Simple SCR exercises

The code in the file `scr-ll.r` creates a log-likelihood function, loads some example data, and fits the 'binary proximity model' described by Efford et al. (2009). The model makes the following assumptions:

- The number of animals' activity centres in the survey region is a Poisson random variable, with expectation equal to animal density, D, multiplied by the area of the survey region.
- The activity centre locations are independent, and are uniformly distributed across the survey region.
- The probability that a detector detects an individual is given by the halfnormal detection function,

$$g(d) = g_0 \exp\left(\frac{-d^2}{2\sigma^2}\right),$$

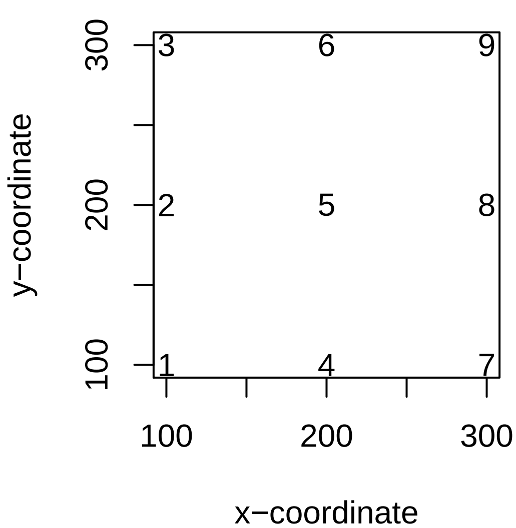
where d is the distance between the animal's activity centre and the detector.

Run the code in `scr-ll.r` and answer the following questions.

General questions

1. Create a plot of the detector locations. Their coodinates can be found in `test.data$traps`.

```
par(mar = c(4, 4, 0, 0), oma = rep(1, 4))
plot(test.data$traps, asp = 1, pch = as.character(1:9),
     xlab = "x-coordinate", ylab = "y-coordinate")
```



We have a three-by-three grid of detectors with a spacing of 100 m between them.

2. Inspect the capture histories in `test.data$bin.capt`. Describe what the first two rows represent.

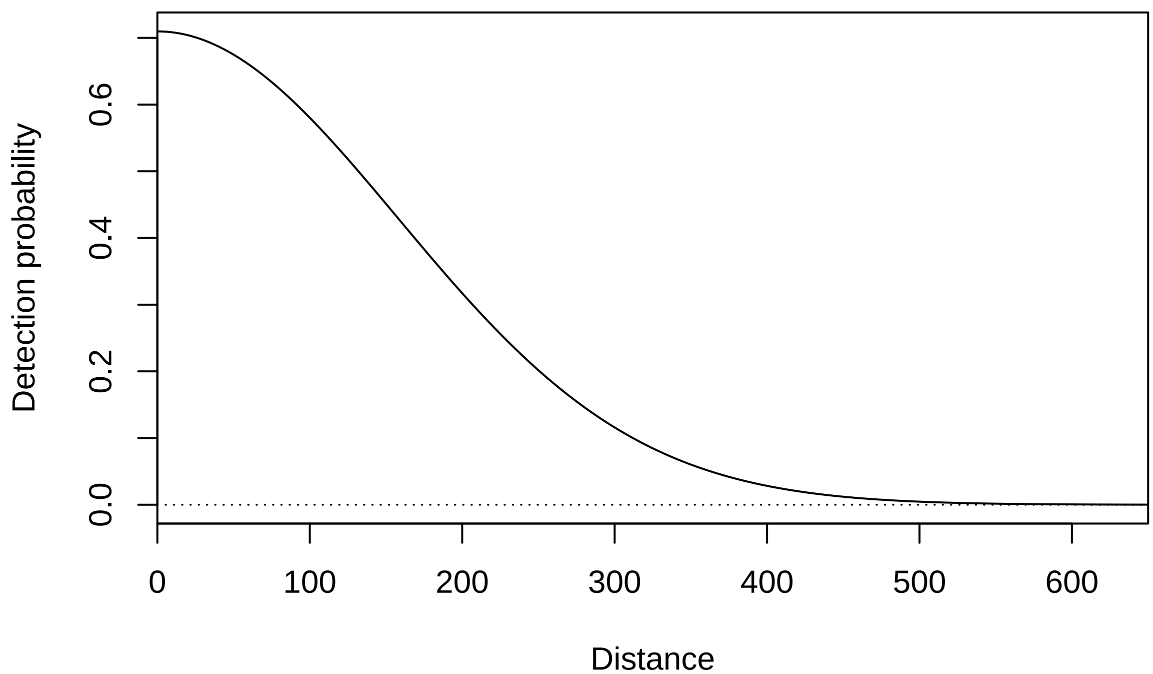
```
head(test.data$bin.capt, 2)
```

```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9]
## [1,]    1    0    0    0    1    0    0    0    0
## [2,]    1    1    0    0    1    0    0    1    1
```

The first animal was detected by detectors 1 and 5 (bottom-left and middle). The second animal was detected by detectors 1, 2, 5, 8, and 9 (bottom-left, middle-left, middle, middle-right, and top-right).

3. The model has estimated animal density, D, and parameters of a halfnormal detection function, g_0 and σ. Create a plot of the detection function estimated by the model.

```
par(mar = c(4, 4, 0, 0), oma = rep(0.1, 4), xaxs = "i")
xx <- seq(0, 650, length.out = 1000)
g0 <- plogis(fit$par[2])
sigma <- exp(fit$par[3])
yy <- g0*exp(-xx^2/(2*sigma^2))
plot(xx, yy, type = "l", xlab = "Distance", ylab = "Detection probability")
abline(h = 0, lty = "dotted")
```



4. Tricky question for STATS 730 graduates only:

   (a) Compute standard errors for the transformed parameters, $\log(D)$, $\text{logit}(g_0)$, and $\log(\sigma)$. The `optim()` argument `hessian` will be useful.

```
hess <- optimHess(fit$par, scr.nll, capt = test.data$bin.capt,
                  traps = test.data$traps, mask = test.data$mask)
vcov.link <- solve(hess)
sqrt(diag(vcov.link))
```

```
## [1] 0.7539109 0.7682073 0.4346113
```

   (b) Compute standard errors for the parameters themselves, D, g_0, and σ.

   (c) Compute confidence intervals for the three parameters.

5. Write some R code that simulates capture histories from a spatial capture-recapture model under the following conditions:

   - The survey region is a square, with x-coordinate limits $(-500, 900)$ and y-coordinate limits also $(-500, 900)$. Note that these coordinates are given in metres.
   - Detectors are deployed on a three-by-three grid with a 100 m spacing between them, so that the columns are located at x-coordinates 100, 200, and 300, and the rows are located at y-coordinates 100, 200, and 300. Note that this is the configuration of the detectors in `test.data$traps`.
   - Animal density is $D = 0.75$ animals per hectare. Note that 1 hectare is $10\,000$ m^2.
   - Conditional on its activity centre location, an individual is detected by a detector with probability given by a halfnormal detection function with $g_0 = 0.9$ and $\sigma = 75$ m.

   For bonus points, write your R code as a function, allowing the user to set their own detector locations and parameter values.

6. Fit a spatial capture-recapture model to your simulated data. Note that you can use the detector locations in `test.data$traps` and the mask in `test.data$mask`. How close are your estimates to the true parameter values?

7. For STATS 730 graduates only: Compute confidence intervals for the three parameters. Did they capture the true parameter values?

8. Run a simulation study, repeating Questions 5–7 a total of 100 times. This involves simulating 100 sets of capture histories, and generating estimates from each. Inspect your 100 sets of estimates.

   (a) How close are the averages of your parameter estimates to the true parameter values?

   (b) For STATS 730 graduates only: How often do your confidence intervals capture the true parameter values?

Questions for `secr` users

9. Fit the same model from `secr-ll.r`, but using the `secr` package. Verify that you get the same parameter estimates. For STATS 730 graduates, also verify that you get the same standard errors. This will require some data reformatting.

Questions for `ascr` users

10. Fit the same model from `secr-ll.r`, but using the `ascr` package. Verify that you get the same parameter estimates. For STATS 730 graduates, also verify that you get the same standard errors.

References

Efford, M. G., Dawson, D. K., & Borchers, D. L. (2009). Population density estimated from locations of individuals on a passive detector array. *Ecology*, *90*, 2676–2682.