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SERIES T: TERMINALS FOR TELEMATIC SERVICES

Continuous tone colour representation method for facsimile

ITU-T Recommendation T.42

(Previously CCITT Recommendation)

ITU-T T-SERIES RECOMMENDATIONS

TERMINALS FOR TELEMATIC SERVICES

For further details, please refer to ITU-T List of Recommendations.

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation T.42 was revised by ITU-T Study Group 8 (1993-1996) and was approved by the WTSC (Geneva, October 9-18, 1996).

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

CONTENTS

SUMMARY

This Recommendation defines a colour data representation method in order to make it possible to interchange continuous tone colour image data over facsimile communication services such as Group 4 and Group 3 facsimile. CIELAB space is selected as the basic colour space. CIE Illuminant D50 and its perfectly diffuse reflecting white point ($X_0 = 96.422$; $Y_0 = 100.000$; $Z_0 = 82.521$) is selected as the basic illuminant and white point respectively. The default gamut range chosen is L* = [0, 100], a* = [–85, 85], b* = [–75, 125]. The exact expression is in terms of offset and scale.

Main differences from the previous version are the following:

1) arbitrary N bit/component extension;

2) colour reproduction information extension.

CONTINUOUS TONE COLOUR REPRESENTATION METHOD FOR FACSIMILE

(revised in 1996)

1 Scope

1.1 This Recommendation defines a continuous tone colour data representation method in order to make it possible to interchange continuous tone colour image data over a facsimile communication service such as Group 4 or Group 3 facsimile.

Its purpose is to specify a colour space, reference white point, illuminant type, gamut range, and colour reproduction information for the interchange of colour data.

1.2 This Recommendation, together with documents such as parts of Recommendations T.4 and T.30, or Recommendations T.563, T.503 and T.521, will define a colour image data format that may be used by colour facsimile service and by other telematic services.

2 Field of application

2.1 This Recommendation defines a colour data representation method which enables a receiver to reproduce colour image data as specified by the sender. The basic values are for hard copy (printed) colour image data.

2.2 It is assumed that when a service is performed using this Recommendation, all non-basic features are subject to negotiation.

3 References

The following references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the references listed below.

– CIE Publication No. 15.2 (1986), *Colorimetry*, Second edition.

– ISO 5-1~4 (1983-1985), *Photography – Density measurements*.

– ISO 13655:1996, *Graphic technology – Spectral measurement and colorimetric computation for graphic arts images*.

4 Definitions

The definitions in Recommendation T.411 apply to this Recommendation.

The definitions in CIE Publication No. 15.2 apply to this Recommendation.

For the purposes of this Recommendation, the following additional definition applies:

CIELAB: This refers to CIE L*a*b* colour space.

5 Conventions

The conventions in CIE Publication No. 15.2 apply to this Recommendation.

The conventions in ISO 13655 apply to this Recommendation.

6 Colour representation model

6.1 Overview

In order to represent continuous tone colour data accurately and uniquely, a device-independent interchange colour space is needed. This colour image space should encode the range of hard copy image data when viewed under the specified viewing conditions.

The following represents an example for the use of this model: a Sender scans an original colour image using a specific device-dependent colour space which may depend on the illuminant and/or filters of a particular scanner system. The Sender converts the device-dependent colour data to the interchange colour representation. The Sender then encodes the data using a coding algorithm such as Recommendation T.81 (JPEG). The Receiver receives the encoded data. The data is decoded and converted to the colour space which is device dependent.

In order to define the colour representation, it is necessary to specify the white point, illuminant and gamut range used in the interchange data representation.

Certain additional information for better and/or more desirable colour reproduction may optionally be specified.

6.2 Colour representation recommendation

6.2.1 1976 CIE L^* a^* b^* (CIELAB) space

6.2.1.1 Colour space specification

In this Recommendation, CIELAB space is the basic value. For interoperability, other colour spaces may be added in the future.

Conversion from spectral measurement data to CIE XYZ is defined in ISO 13655.

Conversion from CIE XYZ colour space to CIELAB is defined as in CIE Publication No. 15.2. (See Appendix II.)

White point and illuminant data, and gamut range are specified in 6.2.1.2 and 6.2.1.3.

6.2.1.2 White point and illuminant data

CIE Illuminant D50 and its perfectly diffuse reflecting white point ($X_0 = 96.422$; $Y_0 = 100.000$; $Z_0 = 82.521$) are the basic values. Other illuminants and/or white points are optional and must be negotiated before use. Optional values are for further study.

6.2.1.3 Gamut range

The basic gamut range is chosen to span the union of available hard copy device gamuts as observed under D50 illumination. This range is as follows, with the exact definition expressed below:

$$
\begin{aligned}
L^* &= [0, 100] \\
a^* &= [-85, 85] \\
b^* &= [-75, 125]
\end{aligned}
$$

The gamut range is expressed as an OFFSET in the communication space and a RANGE, with the exception of the minimum and maximum values, which are explicitly defined in the definitions above.

The calculations from real values $L^*a^*b^*$ to $n_L n_a n_b$ bit integers, which are expressed by $N_L N_a N_b$, are made as follows:

$$
\begin{aligned}
N_L &= [(2^{**}n_L - 1)/RANGE_L] \times L^* + OFFSET_L \\
N_a &= [(2^{**}n_a - 1)/RANGE_a] \times a^* + OFFSET_a \\
N_b &= [(2^{**}n_b - 1)/RANGE_b] \times b^* + OFFSET_b
\end{aligned}
$$

The RANGE, OFFSET pairs for basic range L*, a* and b* for the case where $N_L N_a N_b$ are $n_L n_a n_b$ bit integers are:

Variable	Range	Offset
L^*	100.00	0
a^*	170.00	$2^{**}(n_a - 1)$
b^*	200.00	$2^{**}(n_b - 2) + 2^{**}(n_b - 3)$

In the case of eight-bit values, the calculations are as follows for the basic range:

$$N_L = [255/100] \times L^*$$
$$N_a = [255/170] \times a^* + 128$$
$$N_b = [255/200] \times b^* + 96$$

In the case of twelve-bit values, the calculations are as follows for the basic range:

$$N_L = [4095/100] \times L^*$$
$$N_a = [4095/170] \times a^* + 2048$$
$$N_b = [4095/200] \times b^* + 1536$$

Other gamut range values are optional and must be negotiated before use.

For example, the following optional range:

$$L^* = [0, 100]$$
$$a^* = [-128, 127]$$
$$b^* = [-128, 127]$$

would be expressed using range and offset in the case of eight-bit values by:

$$N_L = [255/100] \times L^*$$
$$N_a = [255/255] \times a^* + 128$$
$$N_b = [255/255] \times b^* + 128$$

In the case of soft copy, optional gamut range may be used because gamut range of soft copy device is different than that of hard copy device.

Note that values of L* greater than 100 are not disallowed, but are not in general reproducible, as they correspond to colours which may be produced by fluorescence or specular reflection in the hard copy case. In the soft copy case, tristimulus values X, Y, Z of image data shall be scaled under the condition that the maximum Y should not be over 100. Usually, the maximum of a monitor or an image may be used for the scaling. Values of L* less than 0 have no physical meaning.

In addition, values of a* outside the range [–500, 500] and values of b* outside the range [–200, 200] are not representable from X, Y, Z tristimulus values, and have no meaning.

7 Colour reproduction information

Colour reproduction information may be optionally provided, in addition to absolute values (L*a*b*values) for colour image data. This information may be used for better and/or more desirable colour reproduction. This information is described in Table 1. Colour reproduction information is a non-basic feature.

Table 1/T.42 – Colour reproduction information list

No.	From Receiver to Sender	From Sender to Receiver	Type of data
1	Device White (Paper white for hard copy, display white for soft copy)	Original* White	L*a*b*
2	Device Black (Cyan + magenta + yellow or + black colorant for hard copy, display black for soft copy)	Original* Black	L*a*b*
3	Device Cyan (Cyan colorant for hard copy, green + blue phosphor for soft copy)	Original* Cyan	L*a*b*
4	Device Magenta (Magenta colorant for hard copy, blue + red phosphor for soft copy)	Original* Magenta	L*a*b*
5	Device Yellow (Yellow colorant for hard copy, red + green phosphor for soft copy)	Original* Yellow	L*a*b*
6	Device Red (Magenta + yellow colorant for hard copy, red phosphor for soft copy)	Original* Red	L*a*b*
7	Device Green (Yellow + cyan colorant for hard copy, green phosphor for soft copy)	Original* Green	L*a*b*
8	Device Blue (Cyan + magenta colorant for hard copy, blue phosphor for soft copy)	Original* Blue	L*a*b*
* Original means not restricted only to input device gamut, but sometimes corresponded to original image data gamut.			

Appendix I

Method for colorimetric calculation from spectral measurement

The following is a brief synopsis of the material presented in ISO 13655, *Graphic Technology – Spectral measurement and colorimetric computation for graphic arts images*.

The data shall be measured from at least 400 nm to at least 700 nm inclusive, at not greater than 20-nm intervals. The reference for spectral data shall be based on computed data at 10-nm intervals where the spectral function is triangular with a 10-nm bandwidth at the half-power point. The measurements will be made with a sample mounted on a back backing, as defined by ISO 5, Part 4, subclause 4.7 The reflectance measurement geometry will be 45/0 or 0/45 as defined in ISO 5, Part 4. The measurement resolution shall be to the nearest 0.01% relative to a perfectly diffuse reflector.

The tristimulus values of the reference white under D50 illumination will be defined as $X_n = 96.422$; $Y_n = 100.000$ and $Z_n = 82.521$. The spectral weights for illuminant D50 and 2° observer are given in Table I.1. These weights, Wx, Wy and Wz, will be used in the following manner to derive the tristimulus values:

$$X = \Sigma_\lambda (R(\lambda)\ Wx(\lambda))$$

summed over λ ranging from 360 to 780 nm. R is the reflectance value as a function of wave length (λ).

Table I.1/T.42 – Spectral weights (W) for illuminant D50 and 2º observer for calculating tristimulus values at 10-nm intervals

Wavelength(nm)	**W(X)**	**W(Y)**	**W(Z)**
360	00000.000	00000.000	000000.001
370	00000.001	00000.000	000000.005
380	00000.003	00000.000	000000.013
390	00000.012	00000.000	000000.057
400	00000.060	00000.002	000000.285
410	00000.234	00000.006	000001.113
420	00000.775	00000.023	000003.723
430	00001.610	00000.066	000007.862
440	00002.453	00000.162	000012.309
450	00002.777	00000.313	000014.647
460	00002.500	00000.514	000014.346
470	00001.717	00000.798	000011.299
480	00000.861	00001.239	000007.309
490	00000.283	00001.839	000004.128
500	00000.040	00002.948	000002.466
510	00000.088	00004.632	000001.447
520	00000.593	00006.587	000000.736
530	00001.590	00008.308	000000.401
540	00002.799	00009.197	000000.196
550	00004.207	00009.650	000000.085
560	00005.657	00009.471	000000.037
570	00007.132	00008.902	000000.020
580	00008.540	00008.112	000000.015
590	00009.255	00006.829	000000.010
600	00009.835	00005.838	000000.007
610	00009.469	00004.753	000000.004
620	00008.009	00003.573	000000.002
630	00005.926	00002.443	000000.001
640	00004.171	00001.629	000000.000
650	00002.609	00000.984	000000.000
660	00001.541	00000.570	000000.000
670	00000.855	00000.313	000000.000
680	00000.434	00000.158	000000.000
690	00000.194	00000.070	000000.000
700	00000.097	00000.035	000000.000
710	00000.050	00000.018	000000.000
720	00000.022	00000.008	000000.000
730	00000.012	00000.004	000000.000
740	00000.006	00000.002	000000.000
750	00000.002	00000.001	000000.000
760	00000.001	00000.000	000000.000
770	00000.001	00000.000	000000.000
780	00000.000	00000.000	000000.000
Total	X = 96.421	Y = 99.997	Z = 82.524

NOTE – This table is extracted from ASTM E308 – 1985. The sums are intended as check-sums for the spectral weights, and are not normative for the white point tristimulus values.

Appendix II

Calculation of CIELAB values from CIEXYZ values

The CIE 1976 L*a*b* colour space is calculated from the tristimulus values X, Y, Z, where X, Y and Z represent the tristimulus values as measured using the procedure of Appendix I. X_n, Y_n and Z_n are tristimulus values from the reference white.

Using these values:

$$L^* = 116 (Y/Y_n)^{1/3} - 16 \quad \text{for } Y/Y_n > 0.008856$$
$$L^* = 903.3\, Y/Y_n \quad \text{for } Y/Y_n \leq 0.008856$$
$$a^* = 500 [(X/X_n)^{1/3} - (Y/Y_n)^{1/3}]$$
$$b^* = 200 [(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}]$$

In addition, if any of the ratios X/X_n, Y/Y_n or Z/Z_n is equal to or less than 0.008856, it is replaced in the above formula by 7.7867F + 16/116, where F is X/X_n, Y/Y_n or Z/Z_n, as the case may be.

Reference

– CIE Publication No. 15.2 (1986), *Colorimetry*, Second edition.

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