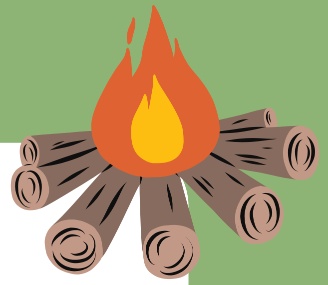

Prediction of Forest Fires

Mathematical Models

Mathematical Model

Mathematical models to predict forest fire behaviours were first introduced in the 1940s and they have been evolving for decades. They consider various aspects and their complex interrelationships: the type of forest fuel (grass, shrub, small trees, large ones), the weather (wind direction,temperature , humidity), the topology of the terrain, and the source of the fire (human activity, lightning).

1

Fire Front Propagation over a 2D Hill with a Burning Structure

The elevation of the hill is assumed to vary in the x- and 10 y-directions with the functional form

$$Z(x,y) = \frac{H}{1+(x/W_x)^2+(y/W_y)^2}$$

where H is the vertical amplitude of the hill in meters, here taken to be 50 meters, Wx is the length scale measured in meters in the x-direction and Wy is the length scale measured in meters in the y-direction; Wx and Wy give the horizontal dimensions of the hill, each assumed to be 100 meters (so the example hill is circular).

2

Fire Prediction Based on CatBoost Algorithm

CatBoost is an algorithm that combines GBDT and categorical features. 'is approach is an improved implementation under the framework of the GBDT algorithm. CatBoost is based on oblivious trees with few parameters and supports categorical variables and high accuracy sexual GBDT framework. 'e main pain point is to efficiently and rationally deal with categorical features. CatBoost is composed of categorical variables and boost.'is study considers many categorical features, such as rainfall, wind direction, slope direction, and land type. CatBoost can be used to quickly process nonnumerical features.

$$x_k^i = \frac{\sum_{j=1}^{n}\left\{x_j^i = x_k^i\right\}.y_i + ap}{\sum_{j=1}^{n}\left\{x_j^k = x_k^i\right\} + a},$$

where p represents the added prior value and the weight coefficient greater than zero. An a priori value is added to significantly reduce the noise points caused by low-frequency features to effectively minimize the overfitting of the model and improve the generalization ability

Prediction using mathematical formula for different factors

1

Air relative humidity

Relative humidity (RH) is the percentage of the actual vapor pressure of air (e) saturation vapor pressure with temperature (E)

$$RH = \frac{e}{E} \times 100\ \%$$

The relative humidity effects on of the fuel moisture content changes. The larger the relative humidity, the faster fuel moisture absorption, the slower evaporation, fuel moisture content increases; Conversely, the slower fuel moisture absorption, the faster evaporation, fuel moisture content is reduced.

Relative humidity can be used to forecast forest fire. In general, RH> 75%, does not fire; RH at 55%~75%, a fire may occur, RH at 30%~55%, may be a major fire; RH <30%, catastrophic fire may occur. But if long-term drought, more than 80% relative humidity may also fire. The relative humidity is high in the morning and evening; while the midday and afternoon sessions relative to the lowest, driest flammable fuel, is prone to forest fires in the period.

2

Daily Maximum Temperature

The daily maximum temperature on the impact of forest fires

$$r_1 = \begin{cases} \dfrac{1}{1 + \left(\dfrac{1}{5}(20 - x_1)\right)^4} & x_1 < 20\,^\circ C \\ 1 & x_1 >= 20\,^\circ C \end{cases}$$

r1 is determined by a single factor in determining the contribution of high fire risk value(%). x1 is the highest temperature of the day, where the temperature is 14:00 as the maximum temperature of the day. At 14:00 the temperature is low, especially in the following 8°C the risk of fire basically no; temperature is between 8°C and 12°C, the degree of risk of fire is gradually increasing; at between 12°C and 20°C, the rapid changes in the risk function, in the low to high transition phase fire should pay particular attention to possible fire; special attention will be above 20°C.

3

Diurnal Temperature Range

The diurnal temperature range effects on forest fires

$$r_2 = \begin{cases} \dfrac{1}{1+(\frac{1}{10}(25-(x_1-x_2)))^6} & (x_1-x_2) < 25\,^{\circ}C \\ 1 & (x_1-x_2) >= 25\,^{\circ}C \end{cases}$$

(x1-x2) is the single factor reflected by the diurnal temperature high fire risk contribution value (%).x1 is the highest temperature of the day, and x2 is the lowest temperature of the day, where the temperature of 2:00 is the minimum temperature of the day. Under normal circumstances, when (x1-x2)<12°C, cloudy, rainy and foggy weather phenomenon more, so difficult to fire; while (x1-x2) is between 12°C and 20°C, the great increase in the degree of risk of fire; when(x1-x2)>20°C, weather controlled by high pressure situation, the performance of sunny, daytime warming intense , afternoon the wind speed increases, the fire to maintain a higher state.

4

24 Hours of Precipitation

24 hours precipitation effects on forest fires

$$r_5 = \begin{cases} \dfrac{1}{1 + x_5^{3}} & x_5 > 0\,mm \\ 1 & x_5 = 0\,mm \end{cases}$$

r5 is reflected in the 24 hours of high fire risk precipitation contribution value (%). x5 is precipitation of 24 hours. Changes in precipitation curve was smooth downward trend, with increasing precipitation, fire danger index declining. When rainfall is less than 1mm, you are in a high fire danger and fire trend will not significantly decrease. At this time if precipitation decreased, it will again appear high fire condition.

5

Wind Speed

The wind speed effects on forest fires

$$r_6 = \begin{cases} \dfrac{1}{1+\left(\dfrac{1}{12}(7-x_6)\right)^{14}} & x_6 < 7m/s \\ 1 & x_6 \geq 7m/s \end{cases}$$

r6 is the single factor reflecting the contribution of high fire risk value (%). x6 is as measured ground 10m~12m height average wind speed at 14:00. In the north the wind and precipitation generally occur simultaneously, so the wind speed measurements to eliminate the influence of its precipitation. W

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THANK YOU