Chapter 6 - Aggregation models

November 10, 2020

Analysis comparing aggregation models.

[1]:
```
import geopandas as gpd
import pandas as pd
import numpy as np
import seaborn as sbn
import matplotlib.pyplot as plt
import momepy as mm
from libpysal.weights import KNN, DistanceBand
from timeit import default_timer as timer
import numpy as np
from tqdm import tqdm
```

0.1 Generate neighbors

[ ]:
```
gpkg = "files/prague_isuf.gpkg"

buildings = gpd.read_file(gpkg, layer="buildings")
streets = gpd.read_file(gpkg, layer='streets')
centroids = gpd.read_file(gpkg, layer='centroids')

buildings['uID'] = range(len(buildings))

tessellation = gpd.read_file(gpkg, layer="tessellation")
tessellation["cellarea"] = tessellation.geometry.area
#
if "cellarea" not in buildings.columns:
    buildings = buildings.merge(tessellation[["uID", "cellarea"]], on="uID")

start = timer()

queen4 = mm.Queen_higher(tessellation, 4)

mean_distances = []
max_distance = []
neighbours = []
variance_area = []  # coefficient of variation
total_area = []
```

```
for index, row in tqdm(tessellation.iterrows(), total=tessellation.shape[0]):
    neighb = queen4.neighbors[index]
    vicinity = tessellation.iloc[neighb]

    neighbours.append(len(neighb))
    if len(neighb) > 0:
        variance_area.append(np.nanstd(vicinity['cellarea']) / np.
↪nanmean(vicinity['cellarea']))
        total_area.append(sum(vicinity['cellarea']))

        centroid = row.geometry.centroid
        distances = []
        for idx, r in vicinity.iterrows():
            distances.append(r.geometry.distance(centroid))

        mean_distances.append(np.nanmean(distances))
        max_distance.append(np.nanmax(distances))
    else:
        variance_area.append(0)
        total_area.append(0)
        mean_distances.append(0)
        max_distance.append(0)

tessellation['q4_md'] = mean_distances
tessellation['q4_n'] = neighbours
tessellation['q4_va'] = variance_area
tessellation['q4_a'] = total_area
tessellation['q4_maxd'] = max_distance
print('Queen 4 done in', timer() - start, 'seconds')

start = timer()

queen9 = mm.Queen_higher(tessellation, 9)

mean_distances = []
max_distance = []
neighbours = []
variance_area = []  # coefficient of variation
total_area = []

for index, row in tqdm(tessellation.iterrows(), total=tessellation.shape[0]):
    neighb = queen9.neighbors[index]
    vicinity = tessellation.iloc[neighb]

    neighbours.append(len(neighb))
    if len(neighb) > 0:
```

```
        variance_area.append(np.nanstd(vicinity['cellarea']) / np.
↪nanmean(vicinity['cellarea']))
        total_area.append(sum(vicinity['cellarea']))

        centroid = row.geometry.centroid
        distances = []
        for idx, r in vicinity.iterrows():
            distances.append(r.geometry.distance(centroid))

        mean_distances.append(np.nanmean(distances))
        max_distance.append(np.nanmax(distances))
    else:
        variance_area.append(0)
        total_area.append(0)
        mean_distances.append(0)
        max_distance.append(0)

tessellation['q9_md'] = mean_distances
tessellation['q9_n'] = neighbours
tessellation['q9_va'] = variance_area
tessellation['q9_a'] = total_area
tessellation['q9_maxd'] = max_distance

print('Queen 9 done in', timer() - start, 'seconds')

tessellation.to_file(gpkg, layer='tessellation', driver='GPKG')

start = timer()

distance200 = DistanceBand.from_dataframe(buildings, 200, silence_warnings=True)

mean_distances = []
max_distance = []
neighbours = []
variance_area = []  # coefficient of variation
total_area = []

for index, row in tqdm(buildings.iterrows(), total=buildings.shape[0]):
    neighb = distance200.neighbors[index]
    vicinity = buildings.iloc[neighb]

    neighbours.append(len(neighb))
    if len(neighb) > 0:
        variance_area.append(np.nanstd(vicinity['cellarea']) / np.
↪nanmean(vicinity['cellarea']))
        total_area.append(sum(vicinity['cellarea']))
```

```
        centroid = row.geometry.centroid
        distances = []
        for idx, r in vicinity.iterrows():
            distances.append(r.geometry.distance(centroid))

        mean_distances.append(np.nanmean(distances))
        max_distance.append(np.nanmax(distances))
    else:
        variance_area.append(0)
        total_area.append(0)
        mean_distances.append(0)
        max_distance.append(0)

buildings['d200_md'] = mean_distances
buildings['d200_n'] = neighbours
buildings['d200_va'] = variance_area
buildings['d200_a'] = total_area
buildings['d200_maxd'] = max_distance
print('Distance 200 done in', timer() - start, 'seconds')

start = timer()
distance400 = DistanceBand.from_dataframe(buildings, 400, silence_warnings=True)

mean_distances = []
max_distance = []
neighbours = []
variance_area = []  # coefficient of variation
total_area = []

for index, row in tqdm(buildings.iterrows(), total=buildings.shape[0]):
    neighb = distance400.neighbors[index]
    vicinity = buildings.iloc[neighb]

    neighbours.append(len(neighb))
    if len(neighb) > 0:
        variance_area.append(np.nanstd(vicinity['cellarea']) / np.
 ↪nanmean(vicinity['cellarea']))
        total_area.append(sum(vicinity['cellarea']))

        centroid = row.geometry.centroid
        distances = []
        for idx, r in vicinity.iterrows():
            distances.append(r.geometry.distance(centroid))

        mean_distances.append(np.nanmean(distances))
        max_distance.append(np.nanmax(distances))
    else:
```

```python
        variance_area.append(0)
        total_area.append(0)
        mean_distances.append(0)
        max_distance.append(0)

buildings['d400_md'] = mean_distances
buildings['d400_n'] = neighbours
buildings['d400_va'] = variance_area
buildings['d400_a'] = total_area
buildings['d400_maxd'] = max_distance
print('Distance 400 done in', timer() - start, 'seconds')


start = timer()
knn70 = KNN.from_dataframe(buildings, k=80)

mean_distances = []
max_distance = []
neighbours = []
variance_area = []  # coefficient of variation
total_area = []

for index, row in tqdm(buildings.iterrows(), total=buildings.shape[0]):
    neighb = knn70.neighbors[index]
    vicinity = buildings.iloc[neighb]

    neighbours.append(len(neighb))
    if len(neighb) > 0:
        variance_area.append(
            np.nanstd(vicinity["cellarea"]) / np.nanmean(vicinity["cellarea"])
        )
        total_area.append(sum(vicinity["cellarea"]))

        centroid = row.geometry.centroid
        distances = []
        for idx, r in vicinity.iterrows():
            distances.append(r.geometry.distance(centroid))

        mean_distances.append(np.nanmean(distances))
        max_distance.append(np.nanmax(distances))
    else:
        variance_area.append(0)
        total_area.append(0)
        mean_distances.append(0)
        max_distance.append(0)

buildings["knn70_md"] = mean_distances
```

```python
buildings["knn70_n"] = neighbours
buildings["knn70_va"] = variance_area
buildings["knn70_a"] = total_area
buildings["knn70_maxd"] = max_distance
print("KNN 70 done in", timer() - start, "seconds")

start = timer()
knn320 = KNN.from_dataframe(buildings, k=431)

mean_distances = []
max_distance = []
neighbours = []
variance_area = []  # coefficient of variation
total_area = []

for index, row in tqdm(buildings.iterrows(), total=buildings.shape[0]):
    neighb = knn320.neighbors[index]
    vicinity = buildings.iloc[neighb]

    neighbours.append(len(neighb))
    if len(neighb) > 0:
        variance_area.append(
            np.nanstd(vicinity["cellarea"]) / np.nanmean(vicinity["cellarea"])
        )
        total_area.append(sum(vicinity["cellarea"]))

        centroid = row.geometry.centroid
        distances = []
        for idx, r in vicinity.iterrows():
            distances.append(r.geometry.distance(centroid))

        mean_distances.append(np.nanmean(distances))
        max_distance.append(np.nanmax(distances))
    else:
        variance_area.append(0)
        total_area.append(0)
        mean_distances.append(0)
        max_distance.append(0)

buildings["knn320_md"] = mean_distances
buildings["knn320_n"] = neighbours
buildings["knn320_va"] = variance_area
buildings["knn320_a"] = total_area
buildings["knn320_maxd"] = max_distance
print("KNN 320 done in", timer() - start, "seconds")
```

```
buildings.to_file(gpkg, layer="buildings", driver="GPKG")
tessellation.to_file(gpkg, layer='tessellation', driver='GPKG')
streets.to_file(gpkg, layer='streets', driver='GPKG')
centroids.to_file(gpkg, layer='centroids', driver='GPKG')

# FIX FOR THE US PAPER 191217
tessellation = gpd.read_file("files/cases.shp.gpkg",␣
 ↪layer="tessellation_buffered")

cases = {
    "vinohrady": 89507,
    "oldtown": 151686,
    "villas": 33231,
    "modernist": 109749,
    "industry": 57315,
}

for case in cases:
    id = (buildings.loc[buildings.uID == cases[case]].index)[0]
    neigh = knn70.neighbors[id]
    tessellation[tessellation["uID"].isin(buildings.loc[neigh].uID)].to_file(
        "files/cases.gpkg", layer="{c}_knn70".format(c=case), driver="GPKG"
    )

for case in cases:
    id = (buildings.loc[buildings.uID == cases[case]].index)[0]
    neigh = knn320.neighbors[id]
    tessellation[tessellation["uID"].isin(buildings.loc[neigh].uID)].to_file(
        "files/cases.gpkg", layer="{c}_knn320".format(c=case), driver="GPKG"
    )
```

0.2 Prepare data for plots

[ ]:
```
buildings = gpd.read_file(
    "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/prague_isuf.gpkg",
    layer="buildings",
)
tessellation = gpd.read_file(
    "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/cases.shp.gpkg",
    layer="tessellation_buffered",
)

queen9 = mm.Queen_higher(9, geodataframe=tessellation)

cases = {
    "vinohrady": 89507,
    "oldtown": 151686,
```

```
    "villas": 33231,
    "modernist": 109749,
    "industry": 57315,
}


for case in cases:
    id = list(tessellation.loc[tessellation.uID == cases[case]].index)[0]
    neigh = queen9.neighbors[id]
    tessellation.iloc[neigh].to_file(
        "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/cases.gpkg",
        layer="{c}_q9".format(c=case),
        driver="GPKG",
    )

bnuildings_sample = buildings[buildings["uID"].isin(tessellation.uID)]

distance200 = DistanceBand.from_dataframe(bnuildings_sample, 200,␣
↪silence_warnings=True)

for case in cases:
    id = (bnuildings_sample.loc[bnuildings_sample.uID == cases[case]].index)[0]
    neigh = distance200.neighbors[id]
    tessellation[tessellation["uID"].isin(bnuildings_sample.loc[neigh].uID)].
↪to_file(
        "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/cases.gpkg",
        layer="{c}_d200".format(c=case),
        driver="GPKG",
    )

distance400 = DistanceBand.from_dataframe(bnuildings_sample, 400,␣
↪silence_warnings=True)

for case in cases:
    id = (bnuildings_sample.loc[bnuildings_sample.uID == cases[case]].index)[0]
    neigh = distance400.neighbors[id]
    tessellation[tessellation["uID"].isin(bnuildings_sample.loc[neigh].uID)].
↪to_file(
        "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/cases.gpkg",
        layer="{c}_d400".format(c=case),
        driver="GPKG",
    )

knn70 = KNN.from_dataframe(bnuildings_sample, k=70)

for case in cases:
    id = (bnuildings_sample.loc[bnuildings_sample.uID == cases[case]].index)[0]
```

```
    neigh = knn70.neighbors[id]
    tessellation[tessellation["uID"].isin(bnuildings_sample.loc[neigh].uID)].
 ↪to_file(
        "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/cases.gpkg",
        layer="{c}_knn70".format(c=case),
        driver="GPKG",
    )

knn320 = KNN.from_dataframe(bnuildings_sample, k=320)

for case in cases:
    id = (bnuildings_sample.loc[bnuildings_sample.uID == cases[case]].index)[0]
    neigh = knn320.neighbors[id]
    tessellation[tessellation["uID"].isin(bnuildings_sample.loc[neigh].uID)].
 ↪to_file(
        "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/cases.gpkg",
        layer="{c}_knn320".format(c=case),
        driver="GPKG",
    )

service200 = gpd.read_file(
    "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/s200_subset.shp"
)
service400 = gpd.read_file(
    "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/s400_subset.shp"
)

centroids = bnuildings_sample.copy()
centroids["geometry"] = centroids.geometry.centroid


def snap_to_line(points, lines, tolerance=100, prefer_endpoint=False,␣
 ↪sindex=None):
    """
    Attempt to snap a line to the nearest line, within tolerance distance.
    Lines must be in a planar (not geographic) projection and points
    must be in the same projection.
    Parameters
    ----------
    points : GeoPandas.DataFrame
        points to snap
    lines : GeoPandas.DataFrame
        lines to snap against
    tolerance : int, optional (default: 100)
        maximum distance between line and point that can still be snapped
    prefer_endpoint : bool, optional (default False)
        if True, will try to match to the nearest endpoint on the nearest line
```

```
        provided that the distance to that endpoint is less than tolerance.
        NOTE: NOT YET WORKING PROPERLY - DO NOT USE!
    Returns
    -------
    geopandas.GeoDataFrame
        output data frame containing:
        * all columns from points except geometry
        * geometry: snapped geometry
        * snap_dist: distance between original point and snapped location
        * nearby: number of nearby lines within tolerance
        * is_endpoint: True if successfully snapped to endpoint
        * any columns joined from lines
    """

    line_columns = list(set(lines.columns).difference({"geometry"}))
    columns = ["geometry", "snap_dist", "nearby", "is_endpoint"] + line_columns

    def snap(point):
        # point = record.geometry
        x, y = point.coords[0][:2]

        # Search window
        window = (x - tolerance, y - tolerance, x + tolerance, y + tolerance)

        # find nearby features
        hits = lines.iloc[list(sindex.intersection(window))].copy()

        # calculate distance to point and
        hits["dist"] = hits.distance(point)
        within_tolerance = hits[hits.dist <= tolerance]

        if len(within_tolerance):
            # find nearest line segment that is within tolerance
            closest = within_tolerance.nsmallest(1, columns=["dist"]).iloc[0]
            line = closest.geometry

            dist = closest.dist
            snapped = None
            is_endpoint = False
            if prefer_endpoint:
                # snap to the nearest endpoint if it is within tolerance
                endpoints = [
                    (pt, point.distance(pt))
                    for pt in (Point(line.coords[0]), Point(line.coords[-1]))
                    if point.distance(pt) < tolerance
                ]
                endpoints = sorted(endpoints, key=lambda x: x[1])
```

```
                if endpoints:
                    snapped, dist = endpoints[0]
                    is_endpoint = True

            if snapped is None:
                snapped = line.interpolate(line.project(point))

            values = [snapped, dist, len(within_tolerance), int(is_endpoint)]

            # Copy attributes from line to point
            values.extend([closest[c] for c in line_columns])

            return gpd.GeoSeries(values, index=columns)

        # create empty record
        # return pd.Series(([None] * 4) + [None for c in line_columns],␣
↪index=columns)
        return pd.Series([None] * len(columns), index=columns)

    if sindex is None:
        sindex = lines.sindex
        # Note: the spatial index is ALWAYS based on the integer index of the
        # geometries and NOT their index

    tqdm.pandas()
    snapped = gpd.GeoDataFrame(points.geometry.progress_apply(snap), crs=points.
↪crs)
    points = points.drop(columns=["geometry"]).join(snapped)
    return points.loc[~points.geometry.isnull()].copy()


streets = gpd.read_file(
    "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/cases_net.gpkg",
    layer="cases_net",
)
snapped = snap_to_line(centroids, streets)

sindex = snapped.sindex

service200["geometry"] = service200.geometry.convex_hull

for case in cases:
    geometry = service200[service200["uID"] == cases[case]].iloc[0].geometry
    possible_matches_index = list(sindex.intersection(geometry.bounds))
    possible_matches = snapped.iloc[possible_matches_index]
    vicinity = possible_matches[possible_matches.intersects(geometry)]
    tessellation[tessellation["uID"].isin(vicinity.uID)].to_file(
```

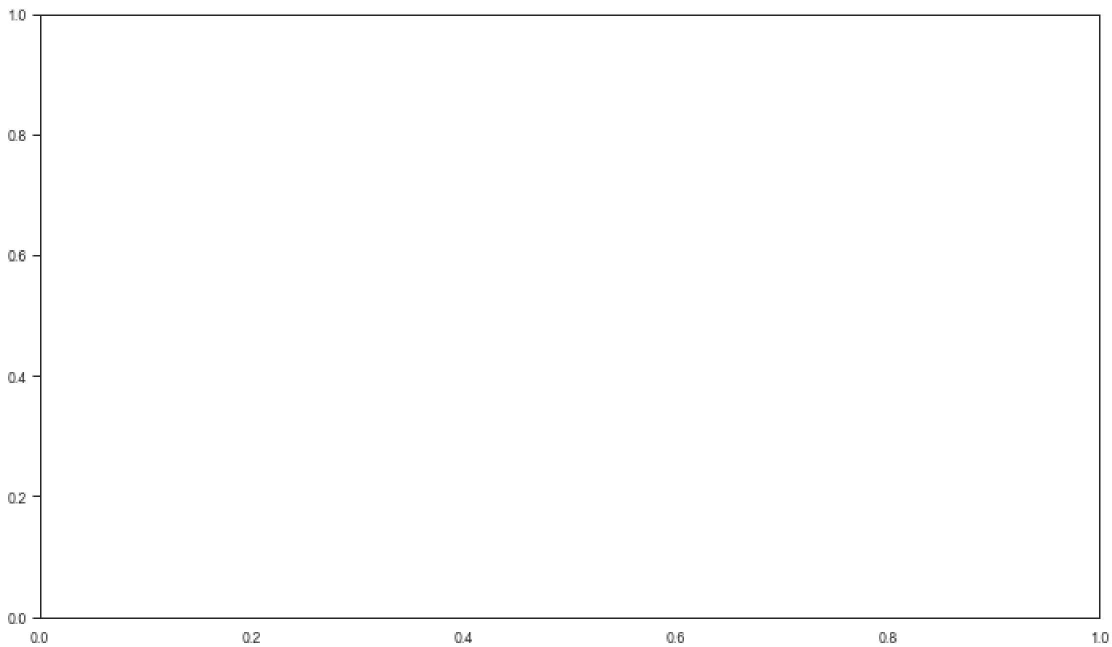
```
        "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/cases.gpkg",
        layer="{c}_r200a".format(c=case),
        driver="GPKG",
    )

service400["geometry"] = service400.geometry.convex_hull

for case in cases:
    geometry = service400[service400["uID"] == cases[case]].iloc[0].geometry
    possible_matches_index = list(sindex.intersection(geometry.bounds))
    possible_matches = snapped.iloc[possible_matches_index]
    vicinity = possible_matches[possible_matches.intersects(geometry)]
    tessellation[tessellation["uID"].isin(vicinity.uID)].to_file(
        "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/cases.gpkg",
        layer="{c}_r400a".format(c=case),
        driver="GPKG",
    )

types = ["r400a", "r200a"]
{
    "vinohrady": 89507,
    "oldtown": 151686,
    "villas": 33231,
    "modernist": 109749,
    "industry": 57315,
}


def _multi2single(gpdf):
    gpdf_singlepoly = gpdf[gpdf.geometry.type == "Polygon"]
    gpdf_multipoly = gpdf[gpdf.geometry.type == "MultiPolygon"]

    for i, row in gpdf_multipoly.iterrows():
        Series_geometries = pd.Series(row.geometry)
        df = pd.concat(
            [gpd.GeoDataFrame(row, crs=gpdf_multipoly.crs).T] *␣
 ↪len(Series_geometries),
            ignore_index=True,
        )
        df["geometry"] = Series_geometries
        gpdf_singlepoly = pd.concat([gpdf_singlepoly, df])

    gpdf_singlepoly.reset_index(inplace=True, drop=True)
    return gpdf_singlepoly


path = "/Users/martin/Dropbox/StrathUni/PhD/Sample Data/ISUF19/cases.gpkg"
```

```
for type in types:
    vinohrady = gpd.read_file(path, layer="vinohrady_{}".format(type))
    oldtown = gpd.read_file(path, layer="oldtown_{}".format(type))
    villas = gpd.read_file(path, layer="villas_{}".format(type))
    modernist = gpd.read_file(path, layer="modernist_{}".format(type))
    industry = gpd.read_file(path, layer="industry_{}".format(type))

    vinohrady["diss"] = 0
    vinohrady = _multi2single(vinohrady.dissolve(by="diss"))
    oldtown["diss"] = 0
    oldtown = _multi2single(oldtown.dissolve(by="diss"))
    villas["diss"] = 0
    villas = _multi2single(villas.dissolve(by="diss"))
    modernist["diss"] = 0
    modernist = _multi2single(modernist.dissolve(by="diss"))
    industry["diss"] = 0
    industry = _multi2single(industry.dissolve(by="diss"))

    merged = vinohrady.append(oldtown.append(villas.append(modernist.
 ↪append(industry))))
    merged.to_file(path, layer=type, driver="GPKG")
```

[2]:
```
data = gpd.read_file('/Users/martin/Dropbox/Academia/Data/Geo/Prague/ISUF19/
 ↪prague_isuf.gpkg', layer='buildings')
columns = ['d200_md', 'd200_n', 'd200_va', 'd200_a',
           'd200_maxd', 'd400_md', 'd400_n', 'd400_va', 'd400_a', 'd400_maxd',
           'knn70_md', 'knn70_n', 'knn70_va', 'knn70_a', 'knn70_maxd',␣
 ↪'knn320_md',
           'knn320_n', 'knn320_va', 'knn320_a', 'knn320_maxd', 'r200a_md',␣
 ↪'r200a_n',
           'r200a_va', 'r200a_a', 'r200a_maxd', 'r400a_md', 'r400a_n',␣
 ↪'r400a_va',
           'r400a_a', 'r400a_maxd', 'q4_md', 'q4_n', 'q4_va', 'q4_a', 'q4_maxd',
           'q9_md', 'q9_n', 'q9_va', 'q9_a', 'q9_maxd']

types = ['d200', 'd400', 'knn70', 'knn320', 'r200a', 'r400a', 'q4', 'q9']
measures = ['md', 'n', 'va', 'a', 'maxd']
```

[3]:
```
summary = pd.DataFrame(index=types)

for i in types:
    for m in measures:
        summary.at[i, '{m}_mean'.format(m=m)] = np.nanmean(data['{i}_{m}'.
 ↪format(i=i, m=m)])
        summary.at[i, '{m}_median'.format(m=m)] = np.nanmedian(data['{i}_{m}'.
 ↪format(i=i, m=m)])
```

```
        summary.at[i, '{m}_stdev'.format(m=m)] = np.nanstd(data['{i}_{m}'.
 ↪format(i=i, m=m)])

sbn.set_style('ticks', {'xtick.bottom': False, 'ytick.left': True, 'legend.
 ↪frameon': False})
sbn.set_context(context='paper', font_scale=1, rc=None)
f, ax = plt.subplots(figsize=(12, 7))
# sbn.distplot(data['d400_maxd'])
small = ['q4', 'knn70', 'r200a', 'd200']
large = ['q9', 'knn320', 'r400a', 'd400']
```



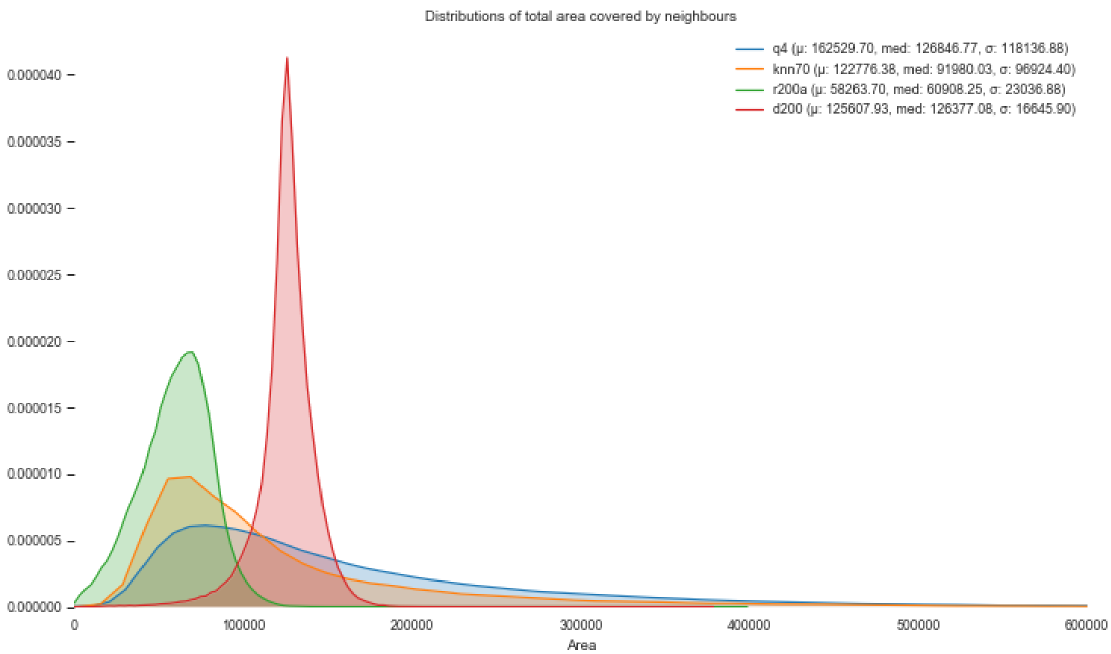
[4]:
```
summary
```

[4]:
```
           md_mean   md_median    md_stdev      n_mean  n_median     n_stdev  \
d200    117.840319  119.094090   12.335967  110.022003     107.0   55.251497
d400    239.837529  241.773290   24.746189  347.232607     342.0  158.612283
knn70   118.651123  100.616550   66.190648   80.000000      80.0    0.000000
knn320  317.744308  280.266111  138.973953  431.000000     431.0    0.000000
r200a    84.547318   88.937252   22.604771   56.658190      52.0   36.533079
r400a   166.949536  172.309337   35.591323  192.883092     182.0  117.716759
q4      114.106275  100.204739   49.662680   81.961721      80.0   24.575174
q9      304.369645  283.639224  101.999606  437.714580     431.0  158.103560

         va_mean  va_median  va_stdev         a_mean        a_median  \
d200    1.206831   1.156109  0.407756  125607.929820  126377.077573
d400    1.497505   1.445989  0.376434  461262.812889  486536.385789
```

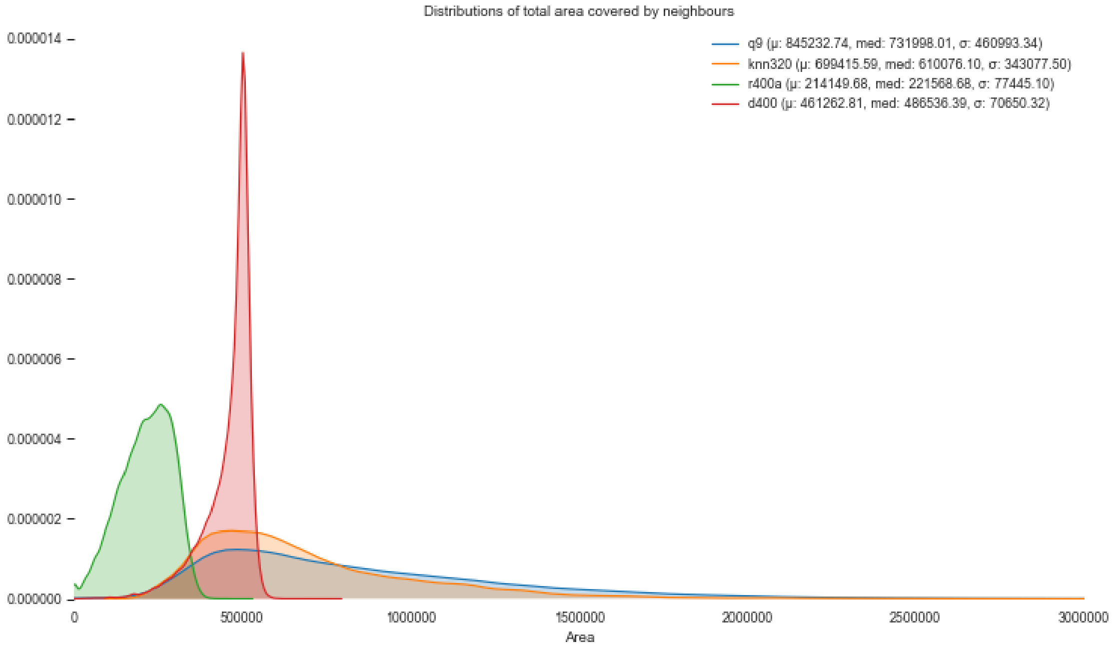
```
knn70    1.140180   1.108066  0.416265  122776.380929   91980.026148
knn320   1.542613   1.510122  0.369543  699415.587825  610076.095339
r200a    0.992782   0.945067  0.453627   58263.702551   60908.254988
r400a    1.276029   1.247344  0.398347  214149.676435  221568.679121
q4       1.277842   1.232894  0.474845  162529.698787  126846.772877
q9       1.607826   1.569826  0.369270  845232.744075  731998.011703

              a_stdev   maxd_mean  maxd_median  maxd_stdev
d200     16645.899030  191.226524   192.794562    9.234644
d400     70650.317530  392.291674   393.482057   11.746102
knn70    96924.397015  188.446526   161.963219   97.705985
knn320  343077.502332  511.740338   455.571140  219.173073
r200a    23036.882863  162.709063   173.069904   44.901203
r400a    77445.104364  328.563011   343.037228   68.664999
q4      118136.878236  254.573310   233.044385  108.525610
q9      460993.336181  695.380187   673.618006  209.977796
```

[5]:

```
# area
f, ax = plt.subplots(figsize=(12, 7))
new_labels = []

for i in small:
    ax = sbn.kdeplot(data['{}_a'.format(i)], shade=True)
    # plt.ylim(0, 1.05)
    plt.xlim(0, 600000)
    new_labels.append('{i} (\u03bc: {m}, med: {med}, \u03c3: {sd})'.format(i=i,␣
 ↪m="{0:.2f}".format(summary.loc[i, 'a_mean']),
                                                                                   ␣
 ↪med="{0:.2f}".format(summary.loc[i, 'a_median']),
                                                                                   ␣
 ↪sd="{0:.2f}".format(summary.loc[i, 'a_stdev'])))
sbn.despine(offset=10, trim=False, left=True, bottom=True)
legend = plt.legend(frameon=False)
# plt.grid(True, which='major', axis='x')
plt.xlabel("Area")
plt.title("Distributions of total area covered by neighbours")
for t, l in zip(legend.texts, new_labels):
    t.set_text(l)
```



[6]:
```
f, ax = plt.subplots(figsize=(12, 7))
new_labels = []

for i in large:
    ax = sbn.kdeplot(data['{}_a'.format(i)], shade=True)
    # plt.ylim(0, 1.05)
    plt.xlim(0, 3000000)
    new_labels.append('{i} (\u03bc: {m}, med: {med}, \u03c3: {sd})'.format(i=i,␣
 ↪m="{0:.2f}".format(summary.loc[i, 'a_mean']),
                                                                                ␣
 ↪med="{0:.2f}".format(summary.loc[i, 'a_median']),
                                                                                ␣
 ↪sd="{0:.2f}".format(summary.loc[i, 'a_stdev'])))
sbn.despine(offset=10, trim=False, left=True, bottom=True)
legend = plt.legend(frameon=False)
# plt.grid(True, which='major', axis='x')
plt.xlabel("Area")
plt.title("Distributions of total area covered by neighbours")
for t, l in zip(legend.texts, new_labels):
    t.set_text(l)
```



Distributions of total area covered by neighbours
q9 (μ: 845232.74, med: 731998.01, σ: 460993.34)
knn320 (μ: 699415.59, med: 610076.10, σ: 343077.50)
r400a (μ: 214149.68, med: 221568.68, σ: 77445.10)
d400 (μ: 461262.81, med: 486536.39, σ: 70650.32)
0.000014
0.000012
0.000010
0.000008
0.000006
0.000004
0.000002
0.000000
0
500000
1000000
1500000
2000000
2500000
3000000
Area