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Research on the location by the use of shadow

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Abstract. Determining the location of videos is an important research direction of video data analysis. Sun shadow positioning technology(SSPT) is a method which was used to fixed position based on analyzing the changes of the sun shadow . Through the analysis of the shadow length data, the relationship between the two functions of the shadow length and time can be obtained. Then through the shortest length of the shadow , the longitude can be found .Finally we can use the genetic algorithm to calculate the latitude on the basis of the known of longitude .

Introduction

Video has become an important way for people to obtain information sources in twenty-first Century. So when we analysis the data , how to determine the location of the video in a number of professional fields is very important .Sun shadow positioning technology(SSPT) is a method which was used to fixed position based on analyzing the changes of the sun shadow , Orientation of the object , length of the object in the video and Local latitude and longitude。

Because of we use cross ratio invariability theory , Vanishing point principle for the measurement of the position and length of an object and the changes of shadow mainly due to earth's rotation and revolution around the sun ,so we can get the shot location of the video by changes in shadow parameters .

In this technology, we mainly consider the following aspects：

（1） Establish the model of the change of the length of the shadow and analyze the relationship among the factors.

（2） On the assumption that the date is known, we can try to find out the location of the shooting video according to the shadow length parameters obtained from the video on the basis of the conclusion .

Some analysis and establish the first model

The shadow length of a fixed height object at different time and different place is different. We can assume that shadow length is a function of object height, latitude and longitude, date and time. Then, we will find the functional relationship between the variables and establish a model to find the location of the shooting.

We need to have an understanding of the sun's direct angle, the angle of the red and the azimuth, before establishing the function relationship And gives a picture of the sun shadow map length change .

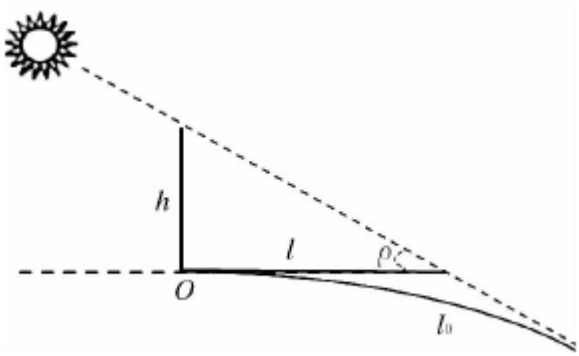

Fig. 1 The simplify sun shoot angle figure

Because the radius of the earth, the earth's surface objects in the shadows can be replaced by the tangent plane shadow long pole. So the equation of rod height and shadow length can be established:

$$h = l * \tan\rho = \frac{l*\sin\rho}{\sqrt{1-\sin^2\rho}} \quad (1)$$

We can find such equations in astronomical calendar:

$$\sin\rho = \sin\varphi * \sin\delta + \mathrm{con}\varphi * \cos\delta * \cos\omega$$

ρ-- Solar zenith angle φ—latitude δ-- Latitude angle ω-- Solar hour angle

The sun's latitude angle is related to the date in this equation:

$$\sin\delta = 0.39795\cos[0.98563(T - 173)] \quad (2)$$

for example T=1 Express January 1st,T=365 Express December 31st ;

the sun angle angel is the center of the sun surface which we can get by Beijing time .

$$\omega = 15^\circ * [t + \frac{120^\circ - \varphi}{15^\circ} - 12] \quad (3)$$

Then we can get the three relations between these parameters which has already been declared above .

The change curve of the object's shadow length

We can know from the established model that the change curve of the object’s shadow length in Beijing time from 3pm to 5pm on September 22 , 2015.And $\varphi = 116.39$ $h = 3$ $T = 256$. Then we draw the curve of the change of time by MATLAB .

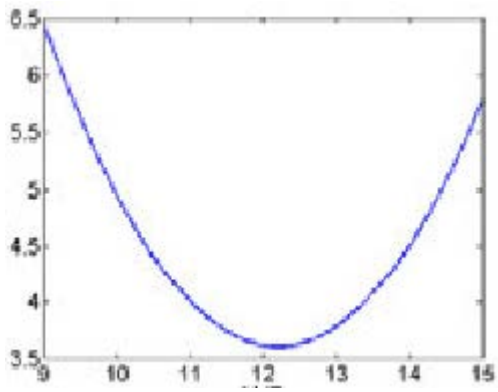

Fig. 2 The curve of change

The shortest shadow length appeared at Longitude 120 degrees, twelve Beijing time . And we found that Every four minutes, once the west longitude .And we can use the found to seek for the shooting place of video .

We can found how shadow change during one day, the longest in the morning, noon the shortest. And this relationship can be built into a parabolic model. So get the conclusion that the smaller the solar zenith angle, the longer the shadow is.

The concrete application of some actual data

First of all, we have a set of shadow parameters in April 18, 2015. We need to establish a two mathematical model .And analyze should be carried out on the shadow length and time based on MATLAB. From the fitting curve we can see that the shadow length is at 12:44, and due to the 'Every four minutes, once the west longitude', we can get the local longitude is 108.96°.

Then can use the genetic algorithm to find the best matching latitude locations. The basic idea of the algorithm is as following : first , choose $\left(-90^{\circ}\mathrm{N}\ ,\ +90^{\circ\mathrm{N}}\right)$ as search scope 。 Then put 1 degree as a span to traverse all points on the longitude. Choose minVar(hi) as a rough search solution . We randomly generate some points as the initial population at the point of 10 degrees. Then we judge whether we can meet the requirements by crossing the variance and some comparison.

Here we will show the specific process of our algorithm:

Step1 calculate the variance of each point by one which between $\left(-90^{\circ}\mathrm{N}\ ,\ +90^{\circ\mathrm{N}}\right)$

Step2 choose the points of minVar(hi) and turn them into a curve

14 : 42	1. 0365	0. 4973	1. 1496
14 : 45	1. 0699	0. 5029	1. 1822
14 : 48	1. 1038	0. 5085	1. 2153
14 : 51	1. 1383	0. 5142	1. 2491
14 : 54	1. 1732	0. 5198	1. 2832
14 : 57	1. 2087	0. 5255	1. 3180
15 : 00	1. 2448	0. 5311	1. 3534
15 : 03	1. 2815	0. 5368	1. 3894
15 : 06	1. 3189	0. 5426	1. 4262
15 : 09	1. 3568	0. 5483	1. 4634
15 : 12	1. 3955	0. 5541	1. 5015
15 : 15	1. 4349	0. 5598	1. 5402
15 : 18	1. 4751	0. 5657	1. 5799
15 : 21	1. 5160	0. 5715	1. 6201
15 : 24	1. 5577	0. 5774	1. 6613
15 : 27	1. 6003	0. 5833	1. 7033
15 : 30	1. 6438	0. 5892	1. 7462
15 : 33	1. 6882	0. 5952	1. 7901
15 : 36	1. 7337	0. 6013	1. 8350
15 : 39	1. 7801	0. 6074	1. 8809
15 : 42	1. 8277	0. 6135	1. 92

Table 1 The test data

Step3 randomly generate some points as the initial population at the point of 10 degree

Step4 Minimum binary encoding for initial population

Step5 Selecting the best individual and selecting, crossover and mutation genetic operation . Repeated

Step6 To determine whether to meet the termination conditions and the final selection of the best individual

Finally we get the conclusion :

variable	Rough solution	exact solution	Real location
latitude	19°N	17°24′7975″N	18.3°N
longitude	109°E	110°51′1037″E	109.5°E

Table 2 Our conclusion data

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