

Automatic Image Processing in Digital Photoprinters

Tobias Damm
Agfa Gevaert AG, Consumer Imaging, Lab Equipment
D-81539 Munich, Germany

Abstract

The conventional photographic system, based on AgX film and paper will be briefly described. There are many issues to be improved by digital image enhancement: at under exposed images the reduced contrast, color saturation and increased grain; cross curving of film and paper; the problems due to the limited contrast rendering ability of the paper with respect to the total dynamic range and the loss of definition at high saturated colors.

Automatic scratch and dust removal and new products with manipulated color saturation (sepia, black & white) are examples for new possibilities due to digitization of the lab equipment.

The digital workflow is also a prerequisite for the production of prints from digital cameras and to provide digital files from scanned film. This market will grow considerably in the near future and the photo industry has to make preparations for this development. But these images exhibit also artifacts like increased noise at under exposure or unbalanced density and color due to misled exposure control of the camera and limited dynamic range of the system.

Although the image enhancement algorithms are well developed for professional applications, their utilization in high productive amateur labs is not simple since the cost performance relations are not acceptable. They lack of the necessary interaction by an operator. Automatic operation of the digital systems in a high productive lab will stay a challenge for the industry.

Introduction

In the past, digital image processing was limited to professional applications because of speed and cost reasons. Only professional photography needed the unlimited flexibility and possibilities of digital image processing and could pay the high cost. In the Minilab market there are now digital machines available from all vendors. Currently they are used mainly for professional applications, but they will be seen in mainstream production as the demand for prints from digital camera files will increase. Driven by the possible quality enhancement and the need to get a share from the digital photography, the wholesale finishing labs are also very much interested in digital solutions. However, in a wholesale finishing environment interactive operation is not feasible.

In this paper the possibilities to remove shortcomings of the conventional photographic system as well as the expansion of photographic production by digital means, focused on Minilab and wholesale finishing labs will be treated. In a digital system the film is scanned with a high resolution, high dynamic film scanner. The data are processed and the corrected data are printed by a digital printer. The image files from digital cameras can also be fed into the processing unit to produce prints and digital image files from film scans can be delivered.

Conventional Photographic System

At the conventional photographic system the color negative film and paper are well adjusted to each other to provide both a good image quality and a high system robustness under amateur conditions. The gradation of the film is designed to be low (γ =0.65) in order to get a high exposure latitude. The paper gradation is about 2.5 in order to get an overall gradation of about 1.4 which gives a high contrast and saturated color impression of the print. There are some shortcomings of the conventional system which can be corrected when processing the images digitally.

Digital Enhancement of the Photographic System

A limited exposure range of the paper is a consequence of the steep gradation. Thus, when a high contrast scene is captured, one has to decide which part of the original dynamic should be transferred to the print. Several methods to modify the total contrast of the original scene have been developed, either by applying an optical dodging mask in a hybrid printer like the Agfa DIMAX, or by reducing the very low frequencies of the image data with a low pass filtering in fully digital systems. The detail contrast is maintained while the limited total contrast ability of the paper is visually better balanced.

Another shortcoming of the chemical photographic system is the reduced gradation of the film when underexposed. This leads to shallow, colorless prints. A digital photo finishing system can compensate for the low film gradation by applying a steep characteristic correction curve. The result is an improved image both in contrast and color saturation since the color separation is also increased while applying a steeping curve.

Although the sensitivity / graininess relation of films has been much improved in recent years, high speed films still exhibit a very high graininess. To a certain extent, this can be compensated by applying a smart filtering of high spatial frequencies of the digital data.

Analyzing further the limitations of the conventional photographic system one is faced with cross curving of film and the paper. Due to design limits of the chemistry, the gradation curves of film and paper are not linear and not parallel for the 3 colors. This leads to color artifacts in shadows and highlights. Digital processing enables to compensate this behavior very easily by applying the proper gradation correction to each color channel.

As already mentioned, the contrast ability of the conventional photographic system is limited. This holds true also for the color contrast which can be rendered. Very saturated colors are clipped when reproduced on paper, the fine definition in saturated color areas is lost. In the conventional system, this artifact is reduced by introducing additional dyes into the system. Digitally it is much easier by smart mapping of the gamut of the digital image data.

Extension of the Production

When having the images digitized, new products and new services are feasible. Prints with changed color saturation like sepia or black & white can be produced very easily.

A considerable improvement of both print quality and productivity / production quality can be realized by digital scratch and dust removal. The scratches and dust on the film are detected in a fourth channel which is separate to the 3 color channels. This information is used to perform an automatic retouching of the image data which are printed then perfectly on the paper.

Digital Print Service

The main extension of the production portfolio is realized by the possibility to get a share of the digital photography. This is one of the driving forces for digitization of the photo labs. When having an installed digital work flow in the Minilab or the wholesale finishing lab, it is easy to feed into this work flow also the data from digital cameras or to output digital images from film. The transfer, storage and processing of the huge amount of data is currently an important task of the whole industry.

The digitally produced images also exhibit photographic problems. The exposure control of digital cameras is equivalent to that of conventional cameras, it can be mislead by the scene. Over and under exposure of the sensor (CCD, CMOS) occurs. The dynamic range of recent sensors is not as wide as that of film. Thus, exposure correction is also an issue in digital photography.

When comparing the prints from different digital cameras with fixed processing, the color and density differences in many cases are larger than at a conventional production with different film types. Although there are several technical committees working on standardization there is a need to automatically compensate for the individual color and density behavior of the cameras similar to the compensation for different film types by total film scanning in order to get a balanced mixed production.

In contrary to the conventional system, a digital camera shows a constant gradation when reducing the exposure. However, the noise is increased considerably. To reduce this noise when processing the digital images is a challenge for the system manufacturers, which will support the position of the photo labs.

Automatic Production

The difficulty in high productive photo finishing environment would be to automatically control all these digitally possible features, i.e. to make really use of the digital potential without reducing the system speed. There is no indication that more information about the original scene, the illumination conditions or any other photographic information will be available when producing the prints as it is available in the conventional photo lab today. Therefore, smart algorithms will still be necessary to discover the right treatment of the image independently whether it comes into the lab in digital ore conventional form.

The design of the digital signal processing will influence the achievable image quality. These image enhancement algorithms are very well investigated in the professional environment and can be purchased from the shelf. The achievable image quality is extraordinary high, the problem is, to apply them to the vast amount of pixel data in acceptable time frame and at affordable cost.

However, these software products usually require some operator interaction to control the image manipulation. The automatic control of the digital possibilities in a high productive lab will stay a challenge for the industry. Smart algorithms like the Agfa TFS technology will remain key features which are necessary to commercialize the possible benefit from the digital possibilities.

Conclusion

Although the chemical photographic system provides a considerable high image quality at very competitive speed and cost, there are some quality issues to be improved by digital processing. But the digital equipment increases the cost of the production. The challenge for the photo industry in particular in the amateur market is to create from the increased image quality an increase of the production quality, i.e. to produce more sellable prints. And of course to reduce the cost per print by maintaining the high speed of recent lab systems by implementing smart automatic control algorithms.

Acknowledgement

The author would like to thank the colleagues of the Basic Research Department of Agfa Lab Equipment for their superior contribution to this paper.

Biography

Dr. Tobias Damm studied physics at Jena University, Germany. He took his diploma in 1981. In 1985 he received a PhD in physics and the Dr. rer. nat. habil. in natural sciences in 1991. His scientific work included laser physics, spectroscopy and scanning microscopy.

Dr. Damm joined Agfa in Leverkusen in 1990, where he started as a technical consultant to develop new systems for the photo market. In 1993 he moved to the Agfa business unit lab-equipment in Munich where he managed projects to introduce digital technology for major applications. Since 1996 he has been head of basic research of the lab-equipment division. He is a member of the IS&T and since 1999 he is the Vice President of the European Chapter of IS&T.