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TERMINALS FOR TELEMATIC SERVICES

CONTINUOUS-TONE COLOUR REPRESENTATION METHOD FOR FACSIMILE

ITU-T Recommendation T.42

(Previously “CCITT Recommendation”)

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 prepared by ITU-T Study Group 8 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 11th of November 1994.

NOTE

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

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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.

Recommendation T.42

CONTINUOUS-TONE COLOUR REPRESENTATION METHOD FOR FACSIMILE

(Geneva, 1994)

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 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 hard copy [printed] colour image data as specified by the sender. The extension of this Recommendation to soft copy [displayed] image data is left for further study.

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 Reference 15.2:1986, *Colorimetry*, 2nd edition.
- ISO 5-1~4 (1983-1985), *Photography – Density Measurements*.
- ISO/DIS 13655: *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 Ref. 15.2:1986, 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 Ref. 15.2:1986 apply to this Recommendation.

The conventions in ISO/DIS 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 hard copy 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.

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/DIS 13655. (See Appendix I.)

Conversion from CIE XYZ colour space to CIELAB is defined as in CIE Ref. 15.2:1986. (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:

L* = [0, 100]

a* = [–85, 85]

b* = [–75, 125]

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

The gamut range is as follows:

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 calculation from a real value L* to an eight bit value, N_L, is made as follows:

$$N_L = (255/\text{RANGE}) * L* + \text{OFFSET}$$

The RANGE, OFFSET pairs for the basic range L*, a* and b* for the case where N_L is an eight bit integer are:

Variable	Range	Offset
L*	100.00	0
a*	170.00	128
b*	200.00	96

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. Values of L* less than 0 have no physical meaning.

In addition, values of a* outside the range [–500, 200] 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

Other sender-specific and/or receiver-specific information such as the media (or substrate) colour, might also be exchanged.

This is for further study.

Appendix I

Method for colorimetric computation from spectral measurement

(This appendix does not form an integral part of this Recommendation)

The following is a brief synopsis of the material presented in ISO/DIS 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 black backing, as defined by ISO 5-4, subclause 4.7. The reflectance measurement geometry will be 45/0 or 0/45 as defined in ISO 5-4. 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 Xn = 96.422. Yn = 100.000, and Zn = 82.521. The spectral weights for illuminant D50 and 2° observer are given in the following table. These weights, Wx, Wy and Wz, will be used in the following manner to derive the tristimulus values:

$$X = \Sigma_{\lambda} (R(\lambda)\, W_x(\lambda))$$

summed over λ ranging from 360 to 780 nm. R is the reflectance value as a function of frequency.

TABLE I.1/T.42

Spectral weights (W) for illuminant D50 and 2° observer for calculating tristimulus values at 10 nm intervals

Wavelength (nm)	W(X)	W(Y)	W(Z)
360	0.000	0.000	0.001
370	0.001	0.000	0.005
380	0.003	0.000	0.013
390	0.012	0.000	0.057
400	0.060	0.002	0.285
410	0.234	0.006	1.113
420	0.775	0.023	3.723
430	1.610	0.066	7.862
440	2.453	0.162	12.309
450	2.777	0.313	14.647
460	2.500	0.514	14.346
470	1.717	0.798	11.299
480	0.861	1.239	7.309
490	0.283	1.839	4.128
500	0.040	2.948	2.466
510	0.088	4.632	1.447
520	0.593	6.587	0.736
530	1.590	8.308	0.401
540	2.799	9.197	0.196
550	4.207	9.650	0.085
560	5.657	9.471	0.037
570	7.132	8.902	0.020
580	8.540	8.112	0.015
590	9.255	6.829	0.010
600	9.835	5.838	0.007
610	9.469	4.753	0.004
620	8.009	3.573	0.002
630	5.926	2.443	0.001
640	4.171	1.629	0.000
650	2.609	0.984	0.000
660	1.541	0.570	0.000
670	0.855	0.313	0.000
680	0.434	0.158	0.000
690	0.194	0.070	0.000
700	0.097	0.035	0.000
710	0.050	0.018	0.000
720	0.022	0.008	0.000
730	0.012	0.004	0.000
740	0.006	0.002	0.000
750	0.002	0.001	0.000
760	0.001	0.000	0.000
770	0.001	0.000	0.000
780	0.000	0.000	0.000
sums	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 CIE XYZ values

(This appendix does not form an integral part of this Recommendation)

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

Using these values:

$L^* = 116(Y/Yn)^{1/3} - 16$ for $Y/Yn > 0.008856$

$L^* = 903.3\ Y/Yn$ for $Y/Yn <= 0.008856$

$a^* = 500\ [(X/Xn)^{1/3} - (Y/Yn)^{1/3}]$

$b^* = 200\ [(Y/Yn)^{1/3} - (Z/Zn)^{1/3}]$

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

Reference

CIE Publication No. 15.2, *Colorimeter*, 2nd edition, 1986.

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