CATHODE RAY TUBES

- Basics:
  - Cathodo-luminescent display
  - Electron gun (cathode)
  - Phosphor screen
  - Deflection of electron beam
  - Modulation
  - Overall anatomy

Cathode

- “Resistive heater”
- Temperature
- Thermal emission
- Two types:
  - Oxide (Ba, Sr, Ca)
  - Dispenser cathodes (W pellet) (higher stabilility and life-time

Electron current needs direction…….

Electron Optics

- Series of electrostatic lenses
- Electron gun
- G1 – control grid (aperture – area)
- G2 & G3 - focus (sometimes G4 & G5)
- Deflection yoke
- Electron beam travel
- Electron beam size and shape
- Collides with phosphor…

Emission of light

- “Cathodo-luminescent” phosphor
- deposited on glass (face plate)
- aluminium layer
- anti-reflective coating
- glass plate has favourable properties

Phosphor details

- Phosphor types: P4, P45, P104
- Luminance efficiency
- Typical luminance levels
- Persistence/decay times
- Phosphor noise
- But a scanning arrangement is required…….

Scanning of the electron beam

- Left to right (Horizontal deflection coils)
- Downward (Vertical deflection coils)
- Horizontal retrace
- New frame (Vertical deflection coils)
- Vertical retrace
- Interlaced Scanning
- Progressive scanning
- Bandwidth

Colour CRTs

- Differences:
    - Image quality
    - Black matrix
    - Colour dots or stripes
    - Low back-scattering materials
    - Shadow mask/aperture grille
    - Mislanding

Spot size

- Gaussian shape
- 50% of maximum luminance
- geographically dependent

Anti reflective treatments

- eliminate static charge & dust
- abrasian resistance
- anti-reflective properties
- Reduce veiling glare
- Thin film layers
- Face plate absorption (good & bad)

ACTIVE MATRIX LIQUID CRYSTAL DISPLAYS

What are liquid crystals?

- Intermediate state of matter
- Properties of solids
- And liquids
- Electrically polarized (diploles)
- Orient along a main axis (director)

Liquid crystal cells

- Aim is to control light transmission
- Orientation needs to be controlled
- On contact with a textured surface…
- Align to the grooves…
- Can lead to a twist (director)
- This director can be influenced by …
- Electrical fields and can effect
- Transmission of light

The display

- Light is generated by a backlight
- Passes through a
- First polarising filter
- LC cell
- Exit polarizing filter

What does all this polarizing mean?

Polarisation

http://www.physicsclassroom.com/Class/light/U12L1e.html

- Unpolarised light
- Polarized light
- The first polarization filters create
- Polarized light… they block a particular light movement
- The exit filter allowing the transmission (or blockage) of the polarized light depending on…..
- The filter & the type of polarized light

So……

LCD Displays (so you tell me)

- Back light
- First polarisation filter will….
- Second polarization will either …..
- But the LCD crystal can effect this relationship
- So the LCD can be in an ON or OFF state
- Depending on voltage changes (image)

Practically therefore an LCD display

- Crossed or co-linear polarisers
- With crossed no light normally (black) unless..
- With co-linear lots of transmission (white) normally unless…
- So you can choose your type but
- White displays demonstrate greater luminance but are not so black

Anatomy

- Polarizer
- Faceplate
- Color filters
- Electrode
- Alignment layer
- Electrode (TFT)
- Glass substrate
- Polariser
- Diffuser
- Edge light or back light

- reflector

Light transmission

- 3-5%
- monochrome are brighter
- backlight v
- edge light
- (lamps/reflector/diffuser)
- high quality polarizers required

EMISSIVE FLAT PANEL DISPLAYS

Two types:

- Field emissive displays
- Organic light emitting displays

Field emissive displays (FEDs)

- Similarity to CRTs
- Cathode and electrons
- Accelerated towards a phosphor
- NOT thermionic emission
- Cold electron source…..
- Microscopic emitter tips
- Diagram

Field emissive displays cont…

- Electrons accelerated through a vacuum….
- Hit a phosphor
- Voltage maintained via ITO and
- Electrode
- Spacers
- Large currents so…
- Focussing
- Focus electrode

Field emissive displays cont…

- Metallic micro-tips or
- Amorphous diamonds
- Evacuation required
- Spacers
- High voltages mean?
- But….
- Advantages
- Disadvantages

Organic light-emitting displays

- Electroluminescence
- Solid state approach
- Direct conversion of…
- Electrical energy into light
- electrical field
- Accelerators of carriers
- Excitation of luminescent centres (phosphors)
- Or….
- No phosphor (LEDs)
- Diagram

Organic light-emitting displays cont…

- Superior light emission
- Range of spectra
- Stable current
- Current challenges with this technology

GRAY SCALE DISPLAY FUNCTIONS (GSDF)

- DICOM Standard
- Variations in monitor displays
- Ensures consistency so back a step
- Pixel values (grey scale values)
- Presentation values
- NOW GSDF
- Digital driving levels (DDLs)
- Luminance values

TG18 PATTERNS

- a large selection, we will focus on…..
- TG18-QC (overall)
- TG18-GV (veiling glare)
- TG18-GQ/GA (veiling glare)
- TG18-CH/KN/MM (anatomy)

TG18-QC (overall)

- Image
- Grid lines (distortions)
- Luminance PATCHES
- Line pairs
- CX patterns
- Contrast detail
- Vertical bars
- White/black bars

TG18-GV[N] (veiling glare)

- Image
- Background
- Large central white circle
- Tiny central dark portion
- 5 low contrast circles
- TG18-GVN
- How many discs?

TG18-GQ/GQB/GQN (veiling glare)

- Images
- GQ= three sections
- GQB = two sections
- GQN = one section (all black)
- Formula:

$$GR = (L_B - L_N)/(L-L_N)$$

- L_B = centre of GQB
- L_N = centre of GQN
- L = centre of GQ

- Acceptable ratio?

TG18-CH/KN/MM (anatomy)

- Physical tests are useful, but….
- So is anatomy
- Chest
- Knee
- Breast

Other comments on AMLCDs

- Not “lambertian”
- Angular dependency
- Crosstalk

IMAGE ASSESSMENT:

RECEIVER OPERATING CHARACTERISTIC

Hierachical model to assess efficacy

- Technical efficiency
- Diagnostic efficacy
- Diagnostic-thinking efficacy
- Therapeutic efficacy
- Patient outcome efficacy
- Societal efficacy
- Importance v ease of assessment so…
- Level 2 commonly used

Diagnostic efficacy

- ? Percentage correct measure…..
- Limitations dependent on prevalence
- Also useful information lost so…
- Sometimes pair of indices…..
- Sensitivity (TPF)
- Specificity (TNF or FPF)
- But there is another factor….
- Human confidence impacts on TPF/FPF

- So….. ROC analysis

Human confidence impacts on TPF/FPF

- 100 films 50 abnormal
- Absolute confidence for positives…
- Impact on TPF?
- Impact on FPF
- Little confidence for positives…
- Impact on TPF?
- Impact on FPF
- So confidence hugely important

ROC analysis

- The graph
- So where would you put ?:
- Absolutely confident
- Very confident
- Quite confident
- Little confidence
- Not a clue
- Ideal graph
- Different graphs…. 2 real options
- So quantification required….

- Generalised ROC analysis
- But what is

TRUTH??????

Limitation of ROC

- Number of lesions????
- Location of lesions????

Localisation ROC (LROC)

- Single location
- So viewer says if lesion is there AND…
- Where it is (location report)
- True positive when
- Correct lesion AND location
- Similar curve, but slightly lower
- LROC & ROC can be calculated
- Similar results found
- Limitation of LROC…..
- One lesion

Free-response operating characteristic (FROC)

- LROC but….
- more than one lesion considered
- Multiple reports per image
- Since more than one FP per image…
- Graph is different (X axis v Y axis)
- Limitation of FROC….
- Location error latitude
- “Satisfaction-of-search” effect
- So y axis is unreliable
- So…..

Alternative free-response operating characteristic (AFROC)

- Similar to FROC except
- Same Y axis however
- X axis based on abnormal images rather than
- Number of abnormal lesions
- Location error still important
- Interdependence of lesion spotting
- JAFROC

Visual Grading Analysis (VGA)

- Normal images
- Anatomical criteria (CEC)
- Reference Image
- Scoring patterns
- Comparisons
- No. of viewers
- Type of viewers

AMBIENT LIGHTING

Introduction

- What is it and why is it important?
- Background lighting
- Luminance
- LUX
- Reflections off screen
- Scattering of light within screen
- Affects contrast
- Eye adaptation….
- Average luminance….
- Contrast response maximised so….

- Ambient lighting should equal image
- Current standards

Introduction cont…

- WHO
- CEC
- Illuminators v monitors
- ACR - illuminators/monitors
- AAPM
- Hypothesis of the current study

METHOD - overview

- Overall study environment
- Wrist images
- Displays
- ROC analysis

METHOD -details

- Display:
- Type, resolution & luminance
- Quality checks & calibration
- Rooms
- Ambient light levels
- Values
- Controlled
- Measured

Method - details

- Image evaluation
- Image type & number
- Truth
- Normals v abnormals

- Presentation of images
- Radiologists
- Specialities - 2 categories
- Scoring
- ROC & Az values
- Statistical analyses

Results

- Summary of observer allocation
- Az values- both categories
- False positives
- False negatives

Discussion/conclusion

- Current standards
- Illuminators v CRTs v LCDs
- Ambient lighting did effect diagnostic efficacy
- Particularly for the non-specialists
- ???? 7 lux ????
- Importance of a multi-metric approach
- Limitations and future work
- Final recommendations