ApplianceTelemetryCorrelationAnalysis

October 19, 2024

0.1 Provided as-is (w/o support)

Kubernetes clusters collect various application and infrastrcuture statistics. While this information is useful, it's very difficult to identify which metrics are useful for monitoring and troubleshooting. The Goal here is to collect this information, and use a statistical model to identify which metrics should be included in reports/dashboard such that: * Unnecessary overhead and sensory overload can be reduced. * Time can be saved by prioritising monitoring the correct metrics.

This process needs to assume `zero knowlidge` of the workings of the cluster, workload being run and any other information. This way, `generic` clusters can be monitored without explicitly programming dashboards based on internal knowlidge. This is also a good method to discover/verify application knowlidge/bottlenecks with statistical data analyis.

0.2 Step1: Data Loading

We will load cpu, memory, task_queue information along with stats from strcutured and unstrucutred scans from csv files stored on disk using the `dataframeLoader` helper.

```
# The dataframeLoader helper function implements the loadApplianceTimeSeriesData method.
# This method loads the csv files, and pivots them to generate distinct "metrics" timeseries.
# see https://github.com/amitgupta7/docker-jupy-ntbk-s3-reporting/blob/main/dataframeLoader.py
```

[1]:
```
import dataframeLoader as dfl
import pandas as pd
from importlib import reload
reload(dfl)

# Provide csv data location and appliance and timerange information.
root = '.dataDir'
fromDt = '2024-08-15'
toDt = '2024-10-15'

# Provide list of prometheus metrics to load.
# metricsArr = ['cpu_used', 'download_workers_count', 'memory_used',␣
 ↪'task_queue_length', 'infra_access_latency', 'pod_cpu_usage',␣
 ↪'pod_memory_usage']
metricsArr = ['cpu_used'
              ,'task_queue_length'
              , 'memory_used'
              ]
```

```
daterange=[fromDt, toDt]
df = dfl.loadApplianceTimeSeriesData(root, metricsArr, daterange)
```

```
loading Unstrctured Data from file: SCANPROC-*.csv

loading Strctured Data from file: STRUCTURED-*.csv

processing securiti_appliance_cpu_used-max*.csv

processing securiti_appliance_cpu_used-avg*.csv

processing securiti_appliance_task_queue_length-max*.csv

processing securiti_appliance_task_queue_length-avg*.csv

processing securiti_appliance_memory_used-max*.csv

processing securiti_appliance_memory_used-avg*.csv

loading Unstrctured Data from file: UNSTRUCTURED-*.csv
```

0.3 Step2: Data Pivoting

We now aggregate the data by `appliance_id` (unique identifier for our cluster) and `ts` timestamp, to get different metrics values as separate columns. Notice there are: * 21 metrics * Tracked every hour

[2]:
```
dfp = df.pivot_table(index=['appliance_id','ts'], columns=['metrics'],␣
 ↪values='value', aggfunc='sum').reset_index()
dfp.head()
```

[2]:
```
metrics                          appliance_id                  ts  \
0        0036f473-ad7f-4439-8d37-f65fdeb50b2d 2024-10-13 14:00:00
1        0036f473-ad7f-4439-8d37-f65fdeb50b2d 2024-10-13 15:00:00
2        0036f473-ad7f-4439-8d37-f65fdeb50b2d 2024-10-13 16:00:00
3        0036f473-ad7f-4439-8d37-f65fdeb50b2d 2024-10-13 17:00:00
4        0036f473-ad7f-4439-8d37-f65fdeb50b2d 2024-10-13 18:00:00

metrics  IdleTimeInHrs  avgFileSizeInMB  cpu_used_avg  cpu_used_max  \
0                  NaN              NaN      3.021810         21.46
1                  NaN              NaN      1.569917          3.14
2                  NaN              NaN      1.748750          2.98
3                  NaN              NaN      1.740000          1.93
4                  NaN              NaN      1.740000          1.93

metrics  dataScannedinGB  fileDownloadTimeInHrs  linkerq_avg  linkerq_max  \
0                    NaN                    NaN          NaN          NaN
1                    NaN                    NaN          NaN          NaN
2                    NaN                    NaN          NaN          NaN
3                    NaN                    NaN          NaN          NaN
4                    NaN                    NaN          NaN          NaN
```

```
metrics  …  memory_used_max  numFilesScanned  numberOfChunksScanned  \
0        …            74.53              NaN                    NaN
1        …            66.62              NaN                    NaN
2        …            66.54              NaN                    NaN
3        …            66.33              NaN                    NaN
4        …            66.33              NaN                    NaN

metrics  numberOfColsScanned  scanTime  taskq_avg  taskq_max  tmp_taskq_avg  \
0                        NaN       NaN        NaN        NaN            NaN
1                        NaN       NaN        NaN        NaN            NaN
2                        NaN       NaN        NaN        NaN            NaN
3                        NaN       NaN        NaN        NaN            NaN
4                        NaN       NaN        NaN        NaN            NaN

metrics  tmp_taskq_max  uniqPodCount
0                  NaN           NaN
1                  NaN           NaN
2                  NaN           NaN
3                  NaN           NaN
4                  NaN           NaN

[5 rows x 21 columns]
```

0.4 Step 3: Data transformation and correlation

We need to acheve two main goals: 1. Isolate data for individual appliance. 2. Remove ghost correlation between unrelated metrics. * We will calculate percentage change between adjacent timeseries values. 3. Calculate absolute correlation between metrics for each single appliance. * Transpose every `metrics` corelation. 4. Generate correlation for every `appliance_id` and `metric` identifier using steps 1, 2 and 3

[3]:
```
# appliance = '01c75278-9c0d-41be-b693-c970b18dbedc'
# for metric in metrics_category_order:
dfc_arr = []
for pod in dfp.appliance_id.unique():
    dfa = dfp[(dfp.appliance_id == pod)]
    dfa = dfa.drop(['appliance_id', 'ts'], axis=1)
    dfa = dfa.pct_change(periods=1, fill_method=None)
    dfca = dfa.corr().abs()
    # print(type(dfca))
    for col in dfca.columns:
        # print(col)
        dfc = dfca[col].to_frame().T
        dfc.insert(0, 'metric', col )
        dfc.insert(0, 'appliance_id', pod )
        dfc_arr.append(dfc)
```

```python
dfc = pd.concat(dfc_arr, ignore_index=True)
dfc.set_index('appliance_id', inplace=True)
dfc.head()
```

[3]:
```
metrics                                         metric  IdleTimeInHrs  \
appliance_id
0036f473-ad7f-4439-8d37-f65fdeb50b2d    IdleTimeInHrs            NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d  avgFileSizeInMB            NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d     cpu_used_avg            NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d     cpu_used_max            NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d  dataScannedinGB            NaN

metrics                               avgFileSizeInMB  cpu_used_avg  \
appliance_id
0036f473-ad7f-4439-8d37-f65fdeb50b2d              NaN           NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d              NaN           NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d              NaN      1.000000
0036f473-ad7f-4439-8d37-f65fdeb50b2d              NaN      0.536825
0036f473-ad7f-4439-8d37-f65fdeb50b2d              NaN           NaN

metrics                               cpu_used_max  dataScannedinGB  \
appliance_id
0036f473-ad7f-4439-8d37-f65fdeb50b2d           NaN              NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d           NaN              NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d      0.536825              NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d      1.000000              NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d           NaN              NaN

metrics                               fileDownloadTimeInHrs  linkerq_avg  \
appliance_id
0036f473-ad7f-4439-8d37-f65fdeb50b2d                    NaN          NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                    NaN          NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                    NaN          NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                    NaN          NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                    NaN          NaN

metrics                               linkerq_max  memory_used_avg  \
appliance_id
0036f473-ad7f-4439-8d37-f65fdeb50b2d          NaN              NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d          NaN              NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d          NaN         0.323098
0036f473-ad7f-4439-8d37-f65fdeb50b2d          NaN         0.907248
0036f473-ad7f-4439-8d37-f65fdeb50b2d          NaN              NaN

metrics                               memory_used_max  numFilesScanned  \
appliance_id
0036f473-ad7f-4439-8d37-f65fdeb50b2d              NaN              NaN
```

```
0036f473-ad7f-4439-8d37-f65fdeb50b2d          NaN              NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d     0.622750              NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d     0.256122              NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d          NaN              NaN

metrics                               numberOfChunksScanned  \
appliance_id
0036f473-ad7f-4439-8d37-f65fdeb50b2d                    NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                    NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                    NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                    NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                    NaN

metrics                               numberOfColsScanned  scanTime  \
appliance_id
0036f473-ad7f-4439-8d37-f65fdeb50b2d                  NaN       NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                  NaN       NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                  NaN       NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                  NaN       NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d                  NaN       NaN

metrics                               taskq_avg  taskq_max  tmp_taskq_avg  \
appliance_id
0036f473-ad7f-4439-8d37-f65fdeb50b2d        NaN        NaN            NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d        NaN        NaN            NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d        NaN        NaN            NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d        NaN        NaN            NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d        NaN        NaN            NaN

metrics                               tmp_taskq_max  uniqPodCount
appliance_id
0036f473-ad7f-4439-8d37-f65fdeb50b2d            NaN           NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d            NaN           NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d            NaN           NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d            NaN           NaN
0036f473-ad7f-4439-8d37-f65fdeb50b2d            NaN           NaN
```

0.5 Step 4: Isolate related metrics using correlation

We now iterate over each `metric`, to see if there is any significant statistical correlation to be found across `appliance_ids`. This is done with two steps:

1. Removing outliers:
    - Remove any metrics with `mean correlation value below the cut-off`. The cut-off can be varied for depending on use cases:
        - 0.9 for Exec Dashboards
        - 0.7 for Customer Ops
        - 0.5 for L1 - support

- 0.3 for L2 - suport

Please note that we are filtering metrics with `mean` correlation below the `low cut-off`. This ensures that atleast half of the values are correlated to reduce outliers.

2. Plot box chart to visually represent metrics with any correlation (for cutoff as 0.3).
3. Decide between `max` or `avg` values if both are present. We chose to display `avg` values metrics in this case.

0.6 Final List of metrics

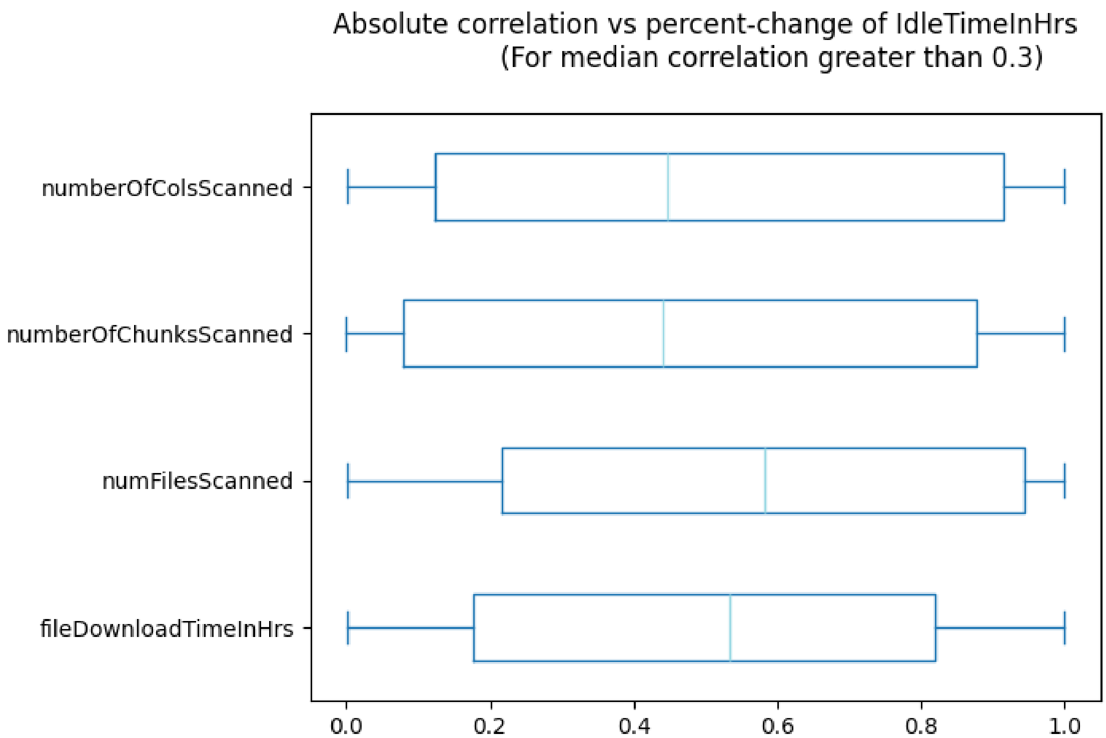
The below table shows the list of `metrics` that are useful with respective correlation `cutoff`. The cut-off values can be interpreted as follows: * below 0.3 negligible correlation * 0.3 to 0.5 Low positive (negative) correlation * 0.5 to 0.7 Moderate positive (negative) correlation * 0.7 to 0.9 High positive (negative) correlation * 0.9 to 0.1 Very High positive (negative) correlation

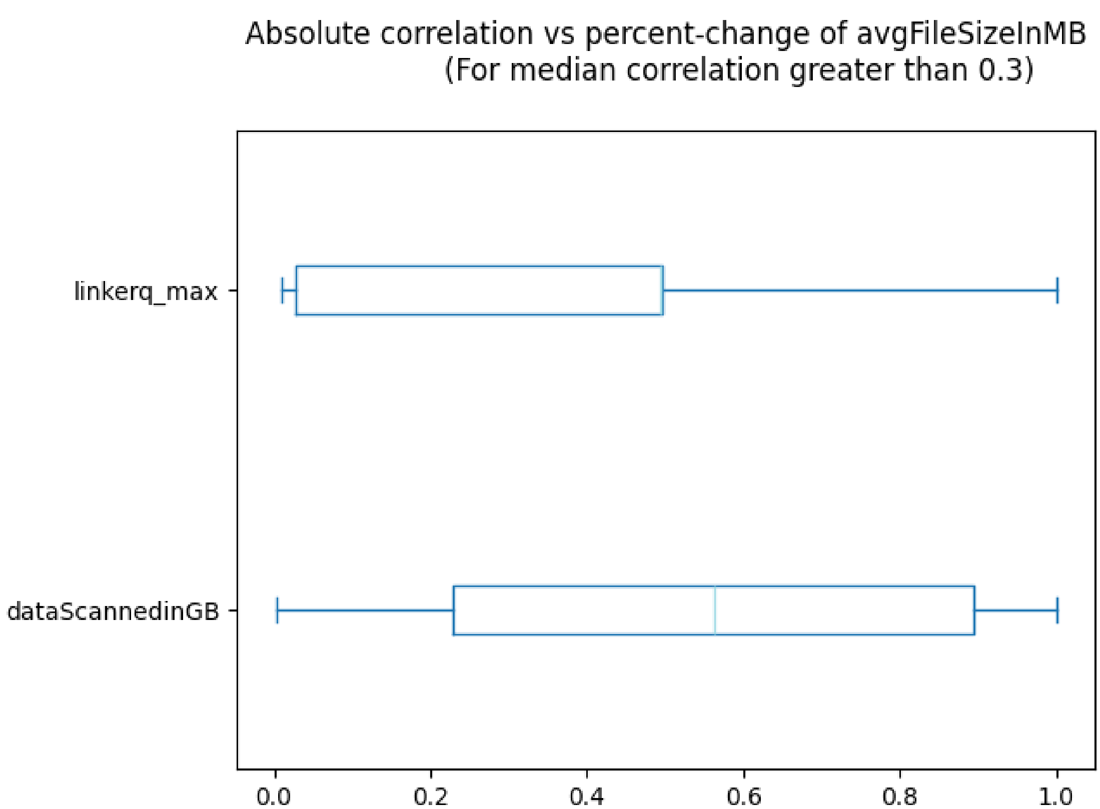
0.9	0.7	0.5	0.3
linkerq_avg	linkerq_avg	linkerq_avg	linkerq_avg
numberOfChunksScanned	numberOfChunksScanned	numberOfChunksScanned	numberOfChunksScanned
numberOfColsScanned	numberOfColsScanned	numberOfColsScanned	numberOfColsScanned
numFilesScanned	numFilesScanned	numFilesScanned	numFilesScanned
	scanTime	scanTime	scanTime
	tmp_taskq_avg	tmp_taskq_avg	tmp_taskq_avg
	fileDownloadTimeInHrs	fileDownloadTimeInHrs	fileDownloadTimeInHrs
		avgFileSizeInMB	avgFileSizeInMB
		dataScannedinGB	dataScannedinGB
		memory_used_avg	memory_used_avg
		IdleTimeInHrs	IdleTimeInHrs
		cpu_used_avg	cpu_used_avg
			uniqPodCount

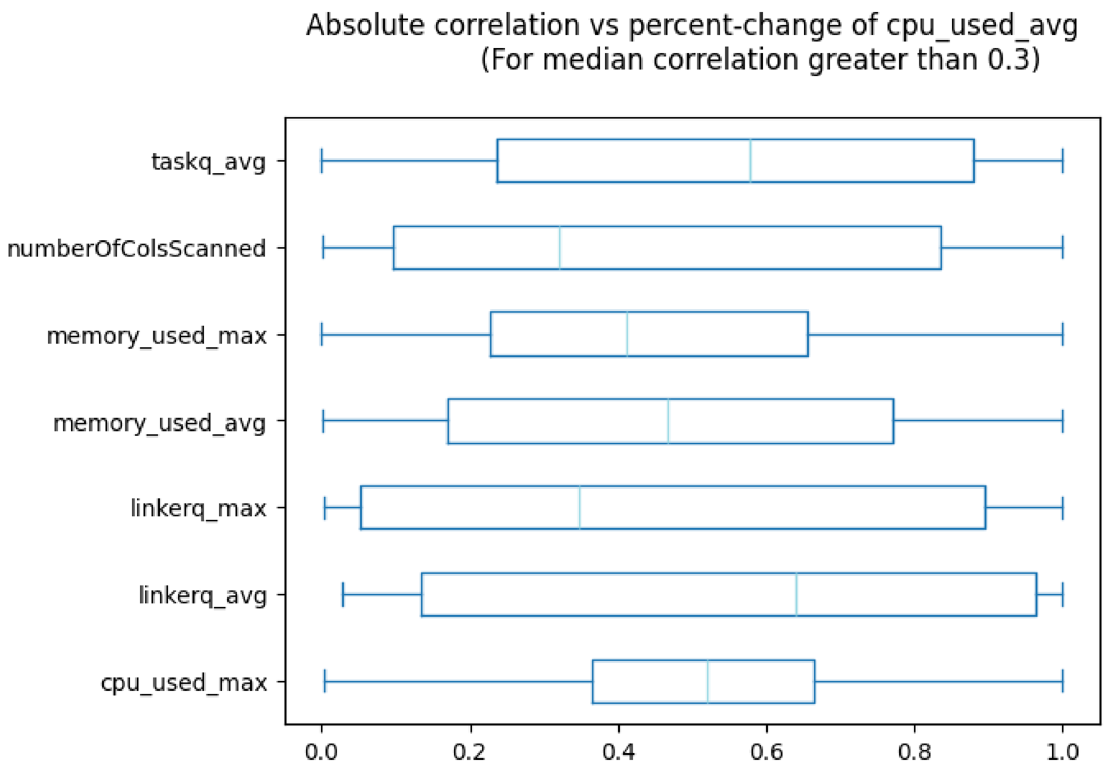
[4]:
```
corr_vals = [0.9, 0.7, 0.5, 0.3]
line = set()
for cutoff in corr_vals:
    arr = []
    for metr in dfc.metric.unique():
        dfcm = dfc[(dfc.metric == metr)]
        dfcm = dfcm.drop('metric', axis=1)
        dfcm = dfcm.drop(metr, axis=1)
        dfcm = dfcm.dropna(axis = 0, how = 'all')
        dfcm = dfcm.loc[:, dfcm.median() > cutoff]
        [arr.append(x) for x in dfcm.columns]
        # dfcm = dfcm.dropna(axis = 1,thresh=getMiniumValidValues(dfcm, pct=10,␣
 ↪ceiling=10))
        # display(dfcm)
        # break
        if(cutoff == 0.3):
```

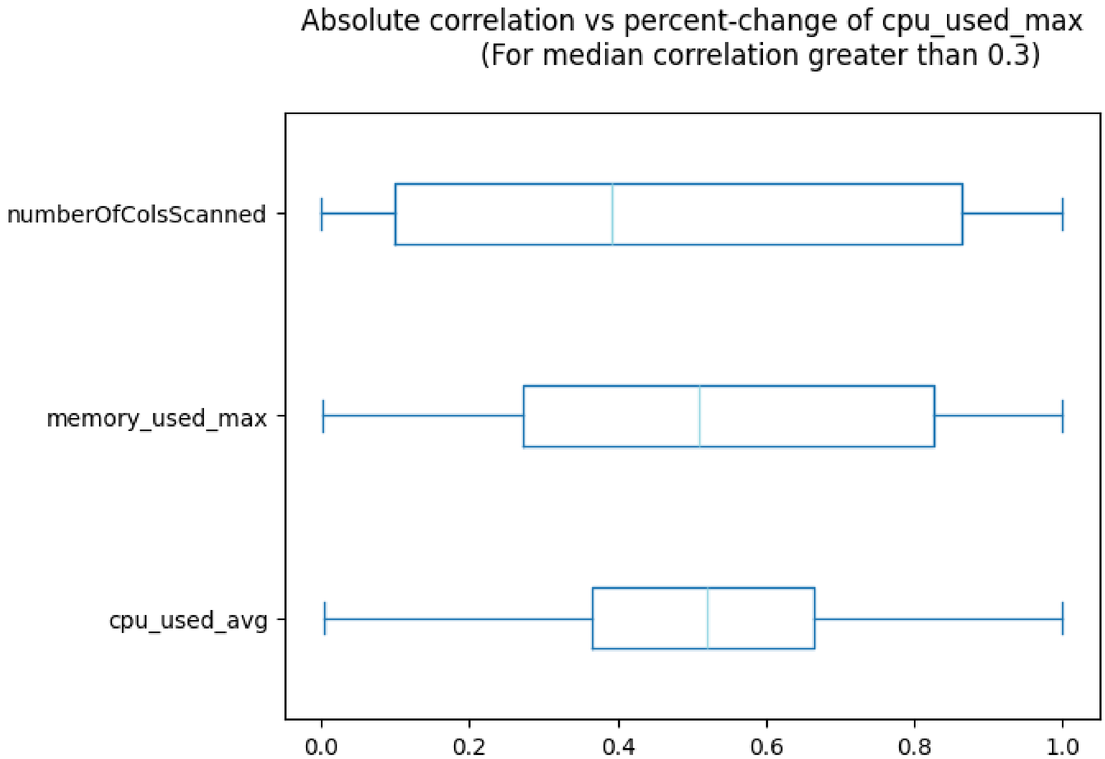
```
            if len(dfcm.columns) > 0:
                title=f'''Absolute correlation vs percent-change of {metr}
                (For median correlation greater than {cutoff})
                '''
                dfcm.plot(kind='box'
                        ,vert=False
                        ,title=title
                        ,colormap='tab20'
                        )
    for met in set(arr):
        if("max" not in met):
            line.add(met)
    print(cutoff, line)
```

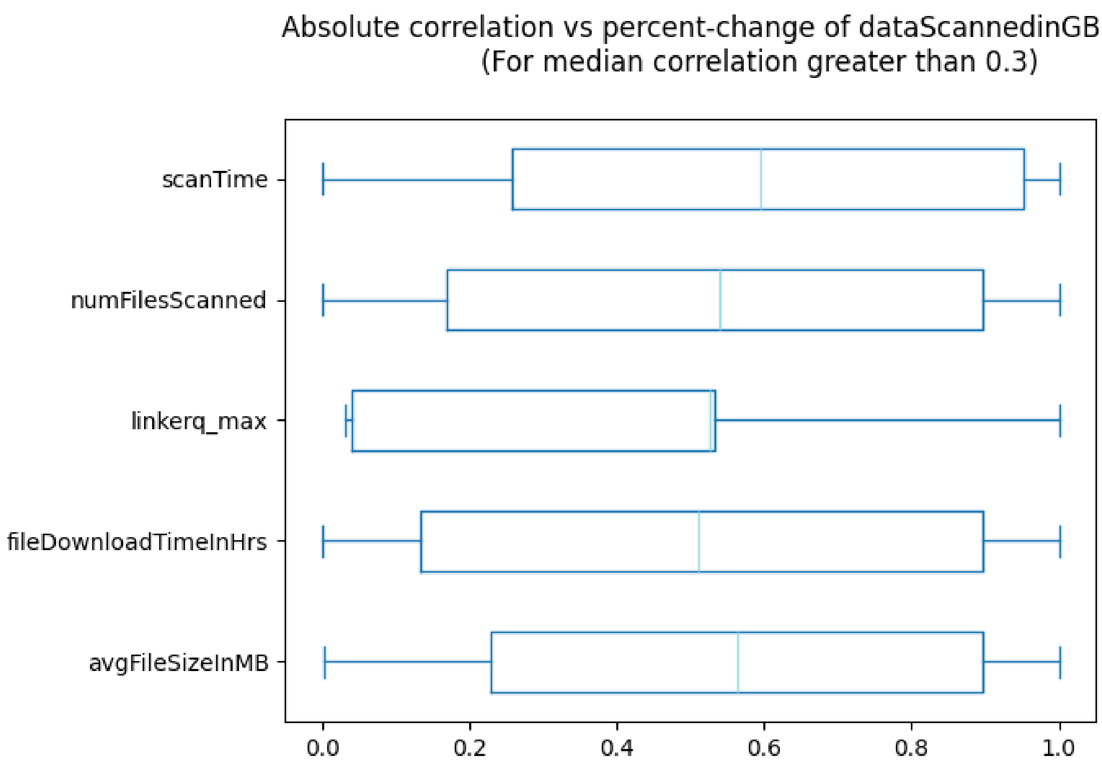
```
0.9 {'numberOfChunksScanned', 'linkerq_avg', 'numberOfColsScanned',
'numFilesScanned'}
0.7 {'numberOfChunksScanned', 'fileDownloadTimeInHrs', 'linkerq_avg',
'numFilesScanned', 'tmp_taskq_avg', 'scanTime', 'numberOfColsScanned'}
0.5 {'cpu_used_avg', 'numberOfChunksScanned', 'fileDownloadTimeInHrs',
'linkerq_avg', 'dataScannedinGB', 'numFilesScanned', 'tmp_taskq_avg',
'scanTime', 'memory_used_avg', 'IdleTimeInHrs', 'numberOfColsScanned',
'taskq_avg', 'avgFileSizeInMB'}

0.3 {'cpu_used_avg', 'numberOfChunksScanned', 'fileDownloadTimeInHrs',
'uniqPodCount', 'linkerq_avg', 'dataScannedinGB', 'numFilesScanned',
'tmp_taskq_avg', 'scanTime', 'memory_used_avg', 'IdleTimeInHrs',
'numberOfColsScanned', 'taskq_avg', 'avgFileSizeInMB'}
```

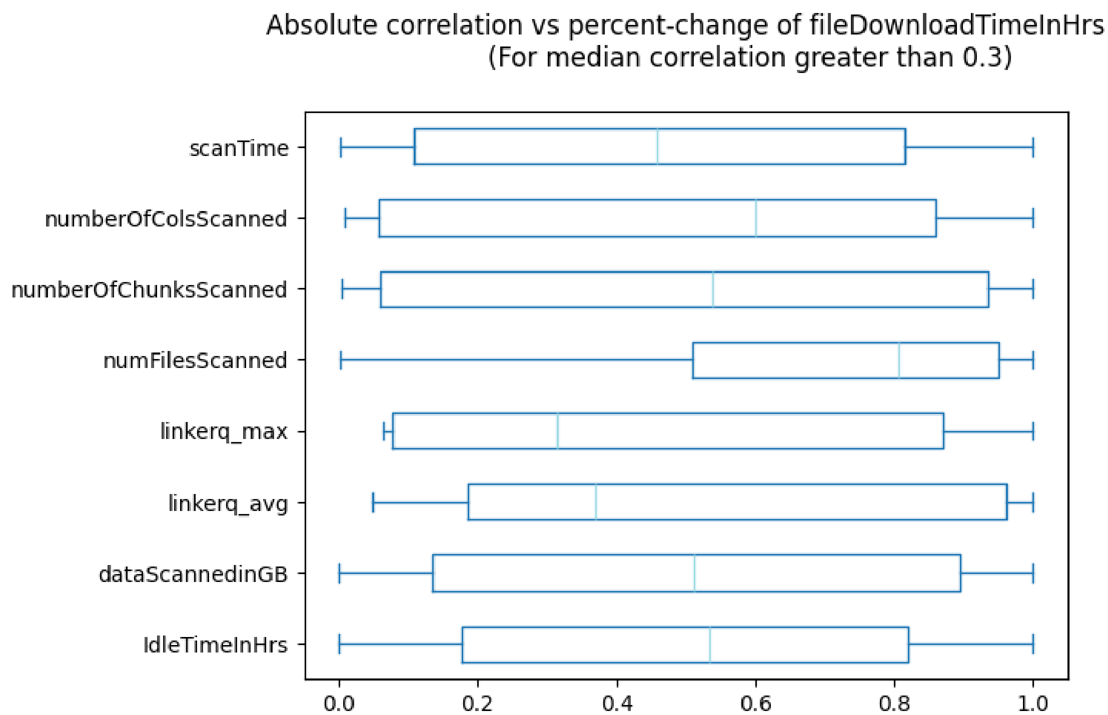

Absolute correlation vs percent-change of IdleTimeInHrs
(For median correlation greater than 0.3)
numberOfColsScanned
numberOfChunksScanned
numFilesScanned
fileDownloadTimeInHrs
0.0
0.2
0.4
0.6
0.8
1.0

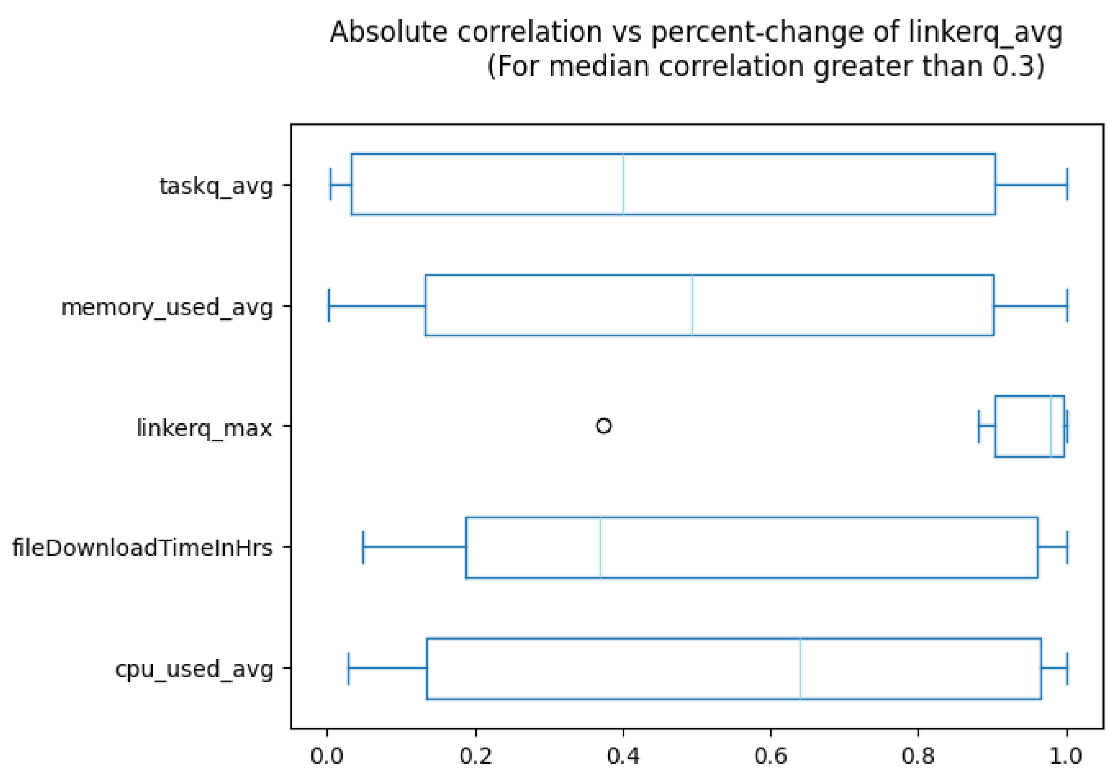

Absolute correlation vs percent-change of avgFileSizeInMB
(For median correlation greater than 0.3)
linkerq_max
dataScannedinGB
0.0
0.2
0.4
0.6
0.8
1.0

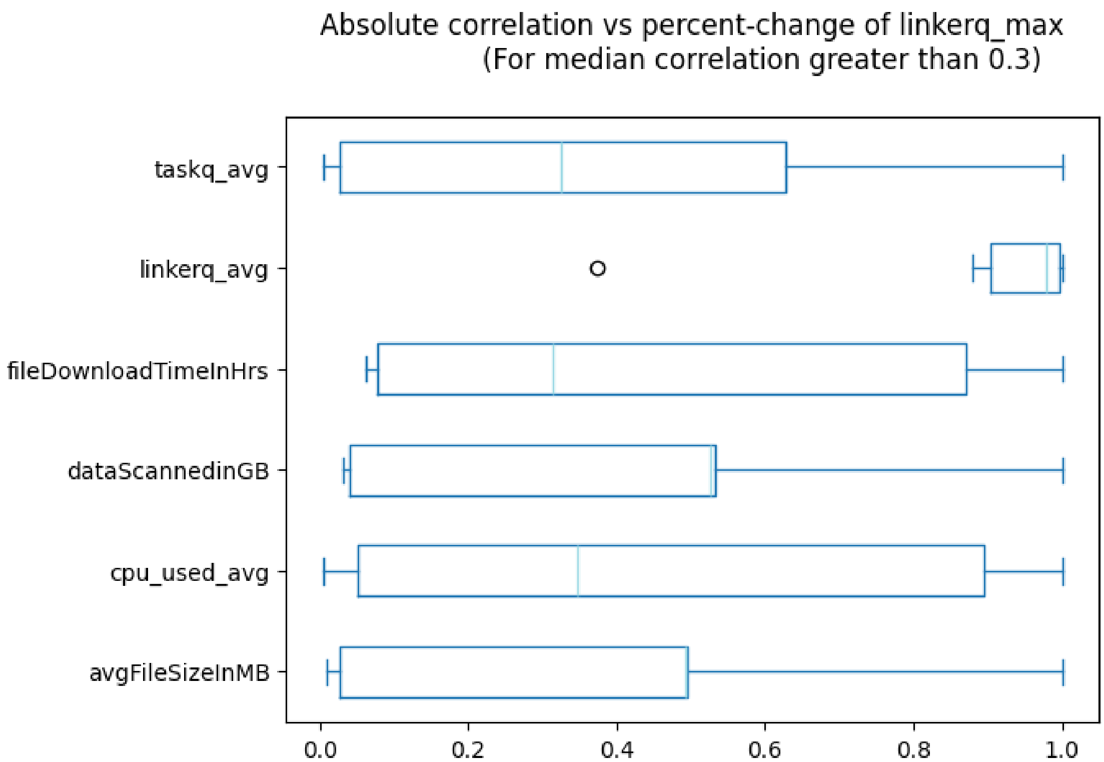

Absolute correlation vs percent-change of cpu_used_avg
(For median correlation greater than 0.3)
taskq_avg
numberOfColsScanned
memory_used_max
memory_used_avg
linkerq_max
linkerq_avg
cpu_used_max
0.0
0.2
0.4
0.6
0.8
1.0

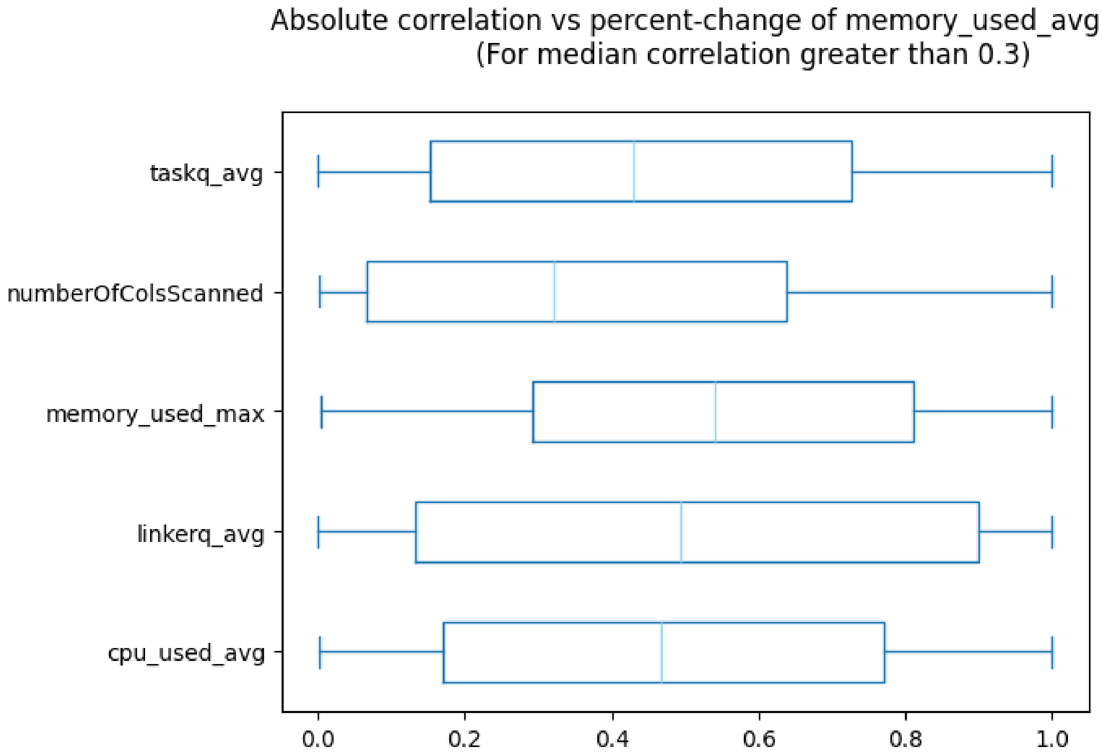

Absolute correlation vs percent-change of cpu_used_max
(For median correlation greater than 0.3)
numberOfColsScanned
memory_used_max
cpu_used_avg
0.0
0.2
0.4
0.6
0.8
1.0

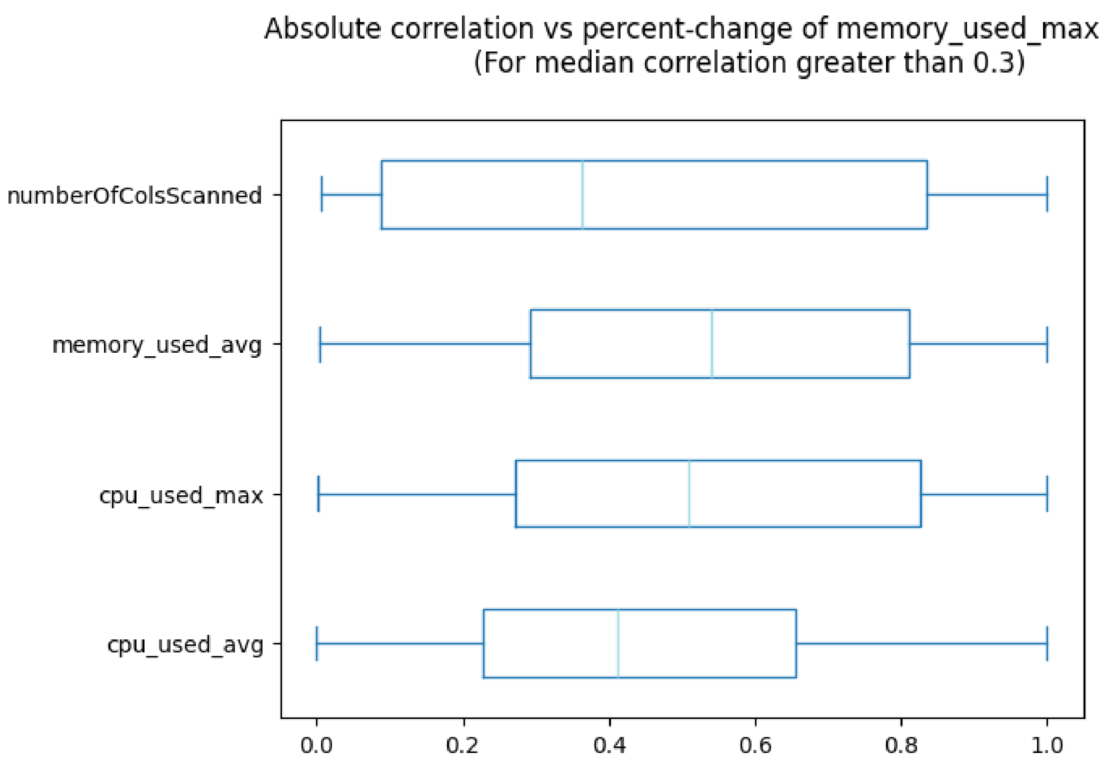

Absolute correlation vs percent-change of dataScannedinGB
(For median correlation greater than 0.3)
scanTime
numFilesScanned
linkerq_max
fileDownloadTimeInHrs
avgFileSizeInMB
0.0
0.2
0.4
0.6
0.8
1.0

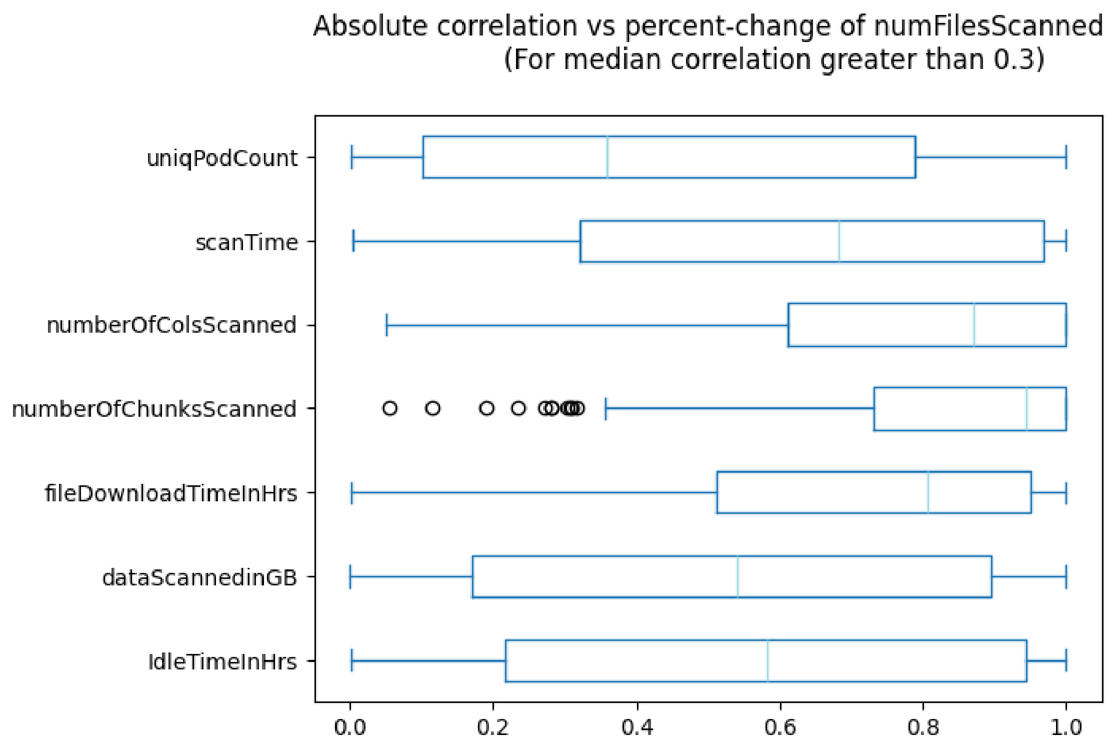

Absolute correlation vs percent-change of fileDownloadTimeInHrs
(For median correlation greater than 0.3)
scanTime
numberOfColsScanned
numberOfChunksScanned
numFilesScanned
linkerq_max
linkerq_avg
dataScannedinGB
IdleTimeInHrs
0.0
0.2
0.4
0.6
0.8
1.0

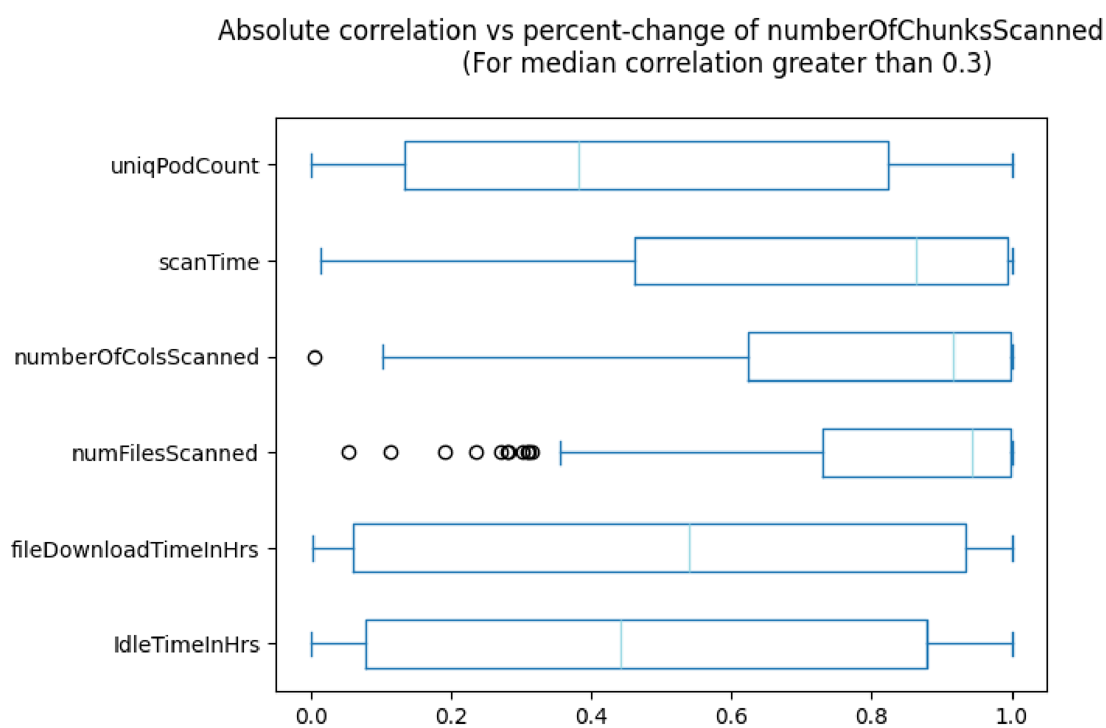

Absolute correlation vs percent-change of linkerq_avg
(For median correlation greater than 0.3)
taskq_avg
memory_used_avg
linkerq_max
fileDownloadTimeInHrs
cpu_used_avg
0.0
0.2
0.4
0.6
0.8
1.0

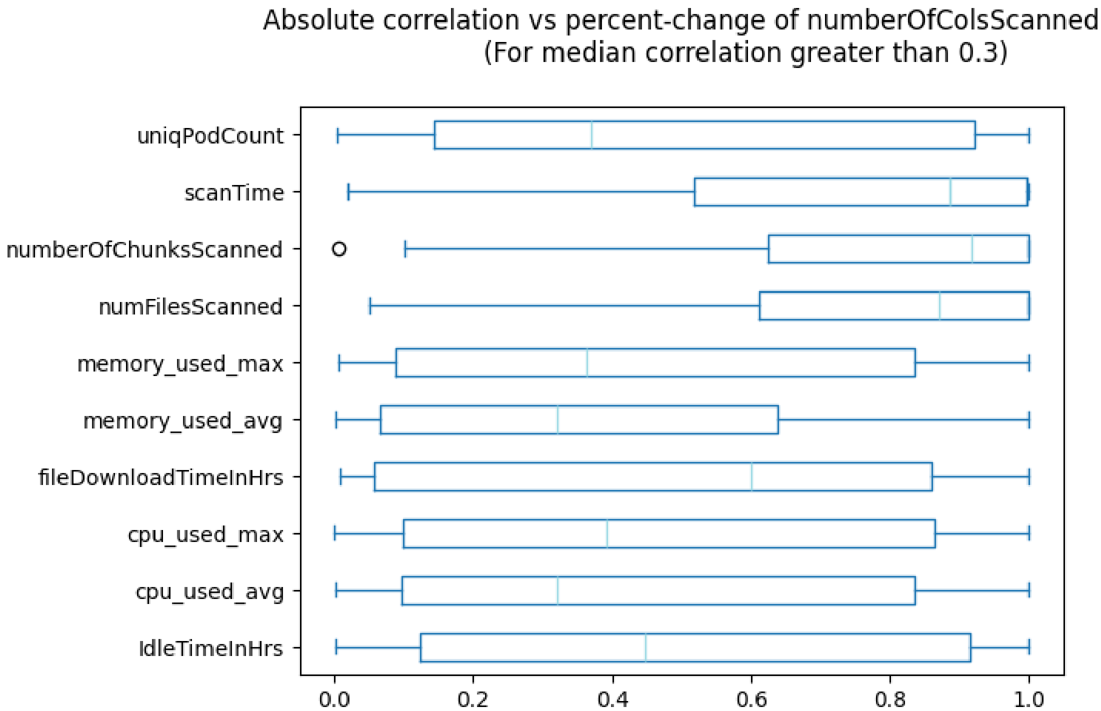

Absolute correlation vs percent-change of linkerq_max
(For median correlation greater than 0.3)
taskq_avg
linkerq_avg
fileDownloadTimeInHrs
dataScannedinGB
cpu_used_avg
avgFileSizeInMB
0.0
0.2
0.4
0.6
0.8
1.0

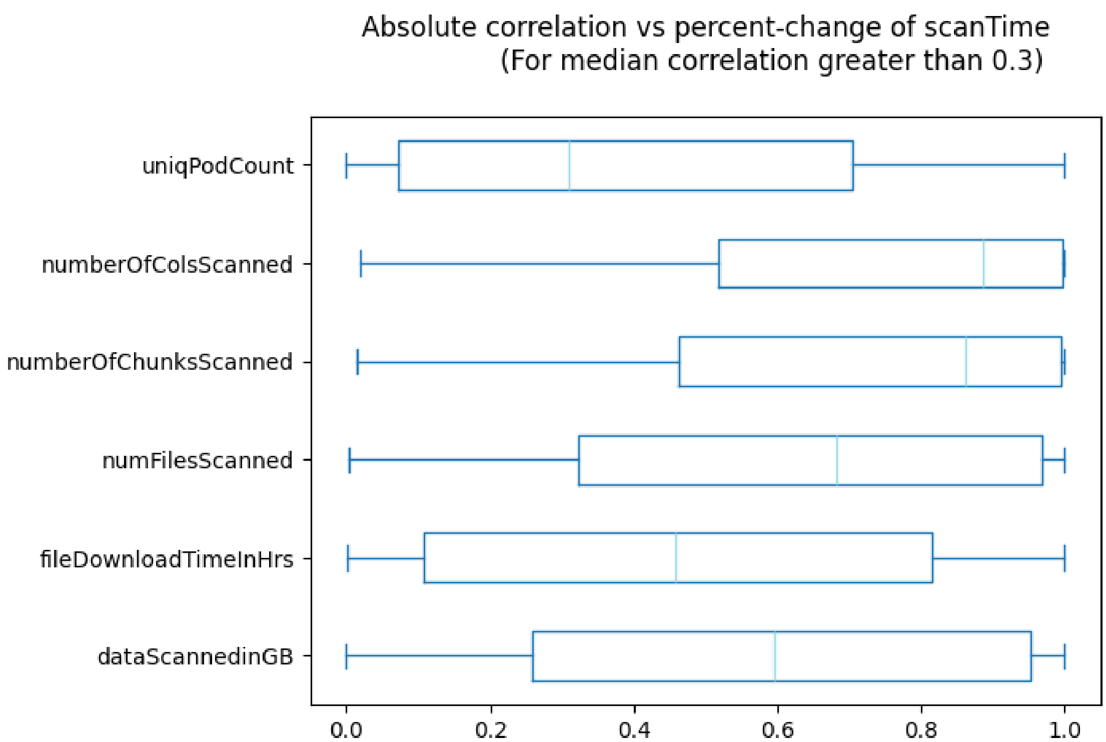

Absolute correlation vs percent-change of memory_used_avg
(For median correlation greater than 0.3)
taskq_avg
numberOfColsScanned
memory_used_max
linkerq_avg
cpu_used_avg
0.0
0.2
0.4
0.6
0.8
1.0

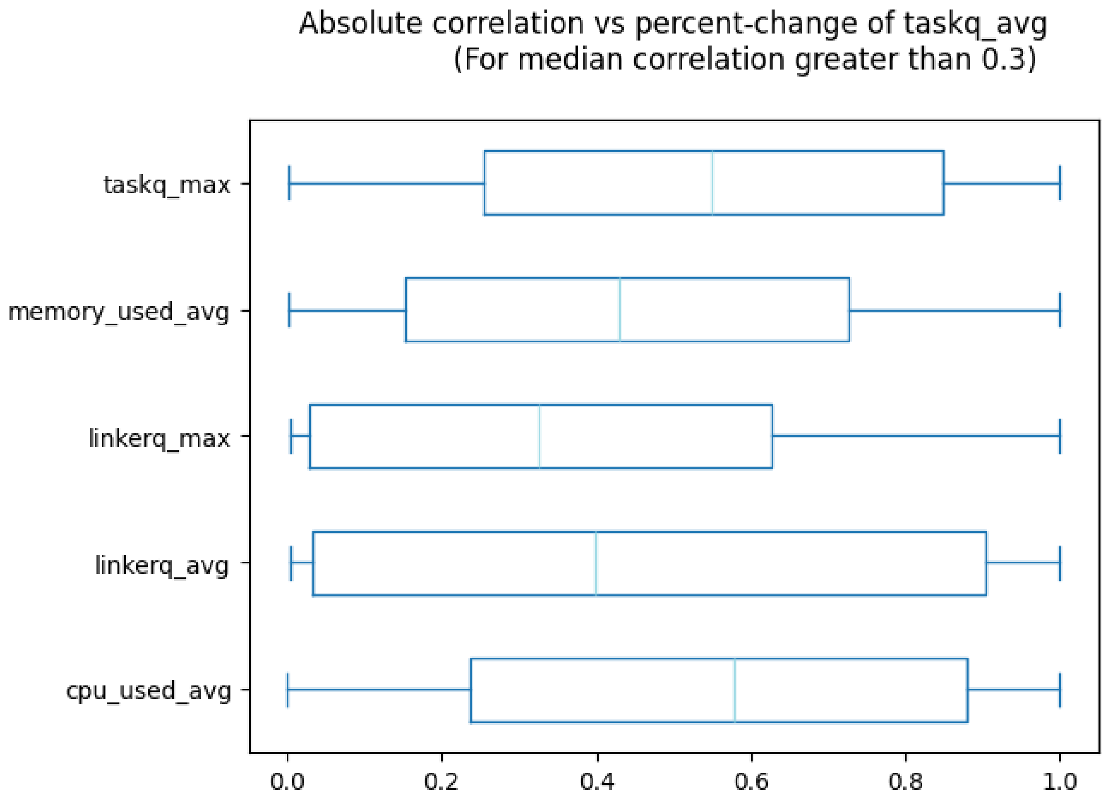

Absolute correlation vs percent-change of memory_used_max
(For median correlation greater than 0.3)
numberOfColsScanned
memory_used_avg
cpu_used_max
cpu_used_avg
0.0
0.2
0.4
0.6
0.8
1.0

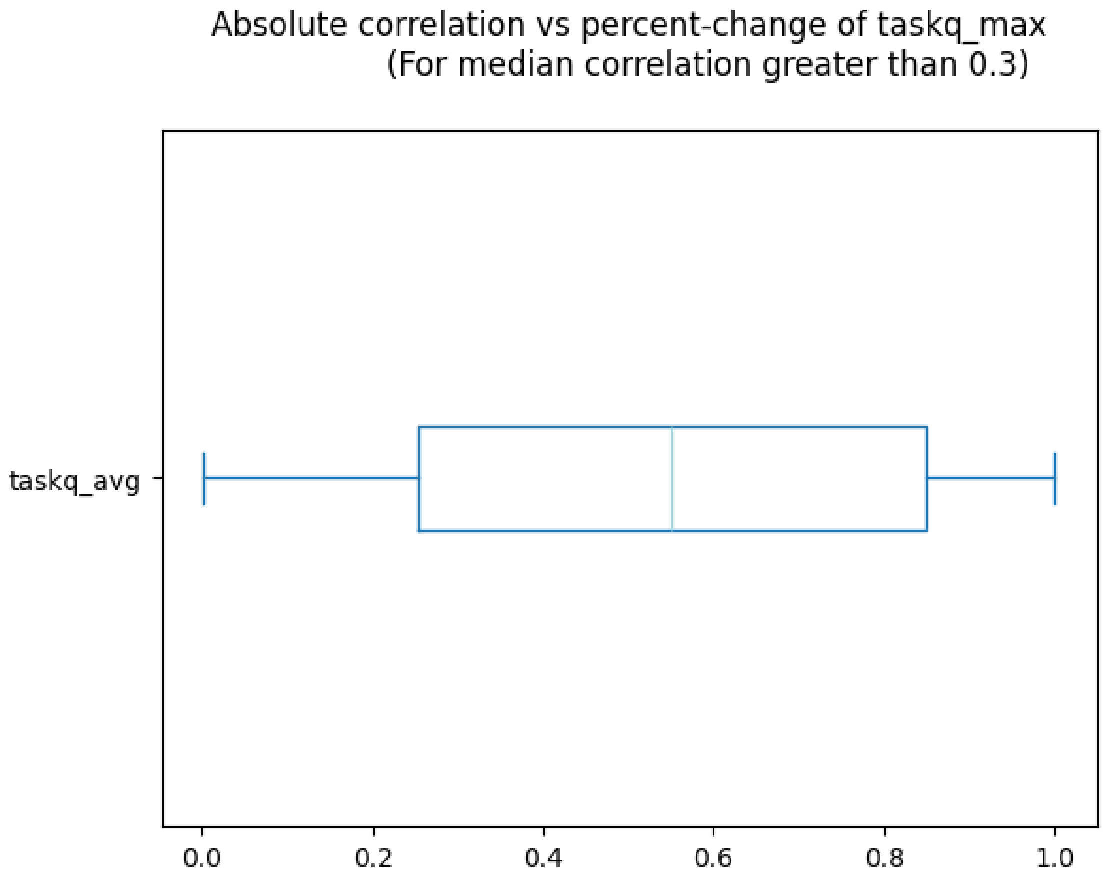

Absolute correlation vs percent-change of numFilesScanned
(For median correlation greater than 0.3)
uniqPodCount
scanTime
numberOfColsScanned
numberOfChunksScanned
fileDownloadTimeInHrs
dataScannedinGB
IdleTimeInHrs
0.0
0.2
0.4
0.6
0.8
1.0

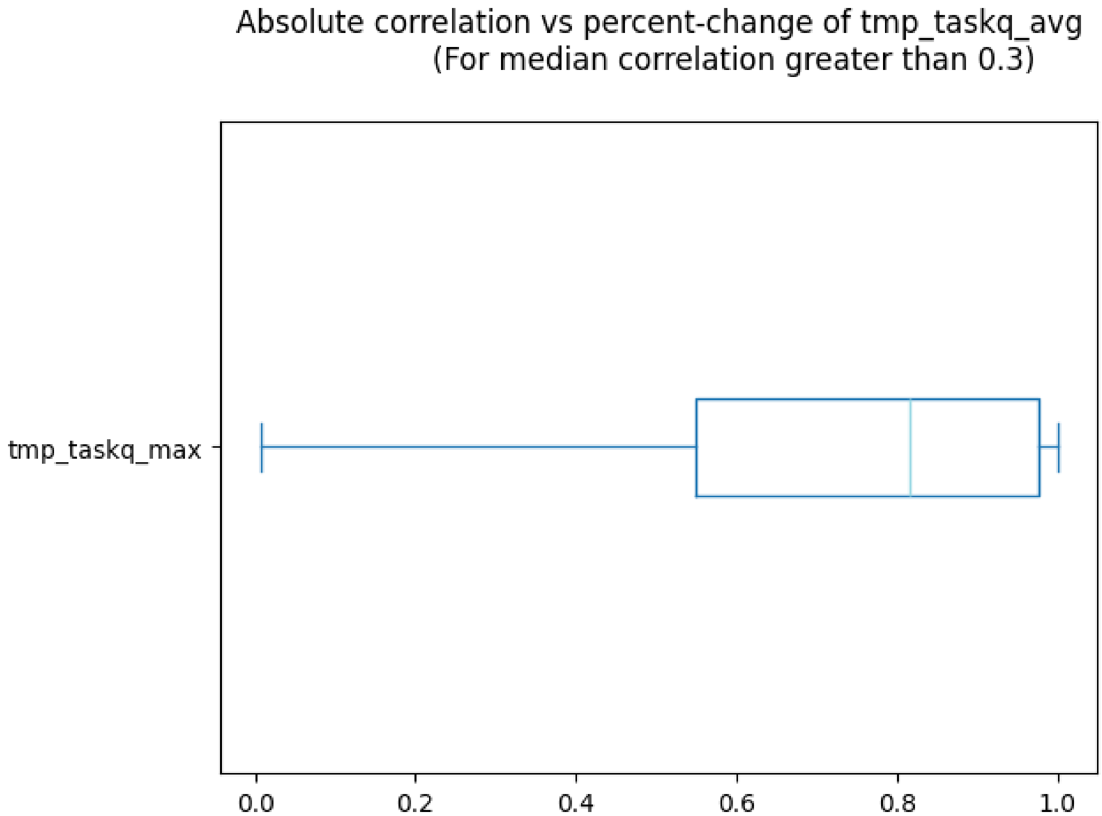

Absolute correlation vs percent-change of numberOfChunksScanned
(For median correlation greater than 0.3)
uniqPodCount
scanTime
numberOfColsScanned
numFilesScanned
fileDownloadTimeInHrs
IdleTimeInHrs
0.0
0.2
0.4
0.6
0.8
1.0

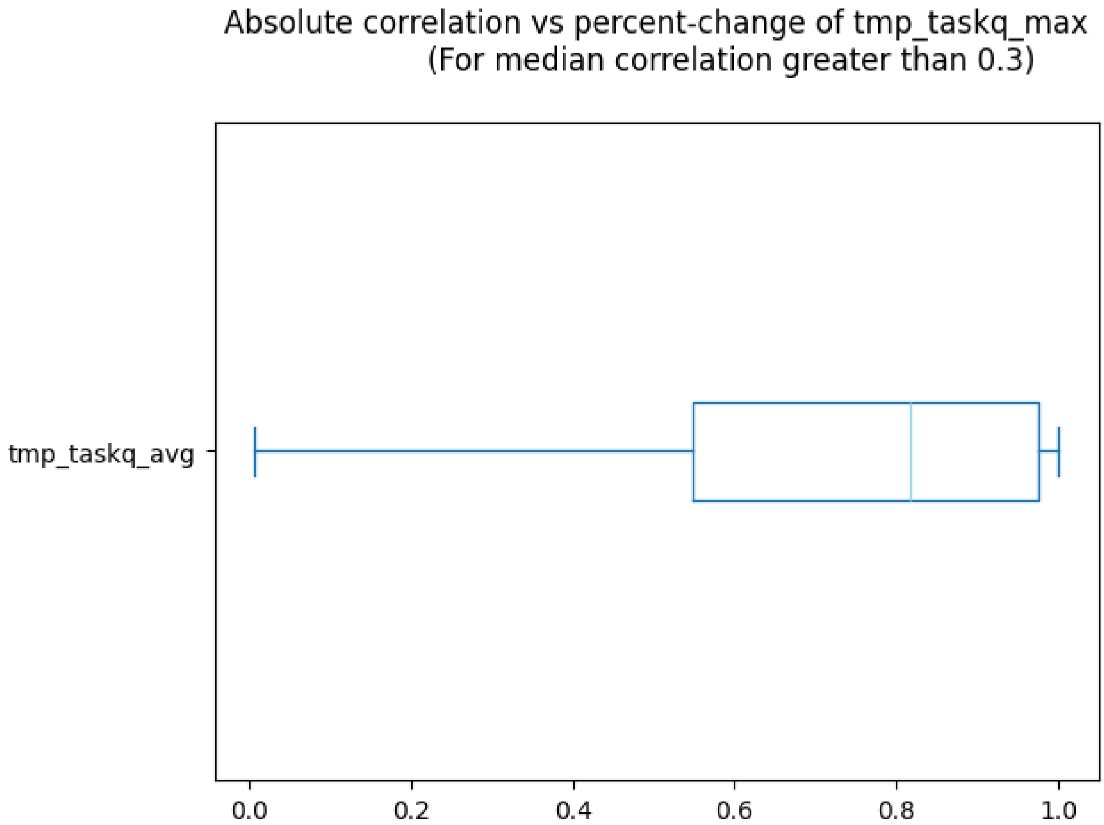

Absolute correlation vs percent-change of numberOfColsScanned
(For median correlation greater than 0.3)
uniqPodCount
scanTime
numberOfChunksScanned
numFilesScanned
memory_used_max
memory_used_avg
fileDownloadTimeInHrs
cpu_used_max
cpu_used_avg
IdleTimeInHrs
0.0
0.2
0.4
0.6
0.8
1.0

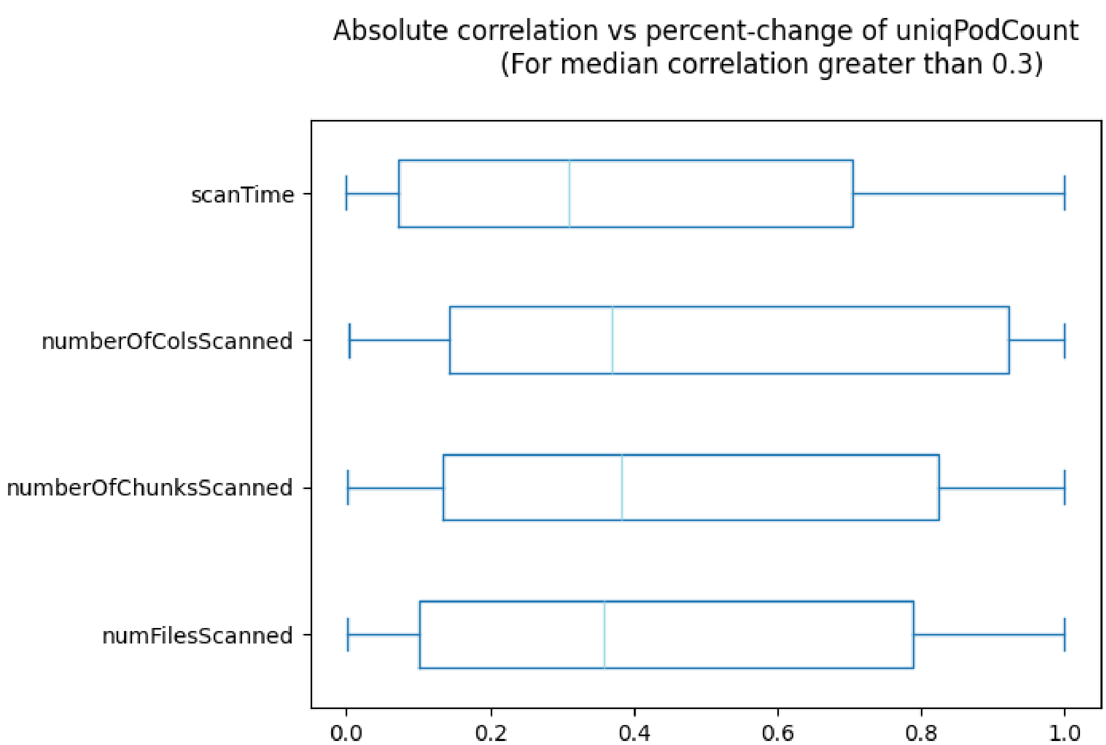

Absolute correlation vs percent-change of scanTime
(For median correlation greater than 0.3)
uniqPodCount
numberOfColsScanned
numberOfChunksScanned
numFilesScanned
fileDownloadTimeInHrs
dataScannedinGB
0.0
0.2
0.4
0.6
0.8
1.0


Absolute correlation vs percent-change of taskq_avg
(For median correlation greater than 0.3)
taskq_max
memory_used_avg
linkerq_max
linkerq_avg
cpu_used_avg
0.0
0.2
0.4
0.6
0.8
1.0


Absolute correlation vs percent-change of taskq_max
(For median correlation greater than 0.3)
taskq_avg
0.0
0.2
0.4
0.6
0.8
1.0


Absolute correlation vs percent-change of tmp_taskq_avg
(For median correlation greater than 0.3)
tmp_taskq_max
0.0
0.2
0.4
0.6
0.8
1.0


Absolute correlation vs percent-change of tmp_taskq_max
(For median correlation greater than 0.3)
tmp_taskq_avg
0.0
0.2
0.4
0.6
0.8
1.0


Absolute correlation vs percent-change of uniqPodCount
(For median correlation greater than 0.3)
scanTime
numberOfColsScanned
numberOfChunksScanned
numFilesScanned
0.0
0.2
0.4
0.6
0.8
1.0