VENI, VIDEO, VICI: THE MERGING OF COMPUTER AND VIDEO TECHNOLOGIES

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Pre-HDTV Milestones

Video Technology

V. Zworkyn invents iconoscope & kinescope
NBC Begins regular broadcasts
First coast-to-coast broadcast
First Color Broadcast
Early Bird 1st TV Satellite
Early HDTV


Computer Technology

Technology Transfer

Vector Displays
Color Raster Systems

Digital Video LCD TV Screens

PONG

Apple II

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### Post-HDTV Milestones

**Video Technology**

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>FCC adopts broadcast standard</td>
</tr>
<tr>
<td></td>
<td>All stations broadcast HDTV</td>
</tr>
<tr>
<td>2000</td>
<td>Advanced Digital Image Architecture</td>
</tr>
<tr>
<td></td>
<td>Ultimate Imaging Systems</td>
</tr>
<tr>
<td>2010</td>
<td>No more NTSC</td>
</tr>
<tr>
<td>2020</td>
<td>Trans-Mortal PONG!</td>
</tr>
<tr>
<td>2030</td>
<td></td>
</tr>
<tr>
<td>2040</td>
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**Computer Technology**

- Neural-nets, parallel systems, organic & optical computers

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### Visual Information Bandwidth

**Visual Factors:**
- Field of View (image size)
- Visual Acuity (pixel size & number of pixels)
- Dynamic Range (number of bits/pixel)
- Color (color components and encoding scheme)
- Image Retension (flicker rate, images/sec)

**Analog Bandwidth (Hz):**
\[
= (\text{Images/sec}) \times (\text{Lines/image}) \times (\text{cycles/line}) \times (\text{Number of Colors})
\]
where 'cycle' is minimum horizontally resolvable unit, one 'on-off'

**Digital Bandwidth (bps):**
\[
= \text{Analog Bandwidth} \times 2 \times \text{pixels/cycle} \times \text{Number bits/pixel}
\]

**Example: Monochrome Broadcast TV**

- 30 frms/sec * 525 lines/frm * 250 'cycles'/line = 4,000,000 cycles/sec = 4 MHz
- at 2 pixels/cycle * 8 bits/pixel = 64 Mbs
Television Frequency Allocation and Bandwidth

Frequency, Hz

Power Radio VHF UHF Microwaves InfraRed Ultraviolet X-rays Gamma Rays

Channel


54 60 65 72 76 82 88

174 180 188 192 198 204 210 216 MHz

Picture Carrier

Color SubCarrier

Sound

Luminance Signal

I-signal

Q-signal

6 MHz

Horizontal Scanning

Workstation Video

1024 Scanlines

60 Full Frames/sec

Non-Interlaced

Television

525 Scanlines

30 Full Frames/sec

2 Interlaced Fields
Workstation RGB Color Domain

Scanline

Red Signal

Green Signal

Blue Signal

NTSC Color Domain

Susceptible to adjacent pixel color interference

Scanline

Luminance Signal

Chrominance Signal

Composite Signal
## American HDTV Time-Table

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>Acceptance of 1125/60 SMPTE 240M Analog HDTV Standard</td>
</tr>
<tr>
<td></td>
<td>(Already delayed because all proposed standards had problems!)</td>
</tr>
<tr>
<td></td>
<td>- Begin ON-AIR Testing</td>
</tr>
<tr>
<td>1995</td>
<td>First Commercial receivers/licenced broadcasts</td>
</tr>
<tr>
<td></td>
<td>(All stations must also simulcast NTSC)</td>
</tr>
<tr>
<td>2000</td>
<td>All Stations must be HDTV capable</td>
</tr>
<tr>
<td></td>
<td>(Simulcast NTSC still enforced)</td>
</tr>
<tr>
<td>2009</td>
<td>Shutdown NTSC Broadcasting</td>
</tr>
<tr>
<td></td>
<td>(Recoup valuable broadcast frequencies &amp; bandwidth)</td>
</tr>
</tbody>
</table>

### HDTV Image Size

<table>
<thead>
<tr>
<th>Aspect Ratio</th>
<th>Visible Image Size in Pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:3</td>
<td>~1280x1024 pixels</td>
</tr>
<tr>
<td>16:9</td>
<td>~1920x1035 pixels</td>
</tr>
</tbody>
</table>

**Comparison of Aspect Ratio and Visible Image Size in Pixels**
Digital HDTV Heirarchy

HDTV Production Standard

Fiber Optics
- 120 Mbps

DBS Satellite
- 60 Mbps

Cable & Broadcast
- 20 Mbps

VCR in EP Mode
- 10 Mbps

Consumer TV

Down-converters

Task Force on Digital Image Architecture

Represents input from SMPTE, IEEE, ATSC

"To develop and propose a structure for a hierarchy of digital standards to facilitate interoperation of high resolution display systems." [That are:]

Open
- In the Public Domain

Interoperable
- Images move across application/industry boundaries

Scalable
- Wide range of image size, color, speed capabilities

Extensible
- Room for future technology

Compatible
- Incorporate existing imaging/television standards
Open Architecture Model

Image Acquisition/Generation

Processing
Production Quality Storage

Contribution Quality Storage

Transport
Distribution Quality Storage

Reconstruction

Display

Future Displays

Wrist Display
- Low power, wire-less transmission, close viewing

Personal Viewer –
- Eyeglass/visor Heads-Up display, head-tracking

Home Entertainment –
- Flat, wall mounted, typically 6 meter diagonal

Physician’s Work Surface –
- X-ray wall, close-viewing, super hi-res, locally magnifiable

Writer’s Table –
- Desk-size, multi-page, pen/touch input, cut/paste

Artist’s Canvas –
- Special color/contrast/texture capabilities, unique input/output control

Make-Up Mirror
- ‘Through-the-screen’ cameras, image processing
The ULTIMATE Imaging System

1) Field of View ~ 1.5π Steradians = 15,000 sq. degrees
   (typical movie screen ~ 1200 sq. degrees)

2) Spatial Resolution ~ 0.65 arcmin = .01 deg.
   Assume 2 pixels per minimum resolution
   implies 16 pixels/sq. arcmin

1 & 2) -> 36,000 x 28,000 pixel screen

3) Color -- 3 components

4) Dynamic Resolution ~ 10^5:1 -> 17 bits

5) Time Resolution ~ 60 images/sec

6) Stereopsis -> x2

= 771 GBytes/sec (not including digital sound, closed-captioning, etc)