Lab: Point Pattern Analysis (Solutions)

Contents

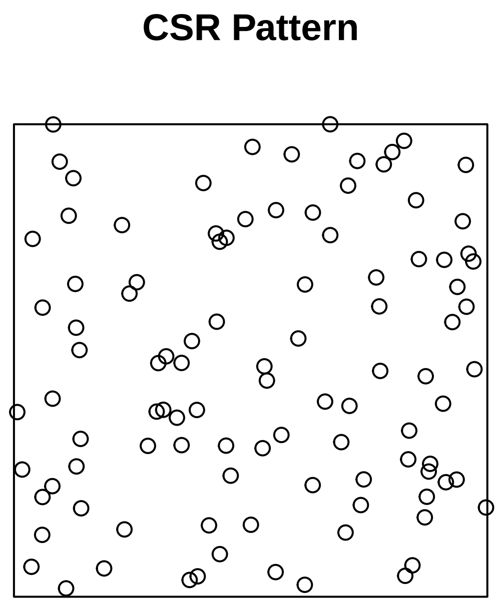
Lab Objective

Analyze spatial point patterns using CSR (complete spatial randomness) as a null model. Detect clustering or repulsion, evaluate the effect of spatial heterogeneity, and test the independence between two point patterns.

Part 1: Introduction and CSR

(1a) Generate a point pattern with complete spatial randomness (CSR) using intensity $\lambda = 100$. Plot it.

```r
library(spatstat)
csr <- rpoispp(lambda = 100)
plot(csr, main = "CSR Pattern")
```

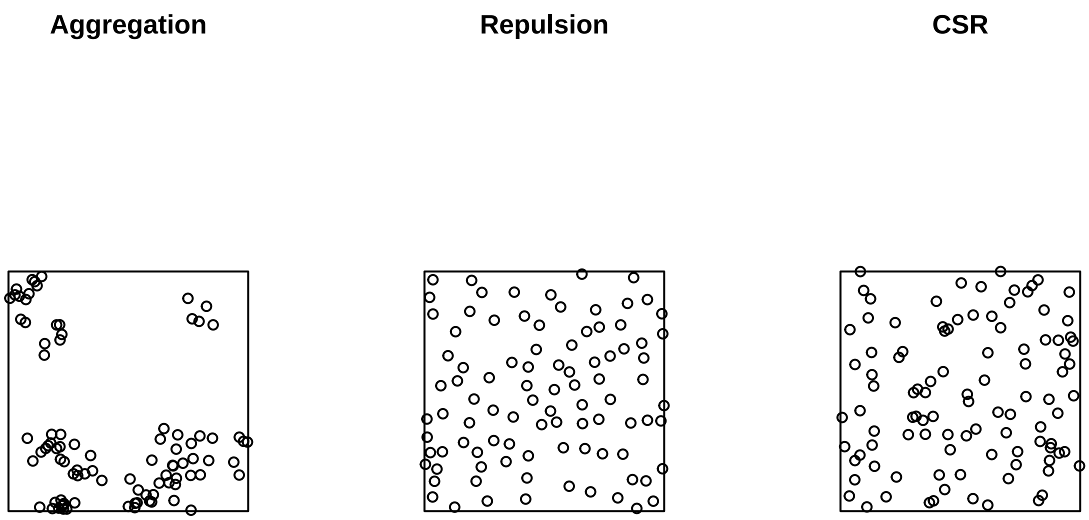


(1b) What is complete spatial randomness (CSR) and which statistical model represents it?

(1C) Generate: an aggregated pattern using rMatClust(), a repulsive pattern using rMaternII(). Plot all three patterns (CSR, aggregation, repulsion) side-by-side.

```
agg <- rMatClust(20, 0.1, 5)
rep <- rMaternII(150, 0.05)

par(mfrow = c(1, 3))
plot(agg, main = "Aggregation")
plot(rep, main = "Repulsion")
plot(csr, main = "CSR")
```



(1d) What visual differences do you observe between the three patterns?

Part 2: Ripley's K and null model testing

(2a) Compute and plot Ripley's K function with simulation envelopes for each of the three patterns.

```
k_agg <- envelope(agg, Kest, correction = "iso")
```

```
## Generating 99 simulations of CSR  ...
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,
## 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,
## 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60,
## 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,
## 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98,
## 99.
##
## Done.
```

```
k_rep <- envelope(rep, Kest, correction = "iso")
```

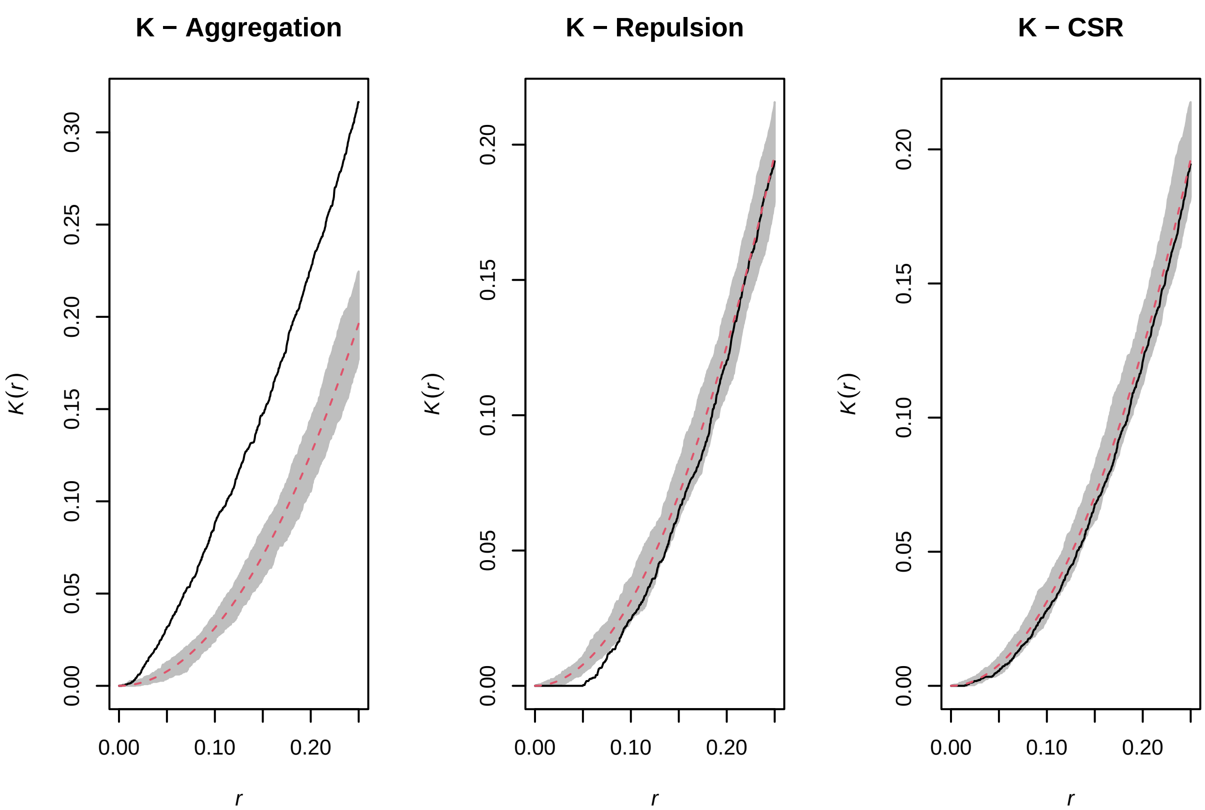
```
## Generating 99 simulations of CSR  ...
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,
## 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,
## 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60,
## 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,
## 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98,
## 99.
```

```
##
## Done.
```

```r
k_csr <- envelope(csr, Kest, correction = "iso")
```

```
## Generating 99 simulations of CSR  ...
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,
## 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,
## 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60,
## 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,
## 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98,
## 99.
##
## Done.
```

```r
par(mfrow = c(1, 3))
plot(k_agg, main = "K - Aggregation", legend = FALSE)
plot(k_rep, main = "K - Repulsion", legend = FALSE)
plot(k_csr, main = "K - CSR", legend = FALSE)
```

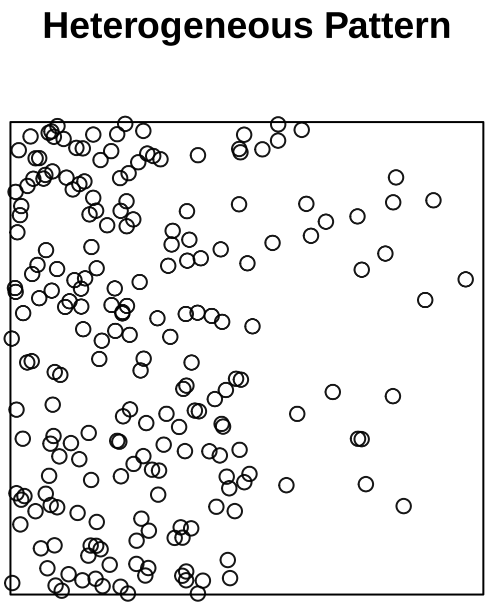


(2b) How do you interpret a K(r) curve above or below the theoretical curve? Which of the patterns significantly deviates from CSR? At what range of distances?

Part 3: Heterogeneous intensity

(3a) Simulate a heterogeneous point pattern with a non-uniform intensity function as argument of *rpoispp*. Plot the pattern.

```r
lambda_gradient <- function(x, y) ifelse(x < 0.5, 500*(1 - x), 200*(1 - x))
het <- rpoispp(lambda_gradient)
plot(het, main = "Heterogeneous Pattern")
```



(3b) Why can a density gradient be mistaken for spatial analyses?

(3c) Compare K estimates with and without correcting for heterogeneity (express the pattern in the *simulate* argument of the function *envelope*).

```r
k_het_naive <- envelope(het, Kest, correction = "iso")
```

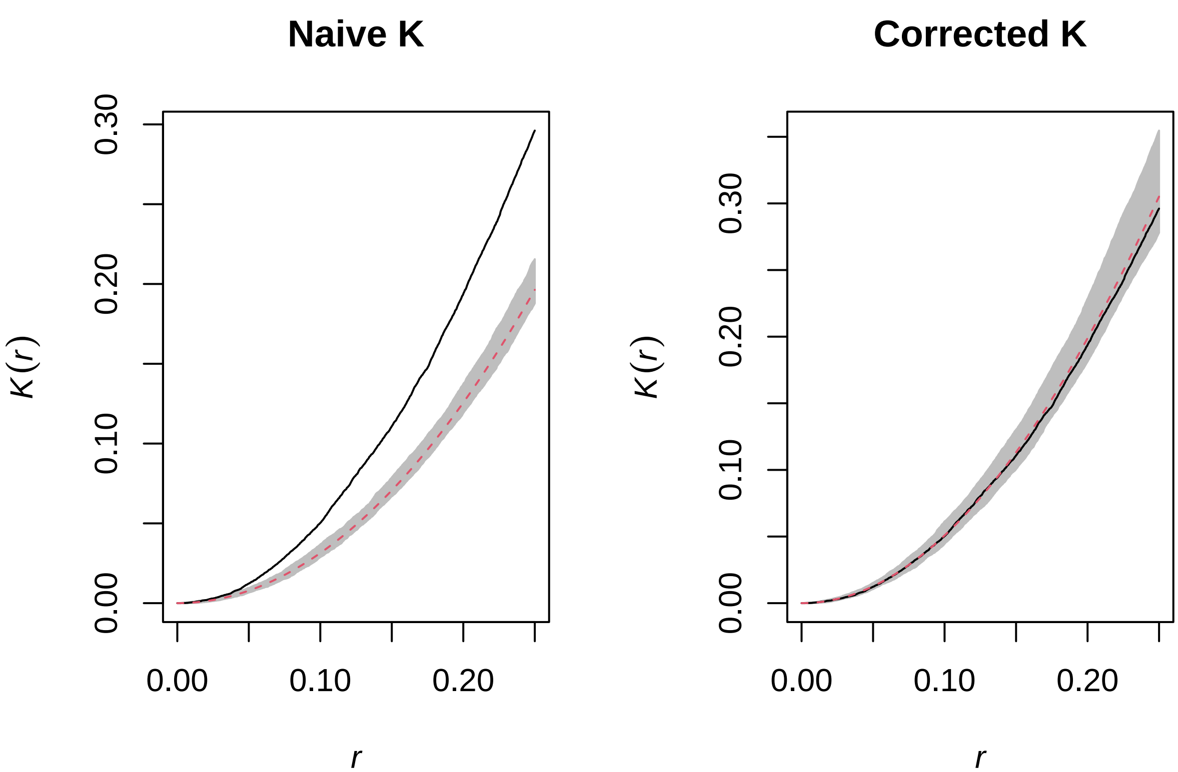
```
## Generating 99 simulations of CSR  ...
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,
## 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,
## 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60,
## 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,
## 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98,
## 99.
##
## Done.
```

```r
k_het_corrected <- envelope(het, Kest, simulate = function(x) rpoispp(lambda_gradient), correction = "i
```

```
## Generating 99 simulations by evaluating function  ...
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,
## 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40,
## 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60,
## 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80,
```

```
## 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98,
## 99.
##
## Done.
```

```r
par(mfrow = c(1, 2))
plot(k_het_naive, main = "Naive K", legend = FALSE)
plot(k_het_corrected, main = "Corrected K", legend = FALSE)
```



(3d) Which characteristic helps distinguish a density gradient from true clustering/aggregation?