

Report of European Tour

RWTH-Aachen / ISEICP-Zürich / GRETAG IMAGING /
ETH Zürich / TU München / Pinakothek München
May 14-22 1998
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Part 1 (May 14-16) Aachen, Germany

Visit to the **Technical Electronics Department** [Institut für Technische Elektronik] of the **Aachen University of Technology** [RWTH-Aachen (Rheinisch-Westfälische Technische Hochschule Aachen)]

After traveling from Rochester to Düsseldorf, Germany, I took a train to Aachen arriving on May 14. In the next day (May 15) I went to the Technical Electronics Department of Aachen University of Technology whose buildings can be seen in the Fig. 1. The RWTH (Aachen University of Technology) has a history of about 120 years and it is the largest university of this kind in Europe with 36.500 students, 250 institutes and departments, 500 professors and 2.700 scientific employees.

The chair and director of the Technical Electronics Department of RWTH is Univ.-Prof. Dr.-Ing. Bernhard Hill who has been working at RWTH-Aachen since 1984 after leaving the Laboratories of Philips in Hamburg. The Technical Electronics Department (ITE) has a field of activity in Color and Electronic Imaging. Figure 2 show Prof. Hill with Dr. Herzog and Mr. König.



Figure 1. Picture of the Technical Electronic Institute building of Aachen University of Technology extracted from the web page <http://www.ite.rwth-aachen.de/indexe.html>



Figure 2. Picture of Prof. Hill (left), Dr. Herzog (center) and Mr. König at the entrance of the Technical Electronic Institute

I had the opportunity to have a look at following projects at the Technical Electronics Department:

I) Multispectral Image Acquisition System - In this system shown in Fig. 3a there is a slide projector lamp that illuminates the target image shown in detail in Fig. 3b and the image is taken by a 2k by 2k pixels resolution black and white Kodak CCD connected to a filter wheel with 16 interference filters. Both the filter wheel movement and the rotation of the mount that alternate the exposition of target image/standard white cardboard (for white spatial calibration) are controlled by the computer.

Mr. König (<http://www.ite.rwth-aachen.de/koenig/>) has been working very actively in the research of the practical problems of building and operating a multispectral scanner such as the influence of filter positioning, angle of incidence of rays in the interference filters, and noise in the performance of the system. He and Mr. Werner Praefcke have been performing simulations comparing many spectral interpolation and reconstruction methods to test their colorimetric accuracy. Mr. Praefcke (<http://www.ient.rwth-aachen.de/praefcke/>) is a Ph.D. degree student at the image processing group of the Institute of Communications Engineering (IENT) at the same University in Aachen.



a. Multispectral image acquisition system

b. Illuminated image

Figure 3. Pictures of the multispectral image acquisition system at the Color and Electronic Imaging department, Technical Electronics Institute, RWTH-Aachen.

II) LED-illuminated CCD slide scanner - Mr. Moon-Cheol Kim (<http://www.ite.rwth-aachen.de/kim/>), a Ph.D. degree student from South Korea showed his research on slide scanner that can accurately reproduce the color of slide images on a display. In this system shown in Fig. 4a the slide film is illuminated by a RGB LED array and the image is capture by a black and white CCD. After appropriate uniformity correction the intensity is corrected by one-dimensional look-up table. Based on color calibration of different devices and considering different viewing conditions using RLAB color appearance model as well as gamut mapping, three dimensional look-up table is calculated for all possible film colors. Mr. Kim intends to perform psychophysical experiments in the future using specially prepared booth like the mount shown in Fig. 4b. As a future project he intends to apply his method for color negatives too.



a) Slide scanner and reproduced image



b) Booth for psychophysical experiments.

Figure 4. LED-illuminated CCD slide scanner

III) Auto-focus slide projector

Mr. Wolfgang Kessler (Kessler@ITE.RWTH-Aachen.de) showed me his auto-focus slide projector system shown in Fig. 5. It is possible to identify two lenses. The forward lens projects the slide on the screen and the lens behind of the projection lens capture the image and there is a mechanical system that maximizes the sharpness of the captured image controlling the focus of the projection lens. Mr. Kessler is the third person from right to left in the portrait of Fig. 6.

IV) **Representation of color gamut** - Dr.-Ing. Patrick Herzog, a senior engineer in the department showed his research on analytical representation of color gamuts that is fully documented in his publications (<http://www.ite.rwth-aachen.de/herzog/indexe.html>). Basically this method that he calls 'gamulyt' represents gamut by distorting functions (a combination of Fourier Series) and scaling functions in cylindrical coordinates.

After a lunch brake, as we have a lot of common interests in research Prof. Hill Dr. Herzog Mr. König and I discussed about multispectral image acquisition. At the end of this part I would like to acknowledge to Prof. Hill for the invitation, Mr. König for arranging this visit and for the members of this department (shown in Fig. 6) who are very kind to show their experimental settings.



Figure 5. Auto-focus slide projector



Figure 6. Members of the Department of electronic imaging

Part 2 (May 17-19) Regensdorf, Switzerland -International Symposium on Electronic Image Capture and Publishing -Visit to GREGTAG IMAGING AG

On May 17 I traveled from Aachen to Regensdorf-Zürich in Mr. Praefcke's car with Mr. König and we registered for the conference.

The International Symposium on Electronic Image Capture and Publishing of EUROPTO series (<http://www.spie.org/europto/>) took place at the Hotel Mövenpick, Regensdorf near Zürich, Switzerland from May 18 to May 20. The objective of the symposium sponsored by EOS - The European Optical Society, SPIE - The International Society for Optical Engineering, IS&T - The Society for Imaging Science & Technology and The Commission of the European Communities, Directorate General for Science, Research and Development is present the latest research in imaging science, color printing and publishing, advanced focal plane arrays and electronic cameras. There were two parallel events: The Advanced Focal Plane Arrays and Electronic Cameras Conference that highlights Focal Plane Arrays technology, cameras and systems issues and The Conference on Electronic Imaging: Processing, Printing and Publishing in Color that I attended. The Conference on Electronic Imaging discussed novel approaches and developments in color, image capture and perception, image processing and compression, databases, network printing and multimedia. The program of the conference can be seen at <http://www.spie.org/web/meetings/programs/eis98/3409.html>. I presented the paper "Multispectral-based colour reproduction research at the Munsell Color Science Laboratory" in session 1 Colour: Multispectral Technology on May 18. I also attended session 2 Color: Appearance and Perception, Session 3 Image capture and scanning on Monday and on Tuesday I attended Session 4 Image processing, Session 5 Halftoning, Session 6 Image compression and Session 7 Printer Control and Printers. I did not attend sessions 8 and 9 on Wednesday because I went to visit Swiss Federal Institute of Technology. Figures 7 and 8 show some pictures taken during the conference.



Figure 7. Dr. Reiner Eschbach, Prof. Hill, Dr. Herzog, Mr. König and Mr. Praefcke in front of Hotel Mövenpick.



Figure 8. Mr. Jan Hardeberg, Mr. Armin Wittmann, Ms. Genevieve Dardier, Dr. Ruedi Gschwind and Prof. Francis Schmitt during lunch break at Regensdorf-Zentrum.

Visit to GRETAG IMAGING AG

Dr. Guido Keller, head of research and development for new imaging technologies at GRETAG IMAGING arranged a visit to this company after the conference on Tuesday, May 19 and 7 people including Prof. Francis Schmitt (Ecole National Superieure des Telecommunications, Paris, France), Prof. Bernhard Hill (RWTH-Aachen), Dr. Patrick Herzog and more 3 researchers from Aachen (Friedhelm König, Werner Praefcke and Moon-Cheol Kim) took part in this visit. After a presentation of the company showing some products, mostly minilabs, film scanners and printing machines, we had the opportunity to see the assembly line of some products such as the Master Flex series minilab for photographic development and printing and the Syntra Printer that uses an improved scanning method called Eye-Tech Scanning that increases up the number of scanning points from the usual 100 points to 1,014 and it measures 30 evenly distributed spectral samplings rather than the usual three RGB samplings. From the measured data it uses principal component analysis to reconstruct original density spectra. More information on GRETAG can be find at <http://www.gretagimaging.ch>. Figure 9 shows the visitors in the entrance of GRETAG IMAGING building.



Figure 9. Picture taken at the entrance of GRETAG IMAGING, Regensdorf, Switzerland.

I would like to acknowledge Dr. Guido Keller and all his coworkers that arranged this very interesting visit.

Part 3 (May 20) Zürich, Switzerland

Visit to the Digital Film Technology Group, Electronics Laboratory [Institut für Elektronik] Swiss Federal Institute of Technology Zürich [ETH - Eidgenössische Technische Hochschule Zürich]

On May 20 I went to visit Swiss Federal Institute of Technology (whose main library building is shown in Fig. 10).

Mr. Armin Wittmann arranged the visit to the Electronics laboratory of Swiss Federal Institute of Technology at Zürich-Zentrum that is located inside the back building of Fig. 11.



Figure 10. Main Building of ETH Swiss Federal Institute of Technology.



Figure 11. The back building hosts the Electronics Laboratory of the ETH

Mr. Armin Wittmann has been actively working in his Ph.D. research on digital restoration of old motion pictures as part of SIRIUS project, a joint project of Swiss Federal Institute of Technology and Basel University. Based on success of previous works on digital restoration of faded color photographs by the Scientific Photographic Laboratory of Basel University headed by Dr. Ruedi Gschwind, this project intends to extend digital restoration to old motion picture films. In this project, scientists with expertise in photographic restoration are working with digital image processing, computer vision and high-performance computing specialists. Computer vision expertise is necessary to deal with dust and scratch removal from old movie films and high-performance computing is necessary because the huge data amount of scanned movie film compared to photographs (e.g., a typical 90 minutes movie corresponds to 1.2 Tbytes of data). In order to support further digital processing they developed a new movie film scanner technology that can give the complete digital representing of any format film strip (frames, analog sound, digital sound, perforation, frame gap area as well as manufacturer codes), can be used to measure dye concentration and could scan even damaged film strips.

Figure 12 shows Armin Wittmann with the movie film scanner. The illumination source of 150 W is located below the scanner avoiding heating of the filmstrip. There are 3 RGB light sources and the light is transmitted to the scanner by fiber optics. Figure 13 shows a detail of the scanner that uses a 2K x 2K CCD. One interesting feature of this scanner is that it does not use the film strip perforation and it reduces the mechanical stress and it can be used for films of various width with small minor adjustments in the scanner. The result is a movie film scanner that scan one frame per second and could produce data for further digital image processing to restore color, geometry distortion, sound and remove dust and scratches. For more information have a look at <http://www.digital-restoration.ethz.ch/>



Figure 12. Armin Wittmann and the movie film scanner of the Electronics Laboratory, ETH Zürich



Figure 13. Detail of the movie film scanner of the Electronics Laboratory, ETH Zürich

I would like to acknowledge Mr. Armin Wittmann for his kindness in showing his project, as well as the tour at ETH-Zürich buildings and showing me interesting places in Zürich.

Part 4 (May 22) München, Germany

Visit to the Technical Electronics Institute of the München University of Technology [Technische Universität München] and München Pinakothek

May 21 was a day off because it was Ascension Day (a Christian National Holiday) in Switzerland and Germany and I went to Luzern, climbed Mount Pilatus and traveled to München, in Germany.

The **München University of Technology** (http://www.tu-muenchen.de/index_e.html) has a history of 130 years and has roughly 21,000 students, 240 full professors and 9,315 full-time employees.

In this university I visited Dr. Reimar Lenz at the Technical Electronics Institute and I also met Dr. Lenz's brother, Dr. Udo Lenz who is full-time working in their company called CCD-Videometrie. Dr. Reimar Lenz is a Ph.D. in Electronical Engineering and Dr. Udo Lenz is a Ph.D. in Nuclear Physics and they joined their skills in electronics, physics and mathematics to produce the first digital camera with sufficient resolution to image artworks with high colorimetric accuracy. The Lenz brothers are pictured in Figs. 14 and 15.



Figure 14. Udo (left) and Reimar Lenz at the entrance of the Electrocommunication and Electrophysics Department of München Technical University



Figure 15. Udo and Reimar Lenz showing their MARC 2 digital camera.

The Lenz brothers have been working in the MARC (that stands for Methodology for Art Reproduction in Color, a European Community project whose aim is to improve the quality of reproduction in art catalogues and books) camera since 1989 and the first MARC camera pictured in Figure 16 was the first still camera comparable to 35 mm slide quality. This camera combines micro- and macro-scanning using a stationary lens with color mosaic mask with filter characteristics closely matched to a linear combination of the CIE1931 XYZ spectral response curves. The micro- and macro-scanning feature provides a full resolution of 20k x 20k pixels although the effective resolution considering the MTF of the system is lower (about 12k x 12k for macro-scanning). This camera is available at the Pinakothek in München, the National Gallery in London and the Byzantine Museum in Athens.

They also developed the MARC 2 camera to be used to digitize old books and documents of the U. S. Library of Congress and its main feature, besides being more compact than the original MARC camera is the fact that it is 20 times more light sensitive than the previous one because much light to perform image capture could damage old books. This camera is shown in Figs. 17 and 18. This digital camera can be connected to a computer (PC, MAC or SUN workstation) using a computer interface board (shown in Fig. 19) by 12 bit data transmission.



Figure 16. MARC project camera (the digital camera attached to a Bronica camera body) of the Pinakothek, München



Figure 17. MARC 2 project camera



Figure 18. Details of MARC 2 project camera showing electronic board, CCD and cables.



Figure 19. Computer interface board for MARC 2 project camera.

To generate the prints in the MARC project, a set of patch is printed and 3D lookup table are generated by non-linear transformations from a full set of measurements for each target paper, ink set and color to convert from tristimulus values to printer CMYK.

During my visit to the university, I presented the research being performed at MCSL and we had plenty of discussion about what would be the sufficient number of parameters to transform camera RGB signals to tristimulus values and about MARC project cameras features.

Pinakothek München

After lunch break it was possible to schedule a visit to the Pinakothek München to have a look at the application of the MARC project camera to digitize artwork paintings. Figures 20 and 21 show the use of MARC project camera for infrared reflectography. The infrared reflectography allows taking picture of the drawings under the paints and it is important to study the creative process of painters and it is also used to detect forgery as exemplified in Fig. 22. Figure 23 shows an example of how images captured for artwork catalogue printing are presented on CRT display. I would like to acknowledge the Lenz brothers for spending their precious time showing me their MARC project camera.

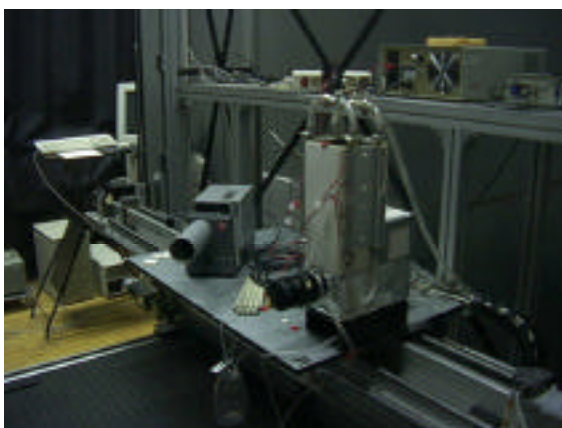


Figure 20. Infrared source and MARC project camera used for infrared reflectography.

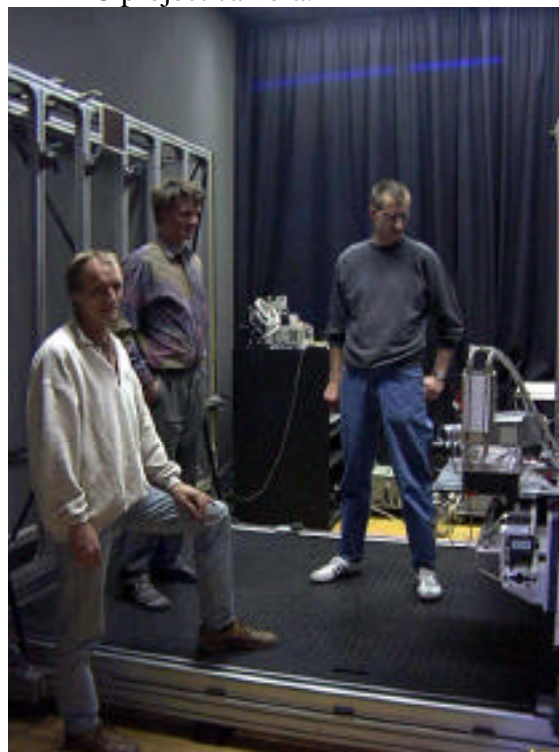


Figure 21. Lenz brothers and a museum staff showing the size of the digitizing system at Pinakothek München



Figure 22. Infrared reflectography used to detect a forgery of an "El Greco" painting



Figure 23. Fully digitized picture (left) by MARC project camera and a zoomed in detail of the painting

Conclusion

During this tour in Germany and Switzerland it was possible to have contact with many researches closely related to the current project I have been working here at Munsell Color Science Laboratory. I had an opportunity to talk with scientists in the Technical University of Aachen on theoretical and practical considerations of multispectral image acquisition and other color reproduction related topics that they have been investigating and simulating. During the International Symposium on Electronic Imaging Capture and Publishing it was possible to have contact with other scientists working with multispectral image acquisition and spectral reconstruction such as Prof. Francis Schmidt of ENST, Paris. The GRETAG IMAGING visit showed that multispectral acquisition is becoming a reality as a commercial product. The visit to the electronics laboratory at the Swiss Federal Institute of Technology showed me a successful example of digital scanning applied to movie film as a part of a project that integrates many fields of knowledge such as photographic restoration, computer vision, high-performance computing and digital image processing. And finally the visit to München University of Technology and the Pinakothek München gave me insights on digital image capture modeling and practical considerations to image artworks using a digital camera based on the vast experience of the Lenz brothers. All these knowledge, discussion and experience will help me to develop a better system for capturing painting images. Finally, I would like to acknowledge Prof. Roy Berns for the opportunity of this technical trip to Europe.