HarranPlain

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Point Pattern

```
harran=read.table("../data/Sites_HarranPlain.csv",
                  sep = ",",
                  header = TRUE) # when knitting: "../data/Sites_HarranPlain.csv"!!!!!
str(harran)
```

```
## 'data.frame':    344 obs. of  5 variables:
##  $ X.1            : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ Name           : Factor w/ 166 levels "Ã mertepe","Ã ncÃ¼l (FALSCH)",..: 24 10 10 67 67 67 67 78 78
##  $ X              : num  38.8 38.9 38.9 38.9 38.9 ...
##  $ Y              : num  37.6 37.7 37.7 37.2 37.2 ...
##  $ Mentioned_Epoch: Factor w/ 179 levels "","-","Aceramic Neolithic ",..: 175 150 139 162 108 151 161
```

spatstat

```
library(sp)
```

```
## Warning: package 'sp' was built under R version 3.3.3
```

```
coordinates(harran) <- ~X+Y
proj4string(harran) <- CRS("+init=epsg:4326")

harran <- spTransform(harran, CRSobj = CRS("+init=epsg:32637"))
str(harran) # for checking
```

```
## Formal class 'SpatialPointsDataFrame' [package "sp"] with 5 slots
##   ..@ data       :'data.frame':  344 obs. of  3 variables:
##   .. ..$ X.1            : int [1:344] 1 2 3 4 5 6 7 8 9 10 ...
##   .. ..$ Name           : Factor w/ 166 levels "Ã mertepe","Ã ncÃ¼l (FALSCH)",..: 24 10 10 67 67 67 67
##   .. ..$ Mentioned_Epoch: Factor w/ 179 levels "","-","Aceramic Neolithic ",..: 175 150 139 162 108 1
##   ..@ coords.nrs : num(0)
##   ..@ coords     : num [1:344, 1:2] 479412 486771 486771 493122 493122 ...
##   .. ..- attr(*, "dimnames")=List of 2
##   .. .. ..$ : chr [1:344] "1" "2" "3" "4" ...
##   .. .. ..$ : chr [1:2] "X" "Y"
##   ..@ bbox       : num [1:2, 1:2] 477942 4062337 514430 4290885
##   .. ..- attr(*, "dimnames")=List of 2
##   .. .. ..$ : chr [1:2] "X" "Y"
##   .. .. ..$ : chr [1:2] "min" "max"
##   ..@ proj4string:Formal class 'CRS' [package "sp"] with 1 slot
##   .. .. ..@ projargs: chr "+init=epsg:32637 +proj=utm +zone=37 +datum=WGS84 +units=m +no_defs +ellps=
```

```
library(spatstat)
```

```
## Warning: package 'spatstat' was built under R version 3.3.3
```

```
## Loading required package: nlme
```

```
## Warning: package 'nlme' was built under R version 3.3.3
```

```
## Loading required package: rpart
```

```
## Warning: package 'rpart' was built under R version 3.3.3
```

```
##
## spatstat 1.51-0       (nickname: 'Poetic Licence')
## For an introduction to spatstat, type 'beginner'
```

```
##
## Note: R version 3.3.1 (2016-06-21) is more than 9 months old; we strongly recommend upgrading to the
```

```
str(harran@coords) # structure
```

```
##  num [1:344, 1:2] 479412 486771 486771 493122 493122 ...
##  - attr(*, "dimnames")=List of 2
##   ..$ : chr [1:344] "1" "2" "3" "4" ...
##   ..$ : chr [1:2] "X" "Y"
```

```
harran_ppp <- ppp(x=harran@coords[,1],
                  y=harran@coords[,2],
                  window = owin(xrange = harran@bbox[1,],
                                yrange = c(min(harran@coords[,2]),
                                           min(harran@coords[,2])+52000)))
```

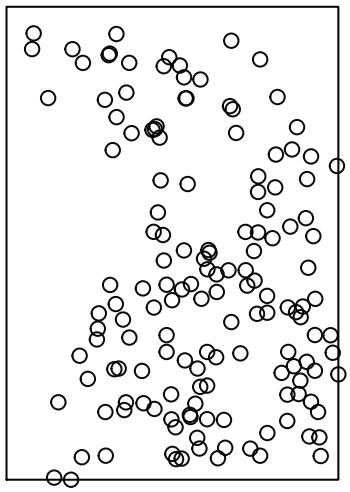
```
## Warning: 65 points were rejected as lying outside the specified window
```

```
## Warning: data contain duplicated points
```

```
harran_ppp=unique.ppp(harran_ppp) # shows number of duplicated points and deletes them/ harran_ppp= has

str(harran_ppp)
```

```
## List of 5
##  $ window    :List of 4
##   ..$ type  : chr "rectangle"
##   ..$ xrange: Named num [1:2] 477942 514430
##   .. ..- attr(*, "names")= chr [1:2] "min" "max"
##   ..$ yrange: num [1:2] 4062337 4114337
##   ..$ units :List of 3
##   .. ..$ singular  : chr "unit"
##   .. ..$ plural    : chr "units"
##   .. ..$ multiplier: num 1
##   .. ..- attr(*, "class")= chr "units"
##   ..- attr(*, "class")= chr "owin"
##  $ n         : int 149
##  $ x         : num [1:149] 485197 491077 482518 497239 495545 ...
##  $ y         : num [1:149] 4109677 4070842 4104300 4083259 4083780 ...
##  $ markformat: chr "none"
##  - attr(*, "class")= chr "ppp"
```

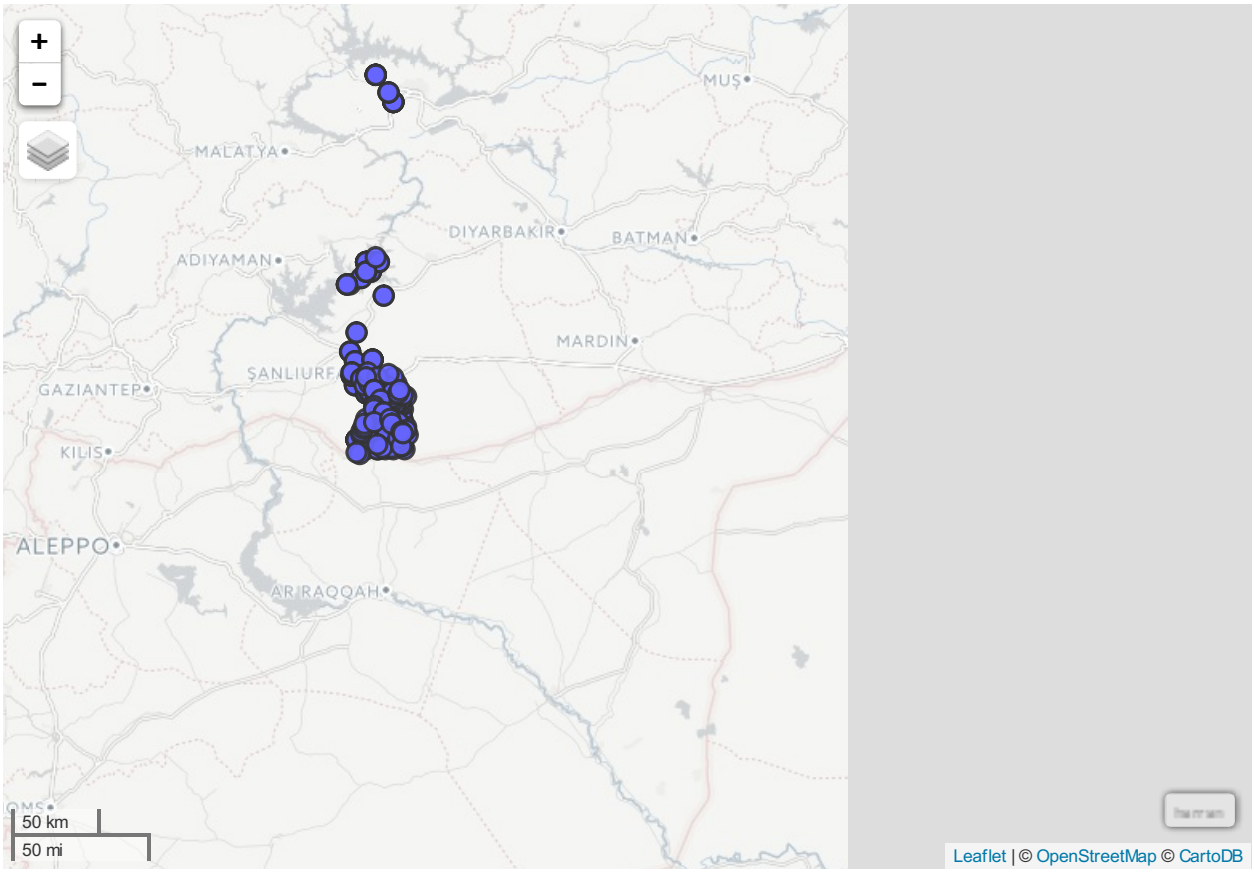
```
plot(harran_ppp)
```




```
library(mapview)
```

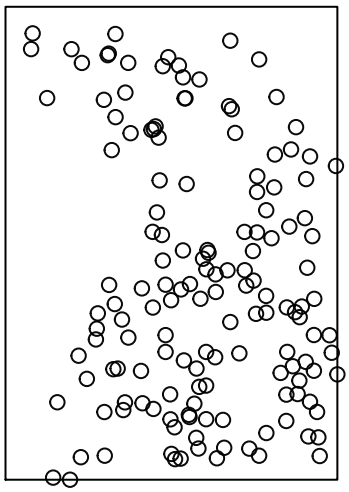
```
## Warning: package 'mapview' was built under R version 3.3.3
## Loading required package: leaflet
## Warning: package 'leaflet' was built under R version 3.3.3
```

```
mapview(harran)
```



Challenge: delete duplicated points

```
harran_ppp=unique.ppp(harran_ppp) # shows number of duplicated points and deletes them/ harran_ppp= has


# or:
#anyDuplicated(harran_ppp)
#harran <- unique(harran_ppp)
#harran_ppp <- harran_ppp[!duplicated(harran_ppp)]

plot(harran_ppp)
```

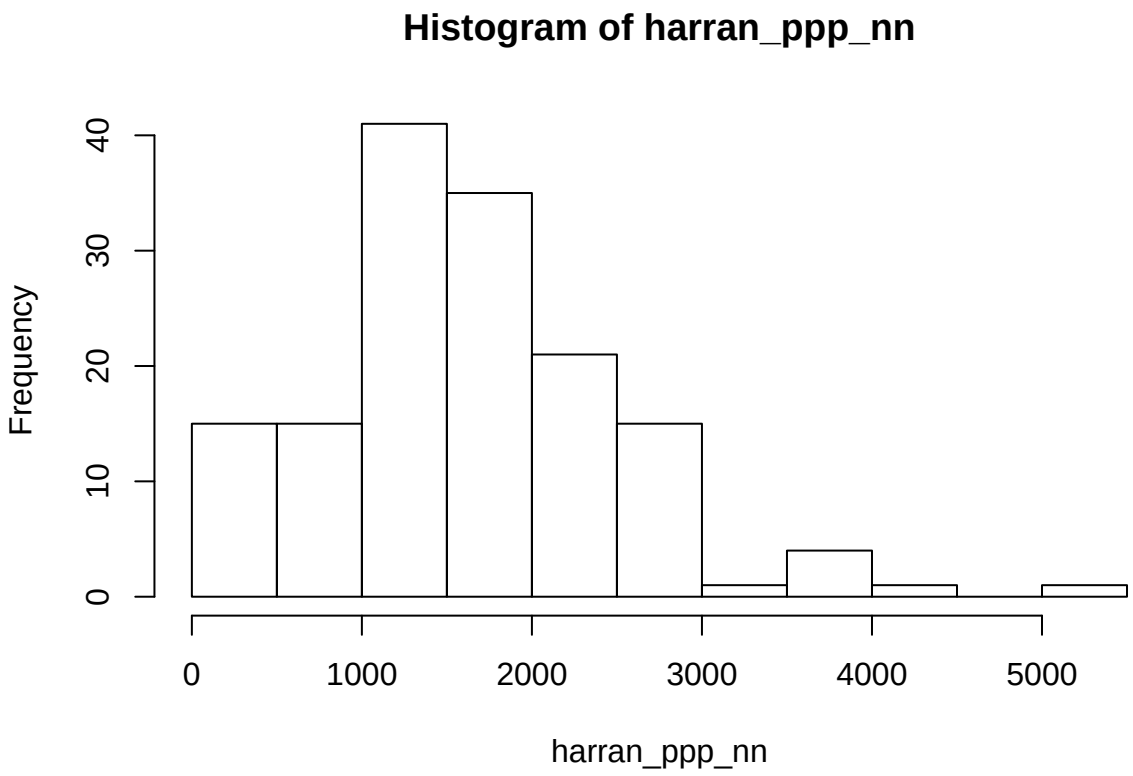


Nearest neighbour distance

```
harran_ppp_nn <- nndist(harran_ppp)
str(harran_ppp_nn) # shows distance within the structure(str)
```

```
##  num [1:149] 1896 868 5436 1149 1772 ...
```

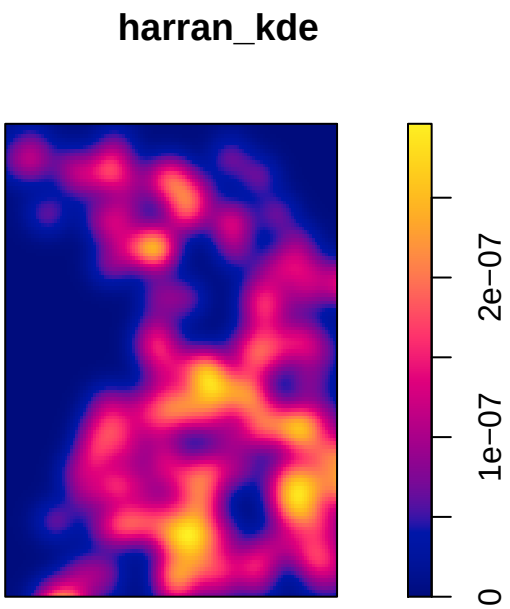
```
hist(harran_ppp_nn)  # plots the nearest neighbour
```




```
#barplot(sort(harran_ppp_nn))
```

challenge: create a kernel density estimation

```
harran_kde <- density.ppp(harran_ppp,sigma = mean(harran_ppp_nn))# see: likelihood cross validation ban
plot(harran_kde)
```



raster

```
library(raster)
```

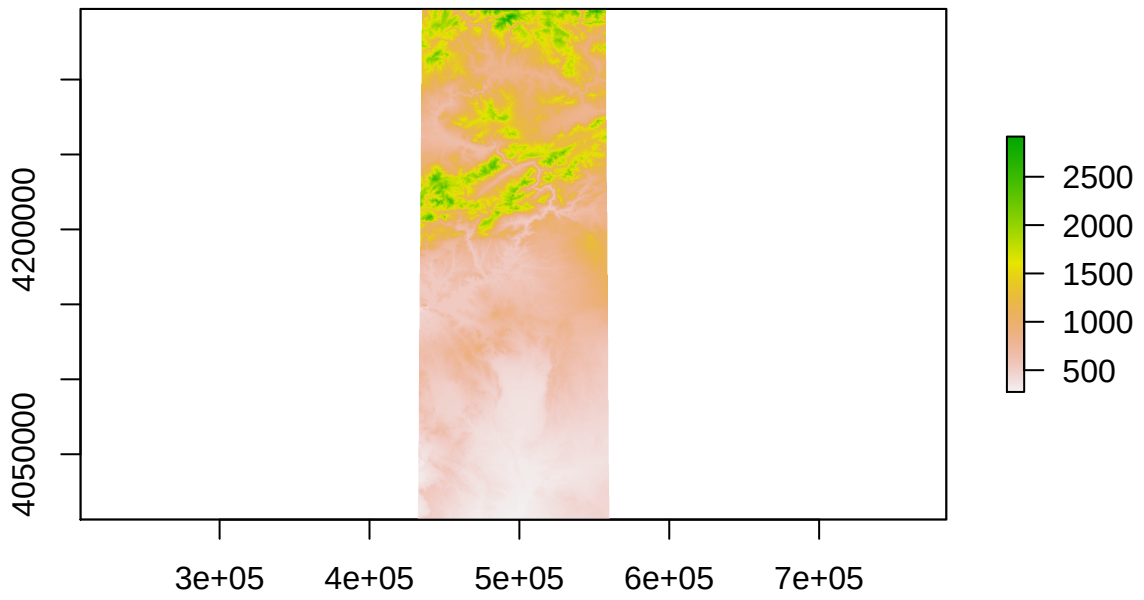
```
## Warning: package 'raster' was built under R version 3.3.3
```

```
##
## Attaching package: 'raster'
```

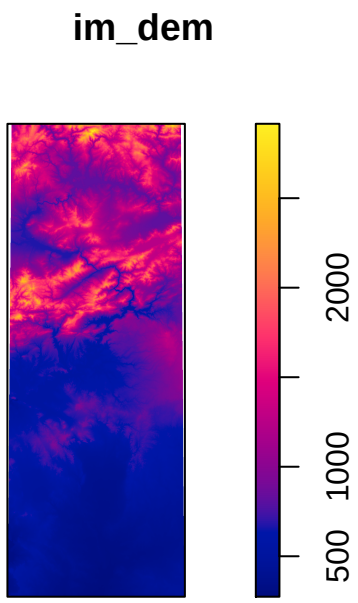
```
## The following objects are masked from 'package:spatstat':
##
##     area, rotate, shift
```

```
## The following object is masked from 'package:nlme':
##
##     getData
```

```
dem <- raster("../data/dem.tif") # see above for problems when knitting

# or: library(rgdal)
#dem <- readGDAL("data/dem.tif")
plot(dem)
```

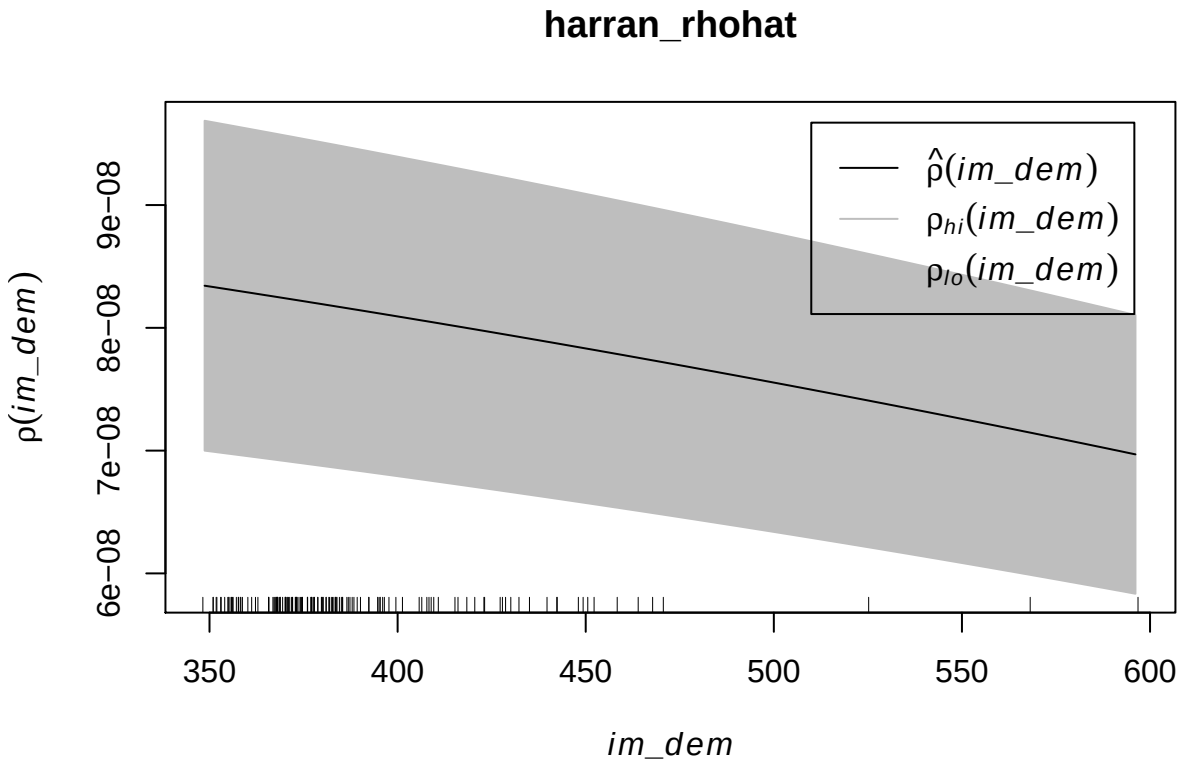



```
im_dem <- as.im(as.image.SpatialGridDataFrame(as(dem,"SpatialGridDataFrame"))) #creates image
plot(im_dem)
```

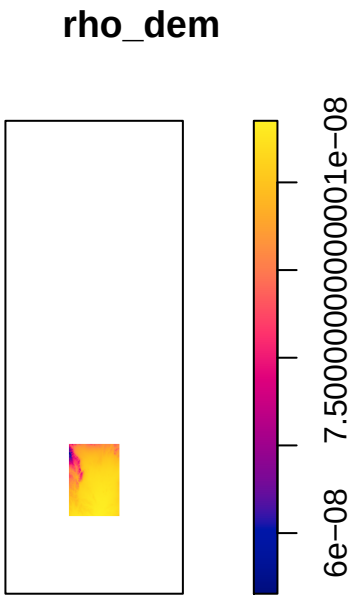


challenge: use rhohat and create a plot

```
#?rhohat # smoothing estimate: changes the raster
harran_rhohat <- rhohat(harran_ppp,im_dem,bw = 200)
              # <- rhohat(harran_ppp, im_dem, bw=200) /gives a more distinct picture

plot(harran_rhohat) #x=elevation y=relative intensity of points -> relation of elevation to pointdensit
```



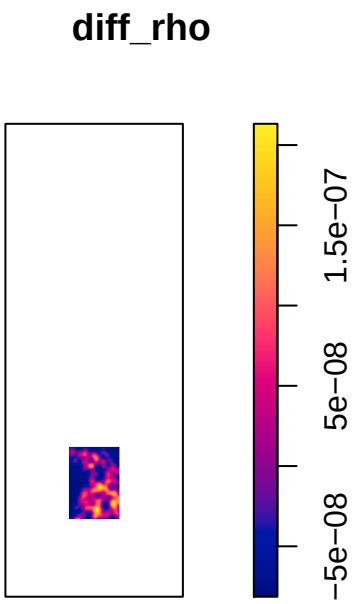

```
rho_dem <- predict(harran_rhohat)
plot(rho_dem)
```




```
diff_rho <- harran_kde-rho_dem
```

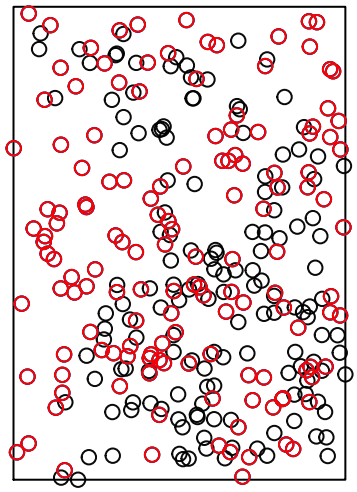
```
## Warning: the images 'e1' and 'e2' were not compatible
```

```
plot(diff_rho)
```



challenge: test poisson, create random points with rpoispp function that have the same intensity like our points

```
set.seed(123)
harran_rpoispp2 <- rpoispp(lambda = harran_ppp$n/area.owin(harran_ppp$window),
                           win=harran_ppp$window)
set.seed(123)
harran_rpoispp3 <- rpoispp(intensity(harran_ppp),win=Window(harran_ppp))
set.seed(123)
harran_rpoispp4 <- rpoispp(ex = harran_ppp)

plot(harran_ppp)
points(harran_rpoispp2,col="green")
points(harran_rpoispp3,col="blue")
points(harran_rpoispp4,col="red")
```




```
# first block is all the same, different ways to get the same result
```

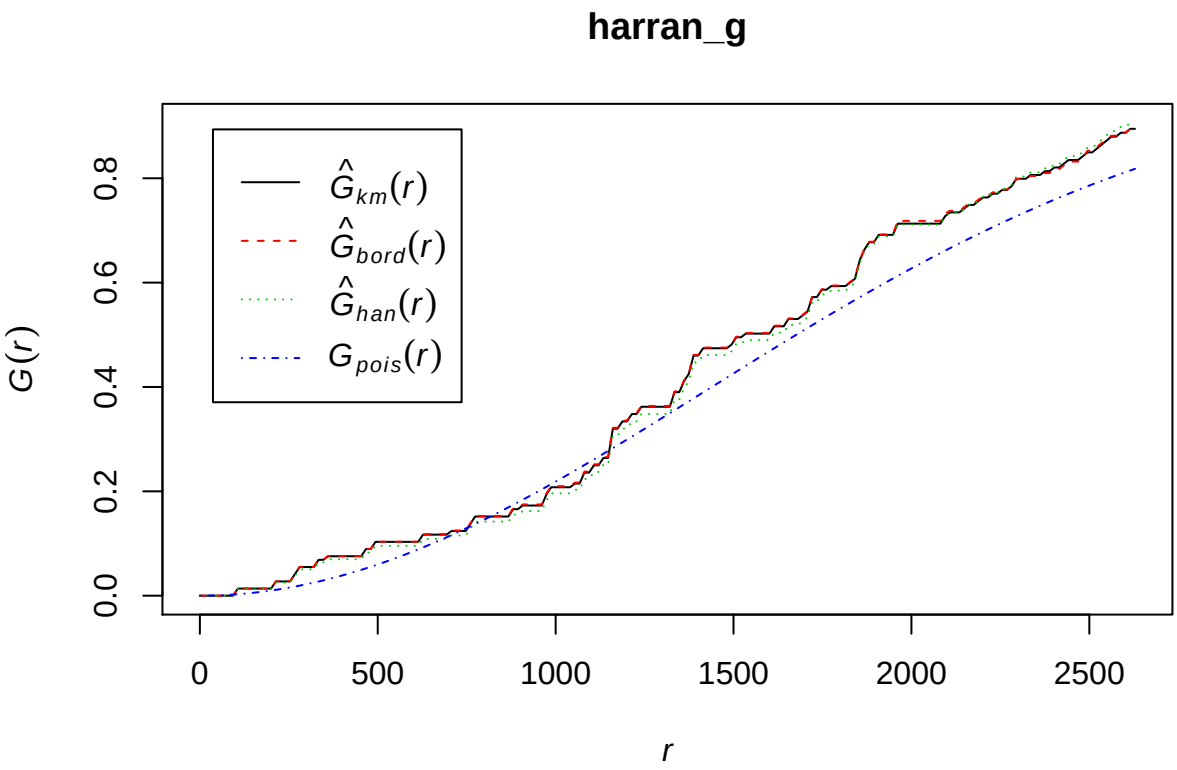
Second order effects

```
harran_g <- Gest(harran_ppp)
str(harran_g)
```

```
## Classes 'fv' and 'data.frame':   513 obs. of  7 variables:
##  $ r      : num  0 13.3 26.7 40 53.4 ...
##  $ theo   : num  0.00 4.39e-05 1.76e-04 3.95e-04 7.02e-04 ...
##  $ han    : num  0 0 0 0 0 ...
##  $ rs     : num  0 0 0 0 0 ...
##  $ km     : num  0 0 0 0 0 ...
##  $ hazard : num  0 0 0 0 0 ...
##  $ theohaz: num  0.00 6.58e-06 1.32e-05 1.97e-05 2.63e-05 ...
##  - attr(*, "argu")= chr "r"
##  - attr(*, "valu")= chr "km"
##  - attr(*, "ylab")= language G(r)
##  - attr(*, "yexp")= language G(r)
##  - attr(*, "fmla")= chr ".~r"
##  - attr(*, "alim")= num  0 2628
##  - attr(*, "labl")= chr  "r" "%s[pois](r)" "hat(%s)[han](r)" "hat(%s)[bord](r)" ...
##  - attr(*, "desc")= chr  "distance argument r" "theoretical Poisson %s" "Hanisch estimate of %s" "bo
##  - attr(*, "units")=List of 3
```

```
##   ..$ singular  : chr "unit"
##   ..$ plural    : chr "units"
##   ..$ multiplier: num 1
##   ..- attr(*, "class")= chr "units"
##  - attr(*, "fname")= chr "G"
##  - attr(*, "dotnames")= chr  "km" "rs" "han" "theo"
```

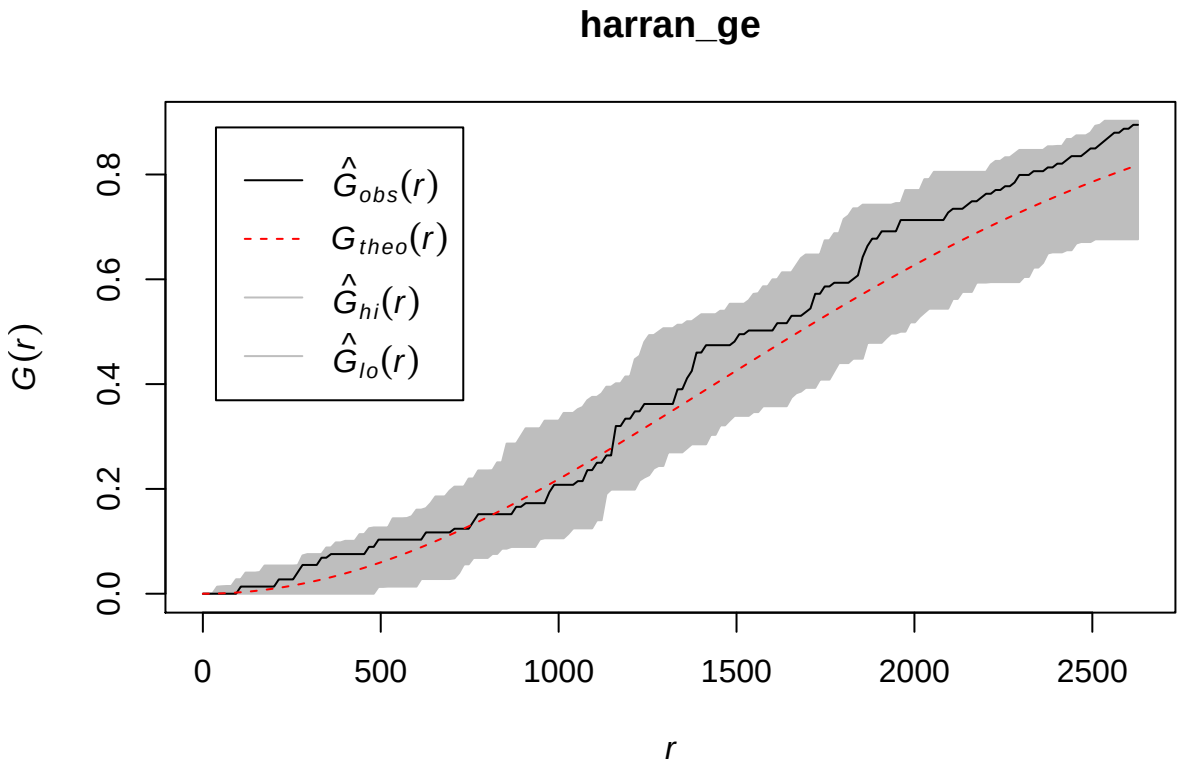
```
plot(harran_g) # x=closest neighbours expected (blue), the rest shows higher than expected clusters y=
```




```
harran_ge <- envelope(harran_ppp,fun = "Gest") # calculates g function for random points
```

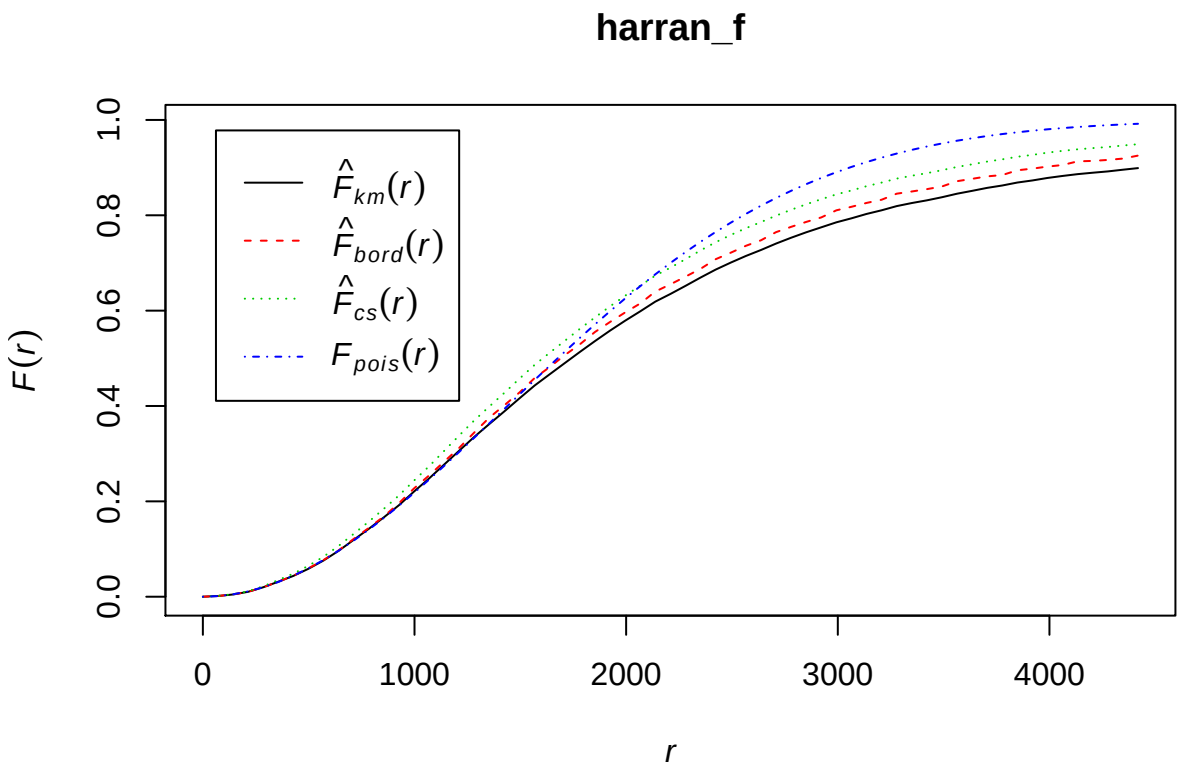
```
## Generating 99 simulations of CSR  ...
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28
## 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 6
## 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98,  99.
##
## Done.
```

```
plot(harran_ge) # grey shadow_ monte Carlo Simulation
```



challenge: do F and K Function

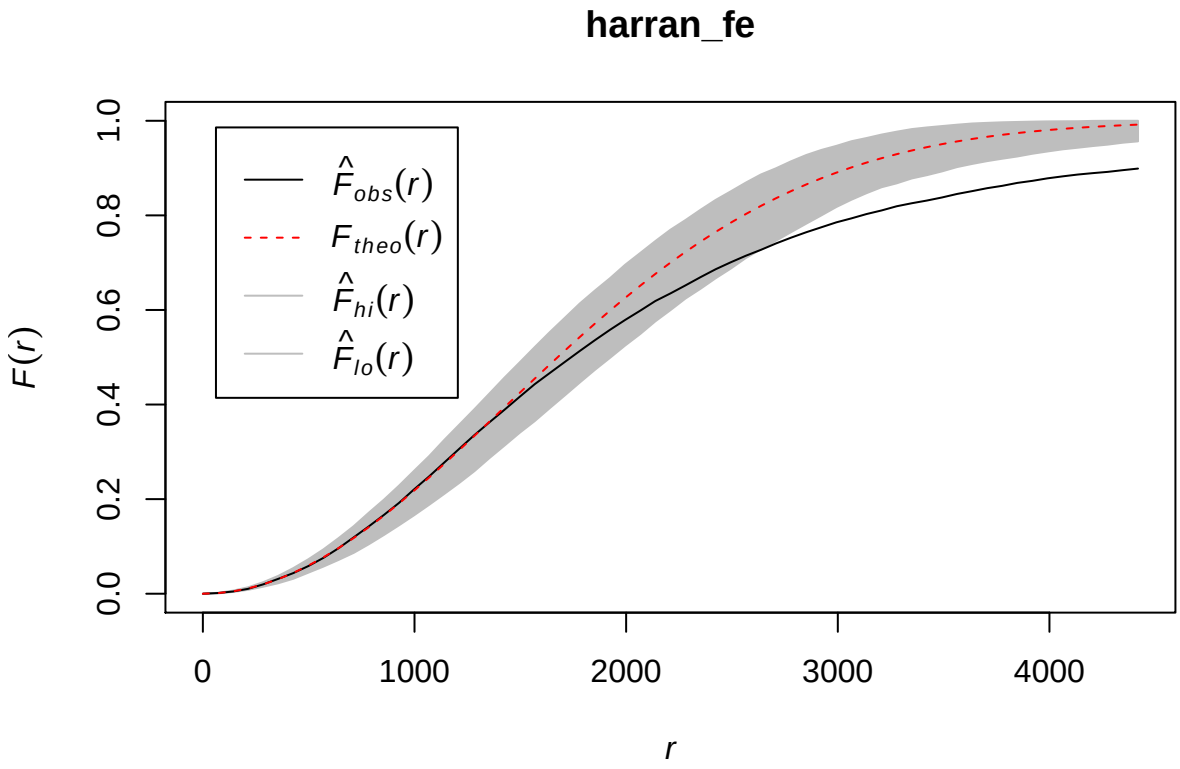
```
#F-function:

harran_f <- Fest(harran_ppp)
plot(harran_f)
```



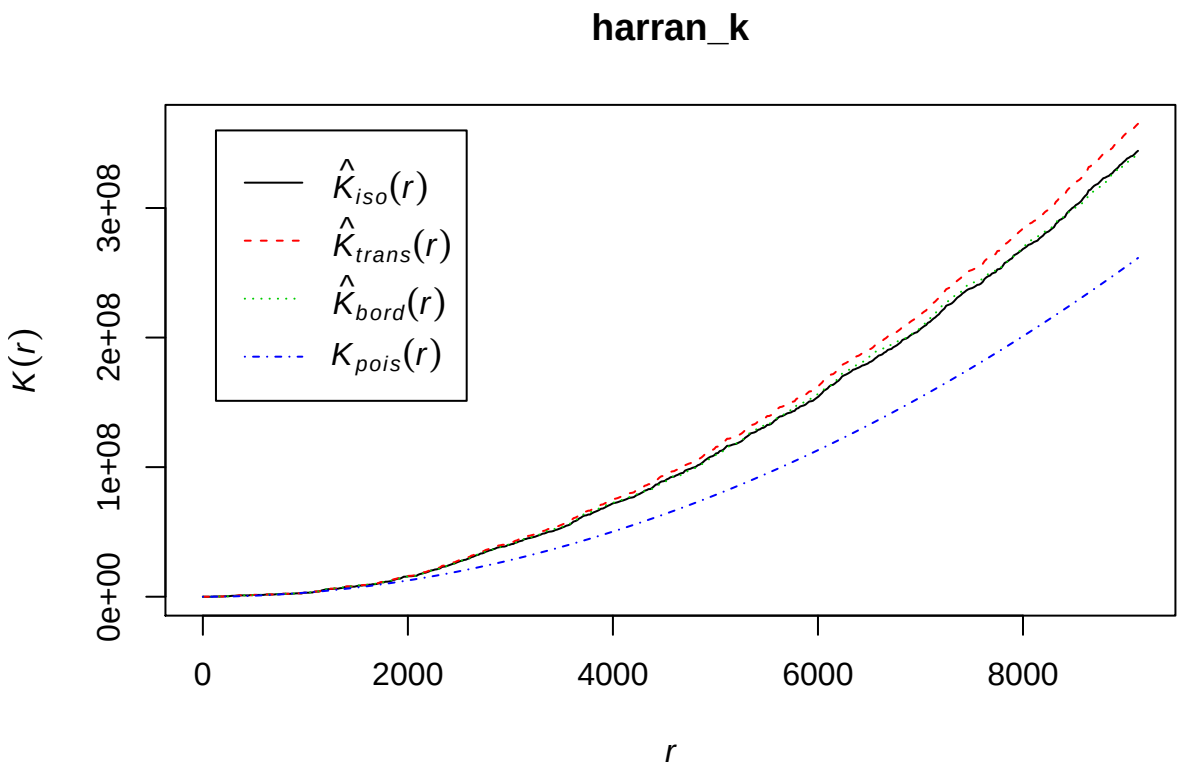

```
harran_fe <- envelope(harran_ppp,fun = "Fest") # calculates f function for random points
```

```
## 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
## 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, 6
## 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98,  99.
##
## Done.
```

```
plot(harran_fe)
```



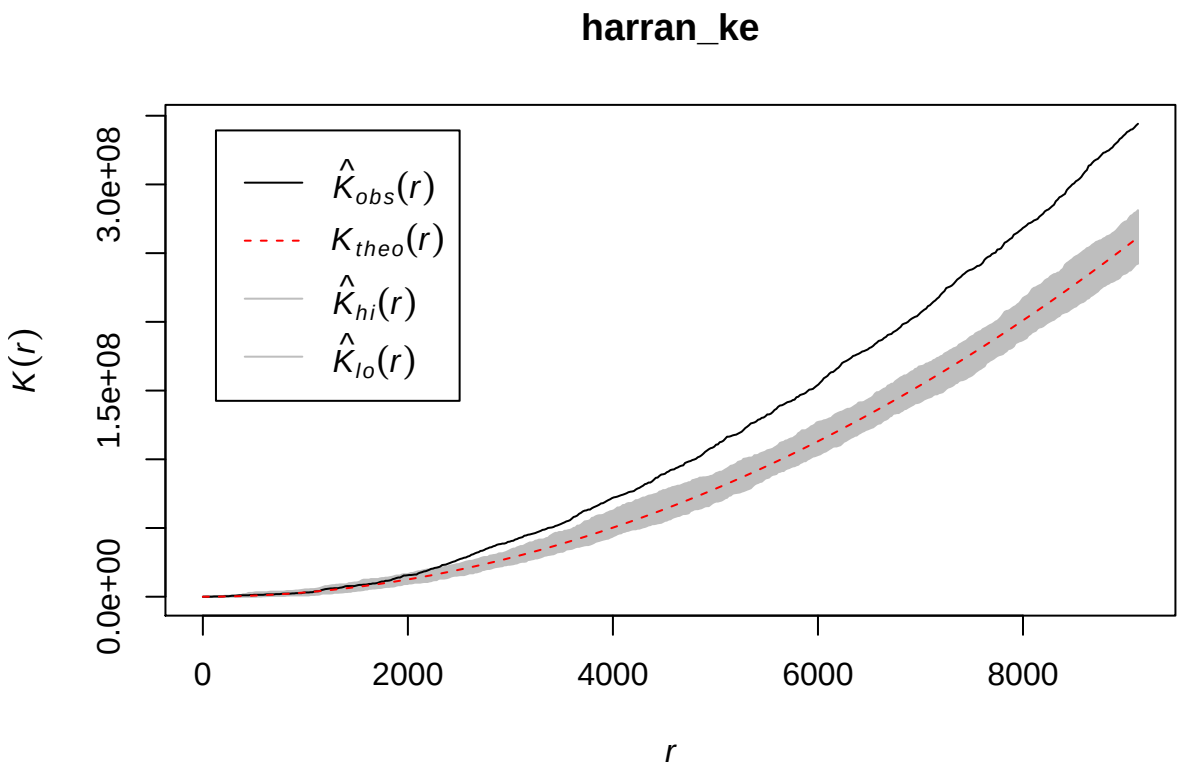

```
## red: expected, black deviates -> expect that the empty spaces are smaller than expected = clustered


#K-function

harran_k <- Kest(harran_ppp)
plot(harran_k)
```




```
harran_ke <- envelope(harran_ppp,fun = "Kest")
```

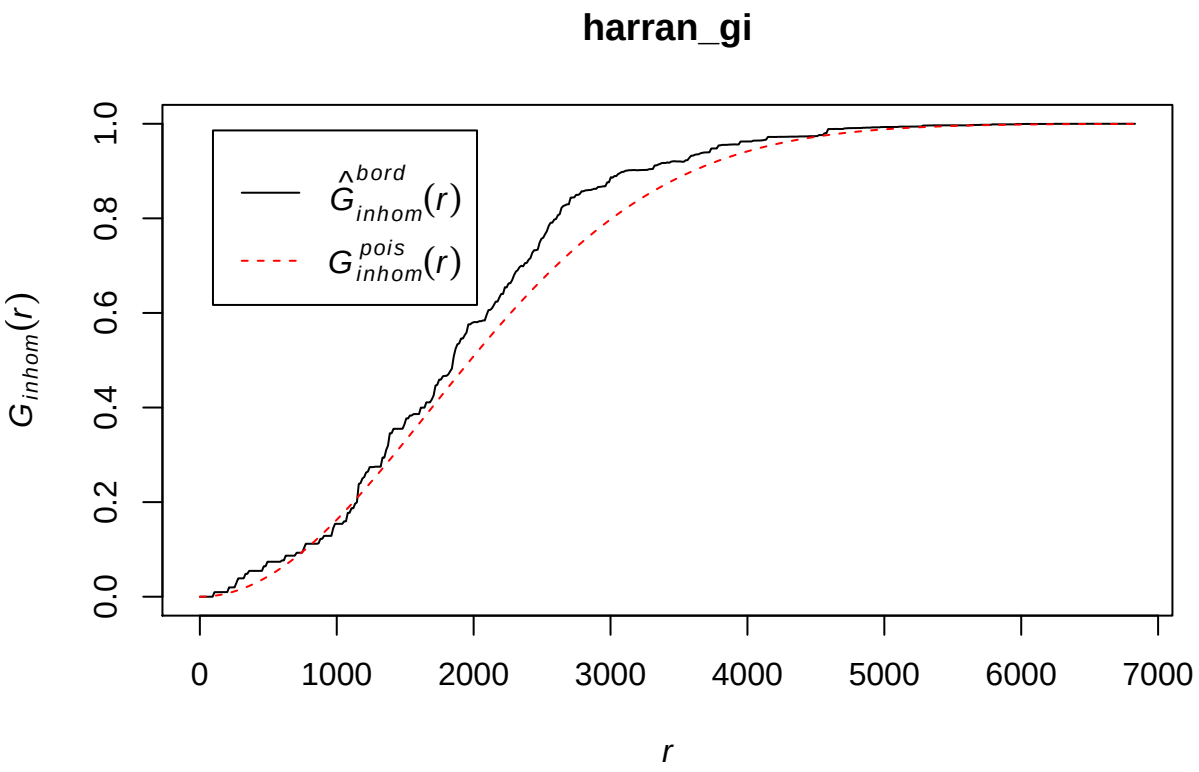
```
## Generating 99 simulations of CSR  ...
## 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28
## 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 6
## 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98,  99.
##
## Done.
```

```
plot(harran_ke)
```

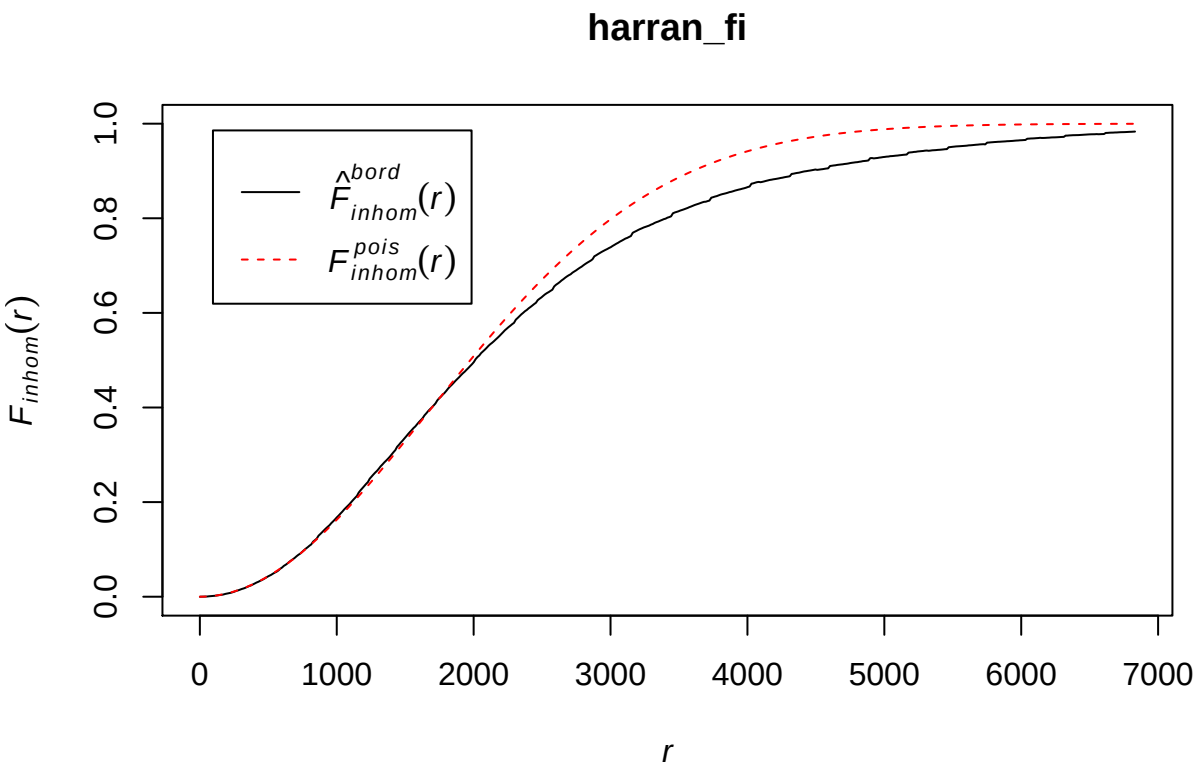


Inhomogeneous Poissonfunction G/F/K

```
harran_gi <- Ginhom(harran_ppp,lambda = predict(harran_rhohat)) # harran_rhohat needs an bandwidth of 2
plot(harran_gi)
```




```
harran_fi <- Finhom(harran_ppp,lambda = predict(harran_rhohat))
plot(harran_fi)
```




```
#par(mfrow = c(1,2))
#plot(harran_gi, xlim = c(0,6000))
#plot(harran_g, xlim = c(0,6000))      Gegenüberstellung
```

Note that the `echo = FALSE` parameter is added to the code chunk to prevent printing of the R code that generated the plot.