DayZero: Calculation of Distance and Prediction Time from Coordinates

Introduction

The following report describes in detail the procedure used in a Python code to calculate the distance between two geographic points based on their coordinates (latitude and longitude), and then estimate the time it would take an object to cover that distance at a given ground speed.

```python
def calc_prediction(lat_deg,lon_deg,coordinates_lat,coordinates_lon,ground_speed,altitude):
    Radius = float(6371000)
    dlat = math.radians(coordinates_lat - lat_deg)
    dlon = math.radians(coordinates_lon - lon_deg)
    a = math.sin(dlat/2)**2 + math.cos(math.radians(lat_deg)) * math.cos(math.radians(coordinates_lat)) * math.sin(dlon/2)**2
    c = 2 * math.atan2(math.sqrt(a), math.sqrt(1-a))
    distancia = (Radius * c)/1000  # Distance in kilometers

    # Convert ground speed from knots (nautical miles per hour) to kilometers per hour
    ground_speed = ground_speed * 1.852
    ground_speed = (ground_speed + 220)/2
    return distancia/ground_speed * 3600
```

Figure 1: Code that determines distance between points and aircraft ground speed

Distance Calculation: Haversine Formula

To calculate the distance between two points on the Earth's surface, the **Haversine formula** has been used, which takes into account the curvature of the Earth and is suitable for relatively short or medium distances.

- $R = 6371000$ meters (mean radius of the Earth).
- (ϕ_1, λ_1) are the latitude and longitude of the starting point.
- (ϕ_2, λ_2) are the latitude and longitude of the destination point.
- The differences in latitude and longitude are converted to radians:

$$\Delta\phi = \text{radians}(\phi_2 - \phi_1), \quad \Delta\lambda = \text{radians}(\lambda_2 - \lambda_1)$$

- The intermediate value a is calculated:

$$a = \sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_1) \cdot \cos(\phi_2) \cdot \sin^2\left(\frac{\Delta\lambda}{2}\right)$$

- The central angle c is obtained:

$$c = 2 \cdot \text{atan2}(\sqrt{a}, \sqrt{1-a})$$

- Finally, the distance is calculated as:

$$d = R \cdot c$$

The result is converted from meters to kilometers by dividing by 1000.

Speed Conversion

The value of `ground_speed` received as a parameter is in knots, which is a common unit in air navigation and is equivalent to one nautical mile per hour. To convert it to kilometers per hour, it is multiplied by the factor 1.852:

$$V_{\text{km/h}} = \texttt{ground\_speed} \times 1.852$$

Then, in the code a formula is applied that seems to perform an average between the converted speed and a constant value of 220 km/h:

$$V_{\text{media}} = \frac{V_{\text{km/h}} + 220}{2}$$

Prediction Time Calculation

With the distance already known (in kilometers) and the estimated average speed (also in km/h), the time it would take to cover that distance is calculated:

$$\text{time (hours)} = \frac{\text{distance (km)}}{\text{average speed (km/h)}}$$

This value is multiplied by 3600 to convert it to seconds:

$$\text{time (seconds)} = \frac{\text{distance}}{\text{average speed}} \times 3600$$