Method of concurrent detection for multiple light sources position by using the PSD

Shiyuan Yang^{a,*}, Kiyotada Matsura^a, Shun Inoue^a, Fenghui Yao^a

^aKyushu Institute of Technology, 1-1 Sensui-cho Tobata-ku Kitakyuusyuu-shi Fukuoka-ken, 804-8550, Japan

*Corresponding Author: yang@elcs.kyutech.ac.jp

Abstract

Now, in the field of medical and ergonomics, using a device using a LED and a plurality of two-dimensional PSD camera, we have analyzed the behavior of a person. It is necessary to detect the position of each of the LED, this device, you must synchronize the two-dimensional PSD camera and LED. In this study, we propose a method for detecting the position of the plurality of light sources at the same time without synchronization. After the LED modulated to a plurality of different frequencies and received by the PSD, extracted by the frequency filter. Thus, it is not necessary to synchronize the PSD and the LED, it is possible to detect the position light sources at the same time a plurality for communication without wired or wireless I enabled.

1. Introduction

Currently, an apparatus using an LED and a plurality of two-dimensional PSD camera for medical care in the field of ergonomics, analyzes the operation of the person is used. This device, we have analyzed works by attaching the LED to the parts of the body that you need to analyze the behavior of the person, to get a continuous two-dimensional spatial coordinates of the LED in the two-dimensional PSD camera. The control device is first connected to the two-dimensional PSD camera to select one of the plurality of LED Specifically, lit. Then, the two-dimensional coordinates of the LED to obtain it in a two-dimensional PSD camera, turn off the LED. Then select another LED, the same processing is performed. By repeating at a high speed for all LED this behavior, we obtain at the same time

the coordinates of a plurality of LED. In other words, it is necessary to synchronize the processing of each of the PSD camera the two-dimensional LED and when to obtain the two-dimensional coordinates of the LED its PSD camera and two-dimensional timing to light the particular LED to match. In short, LED must be connected by a wired controller which is connected to the two-dimensional PSD camera. Therefore, when the LED is attached to the person, so that a wired connection, there is a problem felt by weight, the hard work, the operation of the wearer decreases. In addition, since it is necessary to perform processing at high speed, the number of the LED to be mounted is limited.

After the modulation frequency different to a plurality of LED is the light source was received by the PSD, by incorporating the BPF to extract the frequency of their respective, in this study, a technique we simultaneously detect the position of each light source asynchronously where proposed. This approach, because there is no need to connect wired the LED, the operability is improved. Moreover, in order to incorporate a BPF in parallel by the number of the LED to be mounted, can be detected all at the same time the position of the LED's, you can further speed processing becomes possible, increasing the number of the LED can be mounted. In addition, this paper proposes a method to obtain a two-dimensional coordinates by using a combination of two rod lenses and one-dimensional PSD. This allows the two-dimensional PSD camera than has been conventionally used to obtain two-dimensional coordinates I can be inexpensively. Using a combination of one-dimensional PSD and rod lens as a basis, the paper, he tried to simultaneous detection of one-dimensional coordinates of the two light sources.

2. Principle

2.1 Principle and Configuration

As shown in Figure 1, to obtain a one-dimensional coordinates of the light source, using one-dimensional PSD, the light source (LED infrared), and a lens lot. Condensed by the rod lens infrared LED light is diffused, thereby forming an image on the light receiving surface of the PSD. for light source is received by the PSD, the current is output from the two electrodes of the PSD. By determining the ratio of the two current electrodes, determining the coordinates of the light-receiving surface of the PSD of the light irradiated from the light source. With another mechanism described above, the X-Y two-dimensional coordinates can be obtained.

Be modulated to different frequencies, for the plurality of light sources is arranged on the one-dimensional coordinate. Extracted by the filter circuit current at the same time by irradiating them in the PSD, is output from the PSD. The extraction ratio of the output is obtained on the light receiving surface of the PSD center-of-gravity point for each spot light was irradiated from the plurality of light sources. Finally, to detect one-dimensional coordinates for center of gravity obtained from the light source, and the ratio of the distance from the light source applies a one-dimensional coordinate rod lens of the rod lens and the distance of the PSD.

Figure. 1. Imaging of light by the rod lens.

2.2 Imaging lens

To collect light in general, the imaging lens to the object light irradiation. This time, in order to detect the position using a one-dimensional PSD, the light source is irradiated on a light receiving surface for one-dimensional PSD, I used a rod lens. Illumination lens unit applies the principles of the kaleidoscope, the rod lens, the light repeatedly reflected in the cylinder is characterized by uniform surface to the exit end. Adjust the one-dimensional PSD and perpendicular to the rod lens, disposed parallel to the light receiving surface of the one-dimensional PSD, so as to intersect at one point with respect to the light receiving surface of the one-dimensional PSD collecting light of the light source. Shows the state of the optical imaging of the rod lens in Figure 1.

2.3 Calculation of the position of the light source

Shows the principle for calculation of the position of the light source in Figure 2. One-dimensional PSD and perpendicular to the rod lens is disposed parallel to the light receiving surface of the one-dimensional PSD. In the 1.5 [mm] the radius of the rod lens, is imaged on the light receiving surface from the center of the light receiving surface of the PSD-dimensional, 1 X the distance to the origin O L, from the light source a distance to the origin O of the center point of the rod lens and x the distance of the image of the light source was, expressions such as equation (1) is satisfied.

$$\frac{X}{x} = \frac{L}{1.5} \text{-----(1)}$$

L is known, x is obtained from the output of the electrodes at both ends of a one-dimensional PSD. Thus, we can be able to calculate the distance X from the source origin O to detect the position of the light source.

3. Experiment

3.1 Detection experiment the position of the light source

As a basic experiment, experiment PSD position detection in one-dimensional, two light sources. Assume the influence of ambient light, experimental environment is performed in the dark room and under a fluorescent lamp. The two modulated 2 10 [kHz] for (LED2) 1 [kHz] and (LED1), two light sources are irradiated at the same time the PSD. I shows a one-dimensional coordinates used in the experiment in Figure 3. The origin point 1 [m] was down vertically from the light-receiving surface of the PSD, PSD parallel to the light receiving surface from the origin, setting the one-dimensional coordinates as the negative direction the positive direction, to the left toward the right. In addition, where the light source is installed, to detect the position light sources is set to -20 on the three-dimensional coordinate set 1 [cm], the origin, and 20 [cm]. Was established to coordinate, LED2, LED1 and X1, X2, respectively, were detected coordinates, LED2 , LED1 is the X_{m1}, X_{m2} respectively.

It also detects the position of the time in which only one light source is irradiated for comparison.

Figure.2 -The principle for calculation of the position of the light source

Figure. 3 One-dimensional coordinate set.

3.2 Experiment result

Shown in Table 1, respectively, in Tables 2 and 3, the results. Error, X_{m2} , X_{m1} to be minimized, the result is a value corrected. From the results of Table 1 and Table 2 showed a slightly larger error in the detection result of one light source. It is thought that this is because the accuracy of the device you have configured is low. It is also contemplated in the results in Table 3, there is error in position detection for two light sources, and at the same time possible to detect the position of the light source.

Table.1 One light source position detection result (under fluorescent light)

X1[cm]	Xm1[cm]	X2[cm]	Xm2[cm]
-20	-18.49	-20	-19.28
0	0	0	0
+20	21.51	+20	20.72
average error	1.01	average error	0.48

Table.2 One light source position detection result (under dark room)

X1[cm]	Xm1[cm]	X2[cm]	Xm2[cm]
-20	-18.29	-20	-20
0	0	0	0
+20	21.71	+20	20
average error	1.14	average error	0

Table.3 Two light sources position detection result (under fluorescent light)

X2[cm] X1[cm]		-20	0	20	Xm1 , average error
-20	Xm1[cm]	-20.38	-19.62	-21.51	0.75
	Xm2[cm]	-17.35	0	16.87	
0	Xm1[cm]	0	0	0	0
	Xm2[cm]	-16.39	0	19.76	
20	Xm1[cm]	18.87	21.89	18.87	1.38
	Xm2[cm]	-15.90	0	18.80	
Xm2 , average error		-3.45	0	1.53	

4. Conclusions

In this study, we have proposed the concurrent detection for multiple light sources position in which the modulation at different frequencies. I was able to show that the position of the light source can be detected at the same time more than the result for the experiment.

In the future, it is necessary to increase and improve the detection accuracy can be aimed at, the number of light sources in which the modulation is performed a number of experiments to investigate the upper limit that can be detected simultaneously.

References

- (1) Kenji Nishibori, avant-garde Ishikawa, Hiroshi Takashi Katagiri, people Nishibori Ken: "Measurement of distance and tilt angle of the mirror using the PSD and the light source LED", Transactions of the Japan Society of Mechanical Engineers, 72: pp.112-117, 2006
- (2) Takashi Takeda, Toyohiko Hayashi, Yasuo Nakamura, Issei Kato, Michio Miyakawa: "the position and orientation of the head measurement system using PSD camera", Technical Report of IEICE, MBE94-17: pp.127-134, 1994