

International Telecommunication Union

ITU-R
Radiocommunication Sector of ITU

Report ITU-R BT.2216
(05/2011)

**A perspective of the hierarchy of digital
television image systems based
on human viewing behaviour**

BT Series
Broadcasting service
(television)



International
Telecommunication
Union

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from <http://www.itu.int/ITU-R/go/patents/en> where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

Series of ITU-R Reports

(Also available online at <http://www.itu.int/publ/R-REP/en>)

Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
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

Note: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.

Electronic Publication
Geneva, 2011

© ITU 2011

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without written permission of ITU.

REPORT ITU-R BT.2216

**A perspective of the hierarchy of digital television image systems
based on human viewing behaviour**

(2011)

1 Introduction

Recommendations ITU-R BT.601, ITU-R BT.709, ITU-R BT.1201 and ITU-R BT.1769 define a hierarchy of digital television image systems. Their pixel counts are recalled in Table 1; they stand to each other as multiples of 2 based on the use of square pixels, except for SDTV systems.

TABLE 1

Hierarchy of digital television image systems based on spatial resolution

	SDTV	HDTV	EHRI-1	EHRI-3
Spatial resolution (number of samples)	720 × 576 or 720 × 480-486	1 920 × 1 080	3 840 × 2 160	7 680 × 4 320
Optimal horizontal viewing angle ¹	12°	32°	58°	96°
Aspect ratio	4:3	16:9	16:9	16:9

This text provides a perspective of those digital television image systems, based on four possible viewing behaviours of humans, related to the human field of view².

¹ According to Recommendation ITU-R BT.1845, the “optimal horizontal viewing angle” is the horizontal viewing angle under which an image is seen at its optimal viewing distance; the “optimal viewing distance” of a digital image is the viewing distance at which two adjacent pixels of the source image (before it is remapped on the display) subtend an angle of 1 arc-min at the viewer’s eye. Since this definition is related to average measured values of human sight, which has a wide dispersion among different persons, the angles are given as rough indications only and they should not be taken to exactly and indifferently apply to all persons in all circumstances.

² This perspective takes into account some well-known characteristics of human sight, namely:

- the image on the fovea covers an area of about 15° of the field of view;
- the field of view typically extends 60° upward, 75° downward, 95° outward and 60° inward (towards the nose) with respect to the horizontal forward-looking direction;
- binocular vision typically spans 120° in the horizontal direction.

2 The four viewing behaviours

A possible viewing behaviour (viewing behaviour A) is the one in which the television image at its optimal viewing distance subtends a small enough angle for the viewer to be able to watch it almost without moving his eyes. This happens when the television image on the retina is fully or 525-lines and 625-lines television systems (Recommendation ITU-R BT.601) is respectively 5 and 7 times the picture height. SDTV images thus subtend a nominal horizontal viewing angle of respectively about 11° and 13° at the viewer's eye (see Recommendation ITU-R BT.1845).

In this viewing behaviour, the edges of the television image fall well within the normal area of highest visual acuity in the viewer's field of view (the "fovea"). The viewing experience corresponds to watching an action framed through a small window. Applications of SDTV support this viewing behaviour.

Another possible viewing behaviour (viewing behaviour B) is the one in which the television image at its optimal viewing distance subtends an angle large enough for the viewer to be able to watch it by moving his eyes to follow the action, without moving his head. This happens when the television image on the retina extends into near-peripheral vision, subtending for instance an angle of the order of 30° at the viewer's eye. Since HDTV images (Recommendation ITU-R BT.709) at their optimal viewing distance subtend a horizontal viewing angle of 32° at the viewer's eye, applications of HDTV may be taken as examples of applications that support viewing behaviour B.

In this viewing behaviour, the edges of the television image fall within the viewer's field of view but they are partly outside his area of highest visual acuity. The viewing experience corresponds to watching an action framed through a large window, whose edges may go unnoticed when the viewer's attention is focused on the centre of the image.

A further viewing behaviour (viewing behaviour C) is the one in which the television image at its optimal viewing distance subtends an angle wide enough for the viewer to need to watch it by moving his eyes and also slightly moving his head to follow the action. This begins to happen when the television image on the retina extends beyond near-peripheral vision, e.g. when it subtends a 60° horizontal angle. Since television images conforming to the $3\ 840 \times 2\ 160$ member of the LSDI expanded hierarchy (Recommendation ITU-R BT.1769) subtend a nominal horizontal viewing angle of about 58° at the viewer's eye, applications of this LSDI hierarchy may be taken as examples of applications that support viewing behaviour C.

In this viewing behaviour, the viewer can identify moving objects at the edge of the television image but he cannot see them clearly. His induced reflex is to first move his eyes and then also slightly move his head in order to bring the peripheral action into the fovea and see it clearly. The viewing experience corresponds to watching an action framed through a very large window³.

Yet a further viewing behaviour (viewing behaviour D) is the one in which the television image at its optimal viewing distance subtends an angle so wide that the viewer needs to watch it by moving his eyes and also widely moving his head to follow the action. This happens when the television image on the retina approaches far-peripheral vision, e.g. it subtends an angle of the order of 120° which is the typical maximum viewing angle for binocular vision.

Since television images conforming to the $7\ 680 \times 4\ 320$ member of the LSDI expanded hierarchy (Recommendation ITU-R BT.1769) subtend a nominal horizontal angle of about 96° at the viewer's eye, applications of this hierarchy member may be taken as examples of applications that support a viewing behaviour close to viewing behaviour D.

³ A description of the human head-eye movement coordination mechanism can be found, for instance in H.H.L.M. Goossens and A.J. Van Opstal "Human eye-head coordination in two dimensions under different sensorimotor conditions" - Exp Brain Res (1997) 114:542-560.

In this viewing behaviour, the viewer can detect movement at the edge of his field of view, but he cannot clearly identify the moving objects because his visual acuity is inadequate at the edges of this field of view. Consequently, the viewer's induced reflex is to move first his eyes and then his head to a sufficient extent to bring the moving objects into the fovea and see them clearly. The viewing experience corresponds to watching an action from a balcony banister, where the walls on both sides of the balcony normally go unnoticed. Similarly, the edges of the television image go unnoticed except when the action happens at the edge of it.

3 Peripheral vision as an expression tool for programme directors

Human peripheral vision has comparatively low resolution but it is highly sensitive to movement. The typical reaction to the perception of movement in peripheral vision is to promptly turn one's eyes and head in that direction, in order to bring the image of the moving objects into the fovea. This may be due to a primeval survival mechanism and it is often coupled to increased alertness and sometimes even anxiety.

Programme directors can use peripheral vision as a valuable tool in their toolkit, to convey moods and emotions.

Take the tale of Little Red Riding Hood as an example.

If the director is working in SDTV, he may shoot a sequence showing Little Red Riding Hood picking flowers in the wood. He may then cut to a sequence showing the Big Bad Wolf stealing in behind the bushes. The viewer has no choice but to watch what the director shows him. Not a very exciting experience.

If however the director is working in UHDTV, he may produce a sequence showing Little Red Riding Hood picking flowers in the wood on the right side of the image. The viewer will turn his eyes and head to watch Little Red Riding Hood. The director may then bring in the Big Bad Wolf behind the bushes on the left side of the image. The viewer senses some movement in his left peripheral vision, he will turn his eyes and head in that direction and, lo and behold!, he sees the Big Bad Wolf stealing in behind the bushes. A somewhat more exciting viewing experience, which makes the viewer feel emotionally involved in the action, almost as if he were part of it.

4 Tailoring UHDTV programmes for SDTV distribution

There are various ways to tailor a UHDTV programme for SDTV distribution, and each one poses some problem. For instance:

- the video of the programme could simply be down-sampled. This is technically very simple to do, but it poses the problem that all the small details of the UHDTV image are lost, and those details may contain information that would be important for the appreciation of the programme;
- the programme could be post-produced by passing the signal through an "intelligent" device programmed to "follow the action". For example, the device could be programmed to follow the ball in a soccer match. Such devices exist and have been tested in operation. They have the merit of dispensing from the presence of a programme director, but they produce results which are generally below what the viewer would expect in a well-produced programme of the same genre;

- the programme could be post-produced, panning over it to only show its most important elements. This requires some post-production effort, and should be done under the supervision of the programme creators, since the choice of the most important part of the image is a matter of creative judgment. Furthermore, repeated panning movements may be annoying for the viewer and may distract his attention away from the story that the director is trying to tell;
- the programme could be post-produced by identifying different parts of the original UHDTV image and cutting among them in the same way that one would cut among different cameras. This requires some post-production effort on the part of the programme creators, but the result is more pleasant than the one obtained by panning over the original image.

5 Conclusion

This Report has tried to provide a perspective of current and proposed digital television image systems, including UHDTV, based on four different human viewing behaviours that relate to the human field of view and the way humans look to the world around them.

It has highlighted some of the opportunities and challenges that UHDTV will offer to programme directors in terms of extended creative options and new creative languages.

It has also identified some of the challenges in time and complexity attendant to the possible need to tailor UHDTV programmes for distribution in SDTV and possibly also in HDTV.
