ATLANTIS PRESS

Advances in Economics, Business and Management Research, volume 215

Proceedings of the 2022 7th International Conference on Social Sciences and Economic Development (ICSSED 2022)

The Past and Future Development of Light Meters

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ABSTRACT

By experimenting a variety of both historic and modern light meters and collecting feedbacks from both academic articles and public forums, relatively scientific analytic results toward the development of light meters can be gained. In this article, certain classical and worldwide used models of light meters will be listed and analyzed concerning their potential advantages and disadvantages. Furthermore, there will also be certain expectations towards the future development of light meter combined with the new technology of machine learning.

Keywords: *Light meters; Machine Learning; Photography; Geometrical Optics; Selenium Light Meters; Chemical Light Meters*

1. INTRODUCTION

Since the invention of camera by Joseph Nicéphore Niépce in 1826, human-beings are on the fast and continuous paces of pursuing both photographic techniques and equipment with a relatively higher quality. In the early time of photography, most cameras only had a very limited sizes of apertures which required a long time of exposure. This means even within a big difference of exposure time, the resultant effect of photos would not have a large difference. Thus, in early time most of photographers tend to take photos based on their experience without a light meter. However, with the development of camera, photographers' request for a very short time of exposure (or faster shutter speed) increased, which needs a more accurate exposure time. Therefore, light meters naturally and necessarily become one of the most significant and affective factors for photography, which have the irreplaceable ability of deciding the brightness or the final effects of the resultant pictures. By absorbing outside light and detecting the brightness of environment, a light meter 'speaks out' the intensity of light which will penetrate the lens and expose the films indirectly (although films are gradually abandoned by photographers, people still maintain this definition while using digital cameras for easily explaining the usage of light meters). It is by gaining the values of intensity of surrounding lights, photographers need to adjust the size of apertures and the shutter speeds which are two elements that will directly decide the amount of light that will expose the films. Without gaining sufficient light, the resultant photos will be too dark or even purely black for viewing, vice versa.

With the recent popularity of photography among ordinary populations, more and more civil photographers start to pay attention to the basic theories of cameras they hold. However, though not as significant as the lens and shutters of camera structures, light meter is still one of the important elements of cameras. Thus, this stimulate us to explore the development of light meter from its original type to some modern models like TTL.

By searching newspaper advertisements and brochures (these seemed to be the only resources of light meter models around 19th century) and reading articles from the official websites of certain modern light meter manufacturers, sufficient and reliable sources are collected and summarized in this article.

This article is targeting to popularize the basic theories and development of light meters for photographers and amateurs and one of the directions of their early development.

Types of Light Meters	Reaction Time	Accuracy
Chemical (Test Paper)	15 seconds	Very low (depends on naked eye observations)
Chemial (Photoelectric Selenium)	1-2 seconds	From +2 to -2 near the accurate value
Leica Electrical Meter	0.5-1 seconds	From +1 to -1 near the accurate value
TTL	Very Fast	From +1 to -1 near the accurate value

Figure 1. The reaction time and accuracy of different types of light meters

2. ANALYSIS

2.1 Original light meter based on chemical materials

Different from modern external light meters, chemical light meters always have multiple and variable appearance and size. For instance, some chemical light meters are only as small as snails which can be equipped on the cold boot of camera and some others have a size as big as palms which are usually more functionary. While using old-style film cameras manually, sometimes users can notice a pointer vibrating between a scale which illustrates if the shutter speed and aperture are sufficient for taking a photo under the environment. With more vintage cameras (for examples, bellow cameras and Twin-Lens-Reflection camera (TRL)), light meters are always hidden inside the button or rotary knobs which make them changeable due to the unstable quality of these light meters.

Without the big scale of popularity of electric equipment, chemical light meters are the only choice among photographer which all have the problems of low efficiency and accuracy.

In the first quarter of the 19th century, the invention of chemical actinometer provided users a method of testing the intensity of radiations by certain kinds of chemical substances like iron (III) oxalate which can react under lights with different wavelength. With the same thought, people started to explore chemical substances which can react to have certain changes while being exposed under lights (lights are also kinds of radiations) with different intensity. Invented by William Ford Stanley, the original actinometers with an inner roll of sensitive paper were welcomed by early photographer [1]. By exposing the paper under lights until the colors are stable and comparing the reacted colors of the sensitive paper with the standard forms, it illustrates the actual intensity of lights which help the users to determine the values of shutters and apertures to be chosen. However, due to its long reaction time, high costs and troublesome operations, and after being popular for around 40 years since 1890s, this kind of instruments are abandoned gradually by users.

As photography fields transferred from press using to more public using and meeting the fast development of cameras and their growth of popularity among daily users around 1920's, people started to pursue light meters with both the higher efficiency and low costs.

As the result illustrated, portable equipment like extinctions were invented which supplies a more efficient method of photographic light testing. Designing out of the variations of different chemical materials under variable intensity of light, an extinction light meter has numbers of small windows and only through one of them views are visible. By reading the values signed near the visible windows, users can easily master their needed shutter speed and aperture size in cameras [2]. Latterly, by reducing the size of extinction light meters, designers tried to hide the multiple cameras under the outside shell, which can be adjusted and chosen by rotating the inner part. Another classical type of extinction light meters worked by attenuating lights continuously into the meters until numbers are visible for observing. However, extinction meters still face the problem of long reaction time, due to which they are also abandoned by users.

Another famous model of chemical light meter is electricity free electricity light meter. This kind of meter is the early model of the electricity light meter which behaves as a current meter to test the produced current out of selenium materials in front of the light meter. However, this kind of light meter is not accurate sufficiently for being used for many years. It is a common phenomenon that many of these light meters only have a life span which is ten times shorter that the life span of the cameras.

2.2 Electric light meters

With the popularity of small batteries for daily usages, electric light meters gradually replaced the positions of chemical light

Figure 2. Leica Electric Light Meter

meters with their higher accuracy and shorter reaction time. Without necessity to wait the reactions between the chemical substances under lights and having a relatively higher accuracy, electric meters provided an immediate reading of the values of the intensity of light to help photographers to react fast toward the variable background. Combing shutter speed and size aperture perfectly, AV and TV values are integrated into light meters which assist to find out the needed aperture size or shutter speed while another element is decided to be fixed by users. The most popular kind of electric light meters are electric selenium meters which are invented based on the photoelectric theories. Exposing under light with different intensity, selenium materials will produce current with different intensity while absorbing photos, which can be measured by connecting them with the electric detector. By experimental comparison, the intensity of light can be transferred into the value with their own unit by testing the intensity of currents under certain light intensity. Though chemical materials are still utilized in building this kind of light meters, with the participation of electric detector, which avoid the errors of naked eye observation, the resultant accuracy can be guaranteed.

The same theories are kept and used in the designs and manufactures of modern light meters. Moreover, to gain results with more accuracy, light meters are designed to expose the photoelectric materials to either reflected or incident light.

By testing the intensity of light reflected from targets of photographers, the photoelectric materials produced currents with the reflected image exposed on them [5]. This model can adapt to the variable situations like a strong point of light rather than giving the resultant light intensity directly by surrounding lights which are always be seen as mild light.

Another model works by putting the light meter near the objects and facing the cameras to test the intensity of light incident into the lens of camera directly. This kind of model also helps reflect the brightness of the objects [6].

2.3 Potential problems about electric meters

Although electric light meters are invented to overcome the long-lasting problems of purely chemical meters, there are still potential problems on them.

For reflected meters, except accepting light reflected from objects, it still requires the calculations behind the curtain [3], which finally results in the intensity of the light by utilizing the reflection coefficient. However, this coefficient varies while the incident angles, wavelength of lights and the materials vary. Therefore, the standard coefficient is decided in these calculations, which can help represent the coefficient of all other materials and this is also the reason that the resultant light intensity will be inaccurate due to the inaccurate coefficient.

Problems also happen while using the light meters which imitating the incident light. For targets which are near to the camera, it is easy to gain a relatively accurate light intensity vale but while the targets are far away or too giant like a river or a mountain, it is almost impossible to test the light through this method. That is the reason due to which the usages are finite for this model.

2.4 Comparison of working function

Types of Light Meters	Reaction Time	Accuracy
Chemical (Test Paper)	15 seconds	Very low (depends on naked eye observations)
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Figure 3. The reaction time and accuracy of different types of light meters

In this form, numbers like +1, -1 means one unit over-exposed or one unit under-exposed. Inaccuracy of these types of light meters may cause the unwanted exposed photos. And in the under graph, precise effects are indicated.

TABLE I. EFFECTS OF DIFFERENT DEGREES OF EXPOSING

Zone	Exp. Comp.	Characteristic
0	–5	Pure black
I	–4	
II	–3	
III	–2	Darkest tone with detail
IV	–1	
V	+0	Middle gray (meter indication)
VI	+1	
VII	+2	Lightest tone with detail

VIII	+3	
IX	+4	Pure white

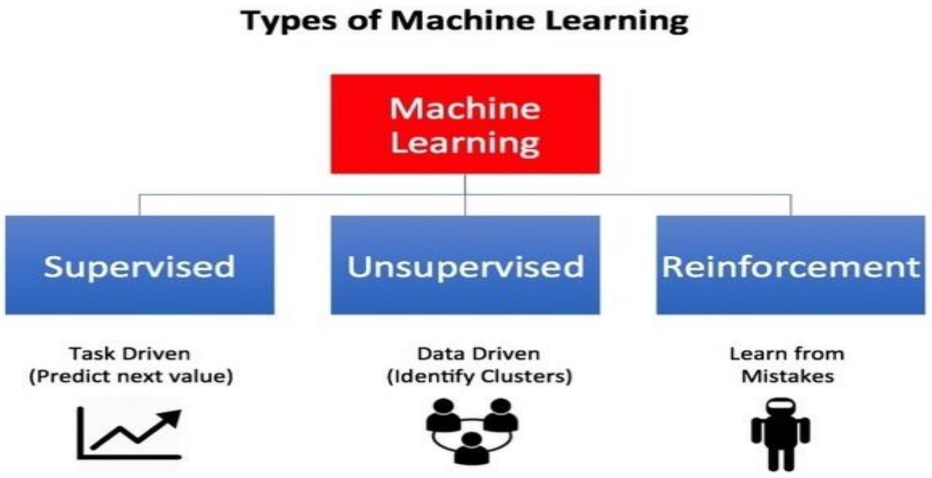

Figure 4. Basic Categories of Machine Learning

2.5 Introduction to machine learning and its useful combination with light meter

As both amateurs and professional photographers began to pursue a more efficient and accurate usage of

light meters, those types mentioned before seemed really delaying the opportunity to snap amazing moments. Meeting the era of the fast development of computers and programming, it is naturally for users to consider the combination of light meters with the modern technology of computers.

Living in an environment surrounded by Artificial Intelligence, machine learning plays an important to build our daily life. With the gradual popularity of programming, machine learning becomes one of the significant elements, which trains the computer for further analysis. For instance, by inputting photographs of numbers and graphs into certain programming, kinds of methods can be developed or in certain aspects, trained by computer automatically to finally result a tool which can identify a new series of photos of certain numbers and graphs.

With the same logic, a smart tool of light meter can also be built to solve the potential problems that modern light meters are still facing. Logically, this tool can automatically understand the distances between the objects and lens of cameras and make corresponding reactions concerning which models to choose (testing reflected light or incident light directly). Furthermore, this kind of programming, which can also be seen as Artificial Intelligence (AI) will be granted the ability of calculating with variable reflection coefficients stored while facing variable colors.

Moreover, with the fast paces of global urbanization, lights which have the wavelength out of visible lights are also need to be considered while building light meter. Although human eyes are not able to detect the strength of invisible lights [4] most types of light meters are still sensitive for them. For instance, selenium light meters can detect the existence of X-ray and react to them. This will seriously influence the result of light testing and furtherly mislead photographer. However, this can be solved easily by Artificial Intelligence which can automatically filter out the incident lights which have the wavelength out of the visible lights range.

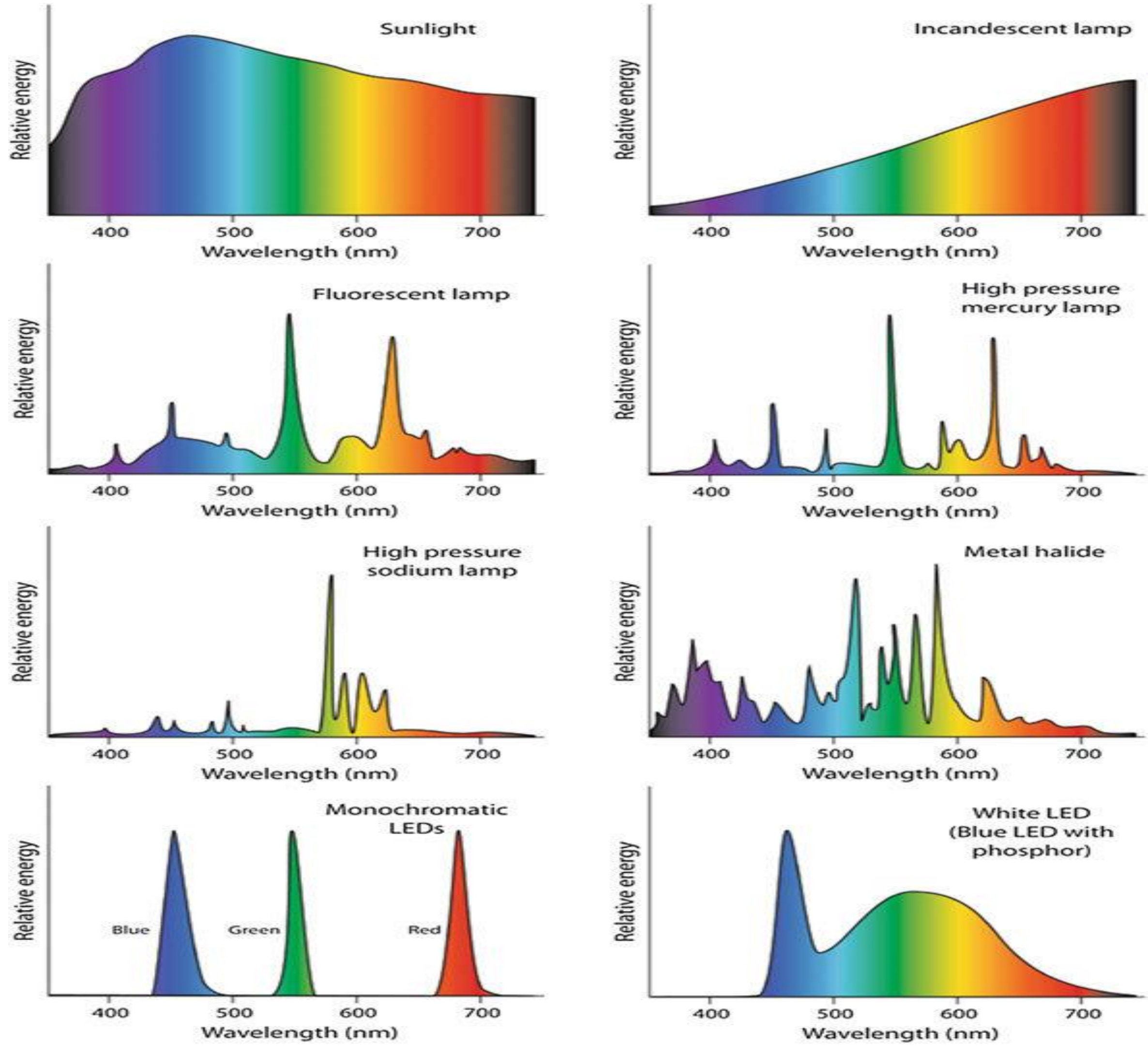

Figure 5. Distribution of wavelengths of lights under different types of light sources (Unit: nanometer)

Out of the achievements of this, it is eligible to gain a relatively accurate value of light intensity towards the outside environment.

2.6 Usage of machine learning

To simplify the understanding of integrating the theories of machine learning into the design of light meters, three main kinds of machine learning will be listed out and discussed respectively for including more details.

(Basic 'Family Tree' of different types of machine learning)

2.6.1 Supervised machine learning

Supervised machine learning utilized gained information as input for the computer to understand and train themselves. For example, by supplying pictures of different animals and detailed information of them, it is easy for computer to train itself to tell different categories of animals. The instance provided before is also an obvious and special kind of machine learning. In the usage of machine learning in light meters, supervised machine learning can be used after gaining sufficient pictures and their corresponding parameters which are related to the light intensity. By analyzing those given data, computer can result in a programming which can automatically analyze similar environment. As mentioned previously, colors in different models can also be inputted for training, which can finally result in the calculations of the final light intensity out of accurate coefficient.

Supervised machine learning can be seemed as the most vital element in the whole usage of machine learning in building light meters due to the fact that millions of examples and their date are necessary or evenly requires to promise the final accuracy of the resultant programming.

2.6.2 Unsupervised machine learning

This category of machine learning means certain automatic working of computers like classifying input materials without tons of original material. This kind of machine learning can be used in light meter building when

AI are required to cognize the distances between the objects and cameras or the colors of the objects as mentioned before. By using this technology, the light meters can react fast while being putting in front of the objects and resulting in certain values of the outside surroundings, which can be used latterly for further calculation of the light intensity and certain other parameters concerning these.

In the potential problems discussed before, the problems about the inaccuracy out of the different reflection coefficients of variable colors and the distances between the lenses of the cameras and the objects can be solved effectively by combing supervised machine learning and unsupervised machine learning.

2.6.3 Reinforcement machine learning

This method of machine learning trains the AI by letting it face the environment and making its judgements and reactions towards the surroundings by itself. After this, people are required to providing feedback to the work of machine and trained the machine by repeating this process.

In building a light meter, reinforcement learning can be utilized while complicated or extreme situations are chosen as objects like taking a photo to tornados or tsunamis which have unnormal light situations. By inputting photos with certain errors like over-exposed photo, the systems will reinforce itself by learning and avoid these errors.

3. CONCLUSIONS

Although abundant and diversified references are utilized to construct this article, uncertain elements still exist potentially. For instances, while experimenting with certain vintage light meters (especially chemical meters with history more than 100 years), errors occur frequently due to the aging of chemical materials exposed in air. On the other hand, certain kind of light meters are rare to find since they have been collections rather than real tools. Thus, academic research is difficult to refer for these ‘antiques’ Out of these elements, this article is still not objectively sufficient. For the machine learning part, there is a lack of storage of certain knowledge about machine learning, more professional and practical information is not able to be mentioned in this article.

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