PAPER 5/Q4

p12q4 NAD 2000

Computer Graphics & Image Processing

Exam Question for Paper 5

(a) Explain how a cathode ray tube (CRT) works, including details of how colour is achieved. [8]

(b) (i) Describe a run-length encoding scheme for encoding images whose pixels have eight bit intensity values [8]

(ii) Calculate the best possible compression ratio achievable with your scheme and describe the situation(s) in which this ratio would be achieved. [2]

(iii) The same for the worst possible compression ratio [2]

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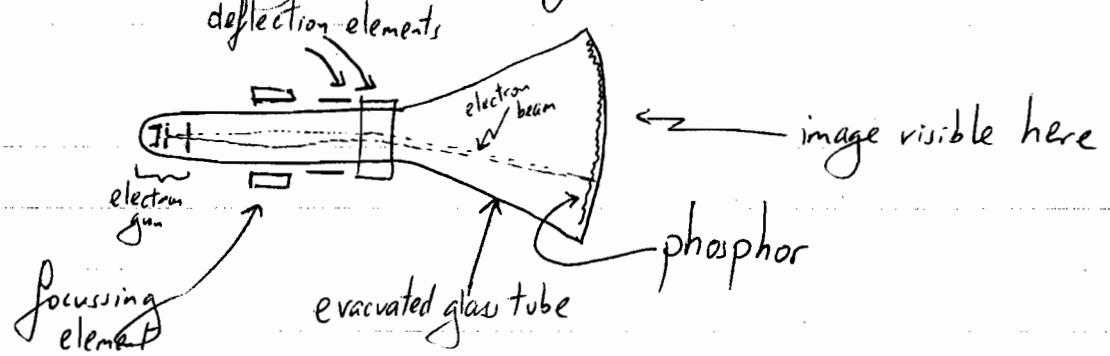
Model answer

(a) a CRT consists of an electron gun firing high speed electrons at a glass screen coated with a phosphor. On hitting the screen the electron excites an atom which, on returning to its ground state, emits visible light.
The electron beam is electromagnetically focussed on the screen to produce a single bright dot.
This dot is scanned across the screen by two sets of electromagnetic control: one moving the electron beam, and hence the dot, left-right and the other moving it up-down.

By scanning the dot across the screen horizontally, while simultaneously moving the dot down the screen slowly, the entire screen can be "painted" with electrons. Varying the voltage on the electron gun ~~allows~~ varies the intensity of the electron beam and hence of the dot of light. Overall control of horizontal & vertical scanning & of electron gun voltage allows the screen to be painted with a 2D image. Refreshing this image sufficiently rapidly (say, 50Hz) gives a human observer the illusion that there is a continuous image on the face of the CRT.



Colour is achieved using three electron guns, three phosphor colours and a physical "shadow mask" which ensures that electrons from a given gun can only hit the appropriate phosphor. The colours are normally chosen to be red, green & blue to give a good range of colour when perceived by a human.

(b)(i) a good scheme is to use an eight bit value to encode the type & length of run.
The first bit encodes the type of run:
0 = run of n identical pixels, value in the following byte
1 = run of n non-identical pixels, values in the following n bytes

The other seven bits encode n.
For the case of identical pixels $n = 3$ to $n = 130$
coded as m: 0000000 thru' m: 1111111 ; $n = m + 3$
For the case of non-identical pixels $n = 1$ to $n = 128$,
so $n = m + 1$.
Two identical pixels in a row are coded as part of a non-identical pixel run; the slight savings here normally mean slightly better compression.

For example:

12 12 12 11 10 9 8 8 8 8

Codes to:

0-3 12 1-3 11 10 9 0-4 8

(b)(ii) the best case occurs when we have an image completely made up of sequences of 130 identical values.

$$\text{Compression ratio} = \frac{2}{130}$$

(b)(iii) the worst case occurs when there are no sequences of identical pixels

$$\text{Compression ratio} = \frac{129}{128}$$