Examples on exam questions for course IN4180

Part 1: knowledge based

1. **Describe the structure of the human retina and the function of all cells.**
   Kegeltjes (midden, weinig, kleur, high wavelengths (details), photopic, 3types S, M & L (many) for small(blue), middle(green) and large(red, yellow) wavelengths) en staafjes (meer rondom midden, veel, alleen luminance verschillen, low wavelengts, scotopic, quick sensors)

2. **Describe the phenomena/process of dark adaptation and light adaptation.**
   Dark adaptation: go from light to dark circumstances → temporal blindness, takes about 15 min. to recover, iris widens pupil to catch more light, pigment bleaching, change in neural processes, cones become more sensitive, then rods become more sensitive.
   Light adaptation: go from dark to light → unpleasant, faster reaction

3. **Discuss the resolvable power of the human eye. What are the smallest details that an averaged viewer can perceive?**
   Spatial: Intrinsic resolution of human eye: 1 arcmin. But: more can be seen, for instance spatial variations to a straight line (Vernier aqcuity) is 10 arcsec.
   Temporal: less sensitive in middle of eye, >70 barely visible. The brighter the image, the more sensitive the human eye to flicker

4. **Describe the consequences of having only one, two, three or more types of cones for the perception of colour.**
   Kleurenblindheid bij 2 zodat je t verschil tussen rood & groen niet kan zien, one type of cone: see no colors but monochromatic, 3 is normal, 4 will probably allow us to see more wavelengths then human or have better color discrimination ability

5. **Describe the difference/relation between luminance and illuminance.**
   Luminous power = 4*pi*I in lumens (I is Intensity of light source)
   Luminance = luminous power of a light source per unit of solid angle and per unit area in lumens/(sr.m^2) = candela/m^2= nit
   Illuminance is intensity of the point light source divided by the square of the distance to point source in lumen/m^2 or lux generated on an area.
   Luminance = illuminance * reflection coefficient / pi (if area is Lambertian reflector)

6. **Shortly describe how light is generated in a CRT, LCD and PDP.**
   CRT: Cathode Ray Tube. Electron gun emits electron beam, aimed at face plate by deflection coil by magnetic field that attracts or repels electrons. On face plate there are dots of phosphor that emit light when hit by electrons. Colour: 3 different colours phosphor and 3 guns and a shadow mask just in front of face plate to make sure 3 beams hit exactly only the right dot by incoming angle.
   LCD: Liquid Crystal Display. A LC layer between 2 polarisers, addressed by an active matrix array of driving elements and illuminated by a backlight. For colour a colour filter is added with spatial distribution of red, green and blue elements. LC molecules have the tendency to adopt a common orientation direction. This

can be changed by putting a voltage on a pixel: then the molecules will orientate according to the electric field.

PDP: Plasma Display Panel. A Ne/Ar mixture or NE/Xe is put on the crossings of the rows (sustain electrodes) and the columns (address electrodes + channels with phosphors). When a voltage is applicated on the electrodes, ionisation occurs, releasing electrons and positive atoms. This ionisation process plays a key role in the generation of light. Ar generates light on discharge, Xe generated UV-light on discharge which excites the phosphors to generate a colour.

7. **Describe and compare the perceived artefacts in motion rendering on a CRT, LCD and PDP.**
   In PDP: false contouring
   In CRT: Flicker
   In LCD: If we follow a moving car, this car will be displayed at one position during the whole frame time, and suddenly, switch to another position at the next frame time. Our eyes integrate this into a **smearing effect** of the car.

8. **Describe the differences and use of additive and subtractive colour mixing.** additief: beeldschermen. Wit = R+G+B subtractive: printers, based on CMY(K). Wit = niks

9. **Describe the various ways of rendering colour in displays, and their advantages/disadvantages!!!.**
   - Optical superposition refers to the fact that red, green and blue light are locally superimposed on the display and hence can not be separated anymore. (Projection displays)
   - Spatial synthesis refers to systems that have the red, green and blue primary spatially ordered in subpixels next to each other. (CRT & LCD & PDP)
   - Temporal synthesis refers to systems that have the red, green and blue primary temporally ordered in sub-frames one after the other.

10. **Describe the Image Quality Circle model and give some examples for the various boxes for:**
    - image quality related to display characteristics
    - image quality related to signal characteristics

Box	display characteristics	signal characteristics
Technology Variables:	Size of pixels	Parameters in signal processing algorithms
Physical Image Characteristics:	Averaged chromomaticity	Pixel differences, correlation coeffs.
Image Quality Attributes:	Brightness, contrast	Noise, blockiness
Image Quality Preference:	Like best, bad quality	Like best, bad quality

11. **Describe an approach to determine the relation between overall image quality and its attributes**
    IQ attributes: Shape genuiness, sharpness, brightness, spatial distortions, colour, contrast. Overall IQ is the weighted sum of all attributes, where the weights express the relative importance of each attribute for a given viewer and given circumstances & image content. A line-up experiment can be done with 4

different displays, and people have to rank these displays and then say what features they thought were important.
For a complete test: make independent attributes (instead of now dependent IQ attributes), determine JND for each attribute, fit the weighted sum equation (incl. Combinations) and quadratic terms because relation is probably not linear.

12. Discuss the four factors that affect perceived contrast on a display

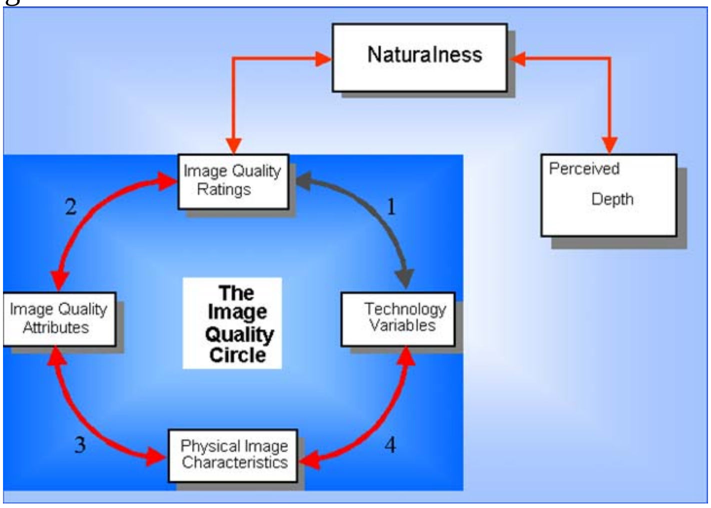
1. maximal contrast ratio (Peak white & Full black)
2. display function (dithering, perceived differences in luminance between various grey scale values)
3. veiling glare (electrons meant for white end up in black regions)
4. amount of reflected ambient light

13. Discuss the three aspects which determine perceived colour rendering on a display

- Position of the primaries (3 values, like RGB)
- Location of the white point
- Display function for each primary
- (Surround)
- (Adaptation level of human eye)

14. What is wrong with the Image Quality Circle model for 3D-TVs?

we can formulate an extension of the Image Quality Circle model, applicable to model the perception of 3D stimuli. For these stimuli, observers assess the perceived image quality (which is mainly related to the visibility and annoyance of artefacts) and the perceived depth, and combine both aspects in a higher order attribute, being naturalness.



15. Explain the difference and the use of double-ended and single-ended objective metrics

Physical characterisation at signal level usually by double-ended measure. Examples are: noise, pixellation, blockiness, ringing, …
Again, physical characterisation at signal level. But, now double-ended measure makes no sense. Examples are: peaking, contrast enhancement, colour rendering improvements

Part 2: discussion items

16. **Describe the colours brown and grey in terms of their hue, brightness, lightness, colourfulness and chroma.**

    Five attributes to fully characterize the appearance of a colour:
    - Brightness
    - Lightness
    - Colourfulness
    - Chroma
    - Hue

17. **Given a certain research question, which methodology would you use to give an answer.**
    1. staircase method for measuring thresholds and just-noticeable differences
    2. tuning method for measuring thresholds and just-noticeable differences
    3. rank order method
    4. paired comparison method for small differences between images
    5. direct scaling method e.g. for measuring degradation of image quality as a function of a given artefact
    6. Recommendations of the ITU to assess image quality (ITU Recommendation BT500.8: Methodology for the subjective assessment of the quality of television pictures)

18. **What would be a valuable approach to design an objective metric for: Sharpness, Luminance non-uniformity, Colour purity**
    Objective metrics characterizing artefacts, i.e. degradation with respect to the original image, usually are so-called double-ended measures. For these measures, it is assumed that the original, undistorted image is available too, such that one can calculate the difference in signal between the distorted and the undistorted image. The quality measure is (in various different ways) deduced from this difference.