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Proposal for Digitization of 35 mm Black and White Film

-Scanning film with digital camera-

주 종 우* Jongwoo Joo

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Abstract

사진 시장은 디지털화 되었지만 아날로그 필름의 정보가 존재하고 있으며 여전히 제작되고 있다. 그러므로 효과적인 디지털화 방법에 대한 연구 분석이 필요하다. 기존의 방법은 스캐너를 이용하는 방법이다. 흑백 필름은 그 입자의 특성상 고해상도 레이저 스캐너로 스캔하기 힘들다. 그러므로 평판스캐너나 가상 드럼 스캐너를 주로 사용하고 있다. 본 연구에서는 디지털 카메라로 촬영하여 데이터를 얻는 방법을 제안하였다. 현재의 디지털카메라 기술은 35미리 흑백 아날로그 필름의 해상도보다 높으며 거의 모든 정보를 디지털화하는 것이 가능하다. 본 연구는 기존 방법인 스캐너로 은염 필름을 디지털화는 작업을 벗어나 디지털 카메라로 은염 필름을 촬영하는 방법을 제안하였으며 기존 스캐닝 작업에 비해 작업시간을 단축시키고 해상도를 향상 시킬 것이다.

key word : 디지털, 은염필름, 흑백필름, 디지털콘텐츠, 색수차, 디지털화

Proposal for Digitization of 35 mm Black and White Film

－Scanning film with digital camera－

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1. Introduction

Photographs have been digitized and technologically reached a plateau. Yet, a plethora of analog silver halide film data is yet to be digitized, in which sense content production is in a transition state. In particular, photographs among other analog contents are records of history, and most of them cannot be reproduced. 35mm b&w films account for the highest percentage of the analog silver halide films(Kim, S. K., Kim, Y. J., 2012, 93-105).The existing digital image processing using flatbed scanners is time-consuming and lacks in resolution even in monochrome photographs. Scanning is sub-divided into flatbed, laser drum and vitual drum methods. As a rule, the laser method supports high-resolution scanning. Yet, laser scanners are not applicable to monochrome films due to their large particles(J. W. Joo, J. W., Kim, D. W., 2015, 10-13) It is expected to be able to digitize images using a digital camera because the current digital camera technology has exceeded the resolution of black and white film. Hence, the present study proposes a system for digitizing 35mm b&w films using a digital camera. In addition, the present study compares with the existing method, which is a digitation method using a scanner for analysis. The present findings will be conducive to facilitating the digitization of silver halide film data.

2 Local and global conditions

1) Local and global research

No research has investigated a system using digital cameras. Most research deals with scanners. The following are representative studies in this field.

Institute	Title
	Content and application
Tele-chips, Inc.	Color Correction Using Polynomial Regression in Film Scanner
	Film scanner is one of the systems, which can acquire high quality and high resolution images. However, due to the nonlinear characteristic of the light source and sensor, colors of the original film image do not correspond to the colors of the scanned image. Therefore, color correction for the scanned digital image is essential in the film scanner. In this paper, polynomial regression method is applied for the color correction to CIE L*a*b* color model data converted from RGB color model data(Kim, T. H., Baek, J. H., 2003, 43-50)
Korean Society of Archives & Records	A Locally Developed Digital Scanner for Archival Management
	Transforming documents and records into archival contents using

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Management	a locally developed scanner(Park, H., Son, Y. S., 2002, 201-212)
Society of Motion Picture and Television Engineers	Digital Film Scanning and Recording: The Technology and Practice
	The subject of system calibration is explored. Issues that affect the exchange of images between facilities are described, including file format and image data storage. Some of the operational issues of digital film scanning and recording are also discussed(Kennel, G., 1994, 174-181)
Hewlett-Packard Development Company	Color and tone correction of a negative film scan using existing silver-halide print
	“This invention relates generally to color correction techniques used in digital color printing and more particularly to improve the color print quality of color printers when reproducing images that have been scanned by a digital scanner. The present invention provides a method and means for creating a high-resolution reproduction of an image that more closely matches the color and tone of an existing photograph made with a traditional photo-finishing process.” (Gennetten, K. D., 2003)

2) Local and global market

- Korean National Archives constantly digitizes national photographic records.
- Kodak (Kodak Alaris) has its archival management specialists convert customers' old photographs into digital images, expanding a new market.
- KENKO TOKINA produces a small film scanner targeted at retail consumers.
- Smartphone-based lomo film scanners are drawing public attention.
- On photographic SNS, e.g. Instagram and Tumblr, analog film photos are popular.
- Local and global film industry scans, remasters and releases classic films.

3. Exisiting theories

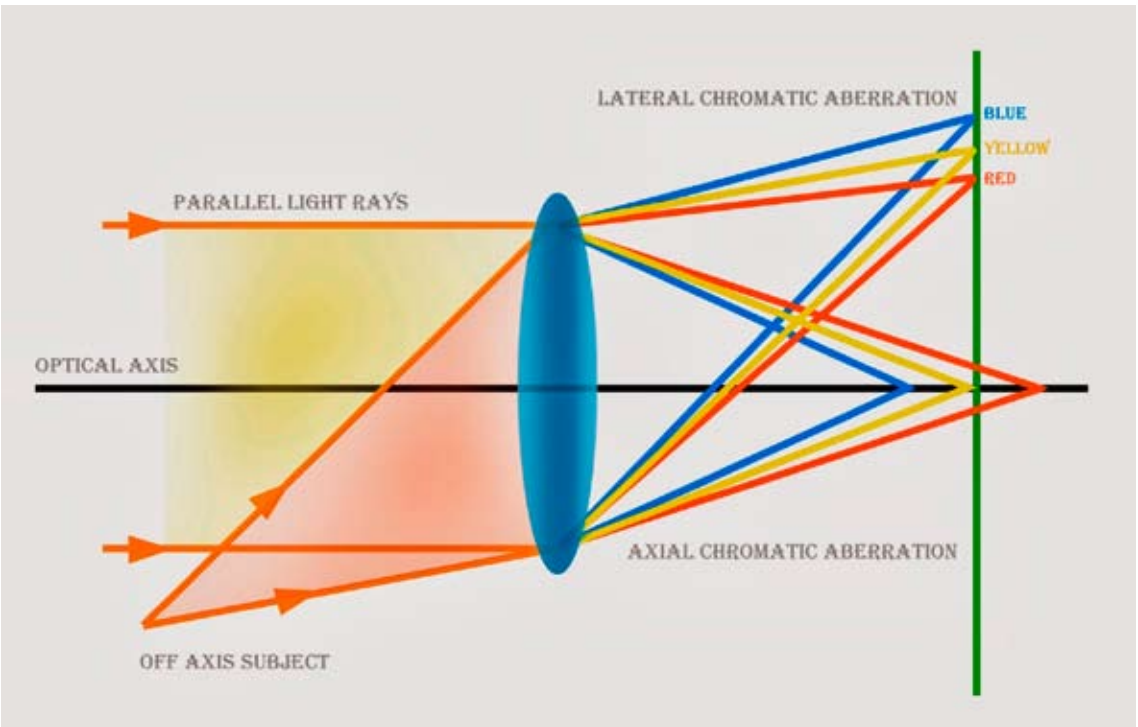
Digital camera image sensors contain photodiodes, or pixels sensitive to light. Photodiodes transform the light coming into the image sensors into electric signals and provide final image pixels with color information. Here, any multiple exposures of a pixel, electric activities inside sensors, and ambient temperature cause the noise. Also, factors influencing the noise include pixel sizes, ISO sensitivity, duration of exposure, types of image sensors, and ADC(Analog to Digital Converter) process(Joo, J. W., 2015, 68-71).

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1) Chromatic aberration

Chromatic aberration is caused by lens dispersion; it occurs when light of different wave length travel through a lens at different speeds. This causes the image to look blurred and also causes noticeable color cast (red, green, blue, yellow, purple or magenta) along the edges, especially of bright objects or where there is high contrast in an image(http://www.school-of-digital-photography.com, 2014). There are many different types of chromatic aberration, and axial chromatic aberration is applicable to this study. Axial chromatic aberration is the failure of a lens to focus at least two out of the three primary colors to the same point on the film plane causing color fringing. Although there are various methods for eliminating chromatic aberration, the best method is to use a specific wavelength band when not using color as in the present study. Such a method for eliminating chromatic aberration will be useful to improve the resolution of products.

<Figure 1>. axial and lateral chromatic aberration of camera lens
(http://4.bp.blogspot.com/axial-and-lateral-chromatic-aberration-of-camera-lens.jpg)



4. System Configuration

This study concerns digitizing 35diISmm monochrome silver halide films. On photographing in visible light, diffraction and chromatic aberration determines the resolution. Infrared is also similar electromagnetic wave with visible light and diffraction and chromatic aberration determines the resolution(Joo, J. W., 2014, 116-131). However, B&W film may not consider the color; the present study intends to enhance the resolution by eliminating the chromatic aberration (using the wavelength

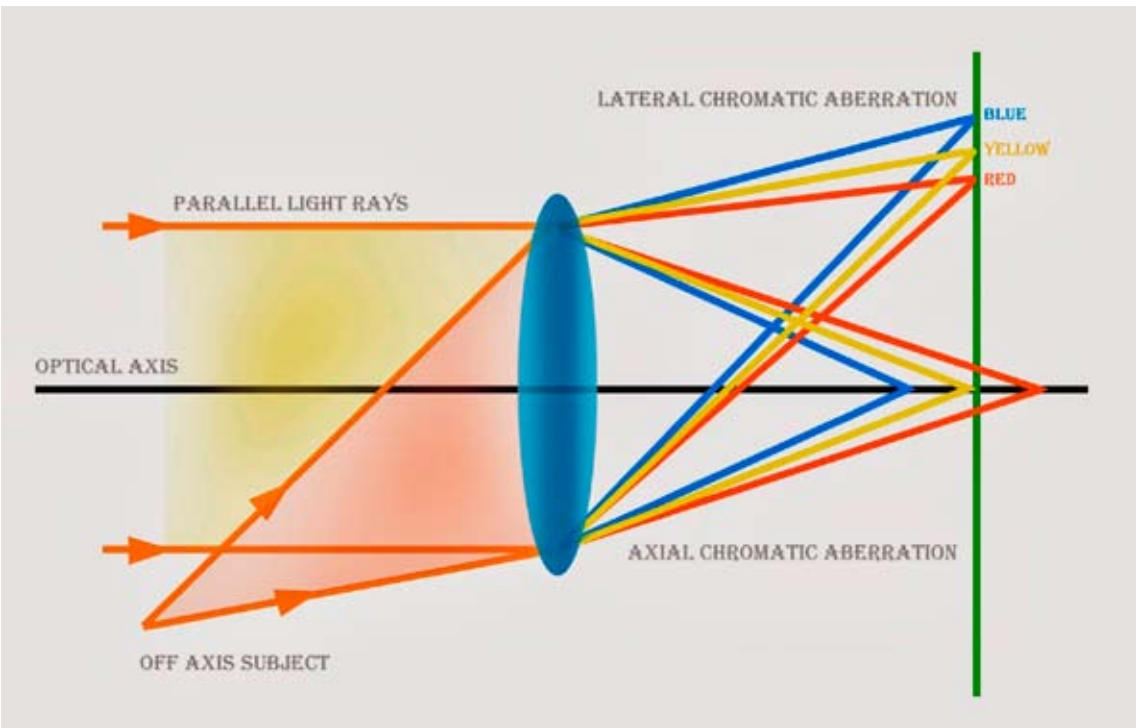
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region).

In this study, a high-resolution digital camera is used for scanning. As 24- mm X 36-mm digital data is equivalent to approximately 22 megapixels, the process requires a digital camera featuring over 22 megapixels. Currently available digital cameras for professionals support more than 22 megapixels. A high-resolution scanner Fuji SP-3000 is used for scanning, and the images are scanned at 40 megapixels higher resolution than the digital camera. Of course many products have higher resolution than SP-3000, it shows similar results with 35 mm black and white film. Other scanners are not commercially used because of their slow processing performance. Moreover, it is considered that Imacon or Fuji products are mainly used because other high-end scanners are too expensive for personal use. In the present study, the results of the digital conversion using a digital camera and scanner are compared and analyzed.

The experiment process is as follows: Standard charts such as ISO 12233 (Resolution Chart) and ISO14524 (Contrast Chart) are taken with an analog camera Nikon F4s. In addition, these two methods using a scanner and a digital camera enable us to obtain digitized images. The resolution of the images created with two paths is analyzed and compared using Imatest software.

<Fig 2>. Diagram of the experiment



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1) Ambience (in reference to ISO standards)

(1) Temperature

The temperature and relative humidity of the target setting for measurement need be 23° C±2° C and 50±20%, respectively. As the temperature may rise and vary due to the illuminant, it is necessary to measure the temperature once the illuminant is sufficiently preheated. As the noise could arise due to the temperature as well in the experiment, the temperature is precisely controlled. The temperature of the setting is kept at 23℃.

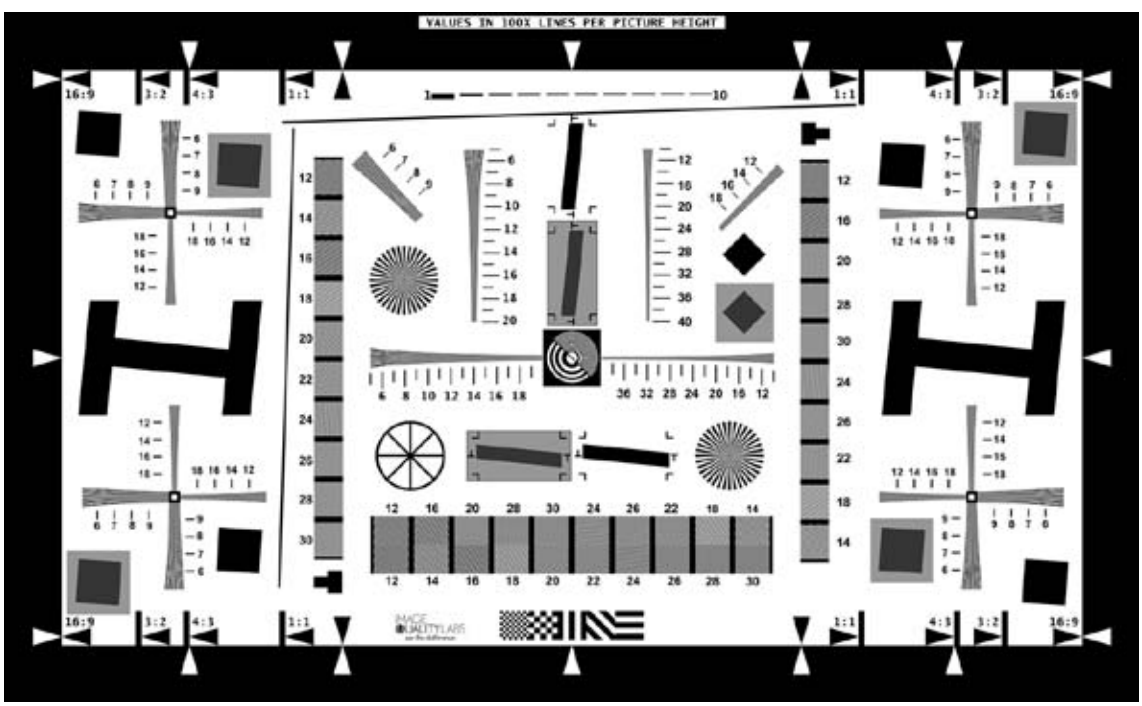
(2) Illuminant

Tungsten light may be used as the main light for measuring the noise. When using the main light, the light's spectrophotometric profile should be equivalent to the CIE standard illuminant D55. Here, D55 illuminant is used.

(3) Chart

The target used here to measure the noise is capable of capturing the optical electrical conversion function (OECF) and the noise patches simultaneously as prescribed in the ISO 14524. Targets are sub-divided into 12-patch reflection and 20-patch transmission types. Importantly, as the visual or other types of noises are calculated based on OECF (optical electrical conversion function) data, the OECF measurement inputs should be accurate. As the standard charts, the ISO 12233 Enhanced Digital camera chart are used.

<Fig 3>. ISO 12233 Enhanced Digital camera chart

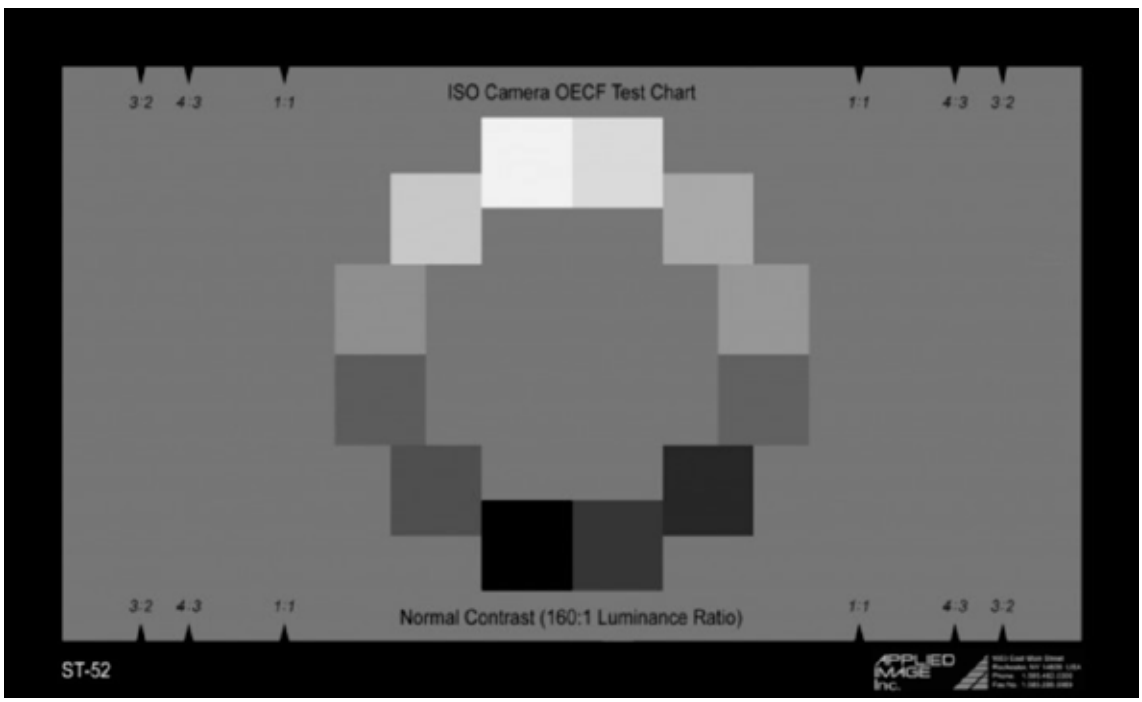


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(4) Camera & Lens

In the present study, Nikon F4S and Nikon D800E are used as an analog camera and a digital camera, respectively. Nikon D800E is a 36.3-megapixel digital camera appropriate for this study. Nikon 105 mm Micro Lens is used to represent the maximum resolution of digital cameras because it can take photographs of an object and image sensor at the size ratio of 1 to 1.

<Fig 4>. ISO 14524 digital camera Contrast chart(ST-52)



(5) Analysis program

Imatest software is used in the present study for the following reasons:

In today's rapidly changing imaging industries, companies feel the pressure to produce cameras at a fast pace that have a higher quality and newer features than the generation before them. Millions of dollars are spent each year developing more capable cameras, so it should follow that companies focus just as heavily on the quality of their image testing software(http://www.imatest.com, 2015)

MTF50 (50% contrast spatial frequency) for the image in cycles/pixel and line widths per picture height (LW/PH). Its relationship to print quality is discussed in the section on Interpretation of MTF50.

MTF50P (spatial frequency where contrast is 50% of its peak value) for the original uncorrected image in cycles/pixel and line widths per picture height (LW/PH). This is same as MTF50 for slightly to moderately sharpened edges, but smaller for oversharpened edges. It may be a better indicator than MTF50 of the perceived sharpness of oversharpened images [10].

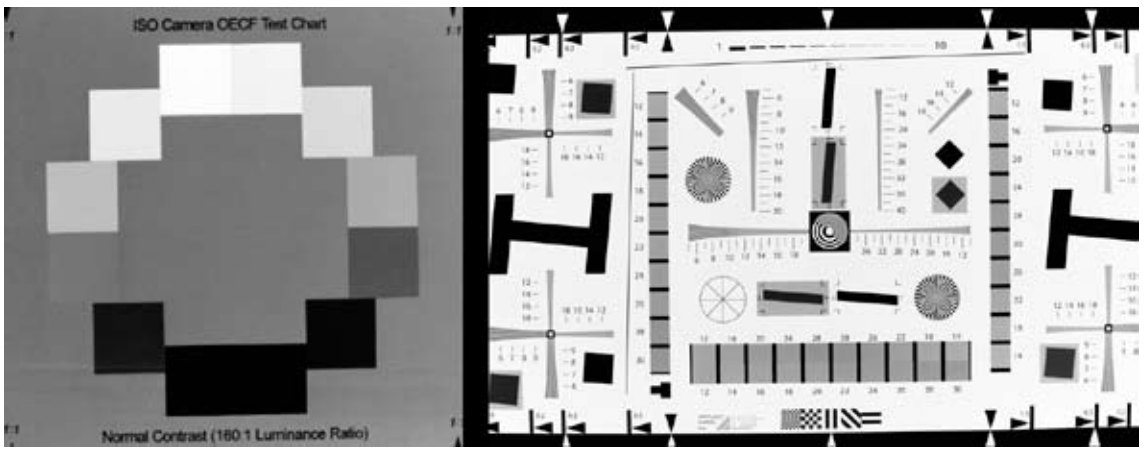
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5. Results and Comparative Analysis

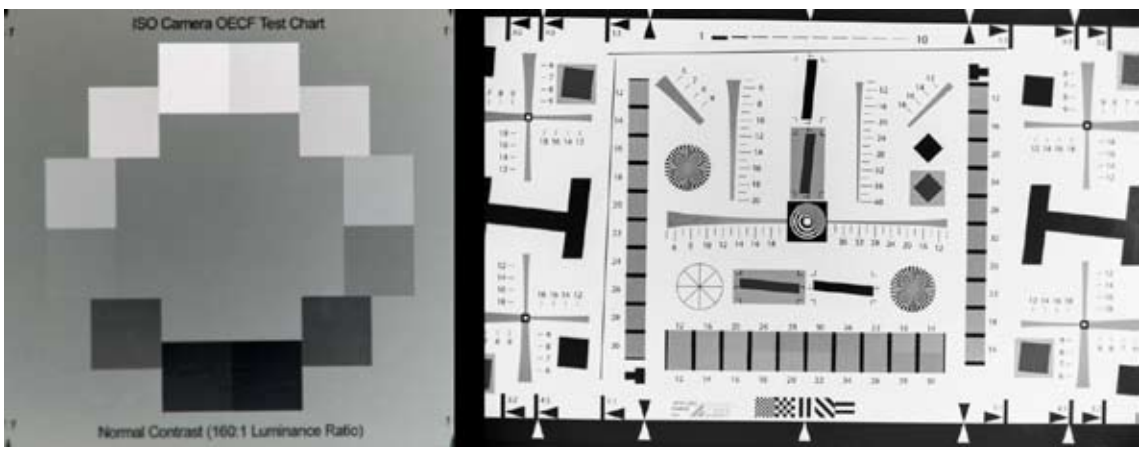
1) Results

The chart described in 4.1.3 is taken, and the images are taken with black and white film first as described above. The results are digitized using the two methods as follows:

(1) Results using a scanner



(2) Results using a camera

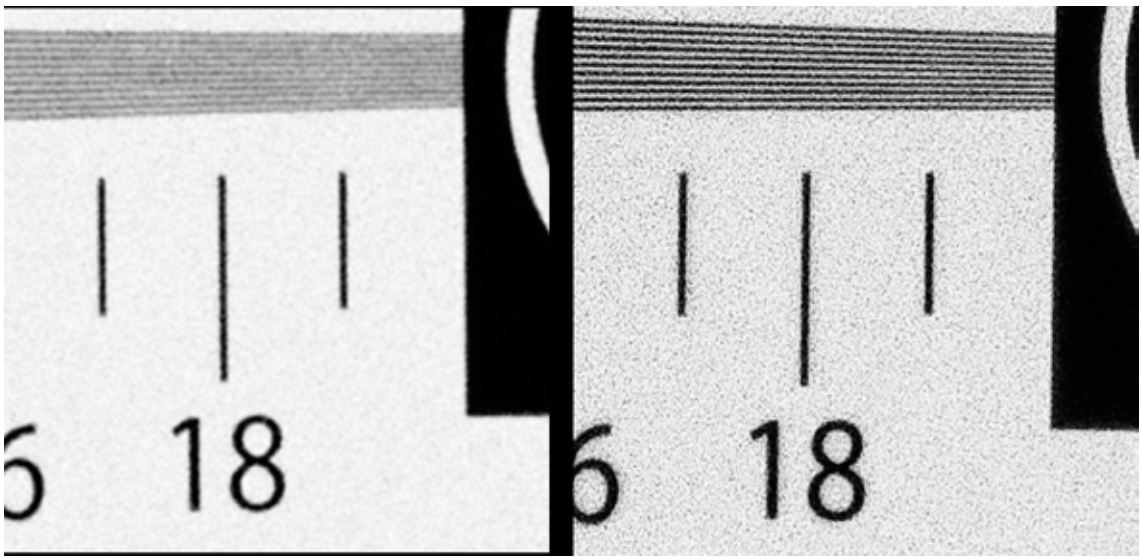


2) Comparison and analysis

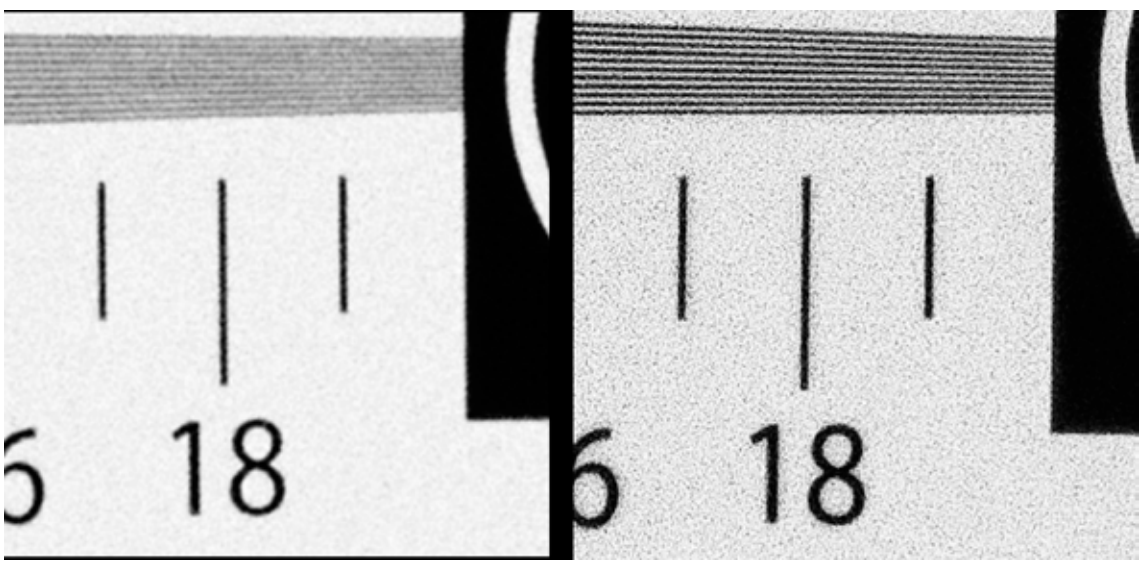
(1) Visible comparison

All the images shown on the left are obtained using a scanner and on the right are obtained using a digital camera.

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When displaying the two digitized ISO 12233 charts on the monitor at film full size, both of them are in good condition. However, when magnifying them as above to compare with one another, the right image taken with the digital camera is better to the naked eye. The following images are shown for additional confirmation. The leaning bar images are the images to be operated by Imatest software.



(2) Numerical comparison

As below, even in numerical comparison, the methods using a scanner and digital camera show 2153 and 3036 LW/PH at MTF 50, respectively. 40% resolution is numerical excellent result. However, they show 1.78 e-15 and 0.211 pixels as chromatic aberration, respectively. The data taken with a digital camera are far superior to those taken with a scanner, and noise caused by chromatic aberration is found to the naked eye. Furthermore, the method using a digital camera looks superior in the magnified images, scanned images look better due to noise and blur when reducing the

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size.

6. Conclusion

The present study successfully digitized 35-mm monochrome films with the resolution superior to that of the films shot in visible light. Using a digital camera in lieu of a scanner leads to high resolution and fast processing. Also, the unit production cost is lower than a high-quality scanner. Lots of media contents prior to the digital era were recorded on analog films. Content production environment is expanded by combining digital content production with the 19th-century analog films. The proposed method can facilitate reusing analog contents dying out, and revitalize the dull analog image market. The proposed method will lay th e foundation for accelerating the digitization of silver halide films. However, with regard to the method using a digital camera, its aesthetic resolution does not seem to be improved because noise overlaps with images due to the chromatic aberration. Therefore, there is need for a follow-up study to provide methods capable of eliminating chromatic aberration. Theoretically, there is a method of minimizing chromatic aberration by reducing wavelength bands.

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Abstract

Photography market has already been digitized. However, the information of analog graphic films photographic films exists and has still been produced. Therefore, there is a need to study and analyze effective digitization methods. The conventional method is performed using a scanner. It is difficult to difficult to scan it by a high-resolution laser scanner due to its nature. Thus, flatbed and virtual drum scanners are mainly used. There exists a need for high resolution scanning methods because these scanners may not be enough to digitize all information about analog films. As an improved method, this study proposes a method of obtaining data by taking images with a digital camera. The present digital camera technology has higher resolution than that of 35 mm black and white analog film and will be able to digitize almost all information.

The present study proposes a method of taking a shot of a silver halide film with a digital camera beyond the established method of using a scanner to digitize the silver halide films. The proposed method will be shorten the processing time and improves the resolution in comparison to the existing scanning process. It will also be analyzed in this paper to compare the two results.

Keywords: Digital, Silver halide film, B&W film, Analog film, Digital contents, Color aberration, 35mm.

Proposal for Digitization of 35 mm Black and White Film

-Scanning film with digital camera-

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