Single-catch SCR with Times

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Summary

Simulations to check the veracity of the new MLE Ben and I came up with.

The negative log-likelihood

```
negll = function(pars,adists,meshdists,capthist,surveyT) {
  nocc = dim(capthist)[3]
  ntraps = dim(capthist)[2]
  n = dim(capthist)[1]
  for(j in 1:nocc) {

  }
}
```

Simulations

Let $\mathbf{s} = (x, y)$ be a generic activity centre location, and $\lambda(d) = \lambda_0 \frac{-d^2}{2\sigma^2} = \lambda_0 \frac{-(x^2+y^2)}{2\sigma^2}$ be the hazard function evaluated at distance $d = \sqrt{x^2 + y^2}$ from the activity centre, where λ_0 and σ are the hazard function parameters.

We have N activity centres, in a region of area A that includes the trap array at its centre.

We assume that the times to detection of animal i at trap k is an exponential random variable with expectation $\lambda(d_{ik})^{-1}$, where d_{ik} is the distanse from i's activity centre (AC) to trap k.

Set up simulation sceanrio and parameters:

```
library(secr)

sigma <- 0.5
s2 = sigma^2
l0 = lambda <- 6

traps <- expand.grid(x = 1:5,y = 1:5)
buffer = 3*sigma
xlim <- range(traps[,1]) + c(-buffer, buffer)
ylim <- range(traps[,2]) + c(-buffer, buffer)
a = 0.25^2
mask <- expand.grid(x = seq(xlim[1], xlim[2], sqrt(a)), y = seq(ylim[1], ylim[2], sqrt(a))  )
nmask <- nrow(mask)
J <- nrow(traps)
```

```r
# Turn traps and mask into secr objects because the function I have for covariance
# assumes that they are. Should no doubt change this in due course ...
simtraps = read.traps(data=traps, type="proximity")

trapdists = edist(simtraps,simtraps) # distance between traps

area <- nrow(mask) * a
targetD = 0.5
D = round(targetD*area)/area # to get integer N
N = D*area

surveyT = 1 # duration of each survey occasion

noccasions = 4 # number of survey occasion

pars = log(c(D=D, lambda0=lambda, sigmasq=sigma^2))
```

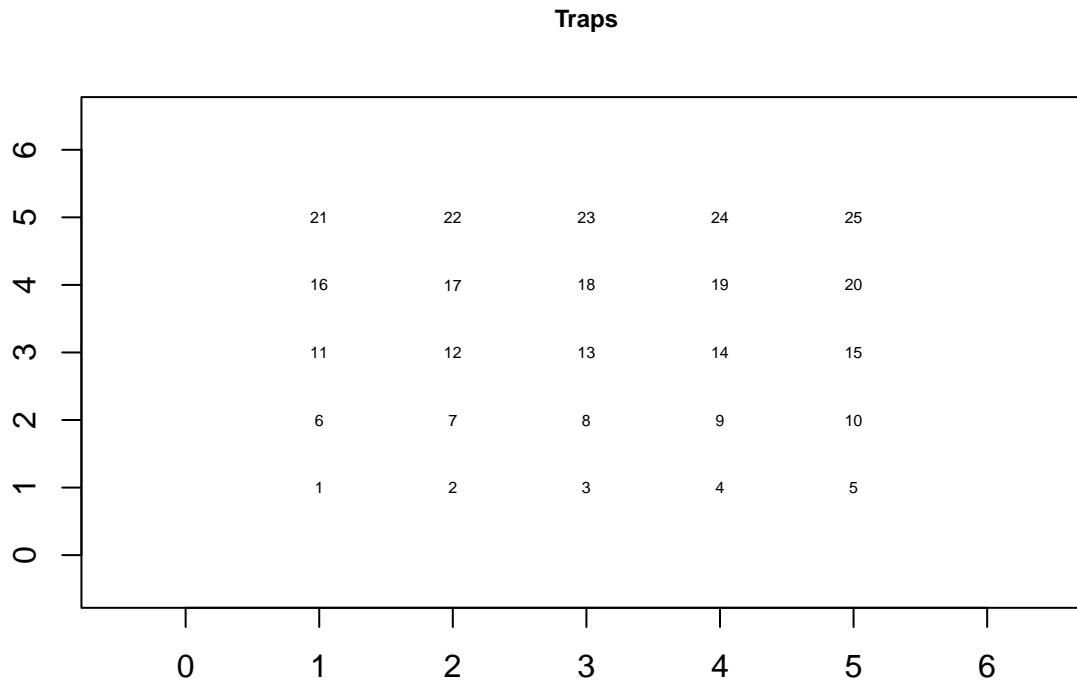So the key parameter values are as follows:

- $\sigma = 0.5$
- $\lambda0 = 6$
- $A = 52.5625$
- $N = 26$
- buffer $= 1.5$

Let's take a look at the traps:

```r
ntraps = dim(traps)[1]
trapno = 1:ntraps
plot(simtraps$x,simtraps$y,col=0,
     xlim=c(min(simtraps$x)-buffer,max(simtraps$x)+buffer),
     ylim=c(min(simtraps$y)-buffer,max(simtraps$y)+buffer),
     xlab="",ylab="",main="Traps",cex.main=0.75)
text(simtraps$x,simtraps$y,labels=trapno,cex=0.5)
```

Traps

Now try simulate a survey in which N is fixed and initial locations are random but then remain fixed for repeat survey occasions.

Simulate surveys and keep counts in a list of length 4, with each element being an array of dimension (26 x 25).

```
set.seed(123)
# Do survey
  # Simulate animal locations once:
  locs <- cbind(x = runif(N, xlim[1], xlim[2]),
                y = runif(N, ylim[1], ylim[2])) # animal locations
  # Simulate noccasions sets of capture times from these locations
  capthist = simSCR.fixedN.single(locs, sigma, lambda, noccasions=noccasions, traps, surveyT=1)
```

Plot animals and traps, showing which were detected

```
caught.by.occasion = apply(capthist,c(1,3),sum)>0 # logical array indicating which animals (row)
                                                  # were caught on each occasion (column)
caught.animals = as.integer(row.names(capthist)) # population number of detected animals
par(mfrow=c(2,2))
for(occ in 1:noccasions) {
  trapind = which(capthist[caught.by.occasion[,occ],,occ]>0,arr.ind = TRUE)
  trapind = trapind[order(trapind[,1]),]
  plot(simtraps$x,simtraps$y,col=0,
       xlim=c(min(simtraps$x)-buffer,max(simtraps$x)+buffer),
       ylim=c(min(simtraps$y)-buffer,max(simtraps$y)+buffer),
     xlab="",ylab="",main=paste("Occasion",occ),cex.main=0.75)
  text(simtraps$x,simtraps$y,labels=trapno,cex=0.5)
  text(locs[,1],locs[,2],labels=1:N,cex=0.5,col="red") # plot all animals
  points(locs[caught.animals,1][caught.by.occasion[,occ]], # plot animals caught on the occasion
         locs[caught.animals,2][caught.by.occasion[,occ]],col="red",cex=1.5)
  text(simtraps$x,simtraps$y,labels=trapno,cex=0.5)
  segments(locs[caught.animals,1][caught.by.occasion[,occ]],
           locs[caught.animals,2][caught.by.occasion[,occ]],
```
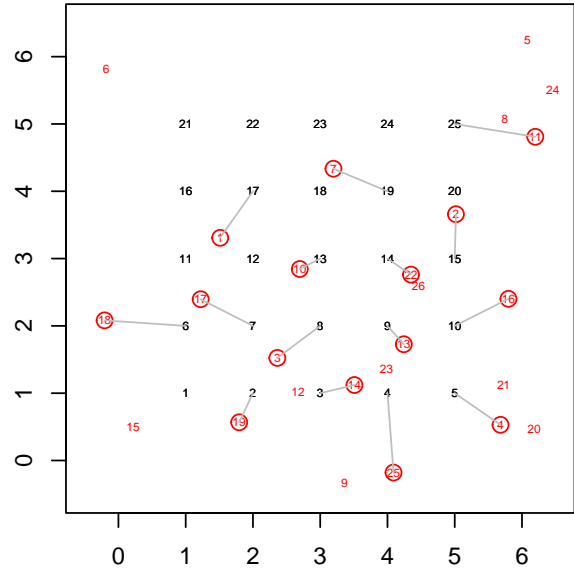
```
        simtraps$x[trapind[,2]], simtraps$y[trapind[,2]],
        col="gray")
}
```
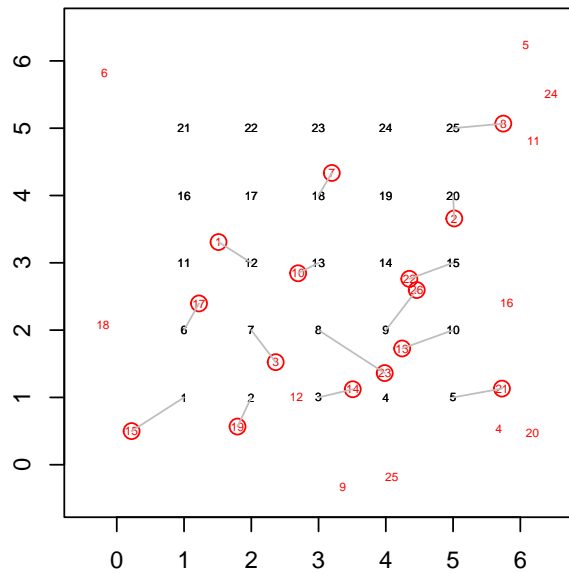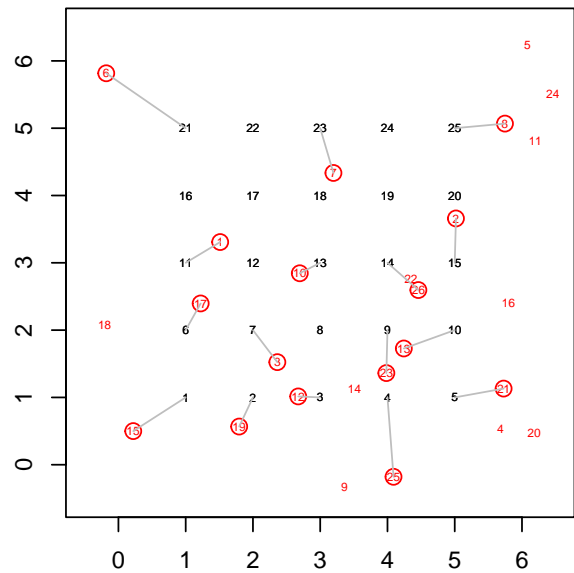
Occasion 1
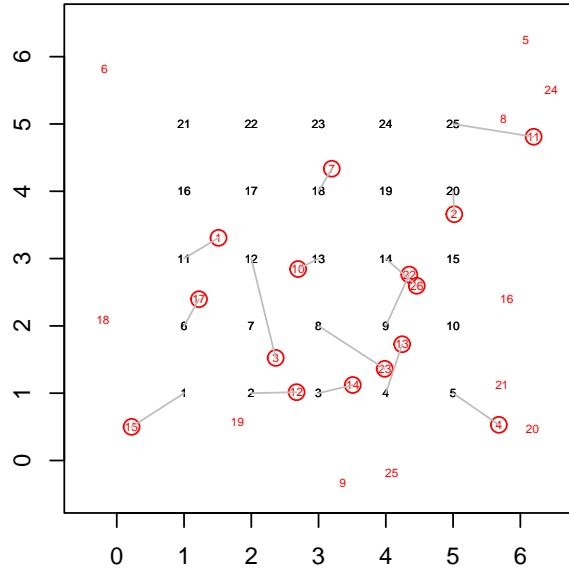
Occasion 2

Occasion 3

Occasion 4

Here are the first 10 rows of the capture history array:

```
capthist[1:10,,]
```

```
## , , occasion = 1
##
```

```
##        trap
## animal 1          2 3 4          5 6 7 8 9 10         11         12         13 14
##      1  0 0.0000000 0 0 0.0000000 0 0 0 0  0 0.3854102 0.00000000 0.0000000  0
##      2  0 0.0000000 0 0 0.0000000 0 0 0 0  0 0.0000000 0.00000000 0.0000000  0
##      3  0 0.0000000 0 0 0.0000000 0 0 0 0  0 0.0000000 0.07777848 0.0000000  0
##      4  0 0.0000000 0 0 0.1237626 0 0 0 0  0 0.0000000 0.00000000 0.0000000  0
##      6  0 0.0000000 0 0 0.0000000 0 0 0 0  0 0.0000000 0.00000000 0.0000000  0
##      7  0 0.0000000 0 0 0.0000000 0 0 0 0  0 0.0000000 0.00000000 0.0000000  0
##      8  0 0.0000000 0 0 0.0000000 0 0 0 0  0 0.0000000 0.00000000 0.0000000  0
##      10 0 0.0000000 0 0 0.0000000 0 0 0 0  0 0.0000000 0.00000000 0.3328487  0
##      11 0 0.0000000 0 0 0.0000000 0 0 0 0  0 0.0000000 0.00000000 0.0000000  0
##      12 0 0.1279426 0 0 0.0000000 0 0 0 0  0 0.0000000 0.00000000 0.0000000  0
##        trap
## animal 15 16 17          18 19         20 21 22 23 24          25
##      1   0  0  0 0.000000000  0 0.0000000  0  0  0  0 0.00000000
##      2   0  0  0 0.000000000  0 0.3202023  0  0  0  0 0.00000000
##      3   0  0  0 0.000000000  0 0.0000000  0  0  0  0 0.00000000
##      4   0  0  0 0.000000000  0 0.0000000  0  0  0  0 0.00000000
##      6   0  0  0 0.000000000  0 0.0000000  0  0  0  0 0.00000000
##      7   0  0  0 0.005448115  0 0.0000000  0  0  0  0 0.00000000
##      8   0  0  0 0.000000000  0 0.0000000  0  0  0  0 0.00000000
##      10  0  0  0 0.000000000  0 0.0000000  0  0  0  0 0.00000000
##      11  0  0  0 0.000000000  0 0.0000000  0  0  0  0 0.05591646
##      12  0  0  0 0.000000000  0 0.0000000  0  0  0  0 0.00000000
##
## , , occasion = 2
##
##        trap
## animal 1 2 3 4          5 6 7          8 9 10 11 12         13 14         15 16
##      1  0 0 0 0 0.00000000 0 0 0.0000000 0  0  0  0 0.0000000  0 0.00000000  0
##      2  0 0 0 0 0.00000000 0 0 0.0000000 0  0  0  0 0.0000000  0 0.03719521  0
##      3  0 0 0 0 0.00000000 0 0 0.3568431 0  0  0  0 0.0000000  0 0.00000000  0
##      4  0 0 0 0 0.08884548 0 0 0.0000000 0  0  0  0 0.0000000  0 0.00000000  0
##      6  0 0 0 0 0.00000000 0 0 0.0000000 0  0  0  0 0.0000000  0 0.00000000  0
##      7  0 0 0 0 0.00000000 0 0 0.0000000 0  0  0  0 0.0000000  0 0.00000000  0
##      8  0 0 0 0 0.00000000 0 0 0.0000000 0  0  0  0 0.0000000  0 0.00000000  0
##      10 0 0 0 0 0.00000000 0 0 0.0000000 0  0  0  0 0.4033898  0 0.00000000  0
##      11 0 0 0 0 0.00000000 0 0 0.0000000 0  0  0  0 0.0000000  0 0.00000000  0
##      12 0 0 0 0 0.00000000 0 0 0.0000000 0  0  0  0 0.0000000  0 0.00000000  0
##        trap
## animal       17 18         19 20 21 22 23 24         25
##      1  0.178981  0 0.00000000  0  0  0  0  0 0.0000000
##      2  0.000000  0 0.00000000  0  0  0  0  0 0.0000000
##      3  0.000000  0 0.00000000  0  0  0  0  0 0.0000000
##      4  0.000000  0 0.00000000  0  0  0  0  0 0.0000000
##      6  0.000000  0 0.00000000  0  0  0  0  0 0.0000000
##      7  0.000000  0 0.00989587  0  0  0  0  0 0.0000000
##      8  0.000000  0 0.00000000  0  0  0  0  0 0.0000000
##      10 0.000000  0 0.00000000  0  0  0  0  0 0.0000000
##      11 0.000000  0 0.00000000  0  0  0  0  0 0.8252798
##      12 0.000000  0 0.00000000  0  0  0  0  0 0.0000000
##
## , , occasion = 3
##
```

```
##        trap
## animal 1 2 3 4 5 6          7 8 9 10 11         12          13 14 15 16 17
##     1  0 0 0 0 0 0 0.00000000 0 0  0  0 0.04149141 0.00000000  0  0  0  0  0
##     2  0 0 0 0 0 0 0.00000000 0 0  0  0 0.00000000 0.00000000  0  0  0  0  0
##     3  0 0 0 0 0 0 0.07697679 0 0  0  0 0.00000000 0.00000000  0  0  0  0  0
##     4  0 0 0 0 0 0 0.00000000 0 0  0  0 0.00000000 0.00000000  0  0  0  0  0
##     6  0 0 0 0 0 0 0.00000000 0 0  0  0 0.00000000 0.00000000  0  0  0  0  0
##     7  0 0 0 0 0 0 0.00000000 0 0  0  0 0.00000000 0.00000000  0  0  0  0  0
##     8  0 0 0 0 0 0 0.00000000 0 0  0  0 0.00000000 0.00000000  0  0  0  0  0
##    10  0 0 0 0 0 0 0.00000000 0 0  0  0 0.00000000 0.06920897  0  0  0  0  0
##    11  0 0 0 0 0 0 0.00000000 0 0  0  0 0.00000000 0.00000000  0  0  0  0  0
##    12  0 0 0 0 0 0 0.00000000 0 0  0  0 0.00000000 0.00000000  0  0  0  0  0
##        trap
## animal         18 19         20 21 22 23 24         25
##     1  0.00000000  0 0.00000000  0  0  0  0 0.0000000
##     2  0.00000000  0 0.01624583  0  0  0  0 0.0000000
##     3  0.00000000  0 0.00000000  0  0  0  0 0.0000000
##     4  0.00000000  0 0.00000000  0  0  0  0 0.0000000
##     6  0.00000000  0 0.00000000  0  0  0  0 0.0000000
##     7  0.03273363  0 0.00000000  0  0  0  0 0.0000000
##     8  0.00000000  0 0.00000000  0  0  0  0 0.4252925
##    10  0.00000000  0 0.00000000  0  0  0  0 0.0000000
##    11  0.00000000  0 0.00000000  0  0  0  0 0.0000000
##    12  0.00000000  0 0.00000000  0  0  0  0 0.0000000
##
## , , occasion = 4
##
##        trap
## animal 1 2          3 4 5 6          7 8 9 10         11 12         13 14
##     1  0 0 0.00000000 0 0 0 0.00000000 0 0  0 0.01676642  0 0.00000000  0
##     2  0 0 0.00000000 0 0 0 0.00000000 0 0  0 0.00000000  0 0.00000000  0
##     3  0 0 0.00000000 0 0 0 0.03832387 0 0  0 0.00000000  0 0.00000000  0
##     4  0 0 0.00000000 0 0 0 0.00000000 0 0  0 0.00000000  0 0.00000000  0
##     6  0 0 0.00000000 0 0 0 0.00000000 0 0  0 0.00000000  0 0.00000000  0
##     7  0 0 0.00000000 0 0 0 0.00000000 0 0  0 0.00000000  0 0.00000000  0
##     8  0 0 0.00000000 0 0 0 0.00000000 0 0  0 0.00000000  0 0.00000000  0
##    10  0 0 0.00000000 0 0 0 0.00000000 0 0  0 0.00000000  0 0.02667168  0
##    11  0 0 0.00000000 0 0 0 0.00000000 0 0  0 0.00000000  0 0.00000000  0
##    12  0 0 0.08106376 0 0 0 0.00000000 0 0  0 0.00000000  0 0.00000000  0
##        trap
## animal         15 16 17 18 19 20         21 22         23 24         25
##     1  0.00000000  0  0  0  0  0 0.0000000  0 0.00000000  0 0.0000000
##     2  0.02763538  0  0  0  0  0 0.0000000  0 0.00000000  0 0.0000000
##     3  0.00000000  0  0  0  0  0 0.0000000  0 0.00000000  0 0.0000000
##     4  0.00000000  0  0  0  0  0 0.0000000  0 0.00000000  0 0.0000000
##     6  0.00000000  0  0  0  0  0 0.4492321  0 0.00000000  0 0.0000000
##     7  0.00000000  0  0  0  0  0 0.0000000  0 0.01671657  0 0.0000000
##     8  0.00000000  0  0  0  0  0 0.0000000  0 0.00000000  0 0.6019012
##    10  0.00000000  0  0  0  0  0 0.0000000  0 0.00000000  0 0.0000000
##    11  0.00000000  0  0  0  0  0 0.0000000  0 0.00000000  0 0.0000000
##    12  0.00000000  0  0  0  0  0 0.0000000  0 0.00000000  0 0.0000000
```