Notebook

March 26, 2021

[1]:
```
dataset_name = 'liu'
```

[2]:
```
%reload_ext autoreload
%autoreload 2
default_figsize=(14,12)
```

[3]:
```
import datasets
import numpy as np
import pandas as pd
import seaborn as sn
import matplotlib.pyplot as plt
import matplotlib
matplotlib.rcParams['figure.figsize'] = (14, 12)


dataset_module = datasets.datasets_by_name_all[dataset_name]
x,y,metadata = dataset_module.load(dropna=True,verbose=True)
y = datasets.map_y_em(y,dataset_name)

# generate dataframe with both x and y
xy = pd.concat([x,y],axis=1)
xy.describe()
```

[3]:

	umag	gmag	rmag	imag	Hamag	Jmag	\
count	281.000000	281.000000	281.000000	281.000000	281.000000	281.000000	
mean	15.111851	14.504733	13.592100	12.929715	13.175018	12.020854	
std	1.816931	1.652762	1.077114	1.025982	1.155292	1.105942	
min	10.980000	10.130000	11.820000	11.100000	11.160000	9.060000	
25%	13.840000	13.140000	12.650000	12.070000	12.100000	11.350000	
50%	14.630000	14.560000	13.580000	12.820000	13.140000	11.810000	
75%	16.180000	15.880000	14.400000	13.660000	14.010000	12.730000	
max	23.710000	18.130000	16.470000	16.310000	16.300000	16.310000	

	Hmag	Kmag	em
count	281.000000	281.000000	281.000000
mean	11.785267	11.635587	0.341637
std	1.167985	1.205151	0.475105

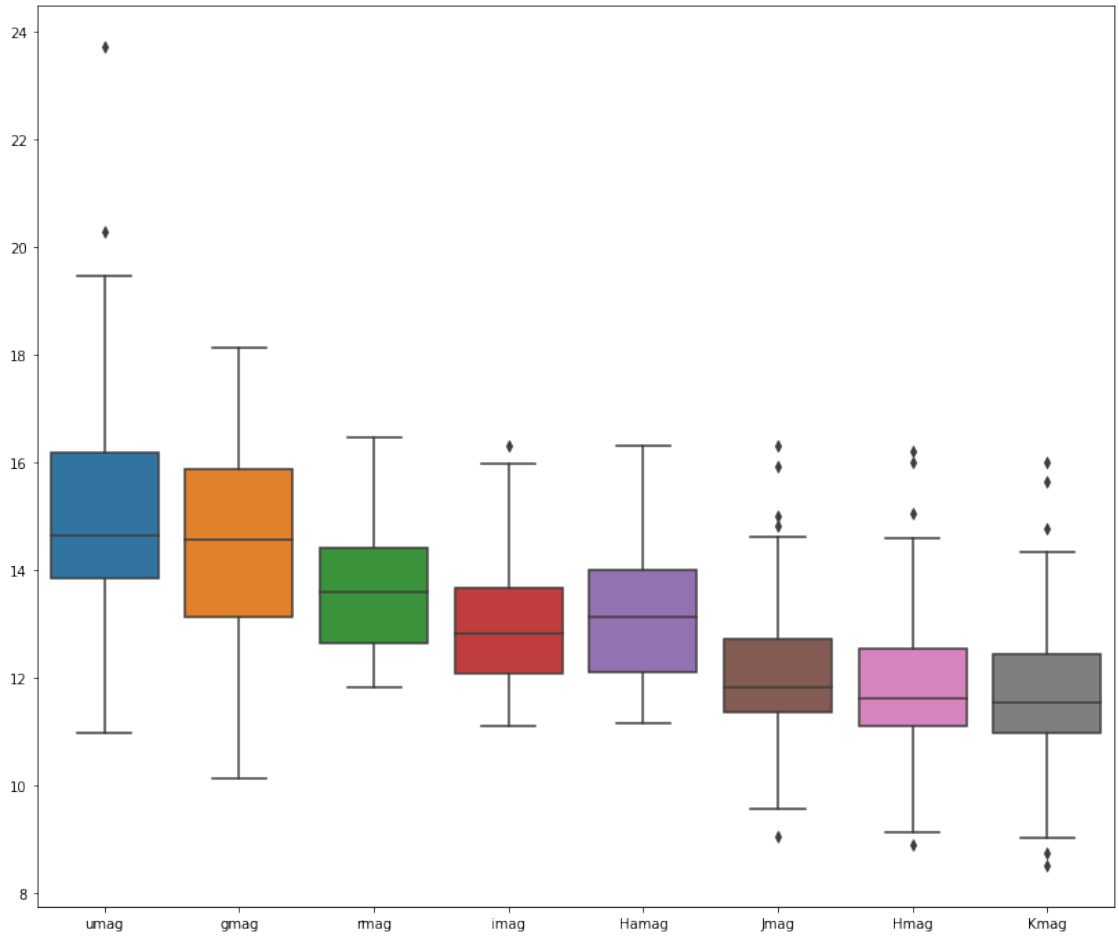
```
min      8.910000    8.510000    0.000000
25%     11.100000   10.970000    0.000000
50%     11.620000   11.550000    0.000000
75%     12.550000   12.430000    1.000000
max     16.210000   16.000000    1.000000
```

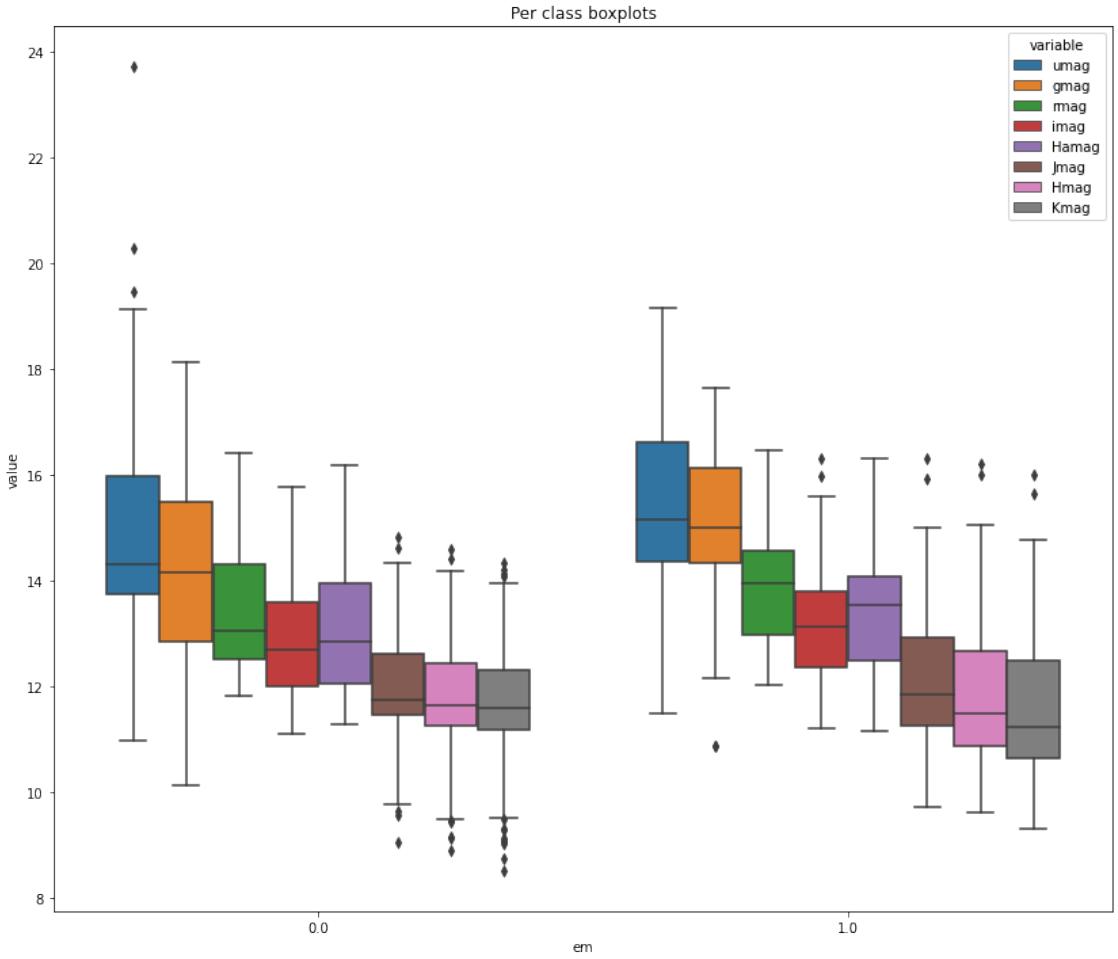
1 Variable visualization

[4]:
```
sn.boxplot(data=x)

plt.figure()
xy_long = pd.melt(xy, id_vars='em')
sn.boxplot(x='em', y='value', hue='variable', data=xy_long)
plt.title("Per class boxplots")
```

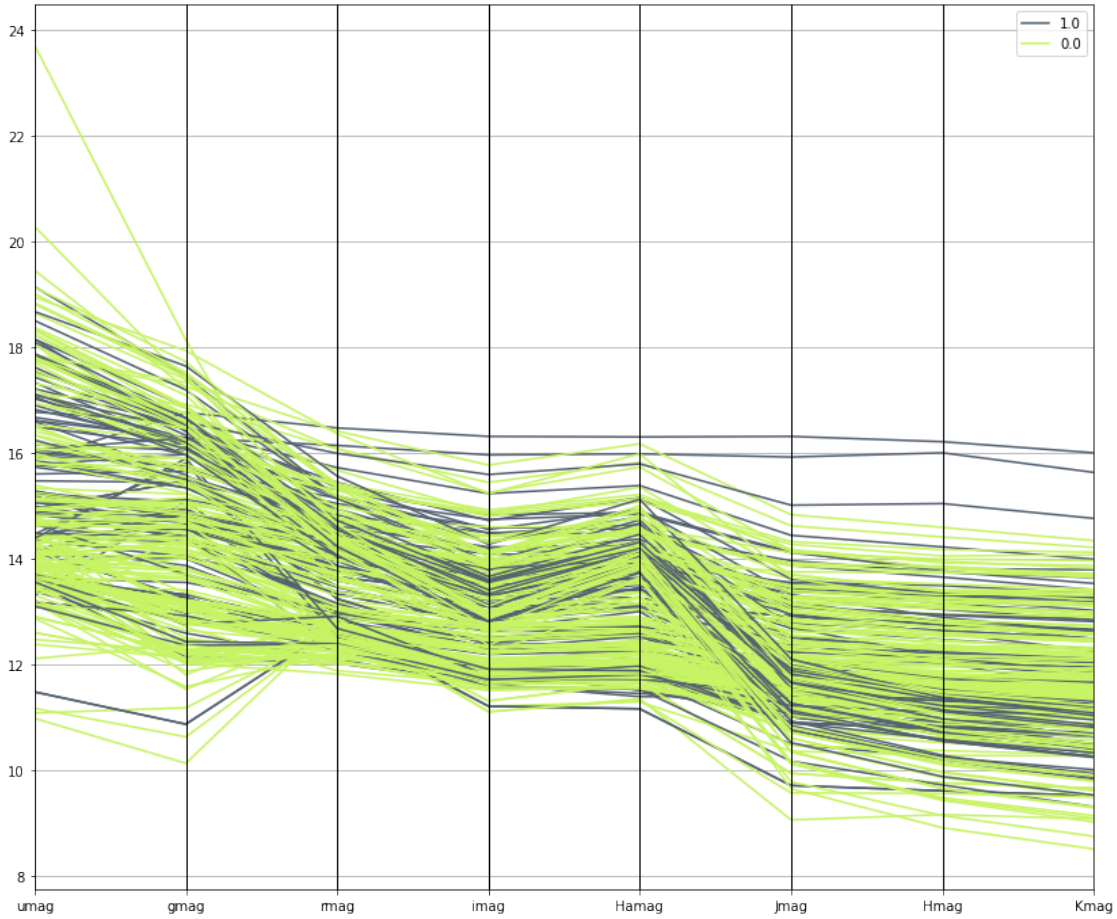
[4]:
```
Text(0.5, 1.0, 'Per class boxplots')
```





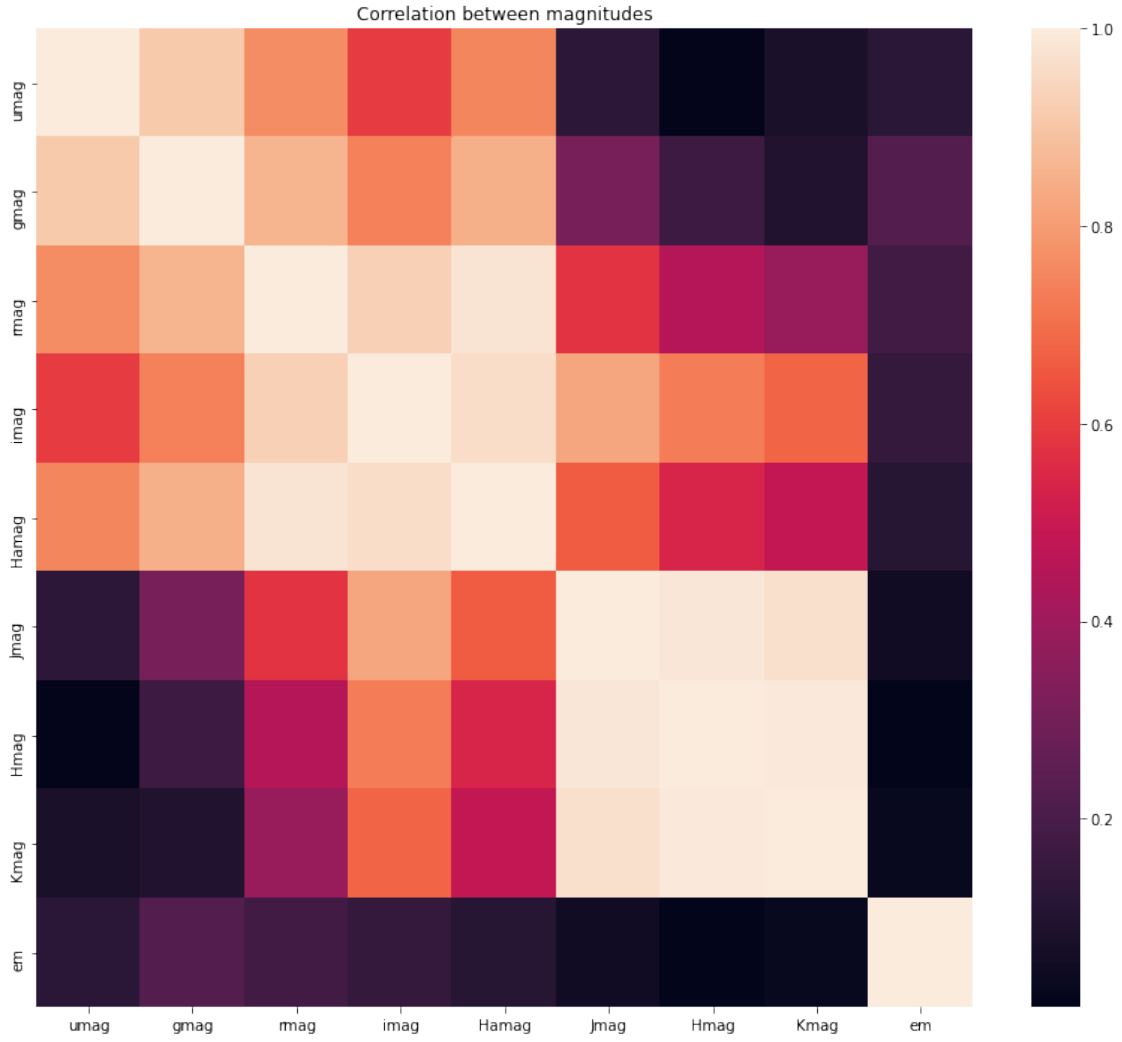
[5]:
```
pd.plotting.parallel_coordinates(xy,"em",color=('#556270','#C7F464'))
```

[5]: <AxesSubplot:>

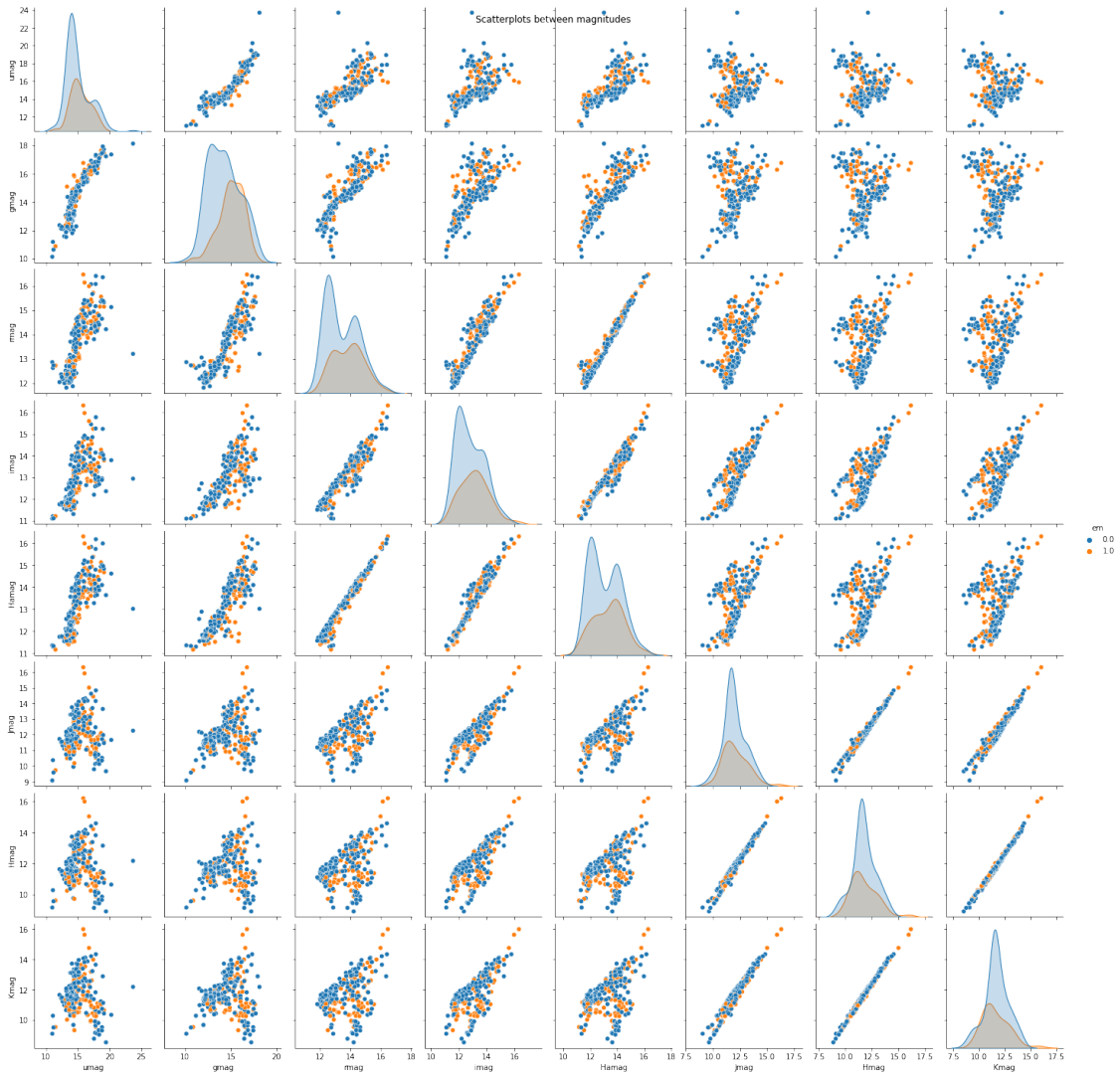


[6]:
```
sn.heatmap(xy.corr().abs())
plt.title("Correlation between magnitudes")
plt.show()

sn.pairplot(xy,hue="em")
plt.suptitle("Scatterplots between magnitudes")
# axes=pd.plotting.scatter_matrix(x,c=y["em"],alpha=0.
 ↪9,grid=False,figsize=(14,12))
```



[6]: Text(0.5, 0.98, 'Scatterplots between magnitudes')



2 Outlier detection via confidence interval

[7]:
```
from scipy import stats
m = len(x.columns) # number of columns = number of hypothesis
confidence= 0.99
adjusted_confidence = 1- (1-confidence)/m  # bonferroni-adjusted confidence
max_zscore = stats.norm.ppf(adjusted_confidence)
print(f"Confidence  (desired): {confidence}")
print(f"Confidence (adjusted): {adjusted_confidence}")
print(f"Z-score    (adjusted): {max_zscore}")

indices = (np.abs(stats.zscore(x-x.mean())) > max_zscore).any(axis=1)
outliers_x = x[indices]
```

```
if dataset_name != "all_em":
    outliers_metadata = metadata[indices]
    outliers_x = pd.concat([outliers_x,outliers_metadata],axis=1)
outliers_x
```

```
Confidence  (desired): 0.99
Confidence (adjusted): 0.99875
Z-score    (adjusted): 3.023341439739154
```

[7]:

	umag	gmag	rmag	imag	Hamag	Jmag	Hmag	Kmag	_RAJ2000_1	\
40	23.71	18.13	13.21	12.94	13.01	12.25	12.17	12.18	93.283401	
88	15.87	16.76	16.47	16.31	16.30	16.31	16.21	16.00	94.851449	
227	16.06	16.28	16.14	15.96	15.98	15.92	16.00	15.63	104.223190	

	model_prob	_DEJ2000_1	original_index	col1	LAMOST_sep	Unnamed: 0
40	0.38	23.857319	632.00	632	2.0	634
88	0.16	23.777745	78.00	78	2.0	78
227	0.00	6.304176	27.00	27	2.0	27

3 Outlier detection via IQR

[8]:
```
iqr_factor=1.5
q25,q75=x.quantile(0.25),x.quantile(0.75)
iqr=q75-q25
min_values = q25-iqr_factor*iqr
max_values = q75+iqr_factor*iqr
# ou
indices = (np.logical_or(x<min_values,x>max_values)).any(axis=1)
outliers_x = x[indices]
if dataset_name != "all_em":
    outliers_metadata = metadata[indices]
    outliers_x = pd.concat([outliers_x,outliers_metadata],axis=1)
outliers_x
```

[8]:

	umag	gmag	rmag	imag	Hamag	Jmag	Hmag	Kmag	_RAJ2000_1	\
40	23.71	18.13	13.21	12.94	13.01	12.25	12.17	12.18	93.283401	
76	10.98	10.13	12.87	11.10	11.35	9.06	9.16	9.08	59.076031	
88	15.87	16.76	16.47	16.31	16.30	16.31	16.21	16.00	94.851449	
129	20.28	17.36	15.13	13.79	14.61	11.66	10.64	10.33	100.553070	
227	16.06	16.28	16.14	15.96	15.98	15.92	16.00	15.63	104.223190	
244	17.85	17.33	16.41	15.77	16.17	14.83	14.59	14.34	83.374873	
255	16.77	16.58	15.99	15.59	15.79	15.01	15.04	14.76	88.270422	
264	19.45	17.23	14.22	12.36	13.63	9.65	8.91	8.51	308.255134	
275	17.56	16.46	13.81	12.20	13.27	9.78	9.14	8.75	308.147236	

	model_prob	_DEJ2000_1	original_index	col1	LAMOST_sep	Unnamed: 0

40	0.38	23.857319	632.00	632	2.0	634
76	0.18	51.133020	937.00	937	2.0	939
88	0.16	23.777745	78.00	78	2.0	78
129	0.09	9.502543	74.00	74	2.0	74
227	0.00	6.304176	27.00	27	2.0	27
244	0.00	29.005993	1.032.00	1032	2.0	1034
255	0.00	22.163427	880.00	880	2.0	882
264	0.00	40.542745	402.00	402	2.0	403
275	0.00	41.245939	401.00	401	2.0	402

4 Analysis of q-features (q_3) (all magnitudes)

[9]:
```
x_np=x.to_numpy()
import qfeatures
coefficients = dataset_module.coefficients
systems = dataset_module.systems
coefficients_np = np.array([coefficients[k] for k in x.columns])
systems = [systems[k] for k in x.columns]
q=qfeatures.calculate(x_np,coefficients_np,x.columns,systems,combination_size=3)
m = q.magnitudes

q_df = pd.DataFrame(m, columns = q.column_names)
q_df.describe()
```

[9]:

	umag_gmag_rmag	umag_gmag_imag	umag_gmag_Hamag	umag_gmag_Jmag	\
count	281.000000	281.000000	281.000000	281.000000	
mean	0.176481	-0.396841	-0.070167	-3.153199	
std	0.828204	0.931151	0.837281	2.455464	
min	-3.024675	-4.052690	-3.552477	-9.888333	
25%	-0.241861	-0.820643	-0.437056	-4.580278	
50%	0.085887	-0.539825	-0.112897	-2.613333	
75%	0.524026	0.015439	0.255280	-1.504306	
max	3.258442	2.916433	2.972150	2.814444	

	umag_gmag_Hmag	umag_gmag_Kmag	umag_rmag_imag	umag_rmag_Hamag	\
count	281.000000	281.000000	281.000000	281.000000	
mean	-5.836835	-9.613043	0.714044	1.114363	
std	4.269958	6.795943	1.040089	1.248407	
min	-17.494783	-28.841438	-4.042982	-3.367383	
25%	-8.132826	-13.151503	0.263977	0.471121	
50%	-4.710435	-7.815948	0.656433	0.916729	
75%	-2.732826	-4.600065	1.151287	1.446168	
max	2.990652	3.563529	10.171579	10.305607	

	umag_rmag_Jmag	umag_rmag_Hmag	…	imag_Hamag_Jmag	imag_Hamag_Hmag	\
count	281.000000	281.000000	…	281.000000	281.000000	

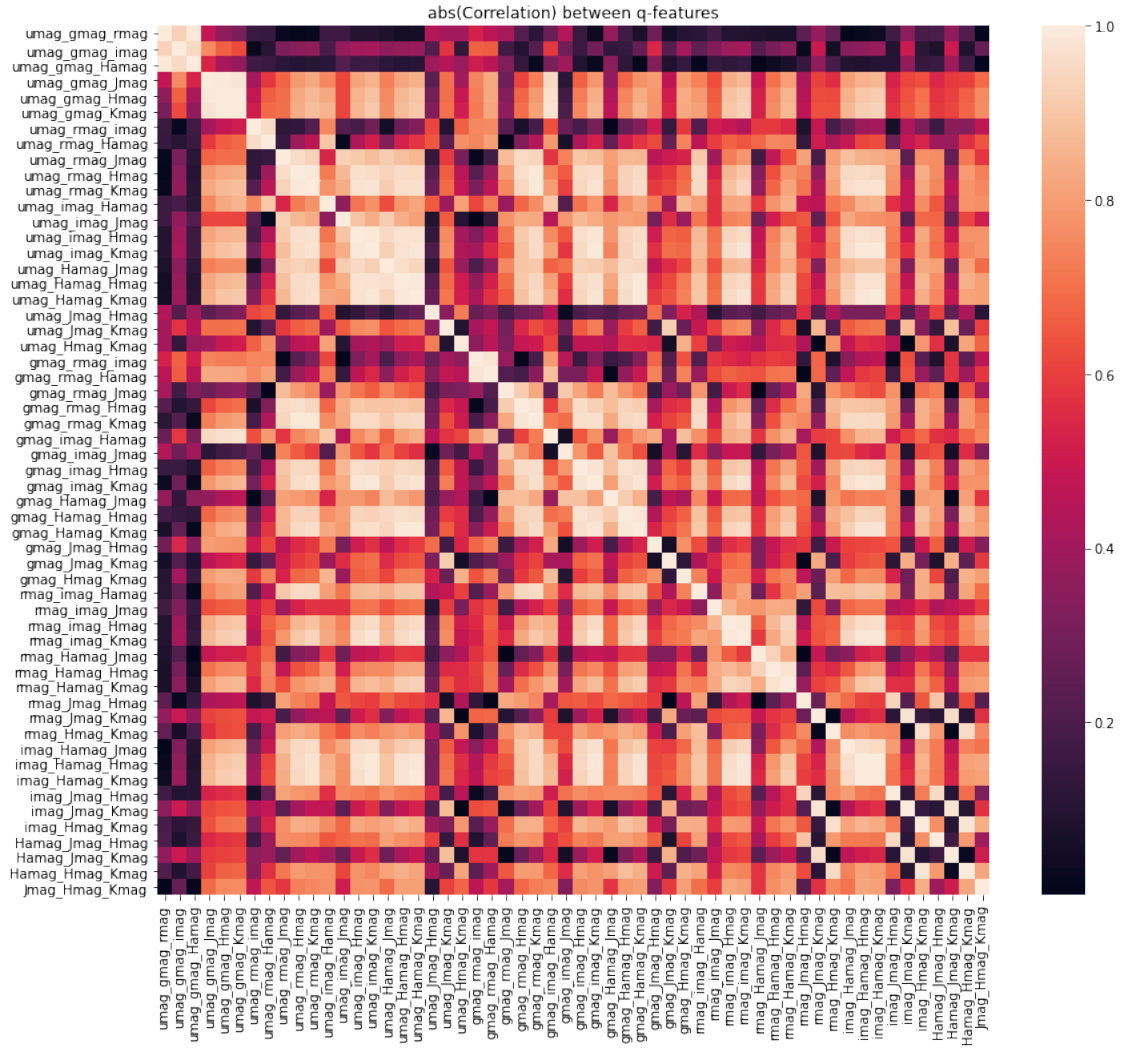
```
mean        -3.019403       -6.650275  …         0.443990         1.053812
std          2.347558        4.640293  …         0.271688         0.745449
min        -12.896667      -18.780435  …         0.004028        -0.038696
25%         -4.200000       -9.076957  …         0.239583         0.489565
50%         -2.366667       -5.164348  …         0.365556         0.825000
75%         -1.322222       -3.123478  …         0.615278         1.424348
max          7.726667        5.797391  …         1.117639         3.142174

       imag_Hamag_Kmag  imag_Jmag_Hmag  imag_Jmag_Kmag  imag_Hmag_Kmag  \
count       281.000000      281.000000      281.000000      281.000000
mean          1.917950        0.401837       -0.337591        0.533012
std           1.392776        0.320037        0.486605        0.524202
min           0.146471       -0.215217       -2.172941       -1.551438
25%           0.849346        0.219783       -0.645294        0.213007
50%           1.470065        0.310217       -0.250000        0.389804
75%           2.493137        0.515435       -0.038235        0.848301
max           5.924771        2.255217        2.104706        1.883660

       Hamag_Jmag_Hmag  Hamag_Jmag_Kmag  Hamag_Hmag_Kmag  Jmag_Hmag_Kmag
count       281.000000      281.000000       281.000000      281.000000
mean          0.426916       -0.633676         0.567980        0.108408
std           0.473221        0.710417         0.746762        0.133023
min          -0.554348       -3.221895        -2.051373       -0.394379
25%           0.156522       -1.002876         0.135490        0.024052
50%           0.291739       -0.444510         0.401569        0.073529
75%           0.648261       -0.143268         0.976667        0.178039
max           2.598696        2.382810         2.523922        0.756601

[8 rows x 56 columns]
```

[10]:
```
sn.heatmap(q_df.corr().abs())
plt.title("abs(Correlation) between q-features")
plt.show()
```



5 Analysis of q-features (q_4) (calculated by system to avoid combinatory explosion)

[11]:
```
x_np=x.to_numpy()
import qfeatures
coefficients = dataset_module.coefficients
systems = dataset_module.systems
coefficients_np = np.array([coefficients[k] for k in x.columns])
systems = [systems[k] for k in x.columns]
q= qfeatures.calculate(x_np,coefficients_np,x.
 ↪columns,systems,combination_size=4,by_system=True)

m = q.magnitudes
```

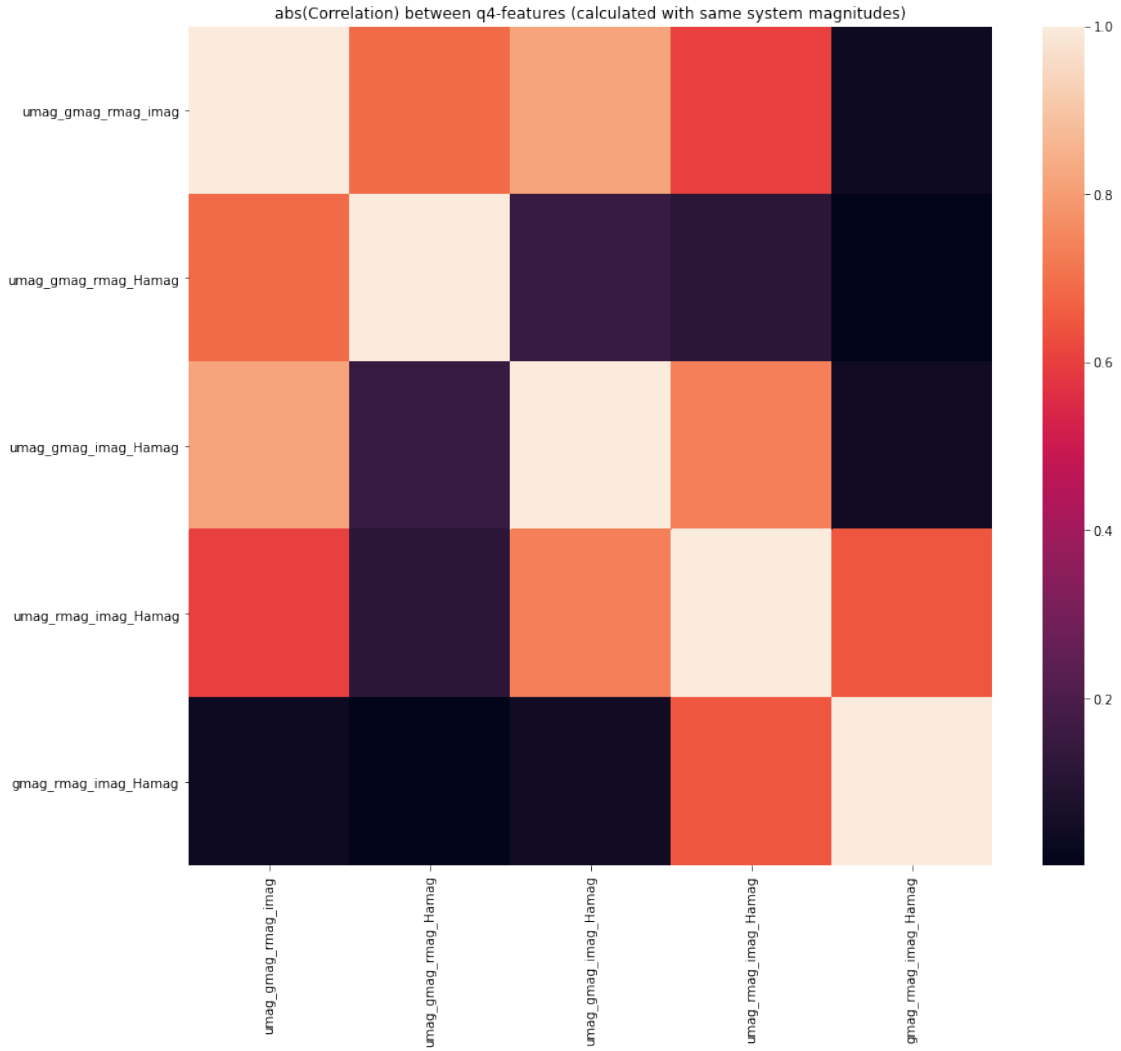
```
q_df = pd.DataFrame(m, columns = q.column_names)
q_df.describe()
```

[11]:

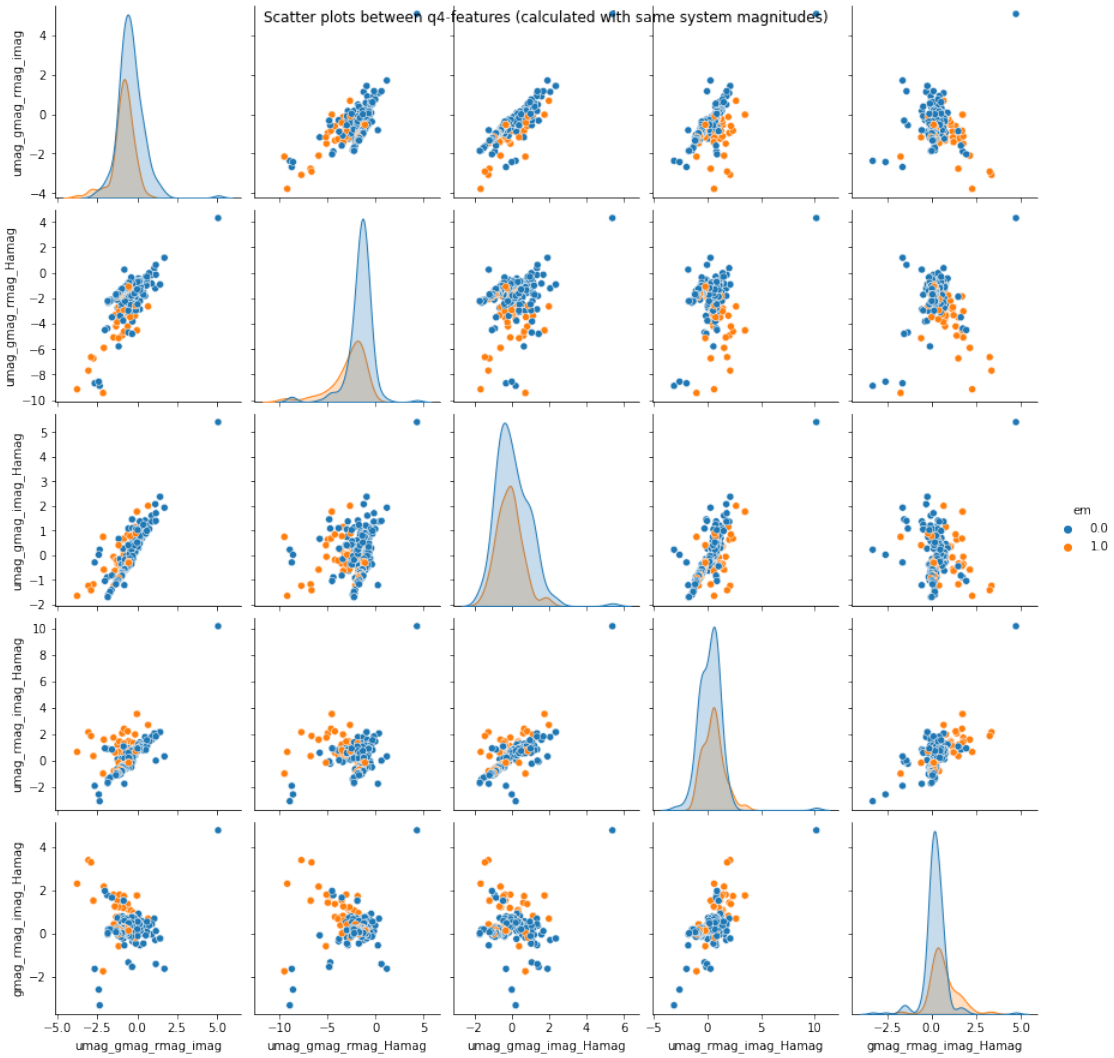
	umag_gmag_rmag_imag	umag_gmag_rmag_Hamag	umag_gmag_imag_Hamag	\
count	281.000000	281.000000	281.000000	
mean	-0.596214	-2.067113	-0.014696	
std	0.821523	1.676793	0.840963	
min	-3.788333	-9.456471	-1.711163	
25%	-0.965500	-2.481176	-0.603023	
50%	-0.625167	-1.647647	-0.114186	
75%	-0.220333	-1.179412	0.420930	
max	5.089500	4.297647	5.402558	

	umag_rmag_imag_Hamag	gmag_rmag_imag_Hamag
count	281.000000	281.000000
mean	0.333171	0.347867
std	1.100247	0.747807
min	-3.099302	-3.315581
25%	-0.465581	0.062558
50%	0.400000	0.254651
75%	0.859767	0.551860
max	10.161395	4.758837

[12]:
```
sn.heatmap(q_df.corr().abs())
_=plt.title("abs(Correlation) between q4-features (calculated with same system␣
 ↪magnitudes)")
```



[13]:
```
q_dfy=pd.concat([q_df,y],axis=1)
sn.pairplot(q_dfy,hue="em")
_=plt.suptitle("Scatter plots between q4-features (calculated with same system␣
 ↪magnitudes)")
```


Scatter plots between q4-features (calculated with same system magnitudes)
umag_gmag_rmag_imag
umag_gmag_rmag_Hamag
umag_gmag_imag_Hamag
umag_rmag_imag_Hamag
gmag_rmag_imag_Hamag
em
0.0
1.0