Control Algorithm of Control of Start and Stop of Data Collection of Dynamic Detection of Airport Flight Aid Light

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***Abstract*—To the problem of control of start and stop position of data collection of airport flight aid light light intensity dynamic detection system, control algorithm based on weight sum function was proposed. The algorithm uses weight sum functions constructed to control the start and stop of detection of light intensity dynamically according to the position of vehicle and illumination values detected, which ensures the full collection of data using to draw isocandela diagram and calculate average light intensity. Experiments showed that this algorithm makes airport flight aid light light intensity dynamic detection system can control start and stop position of data collection reliably, which ensures the integrality of isocandela diagram generated.**

***Index Terms*—weight sum function, flight aid light, dynamic detection, light intensity, isocandela diagram, artificial intelligence**

I. Introduction

Dynamic detection of light intensity of airport flight aid light is a kind of fast detection method of flight aid light in cite. Taking vehicle as holder, sensor belt equipped with 13 illumination sensors is used to collect illumination data continually in the process of running of vehicle. The data collected are changed to light intensity values, based on which isocandela diagram is generated and average light intensity is calculated[1-4].

Control of start and stop of collection of illumination data in dynamic detection of airport flight aid light is one of the key technologies of the system. Light emitted from flight aid light has strong directionality. Data of one tangent plane of main beam of light are collected to generate isocandela diagram in dynamic detection of light intensity. But because of the limitation of storage capacity of computer, it is impossible to collect data of the whole tangent plane. So it is just the data near the centre of the beam and being useful for judging working status of flight aid light are collected, which needs to control the start and stop position of data collection.

Light intensity of light is related with both interval between illumination sensor and light source and illumination detected. A Doppler ranging radar sensor is used to measure the interval in a non-contact manner. Because of the different status of different flight aid light and error of interval measurement caused by initial aiming straight, illumination values detected using illumination sensors and interval measured at the start or stop position of data collection are different to different light.

Recently, artificial intelligence technology has been used more and more in control system, which can overcome some faults of traditional control method and promote precision of control[5-8]. Control of start and stop position of data collection must face the random change of illumination values and interval measured, which makes it hard to control start and stop position of data collection using normal control method. So artificial intelligence technology was introduced to the control system.

In this paper, two weight sum functions were constructed according to experience data of detection. One decides start position, another decides stop position. Two weight sum functions consider changes of illumination values and interval measured synthetically, set the weight relationship of different illumination sensors and interval measured in decision of start or stop data collection through setting different weights to them, use weight sum value of illumination values detected using different illumination sensors and interval measured using Doppler radar sensor to control the start or stop of data collection. Experiment was taken using actual data, result verified the good performance of the control algorithm in control of start and stop of data collection.

II. Dynamic Detection of Light Intensity of Flight Aid Light

There are two kinds of airport flight aid light, pole and inset. Commonly, flight aid light is halogen lamp, the power of which can reach to 200W. The light given out from airport flight aid light is linear polarized light, which has directionality. Inset flight aid light has very strong directionality, light emits to one or two directions as a beam. Figure 1 is the diagram of side and front view of polarize light.

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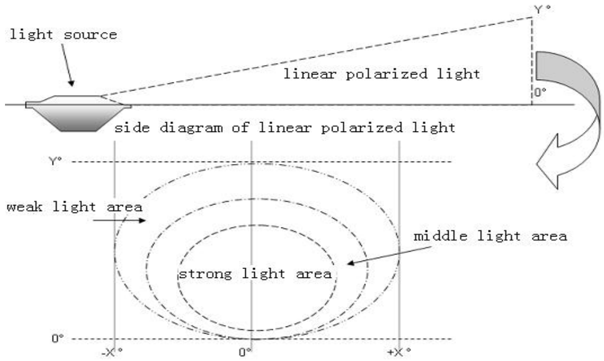


Fig.1 Side and front view of polarize light

Dynamic detection of flight aid light judges working status of flight aid light by detecting the isocandela diagram of the light. Isocandela diagram is a common method to indicate light intensity of light. On a virtual spherical surface, curve made by connecting points of same light intensity is named isocandela curve. Isocandela diagram is the combination of a series of isocandela curves. The horizontal coordinate is the horizontal angle between detection point and light point position. The vertical coordinate is the vertical angle between detection point and light point. Different fault of flight aid light lead to different isocandela diagrams. So, fault of flight aid light could be found out by analyzing the isocandela diagrams[9-10]. Isocandela diagram as shown in figure 2.

Light intensity measurement of flight aid light is taken according to theory of square inverse ratio and theory of cosine. That is light intensity is related with input angle, and is related with illumination and distance to light source. The formula of which is shown in formula 1.

$$I = LD^2 . \quad (1)$$

Where I is light intensity of light, unit is Candela; L is illumination of light, unit is Lux; D is interval between detection point and light source, unit is m.

There are 13 illumination sensors distributed parallel and non-uniform on the front of sensor belt as the illumination detection system. On the back of bottom of sensor belt are 11 location sensors that constructs location system using to detect whether the sensor belt being above the light source. Doppler radar is installed on the back of the vehicle as the ranging system. When

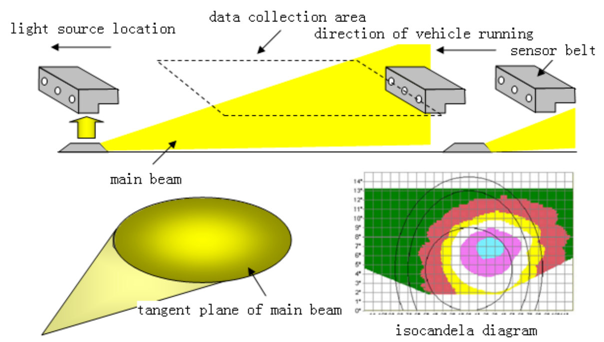


Fig.2 Note how the caption is centered in the column.

detecting, vehicle runs facing light source and along centre line of arrangement of flight aid lights in 40 Km/h. In some range of main beam, taking interval of 1cm, illumination value and interval between detection point and light source are collected using computer of the system. And then the data collected are changed to light intensity values and border search is taken to draw isocandela diagram and calculate average light intensity. As shown in figure 2.

Detection can be divided into 3 stages. They are initial aiming straight, data collection, light source location. Because of reasons of operation error of deriver, vehicle itself, and so on, running of long distance might cause vehicle going away from centre line. Driver must drive the vehicle back to the centre line. This happens between the end of detection of the former light and the start of data collection of the current light. So this stage is called initial aiming straight. After initial aiming straight stage, driver will not adjust the direction of vehicle until the end of light source location stage. Initial aiming straight might make vehicle run extra distance, which would make errors in interval measurement. System collects data of flight aid light in data collection stage. After data collection, system will locate the light source in light source location stage.

Let interval between two lights is r, count of pulses output from Doppler radar ranging sensor is n, distance of a single pulse is v. The distance between detection point of location sensor and detection point of illumination sensor is d_b . Then interval between detection point and light source measured in realtime D_r is :

$$D_r = r - nv - d_b . \quad (2)$$

Thinking of the error Δd caused by initial aiming straight. Actually, Δd can be gotten in light source location stage. Let D_l is interval measured on location point of light source, then:

$$\Delta d = D_l . \quad (3)$$

Interval of data collected D can be corrected as:

$$D = D_r - \Delta d = D_r - D_l . \quad (4)$$

Let $\mathbf{l}=(l_1 \quad l_2 \quad \cdots \quad l_{13})$ is the standard illumination value vector detected by 13 illumination sensors of one type of flight aid light, where $l_i (i = 1,\cdots,13)$ is standard illumination value detected by No. i illumination sensor. Thinking of difference $\Delta l_i (i = 1,\cdots,13)$ caused by different light status, actual collected illumination value $l_{ai} (i = 1,\cdots,13)$ is:

$$l_{ai} = l_i + \Delta l_i , \quad i = 1,\cdots,13 . \quad (5)$$

So the actual collected illumination value vector is $\mathbf{l}_a = (l_{a1},\cdots,l_{a13})$.

Control of start and stop data collection is in data collection stage. In this stage, Δd can not be eliminated and $\Delta l_i\,(i=1,\cdots,13)$ can not be ignored. In this case, D and $\mathbf{l}_a$ must be think of synthetically to control the start position and stop position of data collection in order to ensure the integrality of isocandela diagram generated.

III. Construction of Control Algorithm

Two weight sum functions are constructed. One is for control of start of data collection, another is for control of stop of data collection. They are:

$$\begin{cases} y_s = \mathbf{w}_s(\mathbf{w}_{sl}\mathbf{l}_a{}^T / l_s, (r-D_r)/(r-d_s))^T \\ y_e = \mathbf{w}_e(\mathbf{w}_{el}\mathbf{l}_a{}^T / l_e, D_r / d_e)^T \end{cases} . \quad (6)$$

Where $\mathbf{w}_s = (w_{s1}, w_{s2})$ is weight vector of start control, $\mathbf{w}_{sl} = (w_{sl1},\cdots,w_{sl13})$ is illumination weight vector of start control, l_s is illumination standard value of start control, d_s is interval standard value of start control, $\mathbf{w}_e = (w_{e1}, w_{e2})$ is weight vector of stop control, $\mathbf{w}_{el} = (w_{el1},\cdots,w_{el13})$ is illumination weight vector of stop control, l_e is illumination standard value of stop control, d_e is interval standard value of stop control.

Actually, $\mathbf{w}_{sl}\mathbf{l}_a{}^T / l_s$ and $\mathbf{w}_{el}\mathbf{l}_a{}^T / l_e$ are the ratio of weight sum of illumination values detected using 13 illumination sensors to some a standard value. $(r-D_r)/(r-d_s)$ is the ratio of running distance value to some a standard running distance value. D_r / d_e is the ratio of interval value to some a standard value. Result of weight sum function is weight sum of two of the ratios.

Parameters of weight sum functions are taken according to experience of experiment. Different type of flight aid light may take different parameters because of the difference among them.

The control value is

$$\begin{cases} y_s \ge 1, \text{start} \quad \text{collection} \\ y_s < 1, \text{don't} \quad \text{start} \end{cases},$$

$$\begin{cases} y_e \le 1, \text{stop} \quad \text{collection} \\ y_e > 1, \text{don't} \quad \text{stop} \end{cases}.$$

Control of start and stop of data collection begins from initial aiming straight stage, so the control algorithm is:

(1) Detect illumination values and interval value, calculate y_s value;

(2) If $y_s < 1$ then go to (1), else go to (3);

(3) Detect illumination values and interval value and save them to buffer, calculate y_e value;

(4) If $y_e > 1$ then go to (3), else go to (5);

(5) Stop data collection and go into light source location stage.

IV. Experiment and Analysis

Taking runway centre light for example, the value of weights adopt:

$$\mathbf{w}_s = (0.600, 0.400),$$

$$w_{sli} = 1/13 \approx 0.077, \quad i = 1,\cdots,13,$$

$$l_s = 110,$$

$$d_s = 6.300,$$

$$\mathbf{w}_e = (0.600, 0.400),$$

$$\begin{cases} w_{el1} = w_{el13} = 0.150 \\ w_{el2} = w_{el3} = w_{el12} = w_{el11} = 0.100 \\ w_{eli} = 0.300/7 \approx 0.043 \end{cases},$$

$$l_e = 45,$$

$$d_e = 0.300.$$

Because runway centre light is inset light. From figure 2, it can be seen that to inset light, the range of light covers all the sensor belt at the start position of collection, the range of light is limited to the centre of the sensor belt at the stop position of collection. So the 13 weights of illumination of start control are equal to each other to 1/13. And the weights of illumination of stop control are different to each other, the weight values are smaller near the centre and larger near the two sides, which can make controller be sensible to the steep decrease of illumination of two sides and very sensitive to the control of stop of data collection.

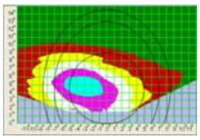
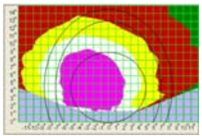
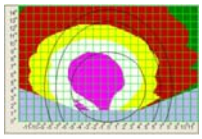
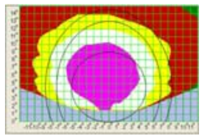
Weight vector of start control and weight vector of stop control make interval distance measured and illumination value detected contain the error of each other. Take start control for example. Weight of illumination value is close to weight of interval distance measured. So only both of the conditions of illumination value and interval distance measured be satisfied could the controller start the data collection. Because of the error in initial aiming straight stage of interval distance measurement, the weight of illumination value is a little bigger than that of interval distance measured. If the error of interval distance measurement was big in aiming straight of vehicle, the interval distance measured would reach to the standard value early. But in this time, the illumination value was far from the standard value, so the start of data collection would not be taken until the illumination value reached to the value very near the standard value, and the position was in the start position desired accordingly in this time, which will prevent the precision of start control from being influenced by the error of interval distance measured. On the other hand, if filament of the flight aid light was aged, the light emitted from the light would be weak. So the position of standard value of illumination would be too close to the light to draw isocandela diagram integrally. In this time, interval distance measured would make start of data collection ahead of the position of standard value of illumination, which could insure the integrality of isocandela diagram.

Some illumination values and interval values in start position or stop position of data collection of continuous 4 runway centre lights of 15m interval distance were chosen to test the control algorithm. The data and control result are listed in table I. Dis is the interval value between detection point and light source, C*i*(*i*=1, …,13) is illumination value detected using No. *i* illumination sensor. It can be seen from the test result that control algorithm can get the control result correctly. The isocandela diagrams of the lights in table I are listed in table II.

TABLE I
TEST RESULT OF CONTROL ALGORITHM

Light No.	Dis	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	y_s	y_e
1	6.203	78	127	129	47	168	174	182	103	131	63	69	112	62	1.010	
	0.283	38	60	57	60	78	66	74	29	27	25	24	17	0		0.869
2	6.422	119	170	134	73	164	160	154	92	102	73	69	91	48	1.002	
	0.005	20	74	46	50	92	126	127	33	71	40	35	50	0		0.629
3	6.152	81	165	119	130	144	168	138	107	97	64	60	88	53	1.000	
	0.057	29	63	40	4	105	157	150	86	104	29	35	62	0		0.731
4	6.271	90	103	105	110	157	177	153	130	124	85	76	70	60	1.005	
	0.009	20	78	47	46	127	196	206	123	163	42	57	68	0		0.902

TABLE II
ISOCANDELA DIAGRAM

Light No.	**1**	**2**	**3**	**4**
isocandela diagram				

It can be seen that the isocandela diagram generated is integrated and correct, which verifies the effectivity of the control algorithm.

V. CONCLUSION

To the problem of start and stop position control of data collection in light intensity dynamic detection system of flight aid light, control algorithm based on weight sum functions was established. Taking experience data as parameters, control algorithm can find start and stop position of data collection automatically and precisely, which ensures the integrality of isocandela diagram generated. Through experiments, the usability of the control algorithm was verified.

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