Video Location Positioning Study Based on Two Steps Greedy Algorithm

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***Abstract*—Determining the location and date of photos and videos is needed in some fields, such as production, public security, public opinions and information. But most photos and videos coming from networks or unclear anonymous sources have no clear information about the photographers and no signs of the location and date, which causes great difficulties in telling the true from the false and maintaining the public liability. It is also an obstacle of confirming and obtaining the evidence in cases. Thus, it is of great significance to clearly confirm the location and date of photos and videos rapidly. Base on the data of the changing lengths and angles on shadow objects in photos and videos, this paper use two-stage greedy algorithm to reduce the errors between the calculation place and the real place gradually for consequently to get the general latitude and longitude of the place. It also discusses the differences of knowing the specific date of the target and not. This method can be used to calculate the latitude and longitude with the shadow information provided by the photos or videos whose time spans are more than 30 minutes. And the error will be in 0.5 degree. The running time is saved above 70% related to the Grid Search.**

Keywords-video shooting point positioning; step two greedy algorithm; photo video information extraction

I. INTRODUCTION

Extracting the shooting location information from the photos and videos has a great help to the obtaining of the legal question and the induction of the shooting location information. With the development of the electronic technique, the internet is full of the photo of no source and no author. In some important occasions, we have to locate the photos and the videos quickly and effectively, so extract the information of photos and videos quickly is becoming more and more important.

Forde E.S. [1] and some other people studied about the time model and the outdoor exposure information of digital camera, implemented the rough localization of digital images by querying the database. This method has an obvious effect if we know the type of the digital camera. But if the camera is not special, or there are no camera information in the photos and videos, we can't get the information of exposure time, posting can't effectively. Jacobs N. [2] and some other people determined the relative position of cameras by identifying the connection of weather situation shot by a massive cameras. But this method can only be used in location of Large-scale monitor group. It cannot be used in locating single photo. Relevant references shows that extracting the video or image point shooting location information is necessary.

We use the 40 minutes continuous video of a straight-bar taken in a sunny day as the data of the study {www.mcm.edu.cn}. We extract the video's location information from the change data of straight-bar's shadow with the passage of time on the level ground. As shown in figure 1, we cut out three picture of the video's start, medial, and the end. We can see that the degree and length of the straight-bar's shadow changed because the relative position of the sun changed as time goes on. Figure 2 is the schematic diagram of straight-bar and the shadow in Figure 1. Shadow A, shadow B, and shadow C, respectively showed the shadow of the same straight-bar in different time.

Reference [3] shows that According to the rules of the solar system, object's length and legal has the function relationship with latitude, longitude, date and the time of the day. The relationship confirms the feasibility of the position with object's shadow information in this paper.

FIGURE I. 40 MINUTES VIDEO DATA DIAGRAM

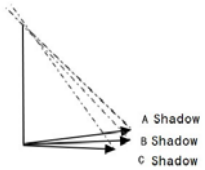

FIGURE II. THE SHADOW DATA CONTRAST

In order to obtain accurate positioning information on the location, Based on the literature, we first extract shadow length and angle straight from the video image with combination of three-dimensional computer reconstruction techniques [4,5]. Then compared the strength and weakness of pinpointing the location in grid search algorithm, greedy

algorithms, two steps greedy search algorithm and other methods. By discuss the different ways in the given date information and not. The final found shows that two steps greedy search algorithm [6,7] obtains a higher location targeting efficiency. The accuracy, however, are basically the same.

II. THE EXTRACTION OF VIDEO AND IMAGES IN THE LENGTH OF THE SHADOW

To quickly locate object's shoot place, we must extract the shadow length data and the shadow degree data from the videos and the photos. Principle of small hole imaging [8] shows that image in the videos and photos is a kind of map which in real word 3d to Two-dimensional surface, in the process of Dimension reduction mapping, information loss is inevitable. Thus, we can't recover the 3d information completely using the 2d information in the image theoretically. Typically, in some special conditions such as the objects are upright and object distance can be estimated. We can design algorithm to extract the 3d object data such as relative length and relative degree.

Figure 3 shows the Imaging figure of 3d space to 2d.

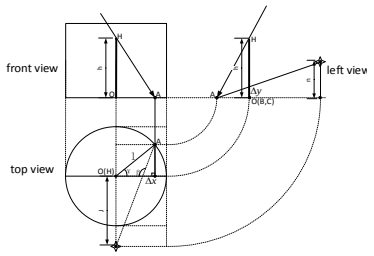

FIGURE III. THREE VIEW DRAWING OF STRAIGHT ROD PROJECTION

Among the figure, OH represents the straight-bar, segment HA represents the sunlight, OA represents the inverted image of straight bar in direct sunlight, Δx and Δy represent the variable quantity of horizontal ordinate. In order to improve a better point of view, T_{OA} is proposed to represent the Projection of OA .

According to the Pythagorean Theorem:

$$T_{OA} = \sqrt{(OA - \Delta x)^2 + \Delta y^2} \tag{1}$$

Δx , Δy is:

$$\Delta x = \frac{l^2 \cos(\alpha)\sin(\alpha)}{U + \sin(\alpha)} \tag{2}$$

$$\Delta y = \frac{nl\sin(\alpha)}{U} \tag{3}$$

The four star sign in Figure 3 means the positions of the cameras. The object distance of cameras is J , the height of the camera is n .

The function of T_{OA} and γ is:

$$T_{OA} = \sqrt{\left(OA - \frac{l^2 \cos(\gamma)\sin(\gamma)}{J + \sin(\gamma)}\right)^2 + \left(\frac{nl\sin(\gamma)}{J}\right)^2} \tag{4}$$

Through above ways, we get the shadow length data in some special time of the video shown in Table 1.

TABLE I. SAMPLE LENGTH OF THE SHADOW IN THE VIDEO

Time(clock :min)	8:54	9:05	9:14	9:21	9:29	9:34
Shadow length(px)	2.4068	2.3681	2.1717	1.9424	1.9284	1.7133

III. THE SHADOW LENGTH FACTOR ANALYSIS AND THE ESTABLISHMENT OF THE MODEL

We all know that shadow length is closely related to four variable, such as latitude, longitude, date and clock time (per minute). Solving the problem of shooting location can be translated into the following planning problems. The objective of the program is to find a combination of the four variables x, y, n, t that makes the length of the square quadratic minimal.

$$\min_{x,y,n} \sum_{i=1}^{n} (f(x,y,n,t) - g(x,y,n,t))^2$$
$$\text{s.t.} \begin{cases} 0 \le x \le 180.0 \\ 0 \le y \le 180.0 \\ 0 \le n \le 360 \\ 0 \le t \le 1440 \end{cases} \tag{5}$$

The variable x, y, n are on behalf of the desired location of the shoot longitude, latitude, date and time of the bell. Suppose that the function g(x, y, n, t) is the actual shadow that is extracted from the picture and the function f(x, y, n, t) is on behalf of the shadow length calculated by the formula. The calculation formula is as follows.

$$f(x,y,n,t) = \frac{L}{\tan(\arcsin(m))}$$
$$\text{m} = \sin\alpha \sin y + \cos\alpha \cos y \cos\omega \tag{6}$$

$$\sin\alpha = 0.39795 \cdot \cos\left[0.98563 \bullet (N - 173)\right] \tag{7}$$

$$\omega = 15 \bullet \left(T + (120° - x)/15° - 12\right) \tag{8}$$

Formula (6) defines the shadow length as the ratio of the actual pole length to the solar elevation at local time; L represents the actual height of an object in the image; α represents solar elevation. The calculation of the solar altitude angle in Formula [3] has a detailed introduction. In formula (7), the sun declination is used as the calculation formula of the s solar elevation. In formula (8), solar hour angle is used as the calculation formula of the s solar elevation. In the formula, α is on behalf of the date of the sun declination and ω represents the solar hour angle at that time.

IV. THE SOLUTION OF THE SHOOTING LOCATION

A. *Location Shooting Date is Known*

To solve this question, if we know the shooting date and clock, we can use the shadow length data (shown as Table 2) to solve the shooting location.

TABLE II. THE DATA USED IN THE SHOOTING DATE UNKNOWN PROBLEM

Shooting date	time	X coordinate(m)	Y coordinate(m)
2015-4-18	14:42	1.0365	0.4973
	14:51	1.1383	0.5142
	15:00	1.2448	0.5311
	…	…	…
	15:33	1.6882	0.5952
	15:42	1.8277	0.6135

Bring the date to our model, because the date is given, the problem can be converted into a searching problem that is finding out the smallest error in all the possible longitude and latitude (x, y) .

Assuming that the accuracy should limited between $\pm 0.5^{\circ}$, we find that this problem's calculated amount is small. It can be solved by the way of mesh search algorithm which is traversing all the possible longitude and latitude with the mesh interval of 0.5°, and computing the shadow length error.

The result of the question shown in Figure 4. We point out series of coordinate that have smaller error. The result of the arithmetic shown that the best answer is $(108.5°E, 19.5°N)$, the deviation to the realistic is less than 1% .

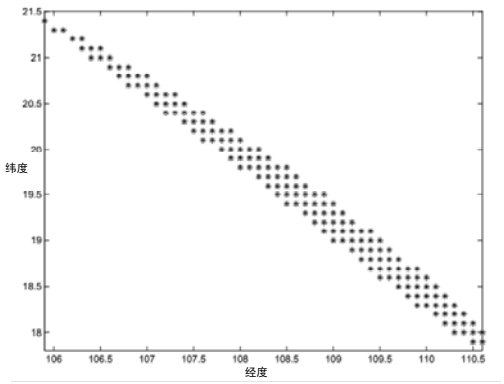

FIGURE IV. GET THE LATITUDE AND LONGITUDE IN THE ERROR IS LESS THAN 0.007

As shown in Figure 4, the distribution image is like a long strip. It is because that the time interval of shadow length data is too short so that the result can't be bound into a smaller range. But this kind of time interval data can also meet our requirements of finding the general shooting location. We think that increasing the time span of the data could shorten the length of the strip and let the solution be more accuracy.

B. *Location Shooting Date is Unknown*

Some photo or video only have the clock sign of the shooting, but not the shooting data information, (data of this kind of question shown as table 3), this kind of photo are also worth to be study. Solving such problems can theoretically use a larger dimension grid search method to simultaneously determine the latitude, longitude and date objects, but the search is so large that dimensions can significantly increase the cost of time and the timelines is poor.

TABLE III. THE DATA USED IN THE SHOOTING DATE UNKNOWN PROBLEM

Shooting date	time	X coordinate(m)	Y coordinate(m)
unknown	12:41	-1.2352	0.173
	12:53	-1.1281	0.2356
	13:05	-1.0237	0.294
	…	…	…
	13:26	-0.8464	0.3876
	13:41	-0.7227	0.4484

In order to solve this problem, the paper compared some common arithmetic such as Grid Search, Greedy Algorithm, etc. A more efficient algorithm called two steps Greedy Algorithm is designed, which contains no less accuracy of the case, to improve the positioning of timeliness.

Grid search algorithm [9] is to divide the to-be-searched parameter into grids in a certain range space and to find the optimal parameters by traversing all the points in those grids. Under this method the optimization interval large enough and small enough to step away from the situation can find global optimal solution. Greedy algorithm [10] at the time of problem solving, always it seems to be made in the current fast algorithm for the best selection. That is, the algorithm greedy

algorithm does not consider the merits of the whole, can only get a sense of local optima.

The two steps greed algorithm in this paper rules the advantages of both. Two steps greedy algorithm is divided into two phases: the first draws on the operating characteristics of the greedy algorithm, locating on the approximate location to determine the solution step by step on the grid. By multiple random starting point of convergence to reduce its fall local minimum probability. The second phase draws characteristic of grid search algorithm using a small range of fine grid search, to ensure the accuracy of the solution.

Figure 5 is a detailed flow chart of two steps greedy algorithm convergence model. This model take random date, latitude and longitude as a starting point, by searching the shadow error in grid nodes nearby to find the optimal point in their local area. Then repeat the above steps, find the smallest error solution from the multiple local optima as the substitution of the global optimal solution.

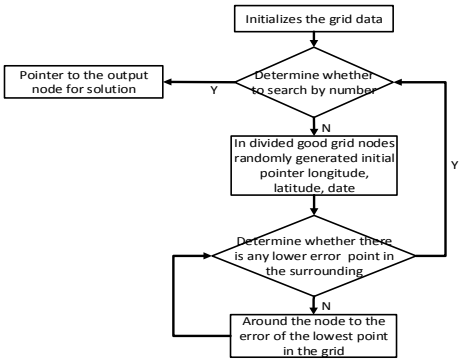

FIGURE V. TWO STEPS GREEDY ALGORITHM CONVERGENCE GRAPH

In order to centralize the optimal solution, the times should satisfy:

$$X > V / L \tag{9}$$

Where , V represents the number of the nodes in all grids , L represents the average length of mesh node.

Result of utilizing the three search algorithm for the video with unknown shooting date stand in a positioning $(79.23\,°E,\ 40.54\,°N)$ straight bar shown in.

TABLE IV. RESULTS OF THREE KIND OF ARITHMETIC

arithmetic	longitude (°E)	Latitude (°N)	Date (day)	Searching Time (hours)	error (km)
mesh search arithmetic	79.2	40.4	20/345	4.12	4.43
Greedy algorithm	79.0	40.4	20	0.05	25.77
greedy algorithm	79.0	40.6	345	0.12	25.63
greedy algorithm	15.6	42.4	45	0.15	7083.93
greedy algorithm	78.6	42.0	48	0.5	76.7725
two-stage greed search algorithm	79.2	40.4	20/345	0.32	4.43

Since the search grid search strategy is to visit all the grid nodes by traversing method, so there is no randomness, the result is very stable. But at the same time the cost is enormous, solving this problem takes a lot of time which can not meet the requirements. Greedy algorithm has been greatly improved in terms of time, but because of its search strategy to focus only on the local drop on error, search results relevant to the choose of the start position. Due to the fact that the starting position is in random of the search, so the results of Greedy Algorithm does not guarantee completely correct. To illustrate this, the table lists the same set of data greedy algorithm carried out four searches, only two can finally get the right result.

Two Steps Greedy method combines the advantages of the Greedy Algorithm and the grid search algorithm, works fast and stably. Of the time in 0.32 hours this question got its final result. The error is within 4.43km, the whole problem solved.

Use two greedy algorithm to solve the shooting position, Figure 3 shows the coordinates of latitudes and longitudes for all. The error is less than 0.003.

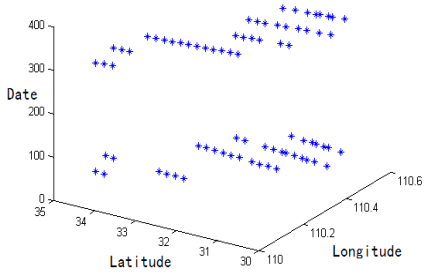

FIGURE VI. LATITUDE AND LONGITUDE INFORMATION DIAGRAM

Figure 6 shows that two greedy algorithm solutions have a symmetrical relationship with the intermediate date = 182 on the vertical axis, which is the result of the sun reciprocates between the south Tropic and north Tropic. Date unknown solution of the latitude and longitude problem shows in pairs.

Additionally, the points that is feasible solved by two steps greedy algorithm draw in Figure 6, an inclined plane exists. This means that when the optimal date changes, the optimum latitude and longitude will have minor changes. Considered that a slight shift in solving the permissible error range.

V. MODEL TEST AND CONCLUSION

A. *Standard Deviation Test*

Obviously the length of the straight bar used for projecting is constant. This paper utilizes the length of shadow that has been obtained and the calculated sun elevation angle data to get the straight bar length. Thereby standard deviation of images obtained as a test target.

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[L_b(i) - \overline{L_b}\right]} \tag{10}$$

Where , σ represents the standard deviation of the straight bar length , $\overline{L_b}$ represents the average value of the straight bar length. , $L_b(i)$ represents the straight bar length calculated by formula as:

$$L_b(i) = f(\mathrm{i}) / \tan\left[\theta(i)\right] \tag{11}$$

Angle $\theta(i)$ is solar elevation angle obtained before.

Examining the longitudes, altitudes and time obtained via two steps greedy algorithm, the result is as the figure below:

TABLE V. THE RESULTS OF STANDARD DEVIATION TEST

Longitud(°E)	Latitude(°N)	Date (day)	Standare deviatition
79.2	40.4	20	0.0004
79.2	40.4	345	0.0003

B. Conclusion

Mathematical model can successfully determine the position of the shadow, calculate the approximate position of the object by the given parameters in a short time (14 minutes). This method can be used to determine not only the date and location of the photo shoot, but also video shooting location information, which improves the ability to obtain information from the picture.

Further image information extracted is the tendency in the soaring information age. The importance of information is unparalleled. Above method can determine the location of the photo and the approximate date from multiple sets of photos, it can be applied to fields like information science, image analysis science and etc.

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