

Digital Services of Photographs

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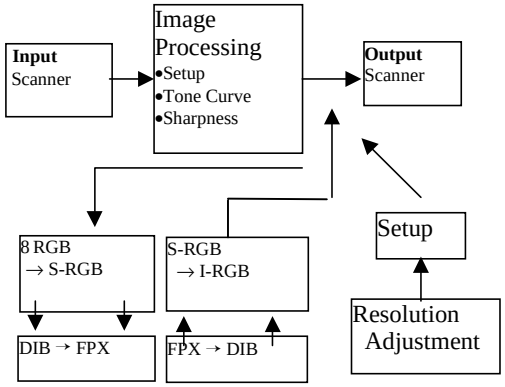
Abstract

FUJI Photo Film is attempting the construction of a new infrastructure corresponding to the digital generation. As the first step, the new digital photo processing for a ordinary amateur user has been launched. We report on the content of this service and the technology which supports it.

Introduction

FUJI PHOTO FILM succeeded in creating the world's first Digital Photo Printer that uses a blue laser and has been selling the equipment since 1996 (Product name: Frontier). Frontier consists of an image reading device, an image processing device, and an image recording device and it can be put to many uses. In addition, the Frontier system is the centerpiece of various digital services which were introduced in the fall of 1997. These services make up what is called F-DI, or Fuji Digital Imaging Service. This service aims to construct an infrastructure that enables the smooth transfer of high quality image data between photofinish shops equipped with abundant image-related experience, equip-ment, and expertise, and home PCs and digital cameras.

Service Outline



(I-RGB =Internal RGB, DIB = Device Independent RGB)

Figure 1. System Configuration

The services generally breakdown as follows.

①conventional film → file output (FPX-CD)
②conventional film → WWW server (network)
③SRGB Data(FD,ZIP,CD) → print(by Frontier)
④SRGB Data(Network) → print (by Frontier)
⑤DSC Data → print (by Frontier after correction)
(DSC = Digital Still Camera)

These services are based on Fuji Photo Film's unique image technologies, such as our high speed digitizing, high speed laser printing, file format, and color management. I would like to take this opportunity to introduce the various elements of these services and discuss the supporting technologies.

Basic Design

When handling images in an open environment, one might ask, "Which HUB space should be chosen?" This is a very important question, and your answer will vary according to what you consider most important. For F-DI, we considered the following two points to be the most important

<condition 1>
Image data provided by F-DI should be viewable on a CRT monitor at a desirable level of image quality without requiring any special processing.

<condition 2>
Image data provided by F-DI should provide equal quality as the print without F-DI service, as long as the data has not been subjected to any special image processing.

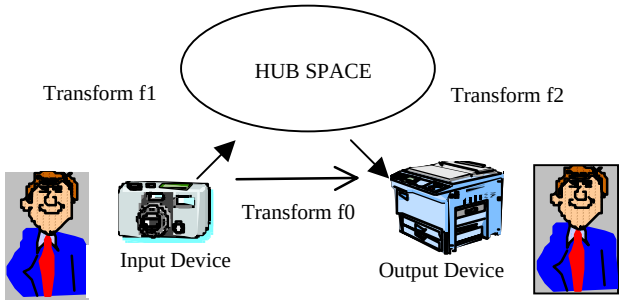


Figure 2. HUB SPACE

Conventional analog systems and closed systems print reproduction objectives have been represented desirably on

the print. That is done by using the suitable tone curve and the color transform as shown in f0 in Fig2. Thus, to achieve <condition 2> above, the function f1*f2 and the function f0 must be almost same. Even with a limited number of gradations, it is very important to achieve the reproduction objective without image deterioration. Furthermore, in order to fulfill <condition 1> above, image data that has undergone conversion f1 must be viewable on a CRT monitor at a desirable level of quality, and it is very important for the image to appear on the CRT to be the same as it appears on the print.

Considering these requirements, we have adopted s-RGB defined by FlashPix as the HUB space for F-DI service. Incidentally, in FlashPix, Photo YCC is also defined.

The CRT being used is assumed to be the following:

Table 1

RGB : ITU-R Rec 709 conformity
The chromaticity coordinates of R,G,B,White
Red (0.640, 0.330, 0.030)
Green (0.300, 0.600, 0.100)
Blue (0.150,0.060, 0.790)
White Point : D65 (0.3127, 0.3290, 0.3583)
Tone Curve:
$R' = 12.92 \cdot R_{S\text{-}RGB} \quad (0 \le R_{S\text{-}RGB} \le 0.00304)$
$R' = 1.055 \cdot R_{S\text{-}RGB}^{(1.0/2.4)} - 0.055$ Others

Feature of Image Files for Output

There are two types of image output services: a media service and a network service. Media service is a service that digitizes negative or positive film and stores the data on a CD-R. Network service stores data on the WWW, rather than on a CD-R, and users can access their data via a web browser.

FlashPix Format

The F-DI Service uses FlashPix for its standard image format. FlashPix is a new format, developed mainly by Eastman Kodak, Live Picture, Microsoft, and Hewlett-Packard, with the objective of quickly and easily handling high resolution images in a PC and network environment. Currently, Fujifilm, Canon, Adobe, Intel , and IBM have also become involved in establishing and popularizing this as an industry standard

The FlashPix format is a hierarchical structure consisting of multiple resolution image data, from high resolution to low resolution, and each layer of data in the hierarchy is made up of a tile structure

Interpolation filters, called decimation filters, are used to create a lower resolution image from the high resolution image by halving the number of vertical and horizontal pixels. FlashPix defines four types of decimation filters, however, since F-DI emphasizes sharpness, a filter size of 8 x 8 has been adopted to cover the entire hierarchy

(2)Resolution (number of pixels)

The following table lists the number of pixels in an image at maximum resolution as used in the current media service (CD-R).

Table 2

File Output

input source	Horizontal (pix)	Vertical (pix)
APS(H,C,P)	1890	1074
135-H	1890	1074
135-F(L)	1524	1074
135-P	1890	672

The number of pixels listed above are equivalent to what is called 4-base. And these were determined based on Frontier's resolution, that is 300 dpi, and printer paper size. For the network service as well, 4-base pixel image data is stored on the hard disk, and will be used when a print is ordered. However, since our high resolution image download service is not yet available (as of February 1998), users will be able to download images as low as 1-base.

(3) Rate of Compression

In F-DI service, the compression rate of image data is different in each hierarchy to keep a high quality. As a result, the data amount is decreased to about 1.5-2MB with the high quality maintained. (The data amount of a FlashPix image without compression is 8 MB.) In general, because redundancy grows in the high resolution image, it is possible to set the compression rate high. A concrete compression rate in F-DI service is as follows.

① Maximum resolution images have the greatest redundancy, but since it is data that is used by the printer, in order to maintain high quality, a compression rate of 3 bpp (bits per pixel) is used (roughly 1/8).
② Second-level hierarchy images are the size most often displayed on CRT monitors and in order to be viewed favorably, a compression rate of 7 bpp is used (roughly 1/3).
③ Images lower than third-level hierarchy have little redundancy and therefore are not compressed.

(4) Color Space

As already expressed when discussing the basic design, our thoughts relating to color space for F-DI are follows:

The photo print should equal the original data. The idea of F-DI service to the relation between the scene brightness and RGB data conforms to one of conventional system. When photo prints are made from negative film using an analog system, the photo subject is shown at its optimum by using setup software to calculate proper exposure and to be multiplied the tone curve of the color paper. With F-DI, the know-how fostered by the analog system has been applied

to the digital system and the same setup process is used to make the print. As a result, the gamma value to the scene brightness of the RGB data output by F-DI service is 1.5~1.8. It is a given that the print will be viewed in a PCS space and it is assumed that the image for F-DI Service output will be viewed on a standard CRT monitor. As a result, with F-DI, we have made it so that if the image data sent to Frontier's printer unit is converted, its appearance will match that on the CRT monitor

Table 3

Viewing Condition

	PCS Space	s-RGB Monitor
Viewing Flare	1.00%	0.5~1.0%
Image Surround	Grey, Reflection Rate is 20%	Grey, Reflection Rate is 20%
Luminance Level	160~640cd/m^2 (200~500Lux)	80 cd/m^2 (100Lux)
Adaptive White	D50 x=0.3457 y=0.3585 Light Source:F8	D65 x=0.3127 y=0.3290

(5) Relationship Between RGB Values and Lab Values When Printing

The relationship between F-DI image pixel value (RGB values) and print density values (L*,a*,b* values) at the time of printing in the lab are as stipulated below.

·Color Chart

Table 4

s-RGB value			L*a*b* value		
R	G	B	L*	a*	B*
112	59	40	30	21	20
208	151	129	62	19	19
41	130	178	48	- 15	- 30
33	71	34	26	- 18	17
128	129	179	52	6	- 24
69	173	180	60	- 28	- 11
210	108	4	52	36	59
24	88	165	36	0	- 43
196	62	67	44	51	26
53	34	85	19	15	- 25
155	174	14	62	- 16	62
224	155	5	63	20	67
0	51	133	24	8	- 46
0	116	55	40	- 36	24
160	18	8	33	51	41
238	193	0	73	8	75
202	78	134	48	49	-5
0	122	170	45	- 17	- 31

·Gradation

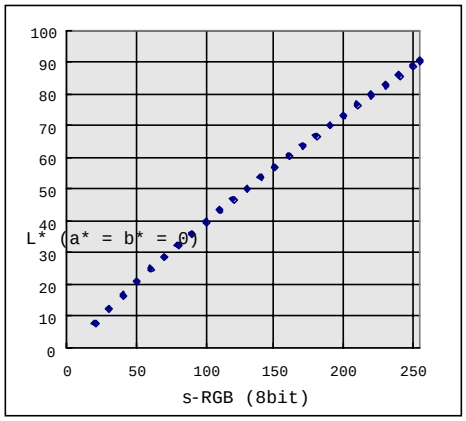


Figure 3.

Feature of the Input Service

The image input service consists of the following three services:

① a media print service for creating order information via special applications
② a network service for interactive ordering via a network
③ a DSC print service for printing the contens of digital camera memory cards

(1) Order Information File

Order files use OLE structured storage developed by Microsoft which contains information relating to print orders at the lab. These files are created using a special application provided by our company. The order files are electronic versions of the order envelope and they make it possible to make complicated orders (such as cropping) that were often difficult to describe on paper. These files may be one way to lower the price of services through rationalization of lab processes

(2) Image Format

① Media Service

The special application offered by our company can read various file formats other than FlashPix, however, when a file is created for input service, it is converted to a FlashPix format.

② Network Service

FlashPix format images are used when an image stored on the server is to be printed, however, there is no need for the user to be aware of the format since it will be processed in the background. Furthermore, when uploading a print, major representative file formats can be used.

③ DSC Print Service

Almost all media and file formats used with the digital camera can be accepted.

(3) Print Size

The print sizes which can be set for service ①and ② are shown in the table below. Only Lv size can be set for service ③.

Table 5

	Horizontal (mm)	Vertical (mm)
Postcard size	102	146
HV size	89	158
Lv size	89	127
PA size	89	254
A5	210	148
A4	210	297

(4) Color Space

For Services ① and ②, the input image data is interpreted as s-RGB, and once reverse conversion of the conversion discussed in "Feature of Image Files for Output (4)" (conversion to Frontier's printer unit color space from s-RGB) has been performed, the image is printed.

In Service ③, setup is performed, and once gradation and color balance adjustments have been made, the image is printed. Since digital cameras do not guarantee that data is s-RGB, new setup software based on the features of a major representative digital camera has been created and image adjustments are being conducted

Summary

In condition, what I tried to present here today was a short, introductory discussion of the digital services Fuji Photo Film, Inc. introduced in the fall of 1997, as well as the underlying technologies. And although the network service and DSC print service are not yet out of the experimental stage, as the infrastructure further develops, the use of these new services is expected to increase. We will continue to provide services that meet user needs in a timely manner.

We'll introduce the latest situation of F-DI service at the conference.

Reference

- FlashPix Format Specification Ver.1.0, Eastman Kodak Company, Sep., 1996
- Development of a Digital Lab System Designed "Frontier" and a Color Paper for the "Frontier" System, FUJIFILM RESEARCH & DEVELOPMENT NO.42 (1997); S. Ohtani, M.Umemoto, M.Matsumoto
- F-DI Standards, - Foundation for Handling of Image Data on F-DI Service - FUJIFILM RESEARCH & DEVELOPMENT NO. 43(1998); N. Nakajima, K. Yamada, S. Ohtsuka, H. Kato