Exploratory analysis

March 18, 2021

[68]:
```
%reload_ext autoreload
%autoreload 2
default_figsize=(14,12)
```

[69]:
```
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_name = "liu"
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()
```

[69]:

	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	

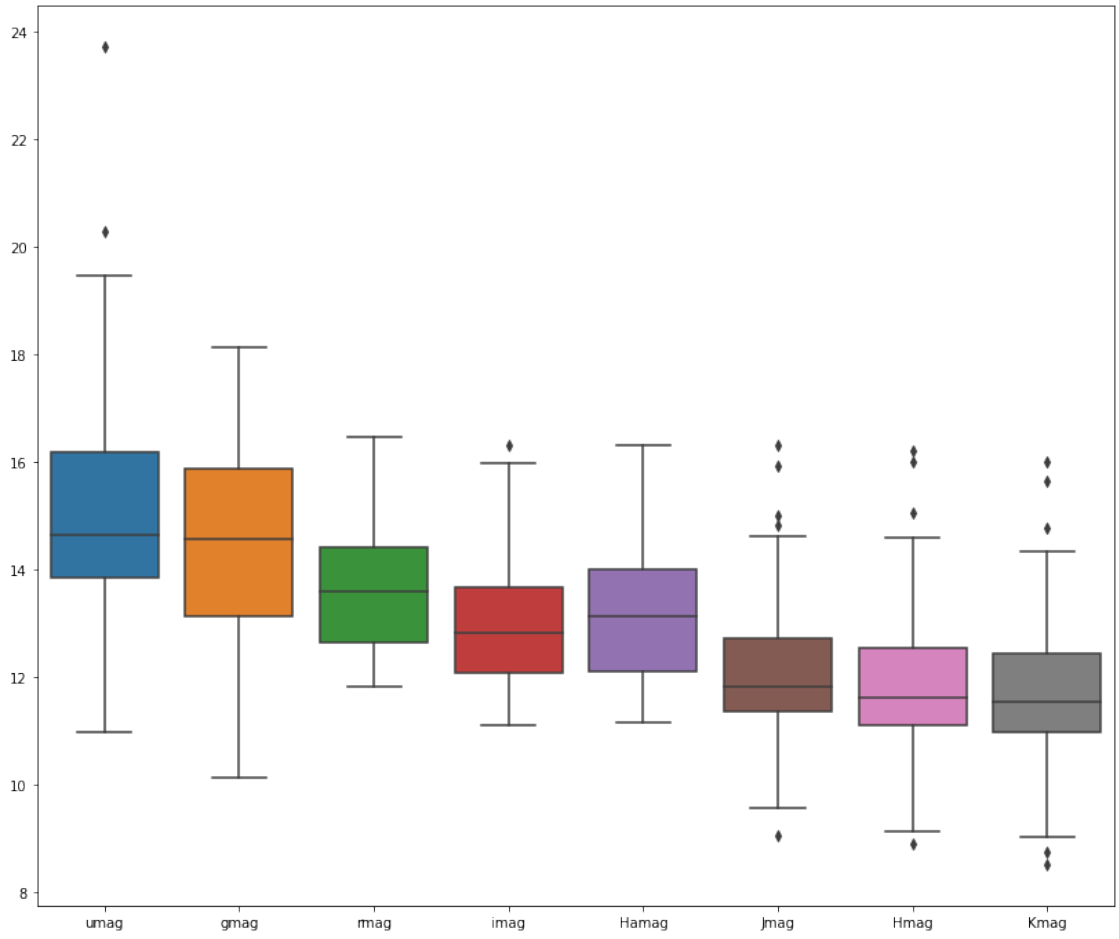
	Hmag	Kmag	em
count	281.000000	281.000000	281.000000
mean	11.785267	11.635587	0.341637
std	1.167985	1.205151	0.475105
min	8.910000	8.510000	0.000000
25%	11.100000	10.970000	0.000000

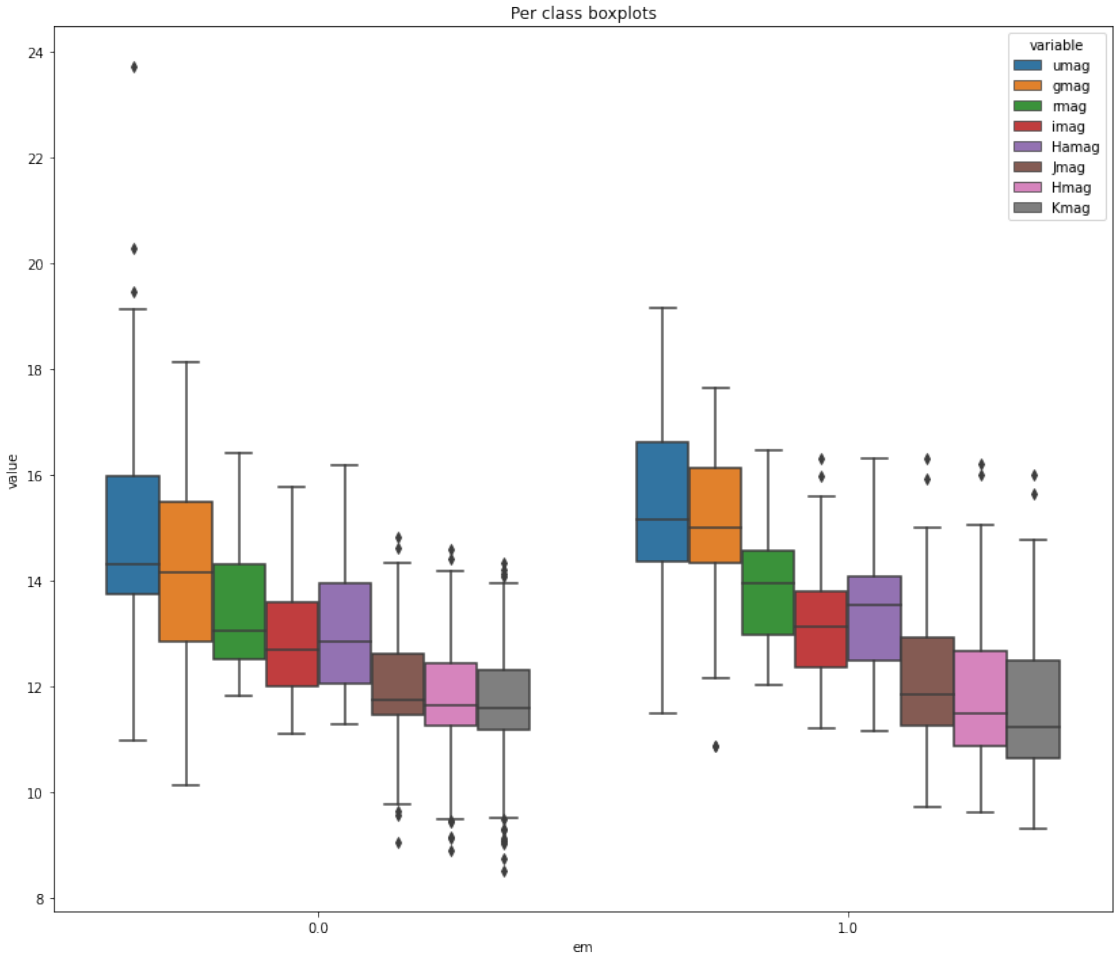
```
50%      11.620000    11.550000    0.000000
75%      12.550000    12.430000    1.000000
max      16.210000    16.000000    1.000000
```

1 Variable visualization

[70]:
```
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")
```

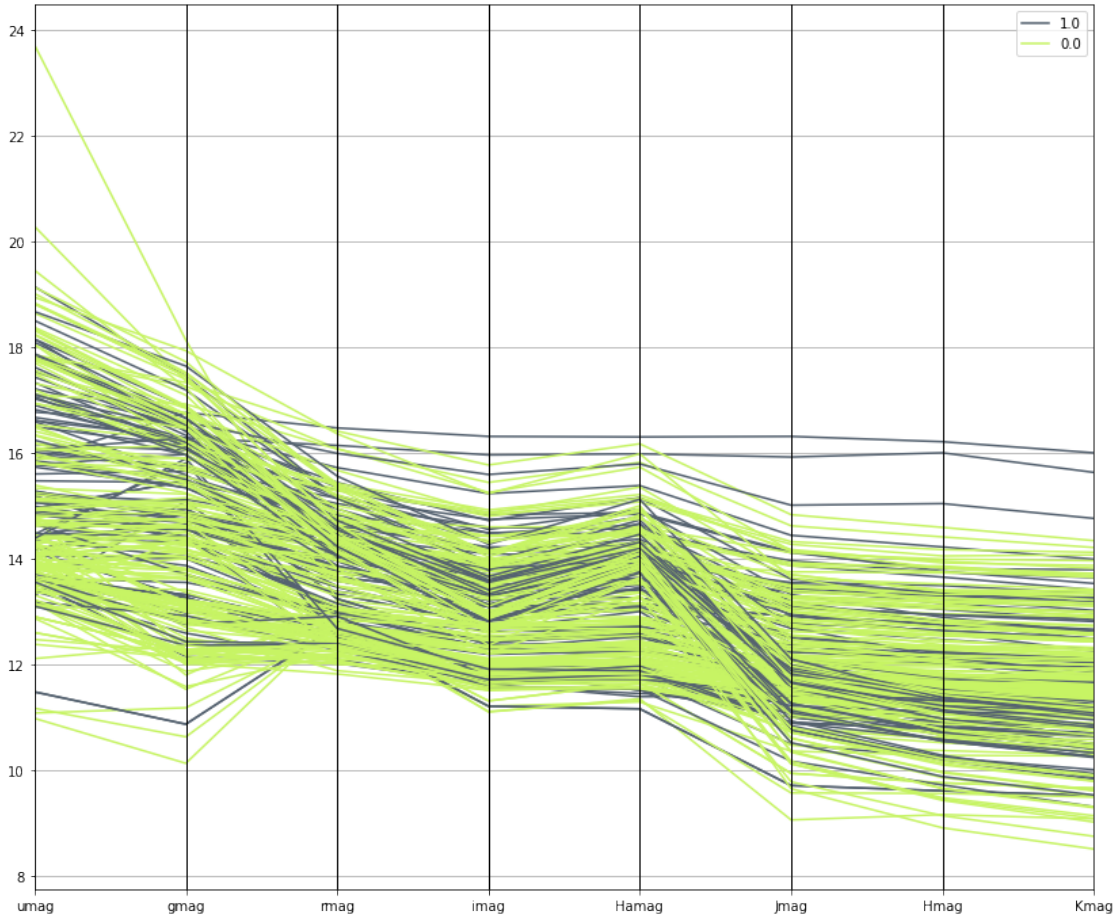
[70]:
```
Text(0.5, 1.0, 'Per class boxplots')
```



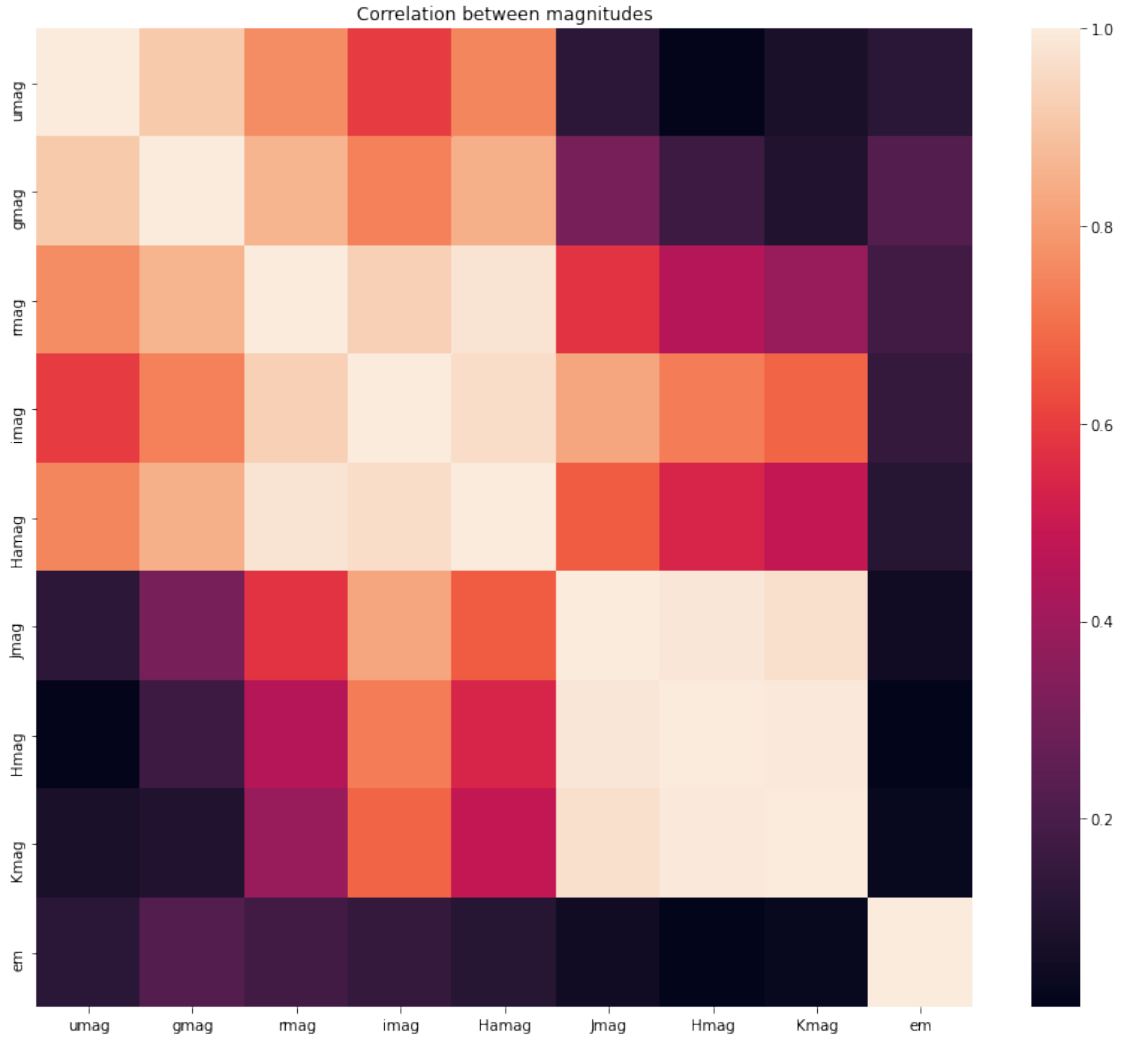


[71]:
```
pd.plotting.parallel_coordinates(xy,"em",color=('#556270','#C7F464'))
```

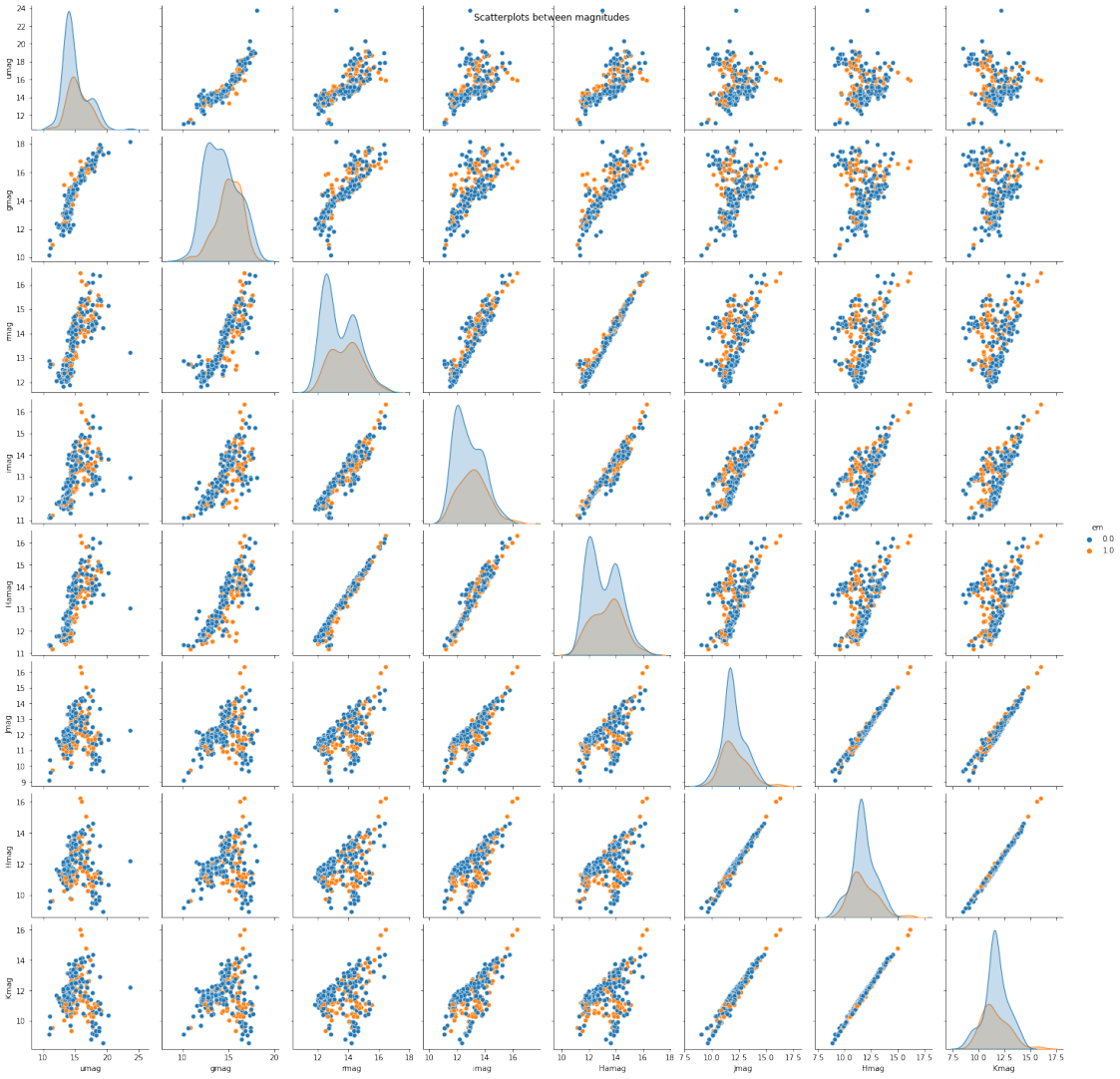
[71]: <AxesSubplot:>



[72]:
```
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))
```



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



2 Outlier detection via confidence interval

[73]:
```
from scipy import stats
m = len(x.columns) # number of columns = number of hypothesis
confidence= 0.98
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 = outliers_x.
 ↪merge(outliers_metadata,left_index=True,right_index=True)
outliers_x
```

```
Confidence  (desired): 0.98
Confidence (adjusted): 0.9975
Z-score    (adjusted): 2.807033768343811
```

[73]:

	umag	gmag	rmag	imag	Hamag	Jmag	Hmag	Kmag	original_index	\
40	23.71	18.13	13.21	12.94	13.01	12.25	12.17	12.18	632.00	
88	15.87	16.76	16.47	16.31	16.30	16.31	16.21	16.00	78.00	
129	20.28	17.36	15.13	13.79	14.61	11.66	10.64	10.33	74.00	
227	16.06	16.28	16.14	15.96	15.98	15.92	16.00	15.63	27.00	

	Unnamed: 0	_DEJ2000_1	col1	LAMOST_sep	_RAJ2000_1	model_prob
40	634	23.857319	632	2.0	93.283401	0.38
88	78	23.777745	78	2.0	94.851449	0.16
129	74	9.502543	74	2.0	100.553070	0.09
227	27	6.304176	27	2.0	104.223190	0.00

3 Outlier detection via IQR

[74]:
```
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 = outliers_x.
 ↪merge(outliers_metadata,left_index=True,right_index=True)
outliers_x
```

[74]:

	umag	gmag	rmag	imag	Hamag	Jmag	Hmag	Kmag	original_index	\
40	23.71	18.13	13.21	12.94	13.01	12.25	12.17	12.18	632.00	
76	10.98	10.13	12.87	11.10	11.35	9.06	9.16	9.08	937.00	
88	15.87	16.76	16.47	16.31	16.30	16.31	16.21	16.00	78.00	
129	20.28	17.36	15.13	13.79	14.61	11.66	10.64	10.33	74.00	
227	16.06	16.28	16.14	15.96	15.98	15.92	16.00	15.63	27.00	
244	17.85	17.33	16.41	15.77	16.17	14.83	14.59	14.34	1.032.00	
255	16.77	16.58	15.99	15.59	15.79	15.01	15.04	14.76	880.00	

```
264  19.45  17.23  14.22  12.36  13.63   9.65   8.91   8.51         402.00
275  17.56  16.46  13.81  12.20  13.27   9.78   9.14   8.75         401.00

     Unnamed: 0  _DEJ2000_1  col1  LAMOST_sep  _RAJ2000_1  model_prob
40          634   23.857319   632         2.0   93.283401        0.38
76          939   51.133020   937         2.0   59.076031        0.18
88           78   23.777745    78         2.0   94.851449        0.16
129          74    9.502543    74         2.0  100.553070        0.09
227          27    6.304176    27         2.0  104.223190        0.00
244        1034   29.005993  1032         2.0   83.374873        0.00
255         882   22.163427   880         2.0   88.270422        0.00
264         403   40.542745   402         2.0  308.255134        0.00
275         402   41.245939   401         2.0  308.147236        0.00
```

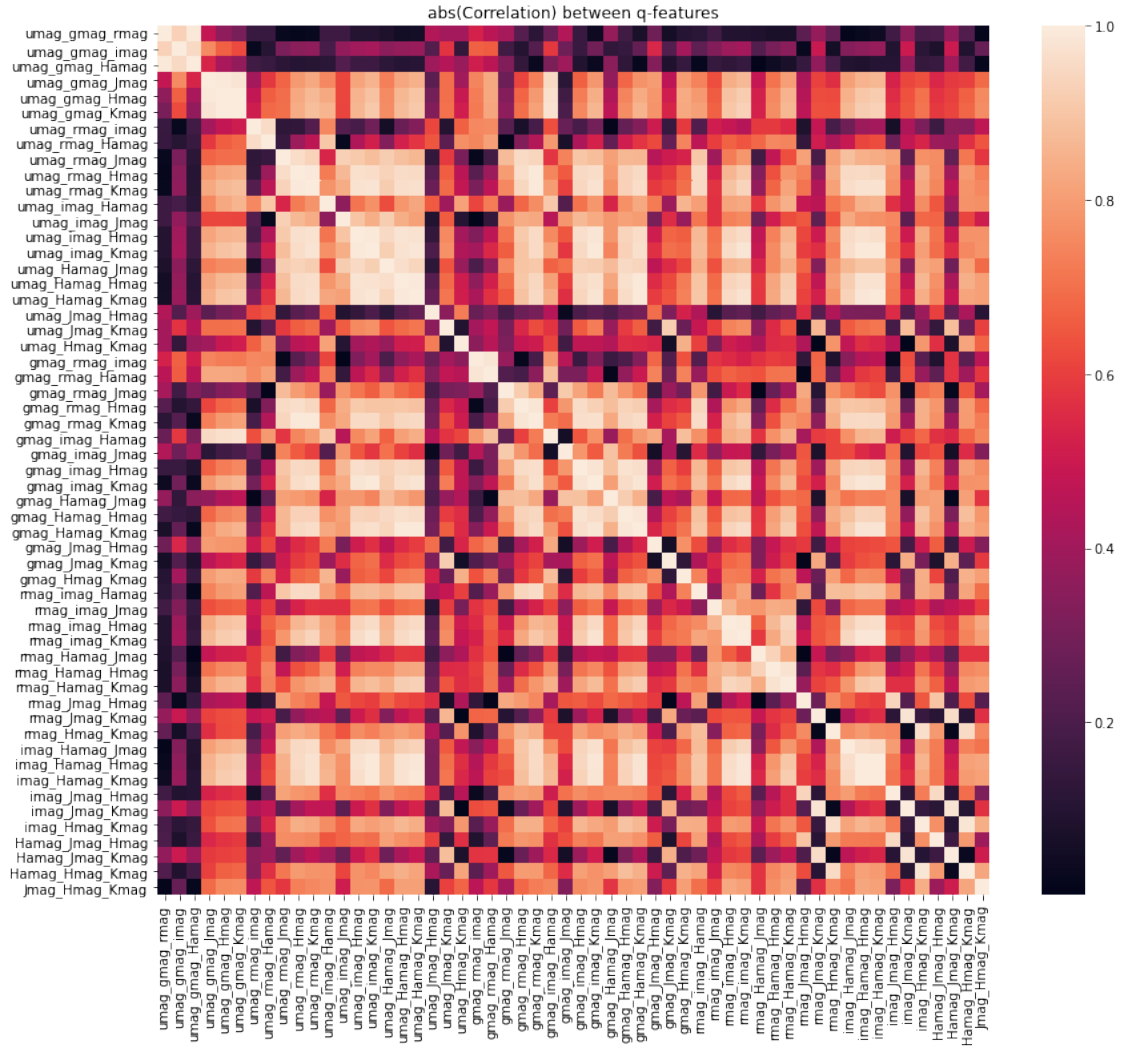
4 Analysis of q-features (q_3) (all magnitudes)

[75]:
```
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()
```

[75]:
```
       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]
```

[76]:
```
sn.heatmap(q_df.corr().abs())
plt.title("abs(Correlation) between q-features")
plt.show()
```



5 Analysis of q-features (q_3) (calculated by system)

[77]:
```
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,by_system=True)

m = q.magnitudes

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

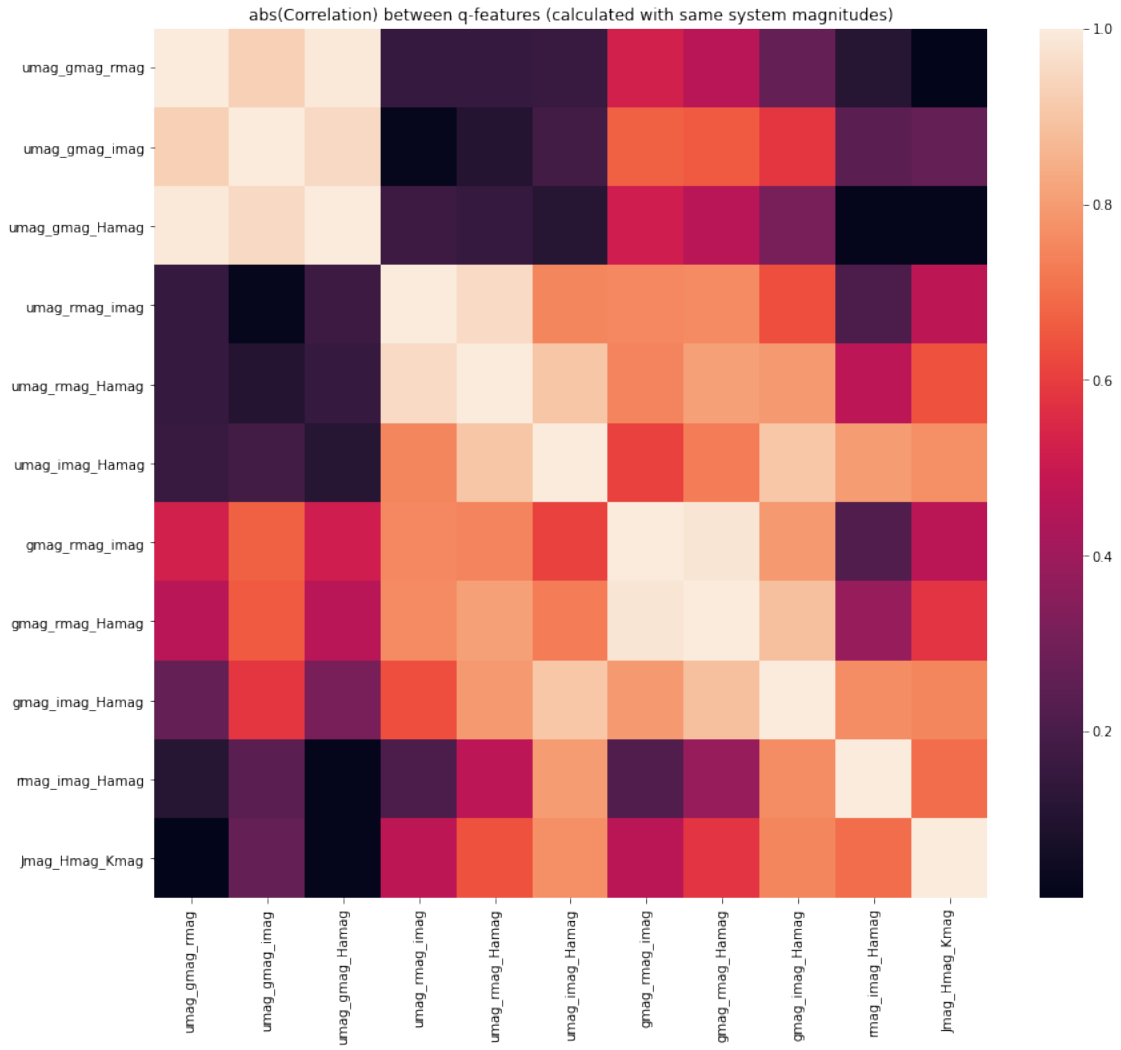
```
q_df.describe()
```

[77]:

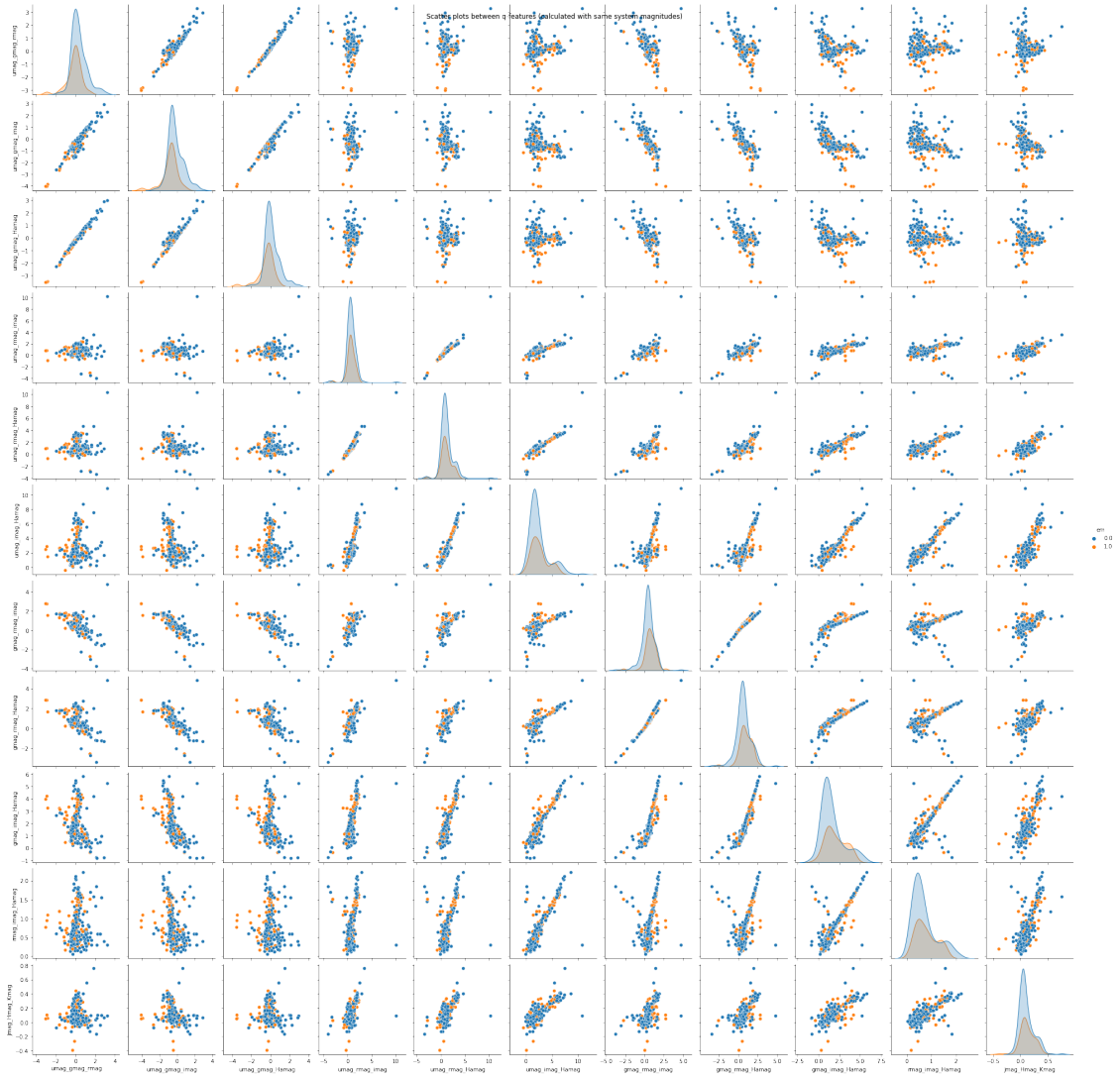
```
       umag_gmag_rmag  umag_gmag_imag  umag_gmag_Hamag  umag_rmag_imag  \
count      281.000000      281.000000       281.000000      281.000000
mean         0.176481       -0.396841        -0.070167        0.714044
std          0.828204        0.931151         0.837281        1.040089
min         -3.024675       -4.052690        -3.552477       -4.042982
25%         -0.241861       -0.820643        -0.437056        0.263977
50%          0.085887       -0.539825        -0.112897        0.656433
75%          0.524026        0.015439         0.255280        1.151287
max          3.258442        2.916433         2.972150       10.171579

       umag_rmag_Hamag  umag_imag_Hamag  gmag_rmag_imag  gmag_rmag_Hamag  \
count       281.000000       281.000000      281.000000       281.000000
mean          1.114363         2.489336        0.529148         0.719684
std           1.248407         1.798995        0.843922         0.931828
min          -3.367383        -0.452523       -3.764737        -3.443178
25%           0.471121         1.403084        0.198947         0.252710
50%           0.916729         1.872710        0.539474         0.632850
75%           1.446168         3.013084        0.925263         1.177944
max          10.305607        10.857664        4.763684         4.827477

       gmag_imag_Hamag  rmag_imag_Hamag  Jmag_Hmag_Kmag
count       281.000000       281.000000      281.000000
mean          1.757275         0.731161        0.108408
std           1.322230         0.473361        0.133023
min          -0.845701         0.045981       -0.394379
25%           0.882290         0.384860        0.024052
50%           1.323178         0.581215        0.073529
75%           2.436355         0.941776        0.178039
max           5.813598         2.216075        0.756601
```

[78]:

```
sn.heatmap(q_df.corr().abs())
plt.title("abs(Correlation) between q-features (calculated with same system␣
 ↪magnitudes)")
plt.show()
q_dfy=pd.concat([q_df,y],axis=1)
sn.pairplot(q_dfy,hue="em")
plt.suptitle("Scatter plots between q-features (calculated with same system␣
 ↪magnitudes)")
```



[78]: Text(0.5, 0.98, 'Scatter plots between q-features (calculated with same system magnitudes)')


Scatter plots between g features calculated with same system magnitudes!
umag_gmag_rmag
umag_gmag_imag
umag_gmag_ilamag
umag_rmag_imag
umag_rmag_ilamag
umag_imag_ilamag
gmag_rmag_imag
gmag_rmag_ilamag
gmag_imag_ilamag
rmag_imag_ilamag
jmag_imag_kmag
err
0.0
1.0