowimgs()   # shows array of images
```



3. Test image slicing

The image slice functions cut-up an image into sub-images. The test function loads an image, slices it up and shows the array of images

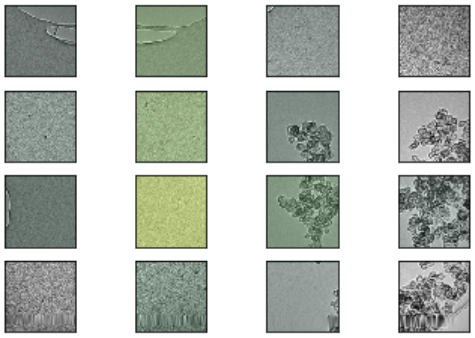
In [6]:
```
tst.test_sliceimage(6,5)
```



4. Test the heatmap display

The heatmap slices up an image and overlays a heat color over the image slice. The test function uses fake heats

In [7]:
```
tst.test_heatmap()
```



5. Test the slice statistics functions

There are individual functions to return the statistics of an image. The **slicestats()** function combines image slicing and

In [8]:
```
# first test dataframe stuff without statistics:
df1 = tst.test_slicestats_df()
df1.head()
```

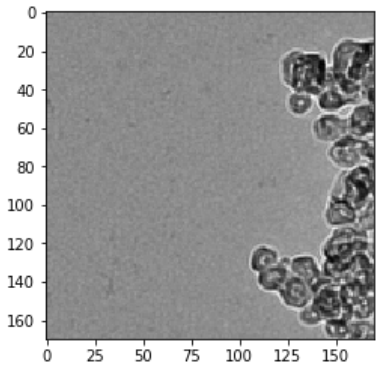
```
          filename  s_y  s_x  n_y  n_x     alias
0  testimage1.tif    0    0    3    3  img0_0-0
1  testimage1.tif    0    1    3    3  img0_0-1
2  testimage1.tif    0    2    3    3  img0_0-2
3  testimage1.tif    1    0    3    3  img0_1-0
4  testimage1.tif    1    1    3    3  img0_1-1
```

Out[8]:

	filename	s_y	s_x	n_y	n_x	alias
0	testimage1.tif	0	0	3	3	img0_0-0
1	testimage1.tif	0	1	3	3	img0_0-1
2	testimage1.tif	0	2	3	3	img0_0-2
3	testimage1.tif	1	0	3	3	img0_1-0
4	testimage1.tif	1	1	3	3	img0_1-1

n_y and n_x are the number of slices in the image in y and x direction; (s_x, s_y) is the slice index

In [9]:
```
# get a single slice from this dataframe:
sliceimg = imgutils.getimgslice(df1, 4)
imgutils.showimg(sliceimg)
```



In [10]:
```
# test the  image statistics functions:
tst.test_statfuncs(sliceimg)
```

```
min:  49.0
max:  233.0
range:  184.0
median:  150.0
mean:  147.05726643598615
std_dev 18.091440389449318
```

Now test the function that combines slicing and statistics:

In [11]:
```
df2 = tst.test_slicestats()
```

	filename	s_y	s_x	n_y	n_x	alias	img_min	img_max	img_mean	img_std
0	testimage1.tif	0	0	4	4	img0_0-0	101.0	203.0	148.400574	6.343692
1	testimage1.tif	0	1	4	4	img0_0-1	96.0	196.0	147.171631	6.953719
2	testimage1.tif	0	2	4	4	img0_0-2	110.0	170.0	145.544128	3.665071
3	testimage1.tif	0	3	4	4	img0_0-3	131.0	154.0	143.726807	2.920801
4	testimage1.tif	1	0	4	4	img0_1-0	122.0	167.0	148.858826	3.525009
5	testimage1.tif	1	1	4	4	img0_1-1	125.0	164.0	148.931152	3.505057
6	testimage1.tif	1	2	4	4	img0_1-2	49.0	233.0	145.732849	20.939712
7	testimage1.tif	1	3	4	4	img0_1-3	56.0	194.0	141.968079	21.179727

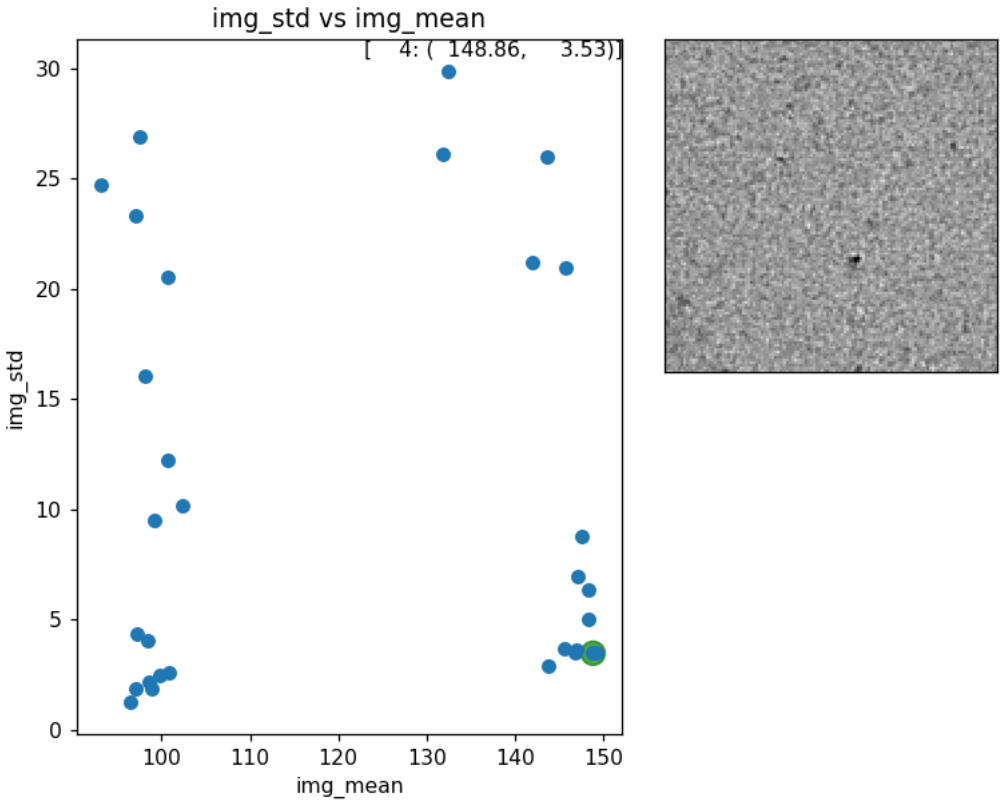
6. Test the visualization of stats (interactive graph with image display)

This is based on a matplotlib graph with events hooked up to show the image that corresponds to the datapoint when clicked.

Notes:

- This function is not without issues, as it requires a switch to turn on interactivity.
- This sometimes requires restarting the kernel for it to work
- Behavior in e.g. PyCharm is slightly different, only updating when rescaling the graph window
- click the 'standby button' (top-right) to fix it into the notebook (if you don't click it, next graphs replace the one still open)

In [12]:
```
# need to tell matplotlib it's in a notebook, otherwise interactivity does not work
%matplotlib notebook
imgutils.plotwithimg(df2, 'img_mean', 'img_std', imgutils.getimgslice)
```



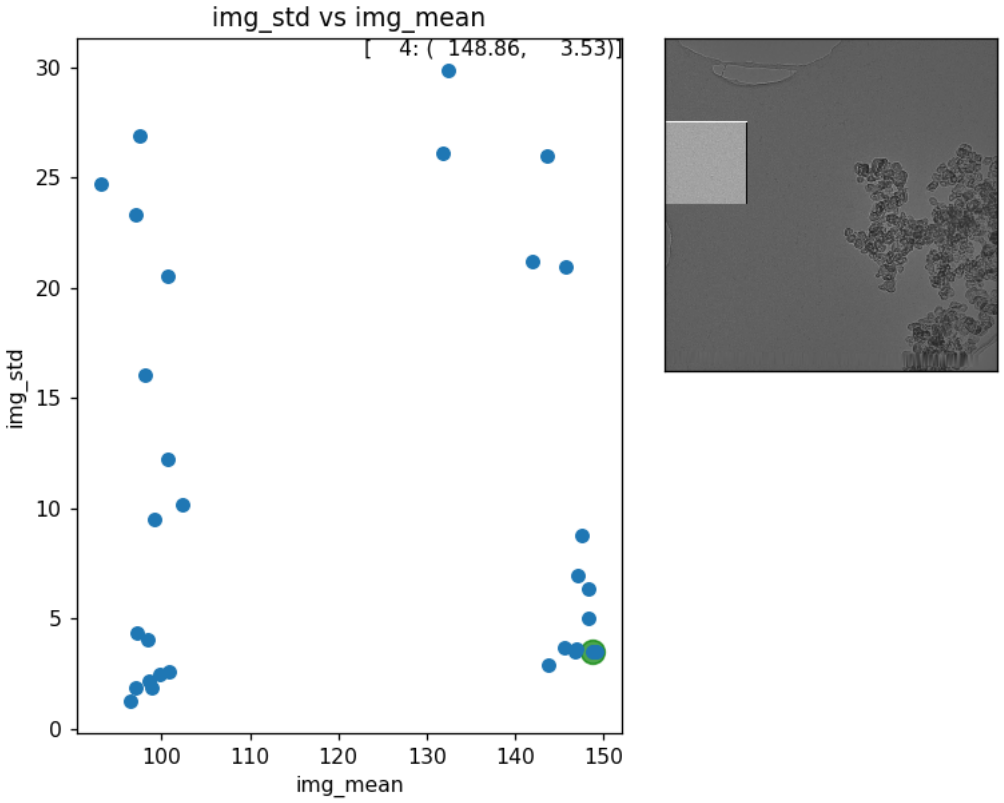
Click on point in lower-right; data point 4 ... is that noise or on a crystal?

Without context (i.e. image surrounding), still hard to judge image!

So I create an alternative image display, which shows the slice in context

(I modified interactive graph plotwithimg so you can inject it with different image display)

In [13]:
```
imgutils.plotwithimg(df2, 'img_mean', 'img_std', imgutils.highlightimgslice, True)
```



Now it's much clearer what the slice of the data point really is.

7. Normalization

The data should actually be normalized to reasonable values. A common way is to use 'standardization' (see https://en.wikipedia.org/wiki/Normalization_(statistics (https://en.wikipedia.org/wiki/Normalization_(statistics))).

In [14]:
```
imgutils.normalize(df2,['img_min'])
df2.head(3)
```

Out[14]:

	filename	s_y	s_x	n_y	n_x	alias	img_min	img_max	img_mean	img_std	|img_min|
0	testimage1.tif	0	0	4	4	img0_0-0	101.0	203.0	148.400574	6.343692	0.723211
1	testimage1.tif	0	1	4	4	img0_0-1	96.0	196.0	147.171631	6.953719	0.578387
2	testimage1.tif	0	2	4	4	img0_0-2	110.0	170.0	145.544128	3.665071	0.983892

In [15]:
```
# check if indeed the mean of standardized column is 0 and has std_dev of 1:
print(df2['|img_min|'].mean())
print(df2['|img_min|'].std())
```

```
-9.8879238130678e-17
1.0
```

Ok (apart from some rounding)

Now apply it to the other columns

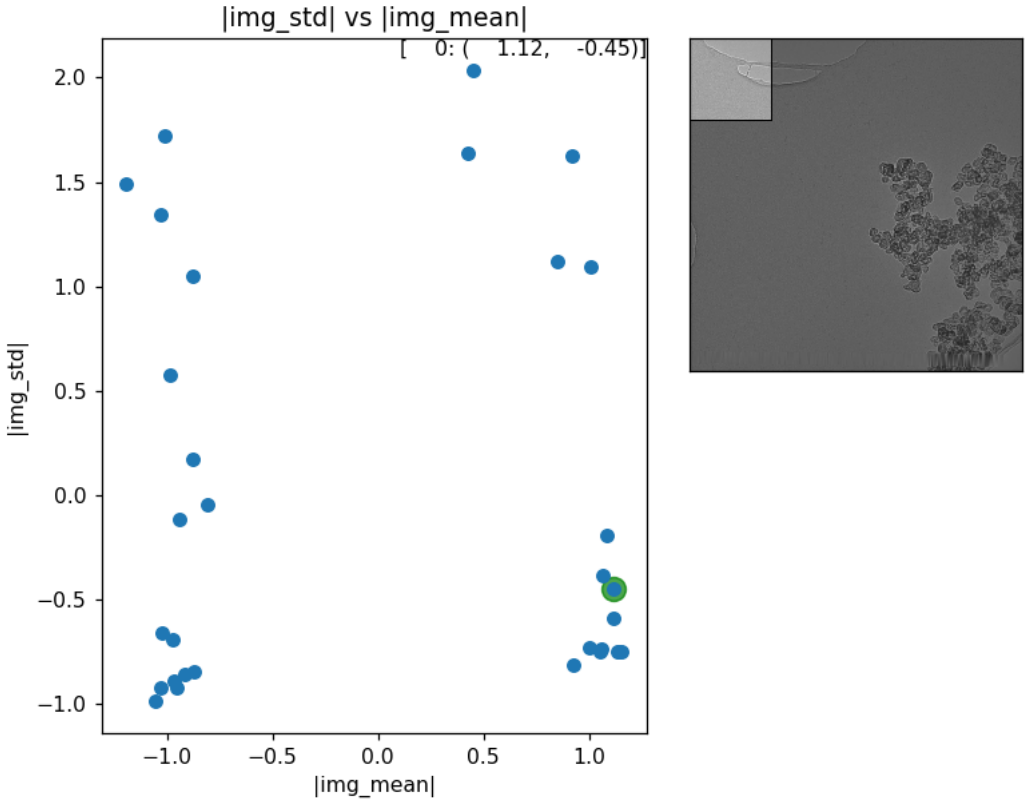
In [16]:
```
imgutils.normalize(df2, ['img_max', 'img_mean', 'img_std'])
df2.head(3)
```

Out[16]:

	filename	s_y	s_x	n_y	n_x	alias	img_min	img_max	img_mean	img_std	|img_min|	|img_max|	|img_mean
0	testimage1.tif	0	0	4	4	img0_0-0	101.0	203.0	148.400574	6.343692	0.723211	0.838037	1.119668
1	testimage1.tif	0	1	4	4	img0_0-1	96.0	196.0	147.171631	6.953719	0.578387	0.664704	1.068205
2	testimage1.tif	0	2	4	4	img0_0-2	110.0	170.0	145.544128	3.665071	0.983892	0.020893	1.000052

Plot the normalized version

In [19]:
```
imgutils.plotwithimg(df2, '|img_mean|', '|img_std|', imgutils.highlightimgslice, True)
```



8. Play more with this test dataset...

Instead of the test-functions, let's use the imgutils functions directly

In [20]:
```
statfuncs = [imgutils.img_min, imgutils.img_max, imgutils.img_range, imgutils.img_mean, imgutils.img_std]
df_imgfiles = imgutils.scanimgdir('', '.tif')
imgfiles = list(df_imgfiles['filename'])
df3 = imgutils.slicestats(imgfiles, 4, 4, statfuncs)
df3.head()
```

Out[20]:

	filename	s_y	s_x	n_y	n_x	alias	img_min	img_max	img_range	img_mean	img_std
0	testimage1.tif	0	0	4	4	img0_0-0	101.0	203.0	102.0	148.400574	6.343692
1	testimage1.tif	0	1	4	4	img0_0-1	96.0	196.0	100.0	147.171631	6.953719
2	testimage1.tif	0	2	4	4	img0_0-2	110.0	170.0	60.0	145.544128	3.665071
3	testimage1.tif	0	3	4	4	img0_0-3	131.0	154.0	23.0	143.726807	2.920801
4	testimage1.tif	1	0	4	4	img0_1-0	122.0	167.0	45.0	148.858826	3.525009

In [21]:
```
imgutils.normalize(df3, ['img_min', 'img_max', 'img_range', 'img_mean', 'img_std'])
df3.head(2)
```

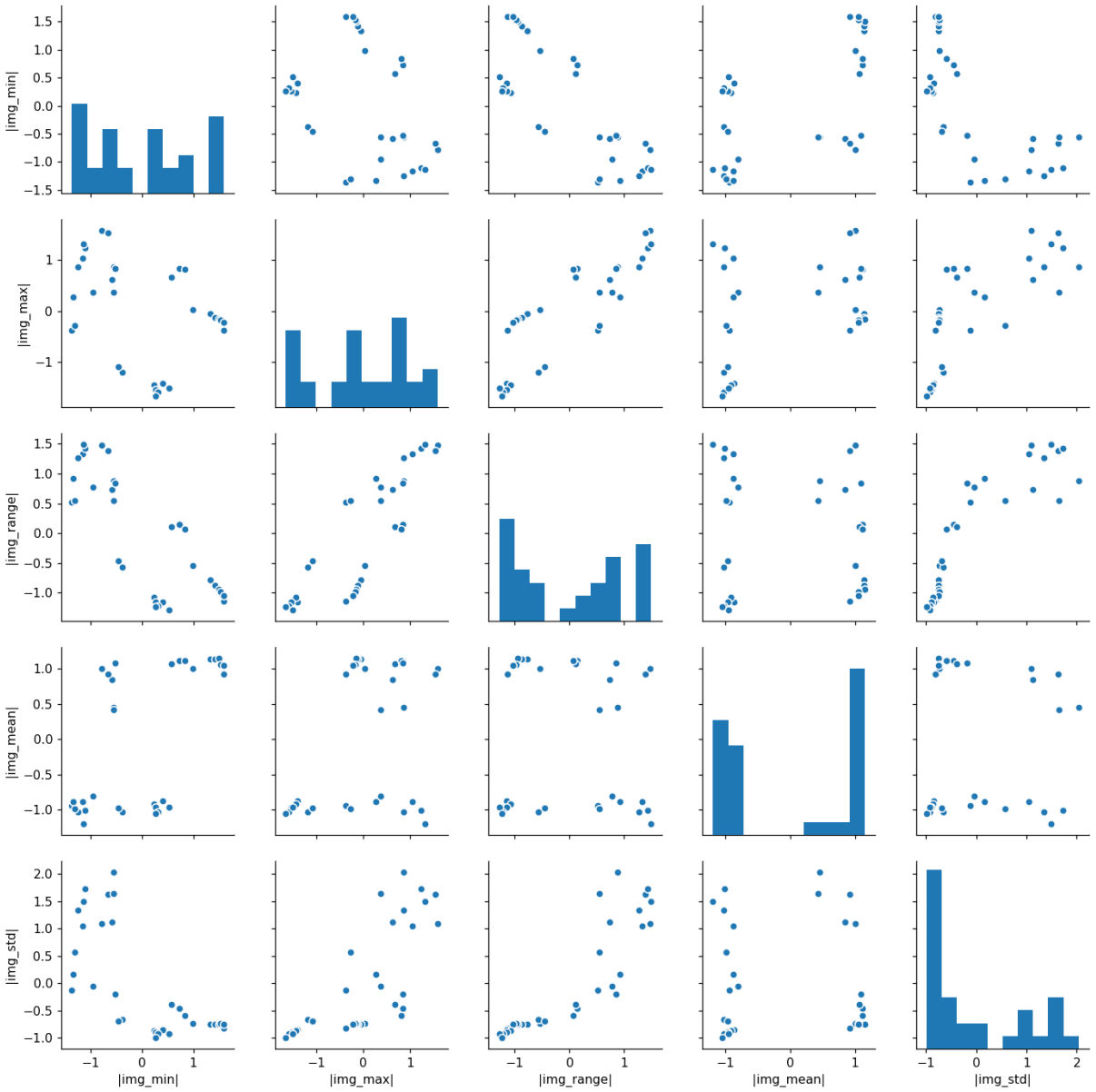
Out[21]:

	filename	s_y	s_x	n_y	n_x	alias	img_min	img_max	img_range	img_mean	img_std	|img_min|	|img_max|
0	testimage1.tif	0	0	4	4	img0_0-0	101.0	203.0	102.0	148.400574	6.343692	0.723211	0.838037
1	testimage1.tif	0	1	4	4	img0_0-1	96.0	196.0	100.0	147.171631	6.953719	0.578387	0.664704

Let's do a 'pair-plot' to see if there something obvious

In [23]:
```
import seaborn as sb
```

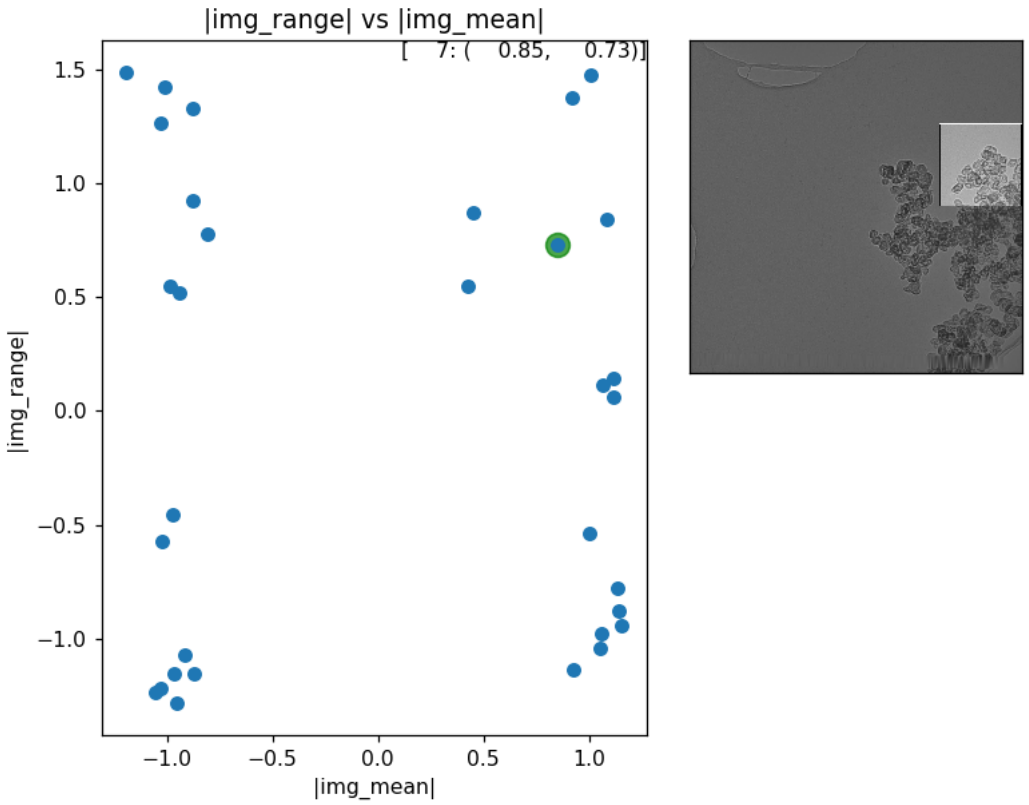
In [24]:
```
sb.pairplot(df3, vars=['|img_min|','|img_max|', '|img_range|','|img_mean|', '|img_std|'])
```



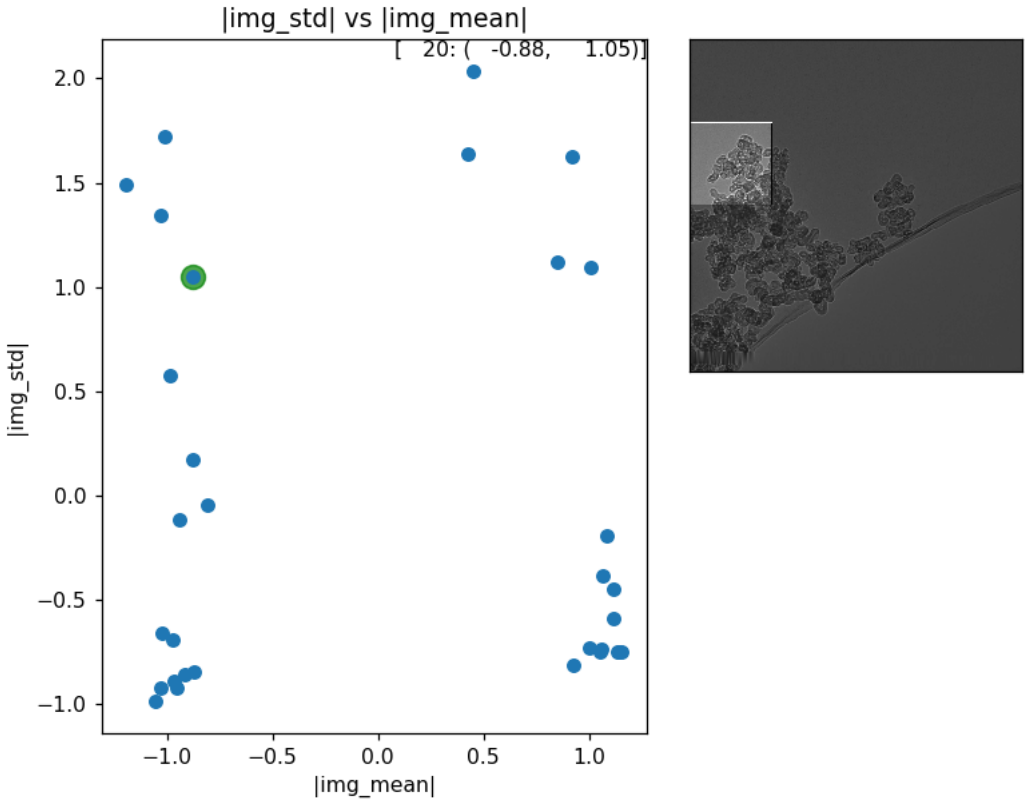
Out[24]: <seaborn.axisgrid.PairGrid at 0xcbc52e8>

Let's inspect some combinations that have 'signs of clustering' in the interactive graph

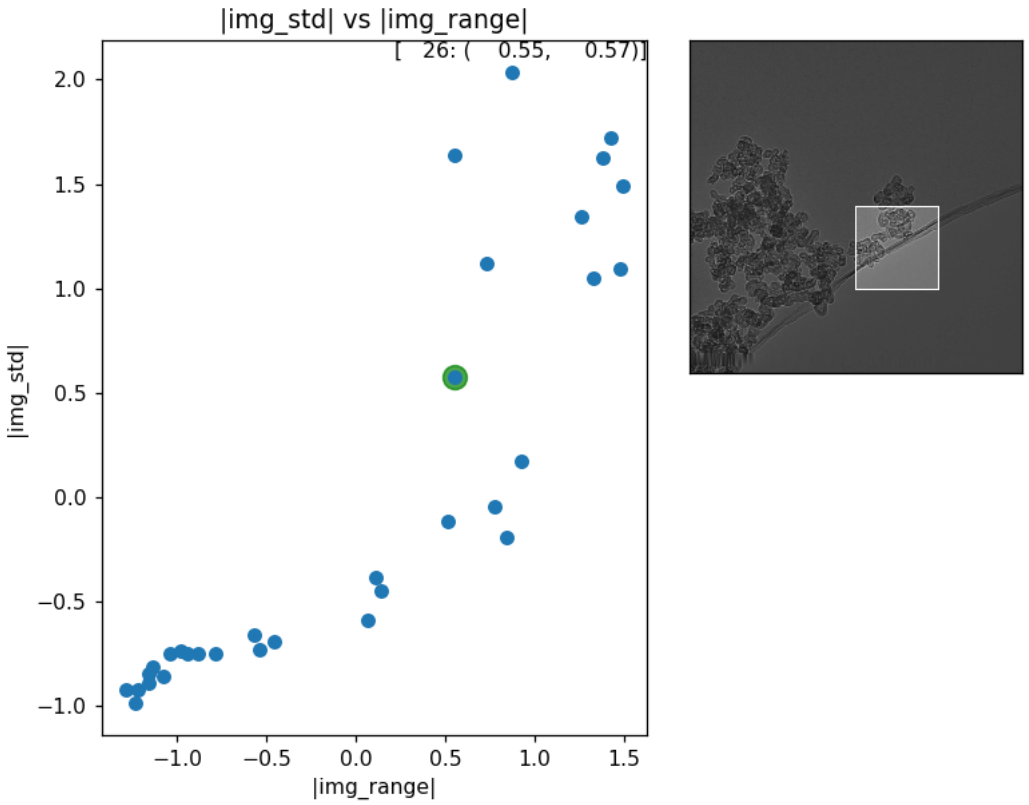
In [25]:
```
imgutils.plotwithimg(df3, '|img_mean|', '|img_range|', imgutils.highlightimgslice, True)
```



In [26]:
```
imgutils.plotwithimg(df3, '|img_mean|', '|img_std|', imgutils.highlightimgslice, True)
```



In [27]:
```
imgutils.plotwithimg(df3, '|img_range|', '|img_std|', imgutils.highlightimgslice, True)
```



9. Conclusions

- Build a number of infrastructural functions for the data engineering and exploration
- This notebook demonstrates how to use these functions
- It also shows with the test images that the concept of using simple statics on sub-images to reveal particles looks promosing!

10. Next steps: Try this out on larger set!

Michael Janus, 14 June 2018