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Radiocommunication Sector of ITU

Recommendation ITU-R BT.1845-1
(03/2010)

Guidelines on metrics to be used when tailoring television programmes to broadcasting applications at various image quality levels, display sizes and aspect ratios

BT Series

Broadcasting service (television)

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Series	Title
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BS	Broadcasting service (sound)
BT	**Broadcasting service (television)**
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
Geneva, 2017

RECOMMENDATION ITU-R BT.1845-1*

Guidelines on metrics to be used when tailoring** television programmes to broadcasting applications at various image quality levels, display sizes and aspect ratios

(2008-2010)

Scope

This Recommendation provides some guidance on the metrics relevant to the choice of image rasters that may be appropriate when tailoring television programme material to broadcasting applications which are characterized by presentation requirements different from those for which the programme was originally produced.

Keywords

Display Size, Viewing Distance, Flat Panel, Image System

The ITU Radiocommunication Assembly,

considering

a) that the typical value of the minimum angular resolution of human vision in both the vertical and horizontal directions is 1 arc-min, which corresponds to the ability to discriminate detail that subtends an angle of 1 arc-min at the viewer's eye, within a rather wide range of values for image contrast and mean luminance; the same may also apply to the ability of the human eye to discriminate edge transitions;

b) that, consequently, the optimal viewing distance for digital images can be taken to be the one at which the pixel pitch of the digital source image subtends an angle of 1 arc-min at the viewer's eye;

c) that this characteristic of the human visual acuity applies to static images, since moving images may look blurred due to the limited ability of the display to portray movement, and of the human eye to follow movement on the display;

d) that the static resolution of images is thus an appropriate parameter to characterize the resolution of image systems;

e) that it is generally recognized that the normal reading distance is about 35 cm and the closest distance to which the human eye can comfortably focus ("accommodate") for extended periods of time (the "closest comfortable viewing distance") can be taken to typically be 25 cm[1]; this has a

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* Radiocommunication Study Group 6 made editorial amendments to this Recommendation in October 2011 and in October 2017 in accordance with Resolution ITU-R 1.

** The verb "to tailor" is used in this text to indicate the post-processing operations required to adapt programme material for its presentation in broadcasting applications different from the one for which it had been originally produced, e.g. in terms of image size resolution, viewing conditions, etc.

bearing on the finest image detail that the human eye can comfortably resolve on small displays such as those of cellular phones, hand-held receivers and similar portable devices when they are used to display television programming;

f) that consideration of the "optimal viewing distance" and of the "closest comfortable viewing distance" may provide a scientific foundation to plot various image systems and display sizes in a common, static resolution space and table, based on objective technical parameter values[2],

further considering

a) that digital television image systems for production are based on a matrix of pixels, and digital flat-panel television displays also use a presentation based on a matrix of pixels;

b) that the pixel density in the presentation matrix and the way its pixels are addressed are not necessarily related to the pixel density and addressing method used at source; consequently the source images to be displayed may need to be processed in the display, in order to re-map their pixel matrix on the pixel matrix of the display and to generally tailor them to the characteristics of the display,

recommends

1 that the "optimal viewing distance", the "optimal horizontal viewing angle" and the "closest comfortable viewing distance" should be used as guidelines on metrics applicable to digital image systems; these are shown for various digital image systems in Table 1 and Fig. 1;

2 that Table 1 and Fig. 1 should be taken into consideration to assist administrations in identifying the digital image systems that best fit the viewing conditions of various television broadcasting applications, based on the optimal viewing distance or on the optimal horizontal viewing angle foreseen for each application;

3 that in particular, the column of Table 1 entitled "Minimum display size (mm) at the closest comfortable viewing distance" should be taken into consideration as a help in identifying the maximum image resolution needed to present television images on cell-phones or hand-held receivers that have comparatively small screens designed to be watched at close distance;

4 that the following Notes should be regarded as part of this Recommendation:

NOTE 1 – For the purpose of this Recommendation the "optimal viewing distance" of a digital image is defined as the viewing distance at which two adjacent pixels of the source image (before it is re-mapped on the display) subtend an angle of 1 arc-min at the viewer's eye.

NOTE 2 – For the purpose of this Recommendation the "optimal horizontal viewing angle" is the horizontal viewing angle under which an image is seen at its optimal viewing distance.

NOTE 3 – This approach was already conceptually delineated in Recommendation ITU-R BT.1127.

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[1] Accommodation is the process by which the eye changes its focal distance to enable a clear vision of near or far objects. Generally, the eyes of very young individuals can focus on objects as close as about 8 cm. The range of accommodation, however, declines with age until, at the age of about 50, the minimal focusing distance becomes greater than the reading distance, which is about 35 cm, and the individual becomes presbyopic and needs reading glasses. For the purpose of this Recommendation we assume a closest comfortable viewing distance of 25 cm, which is closer than the reading distance, but should still allow prolonged viewing without excessive eye fatigue.

[2] Consideration of the closest comfortable viewing distance is appropriate for real images presented on a screen. It is not appropriate for virtual images, such as those presented in holography.

TABLE 1

Optimal horizontal viewing angle, optimal viewing distance in image heights (H) and minimum display size at the closest comfortable viewing distance (250 mm) for various digital image systems

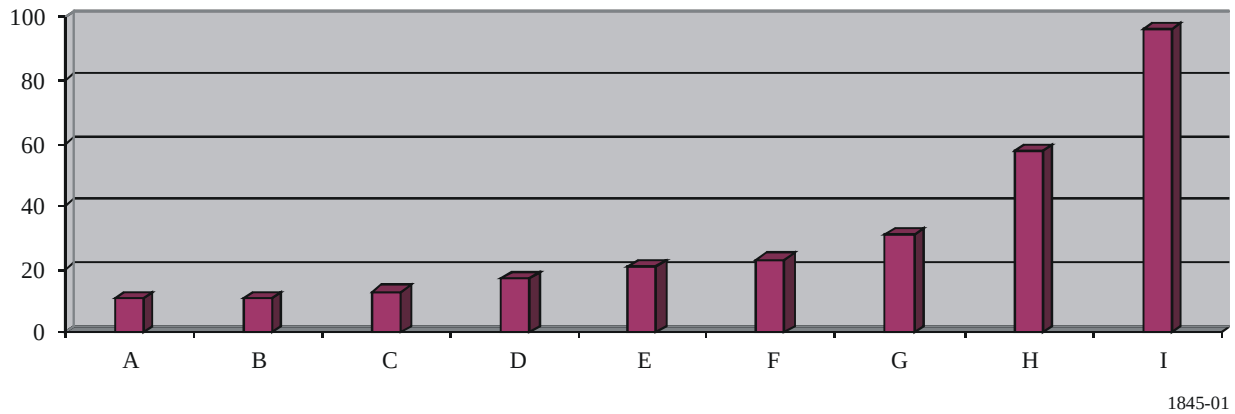
Bar in Fig. 1	Image system (*h* × *v*)	Reference	Aspect ratio (*a*: *b*)	Pixel aspect ratio (*r*)	Optimal horizontal viewing angle (θ)[1]	Optimal viewing distance (*d*)[1]	Mi Minimum display size (mm) at the closest comfortable viewing distance (*m* × *n*)[2]
A	720 × 485	Rec. ITU-R BT.601	4:3	0.89	11°	7 *H*	48 × 36
B	640 × 480	VGA	4:3	1	11°	7 *H*	48 × 36
C	720 × 576	Rec. ITU-R BT.601	4:3	1.07	13°	6 *H*	56 × 42
D	1 024 × 768	XGA	4:3	1	17°	4.5 *H*	74 × 56
E	1 280 × 720	Rec. ITU-R BT.1543	16:9	1	21°	4.8 *H*	93 × 52
F	1 400 × 1 050	SXGA+	4:3	1	23°	3.3 *H*	101 × 76
G	1 920 × 1 080	Rec. ITU-R BT.709	16:9	1	31°	3.2 *H*	139 × 78
H	3 840 × 2 160	Rec. ITU-R BT.2020	16:9	1	58°	1.6 *H*	278 × 156
I	7 680 × 4 320	Rec. ITU-R BT.2020	16:9	1	96°	0.8 *H*	556 × 313

(1) The optimal viewing distance (*d*) and the optimal horizontal viewing angle (θ) are derived as described in Appendix 1.

(2) It is assumed that the screen resolution capability is adequate to properly display the relevant image system. The minimum display size *m* × *n* mm at the closest comfortable viewing distance 250 mm is derived as described in Appendix 1.

FIGURE 1

Optimal horizontal viewing angle (degrees) for various digital image systems



NOTES:

Column 2 of Table 1 gives the sampling pixel structures for the image systems denoted as A, B, etc. in Table 1 and Fig. 1; column 3 gives the related reference ITU-R BT Recommendations.

Rows H and I in Table 1 and the related bars in Fig. 1 identify the image systems recommended for ultra-high definition television (UHDTV).

Rows B, D and F in Table 1 and the related bars in Fig. 1 identify some image systems used in computers.

Table 1 and Fig. 1 include (as examples) only some of the image rasters used in computers. For instance, the 1 366 × 768 image raster used in several consumer television sets is not included, since its optimal viewing distance is very close to the one indicated in row E of Table 1 for the system of Recommendation ITU-R BT.1543, which has a similar pixel count.

Appendix 1
(Informative)

Optimal viewing distance and horizontal viewing angle

The optimal viewing distance (d) and the optimal horizontal viewing angle (θ) are derived as described below:

$$\tan(1\ \text{arcminute}) = \tan\left(\frac{1}{60}\text{degree}\right) = \frac{1/v}{d}$$

$$d = \frac{1}{v \cdot \tan\left(\frac{1}{60}\ \text{degree}\right)}$$

$$\tan\left(\frac{\theta}{2}\right) = \frac{(\frac{a}{b})/2}{d}$$

$$\theta = 2 \cdot \arctan\left(\frac{a}{2bd}\right)$$

Comfortable viewing distance

The minimum display size $m \times n$ mm at the closest comfortable viewing distance 250 mm is derived as described below:

$$n = \frac{250}{d}$$

$$m = \left(\frac{a}{b}\right) \cdot n$$