

Project 2

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1. Regular (Exhaustive Census) Quadrat Count Method

1.0 How Many quadrats should I use?

1.0.1 First Try 10 x 10, 100 quadrats

The quadrat count results range from 0 to 15160, the mean quadrat count is $156,259 / 100 = 1,562.59$. The total rows of 'No. of events, K' is 67. Here is the map if I use 10x10:

First Try: Regular Quadrat Count (10x10)

772	1149	0	0	0	0	0	0	0	0
2314	2453	6881	15160	1466	577	1097	1256	915	17
1718	7852	8354	4851	463	633	1011	1564	921	9
3294	6593	2329	760	388	1001	688	126	43	4
1773	2786	6401	1845	1712	582	40	45	2	0
517	3845	10659	5568	133	1	1	0	2	0
639	5791	8684	1411	2	1	0	0	0	5
1976	3797	2869	118	8	2	0	0	1	0
4061	5386	242	20	10	0	0	0	0	0
5087	2497	129	80	2	0	0	0	0	0

1.0.2 Second Try 20 x 20, 400 quadrats

The quadrat count results range from 0 to 6,367, the mean quadrat count is $156,259 / 400 = 390$. The total rows of 'No. of events, K' is 202. Here is the map if I use 20x20:

Second Try: Regular Quadrat Count (20x20)

0	31	520	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	703	620	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
384	517	759	540	1283	81	561	1125	567	255	122	122	131	132	208	185	257	98	8	0	0
698	715	578	576	2193	537	51697	1921	477	167	103	230	258	486	402	461	344	216	6	3	0
331	471	466	1866	754	2323	2471	604	199	41	340	225	332	333	309	529	627	144	5	4	0
248	668	1489	4333	1053	547	1519	457	47	176	39	29	159	187	353	373	126	24	0	0	0
881	1124	1319	1998	781	602	205	207	110	156	95	119	346	56	21	0	36	0	0	2	0
533	756	722	1534	395	551	138	210	81	41	336	451	174	112	91	14	6	1	2	0	0
717	688	619	634	1399	730	454	432	44	227	469	21	0	40	44	1	2	0	0	0	0
169	199	452	1081	2801	1471	889	170	227	1214	92	0	0	0	0	0	0	0	0	0	0
25	111	429	1158	2767	2354	2600	891	69	43	1	0	0	0	0	0	0	2	0	0	0
88	293	569	1659	2768	2867	1478	599	21	0	0	0	0	1	0	0	0	0	0	0	0
69	244	333	2431	2635	1921	1143	14	1	0	0	0	0	0	0	0	0	0	0	0	0
135	191	639	2668	3054	1074	251	3	1	0	1	0	0	0	0	0	0	0	0	0	5
329	387	448	1193	1758	452	78	19	0	1	2	0	0	0	0	0	0	1	0	0	0
726	534	652	1439	433	226	11	10	7	0	0	0	0	0	0	0	0	0	0	0	0
853	952	1392	1578	87	46	14	0	6	0	0	0	0	0	0	0	0	0	0	0	0
994	1262	172	695	55	54	5	1	3	1	0	0	0	0	0	0	0	0	0	0	0
1573	1631	1497	100	43	25	4	30	2	0	0	0	0	0	0	0	0	0	0	0	0
1019	1038	733	157	49	12	3	43	0	0	0	0	0	0	0	0	0	0	0	0	0

It looks like more detailed than first try.

1.0.3 Third Try 30 x 30, 900 quadrats

The quadrat count results range from 0 to 3,961, the mean quadrat count is 156, 259 / 900 = 174. The total rows of 'No. of events, K' is 323. Here is the map if I use 30x30:

Third Try: Regular Quadrat Count (30x30)

0	0	0	0	143	133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	324	354	119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	103	339	218	182	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	117	223	399	164	224	607	178	13	129	100	333	370	219	66	106	18	50	77	51	29
196	448	286	423	184	331	129	238	470	194	605	592	204	118	132	16	130	88	7	178	124
184	525	244	222	180	356	328	31	466	393	51	48	112	213	98	35	19	26	124	137	246
135	271	260	241	293	756	216	86	663	316	2578	363	149	30	22	122	153	103	189	196	146
9	111	147	282	508	336	553	140	119	167	135	236	45	18	15	83	56	82	49	104	69
73	327	385	687	109	24	351	79	66	66	61	59	45	28	49	173	61	1	4	17	0
350	395	623	542	104	911	27	408	312	107	187	33	55	61	45	28	49	173	61	1	5
266	434	344	217	508	690	117	104	159	62	148	15	53	8	51	120	104	164	213	82	11
182	379	321	232	455	634	186	293	323	58	42	108	69	8	24	187	60	244	17	70	60
300	479	279	460	247	416	486	249	119	336	50	3	34	74	293	24	3	0	40	41	4
162	288	148	73	127	454	102	608	461	188	266	227	34	352	448	258	1	0	0	0	0
45	32	40	188	403	512	12	238	134	444	619	130	10	31	361	325	3	0	0	0	0
24	12	21	149	417	503	196	134	771	148	506	245	27	60	5	1	0	0	0	0	0
21	14	185	160	403	747	129	132	251	158	951	14	216	13	23	0	0	0	0	1	0
62	29	149	191	395	528	118	126	171	746	73	407	24	4	1	0	0	0	0	0	0
43	110	85	83	363	105	10	107	290	188	188	51	128	4	1	0	0	0	0	0	0
36	19	92	130	401	132	13	304	105	503	239	2	0	0	0	0	0	0	0	0	0
64	78	112	150	83	673	13	368	104	284	76	73	0	1	0	0	0	0	0	0	2
145	204	83	55	364	71	110	57	141	95	17	60	1	0	0	1	0	0	0	0	0
160	345	77	102	463	549	164	280	17	16	13	0	0	0	0	2	0	0	0	0	1
323	435	206	288	616	603	81	132	4	8	3	0	0	7	0	0	0	0	0	0	0
460	301	470	467	74	758	40	20	10	8	3	0	0	6	0	0	0	0	0	0	0
289	52	1450	67	308	3	198	41	29	29	5	3	0	0	0	0	0	0	0	0	0
405	505	645	667	92	4	21	26	29	18	0	0	1	3	1	0	0	0	0	0	0
304	638	802	199	216	21	19	22	16	2	1	11	0	1	0	0	0	0	0	0	0
426	524	1729	107	74	36	19	4	0	1	0	42	1	0	0	0	0	0	0	0	0
311	547	470	416	101	60	21	21	7	3	0	20	0	0	0	0	0	0	0	0	0

It looks good, but we can still try more quadrats.

1.0.4 Forth Try 40 x 40, 1,600 quadrats

The quadrat count results range from 0 to 2,657, the mean quadrat count is 156, $259 / 1600 = 98$. The total rows of 'No. of events, K' is 363. Here is the map if I use 40x40:

Forth Try: Regular Quadrat Count (40x40)

I think I should stop here, because, although we may get better vmr in the end, the plot of text and rectangles are overlapped. It's not clear enough for us to see the exact count for each quadrat. Therefore, I will use 30x30 quadrats for both regular and random quadrat count later.

1.1 Map

Regular Quadrat Count (30x30)

1.2 Table

Regular Quadrat Count Table

No. of Events (K)	No. of Events (X)	K - u	(K - u)^2	X(K - u)^2
0	388	-173.6211111	3.014429e+04	1.169598e+07
1	26	-172.6211111	2.979805e+04	7.747492e+05
2	11	-171.6211111	2.945381e+04	3.239919e+05
3	13	-170.6211111	2.911156e+04	3.784503e+05
4	8	-169.6211111	2.877132e+04	2.301706e+05
5	5	-168.6211111	2.843308e+04	1.421654e+05
6	4	-167.6211111	2.809684e+04	1.123873e+05
7	6	-166.6211111	2.776259e+04	1.665756e+05
8	4	-165.6211111	2.743035e+04	1.097214e+05
9	2	-164.6211111	2.710011e+04	5.420022e+04
10	2	-163.6211111	2.677187e+04	5.354374e+04
11	2	-162.6211111	2.644563e+04	5.289125e+04
12	1	-161.6211111	2.612138e+04	2.612138e+04
13	3	-160.6211111	2.579914e+04	7.739742e+04
14	1	-159.6211111	2.547890e+04	2.547890e+04

15	2	-158.6211111	2.516066e+04	5.032131e+04
16	4	-157.6211111	2.484441e+04	9.937766e+04
17	4	-156.6211111	2.453017e+04	9.812069e+04
18	3	-155.6211111	2.421793e+04	7.265379e+04
19	4	-154.6211111	2.390769e+04	9.563075e+04
20	2	-153.6211111	2.359945e+04	4.719889e+04
21	6	-152.6211111	2.329320e+04	1.397592e+05
22	2	-151.6211111	2.298896e+04	4.597792e+04
23	1	-150.6211111	2.268672e+04	2.268672e+04
24	6	-149.6211111	2.238648e+04	1.343189e+05
25	2	-148.6211111	2.208823e+04	4.417647e+04
26	2	-147.6211111	2.179199e+04	4.358398e+04
27	2	-146.6211111	2.149775e+04	4.299550e+04
28	1	-145.6211111	2.120551e+04	2.120551e+04
29	5	-144.6211111	2.091527e+04	1.045763e+05
30	1	-143.6211111	2.062702e+04	2.062702e+04
31	2	-142.6211111	2.034078e+04	4.068156e+04
32	1	-141.6211111	2.005654e+04	2.005654e+04
33	1	-140.6211111	1.977430e+04	1.977430e+04
34	2	-139.6211111	1.949405e+04	3.898811e+04
35	2	-138.6211111	1.921581e+04	3.843162e+04
36	2	-137.6211111	1.893957e+04	3.787914e+04
40	3	-133.6211111	1.785460e+04	5.356380e+04
41	2	-132.6211111	1.758836e+04	3.517672e+04
42	2	-131.6211111	1.732412e+04	3.464823e+04
43	1	-130.6211111	1.706187e+04	1.706187e+04
45	3	-128.6211111	1.654339e+04	4.963017e+04
47	1	-126.6211111	1.603291e+04	1.603291e+04
49	3	-124.6211111	1.553042e+04	4.659126e+04
50	2	-123.6211111	1.528218e+04	3.056436e+04
51	2	-122.6211111	1.503594e+04	3.007187e+04
53	1	-120.6211111	1.454945e+04	1.454945e+04
55	2	-118.6211111	1.407097e+04	2.814194e+04
56	2	-117.6211111	1.383473e+04	2.766945e+04
57	1	-116.6211111	1.360048e+04	1.360048e+04
58	1	-115.6211111	1.336824e+04	1.336824e+04

59	2	-114.6211111	1.313800e+04	2.627600e+04
60	6	-113.6211111	1.290976e+04	7.745854e+04
61	2	-112.6211111	1.268351e+04	2.536703e+04
62	2	-111.6211111	1.245927e+04	2.491854e+04
64	1	-109.6211111	1.201679e+04	1.201679e+04
66	1	-107.6211111	1.158230e+04	1.158230e+04
68	1	-105.6211111	1.115582e+04	1.115582e+04
69	3	-104.6211111	1.094558e+04	3.283673e+04
70	1	-103.6211111	1.073733e+04	1.073733e+04
73	3	-100.6211111	1.012461e+04	3.037382e+04
74	2	-99.6211111	9.924366e+03	1.984873e+04
76	1	-97.6211111	9.529881e+03	9.529881e+03
77	3	-96.6211111	9.335639e+03	2.800692e+04
78	1	-95.6211111	9.143397e+03	9.143397e+03
81	1	-92.6211111	8.578670e+03	8.578670e+03
82	3	-91.6211111	8.394428e+03	2.518328e+04
83	4	-90.6211111	8.212186e+03	3.284874e+04
85	1	-88.6211111	7.853701e+03	7.853701e+03
88	1	-85.6211111	7.330975e+03	7.330975e+03
91	2	-82.6211111	6.826248e+03	1.365250e+04
92	1	-81.6211111	6.662006e+03	6.662006e+03
94	1	-79.6211111	6.339521e+03	6.339521e+03
95	1	-78.6211111	6.181279e+03	6.181279e+03
98	1	-75.6211111	5.718552e+03	5.718552e+03
101	1	-72.6211111	5.273826e+03	5.273826e+03
102	1	-71.6211111	5.129584e+03	5.129584e+03
103	2	-70.6211111	4.987341e+03	9.974683e+03
104	3	-69.6211111	4.847099e+03	1.454130e+04
106	1	-67.6211111	4.572615e+03	4.572615e+03
107	1	-66.6211111	4.438372e+03	4.438372e+03
108	1	-65.6211111	4.306130e+03	4.306130e+03
110	1	-63.6211111	4.047646e+03	4.047646e+03
111	1	-62.6211111	3.921404e+03	3.921404e+03
112	2	-61.6211111	3.797161e+03	7.594323e+03
114	1	-59.6211111	3.554677e+03	3.554677e+03
116	1	-57.6211111	3.320192e+03	3.320192e+03

117	2	-56.6211111	3.205950e+03	6.411900e+03
118	2	-55.6211111	3.093708e+03	6.187416e+03
119	2	-54.6211111	2.983466e+03	5.966932e+03
120	1	-53.6211111	2.875224e+03	2.875224e+03
122	1	-51.6211111	2.664739e+03	2.664739e+03
124	2	-49.6211111	2.462255e+03	4.924509e+03
128	1	-45.6211111	2.081286e+03	2.081286e+03
130	3	-43.6211111	1.902801e+03	5.708404e+03
132	2	-41.6211111	1.732317e+03	3.464634e+03
133	3	-40.6211111	1.650075e+03	4.950224e+03
134	2	-39.6211111	1.569832e+03	3.139665e+03
135	2	-38.6211111	1.491590e+03	2.983180e+03
136	2	-37.6211111	1.415348e+03	2.830696e+03
137	2	-36.6211111	1.341106e+03	2.682212e+03
139	1	-34.6211111	1.198621e+03	1.198621e+03
142	1	-31.6211111	9.998947e+02	9.998947e+02
143	1	-30.6211111	9.376524e+02	9.376524e+02
145	1	-28.6211111	8.191680e+02	8.191680e+02
146	1	-27.6211111	7.629258e+02	7.629258e+02
147	1	-26.6211111	7.086836e+02	7.086836e+02
148	2	-25.6211111	6.564413e+02	1.312883e+03
149	4	-24.6211111	6.061991e+02	2.424796e+03
150	1	-23.6211111	5.579569e+02	5.579569e+02
153	1	-20.6211111	4.252302e+02	4.252302e+02
154	1	-19.6211111	3.849880e+02	3.849880e+02
158	1	-15.6211111	2.440191e+02	2.440191e+02
159	1	-14.6211111	2.137769e+02	2.137769e+02
160	2	-13.6211111	1.855347e+02	3.710693e+02
162	1	-11.6211111	1.350502e+02	1.350502e+02
164	2	-9.6211111	9.256578e+01	1.851316e+02
165	1	-8.6211111	7.432356e+01	7.432356e+01
166	1	-7.6211111	5.808133e+01	5.808133e+01
167	1	-6.6211111	4.383911e+01	4.383911e+01
173	1	-0.6211111	3.857790e-01	3.857790e-01
178	2	4.3788889	1.917467e+01	3.834934e+01
180	1	6.3788889	4.069022e+01	4.069022e+01

182	2	8.3788889	7.020578e+01	1.404116e+02
184	1	10.3788889	1.077213e+02	1.077213e+02
185	1	11.3788889	1.294791e+02	1.294791e+02
186	1	12.3788889	1.532369e+02	1.532369e+02
187	2	13.3788889	1.789947e+02	3.579893e+02
188	2	14.3788889	2.067524e+02	4.135049e+02
189	1	15.3788889	2.365102e+02	2.365102e+02
191	1	17.3788889	3.020258e+02	3.020258e+02
192	1	18.3788889	3.377836e+02	3.377836e+02
196	2	22.3788889	5.008147e+02	1.001629e+03
198	1	24.3788889	5.943302e+02	5.943302e+02
204	1	30.3788889	9.228769e+02	9.228769e+02
206	1	32.3788889	1.048392e+03	1.048392e+03
207	1	33.3788889	1.114150e+03	1.114150e+03
213	2	39.3788889	1.550697e+03	3.101394e+03
216	3	42.3788889	1.795970e+03	5.387911e+03
217	1	43.3788889	1.881728e+03	1.881728e+03
218	1	44.3788889	1.969486e+03	1.969486e+03
219	1	45.3788889	2.059244e+03	2.059244e+03
222	1	48.3788889	2.340517e+03	2.340517e+03
223	1	49.3788889	2.438275e+03	2.438275e+03
224	1	50.3788889	2.538032e+03	2.538032e+03
226	1	52.3788889	2.743548e+03	2.743548e+03
227	1	53.3788889	2.849306e+03	2.849306e+03
232	2	58.3788889	3.408095e+03	6.816189e+03
233	1	59.3788889	3.525852e+03	3.525852e+03
236	2	62.3788889	3.891126e+03	7.782252e+03
239	1	65.3788889	4.274399e+03	4.274399e+03
241	1	67.3788889	4.539915e+03	4.539915e+03
244	2	70.3788889	4.953188e+03	9.906376e+03
245	1	71.3788889	5.094946e+03	5.094946e+03
246	2	72.3788889	5.238704e+03	1.047741e+04
247	1	73.3788889	5.384461e+03	5.384461e+03
249	1	75.3788889	5.681977e+03	5.681977e+03
250	1	76.3788889	5.833735e+03	5.833735e+03
258	1	84.3788889	7.119797e+03	7.119797e+03

259	1	85.3788889	7.289555e+03	7.289555e+03
260	1	86.3788889	7.461312e+03	7.461312e+03
266	2	92.3788889	8.533859e+03	1.706772e+04
271	1	97.3788889	9.482648e+03	9.482648e+03
278	1	104.3788889	1.089495e+04	1.089495e+04
279	1	105.3788889	1.110471e+04	1.110471e+04
280	1	106.3788889	1.131647e+04	1.131647e+04
282	1	108.3788889	1.174598e+04	1.174598e+04
283	1	109.3788889	1.196374e+04	1.196374e+04
284	1	110.3788889	1.218350e+04	1.218350e+04
286	1	112.3788889	1.262901e+04	1.262901e+04
288	1	114.3788889	1.308253e+04	1.308253e+04
289	1	115.3788889	1.331229e+04	1.331229e+04
293	3	119.3788889	1.425132e+04	4.275396e+04
300	1	126.3788889	1.597162e+04	1.597162e+04
301	1	127.3788889	1.622538e+04	1.622538e+04
311	1	137.3788889	1.887296e+04	1.887296e+04
312	1	138.3788889	1.914872e+04	1.914872e+04
321	1	147.3788889	2.172054e+04	2.172054e+04
323	2	149.3788889	2.231405e+04	4.462810e+04
324	1	150.3788889	2.261381e+04	2.261381e+04
327	1	153.3788889	2.352508e+04	2.352508e+04
328	1	154.3788889	2.383284e+04	2.383284e+04
331	1	157.3788889	2.476811e+04	2.476811e+04
336	1	162.3788889	2.636690e+04	2.636690e+04
339	1	165.3788889	2.735018e+04	2.735018e+04
343	1	169.3788889	2.868921e+04	2.868921e+04
344	1	170.3788889	2.902897e+04	2.902897e+04
350	1	176.3788889	3.110951e+04	3.110951e+04
351	1	177.3788889	3.146327e+04	3.146327e+04
352	1	178.3788889	3.181903e+04	3.181903e+04
354	1	180.3788889	3.253654e+04	3.253654e+04
356	1	182.3788889	3.326206e+04	3.326206e+04
361	1	187.3788889	3.511085e+04	3.511085e+04
363	1	189.3788889	3.586436e+04	3.586436e+04
364	1	190.3788889	3.624412e+04	3.624412e+04

372	1	198.3788889	3.935418e+04	3.935418e+04
375	1	201.3788889	4.055346e+04	4.055346e+04
378	1	204.3788889	4.177073e+04	4.177073e+04
379	1	205.3788889	4.218049e+04	4.218049e+04
383	1	209.3788889	4.383952e+04	4.383952e+04
385	1	211.3788889	4.468103e+04	4.468103e+04
386	1	212.3788889	4.510479e+04	4.510479e+04
395	2	221.3788889	4.900861e+04	9.801722e+04
399	1	225.3788889	5.079564e+04	5.079564e+04
403	2	229.3788889	5.261467e+04	1.052293e+05
405	1	231.3788889	5.353619e+04	5.353619e+04
407	1	233.3788889	5.446571e+04	5.446571e+04
415	1	241.3788889	5.826377e+04	5.826377e+04
416	1	242.3788889	5.874753e+04	5.874753e+04
417	1	243.3788889	5.923328e+04	5.923328e+04
418	1	244.3788889	5.972104e+04	5.972104e+04
423	1	249.3788889	6.218983e+04	6.218983e+04
426	1	252.3788889	6.369510e+04	6.369510e+04
434	1	260.3788889	6.779717e+04	6.779717e+04
435	1	261.3788889	6.831892e+04	6.831892e+04
440	1	266.3788889	7.095771e+04	7.095771e+04
448	2	274.3788889	7.528377e+04	1.505675e+05
454	1	280.3788889	7.861232e+04	7.861232e+04
455	1	281.3788889	7.917408e+04	7.917408e+04
459	1	285.3788889	8.144111e+04	8.144111e+04
460	1	286.3788889	8.201287e+04	8.201287e+04
461	2	287.3788889	8.258663e+04	1.651733e+05
463	1	289.3788889	8.374014e+04	8.374014e+04
464	1	290.3788889	8.431990e+04	8.431990e+04
466	1	292.3788889	8.548541e+04	8.548541e+04
470	2	296.3788889	8.784045e+04	1.756809e+05
479	1	305.3788889	9.325627e+04	9.325627e+04
494	1	320.3788889	1.026426e+05	1.026426e+05
503	2	329.3788889	1.084905e+05	2.169809e+05
505	1	331.3788889	1.098120e+05	1.098120e+05
508	1	334.3788889	1.118092e+05	1.118092e+05

517	1	343.3788889	1.179091e+05	1.179091e+05
518	1	344.3788889	1.185968e+05	1.185968e+05
521	1	347.3788889	1.206721e+05	1.206721e+05
524	1	350.3788889	1.227654e+05	1.227654e+05
525	1	351.3788889	1.234671e+05	1.234671e+05
540	1	366.3788889	1.342335e+05	1.342335e+05
542	1	368.3788889	1.357030e+05	1.357030e+05
553	1	379.3788889	1.439283e+05	1.439283e+05
578	1	404.3788889	1.635223e+05	1.635223e+05
582	1	408.3788889	1.667733e+05	1.667733e+05
603	1	429.3788889	1.843662e+05	1.843662e+05
606	1	432.3788889	1.869515e+05	1.869515e+05
607	2	433.3788889	1.878173e+05	3.756345e+05
616	1	442.3788889	1.956991e+05	1.956991e+05
619	1	445.3788889	1.983624e+05	1.983624e+05
623	1	449.3788889	2.019414e+05	2.019414e+05
634	1	460.3788889	2.119487e+05	2.119487e+05
638	1	464.3788889	2.156478e+05	2.156478e+05
645	1	471.3788889	2.221981e+05	2.221981e+05
667	1	493.3788889	2.434227e+05	2.434227e+05
673	2	499.3788889	2.493793e+05	4.987585e+05
675	1	501.3788889	2.513808e+05	2.513808e+05
687	1	513.3788889	2.635579e+05	2.635579e+05
690	1	516.3788889	2.666472e+05	2.666472e+05
693	1	519.3788889	2.697544e+05	2.697544e+05
702	1	528.3788889	2.791843e+05	2.791843e+05
704	1	530.3788889	2.813018e+05	2.813018e+05
711	1	537.3788889	2.887761e+05	2.887761e+05
714	1	540.3788889	2.920093e+05	2.920093e+05
725	1	551.3788889	3.040187e+05	3.040187e+05
741	1	567.3788889	3.219188e+05	3.219188e+05
756	1	582.3788889	3.391652e+05	3.391652e+05
761	1	587.3788889	3.450140e+05	3.450140e+05
768	1	594.3788889	3.532863e+05	3.532863e+05
769	1	595.3788889	3.544760e+05	3.544760e+05
771	1	597.3788889	3.568615e+05	3.568615e+05

802	1	628.3788889	3.948600e+05	3.948600e+05
808	2	634.3788889	4.024366e+05	8.048731e+05
813	1	639.3788889	4.088054e+05	4.088054e+05
815	1	641.3788889	4.113669e+05	4.113669e+05
861	1	687.3788889	4.724897e+05	4.724897e+05
865	1	691.3788889	4.780048e+05	4.780048e+05
895	1	721.3788889	5.203875e+05	5.203875e+05
896	1	722.3788889	5.218313e+05	5.218313e+05
901	1	727.3788889	5.290800e+05	5.290800e+05
911	1	737.3788889	5.437276e+05	5.437276e+05
924	1	750.3788889	5.630685e+05	5.630685e+05
925	1	751.3788889	5.645702e+05	5.645702e+05
933	1	759.3788889	5.766563e+05	5.766563e+05
946	1	772.3788889	5.965691e+05	5.965691e+05
967	1	793.3788889	6.294501e+05	6.294501e+05
1006	1	832.3788889	6.928546e+05	6.928546e+05
1014	1	840.3788889	7.062367e+05	7.062367e+05
1025	1	851.3788889	7.248460e+05	7.248460e+05
1055	1	881.3788889	7.768287e+05	7.768287e+05
1058	1	884.3788889	7.821260e+05	7.821260e+05
1072	1	898.3788889	8.070846e+05	8.070846e+05
1104	1	930.3788889	8.656049e+05	8.656049e+05
1108	1	934.3788889	8.730639e+05	8.730639e+05
1114	1	940.3788889	8.843125e+05	8.843125e+05
1134	1	960.3788889	9.223276e+05	9.223276e+05
1135	1	961.3788889	9.242494e+05	9.242494e+05
1140	1	966.3788889	9.338882e+05	9.338882e+05
1175	1	1001.3788889	1.002760e+06	1.002760e+06
1180	1	1006.3788889	1.012798e+06	1.012798e+06
1181	1	1007.3788889	1.014812e+06	1.014812e+06
1195	1	1021.3788889	1.043215e+06	1.043215e+06
1206	1	1032.3788889	1.065806e+06	1.065806e+06
1224	1	1050.3788889	1.103296e+06	1.103296e+06
1229	1	1055.3788889	1.113825e+06	1.113825e+06
1238	1	1064.3788889	1.132902e+06	1.132902e+06
1262	1	1088.3788889	1.184569e+06	1.184569e+06

1269	1	1095.3788889	1.199855e+06	1.199855e+06
1294	1	1120.3788889	1.255249e+06	1.255249e+06
1304	1	1130.3788889	1.277756e+06	1.277756e+06
1315	1	1141.3788889	1.302746e+06	1.302746e+06
1325	1	1151.3788889	1.325673e+06	1.325673e+06
1364	1	1190.3788889	1.417002e+06	1.417002e+06
1368	1	1194.3788889	1.426541e+06	1.426541e+06
1388	1	1214.3788889	1.474716e+06	1.474716e+06
1392	1	1218.3788889	1.484447e+06	1.484447e+06
1437	1	1263.3788889	1.596126e+06	1.596126e+06
1518	1	1344.3788889	1.807355e+06	1.807355e+06
1566	1	1392.3788889	1.938719e+06	1.938719e+06
1608	1	1434.3788889	2.057443e+06	2.057443e+06
1668	1	1494.3788889	2.233168e+06	2.233168e+06
2104	1	1930.3788889	3.726363e+06	3.726363e+06
2113	1	1939.3788889	3.761190e+06	3.761190e+06
2635	1	2461.3788889	6.058386e+06	6.058386e+06
3081	1	2907.3788889	8.452852e+06	8.452852e+06
3195	1	3021.3788889	9.128730e+06	9.128730e+06
3961	1	3787.3788889	1.434424e+07	1.434424e+07

1.3 Summary Report

Variance $s^2 = \text{sum}(X(K-u)^2) / (900 - 1) = 137,760.15$

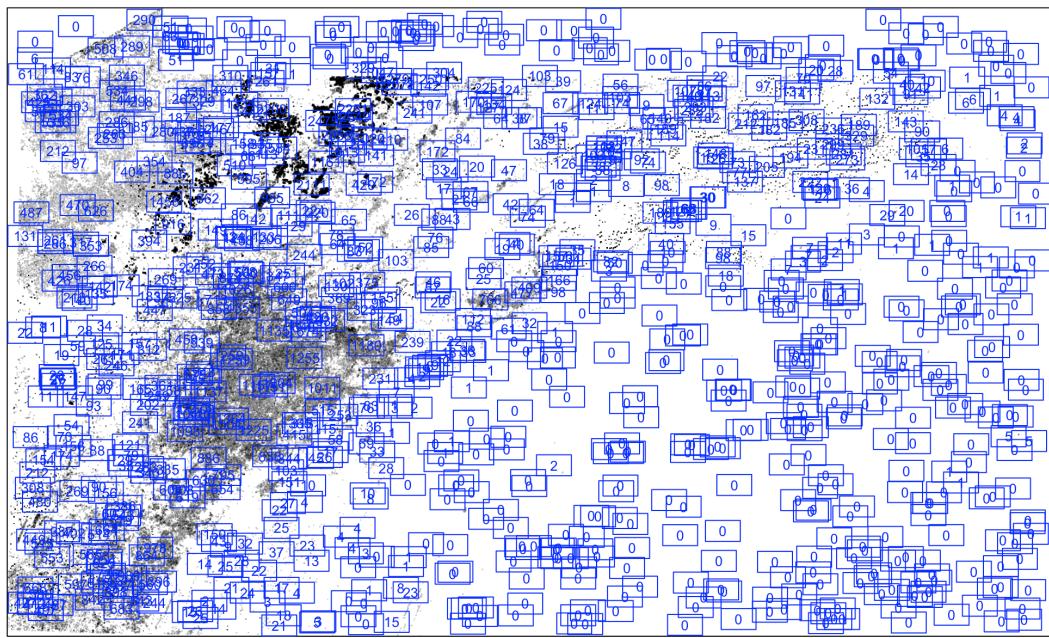
VMR = $137,760.15 / \text{mean quadrat count} = 137,760.15 / 173.62 = 793.45$

VMR for regular quadrat count method is around 793.45, which is much amazingly greater than 1.0. Which means the points in this pattern is strongly clustered.

2. Random Sampling Quadrat Count Method

2.1 Map

Random Quadrat Count (900 rectangles)



2.2 Table

Random Quadrat Count Table

No. of Events (K)	No. of Events (X)	K - u	$(K - u)^2$	$X(K - u)^2$
0	385	-173.6211111	3.014429e+04	1.160555e+07
1	30	-172.6211111	2.979805e+04	8.939414e+05
2	15	-171.6211111	2.945381e+04	4.418071e+05
3	7	-170.6211111	2.911156e+04	2.037809e+05
4	7	-169.6211111	2.877132e+04	2.013992e+05
5	3	-168.6211111	2.843308e+04	8.529924e+04
6	4	-167.6211111	2.809684e+04	1.123873e+05
7	3	-166.6211111	2.776259e+04	8.328778e+04
8	6	-165.6211111	2.743035e+04	1.645821e+05
9	3	-164.6211111	2.710011e+04	8.130033e+04
10	6	-163.6211111	2.677187e+04	1.606312e+05
11	2	-162.6211111	2.644563e+04	5.289125e+04
12	2	-161.6211111	2.612138e+04	5.224277e+04

13	2	-160.6211111	2.579914e+04	5.159828e+04
14	3	-159.6211111	2.547890e+04	7.643670e+04
15	3	-158.6211111	2.516066e+04	7.548197e+04
17	4	-156.6211111	2.453017e+04	9.812069e+04
18	2	-155.6211111	2.421793e+04	4.843586e+04
19	4	-154.6211111	2.390769e+04	9.563075e+04
20	4	-153.6211111	2.359945e+04	9.439778e+04
21	1	-152.6211111	2.329320e+04	2.329320e+04
22	8	-151.6211111	2.298896e+04	1.839117e+05
23	6	-150.6211111	2.268672e+04	1.361203e+05
24	4	-149.6211111	2.238648e+04	8.954591e+04
25	3	-148.6211111	2.208823e+04	6.626470e+04
26	4	-147.6211111	2.179199e+04	8.716797e+04
27	3	-146.6211111	2.149775e+04	6.449325e+04
28	1	-145.6211111	2.120551e+04	2.120551e+04
29	3	-144.6211111	2.091527e+04	6.274580e+04
30	1	-143.6211111	2.062702e+04	2.062702e+04
32	2	-141.6211111	2.005654e+04	4.011308e+04
33	2	-140.6211111	1.977430e+04	3.954859e+04
34	1	-139.6211111	1.949405e+04	1.949405e+04
35	2	-138.6211111	1.921581e+04	3.843162e+04
36	2	-137.6211111	1.893957e+04	3.787914e+04
39	1	-134.6211111	1.812284e+04	1.812284e+04
40	1	-133.6211111	1.785460e+04	1.785460e+04
41	2	-132.6211111	1.758836e+04	3.517672e+04
43	1	-130.6211111	1.706187e+04	1.706187e+04
44	3	-129.6211111	1.680163e+04	5.040490e+04
45	2	-128.6211111	1.654339e+04	3.308678e+04
46	1	-127.6211111	1.628715e+04	1.628715e+04
47	1	-126.6211111	1.603291e+04	1.603291e+04
48	1	-125.6211111	1.578066e+04	1.578066e+04
50	2	-123.6211111	1.528218e+04	3.056436e+04
52	1	-121.6211111	1.479169e+04	1.479169e+04
54	2	-119.6211111	1.430921e+04	2.861842e+04
56	1	-117.6211111	1.383473e+04	1.383473e+04
58	3	-115.6211111	1.336824e+04	4.010472e+04

59	1	-114.6211111	1.313800e+04	1.313800e+04
60	1	-113.6211111	1.290976e+04	1.290976e+04
61	1	-112.6211111	1.268351e+04	1.268351e+04
62	1	-111.6211111	1.245927e+04	1.245927e+04
63	1	-110.6211111	1.223703e+04	1.223703e+04
64	1	-109.6211111	1.201679e+04	1.201679e+04
68	2	-105.6211111	1.115582e+04	2.231164e+04
69	1	-104.6211111	1.094558e+04	1.094558e+04
70	1	-103.6211111	1.073733e+04	1.073733e+04
73	1	-100.6211111	1.012461e+04	1.012461e+04
74	3	-99.6211111	9.924366e+03	2.977310e+04
75	1	-98.6211111	9.726124e+03	9.726124e+03
76	1	-97.6211111	9.529881e+03	9.529881e+03
77	1	-96.6211111	9.335639e+03	9.335639e+03
78	1	-95.6211111	9.143397e+03	9.143397e+03
79	1	-94.6211111	8.953155e+03	8.953155e+03
80	1	-93.6211111	8.764912e+03	8.764912e+03
83	1	-90.6211111	8.212186e+03	8.212186e+03
84	1	-89.6211111	8.031944e+03	8.031944e+03
85	1	-88.6211111	7.853701e+03	7.853701e+03
86	1	-87.6211111	7.677459e+03	7.677459e+03
89	1	-84.6211111	7.160732e+03	7.160732e+03
90	2	-83.6211111	6.992490e+03	1.398498e+04
91	3	-82.6211111	6.826248e+03	2.047874e+04
92	1	-81.6211111	6.662006e+03	6.662006e+03
94	2	-79.6211111	6.339521e+03	1.267904e+04
95	1	-78.6211111	6.181279e+03	6.181279e+03
96	1	-77.6211111	6.025037e+03	6.025037e+03
99	1	-74.6211111	5.568310e+03	5.568310e+03
101	4	-72.6211111	5.273826e+03	2.109530e+04
102	1	-71.6211111	5.129584e+03	5.129584e+03
103	3	-70.6211111	4.987341e+03	1.496202e+04
104	3	-69.6211111	4.847099e+03	1.454130e+04
109	1	-64.6211111	4.175888e+03	4.175888e+03
110	5	-63.6211111	4.047646e+03	2.023823e+04
112	1	-61.6211111	3.797161e+03	3.797161e+03

113	3	-60.6211111	3.674919e+03	1.102476e+04
116	2	-57.6211111	3.320192e+03	6.640385e+03
118	1	-55.6211111	3.093708e+03	3.093708e+03
120	1	-53.6211111	2.875224e+03	2.875224e+03
121	2	-52.6211111	2.768981e+03	5.537963e+03
122	2	-51.6211111	2.664739e+03	5.329478e+03
123	2	-50.6211111	2.562497e+03	5.124994e+03
124	1	-49.6211111	2.462255e+03	2.462255e+03
127	2	-46.6211111	2.173528e+03	4.347056e+03
132	1	-41.6211111	1.732317e+03	1.732317e+03
133	1	-40.6211111	1.650075e+03	1.650075e+03
134	1	-39.6211111	1.569832e+03	1.569832e+03
135	2	-38.6211111	1.491590e+03	2.983180e+03
136	1	-37.6211111	1.415348e+03	1.415348e+03
138	1	-35.6211111	1.268864e+03	1.268864e+03
139	1	-34.6211111	1.198621e+03	1.198621e+03
140	1	-33.6211111	1.130379e+03	1.130379e+03
141	1	-32.6211111	1.064137e+03	1.064137e+03
142	1	-31.6211111	9.998947e+02	9.998947e+02
145	1	-28.6211111	8.191680e+02	8.191680e+02
146	2	-27.6211111	7.629258e+02	1.525852e+03
147	1	-26.6211111	7.086836e+02	7.086836e+02
149	1	-24.6211111	6.061991e+02	6.061991e+02
151	1	-22.6211111	5.117147e+02	5.117147e+02
157	1	-16.6211111	2.762613e+02	2.762613e+02
158	1	-15.6211111	2.440191e+02	2.440191e+02
159	3	-14.6211111	2.137769e+02	6.413307e+02
160	1	-13.6211111	1.855347e+02	1.855347e+02
161	1	-12.6211111	1.592924e+02	1.592924e+02
162	1	-11.6211111	1.350502e+02	1.350502e+02
164	1	-9.6211111	9.256578e+01	9.256578e+01
165	1	-8.6211111	7.432356e+01	7.432356e+01
166	1	-7.6211111	5.808133e+01	5.808133e+01
167	1	-6.6211111	4.383911e+01	4.383911e+01
170	1	-3.6211111	1.311245e+01	1.311245e+01
171	1	-2.6211111	6.870223e+00	6.870223e+00

172	1	-1.6211111	2.628001e+00	2.628001e+00
173	1	-0.6211111	3.857790e-01	3.857790e-01
174	1	0.3788889	1.435568e-01	1.435568e-01
175	1	1.3788889	1.901335e+00	1.901335e+00
176	1	2.3788889	5.659112e+00	5.659112e+00
177	1	3.3788889	1.141689e+01	1.141689e+01
178	1	4.3788889	1.917467e+01	1.917467e+01
180	1	6.3788889	4.069022e+01	4.069022e+01
185	1	11.3788889	1.294791e+02	1.294791e+02
186	1	12.3788889	1.532369e+02	1.532369e+02
187	3	13.3788889	1.789947e+02	5.369840e+02
188	1	14.3788889	2.067524e+02	2.067524e+02
189	1	15.3788889	2.365102e+02	2.365102e+02
191	1	17.3788889	3.020258e+02	3.020258e+02
192	2	18.3788889	3.377836e+02	6.755671e+02
194	1	20.3788889	4.152991e+02	4.152991e+02
196	1	22.3788889	5.008147e+02	5.008147e+02
197	1	23.3788889	5.465724e+02	5.465724e+02
200	1	26.3788889	6.958458e+02	6.958458e+02
201	1	27.3788889	7.496036e+02	7.496036e+02
203	1	29.3788889	8.631191e+02	8.631191e+02
208	1	34.3788889	1.181908e+03	1.181908e+03
209	1	35.3788889	1.251666e+03	1.251666e+03
211	1	37.3788889	1.397181e+03	1.397181e+03
212	1	38.3788889	1.472939e+03	1.472939e+03
213	1	39.3788889	1.550697e+03	1.550697e+03
215	1	41.3788889	1.712212e+03	1.712212e+03
217	1	43.3788889	1.881728e+03	1.881728e+03
218	3	44.3788889	1.969486e+03	5.908457e+03
223	1	49.3788889	2.438275e+03	2.438275e+03
224	2	50.3788889	2.538032e+03	5.076065e+03
227	2	53.3788889	2.849306e+03	5.698612e+03
228	3	54.3788889	2.957064e+03	8.871191e+03
229	2	55.3788889	3.066821e+03	6.133643e+03
230	1	56.3788889	3.178579e+03	3.178579e+03
231	1	57.3788889	3.292337e+03	3.292337e+03

232	1	58.3788889	3.408095e+03	3.408095e+03
233	1	59.3788889	3.525852e+03	3.525852e+03
234	1	60.3788889	3.645610e+03	3.645610e+03
235	2	61.3788889	3.767368e+03	7.534736e+03
238	1	64.3788889	4.144641e+03	4.144641e+03
244	1	70.3788889	4.953188e+03	4.953188e+03
246	1	72.3788889	5.238704e+03	5.238704e+03
247	1	73.3788889	5.384461e+03	5.384461e+03
248	3	74.3788889	5.532219e+03	1.659666e+04
249	1	75.3788889	5.681977e+03	5.681977e+03
250	1	76.3788889	5.833735e+03	5.833735e+03
251	2	77.3788889	5.987492e+03	1.197498e+04
252	1	78.3788889	6.143250e+03	6.143250e+03
256	1	82.3788889	6.786281e+03	6.786281e+03
257	2	83.3788889	6.952039e+03	1.390408e+04
260	1	86.3788889	7.461312e+03	7.461312e+03
266	1	92.3788889	8.533859e+03	8.533859e+03
268	1	94.3788889	8.907375e+03	8.907375e+03
272	1	98.3788889	9.678406e+03	9.678406e+03
275	2	101.3788889	1.027768e+04	2.055536e+04
277	1	103.3788889	1.068719e+04	1.068719e+04
279	1	105.3788889	1.110471e+04	1.110471e+04
283	1	109.3788889	1.196374e+04	1.196374e+04
287	1	113.3788889	1.285477e+04	1.285477e+04
290	2	116.3788889	1.354405e+04	2.708809e+04
298	1	124.3788889	1.547011e+04	1.547011e+04
302	1	128.3788889	1.648114e+04	1.648114e+04
312	1	138.3788889	1.914872e+04	1.914872e+04
313	1	139.3788889	1.942647e+04	1.942647e+04
315	1	141.3788889	1.998799e+04	1.998799e+04
318	1	144.3788889	2.084526e+04	2.084526e+04
320	1	146.3788889	2.142678e+04	2.142678e+04
326	1	152.3788889	2.321933e+04	2.321933e+04
327	1	153.3788889	2.352508e+04	2.352508e+04
331	2	157.3788889	2.476811e+04	4.953623e+04
339	1	165.3788889	2.735018e+04	2.735018e+04

340	1	166.3788889	2.768193e+04	2.768193e+04
343	1	169.3788889	2.868921e+04	2.868921e+04
348	1	174.3788889	3.040800e+04	3.040800e+04
350	1	176.3788889	3.110951e+04	3.110951e+04
351	1	177.3788889	3.146327e+04	3.146327e+04
352	1	178.3788889	3.181903e+04	3.181903e+04
361	1	187.3788889	3.511085e+04	3.511085e+04
364	1	190.3788889	3.624412e+04	3.624412e+04
367	1	193.3788889	3.739539e+04	3.739539e+04
368	1	194.3788889	3.778315e+04	3.778315e+04
374	1	200.3788889	4.015170e+04	4.015170e+04
375	1	201.3788889	4.055346e+04	4.055346e+04
376	1	202.3788889	4.095721e+04	4.095721e+04
379	1	205.3788889	4.218049e+04	4.218049e+04
382	1	208.3788889	4.342176e+04	4.342176e+04
384	1	210.3788889	4.425928e+04	4.425928e+04
386	1	212.3788889	4.510479e+04	4.510479e+04
393	1	219.3788889	4.812710e+04	4.812710e+04
396	1	222.3788889	4.945237e+04	4.945237e+04
398	1	224.3788889	5.034589e+04	5.034589e+04
401	1	227.3788889	5.170116e+04	5.170116e+04
404	1	230.3788889	5.307443e+04	5.307443e+04
405	1	231.3788889	5.353619e+04	5.353619e+04
412	1	238.3788889	5.682449e+04	5.682449e+04
413	1	239.3788889	5.730225e+04	5.730225e+04
420	1	246.3788889	6.070256e+04	6.070256e+04
430	1	256.3788889	6.573013e+04	6.573013e+04
431	1	257.3788889	6.624389e+04	6.624389e+04
442	1	268.3788889	7.202723e+04	7.202723e+04
449	1	275.3788889	7.583353e+04	7.583353e+04
450	1	276.3788889	7.638529e+04	7.638529e+04
453	1	279.3788889	7.805256e+04	7.805256e+04
457	2	283.3788889	8.030359e+04	1.606072e+05
459	2	285.3788889	8.144111e+04	1.628822e+05
468	1	294.3788889	8.665893e+04	8.665893e+04
479	1	305.3788889	9.325627e+04	9.325627e+04

480	2	306.3788889	9.386802e+04	1.877360e+05
485	1	311.3788889	9.695681e+04	9.695681e+04
486	1	312.3788889	9.758057e+04	9.758057e+04
487	1	313.3788889	9.820633e+04	9.820633e+04
491	1	317.3788889	1.007294e+05	1.007294e+05
494	2	320.3788889	1.026426e+05	2.052853e+05
495	1	321.3788889	1.032844e+05	1.032844e+05
506	1	332.3788889	1.104757e+05	1.104757e+05
510	1	336.3788889	1.131508e+05	1.131508e+05
513	1	339.3788889	1.151780e+05	1.151780e+05
533	1	359.3788889	1.291532e+05	1.291532e+05
537	1	363.3788889	1.320442e+05	1.320442e+05
542	1	368.3788889	1.357030e+05	1.357030e+05
552	1	378.3788889	1.431706e+05	1.431706e+05
554	1	380.3788889	1.446881e+05	1.446881e+05
555	1	381.3788889	1.454499e+05	1.454499e+05
558	1	384.3788889	1.477471e+05	1.477471e+05
560	1	386.3788889	1.492886e+05	1.492886e+05
561	1	387.3788889	1.500624e+05	1.500624e+05
562	1	388.3788889	1.508382e+05	1.508382e+05
574	1	400.3788889	1.603033e+05	1.603033e+05
576	2	402.3788889	1.619088e+05	3.238175e+05
581	1	407.3788889	1.659576e+05	1.659576e+05
583	1	409.3788889	1.675911e+05	1.675911e+05
605	1	431.3788889	1.860877e+05	1.860877e+05
608	1	434.3788889	1.886850e+05	1.886850e+05
622	1	448.3788889	2.010436e+05	2.010436e+05
625	1	451.3788889	2.037429e+05	2.037429e+05
627	1	453.3788889	2.055524e+05	2.055524e+05
630	1	456.3788889	2.082817e+05	2.082817e+05
651	1	477.3788889	2.278906e+05	2.278906e+05
659	1	485.3788889	2.355927e+05	2.355927e+05
661	1	487.3788889	2.375382e+05	2.375382e+05
663	1	489.3788889	2.394917e+05	2.394917e+05
668	1	494.3788889	2.444105e+05	2.444105e+05
670	1	496.3788889	2.463920e+05	2.463920e+05

678	2	504.3788889	2.543981e+05	5.087961e+05
693	1	519.3788889	2.697544e+05	2.697544e+05
694	1	520.3788889	2.707942e+05	2.707942e+05
699	1	525.3788889	2.760230e+05	2.760230e+05
731	1	557.3788889	3.106712e+05	3.106712e+05
733	1	559.3788889	3.129047e+05	3.129047e+05
744	1	570.3788889	3.253321e+05	3.253321e+05
767	1	593.3788889	3.520985e+05	3.520985e+05
770	1	596.3788889	3.556678e+05	3.556678e+05
788	1	614.3788889	3.774614e+05	3.774614e+05
800	1	626.3788889	3.923505e+05	3.923505e+05
802	1	628.3788889	3.948600e+05	3.948600e+05
806	1	632.3788889	3.999031e+05	3.999031e+05
807	1	633.3788889	4.011688e+05	4.011688e+05
810	1	636.3788889	4.049781e+05	4.049781e+05
856	2	682.3788889	4.656409e+05	9.312819e+05
868	1	694.3788889	4.821620e+05	4.821620e+05
874	1	700.3788889	4.905306e+05	4.905306e+05
878	2	704.3788889	4.961496e+05	9.922992e+05
880	1	706.3788889	4.989711e+05	4.989711e+05
901	1	727.3788889	5.290800e+05	5.290800e+05
907	1	733.3788889	5.378446e+05	5.378446e+05
913	1	739.3788889	5.466811e+05	5.466811e+05
917	1	743.3788889	5.526122e+05	5.526122e+05
931	1	757.3788889	5.736228e+05	5.736228e+05
946	1	772.3788889	5.965691e+05	5.965691e+05
948	1	774.3788889	5.996627e+05	5.996627e+05
969	1	795.3788889	6.326276e+05	6.326276e+05
993	1	819.3788889	6.713818e+05	6.713818e+05
1004	1	830.3788889	6.895291e+05	6.895291e+05
1006	2	832.3788889	6.928546e+05	1.385709e+06
1014	1	840.3788889	7.062367e+05	7.062367e+05
1031	2	857.3788889	7.350986e+05	1.470197e+06
1035	1	861.3788889	7.419736e+05	7.419736e+05
1048	1	874.3788889	7.645384e+05	7.645384e+05
1054	1	880.3788889	7.750670e+05	7.750670e+05

1062	1	888.3788889	7.892171e+05	7.892171e+05
1133	1	959.3788889	9.204079e+05	9.204079e+05
1138	1	964.3788889	9.300266e+05	9.300266e+05
1142	1	968.3788889	9.377577e+05	9.377577e+05
1159	1	985.3788889	9.709716e+05	9.709716e+05
1160	1	986.3788889	9.729433e+05	9.729433e+05
1163	1	989.3788889	9.788706e+05	9.788706e+05
1180	1	1006.3788889	1.012798e+06	1.012798e+06
1187	1	1013.3788889	1.026937e+06	1.026937e+06
1191	1	1017.3788889	1.035060e+06	1.035060e+06
1225	1	1051.3788889	1.105398e+06	1.105398e+06
1237	1	1063.3788889	1.130775e+06	1.130775e+06
1254	1	1080.3788889	1.167219e+06	1.167219e+06
1294	1	1120.3788889	1.255249e+06	1.255249e+06
1295	1	1121.3788889	1.257491e+06	1.257491e+06
1367	1	1193.3788889	1.424153e+06	1.424153e+06
1414	1	1240.3788889	1.538540e+06	1.538540e+06
1447	1	1273.3788889	1.621494e+06	1.621494e+06
1490	1	1316.3788889	1.732853e+06	1.732853e+06
1606	1	1432.3788889	2.051709e+06	2.051709e+06
1664	1	1490.3788889	2.221229e+06	2.221229e+06
1666	1	1492.3788889	2.227195e+06	2.227195e+06
1802	1	1628.3788889	2.651618e+06	2.651618e+06
1973	1	1799.3788889	3.237764e+06	3.237764e+06
2420	1	2246.3788889	5.046218e+06	5.046218e+06
2776	1	2602.3788889	6.772376e+06	6.772376e+06
2866	1	2692.3788889	7.248904e+06	7.248904e+06
2943	1	2769.3788889	7.669459e+06	7.669459e+06
2993	1	2819.3788889	7.948897e+06	7.948897e+06
3021	1	2847.3788889	8.107567e+06	8.107567e+06
4173	1	3999.3788889	1.599503e+07	1.599503e+07

2.3 Summary Report

Variance $s^2 = \text{sum}(X(K-u)^2) / (900 - 1) = 154,206.19$

VMR = 154,206.19 / mean quadrat count = 154,206.19 / 173.62 = 888.18

VMR for random quadrat count method is around 888.18, which is still much much greater than 1.0. Which means the points in this pattern is strongly clustered.

3. Code

```
##### Open Packages #####
library(rgdal) # Bindings for the geospatial data abstraction library. Function readOGR belongs to this package.
library(spatstat) # Spatial Point Pattern Analysis, Model-Fitting, Simulation, Tests
library(sp)
library(mapproj)
library(maps)
library(graphics)

##### Import Dataset #####
getwd() # get the working directory
list.files() # List the Files in a Directory
OilGasLocationPA <- readOGR(dsn = "/Users/qijiawen/Desktop/2017 Spring/Spatial Data Analytics/Project 2",
  layer = "OilGasLocationPA") # read OilGasLocationPA shapefile
summary(OilGasLocationPA) # get a summary # Totally there are 156259 records
OilGasLocationPA.spatialPoints <- as(OilGasLocationPA, "SpatialPoints") # change spatial points data frame to Spatial Points
OilGasLocationPA.ppp <- as(OilGasLocationPA.spatialPoints, "ppp") # change spatial points to spatial point pattern class ppp

##### Regular Quadrat Count Method #####
##### Determine The Number of Quadrats #####
##### 10 x 10 #####
try1 <- quadratcount(OilGasLocationPA.ppp, nx = 10, ny = 10) ## try 100 quadrats
table(try1) ## aggregate the result from 0 to 15160
mean = length(OilGasLocationPA)/100 ## mean is 1562
length(table(try1)) ## 67 records
plot(OilGasLocationPA.ppp, pch = ".", main = "First Try: Regular Quadrat Count (10x10)") # plot points as background map
plot(try1, add = TRUE, col = "red")

##### 20 x 20 #####
try2 <- quadratcount(OilGasLocationPA.ppp, nx = 20, ny = 20) ## try 400 quadrats
table(try2) ## aggregate the result from 0 to 6367
mean = length(OilGasLocationPA)/400 ## mean is 390
length(table(try2)) ## 202 records
plot(OilGasLocationPA.ppp, pch = ".", main = "Second Try: Regular Quadrat Cou
```

```

nt (20x20)") # plot points as background map
plot(try2, add = TRUE, col = "red")

##### 30 x 30 #####
try3 <- quadratcount(OilGasLocationPA.ppp, nx = 30, ny = 30) ## try 900 quadrats
table(try3) ## aggregate the result from 0 to 3961
mean = length(OilGasLocationPA)/900 ## mean is 174
length(table(try3)) ## 323 records
plot(OilGasLocationPA.ppp, pch = ".", main = "Third Try: Regular Quadrat Count (30x30)") # plot points as background map
plot(try3, add = TRUE, col = "red")

##### 40 x 40 #####
try4 <- quadratcount(OilGasLocationPA.ppp, nx = 40, ny = 40) ## try 1600 quadrats
table(try4) ## aggregate the result from 0 to 2657
mean = length(OilGasLocationPA)/1600 ## mean is 98
length(table(try4)) ## 363 records
plot(OilGasLocationPA.ppp, pch = ".", main = "Forth Try: Regular Quadrat Count (40x40)") # plot points as background map
plot(try4, add = TRUE, col = "red")

##### Map #####
plot(OilGasLocationPA.ppp, pch = ".", main = "Regular Quadrat Count (30x30)") # plot points as background map
RegularQuadratCount <- quadratcount(OilGasLocationPA.ppp, nx = 30, ny = 30)
# Divides window into quadrats and counts the numbers of points in each quadrat
plot(RegularQuadratCount, add = TRUE, col = "red") # Plot the count

##### Table #####
RegularQuadratTable <- table(RegularQuadratCount) ## aggregate and sort
RegularQuadratTable <- as.data.frame(RegularQuadratTable) ## create the table
colnames(RegularQuadratTable) <- c("No. of Events (K)", "No. of Quadrats(X)")
u <- length(OilGasLocationPA)/900 # calculate the u 'mean quadrat count' 173.62
RegularQuadratTable$`No. of Events (K)` <- as.integer(as.character(RegularQuadratTable$`No. of Events (K)`)) # change factor to integer
RegularQuadratTable$`K-u` <- RegularQuadratTable$`No. of Events (K)` - u ## calculate k-u
RegularQuadratTable$`(K-u)^2` <- RegularQuadratTable$`K-u` * RegularQuadratTable$`K-u` # calculate (K-u)^2
RegularQuadratTable$`X(K-u)^2` <- RegularQuadratTable$`No. of Quadrats(X)` *
  RegularQuadratTable$`(K-u)^2` # calculate X(K-u)^2
write.csv(RegularQuadratTable, "Regular.csv", row.names = FALSE)

##### Summary: Calculate VMR #####
RegularVariance = sum(RegularQuadratTable$`X(K-u)^2`)/(900 - 1) # calculate the variance s^2

```

```

RegularVMR <- RegularVariance/u # variance mean ratio

##### Random Quadrat Count Method #####
coords <- as.data.frame(OilGasLocationPA@coords) # get the coords table
x.max <- max(coords$coords.x1) # max for x
x.min <- min(coords$coords.x1) # min for y
y.max <- max(coords$coords.x2) # max for y
y.min <- min(coords$coords.x2) # max for x
quadratLength <- (x.max - x.min)/30 # the same length as regular
quadratWidth <- (y.max - y.min)/30 # the same width as regular
set.seed(1) ## to get same result, my favorite seed
randomX <- runif(900, min = x.min, max = x.max - quadratLength) # generate 900 random x
randomY <- runif(900, min = y.min + quadratWidth, max = y.max) # generate 900 random y
randomQuadratCount <- matrix()
# count the number of event for each random quadrat
for (i in 1:900) {
  # get four corner coordinates
  x.left = randomX[i]
  x.right = randomX[i] + quadratLength
  y.top = randomY[i]
  y.bottom = randomY[i] - quadratWidth
  # do filters for four sides
  conditionLeft <- coords[coords$coords.x1 > x.left, ]
  conditionRight <- conditionLeft[conditionLeft$coords.x1 < x.right, ]
  conditionTop <- conditionRight[conditionRight$coords.x2 < y.top, ]
  conditionBottom <- conditionTop[conditionTop$coords.x2 > y.bottom, ]
  randomQuadratCount[i] <- nrow(conditionBottom) # count number of points
}

##### Map #####
plot(OilGasLocationPA.ppp, pch = ".", main = "Random Quadrat Count (900 rectangles)") # plot points as background map
for (i in 1:900) {
  rect(xleft = randomX[i], ybottom = randomY[i] - quadratWidth, xright = randomX[i] +
        quadratLength, ytop = randomY[i], border = "blue") ## draw rectangles
  text(randomX[i] + 0.5 * quadratLength, randomY[i] - 0.5 * quadratWidth,
       randomQuadratCount[i], col = "blue", cex = 0.8) ## add count text
}

##### Table #####
RandomCountTable <- table(randomQuadratCount) ## aggregate and sort
RandomCountTable <- as.data.frame(RandomCountTable) ## create the table
colnames(RandomCountTable) <- c("No. of Events (K)", "No. of Quadrats(X)")
RandomCountTable$`No. of Events (K)` <- as.integer(as.character(RandomCountTable$`No. of Events (K)`)) # change factor to integer
RandomCountTable$`K-u` <- RandomCountTable$`No. of Events (K)` - u ## calcul

```

```

ate k-u
RandomCountTable$` $(K-u)^2$ ` <- RandomCountTable$` $K-u$ ` * RandomCountTable$` $K-u$ `
# calculate  $(K-u)^2$ 
RandomCountTable$` $X(K-u)^2$ ` <- RandomCountTable$`No. of Quadrats(X)` * Random
CountTable$` $(K-u)^2$ ` # calculate  $X(K-u)^2$ 
write.csv(RandomCountTable, "Random.csv", row.names = FALSE)

##### Summary: Calculate VMR #####
RandomVariance = sum(RandomCountTable$` $X(K-u)^2$ `) / (900 - 1) # calculate the
variance s^2
RandomVMR <- RandomVariance/u # variance mean ratio

```