Solaris

An API to Calculate Time of Major Phenomenons on Earth Just by position and a Date.

C Project

1. Intro

Inspired by the sun_info() function in PHP we decided to make a function which calculates the the timing of some of the astronomical events like sunrise, sunset, civil twilight, nautical twilight and astronomical twilight in such a way that any function can be used independently for the general time calculation or for development of more advanced API.

This API allows user to calculate all above mention time and it can also be used to predict the daylength of upcoming days.

How can we predict sunrise , sunset and twilight time just by coordinates?

Note

For this API several references, observation and old ideas are taken and we tried to do the whole process in such a way that error can be minimised.

Lots of Math! With some observations.

(Whole process is divided into chain of process. In each step some value is calculated which serves as input for next process along with existing values but it all starts with latitude, longitude and a date.)

Note

We tried to keep result as much precise and accurate but as time zones are not uniformly distributed some avoidable error is part of solution.

2. Sunrise & Sunset

Sunrise and sunset are two important phenomena of nature.Length of the day is determined by these two phenomenons.

Here we we will not only prove that there exist some relation between these phenomena but also calculate the exact time of these phenomenons with small avoidable error.

This algorithm not only calculates the time but also shows what factor can affect these natural phenomenons.

Sunrise & Sunset Equation

Step 1 ► Julian date is calculated from date which will be used to calculate Julian no.

Step 2 ► Then mean Solar noon is calculated from longitude and julian day.

Step 3 ► Mean solar noon is used to calculate the mean solar anomaly.

Step 4 ► This value will give the equation of the center of the earth.

Step 5 ► Now we can easily calculate ecliptic longitude with mean solar anomaly and equation of center.

Step 6 ► Above calculated value will help us to calculate solar transit.

Step 7 ► With ecliptic longitude we have to calculate the declination of the sun.

Step 8 ► For the correction of atmospheric refraction Hour angle is calculated from observer's zenith with the help of north latitude and declination angle of sun.

Step 9 ► $J_{sunrise} = J_{transit}$ -(Hour angle)/360

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Calculate current Julian day

$$n = J_{date} - 2451545.0 + 0.0008$$

Mean solar noon

$$J^{\star} = n - \frac{l_w}{360^\circ}$$

Solar mean anomaly

$$M = (357.5291 + 0.98560028 \times J^{\star}) \mod 360$$

Equation of the center

$$C = 1.9148\sin(M) + 0.0200\sin(2M) + 0.0003\sin(3M)$$

Ecliptic longitude

$$\lambda = (M + C + 180 + 102.9372) \mod 360$$

Solar transit

$$J_{transit} = 2451545.5 + J^{\star} + 0.0053\sin M - 0.0069\sin(2\lambda)$$

Declination of the Sun

$$\sin\delta = \sin\lambda \times \sin 23.44^\circ$$

Hour angle

$$\cos\omega_\circ = \frac{\sin(-0.83^\circ) - \sin\phi \times \sin\delta}{\cos\phi \times \cos\delta}$$

Calculate sunrise and sunset

$$J_{set} = J_{transit} + \frac{\omega_\circ}{360^\circ}$$

$$J_{rise} = J_{transit} - \frac{\omega_\circ}{360^\circ}$$

3. Twilight

Like sunrise and sunset, twilight is also an important phenomenon. Twilight on earth is the illumination of the lower atmosphere when the Sun itself is not directly visible because it is below the horizon. Twilight is produced by sunlight scattering in the upper atmosphere, illuminating the lower atmosphere so that Earth's Surface is neither completely lit nor completely dark. The word *twilight* is also used to denote the periods of time when this illumination occurs.

Civil Twilight

Morning civil twilight begins when the geometric center of the sun is 6° below the horizon and ends at sunrise which we call dawn.

Evening civil twilight begins at sunset and ends when the geometric center of the sun reaches 6° below the horizon commonly called dusk.

Nautical Twilight

Morning nautical twilight begins (nautical dawn) when the geometric center of the sun is 12° below the horizon in the morning and ends when the geometric center of the sun is 6° below the horizon in the morning.

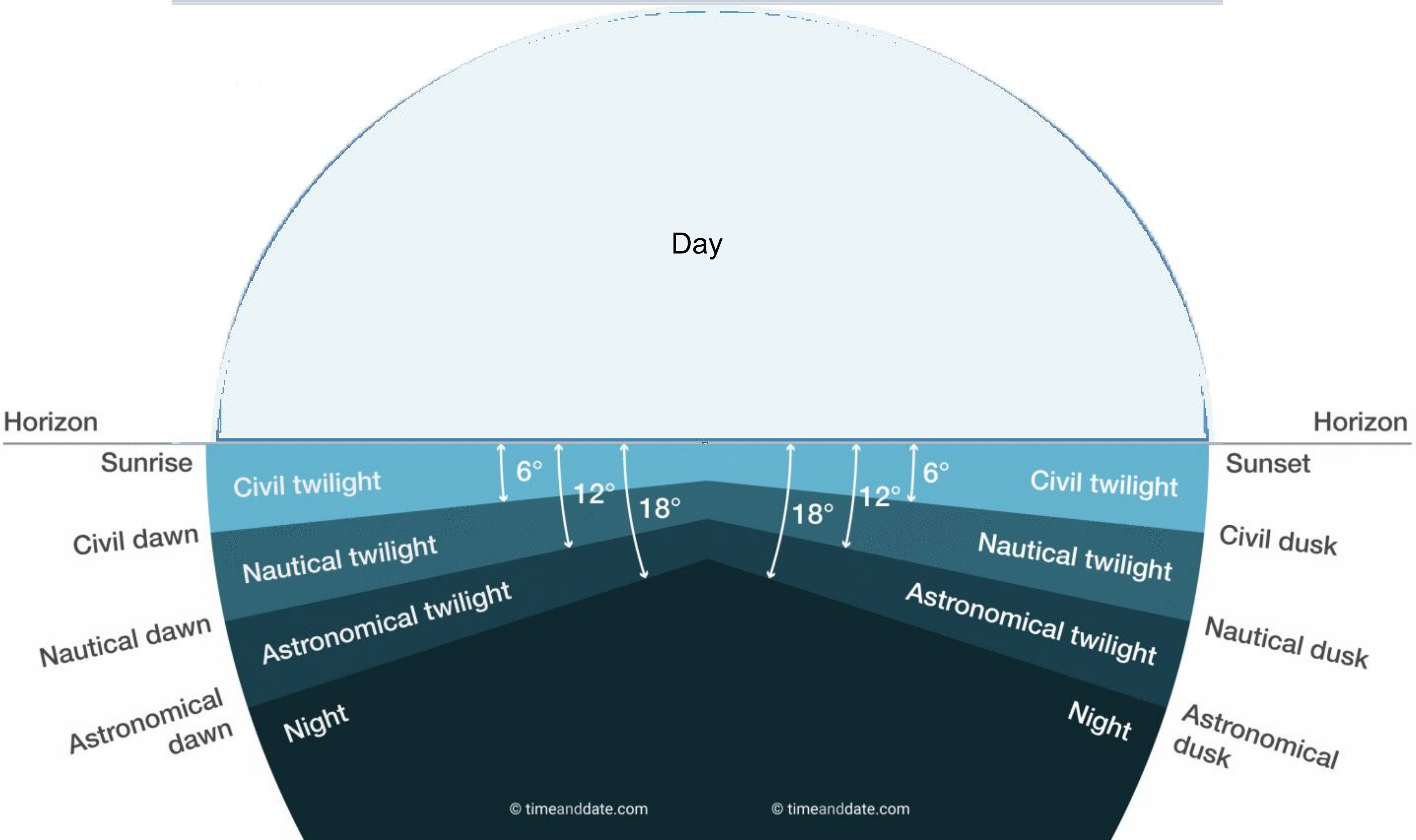
Evening nautical twilight begins when the geometric center of the sun is 6° below the horizon in the evening and ends (nautical dusk) when the geometric center of the sun is 12° below the horizon in the evening.

Astronomical Twilight

Astronomical dawn is the moment when the geometric center of the Sun is 18 degrees below the horizon in the morning.

Astronomical dusk is the moment when the geometric center of the Sun is 18 degrees below the horizon in the evening.

After astronomical dusk and before astronomical dawn, the sky is not illuminated by the sun.


Day
Horizon
Horizon
Sunrise
Sunset
Civil twilight
Civil twilight
6°
12°
18°
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Civil dawn
Civil dusk
Nautical twilight
Nautical twilight
Nautical dawn
Nautical dusk
Astronomical twilight
Astronomical twilight
Astronomical dawn
Astronomical dusk
Night
Night
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Twilight Equation

Step 1 ► Julian date is calculated from julian date which will be used to calculate Julian no.

Step 2 ► Calculate the inclination of earth's axis inclination of obliquity of ecliptic.

Step 3 ► Now we compute sun’s ecliptic longitude.

Step 4 ► From here declination of sun can be easily calculated.

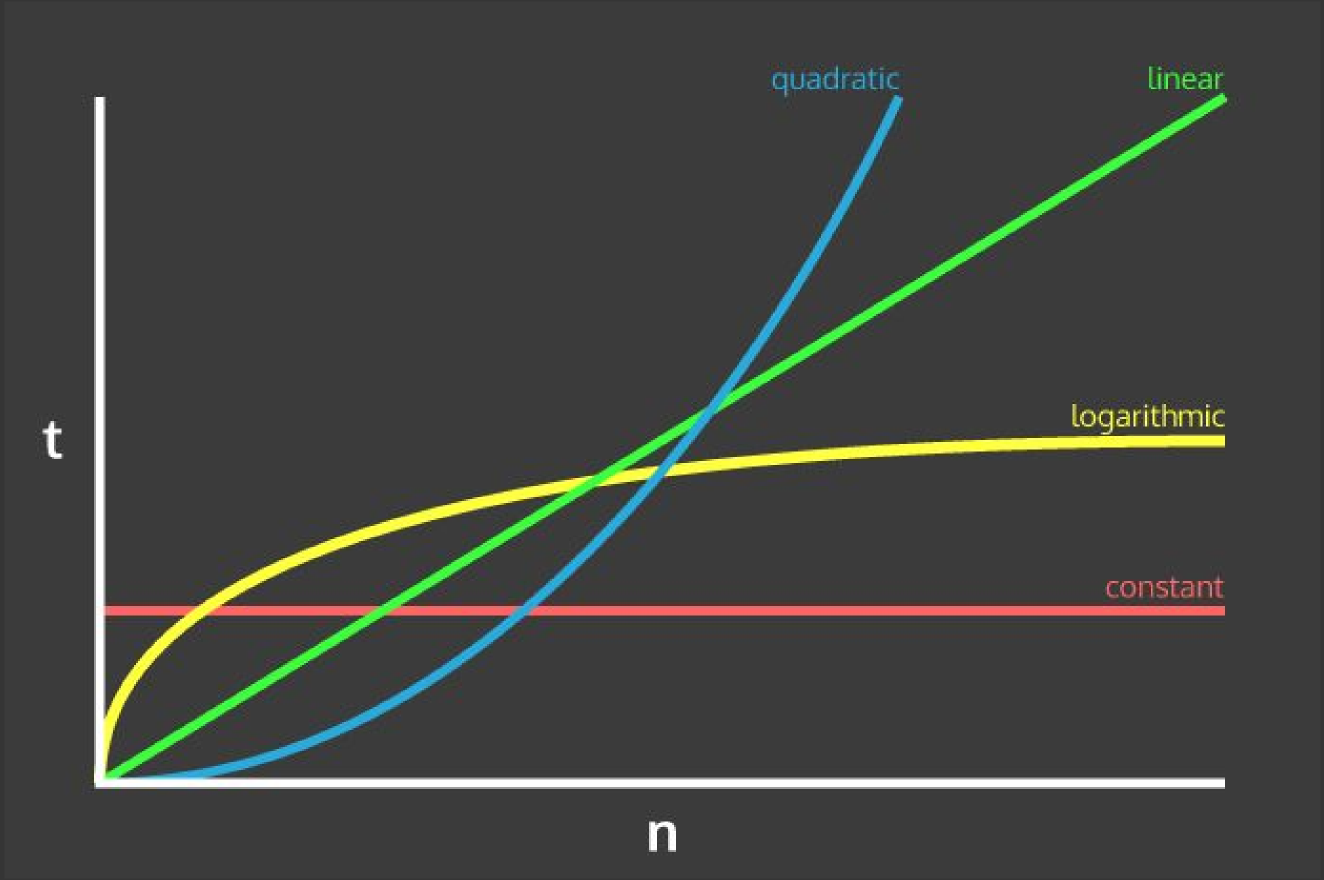
Step 5 ► For further operation we need sun's apparent radius which can be easily calculated using the solar distance.

Step 6 ► Finally diurnal arc is computed that the sun traverse to reach specific altitude.

Step 7 ► Altitude depend totally on angle in each case which we are considering. In Case of civil dawn angle is $+6^{o}$, nautical dawn is 12^{o} and astronomical dawn Is 18^{o}.

Step 8 ► Using trigonometric relation altitude can be calculated.

TIME COMPLEXITY



Naive Implementation

Sunset_Sunrise_Twilight (“Past_data_record_file”, date, longitude, latitude)

```
{
     while (record != NULL)
     |    Read data
     +---end while

     Relation <- Regression (independent_values[ ] , results [ ])

     Result <- Relation (date, longitude, latitude)

     Display (Result)
}
```

Time complexity of this implementation of **O(C^2.N)** where N is no of training examples (here it is no of records in Past_Record_Data_File) and C is no of features. As no of features (like civil dusk, civil dawn, sunrise etc) is constant so this will algo will run in **O(N)** time complexity.

Mathematical Implementation

- This implementation include some bunch of function with many variables using many other function and performing mathematical calculation without any iteration or any loop.

- As there is no iteration so time time complexity of this equation will be **O(1).**

- This algorithm has better accuracy than the naive implementation because it deals with the real phenomenon rather than matching the pattern in already occurred phenomenon.

Where it can be used?

In those fields where navigation is an important part like shipping.

Studying the changes occurring in Sun and Earth.

Better categorization of the time zones across the globe.

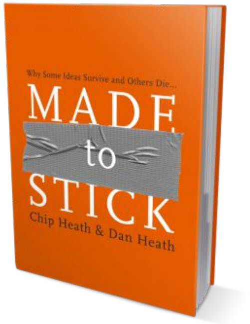
Bibliography

- **Explanatory Supplement to the Astronomical Almanac**; Sean E. Urban, US Naval Observatory and P. Kenneth Seidelmann, University of Virginia .

- **Astronomical Algorithms**; Jeenus Meerus

- aa.usno.navy.mil
- wikipedia.org/sunrise_equation.php

Finish


Why Some Ideas Survive and Others Die...
MADE
to
STICK
Chip Heath & Dan Heath