PERCEIVED QUALITY OF A MEDICAL IMAGE: EVALUATION AND IMPROVEMENT

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Visual Quality in Diverse Flavours

- Quality evaluation
- Quality enhancement

Application fields:

- Consumer video
- Forensics
- Medical images

Perceived Quality of Image in Top-of-the-range TV Sets

- **Long-term purpose:**
  Define type and params. of operators in the processing chain

- **Problems:**
  - No original reference signal
  - No info about previous processing (coding type, compression ratio, frame reshaping or cropping, scaling)
  - Very variable quality of source data
  - Variable visualization environment, user preferences
  - “Real”-time operation

- **Approach:**
  Search for, and measure intensity of, typical known artifacts

(cooperation with former Philips Consumer Electronics)

Perceived Quality of Image in Top-of-the-range TV Sets

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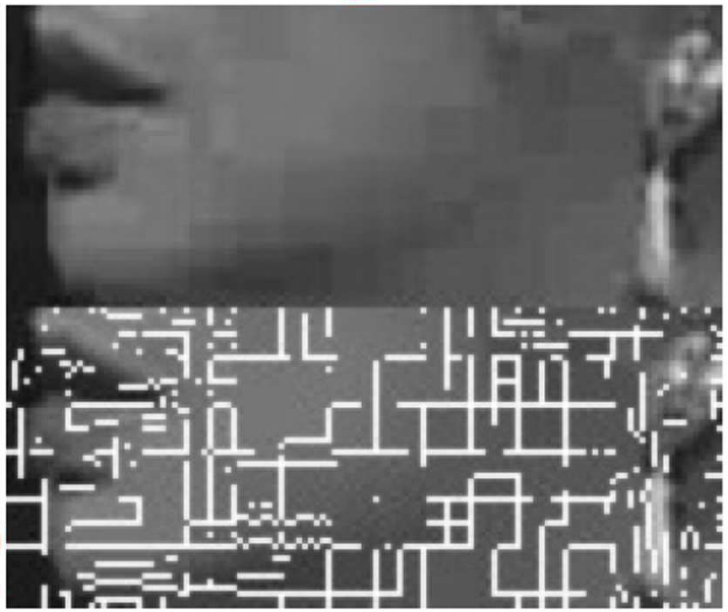
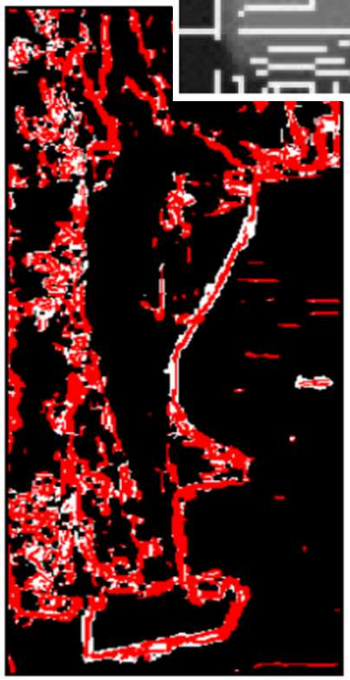
No-Reference Video Quality Assessment

- Blockiness
  - non-uniform and moving grid
- Blurriness
  - visual attention
  - presence of clutter





High-Dynamic-Range Images

Easy to acquire...

...difficult to display

→ Suitable display hw

→ Automatic space-variant luminance mapping

- *(industrial appl. exist, e.g.: arc welding aid)*
- Quality criteria depend on application

High-Dynamic-Range Images

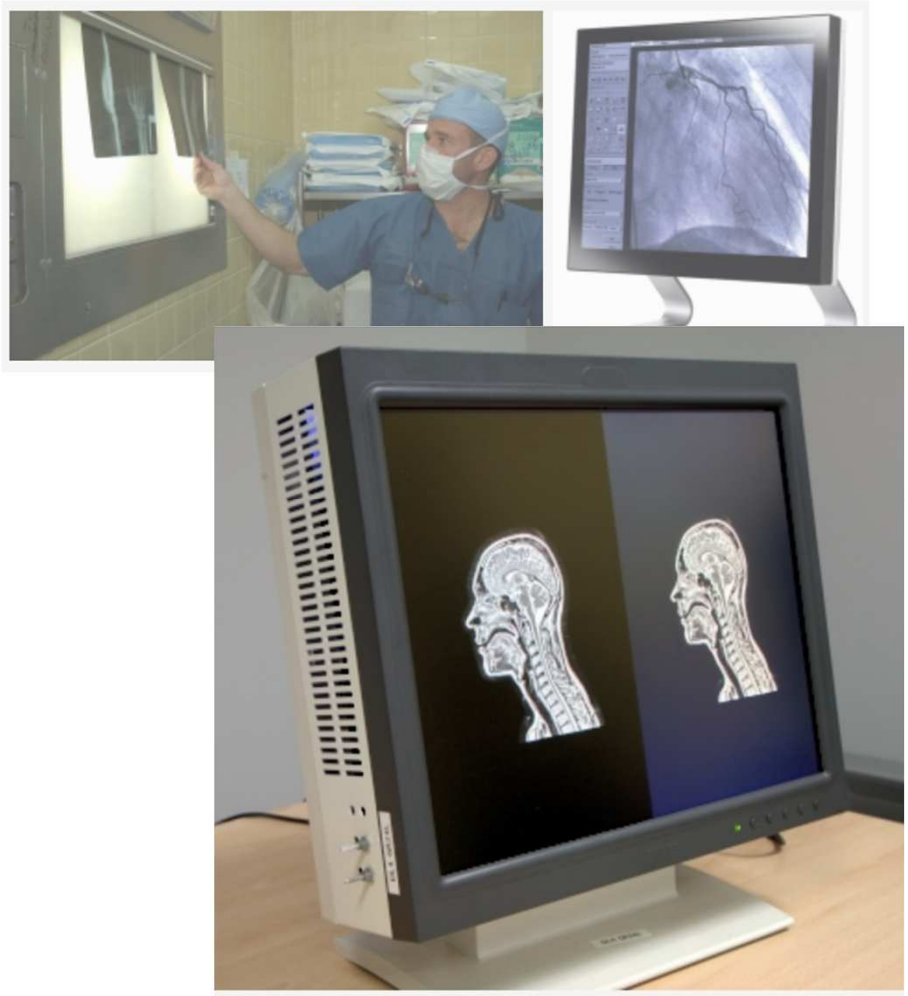
Dual-Layer Display for Medical Applications

Film-based radiographic image on a light box:
0.5 - 3000 cd/m²

Medical-grade LCD:
1 - 500 cd/m²

→ Dual-panel LCD prototype yields: *<0.1 - 600 cd/m², pseudo-16-bit*

(EU project, cooperation with FIMI – Barco)



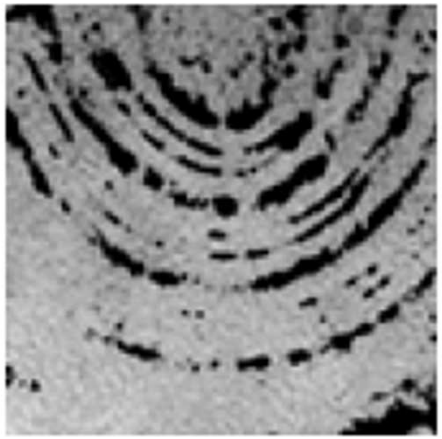
Forensic applications

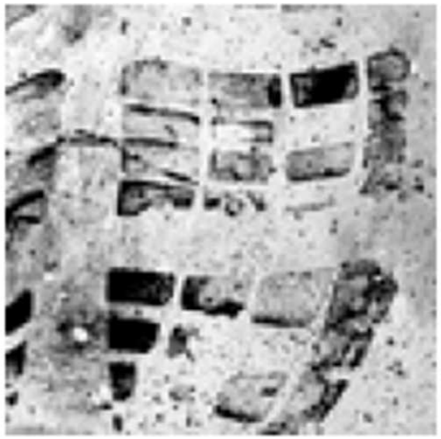
Automatic Footwear Retrieval for Crime Scene Shoe Marks

- Identification of make and model

Real marks are

- made on different surfaces
- due to different substances
- only partially visible
- formed by different superposed textures



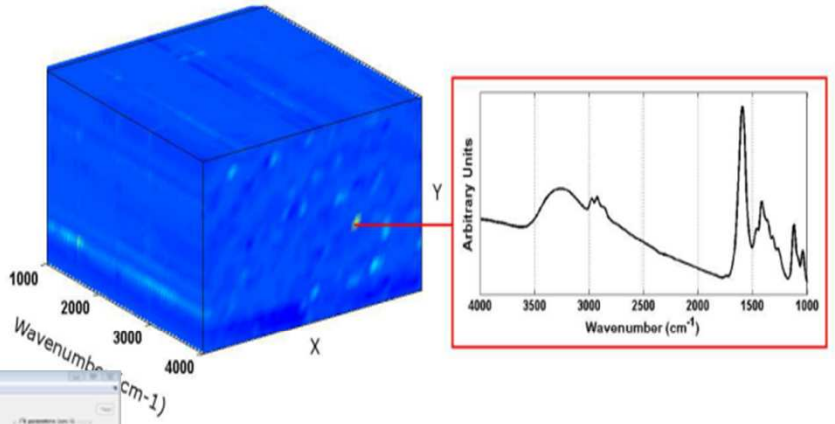


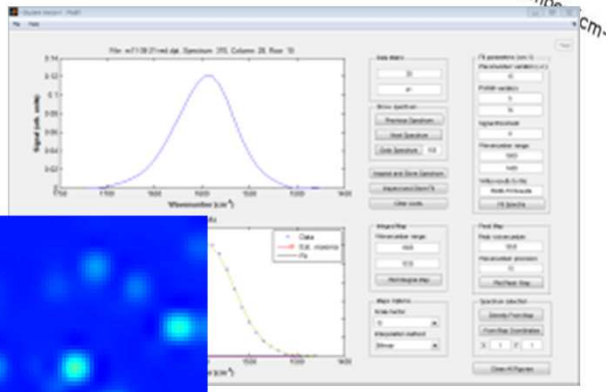
→ translation- and rotation-invariant Fourier descriptors

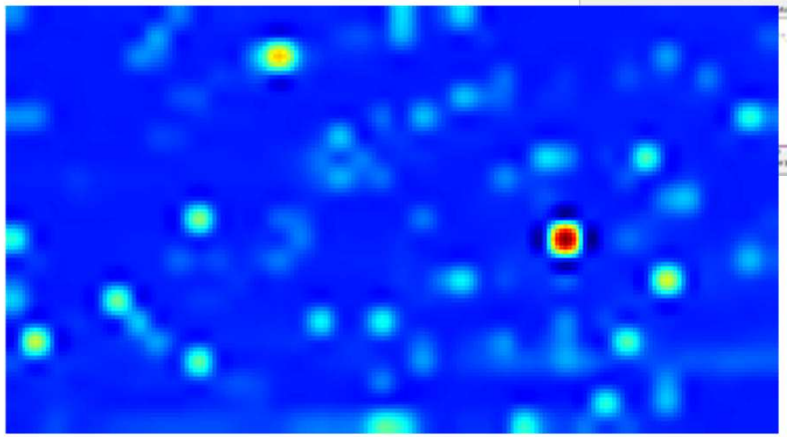
Forensic applications

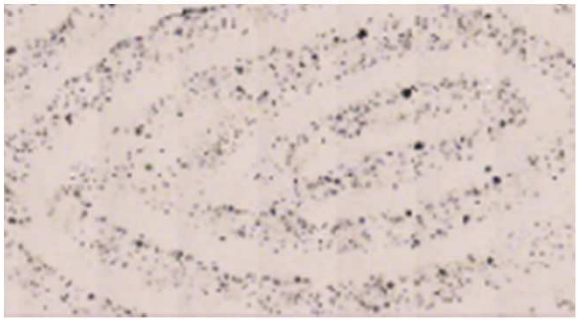
Chemical analysis of fingerprints using synchrotron radiation

- Fingerprint deposition
- FT-IRMS acquisition
- Spectral analysis
- Mapping





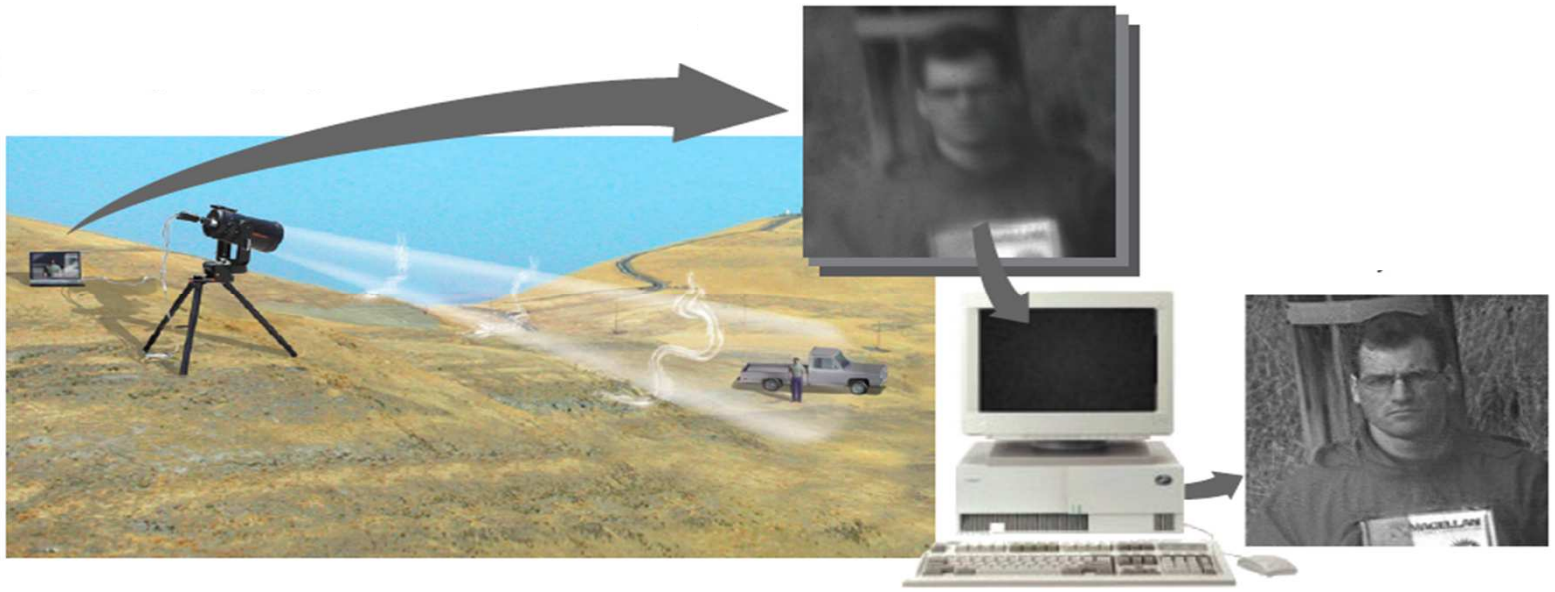




Forensic applications

Image recovery from video affected by air turbulence

- In forensic applications, this may happen in intelligence operations, when the target is far (several km)



- The *Bispectrum* solves a phase-recovery issue in spatially-variable image deconvolution
- (This is a classical problem in astronomy)

Forensic applications

AMPED SOFTWARE

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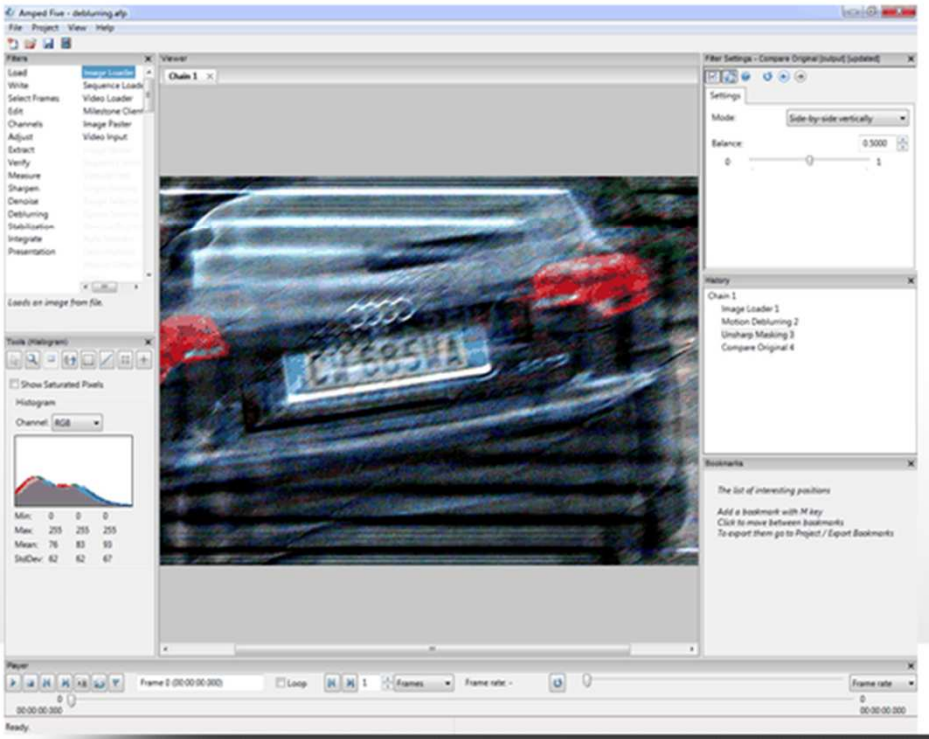
Amped Five

Forensic Video Enhancement Software

- ✓ Load images and videos in any format
- ✓ See license plates, faces and anything else better
- ✓ Automatic generation of a detailed report with the scientific methodology used

Learn More!

or contact us

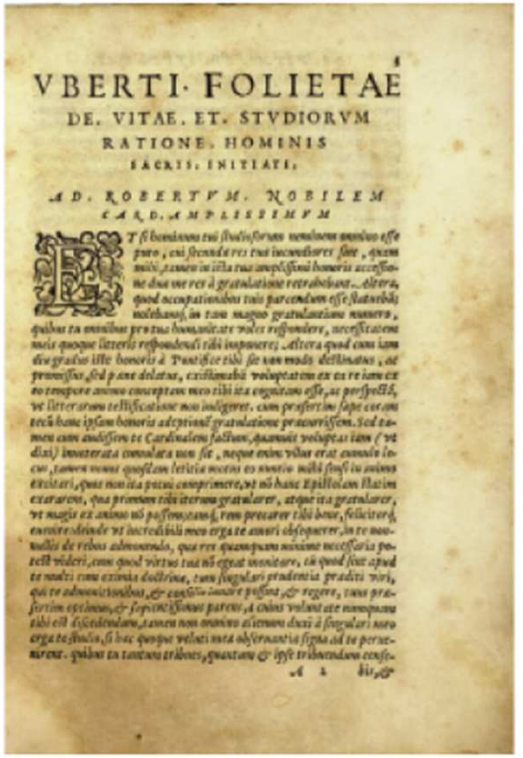


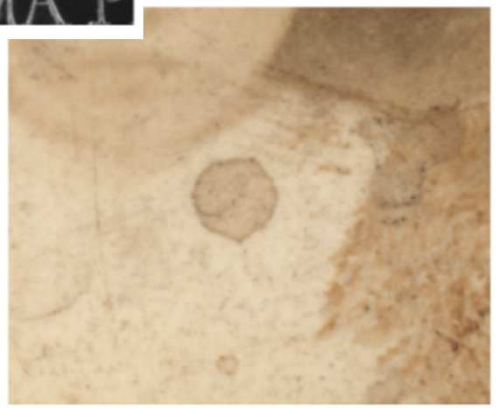
AMPED FIVE

Amped Five is the most complete software for enhancing and analyzing images and videos during investigations. A single tool to analyze crime scene photos, enhance surveillance and intelligence video with a workflow compatible with forensic needs. Read more >>

Digital Restoration of Antique Documents

- Ancient books
- Photographic Prints
- Glass photographic negatives
- Movies and
- Analogue videotapes


VBERTI · FOLIETAE
DE. VITAE. ET. STVDIORVM
RATIONE. HOMINIS
SACRIS. INITIATI.
AD. ROBERTVM. NOBILEM
CARD. AMPLISSIMVM



Real-time image processing

- A wide range of applications
  - *Digital cameras*
  - *Smartphones and tablets*
  - *Consumer TV*
  - *Medical (surgery, diagnostic radiology)*
- Constraints
  - *Real-time response*
  - *Low power consumption*
  - *High computational effort (complex algorithms, large datasets)*
- Solution
  - *Embedded Systems (Processor + dedicated Hardware)*
  - *Flexible and effective architecture*

Future ???  projects

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- **3D visualization in image-guided surgery**
  (EU-Artemis)

- **Cognitive techniques for multi-sensor surveillance networks**
  (National project)

Cyclic and person-centric Health management:
Integrated appRoach for hOme, mobile and clinical eNvironments

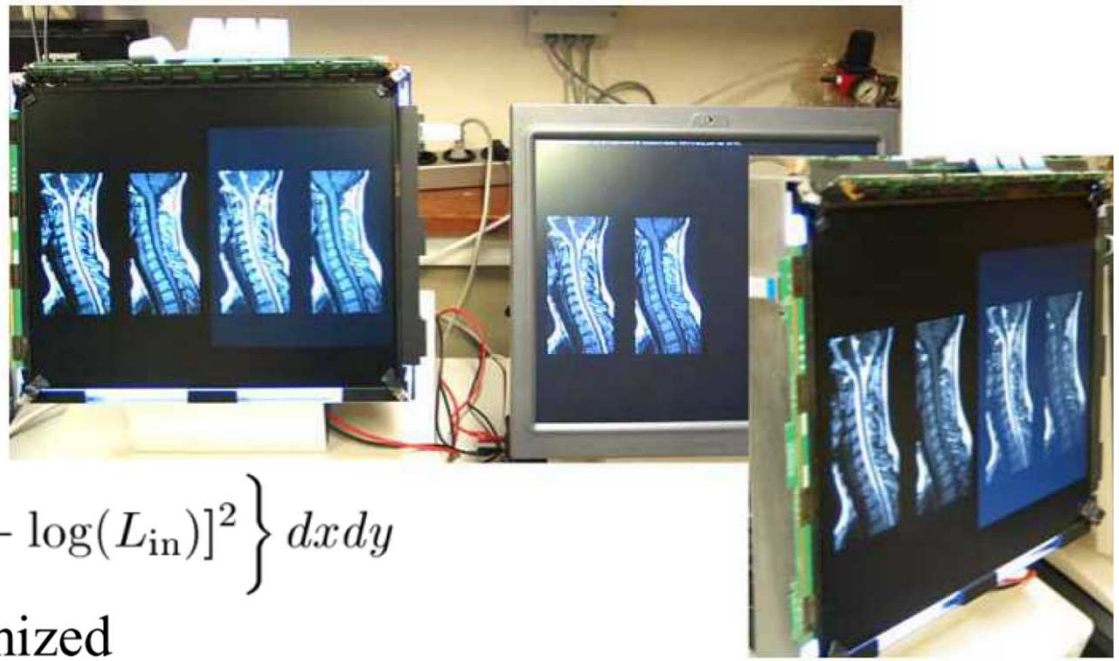
ARTEMIS Joint Undertaking

- 2010 – 2013
- 26 partners in 8 countries
- 18 M€
- http://www.chiron-project.eu

HDR for Medical Applications

Image Processing

Dual Layer Display



$$\iint \left\{ \frac{1}{2} |\nabla \mathcal{L}_{\mathrm{b}}|^2 + \frac{w_{\mathrm{ad}}}{2} [\mathcal{L}_{\mathrm{b}} + \mathcal{L}_{\mathrm{f}} - \log(L_{\mathrm{in}})]^2 \right\} dx dy$$

Table 1: Functionals to be minimized

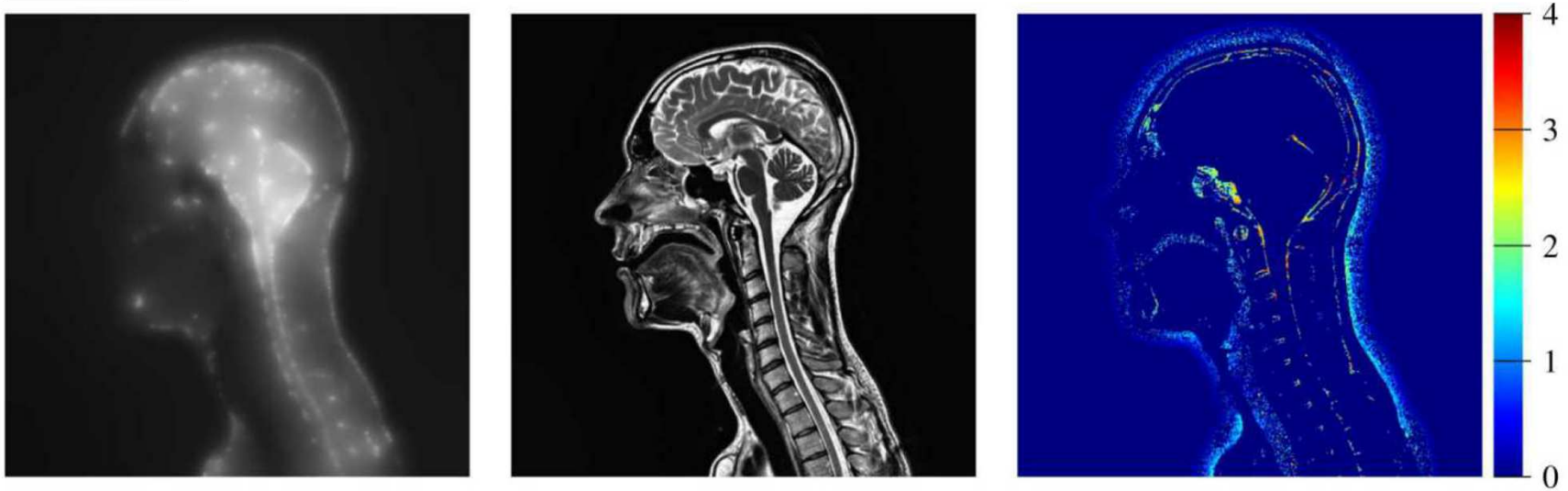


Fig. 2: Back- and front-panel images, and (right) image of the reconstruction error

HDR for Medical Applications

DICOM Grayscale Standard Display Function

- perceptively uniform (Barten's model)

- *not adequate for low luminance values*
- *veiling glare effects*
- *ambient illumination is critical*

(cooperation with US FDA)

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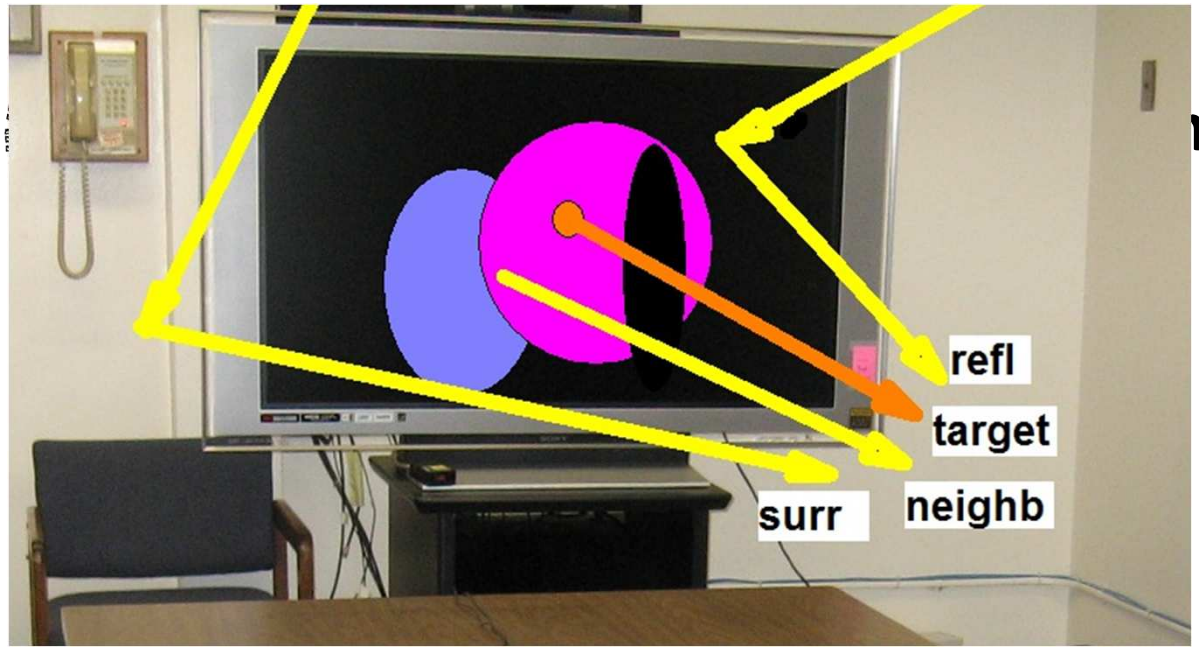


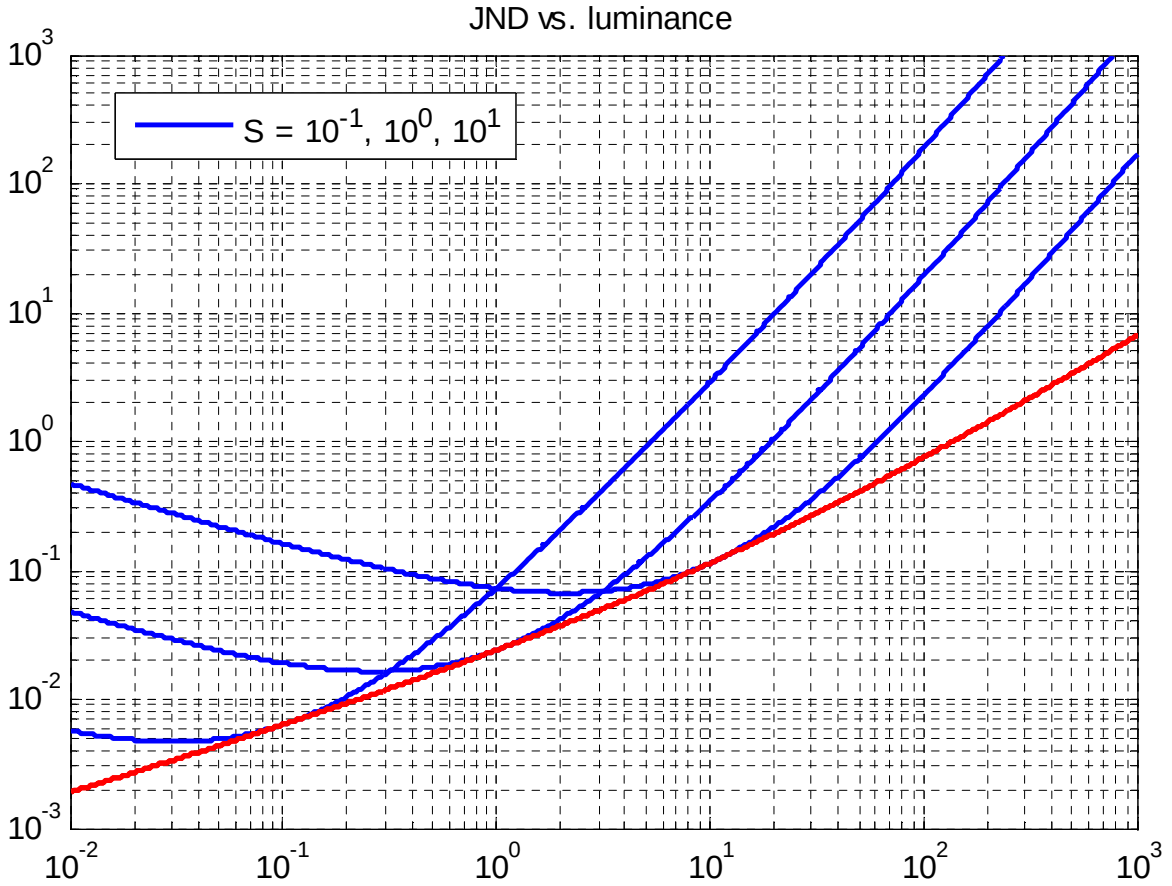
- Ambient illuminance
  - Calibrated photometer
- Ambient light distribution
- Reflected light as seen by the observer
  - diffused / specular reflections

→ Psychophysical experiments

  - Staircase method on different background levels

HVS adaptation

Fixed- and variable-adaptation models based on Naka-Rushton eq.: $P(L,S) = L / (L+S)$ yield TVI curves:



A modern medical display should behave as a

cognitive system

The purpose of a cognitive system is to produce a response to appropriate percepts. The response may be a direct physical action which may change the state of the system or its environment. (…) As important as the percepts, is the dependence upon context.

Gösta H. Granlund, Linköping University

Mantiuk 2011: HDR-VDP-2

- **Mantiuk11 (HDR-VDP-2)**: hdr vision model, for visibility of differences and quality evaluation [*not for detail detection*]
  - Optical and retinal pathway (light scattering, photoreceptor sensitivity, luminance and texture masking)
  - multiscale decomposition
  - neural noise
  - psychometric function with spatial integration
- 4AFC + QUEST procedure for CSF calibration
- Display range starts from 0.02 cd/m2 → dark portion is of interest
- Model sw: hdrvdp-2.1.1 (http://hdrvdp.sourceforge.net/)

Wrapping it all up

- **E**xploiting HVS properties is essential to exploit display performances
- **P**ersonalized properties are a plus (age, distance from the screen)
- **I**llumination conditions (intensity, distribution) in the actual environment should be considered
- **P**ortions of the image itself can influence the perception of the image details

→ ***Cognitive displays***

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