Easter-based walks on a sphere

Denis Roegel

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For 颖颖.

Abstract

In this brief note, we use Easter dates to walk "randomly" on a sphere.

Easter is a moving feast, and our aim in this brief note is to construct some æsthetic summary of the dates of Easter.

1 The date of Easter

The date of Easter for a given year Y can be computed using various algorithms, for instance the one due to Gauss [1]. The version for the Julian calendar (until 1582) is the following:

$$\begin{aligned}
a &\leftarrow Y \bmod 19 \\
b &\leftarrow Y \bmod 4 \\
c &\leftarrow Y \bmod 7 \\
M &\leftarrow 15 \\
N &\leftarrow 6 \\
d &\leftarrow (19a+M) \bmod 30 \\
e &\leftarrow (2b+4c+6d+N) \bmod 7
\end{aligned}$$

Julian Easter then takes place on March $22+d+e$ or April $d+e-9$. In the Julian calendar, the dates of Easter repeat in the same order after 532 years.

In the Gregorian calendar, the computation of Easter has been made more complex and the same dates of Easter repeat only after 5 700 000 years. In the

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new algorithm, M and N are only constant within a given century, and then slowly vary:

$$
\begin{aligned}
a &\leftarrow Y \bmod 19 \\
b &\leftarrow Y \bmod 4 \\
c &\leftarrow Y \bmod 7 \\
k &\leftarrow \lfloor Y/100 \rfloor \\
p &\leftarrow \lfloor (13+8k)/25 \rfloor \\
q &\leftarrow \lfloor k/4 \rfloor \\
M &\leftarrow (15-p+k-q) \bmod 30 \\
N &\leftarrow (4+k-q) \bmod 7 \\
d &\leftarrow (19a+M) \bmod 30 \\
e &\leftarrow (2b+4c+6d+N) \bmod 7
\end{aligned}
$$

Gregorian Easter then occurs on March $22+d+e$ or April $d+e-9$, but there are two exceptions:

- if $d=29$ and $e=6$, the above calculation returns April 26, and it should be replaced by April 19;
- if $d=28$, $e=6$, and $(11M+11) \bmod 30 < 19$, April 25 should be replaced by April 18.

2 Color encoding of Easter dates

Our aim is to visualize the dates of Easter in 3D,[1] and with a color encoding of the dates. Our color encoding, chosen more or less randomly, is the following, for March 22 (22M) to April 25 (25A):

22M	23M	24M	25M	26M	27M	28M
29M	30M	31M	1A	2A	3A	4A
5A	6A	7A	8A	9A	10A	11A
12A	13A	14A	15A	16A	17A	18A
19A	20A	21A	22A	23A	24A	25A

[1] See [2] for a companion note with a different representation, based on the same encoding.

3 Julian Easter

The "random" walk of figure 1 is in fact not random at all. We start on some point on the sphere, and we move on the surface of the sphere, either slightly left or slightly right, depending on how close the date of Easter is from either ends. This walk is not closed.

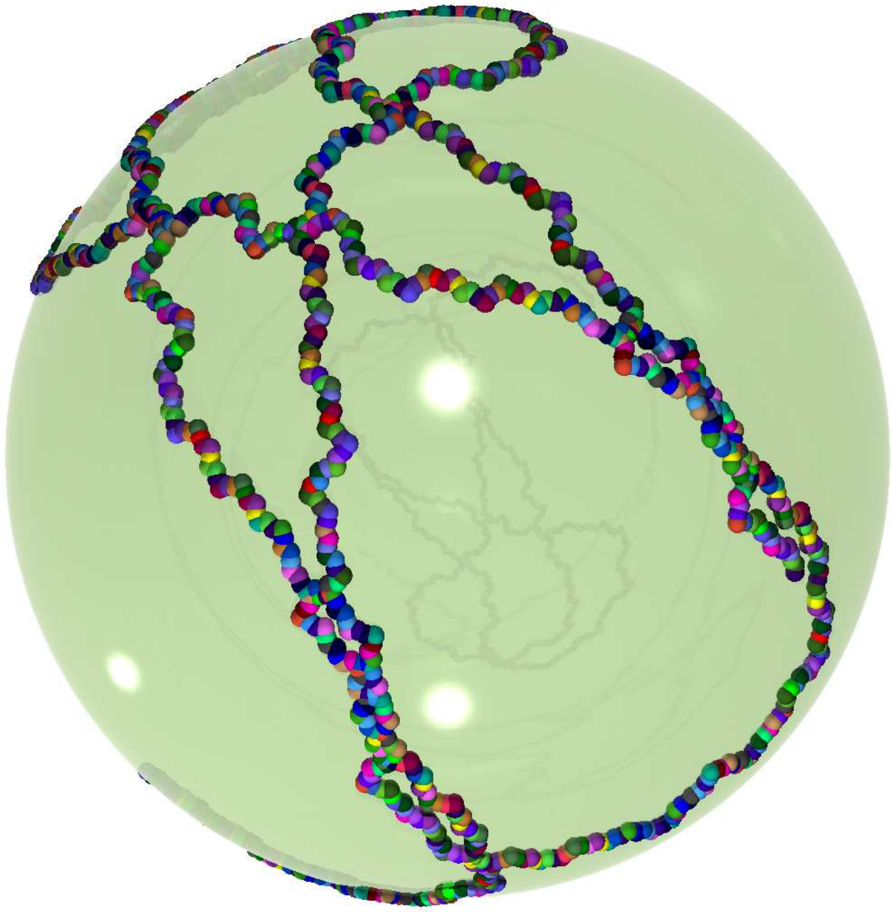

Figure 1: Julian Easter dates over 1064 years.

4 Gregorian Easter

Figure 2 shows a walk based on the date of Easter in the Gregorian calendar, but only over of period of 100000 years.

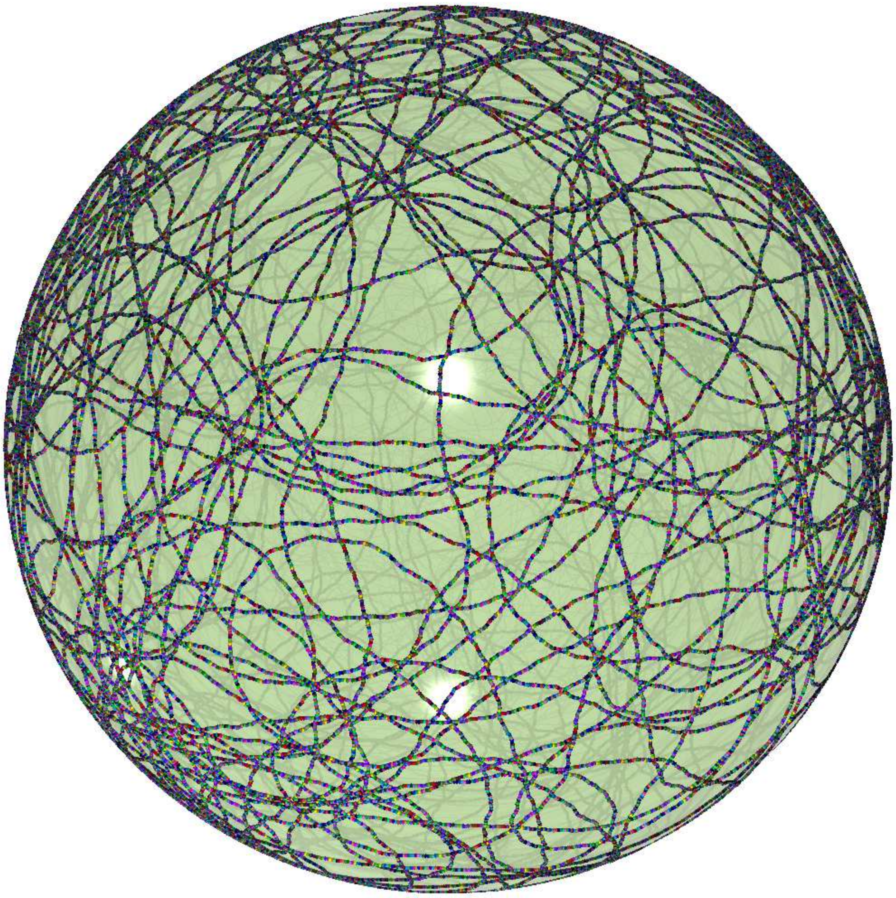

Figure 2: Gregorian Easter over a period of 100000 years.

References

[1] Jean Meeus. *Astronomical algorithms*. Richmond, Virginia: Willmann-Bell, 1999. [2nd edition].

[2] Denis Roegel. Easter bracelets for 5 700 000 years. Technical report, LORIA, 2014.