Sean Connelly
UPP 465
Professor Tilahun
3/3/20

Spatial Statistics – Point Pattern Analysis Lab

Three point pattern event data - Pattern 1, Pattern 2, and Pattern 3 - have been provided to you. Your task in this assignment is to examine these three patterns and report back on your findings. Specifically, answer the following questions:

1. Populate the table below:

Data	Number of Events	Area of Observation	Average Intensity
Pattern 1	508	100	5.08 per unit area
Pattern 2	423	100	4.23 per unit area
Pattern 3	116	100	1.16 per unit area

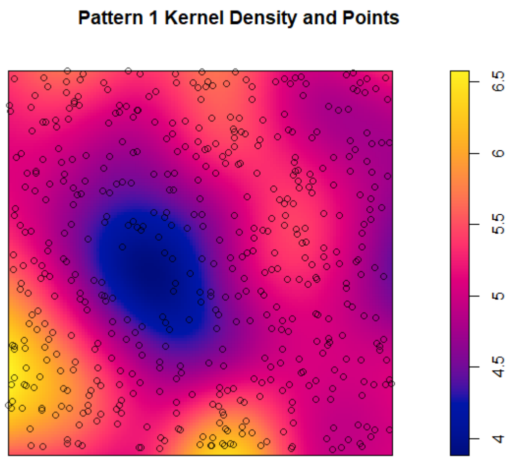
2. Assessment of point patterns requires you to compare your event data against a pattern of CSR with the same level of average intensity. For each of the three patterns, if you were to carve out a 2 square unit area:
   a. How many points do you expect to see in that area if the pattern is CSR? (e.g Pattern 1)

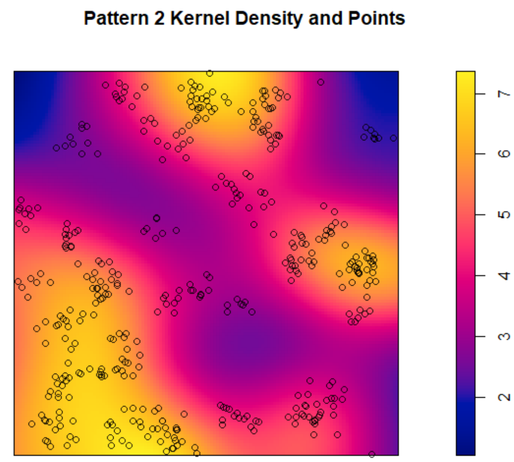
      Under CSR, expected $n = \lambda A$
      $n = (5.08)(2)$
      $n = (5.08)(2)$
      $n = 10.16$
   b. What is the probability of observing exactly 5 events in the 2 square unit area if the pattern is CSR? (e.g Pattern 1)

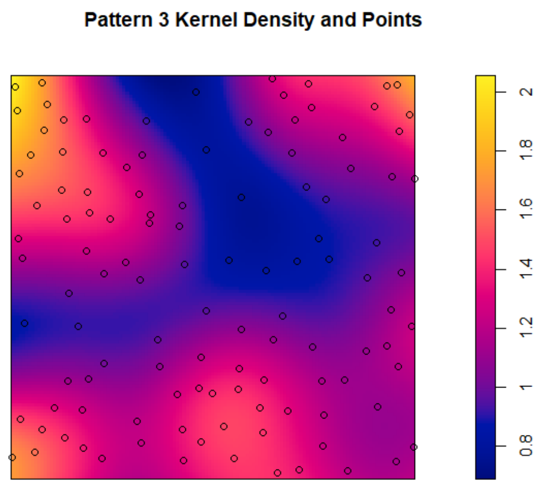
      $P(X = x) = (e^{-\lambda}\lambda^{x}) / x!$
      $P(X = 5) = (e^{-10.16}10.16^{5}) / 5!$
      $P(X = 5) = (e^{-10.16}10.16^{5}) / 5!$
      $P(X = 5) = 0.0349$
   c. Populate the table below. Show your detailed work for both a and b for one of the patterns.

Data	Expected Count in 2 Square Unit Area	Probability(X=5) in the 2 Square Unit Area
Pattern 1	10.16	0.0349
Pattern 2	8.46	0.0765
Pattern 3	2.32	0.0550

3. For each pattern, estimate the Kernel Density and show a plot overlaid with the point patterns.





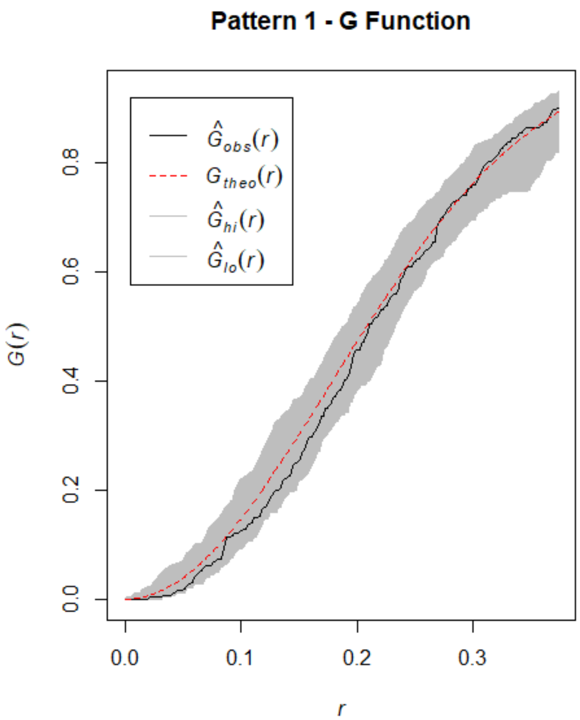


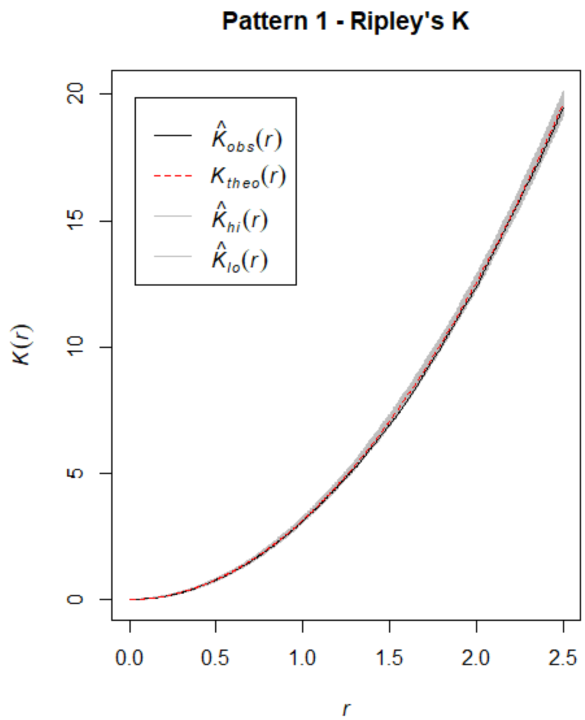
4. Using the G function and the Ripley's K function assess whether each point pattern resembles a CSR, a clustered pattern, or a regular pattern. Include figures that show the envelope and the values of the G and K functions for all three patterns. Briefly explain the figures and your conclusion

Data	Pattern Type
Pattern 1	CSR
Pattern 2	Clustered
Pattern 3	Regular

Please see the plots on the pages below for a more detailed discussion on the patterns.

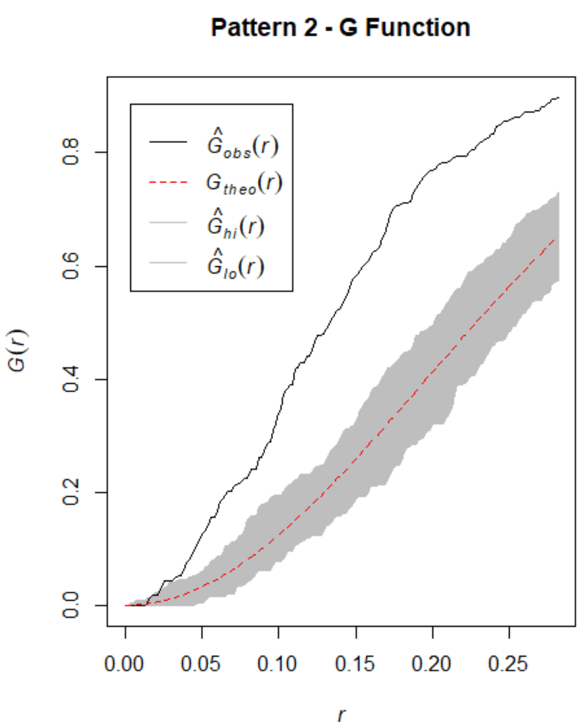
Pattern 1 shows clear signs of Complete Spatial Randomness. Both G(r) and K(r) observed values fall well within the randomization envelope.

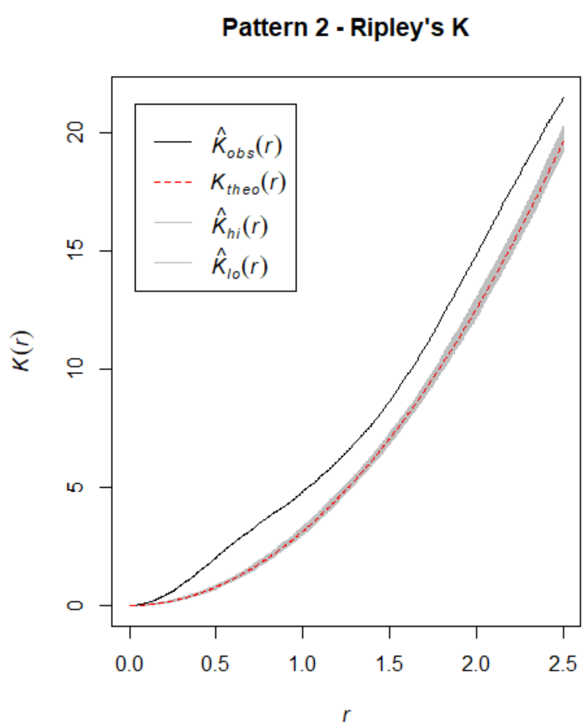




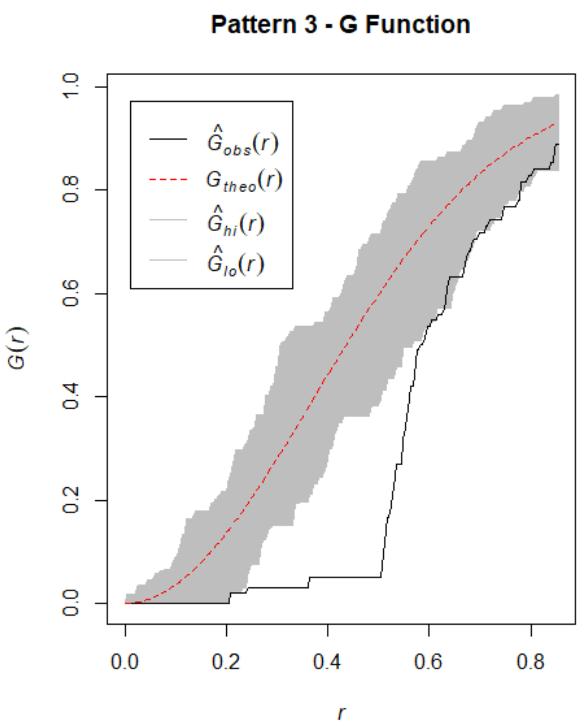
\

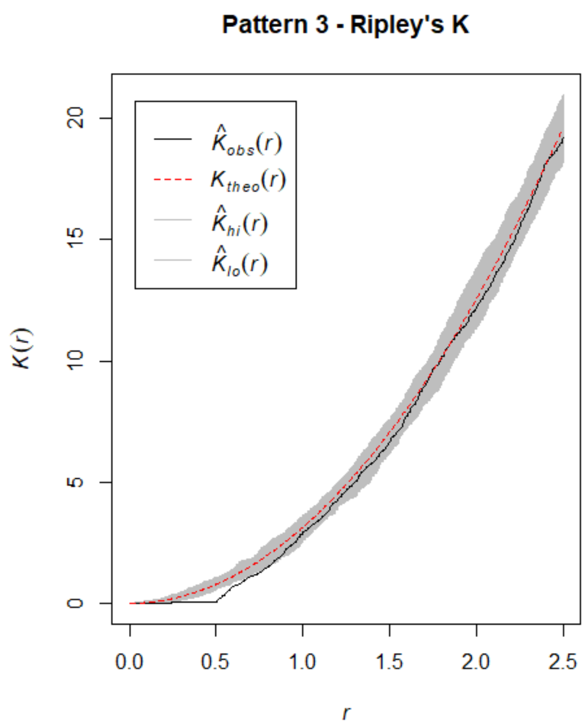
Pattern 2 shows evidence of clustering. Both G(r) and K(r) observed values are above the randomization envelope for all reasonable values of r.





Pattern 3 is the most complicated pattern of the point event datasets analyzed. G(*r*) suggests that that Pattern 3 is regularly spaced, however this finding is less certain as *r* increases. Ripley's K, which measures how many events there are at any given *r*, hints towards CSR, however, the relative lack of events and intensity compared to Patterns 1 and 2 may mean the function is biased at high levels of *r*. There is more evidence to suggest that Pattern 3 is regular.





```
# Load libraries ----------------------------------------------------------
#make sure the below libraries are installed on your machine. Use
install.packages("LIBRARYNAME")
rm(list = ls()) #clear objects in memory
# Set working directory
setwd(paste0(here::here(), "/06_PPA_Assignment"))
# Load additional libraries
pacman::p_load(tidyverse, # for basic data manipulation, visualization
scales, # for formatting number output
patchwork, # for arranging ggplots in grids
sf, # simple features for spatial
nngeo, # nearest neighbors
summarytools, # for checking data frame characteristics
here, # for relative file paths
knitr, # for tables
kableExtra, # table styling
janitor) # for cleaning and tabulations
#load your spatial libraries
library(sp)
library(raster)
library(spatstat)
library(rgdal)
library(maptools)
library(rgeos)
library(GISTools)
library(shapefiles)
library(aspace)
options(stringsAsFactors = FALSE, scipen = 999)
# Assignment --------------------------------------------------------------
# Import point patterns data
p1 <- readRDS("Raw_Data/pattern1.rds")
p2 <- readRDS("Raw_Data/pattern2.rds")
p3 <- readRDS("Raw_Data/pattern3.rds")
# 1. Populate the table below
# Number of events
p1$n
p2$n
p3$n
# Area of observation
spatstat::area(p1$window)
spatstat::area(p2$window)
spatstat::area(p3$window)
# Average intensity
p1$n / spatstat::area(p1$window)
p2$n / spatstat::area(p2$window)
p3$n / spatstat::area(p3$window)
# 2. Assessment of point patterns requires you to compare your event data
against a pattern of CSR with the same level of average intensity. For each of
the three patterns, if you were to carve out a 2 square unit area:
# a. How many points do you expect to see in that area if the pattern is
CSR?
p1_csr_hat <- (p1$n / spatstat::area(p1$window)) * 2
p2_csr_hat <- (p2$n / spatstat::area(p2$window)) * 2
p3_csr_hat <- (p3$n / spatstat::area(p3$window)) * 2
p1_csr_hat
p2_csr_hat
p3_csr_hat
# b. What is the prob of observing exactly 5 events in the 2 square unit
```

area if the pattern is CSR?
p1_prob5 <- (exp(-p1_csr_hat) * (p1_csr_hat ^ 5)) / factorial(5)
p2_prob5 <- (exp(-p2_csr_hat) * (p2_csr_hat ^ 5)) / factorial(5)
p3_prob5 <- (exp(-p3_csr_hat) * (p3_csr_hat ^ 5)) / factorial(5)
p1_prob5
p2_prob5
p3_prob5
# 3. For each pattern, estimate the Kernel Density and show a plot overlaid with the point patterns.
# Calculate densities
p1_density <- density(p1)
p2_density <- density(p2)
p3_density <- density(p3)
# P1
plot(p1_density, main = "Pattern 1 Kernel Density and Points")
plot(p1, add = TRUE)
# P2
plot(p2_density, main = "Pattern 2 Kernel Density and Points")
plot(p2, add = TRUE)
# P3
plot(p3_density, main = "Pattern 3 Kernel Density and Points")
plot(p3, add = TRUE)
# 4. Using the G function and the Ripley's K function assess whether each point pattern resembles a CSR, a clustered pattern, or a regular pattern. Include figures that show the envelope and the values of the G and K functions for all three patterns. Briefly explain the figures and your conclusion
# P1, G and Ripley's K
par(mfrow = c(1, 2))
p1_g_env <- envelope(p1, Gest)
plot(p1_g_env, main = "Pattern 1 - G Function")
p1_k_env <- envelope(p1, Kest)
plot(p1_k_env, main = "Pattern 1 - Ripley's K")
# P2, G and Ripley's K
par(mfrow = c(1, 2))
p2_g_env <- envelope(p2, Gest)
plot(p2_g_env, main = "Pattern 2 - G Function")
p2_k_env <- envelope(p2, Kest)
plot(p2_k_env, main = "Pattern 2 - Ripley's K")
# P3, G and Ripley's K
par(mfrow = c(1, 2))
p3_g_env <- envelope(p3, Gest)
plot(p3_g_env, main = "Pattern 3 - G Function")
p3_k_env <- envelope(p3, Kest)
plot(p3_k_env, main = "Pattern 3 - Ripley's K")