

## 1 Some simulations

```
> library(resper)
```

First of all, let's check if the algorithm samples the permutations with similar frequencies. To that end, we build a tridiagonal matrix, which would correspond to a run of equidistant numbers and a lag that covers up to three numbers at once.

```
> m <- toeplitz(c(rep(1, 2), rep(0, 5)))
```

|      | [,1] | [,2] | [,3] | [,4] | [,5] | [,6] | [,7] |
|------|------|------|------|------|------|------|------|
| [1,] | 1    | 1    | 0    | 0    | 0    | 0    | 0    |
| [2,] | 1    | 1    | 1    | 0    | 0    | 0    | 0    |
| [3,] | 0    | 1    | 1    | 1    | 0    | 0    | 0    |
| [4,] | 0    | 0    | 1    | 1    | 1    | 0    | 0    |
| [5,] | 0    | 0    | 0    | 1    | 1    | 1    | 0    |
| [6,] | 0    | 0    | 0    | 0    | 1    | 1    | 1    |
| [7,] | 0    | 0    | 0    | 0    | 0    | 1    | 1    |

```
> print(m)
```

|      | [,1] | [,2] | [,3] | [,4] | [,5] | [,6] | [,7] |
|------|------|------|------|------|------|------|------|
| [1,] | 1    | 1    | 0    | 0    | 0    | 0    | 0    |
| [2,] | 1    | 1    | 1    | 0    | 0    | 0    | 0    |
| [3,] | 0    | 1    | 1    | 1    | 0    | 0    | 0    |
| [4,] | 0    | 0    | 1    | 1    | 1    | 0    | 0    |
| [5,] | 0    | 0    | 0    | 1    | 1    | 1    | 0    |
| [6,] | 0    | 0    | 0    | 0    | 1    | 1    | 1    |
| [7,] | 0    | 0    | 0    | 0    | 0    | 1    | 1    |

|      | [,1] | [,2] | [,3] | [,4] | [,5] | [,6] | [,7] |
|------|------|------|------|------|------|------|------|
| [1,] | 1    | 1    | 0    | 0    | 0    | 0    | 0    |
| [2,] | 1    | 1    | 1    | 0    | 0    | 0    | 0    |
| [3,] | 0    | 1    | 1    | 1    | 0    | 0    | 0    |
| [4,] | 0    | 0    | 1    | 1    | 1    | 0    | 0    |
| [5,] | 0    | 0    | 0    | 1    | 1    | 1    | 0    |
| [6,] | 0    | 0    | 0    | 0    | 1    | 1    | 1    |
| [7,] | 0    | 0    | 0    | 0    | 0    | 1    | 1    |

A nice result is that the permanent of an  $n - dimensional$  tridiagonal matrix is the  $n+1$ th Fibonacci number. The algorithm therefore should sample from 21 realizations of the permutation with probability  $1/21$  each. Let's sample with the classical algorithm:

```
> anziter <- 1000  
> byrow.times <- NULL  
> byrow.perms <- NULL
```

```

> byrow.rejects <- NULL
> for (i in 1:anziter) {
+   byrow.times <- rbind(byrow.times, system.time(p <- ResperByrow(m)))
+   byrow.perms <- rbind(byrow.perms, p$perm)
+   byrow.rejects <- c(byrow.rejects, p$reject)
+ }

```

Now let's look at the result. The permutations are first mapped to single elements that are distinguished between one another. As no number is greater than 9, one can simply convert the permutations into eight-digit numbers.

```

> pn <- apply(t(byrow.perms) * 10^(6:0), 2, sum)

```

```

[1] 2135476 2135467 2135476 1243657 1243567 2134567 1324567 2143657 1234567
[10] 2134576 2134657 1235467 1234657 1235476 1324567 2143567 1234657 1234576
[19] 1234576 2134657 1325467 1234576 1234576 1243576 1234567 1235476 1324576
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[982] 2135467 2143576 2135467 2135467 1234657 2143657 1325476 1235476 1243576
[991] 2135476 1234576 1243657 1234576 2134657 1325476 2143657 1243576 2143576
[1000] 1324567

```

```
> table(pn)
```

```
pn
```

```

1234567 1234576 1234657 1235467 1235476 1243567 1243576 1243657 1324567 1324576
      55      58      38      38      51      49      45      47      41      55
1324657 1325467 1325476 2134567 2134576 2134657 2135467 2135476 2143567 2143576

```

```

45      40      57      47      51      47      52      44      45      49
2143657
46

```

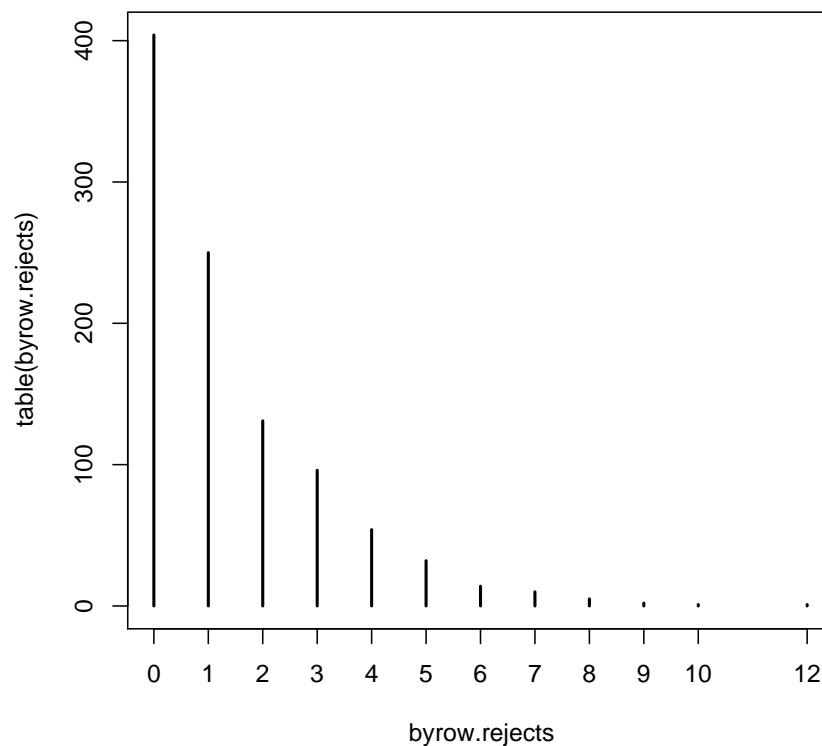
The computation times that this has taken are logged by attempt. Obviously, the distribution of times is very skewed.

```
> summary(byrow.times)
```

| X1      |          | X2      |          | X3      |          | X4      |    | X5      |    |
|---------|----------|---------|----------|---------|----------|---------|----|---------|----|
| Min.    | :0.02000 | Min.    | :0.00000 | Min.    | :0.04000 | Min.    | :0 | Min.    | :0 |
| 1st Qu. | :0.04000 | 1st Qu. | :0.00000 | 1st Qu. | :0.05000 | 1st Qu. | :0 | 1st Qu. | :0 |
| Median  | :0.06000 | Median  | :0.00000 | Median  | :0.07000 | Median  | :0 | Median  | :0 |
| Mean    | :0.07644 | Mean    | :0.00047 | Mean    | :0.08048 | Mean    | :0 | Mean    | :0 |
| 3rd Qu. | :0.10000 | 3rd Qu. | :0.00000 | 3rd Qu. | :0.10000 | 3rd Qu. | :0 | 3rd Qu. | :0 |
| Max.    | :0.30000 | Max.    | :0.02000 | Max.    | :0.33000 | Max.    | :0 | Max.    | :0 |

This is caused by the roughly geometrical distribution of the number of rejections.

```
> plot(table(byrow.rejects))
```



Let's see if the clotting algorithm performs better.

```

> anziter <- 1000
> clot.times <- NULL
> clot.perms <- NULL
> clot.rejects <- NULL
> for (i in 1:anziter) {
+   clot.times <- rbind(clot.times, system.time(p <- ResperClot(m)))
+   clot.perms <- rbind(clot.perms, p$perm)
+   clot.rejects <- c(clot.rejects, p$reject)
+ }

```

The tabulation of the permutation samples:

```

> pn <- apply(t(clot.perms) * 10^(6:0), 2, sum)

```

|       |         |         |         |         |         |         |         |         |         |
|-------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| [1]   | 2143657 | 2134657 | 2143576 | 1234657 | 1324567 | 2135467 | 1235467 | 2135476 | 1235476 |
| [10]  | 2134576 | 1324576 | 1243567 | 1324657 | 1325476 | 1325467 | 2134657 | 1243576 | 2143576 |
| [19]  | 2135467 | 2134567 | 2134567 | 2143567 | 2134657 | 1234576 | 1235467 | 1325476 | 1234657 |
| [28]  | 2143576 | 1325467 | 1325467 | 2143576 | 2134567 | 1324567 | 1234657 | 1234567 | 1243567 |
| [37]  | 2134576 | 1234576 | 1243657 | 2135467 | 1234576 | 2135476 | 1234567 | 1234657 | 1243567 |
| [46]  | 1243657 | 2143657 | 1324657 | 1243576 | 2135467 | 1235476 | 1324576 | 2134576 | 1243657 |
| [55]  | 2143576 | 1235467 | 2134657 | 1324567 | 1235467 | 2134567 | 1234576 | 1324567 | 2134657 |
| [64]  | 1234576 | 1325476 | 1325467 | 1235467 | 1234567 | 1234657 | 2134657 | 2134576 | 1243567 |
| [73]  | 1243576 | 2134576 | 1234567 | 1324657 | 1234657 | 1324567 | 2134567 | 2134657 | 2143567 |
| [82]  | 1235476 | 1324576 | 1234567 | 2134567 | 1325476 | 1325467 | 2135467 | 2134576 | 2134576 |
| [91]  | 1234657 | 2143567 | 1325476 | 1243567 | 1324576 | 1325476 | 1235476 | 1324576 | 2135467 |
| [100] | 1324567 | 2134657 | 2134657 | 1325467 | 1235467 | 2143567 | 1243567 | 2134576 | 1235476 |
| [109] | 1234576 | 2134567 | 2134576 | 1235476 | 1234657 | 1325467 | 1234576 | 1234567 | 1325467 |
| [118] | 1243567 | 1243657 | 1234567 | 2143567 | 1243657 | 2135467 | 2134657 | 2134657 | 1234576 |
| [127] | 1234567 | 1325467 | 1324567 | 1324576 | 1243576 | 2135476 | 2135476 | 2143576 | 1243576 |
| [136] | 2143567 | 2143657 | 2134567 | 2143657 | 2134567 | 2143657 | 1234576 | 1325476 | 2143576 |
| [145] | 1325467 | 1324567 | 2143657 | 1243576 | 1234657 | 1324657 | 2135476 | 1234657 | 1324657 |
| [154] | 1324567 | 1243576 | 1324567 | 2134657 | 1243657 | 2135467 | 1235467 | 1324657 | 2143576 |
| [163] | 1235467 | 1243567 | 1234567 | 2143657 | 1234657 | 1234657 | 2143567 | 1235476 | 1234567 |
| [172] | 2134567 | 2134567 | 1324567 | 1324567 | 1243576 | 1243657 | 1235476 | 2134576 | 1234567 |
| [181] | 1324657 | 2143567 | 2135476 | 1234657 | 2134657 | 1324567 | 1243657 | 2135467 | 1234657 |
| [190] | 1235476 | 1325467 | 1324567 | 1325467 | 1234657 | 1243567 | 1243567 | 2134567 | 1234567 |
| [199] | 1243657 | 1325467 | 2134576 | 2134657 | 1324657 | 2134567 | 2134567 | 1324576 | 2135476 |
| [208] | 2143567 | 1235476 | 1234576 | 1235467 | 2134576 | 1234567 | 1234657 | 1324576 | 2143576 |
| [217] | 2134657 | 1324567 | 2143657 | 2143567 | 2143576 | 1324567 | 1325467 | 1325476 | 1235467 |
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| [235] | 1243567 | 1234576 | 2143567 | 1324567 | 2135467 | 2143567 | 2135467 | 1235467 | 1324657 |
| [244] | 1243567 | 2135476 | 1324567 | 1243657 | 2135467 | 1324657 | 2135467 | 2135476 | 1234657 |
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| [262] | 1324657 | 1243576 | 2143567 | 2135476 | 2134567 | 2143567 | 2135467 | 1243657 | 1234657 |

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```

```
> table(pn)
```

```
pn
```

```

1234567 1234576 1234657 1235467 1235476 1243567 1243576 1243657 1324567 1324576
      57      54      59      42      39      50      45      41      54      52

```



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1324657 1325467 1325476 2134567 2134576 2134657 2135467 2135476 2143567 2143576
      44      41      45      44      47      74      50      45      39      41
2143657
      37

```

The summary of the computing time:

```
> summary(clot.times)
```

| X1              | X2              | X3              | X4        | X5        |
|-----------------|-----------------|-----------------|-----------|-----------|
| Min. :0.03000   | Min. :0.00000   | Min. :0.04000   | Min. :0   | Min. :0   |
| 1st Qu.:0.05000 | 1st Qu.:0.00000 | 1st Qu.:0.05000 | 1st Qu.:0 | 1st Qu.:0 |
| Median :0.07000 | Median :0.00000 | Median :0.07000 | Median :0 | Median :0 |
| Mean :0.07491   | Mean :0.00042   | Mean :0.07865   | Mean :0   | Mean :0   |
| 3rd Qu.:0.09000 | 3rd Qu.:0.00000 | 3rd Qu.:0.09000 | 3rd Qu.:0 | 3rd Qu.:0 |
| Max. :0.27000   | Max. :0.02000   | Max. :0.29000   | Max. :0   | Max. :0   |

And finally, the bar chart of the rejections:

```
> plot(table(clot.rejects))
```

