Visual Ergonomics Challenges in Information-Intensive Mobile Displays

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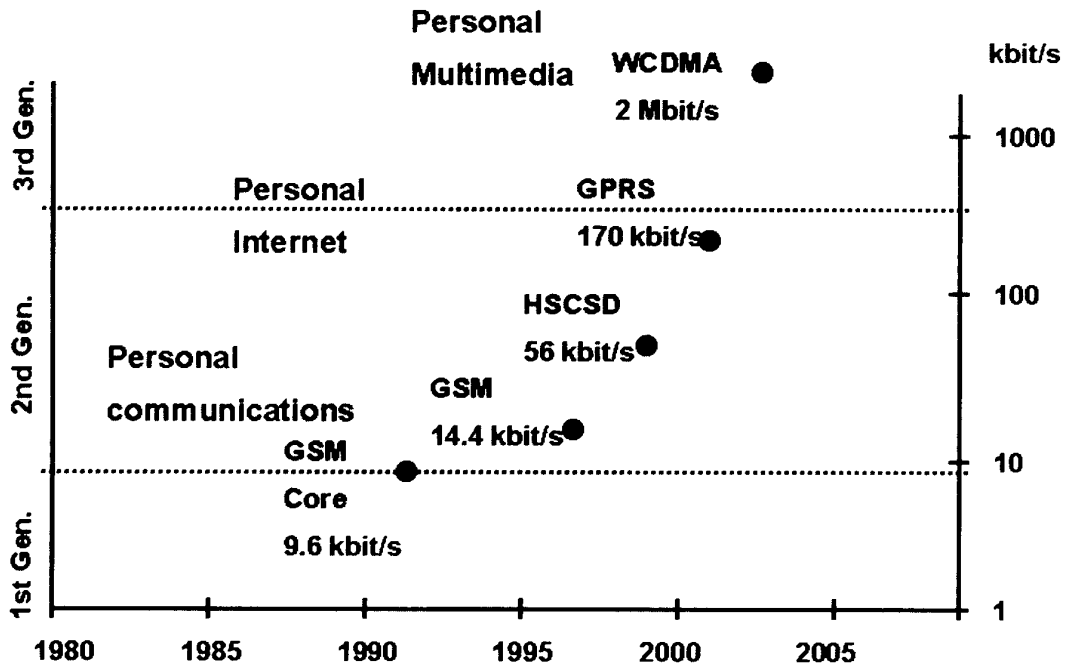
Outline

- Infrastructure and enabling technologies
- Aspects of high information content
- Visual communication potential of high bandwidths
- Limitations imposed by visual ergonomics:
  - Design for all users and markets
  - Visual usability in all locations and luminous environments
  - Common applications and their ergonomic rules of thumb
- Challenge: Feature balancing
- Conclusions

Evolution of wireless infrastructures

Mobile telephony



Infrastructure	Bitrate (Mbps)
Flash memory*	80
Hard disk*	320
1G	0.01
2G	0.028
2.5G	0.17
3G	2
Blue Tooth	0.7
WLAN (802.11a)	54
WLAN (802.11c)	11
DVB-T 13 segment	23
DVB-T 1 segment	1.8

* 1 GB corresponds to > 2 hours of MPEG4 video @ 1 Mbps

Aspects of high-information content

Physical and perceivable information amounts do not coincide:

- Invisible lossy image/video compression possible
- Large colour depth often not perceivable due to low contrast and/or narrow gamut
- High-content text can be transmitted over low bandwidth via local rendering

Ergonomics concerns:

- Text/graphics legibility: high-contrast, high spatial frequency content
- Photos: lower contrast and spatial frequency
- Video fidelity: motion blur, lower contrast and spatial frequency

Infrastructures and potential visual content

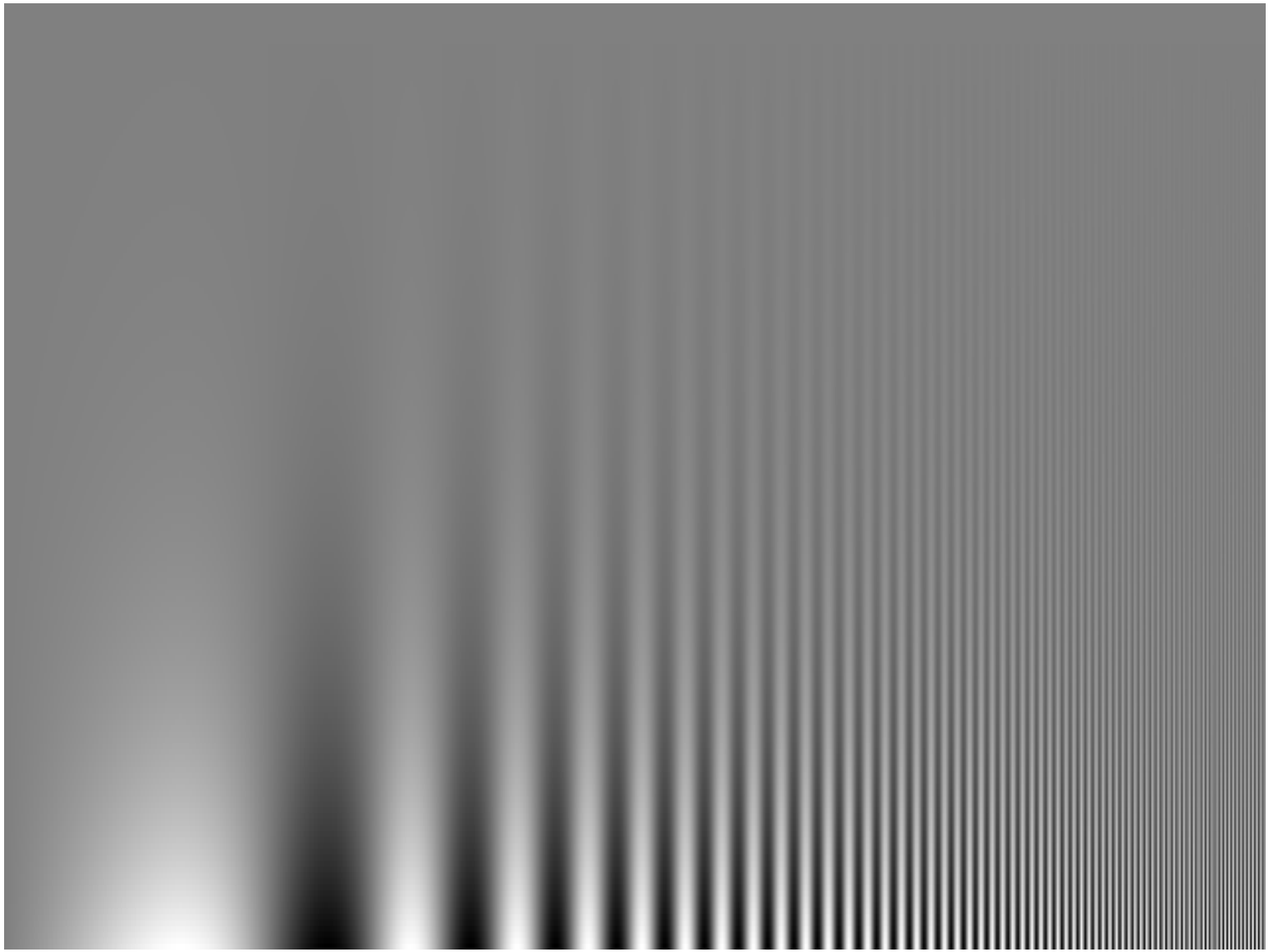
Infrastructure	Bitrate (Mbps)	Max frame rate (Hz)	Color depth (bits)		Resolution (PPI)	
			Video	Still	Video	Still
Flash memory*	80	6826.7	3641	10923	1600	2771
Hard disk*	320	27306.7	14564	43691	3200	5543
1G	0.01	0.4	0	1	18	31
2G	0.028	1.2	1	2	30	52
2.5G	0.17	7.3	4	12	74	128
3G	2	85.3	46	137	253	438
Blue Tooth	0.7	29.9	16	48	150	259
WLAN (802.11a)	54	2304.0	1229	3686	1315	2277
WLAN (802.11c)	11	469.3	250	751	593	1028
DVB-T 13 segment	23	981.3	523	1570	858	1486
DVB-T 1 segment	1.8	76.8	41	123	240	416
* 1 GB corresponds to > 2 hours of MPEG4 video @ 1 Mbps						

Assumptions

Rows	320	Display size (inch)	2
Columns	240	Download time (s)	1
Colour depth (bits)	16	Frame rate (Hz)	30
Video compression	100	Image compression	10
Aspect ratio	1.333	Bandwidth usage	0.5
Calculation based on throughput of infrastructure only			

Campbell-Robson CSF Chart

Low contrast



High contrast

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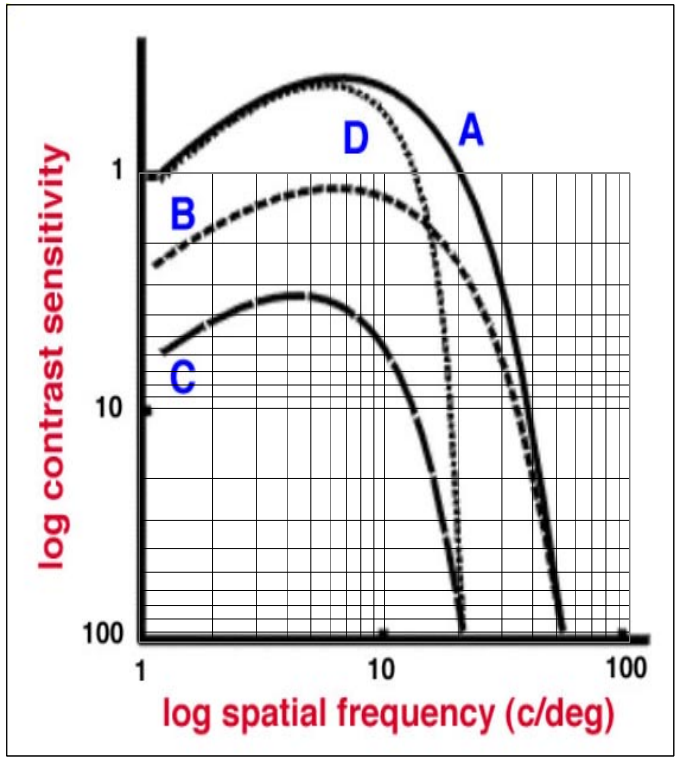
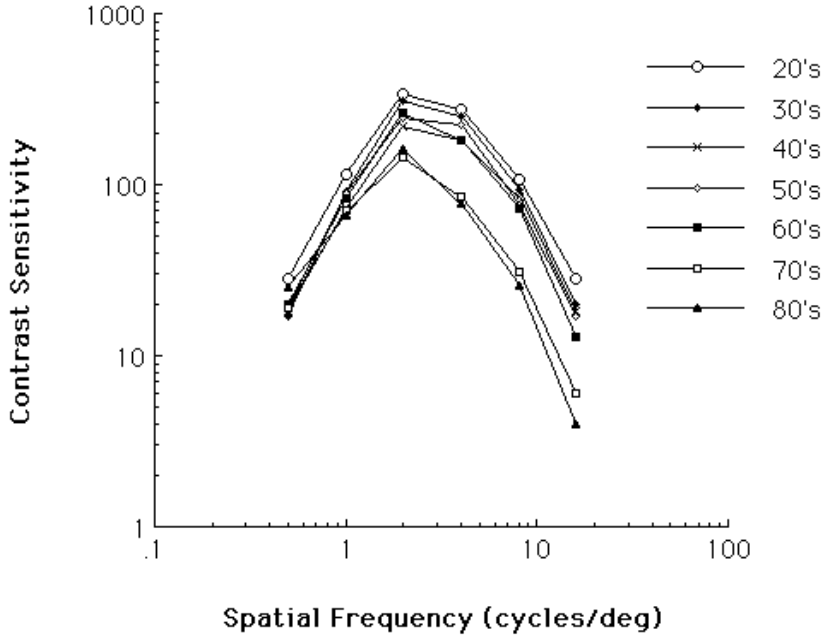
Design for everybody – contrast sensitivity

- A = Normal young adult
- B = Patient with multiple sclerosis
- D = Mild amblyopia
- C = Severe amblyopia or cataract





Source: USD Internet Sensation & Perception Laboratory
http://www.usd.edu/psyc301/CSFIntro.htm

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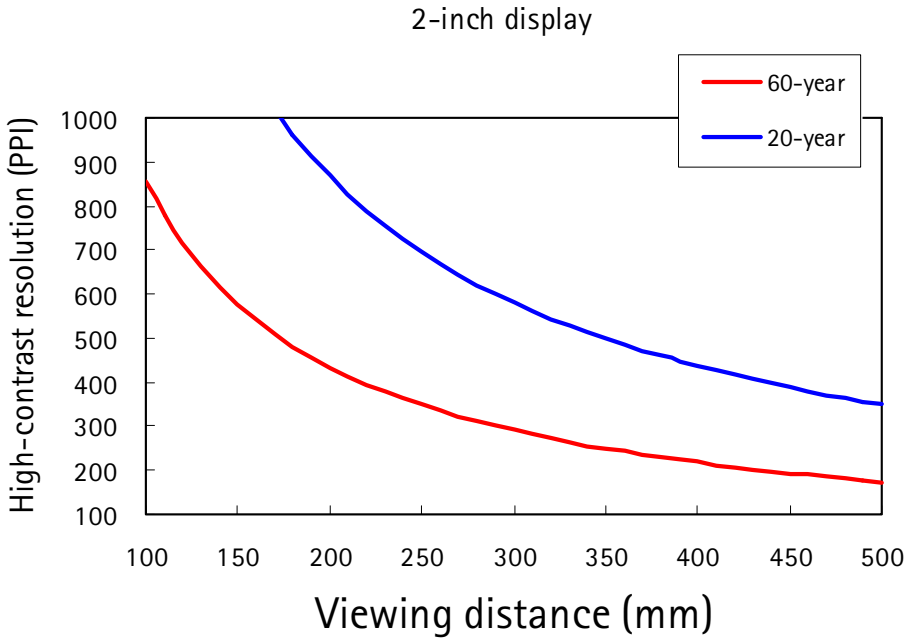
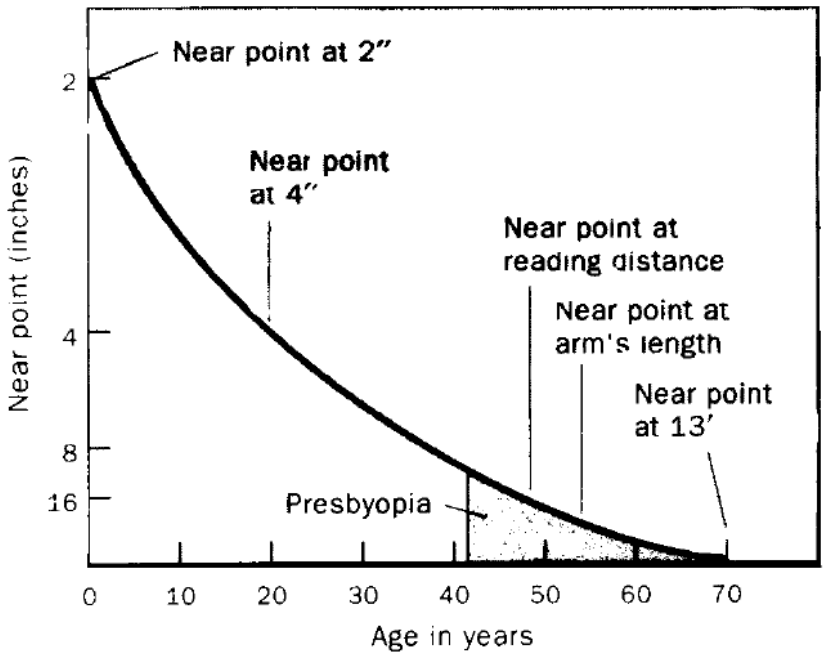
Design for everybody – viewing distance





Source: University of Abertay Dundee

- Young people benefit from > 500 PPI in high-contrast regime
- Viewing distance and contrast sensitivity varies hugely by age
- Character height and content must be adjusted accordingly

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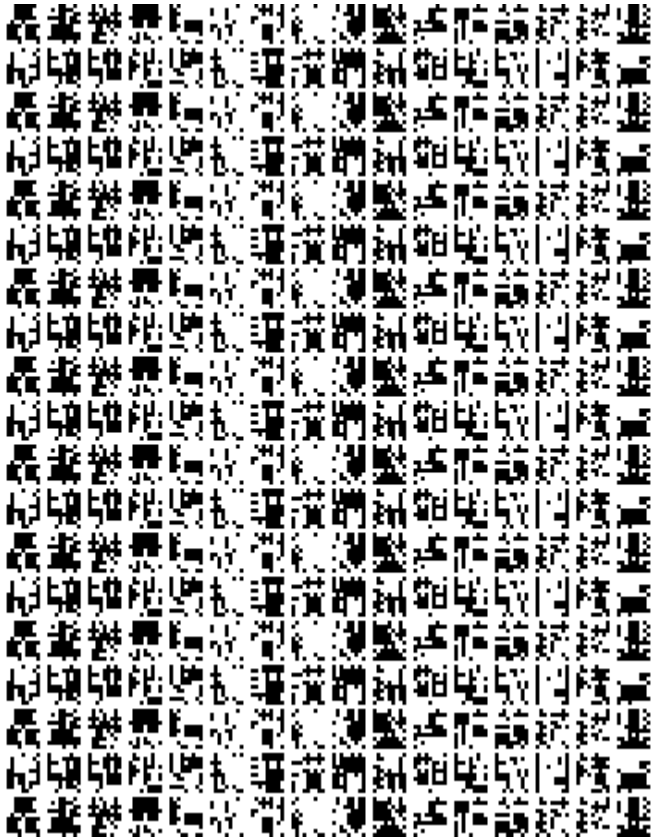
Design for everybody – contrast limits

User category	High contrast limit		Low contrast limit	
	Cycles/degree	Resolution (PPI)	Cycles/degree	Resolution (PPI)
10-year old child	120	1161	7	68
20-year old adult	60	581	7	68
60-year old adult	30	290	7	68
Person with mild amblyopia	20	194	6	58
Person with cataract	15	145	3.5	34
Diagonal size (inch)	2			
Viewing distance (mm)	300			
FOV (deg)	9.679001581			

- Large range of resolution for different ages
- Low perceived contrast can jeopardize high-resolution visibility
- Safe design is 5 – 10 pixels/deg
- High information content incompatible with safe design

Design for every market – an example



12 pt fonts @ 2" 125 PPI

12 pt fonts @ 2" 250 PPI

Today's resolution insufficient for Asian messaging !

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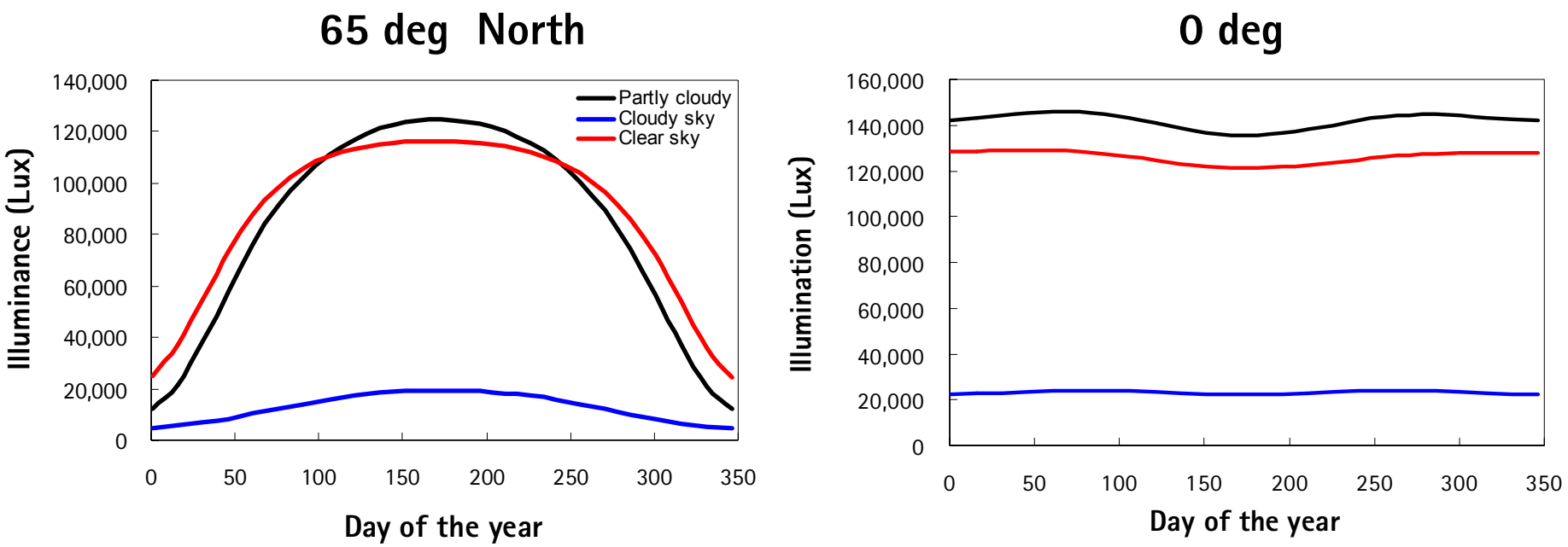
Design for every market – reading tasks

- SMS and Email messaging established, also in Asia
- GPRS/Packet data for web browsing
- Ebook applications emerging

Viewing distance (mm):	400		Font matrix/resolution (PPI)					
Reading task	Font size (')	Phone example	24	22	20	18	16	14
			Asian fonts			Western fonts		
User with reduced vision	22	All info on UI	238	218	198	179	159	139
Long complex reading	20	E-book	262	240	218	196	175	153
Short complex reading	16	Web page	327	300	273	246	218	191
Simple/familiar content	13	SMS/Email	403	369	336	302	269	235
Iconic reading/labels	10	Menu icons	524	480	437	393	349	306
Small details	10		524	480	437	393	349	306

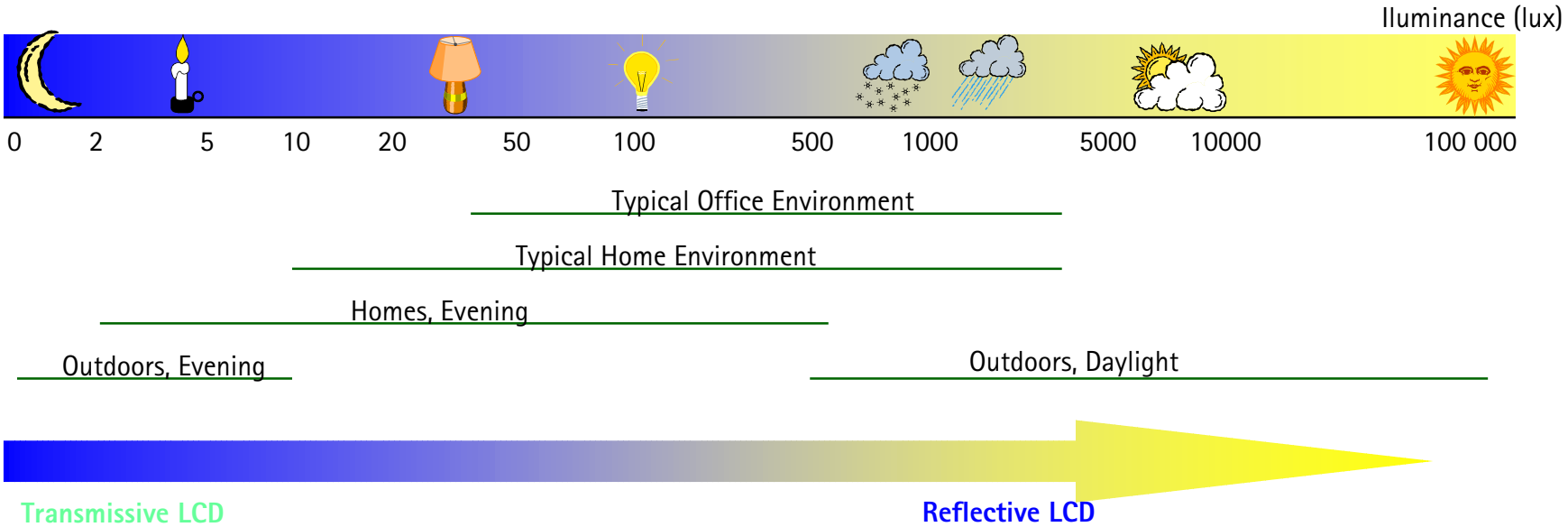
Design for every location



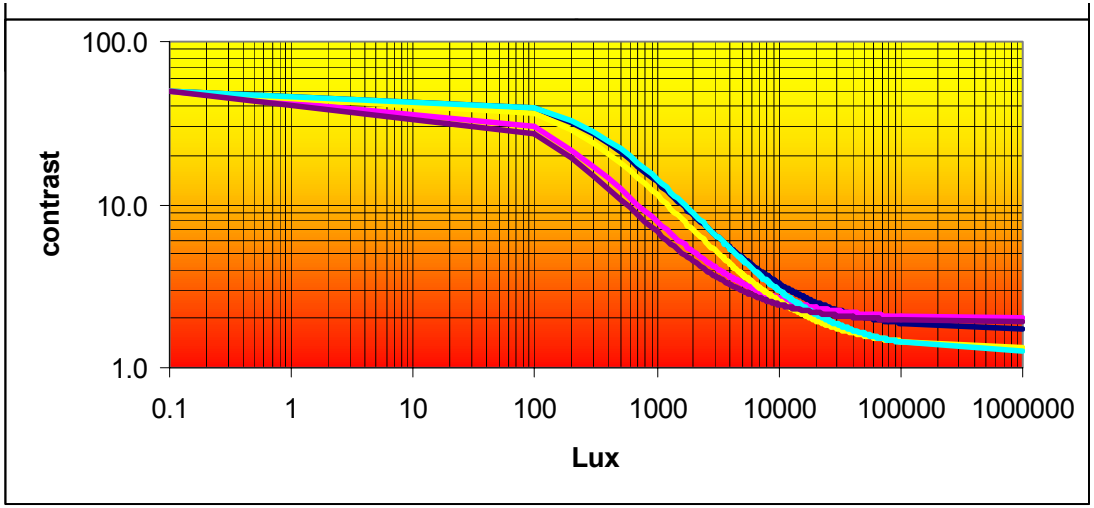
Source: The IESNA Lighting handbook, 9th edition, chapter 8

- Illuminance varies significantly by region and season
- Indoor/outdoor user patterns differ by region
- Perceived display contrast varies accordingly

Design for every luminous environment



Examples of measured displays:



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Design for every application

- Native web content creation assumes 800 pixel width
- Fixed-width frames and too small pixel width radically reduces web browsing usability
- A large portion of users (e.g. young adults, children) can utilize a 800 pixel width on a normal 2-inch, 16:9 display (459 PPI)
- Scalable fonts and UI needed to accommodate the wide range of users, luminous environments, and contents
- Some infrastructures allow full frame rate -> blur-free video displays needed
- Large bit depth available -> colour gamut needs to be extended for camera applications

Balancing performance

- Industrial design often contradicts ideal optical design
- Specification race is ongoing but actual contrast ratio and colour gamut (CIELAB) is limited
- High video performance and wide gamut require high power (transmissive/emissive display+large luminance)
- Large bit depth, pixel count, and scalable UI requires higher system performance

Balancing visual performance, power consumption, cost, and industrial design is the key!

Conclusions

- Bandwidth and storage is abundant - displays lagging behind
- Contrast in actual environments reduces perceivable resolution and colour range
- UI size needs to vary significantly to accommodate all tasks, users, location, and luminous environments
- Text services in Asia require higher resolution displays
  - BUT task-wise character height guidelines are missing
- Bandwidth supports full video but are moving image quality aspects from the TV world relevant to mobile displays?
- Feature balancing is the major challenge