

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] 2143576 2135467 2134657 2143657 2143657 1235467 1325467 2143576 1324657
[10] 1324657 2143657 1235467 1324567 1235476 1324576 1234657 1243576 1235476
[19] 2134657 2134657 1325467 2143576 1234567 1324567 2135467 1235476 2134657
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[244] 2143657 1324576 1325467 1325476 2143567 2143567 1234576 1325476 1324567
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[991] 1235467 2143657 2143567 1235467 1243657 1235467 2134576 1325467 1243567
[1000] 2143657

```

```
> table(pn)
```

```

pn
1234567 1234576 1234657 1235467 1235476 1243567 1243576 1243657 1324567 1324576
      52      47      44      57      50      46      45      50      39      52
1324657 1325467 1325476 2134567 2134576 2134657 2135467 2135476 2143567 2143576

```

```

48      48      46      28      54      41      52      48      48      45
2143657
60

```

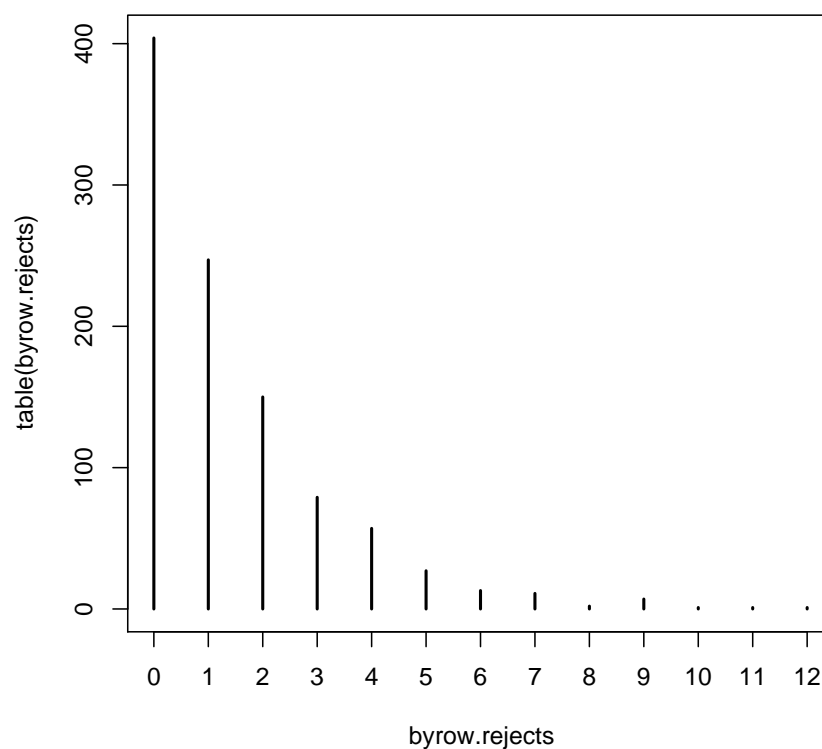
The computation times that this has taken are logged by attempt. Obviously, the distribution of times is very skewed.

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

| X1 | | X2 | | X3 | | X4 | | X5 | |
|---------|----------|---------|----------|---------|----------|---------|----|---------|----|
| Min. | :0.03000 | 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 | :0.07748 | Mean | :0.00046 | Mean | :0.09272 | Mean | :0 | Mean | :0 |
| 3rd Qu. | :0.10000 | 3rd Qu. | :0.00000 | 3rd Qu. | :0.11000 | 3rd Qu. | :0 | 3rd Qu. | :0 |
| Max. | :0.37000 | Max. | :0.02000 | Max. | :1.17000 | 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] | 2134657 | 1324657 | 2134567 | 2143657 | 1324567 | 1325467 | 2134657 | 1235476 | 1243576 |
| [10] | 1235467 | 2134657 | 1235476 | 1234657 | 2143567 | 1324657 | 2135476 | 1235476 | 1234576 |
| [19] | 2134657 | 2143567 | 1235467 | 2134567 | 1234567 | 1324657 | 1234657 | 2143567 | 1234657 |
| [28] | 2143576 | 1243567 | 1324576 | 1324576 | 2134567 | 1325476 | 2143567 | 1324657 | 1324657 |
| [37] | 2143657 | 2143657 | 1324576 | 1235467 | 2143567 | 1234576 | 2134567 | 1234657 | 2135476 |
| [46] | 1324576 | 1324576 | 2135476 | 1324567 | 2135467 | 2134576 | 1234567 | 1324657 | 1324567 |
| [55] | 2143576 | 1243657 | 2135467 | 1324657 | 1324567 | 1324657 | 1234567 | 1243576 | 2134576 |
| [64] | 1324576 | 2135467 | 1324567 | 1234576 | 2135467 | 1324576 | 1325467 | 2134576 | 1235467 |
| [73] | 2143576 | 1234567 | 1234567 | 1243657 | 1234567 | 1324657 | 2143657 | 1243567 | 1324567 |
| [82] | 2143567 | 2143567 | 2143576 | 1324576 | 2143657 | 1324567 | 1324657 | 1243657 | 1324657 |
| [91] | 1324657 | 1324567 | 1325476 | 2134576 | 2143657 | 2143657 | 1234657 | 1234567 | 2135467 |
| [100] | 1243657 | 1234576 | 1235467 | 1325476 | 1324576 | 2143567 | 1324576 | 2134567 | 1234657 |
| [109] | 1234567 | 1234657 | 2143567 | 1325467 | 1325476 | 1234657 | 1234576 | 1325467 | 1324576 |
| [118] | 2135476 | 2143567 | 1325467 | 2143657 | 2135467 | 1234657 | 1324657 | 2134567 | 2143657 |
| [127] | 1324567 | 1243567 | 1325467 | 1243657 | 2143576 | 1234576 | 2135476 | 2135467 | 2134576 |
| [136] | 1243657 | 1324657 | 1234657 | 2143657 | 2134657 | 1234576 | 2134576 | 1324567 | 1235476 |
| [145] | 2134657 | 1235476 | 1243567 | 1243567 | 2143567 | 2135467 | 1234657 | 2134576 | 1325476 |
| [154] | 2135476 | 2143567 | 1324567 | 1243567 | 1324576 | 1243657 | 1324576 | 2134567 | 2143567 |
| [163] | 1234576 | 1324576 | 2143567 | 2134567 | 2134657 | 1243567 | 2143576 | 1243657 | 2134576 |
| [172] | 2134567 | 2134657 | 2135476 | 1243657 | 1234657 | 1325476 | 2143576 | 1235467 | 2143567 |
| [181] | 1243576 | 1325467 | 1243576 | 1234567 | 1243657 | 2134657 | 1243567 | 1324576 | 1234567 |
| [190] | 1235467 | 2143576 | 1325476 | 1243657 | 1235467 | 1243576 | 1243567 | 1234657 | 1243657 |
| [199] | 1324576 | 1234576 | 1324567 | 2143657 | 1324657 | 2143576 | 2135476 | 2143657 | 2134657 |
| [208] | 2134567 | 2135476 | 2134576 | 2134657 | 1324576 | 1324657 | 1235467 | 2134657 | 1235467 |
| [217] | 2135476 | 1243657 | 1325467 | 1325476 | 2143657 | 2134576 | 2134657 | 1243576 | 1243657 |
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| [235] | 2134576 | 2143576 | 1325476 | 2135476 | 2134567 | 2135476 | 1324567 | 1234567 | 1324576 |
| [244] | 1235467 | 1234576 | 2134657 | 1234567 | 2143567 | 2135476 | 1234657 | 1234567 | 1235467 |
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[667] 2143657 2135467 1243567 1324567 1234657 1234576 1234657 2143576 2143657
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[991] 1234567 1325476 2134657 2143657 2143576 1243576 2134657 1324576 1243567
[1000] 1234576

```

```
> table(pn)
```

```
pn
```

```

1234567 1234576 1234657 1235467 1235476 1243567 1243576 1243657 1324567 1324576
      45      57      55      46      36      40      40      45      53      55

```



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1324657 1325467 1325476 2134567 2134576 2134657 2135467 2135476 2143567 2143576
      64      40      47      55      37      60      35      44      53      47
2143657
      46

```

The summary of the computing time:

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

| X1 | X2 | X3 | X4 | X5 |
|-----------------|-----------------|-----------------|-----------|-----------|
| Min. :0.02000 | 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 :0.07373 | Mean :0.00053 | Mean :0.08646 | Mean :0 | Mean :0 |
| 3rd Qu.:0.09000 | 3rd Qu.:0.00000 | 3rd Qu.:0.09000 | 3rd Qu.:0 | 3rd Qu.:0 |
| Max. :0.22000 | Max. :0.02000 | Max. :0.84000 | Max. :0 | Max. :0 |

And finally, the bar chart of the rejections:

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

