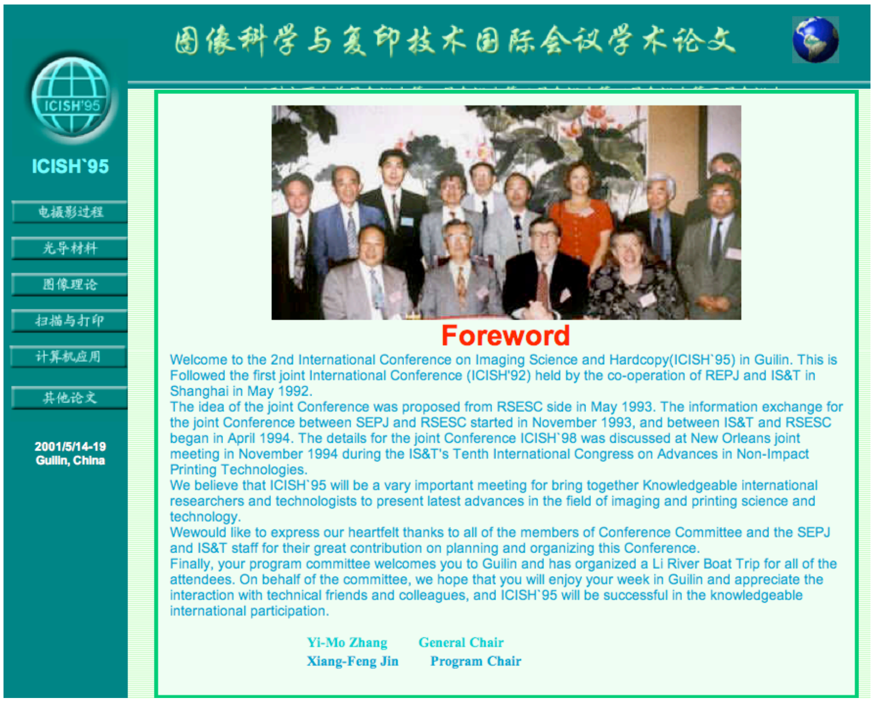
http://www.rsess.com/95/95frame.htm


图像科学与复印技术国际会议学术论文

ICISH'95

ICISH`95

电摄影过程

光导材料

图像理论

扫描与打印

计算机应用

其他论文

2001/5/14-19
Guilin, China

Foreword

Welcome to the 2nd International Conference on Imaging Science and Hardcopy(ICISH`95) in Guilin. This is Followed the first joint International Conference (ICISH'92) held by the co-operation of REPJ and IS&T in Shanghai in May 1992.
The idea of the joint Conference was proposed from RSESC side in May 1993. The information exchange for the joint Conference between SEPJ and RSESC started in November 1993, and between IS&T and RSESC began in April 1994. The details for the joint Conference ICISH`98 was discussed at New Orleans joint meeting in November 1994 during the IS&T's Tenth International Congress on Advances in Non-Impact Printing Technologies.
We believe that ICISH`95 will be a vary important meeting for bring together Knowledgeable international researchers and technologists to present latest advances in the field of imaging and printing science and technology.
Wewould like to express our heartfelt thanks to all of the members of Conference Committee and the SEPJ and IS&T staff for their great contribution on planning and organizing this Conference.
Finally, your program committee welcomes you to Guilin and has organized a Li River Boat Trip for all of the attendees. On behalf of the committee, we hope that you will enjoy your week in Guilin and appreciate the interaction with technical friends and colleagues, and ICISH`95 will be successful in the knowledgeable international participation.

Yi-Mo Zhang General Chair
Xiang-Feng Jin Program Chair

reprint of:

J. J. McCann, "Digital Color Transforms Applied to Fine Art Reproduction", in Proc. of 2nd International Conference on Imaging Science and Hardcopy, Reprographic Scientists and Engineers Society, China Instrumentation Society, Guilin, p. 221, 1995.

◆特 集◆

Digital Color Transformations applied to Fine Art Reproductions

John J. McCann*

Polaroid Vision Research Laboratory, Cambridge, MA 02178, USA

This paper reviews the photographic and digital image processing of Polaroid Replicas. This process combines the best and most practical features of instant photography and color image processing to make reproductions that look like the original art. This paper describes the technology and provides examples of masterpiece reproductions such as *Ladies Preparing Newly Woven Silk*, by Emperor Hui-chang.

Introduction

The Polaroid Replicas project is the result of working for many years with the Museum of Fine Arts, Boston. Initially, we made actual-size reproductions by direct instant photography. We built a room-size camera inside the Museum. We made special long focal-length, large-aperture lenses to form 1:1 images of the original art. We made actual size reproductions and compared them to the original.

Response Characteristics of Films

Photographic film is an ideal material for reproducing fine art masterpieces. It is continuous tone. There are no artifacts introduced by the reproduction process. It has a very high resolution to record minute details so important in analyzing and appreciating the art and its history. The image dyes are very stable when exposed to light. The limitation of photography is that one can perfectly match only one color in an image. One can make the entire print lighter or darker. One can make the entire print redder or greener. Any improvement in one part of the image will affect all other parts of the image. The input-output characteristic curve for film is often called an H&D curve. It is named after Hurter and Driffeld, two English photographic scientists.[1] It is the plot of log exposure verses optical density (OD) of the resulting photograph. Optical density is log of the reciprocal of reflectance. If a film were designed to exactly reproduce the original scene, it would have a slope 1.0 H&D curve. Input light would equal output reflectance for all values. When the slope is higher than 1.0, the image has more contrast between similar exposures than the original. Here, there are bigger differences in density compared to the original. When the slope is less than 1.0, the image has more compressed gray values than the original. Here there are smaller differences in similar densities compared to the original.

All color print film manufacturers use very similar H& D curves. In the region of light gray, or Caucasian and Asian skin tones, the slope is 1.0. Colors in this region are reproduced accurately, compared with the original. Colors lighter than skin tones have a much lower slope. Whites and specular highlights are compressed together in the color print. Middle grays are expanded. The print makes middle grays darker than the original. Dark grays have a slope of 1.0. Blacks are compressed. The high slope in the middle-tone is key to making very colorful pictures. A red has a very light tone in long-wave, or red light. Red is middle-to-dark gray in green and blue light. High-slope films that increase the darkness of the middle tones increase the saturation of colors. The exact slope of color film H&D curves have been determined by many consumer acceptance tests. Consumers never select slope 1.0 films as their favorite. Nevertheless, slope 1.0 without any loss of saturation is the ideal film for art reproduction.

H. deRidder, et al recent measurements show that observers prefer images that are more saturated than realistic images.[2] Their experiments showed observers a sequence of images that varied from low saturation, through actual to high saturation. They asked observers to select the most "natural" image and in a separate experiment they asked observers to select the preferred image. The data showed that observers preferred a more saturated image than the one that they selected as most "natural". These experiments show that people select pictures of slightly higher saturation than realistic pictures. Although people prefer a boost in saturation for pictures, the same boost distorts a reproduction of fine art. The problem for making the most accurate reproduction is to remove the film's boost in saturation put in at the factory.

Photo and Electronic Imaging

The most powerful tool of electronic imaging is that each picture element is independent of all other pixels. Electronic imaging breaks the constraints of the H&D curve. Computer image processing controls the output to be any function of the input. The biggest problem with high quality images is the massive number of pixels. Replicas use 100 million pixels. Any fast computer calculation takes a long time when repeated 100 million times. Printing very large format images from very large pixel arrays is slow and expensive.

Polaroid's Vision Research Laboratory developed a digital calibration system for reproductions. It captures an image as a digital array. It applies a color transform that makes a reproduction with slope 1.0. It calculates a distorted tone-scale image that anticipates and corrects the factory-made film properties. The "Master" has a tone-scale curve designed in combination with the print film tone-scale curves. This combination is slope 1.0 at full saturation. The "Master" has in it corrections that remove the characteristic properties of the print film. The difficult part of this is to control color saturation, throughout the entire color space, while changing the high-slope part of the response curve from 1.6 to 1.0. The "Master" image has a very unusual appearance. The purpose of the image is not for viewing by humans. It is designed to be viewed by a film and to compensate for the film's factory-made properties.

Color Calibration

The process begins by creating a digital display in a computer. This test target has 512 different patches. This breaks down to all combinations of 8 levels of red, 8 levels of green and 8 levels of blue. These 512 patches cover the entire 3-D volume of digital color space. We make a print on Polacolor film from this test target. Digits are converted to color film patches. These test targets are used to calibrate the Image Capture, Image Scanning, and Image Printing.

Illumination on the original is directional, projected light. The test target is in front of the original art and photographed with 20 by 25 cm, high-resolution film. Usually we use negative film because of the extended range of film sensitivity. After the test target, we photograph the original art. Both the calibration target and original films are processed at the same time. The developed films are scanned on a drum scanner at 1200 dpi, 24 bit. This makes a 300 megabyte file.

Start with RGB triplet number
▼
Write Target (triplets) to film
▼
Place Target in front of Original
▼
Photograph Target & Original
▼
Scan Target to get new RGB triplets
▼
Correct for system effects
▼
Scan photograph of Original
▼
Apply corrections to Original
▼
Print "Master" on film recorder
▼
Optical print of "Master"

Table 1. This is the list of operations used to make a Replica. It begins with creating a triplet of RGB numbers, later compares those with scanner triplets to calculate the color transform. That transform is applied to the scan of the "Original" to make the "Master" positive transparency used to optically print the Replica image on print film.

Color Transform

Automated software selects the test target pixels within patches and averages the scanned pixel values. These scanner readings are averaged as well. The computer created these color patches from triplets of digits. The output from the scanner average is a second triplet of digits. The color transform program calculates the 3-D transform necessary to convert the scanner output values back to the original target values. The printer can repeat the process to make the calibration target. By definition the 3-D transform has corrected the scanned digits back to the original values. The second print of the calibration target will be an exact match within experimental error. The photograph of the painting is processed with the same transform as the calibration target. The printing process first makes a 25 by 25 cm positive transparency of the original painting. The transparency is printed using the room-size camera as an enlarger on positive Polaroid film. The 3-D color correction is calculated in a hardware board resident in the film recorder. A computer program uses the 512 input calibration target data and the 512 averaged scanner output data to calculate 60,000 coefficients that are loaded into the hardware transform board. The board then can calculate the output values for each pixel in real time as the scanned data is read from the scanner file for the original. The transparency film recorder exposes the "Master" transparency.

Printing the Replica

The next step is to use the room-size camera as an enlarger. The "Master" is imaged onto the light-sensitive film (negative). Usually the 25 by 25 cm Master is enlarged to the same size as the original. The light source is a photographic strobe with tungsten "modeling" light. The incandescent lamp is used for focusing the "Master" on the image plane. The strobe lamp is used for exposing the negative. A giant Polaroid processor is in a room-size camera. The lnegative is spooled at the top, 3 m off the floor. The positive print paper is at the bottom, 0.7 m off the floor. The chemical reagent, or developer, is applied between the positive and the negative. After the shutter opens, the strobe behind the transparent master discharges, and the shutter closes, the operator turns on a motor that drives a pair of titanium rolls that marries the positive and negative sheets and meters a precise amount of reagent between the sheets. The operator turns on the lights inside the camera, while the combined positive and negative are held in the air. The technicians place the print on the floor, and wait 90 seconds for the dyes to transfer from the negative to the positive. They then peel away the black-backed negative leaving a finished actual-size reproduction of the painting.

Framing and Display

The print is mounted on a stiff archival board. It is then sprayed with a matte-surface, ultraviolet light absorbing protective spray. The prints are then framed as appropriate for the original.

An Example

One of the first masterpieces we reproduced was a Chinese scroll *Ladies Preparing Newly Woven Silk*. It was painted by Emperor Hui-tsung, 1082-1135. This hand scroll is ink, with colors and gold on silk. This Chinese figure painting is the result of combining two of the emperor's hobbies, painting and collecting. The painting carries an inscription by Emperor Chang-tsang of the Chin dynasty(1188-1208) calling this painting a copy of an eighth century painting by Chang Hsuan. The painting shows ladies of the court in formal dress performing the various steps in making silk. These same figures are in a much later scroll, *Scholars of the Northern Ch'i Dynasty Collating the Classics*..

Summary

This paper describes a combined digital and photographic technique. Digital image processing corrects the color boost built into films at the factory. The digital correction makes possible exact reproductions because each square millimeter of print has an individually computed exposure, independent of every of the pixel in the picture. This allows images to look exactly like the originals.

Using a "Master" to print the final image has three distinct advantages: First, photographs have very high resolution, roughly 25 times more data per square area than digital thermal printers. Second, all the data is transmitted in parallel by a printing lens. A strobe light can print 100 megapixels in 1/100 th of a second. A thermal printer takes 200 seconds for 10 megapixels. That is 20,000 times faster to write 10 times more data. The room-size camera with strobe has a data transmission rate of 1 terabit per second. Third, the prints can be very large. The room-size camera makes up to 1m by 2m prints.

References

* mccanns@tiac.net

[1] J.M.Eder, *History of photography*, E.Epsteam, trans. Dover, New York, (1978),453.

[2] H.deRidder, F.J.J. Blommaert, E.E. Fedorovskaya, *Naturalness and image quality: chroma and hue variation in color images and natural scenes*, SPIE Proc. 2411, in press, (1995).