The Luminous Intensity Data Acquirement Of Luminaries On A Photograph By Using Image Processing Techniques

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***Abstract*— Luminous intensity data is an indicator which describes the photometric properties of the luminaries. The basis of the photometric outputs of a luminaries can be obtained by using this data. In computerized design programs, the lighting design luminaires are mostly derived by using special formats obtained from luminaire luminous intensity data. The accuracy of simulations depends on the accuracy of the measurements. One of the leading traditional methods used to measure the luminous intensity data is using the mathematical output obtained from the measurements taken from a luxmeter where it should be placed to the luminous intensity formula, the angle and the distance. Instead of this operation requiring method, using the cameras becomes a more preferable measurement method with the increasing technology usage where it makes measurements more accurate with repeatability options and with fewer steps. Another advantage of the cameras over other measurements methods is making measurements with using less space. In the study, a method has been developed which obtains parallel values with direct luminous intensity and the photos obtained from the cameras by using image processing algorithms. Special filters are produced in order to apply this method on the armature photo.**

***Index Terms*— Luminous intensity data, goniophotometer, computer vision, image processing.**

I. Introduction

Light manufacturing, distribution, implementation and measurement are fundamental issues of illumination. The aim of the illumination is using the light as requested. The light comes from the source can be brought to the desired shape by using the luminiares. The luminiares are being used to regulate the lamp or to regulate, to filter or to change the light distribution of the lamp. The most important illumination application can be carried out by using the fitting luminaire in the proper places [1].

The photometric specifications of the luminaries must be known in order to make efficient illumination designs in these days, where energy efficiency is becoming increasingly important. One the most widely used photometric data are luminous intensity data for the illumination designs. Luminous intensity data is one of the main photometric units that give information about the distribution of the light of a luminaries.

Manuscript received February 6, 2014. This work was supported in part by Scientific Research Projects Unit of Süleyman Demirel University. (Project Number: 3191-YL1-12)

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Image processing algorithms have been used in various fields with the rapid development of technology. Due to high accuracy, image processing algorithms are often preferred for various error detection automations and measurement systems. Moreover, the photometric analysis can be done on smaller areas more effectively due to having analysis on the photos obtained from image processing artificial vision equipment.

Various studies are made in order to obtain the luminous intensity data on smaller areas. Muñoz-Martínez and their friends measured the photometric values by traditional methods in their studies. However, to reduce the size of the measuring device they have used two mirrors. The measurements of the device are tested which has a motion control mechanism and it was found that the measurements made by the device is suitable for commercial solutions [2]. Andersen has developed a special measurement device in order to get the right illumination for the buildings in his study. This device measures the photometric values with a maximum error margin of 10% by using digital imaging techniques [3].

II. Methods and Materials

Luminous intensity data gives detailed information about the distribution of light comes from the designed luminaries. They are some basic data types which provide information about the luminaries during the design process. These curves are generated by devices called goniophotometers. Goniophotometers are the devices used to measure the lightening level. Goniophotometric measurements, in general help determining the spatial distribution of the luminous intensity of a luminaire that shows in which direction and with how much flux of the light has gone from the luminaire [4].

In order to obtain the luminous intensity data traditionally, special photometric heads are being used. Luminous intensity data are being obtained by using the data obtained from these photometric heads and calculations based on the distance between the device and photometric head. In this study, computer vision equipment is used instead of photometric head. The light intensity was reached directly by using image processing algorithms on the images comes from computer vision equipment. Thus, the distance between the device and the computer vision equipment is reduced as much as possible which gives a possibility to make effective photometric measurements on a smaller scale.

With the prepared system, mostly pre-recorded available images are being processed. The images are being filtered by the image processing techniques, treated with various

conversion and display techniques, separated into components or being modeled [5].

With the rapid development of technology there has been developments on the measurements systems. Along with these developments by using cameras and computer technologies, it became possible to have measurement systems on a higher scale range and repeatable measurements. In addition to the camera application image processing algorithms increased the photo measurement features. Thus, the glare, the luminous intensity and color variations on the photo have become observable. The cameras unlike the classical photometric measurements, has a working principle based on superficial area light. Thanks to these features cameras are capable of multiple simultaneous photometric analyses [6]. And thanks again to these features photometric data can be obtained efficiently with the help of cameras.

III. Working Principle Of the System

A. Obtaining Luminous Intensity Data by Image Processing

In this study, the luminous intensity data calculations were performed by using various image processing algorithms on the taken images with the help of the cameras. The biggest advantage obtained in this study is having the distance between the camera and the goniophotometer shorter and shorter. This advantage makes large luminaries measurements possible. Also thanks to the shortened distance measurement environment has been reduced in size. Thus, the small companies can make their photometric measurements without special measurement rooms in small spaces. With these developments, each illumination company can obtain the luminous intensity data from the products that they are producing very easily.

The first step is taking pictures of the luminaries between the angle of 0 º and 180 º in order to calculate the luminous intensity data. The camera is fixed, and the luminaries is being rotated and the computer takes pictures automatically for every 5 º. Figure 1 shows that a total of 37 pictures are taken at different angles.

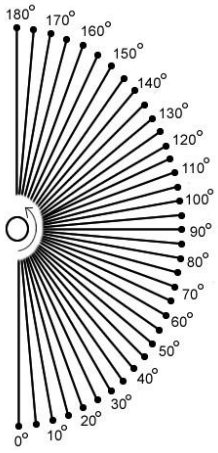

Fig. 1. Photographing angles

In Figure 2, there are 2 sample photos taken on angles of 30º and 60º.

Fig. 2. Taken photos on angles of 30º (right), taken photos on angles of 60º (left)

The created software is creating data for the analysis by using the 37 photos taken by the camera automatically and recorded to the computer. The photos are shown to the users on the software interface after completion of the photographing period. All photos are provided on the interface to the users with different angles which makes users to see the changes on the picture. On Figure 3, 37 photos are shown between the angles of 0º and 180º.

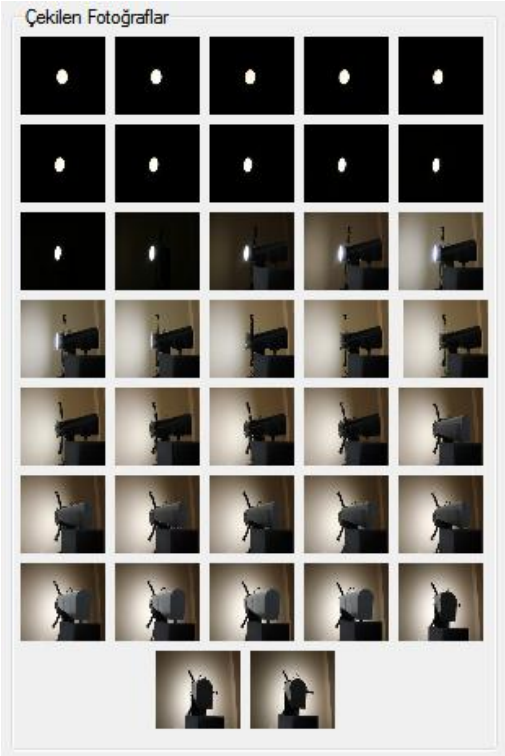

Fig. 3. Taken photos

After viewing photographs taken automatically at the interface, the luminous intensity is being calculated by using the prepared image processing algorithms. First the images are reduced to the grey colored level to avoid analysis to be affected from environmental colors. The formula on equation 1st is used in order to reduce the photos to the grey level.

$$I_{grey}(p) = \frac{I_R(p) + I_G(p) + I_B(p)}{3} \quad (1)$$

The photo is reduced to the binary level to have only luminous data on the grey leveled pictures. The formula on equation 2nd is used in order to reduce the photos to the grey level.

$$I_{bin}(p) = \begin{cases} 1 & \text{if } I_{grey}(p)d \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

According to the luminous threshold established with the formula on equation 2, there is only luminous data remained on the picture. Thus, the step has been achieved where the luminous intensity data from photographs can be reached. The images obtained on this level are shown in Figure 4.

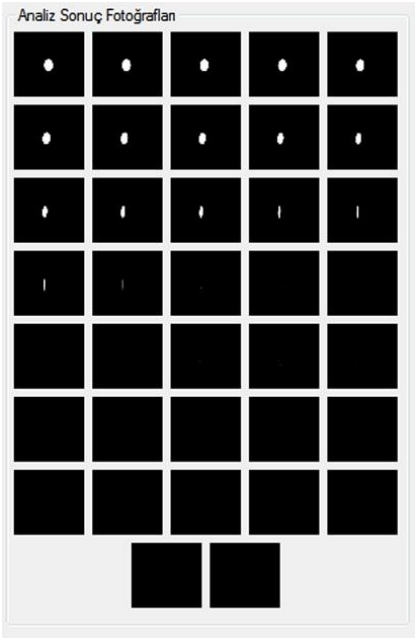

Fig. 4. Processed images

In the final stage, the luminous data is also obtained by subtracting the histogram for each processed image. Accordingly, in the right side of the photos of the histogram plot of concentration can be calculated based on the luminous intensity data. Because if the concentration is on the left side then the photo is dark, if on the right side then the photo is bright. According to this histogram comment, only right sides of the histograms are taken into the account to calculate the luminous intensity data. When the images are reviewed on Fig. 3, it can be observed that the pictures on an angle of 0° have the most powerful luminous intensity. Because the luminary is located directly across the camera at this angle. When it is located at 180° the luminous intensity is at the lowest level because the luminaire and the camera face to the same direction.

The formula on Equation 3rd is used for the luminous intensity data obtained by the measurements from the luxmeter for each angle value.

$$E = \frac{I}{r^2}.\cos\alpha \quad (3)$$

Both measurement values of the luminaries are shown on the interface in order to compare the measurements made with traditional measurement methods and image processing method. On Table 1st, the angle of the measurement, the luminous intensity data obtained from luxmeter and luminous intensity data obtained from the camera is shown.

TABLE I: LUMINOUS INTENSITY DATA

Analysis No	Angle Value	Calculated Luminous Intensity	The results of the measurement of camera
1	0	445	442
2	5	441	438
3	10	431	429
4	15	416	415
5	20	395	397
6	25	368	378
7	30	338	349
8	35	304	324
9	40	268	293
10	45	231	258
11	50	188	226
12	55	157	195
13	60	123	159
14	65	91	123
15	70	64	93
16	75	41	55
17	80	22	17
18	85	7	0
19	90	0	0
20	95	0	0
21	100	0	0
22	105	0	0
23	110	0	0
24	115	0	0
25	120	0	0
26	125	0	0
27	130	0	0
28	135	0	0
29	140	0	0
30	145	0	0
31	150	0	0
32	155	0	0
33	160	0	0
34	165	0	0
35	170	0	0
36	175	0	0
37	180	0	0

The analysis results are shown to the software user on Figure 5 as it is on the software interface.

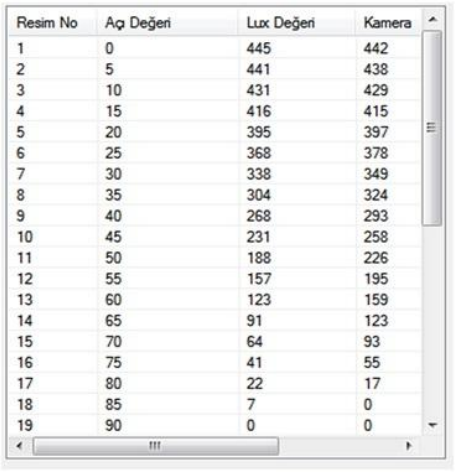

Fig. 5. Software results

In Figure 6 there is shown a flow chart of operation of the system.

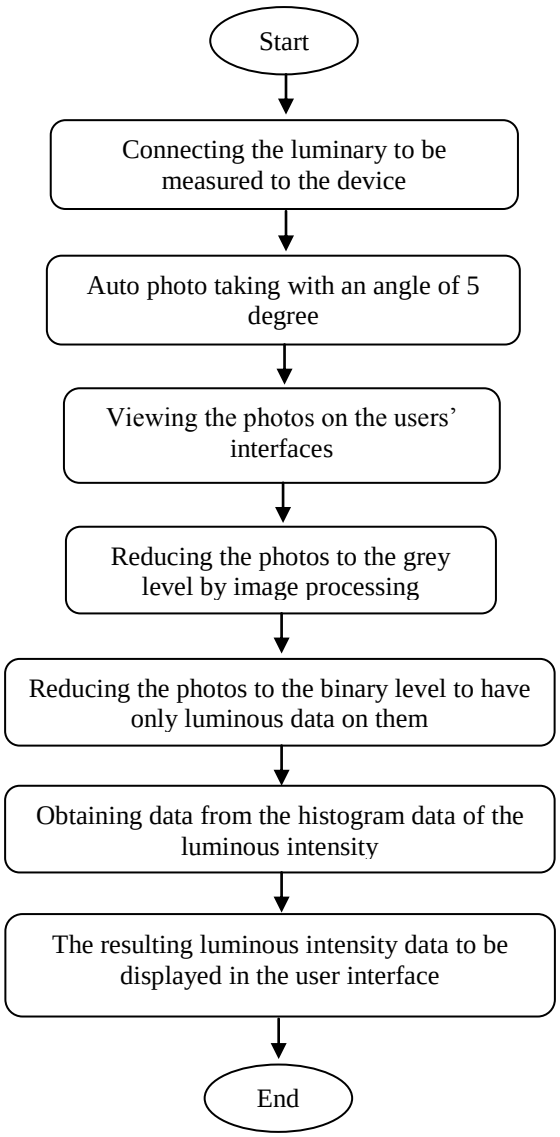

Fig. 6. The flow chart of the system

IV. CONCLUSION

Nowadays, image processing has become a popular subject. With the rapid development of computer vision equipment, photometric measurement systems have started to use image processing. The measurement systems made with the cameras are working based on surface area which makes the systems possible to measure more than one photometric point at a time such as luminance photo luster, color temperature, color rendering. The measurement distances are shortened by using the cameras on the measurement systems, and it became easier for the companies to measure the luminous intensity data. The measurements are repeatable on the camera measurement systems, because the images are being recorded to the database. In this study, luminous intensity data are obtained by the image processing algorithms taken from the computer vision equipment. Measurements can be affected by vibration. Therefore, anti-vibration mechanisms can be used. During the measurements, the camera only focuses to the source of light which makes a very small amount of reflected radiation is involved in the photometric measurements. So the camera systems are light-based measurement systems.

ACKNOWLEDGMENT

This work was supported in part by Scientific Research Projects Unit of Süleyman Demirel University. (Project Number: 3191-YL1-12)

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