Example knitr document: estimating PI

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1 Introduction

This is an example document created using the knitr system http://yihui.name/knitr/. knitr is a tool for combining both documentation and R code within the same file, similar to Sweave. For this document, the master file is `estimatek.Rmd`. This is processed by knitr in R, which runs the R code to generate textual/graphical output, and also creates a HTML document. On recent machines, once bookdown, rmarkdown and knitr are installed, you should be able to generate the html using:

```
require(rmarkdown)
render('estimatek.Rnw')
```

Within RStudio, there is a handy "Knit HTML" button.

1.1 knitr setup

One useful facility in knitr is it has built-in support for caching. By default it is turned off in this document, but change FALSE to TRUE in the following code-chunk and see if you can work out what happens:

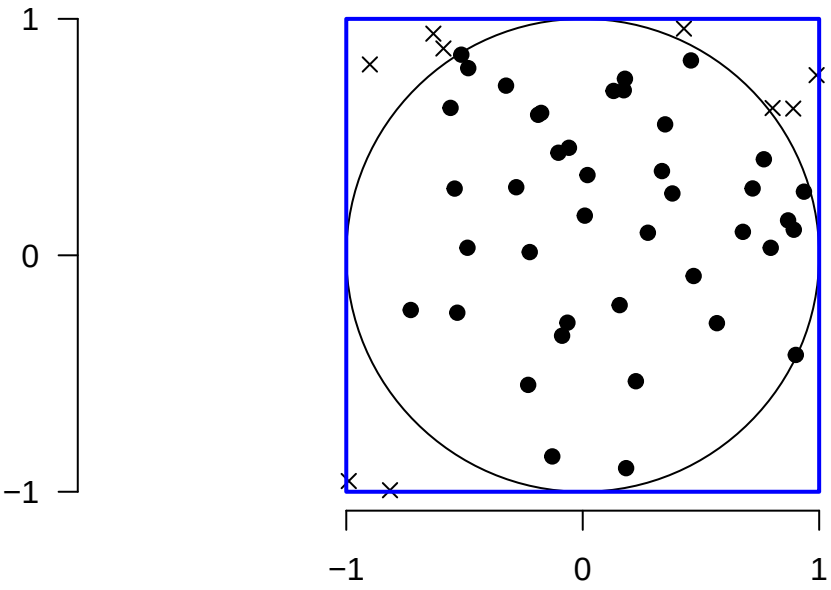
```
require(knitr)
## Loading required package: knitr
require(xtable)
## Loading required package: xtable
opts_chunk$set(cache=FALSE)      # $ (dollar needed by Emacs.)
```

2 Task: estimate the value of π

Our task is to estimate the value of π by simulating darts being thrown at a dartboard. Imagine that the person throwing the darts is not very good, and randomly throws each dart so that it falls uniformly within a square of side length $2r$, with the dartboard of radius r centred within that square. If the player throws n darts, and d of them hit the dartboard, then for large enough n, the ratio d/n should approximate the ratio of the area of the dartboard to the enclosing square, $\pi r^2/4r^2 \equiv \pi/4$. From this, we can estimate $\pi \approx 4d/n$.

We start with an example, using R to draw both the dartboard and the surrounding square, together with `n=50` darts. The radius of the dartboard here is 1 unit, although the value is not important.

```
r <- 1
n <- 50
par(las=1)
plot(NA, xlim=c(-r,r), ylim=c(-r,r), asp=1, bty='n',
     xaxt='n', yaxt='n', xlab='', ylab='')
axis(1, at=c(-r,0,r)); axis(2, at=c(-r,0,r))
symbols(x=0, y=0, circles=r, inch=F, add=T)
x <- runif(n, -r, r);  y <- runif(n, -r, r)
inside <- (x^2 + y^2) < r^2
d <- sum(inside)
points(x, y, pch=ifelse(inside, 19, 4))
rect(-r, -r, r, r, border='blue', lwd=2)
```



A dart is drawn as a filled circle if it falls within the dartboard, else it is drawn as a cross. In this case the number of darts within the circle is 41, and so the estimated value is $\pi \approx 3.28$.

The estimate of π should improve as we increase the number of darts thrown at the dartboard. To verify this, we write a short function that, given the number of darts to throw, n, returns an estimate of π.

```
estimate.pi <- function(n=1000) {
  ## Return an estimate of PI using dartboard
  ## method with N trials.
  r <- 1 ## radius of dartboard
  x <- runif(n, min=-r, max=r)
  y <- runif(n, min=-r, max=r)
```

```
  l <- sqrt(x^2 + y^2)
  d <- sum(l<r)
  4*d/n
}
```

We can then test the procedure a few times, using the default number of darts, 1000:

```
replicate(9, estimate.pi())
```

```
## [1] 3.092 3.144 3.208 3.116 3.052 3.060 3.216 3.064 3.148
```

Finally, for a given value of n, we can show 99 estimates of π, as clearly the estimate will vary from run to run. In Figure 1, we compare the estimates of π for three different values of n.

```
ns <- 10^c(2,3,4)
res <- lapply(ns, function(n) replicate(99, estimate.pi(n)))
par(las=1, bty='n')
stripchart(res, method="jitter", group.names=ns,
           xlab="number of darts",
           ylab=expression(paste('estimate of ', pi)),
           vert=TRUE, pch=20, cex=0.5)
abline(h=pi, col='red')
```

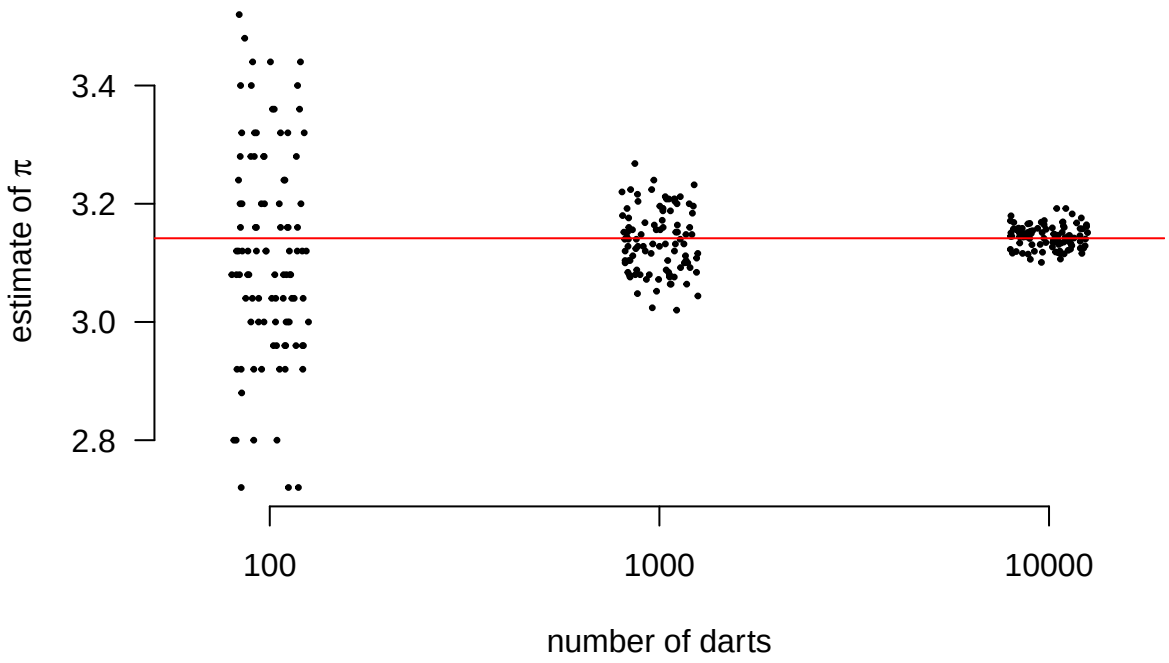


Figure 1: Estimates of Pi as we increase number of darts

3 Example table output

Here is a simple table.

Table 1: Example output from xtable

name	age	height
joe	19	1.80
ann	24	1.75
bob	27	1.70

```
df = data.frame(name=c("joe", "ann", "bob"),
  age=c(19, 24, 27),
  height=c(1.8, 1.75, 1.7))
df
```

```
##   name age height
## 1  joe  19   1.80
## 2  ann  24   1.75
## 3  bob  27   1.70
```

Or you can add a caption as shown in Table 1:

```
kable(df, booktabs=TRUE, caption="Example output from xtable")
```

4 References to literature

Bookdown can refer to references. For example, this is the original citation for R (Ihaka and Gentleman 1996). For more details regarding knitr, check out the book (Xie 2015).

Further details are available at https://rmarkdown.rstudio.com/authoring_bibliographies_and_citations.html.

5 Exercises

1. Add an extra set of trials for n=10 darts thrown.
2. Experiment switching the cache on (Section 1.1). Where are the intermediate results stored? When is the code rerun?
3. Add another reference to the document. (BibTeX entries can be downloaded from Google Scholar, amongst other places.)
4. Can you get pdf output as well as HTML output? (Hint: check Makefile)
5. Explore the printr package for printing tables and matrices https://yihui.name/printr/.

5.1 Compiling this document

```
rmarkdown::render('estimatek.Rmd')
```

References

Ihaka, Ross, and Robert Gentleman. 1996. "R: A Language for Data Analysis and Graphics." *J. Comput. Graph. Stat.* 5 (3). Taylor & Francis, Ltd. on behalf of the American Statistical Association, Institute of Mathematical Statistics,; Interface Foundation of America: 299–314. doi:10.2307/1390807.

Xie, Yihui. 2015. *Dynamic Documents with R and Knitr*. 2nd ed. Boca Raton, Florida: Chapman; Hall/CRC. https://yihui.name/knitr/.