Enhancing the " Dynamic Range " of Scanned Images

Ibrahim Esmat Wali,
Printing, Publishing & Packaging Department, Faculty of Applied Art, Helwan University

Abstract:
 When digitizing images to computer normally the image is subject to some changes in the color tonal value, thus a post scanning process is a must to restore some of it's original color quality.
before the use of scanner a manual process is performed to give this action, with the use of digital software anew technique is need to give the same function enhancing the quality of the image color in the form of expanding the image dynamic range.
The problem of the present study is the scanning of images causes some loss in color data (in the form of shrinking the dynamic rage) this can be reviewed using the " Histogram " of the scanned image comparing with the dynamic range of the original print and measured using the info palette. Some tonal correction operation that were carried out using the "photo-mechanical camera" are no longer been used, and therefore we lost this function when "photo-mechanical camera" is no longer been used that's when we need to find a new digital function to replace that fatal tonal correction operation. Therefore the target of this paper has been to convert the "photo-mechanical camera" tonal correction technique into a digital process by expanding the dynamic range of scanned image.

Introduction:
The first stage in the printing industry is the creating the design, and that stage needs to use images in the design, for the first ages we used to do what is called " Photo Montage " and that step is carried out manually by the designer side, then the designer sends the design to the "photo-mechanical camera" which converts the design into a film to be used to create the printing plate.
The "photo-mechanical camera" was to convert the hard copy into a light sensitive media called " Film".
The "photo-mechanical camera" is used therefore to create the final design with very little space fore corrections.
Scanners have replaced the conventional "photo-mechanical camera" as a digital input device in the field of printing and advertising. this is clear when reviewing the major international expiations of printing we would find that no "photo-mechanical camera" are produced long time ago.
The most familiar sensor of scanner is the photodiode, which is constructed of silicon materials and whose output voltage waveform is proportional to light. The use of a filter in front of a sensor improves selectivity. For example, a green (pass) filter in front of a light sensor favors light in the green and of the color spectrum. As a consequence, the sensor output will be stronger for green light than for other components in the visible spectrum. [Gonzalez, 2008; p48]

Statement of the problem:
Scanning images causes some loss in color data (in the form of shrinking the dynamic rage) this can be reviewed using the " Histogram " of the scanned image comparing with the dynamic range of the original print and measured using the info palette.

Objective:
Some tonal correction operation that were carried out using the "photo-mechanical camera" are no longer been used, and therefore we lost this function when "photo-mechanical camera" is no longer been used that's when we need to find a new digital function to replace that fatal tonal correction operation.
The target of this paper is to convert the "photo-mechanical camera" tonal correction technique into a digital process by expanding the dynamic range of scanned image.

Conventional images quality enhancing:
The photographic procedures made it possible to capture pictures on film. [Kipphan, 2001; p26]
This is done using the "conventional photo-mechanical camera" and later process action "Exposure compensation" called "Pump exposure" should be done to expand the dynamic range of final image, that technique is used for adjusting the main exposure, "Pump exposure" is commonly applied to the photo-mechanical film after the "Main Exposure" is done to add additional tones to the latent image formed in the

photo-mechanical film, which acts like increasing the amount of colors in the image.

Dynamic Range in digital images:

Dynamic range describes the ratio between the maximum and minimum measurable light intensities (white and black, respectively). In the real world, one never encounters true white or black — only varying degrees of light source intensity and subject reflectivity. Therefore the concept of dynamic range becomes more complicated, and depends on whether you are describing a capture device (such as a camera or scanner), a display device (such as a print or computer display), or the subject itself. [www.cambridgeincolour.com]

Dynamic range can be illustrated visually in the "Histogram" diagram.

Histogram:

Histogram is the key to understand digital images [dpreview.com], it is an analytical diagram that displays the quality of colors in the image, by representing the amount of each color value as a line starting with the 0% to 100% for every Color Channel.
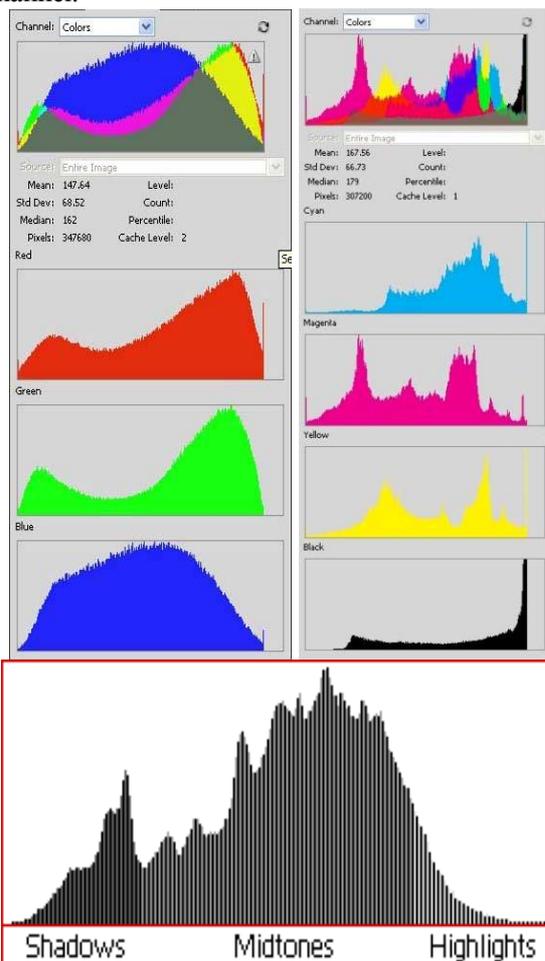

Figure [1] Histogram as displayed in a Graphic Software

Research methodology:
I used the experimental methodology

Procedure:

Digital technique is to be applied to the digital image to increases the "dynamic range", the "dynamic range" is calculated again for the result image, a comparison between the original soft copy and digital corrected image will be carried out and a discussion is to made to describe the results, these techniques would help the scanner and digital camera to produce images for the print production.

The "Histogram "displays the dynamic range of digital images so that it can be enhanced using some image processing techniques,

A "dynamic range" of a full color digital image is measured using the "Info Palette" in "Adobe Photoshop", a "dynamic range" for the hard copy is calculated by reading the tonal value of "Shadow" and "Highlight".

Materials:
1- IT8.7/3 color Chart
2- Adobe Photoshop CC
3- Konica Minolta bizhub PRO C5500 Color Printer
4- Canon LIDE 110 scanner
5- Techkon Spectro-Densitometer

Experimental work:

A gray scale for every primary printing color is printed using a digital laser printer, then every pot color value is measured to state the real tone value for the print sample, then the print sample is scanned and another similar measurement is done using a software to state the real tone value after the scanning process then I calculated the dynamic range for the image after printing and after scanning.

A clear difference occurred, and then I used a digital command " Levels " to enhance the High Light and Shadow of the image to increase the image dynamic range.

A conclusion is carried to state the best settings for every primary printing color that gives the highest possible dynamic range.

An IT8.7/3 color chart is printed using "Konica Minolta bizhub PRO C5500 Color"; which uses Simitri HD Color Polymerized Toner and S.E.A.D. imaging technology for consistently outstanding image quality. [http://kmbs.konicaminolta.us]

I print the IT8.7/3 using a 80 gm plain white paper, the machine uses no color management software so that it printed directly the color it receives without any conversion.
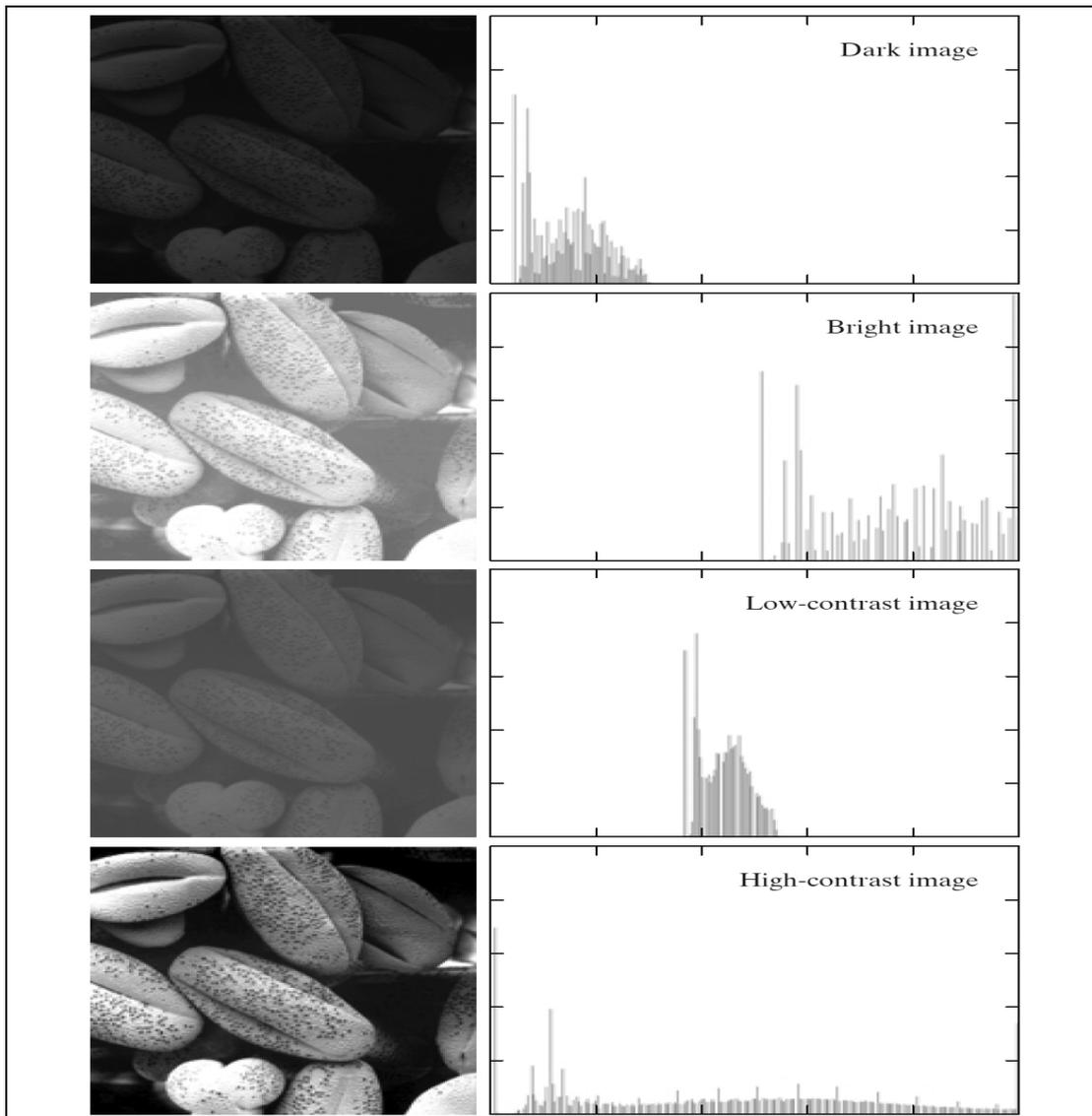
Figure [2] Histogram displays the dynamic range of the image [Gonzalez, 2001; p90]

Figure [3] The soft copy of the IT8 Color Chart

Figure [4] IT8 print using 80 gm plain white paper

" Techkon Spectro-Densitometer " is used to measure the dot area of; Cyan, Magenta, Yellow and Black gray scale to state the dot area value in print.

A Canon LIDE 110 scanner is used to scan prints, all color and details corrections are disabled in the

scanner software.

As every spot color is printed as dots so that a cretin technique is needed to convert it into one solid color that represents the average value of the spot color.

A 3.0 px. Of Gaussian Blur Filter is applied to each spot color to be measured.

The Info Palette in Adobe Photoshop CC is used to measure the dot value with a color sampling of 31 px. in the scanned spot color, results of the measurement is then recorded.

Regarding the results it's clear that the dynamic range of the image got shallow when the IT8 print sample scanned.

Enhancing the dynamic range:

Solving the problem of dynamic range needs to use a Local Operation Commands, so that when we enhance a portion of the dynamic range we also give so little correction to the areas next to it, other wise the image would have some type of color banding in the image.

I used the " Levels " command with a sequence of ascending values in the CMYK image for restoring the High Light and the Shadow in the form of numbers to be added and subtracted, with the following settings:

1- High Light:245 / Shadow:10
2- High Light:235 / Shadow:20
3- High Light:225 / Shadow:30
4- High Light:215 / Shadow:40
5- High Light:205 / Shadow:50
6- High Light:195 / Shadow:60

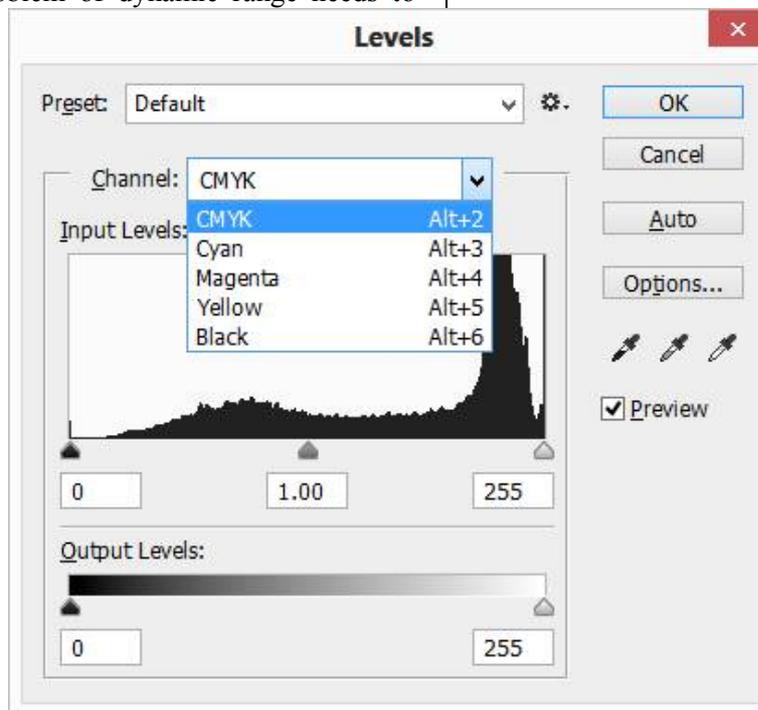Figure [5] Using the Levels command in CMYK color mode

Results:

To evaluate this technique I measured the dynamic range for every setting with the black ink, to make sure it enhances the dynamic range.

The results were shown in table (1)

Table [1] the Black ink response to the dynamic rage enhancement

Black Ink													
Actual Value	90	80	70	60	50	40	30	20	10	8	6	4	2
Print Value	97	92	86	80	73	62	46	33	20	16	13	10	8
Scan Value	82	73	67	62	57	49	39	32	25	24	21	19	17
H.L245/Sh.10	83	74	68	62	56	48	37	29	22	21	18	15	13
H.L235/Sh.20	85	76	69	62	57	47	35	26	9	17	14	10	8
H.L225/Sh.30	87	77	69	63	56	46	33	22	14	13	9	5	3
H.L215/Sh.40	90	79	71	64	56	45	29	18	9	6	3	1	0
H.L205/Sh.50	93	81	72	64	55	43	26	12	3	2	1	0	0
H.L195/Sh.60	95	84	74	65	54	40	20	6	1	0	0	0	0
Dynamic range of the Black print sample: 97 – 8 = 89													
Dynamic range of the Black scan sample: 82 – 17 = 65													
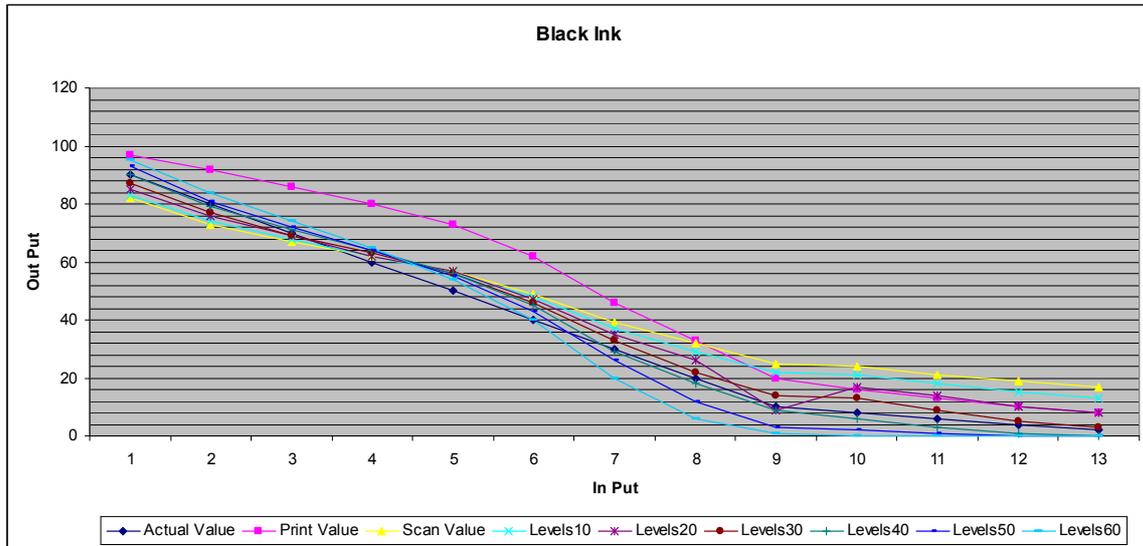
Figure [6] the Black ink response to the dynamic rage enhancement

Cyan Ink													
Actual Value	90	80	70	60	50	40	30	20	10	8	6	4	2
Print Value	99	98	93	88	79	65	50	37	27	25	21	16	14
Scan Value	75	79	68	59	41	33	26	19	18	18	16	15	11
H.L245/Sh.10	78	82	70	60	40	31	24	16	16	15	13	12	7
H.L235/Sh.20	87	85	80	75	62	44	29	22	14	13	12	10	9
H.L225/Sh.30	90	89	83	78	64	43	27	19	10	9	8	6	4
H.L215/Sh.40	95	93	87	81	66	42	25	15	5	5	3	1	0
H.L205/Sh.50	100	99	92	85	67	41	22	11	1	0	0	0	0
H.L195/Sh.60	100	100	98	90	69	40	18	5	0	0	0	0	0
Table [2] the Cyan ink response to the dynamic rage enhancement													

Dynamic range of the Cyan print sample: 99 - 14= 85
Dynamic range of the Cyan scan sample: 75 – 11 = 64
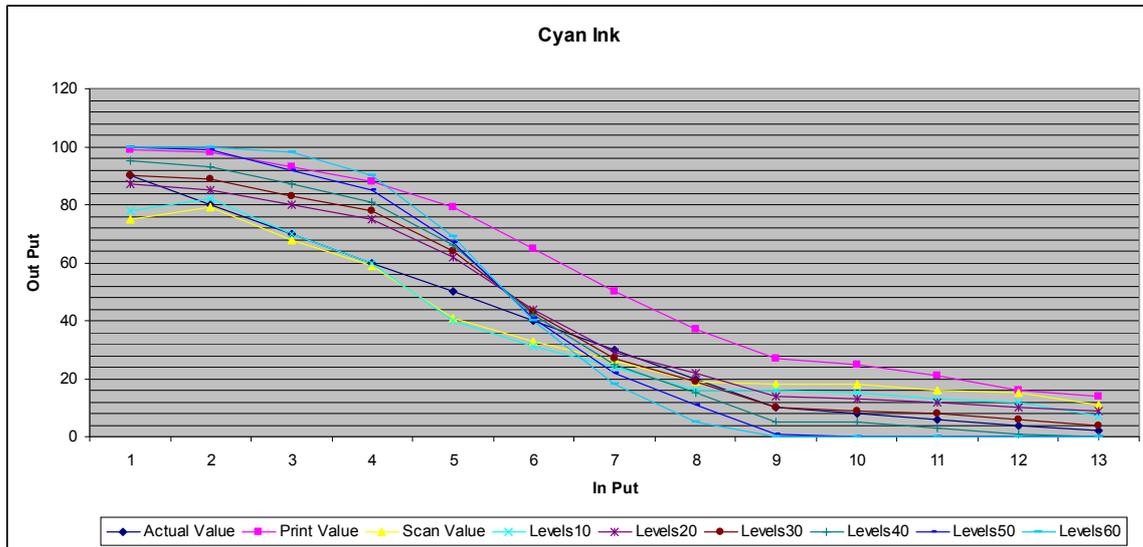
Figure [7] the Cyan ink response to the dynamic rage enhancement

Table [3] the Magenta ink response to the dynamic rage enhancement

Magenta Ink													
Actual Value	90	80	70	60	50	40	30	20	10	8	6	4	2
Print Value	99	93	87	77	68	56	44	31	24	20	13	9	5
Scan Value	87	78	72	60	52	38	30	22	15	14	11	10	8

H.L245/Sh.10	90	81	74	61	52	37	28	20	12	11	8	7	5
H.L235/Sh.20	97	82	77	62	47	30	23	13	5	3	3	1	0
H.L225/Sh.30	97	84	77	62	51	35	23	12	4	4	2	0	0
H.L215/Sh.40	100	98	94	93	72	52	20	1	0	0	0	0	0
H.L205/Sh.50	100	97	96	87	61	4	0	0	0	0	0	0	0
H.L195/Sh.60	100	100	100	100	73	0	0	0	0	0	0	0	0

Dynamic range of the Magenta print sample: 99 – 5 = 94
Dynamic range of the Magenta scan sample: 87 – 8 = 79

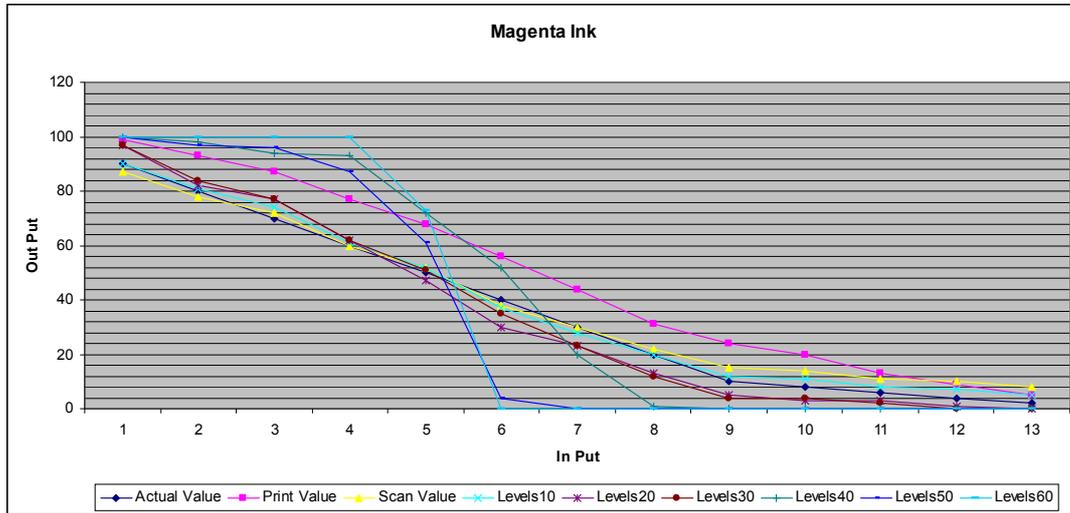**Figure [8] the Magenta ink response to the dynamic rage enhancement**

Yellow Ink													
Actual Value	90	80	70	60	50	40	30	20	10	8	6	4	2
Print Value	98	90	78	69	57	46	33	24	10	8	6	5	4
Scan Value	91	84	67	56	46	33	24	21	12	9	8	7	6
H.L245/Sh.10	90	87	68	56	45	31	23	18	9	5	4	3	2
H.L235/Sh.20	100	94	73	59	45	29	16	15	0	0	0	0	0
H.L225/Sh.30	100	00	80	60	3	24	6	0	0	0	0	0	0
H.L215/Sh.40	100	100	94	64	43	15	0	0	0	0	0	0	0
H.L205/Sh.50	100	100	100	69	33	0	0	0	0	0	0	0	0
H.L195/Sh.60	100	100	100	93	34	0	0	0	0	0	0	0	0
Table [4] the Yellow ink response to the dynamic rage enhancement													

Dynamic range of the Yellow print sample: 98 – 4 = 94
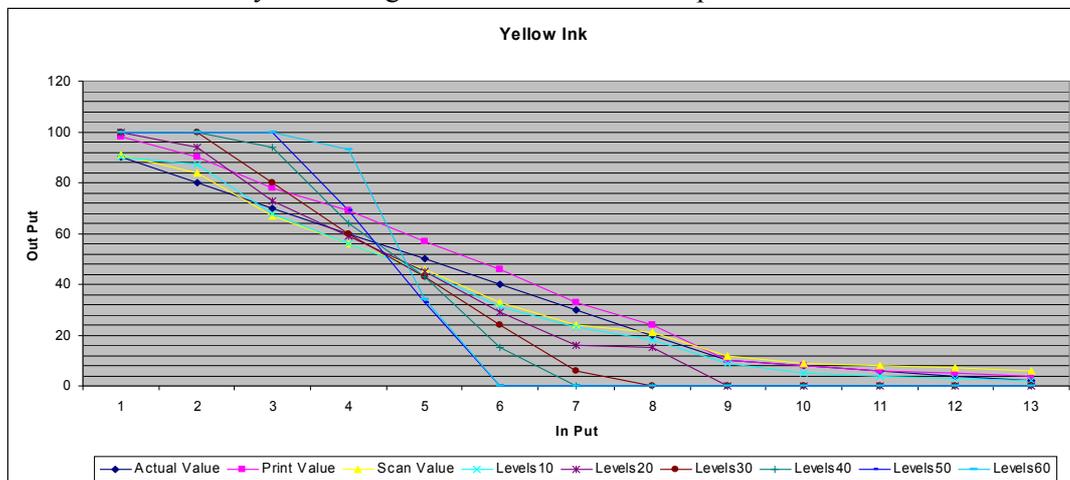Dynamic range of the Yellow scan sample: 98 – 6 = 92

Figure [9] the Yellow ink response to the dynamic rage enhancement

Discussion:

The image dynamic range shows a good respond to the " Levels " command with a variety of value to the Black, Cyan, Magenta and Yellow.

Regarding the values measured about its clear the most near values of the " Levels " corrected tone to the original values are:
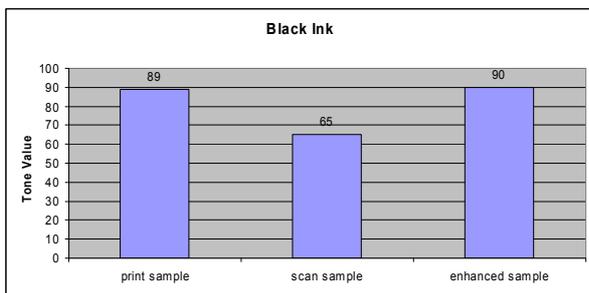
The Black Ink:

For the Shadow: +30, for the High Light: -40 (table 1)

Dynamic range of the Black print sample: 97 – 8 = 89

Dynamic range of the Black scan sample: 82 – 17 = 65

Dynamic range of the Black enhanced sample: 90 – 0 = 90

Black Ink

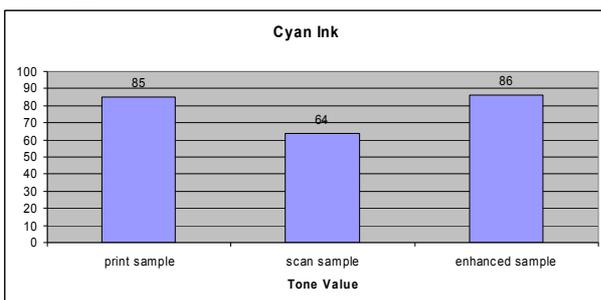**Figure [10] the Black ink before and after correction**

The Cyan Ink:

For the Shadow: +30, for the High Light: -30 (table 2)

Dynamic range of the Cyan print sample: 99 - 14= 85

Dynamic range of the Cyan scan sample: 75 – 11 = 64

Dynamic range of the Cyan enhanced sample: 90 – 4 = 86

Cyan Ink

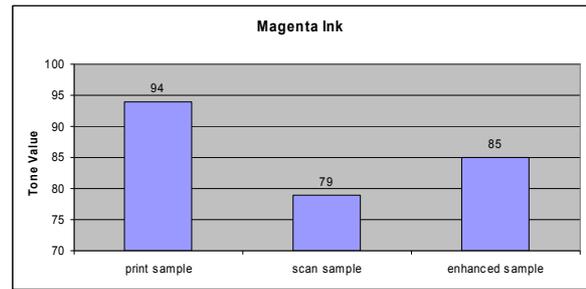**Figure [11] the Cyan ink before and after correction**

The Magenta Ink:

For the Shadow: +10, for the High Light: -10 (table 3)

Dynamic range of the Magenta print sample: 99 – 5 = 94

Dynamic range of the Magenta scan sample: 87 – 8 = 79

Dynamic range of the Magenta enhanced sample:

90 – 5 = 85

Magenta Ink

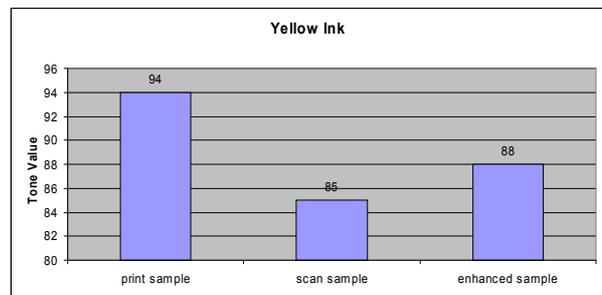**Figure [12] the Magenta ink before and after correction**

The Yellow Ink:

For the Shadow: +10, for the High Light: -10 (table 4)

Dynamic range of the Yellow print sample: 98 – 4 = 94

Dynamic range of the Yellow scan sample: 98 – 6 = 92

Dynamic range of the Yellow enhanced sample:

90 – 2 = 88

Yellow Ink

Figure [13] the Yellow ink before and after correction

Hence i recommend users of the scanner to enhance the dynamic range of their images with the values mentioned to the Black, Cyan, Magenta and Yellow.

Conclusion:

transforming images from one hard copy to soft copy causes some loss in the color quality, using a digital technique can help restoring some of color data of the image, and scanner users can get advantage of this technique.

References:

1- Rafael C. Gonzalez, Richard E. Woods, **Digital Image Processing**, third edition, USA, Prentice Hall, 2008.

2- Rafael C. Gonzalez, Richard E. Woods, **Digital Image Processing**, second edition, USA, Prentice Hall, 2001.

3- Helmut Kipphan, **Handbook of Print Media Technologies and Production Methods**, first Edition, Germany, Springer, 2001.