Beeldbewerken
Assignment 3: "Finding Waldo"

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November 7, 2011

1 Histogram intersection

1.1 Colour histogram exercise

1.1.1 "What type of array do you need to store a colour histogram?"

One needs an array (of floats) of dimension n where n is the number of components in the colour model. In this case, a three dimensional array. The indexes in each dimension together index the bins of a three dimensional histogram. The values in the ultimately indexed elements represent the numbers of pixels in the image that display the colour corresponding to that bin.

1.2 Histogram intersection exercise

1.3 Colour model exercise

For this exercise we have chosen the YUV colour model. We had initially chosen HSV, an implementation for which is embedded in our application. However, we chose YUV since HSV is sometimes classified as a sub-representation of RGB, and not as a distinct colour model.


(a) air1

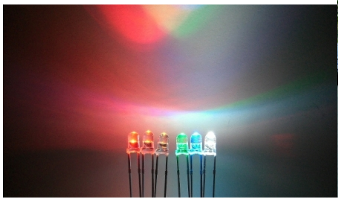

(b) air2


(c) air3


(d) air4


(e) bre1


(f) bre2


(g) leds


(h) fire


(i) lbug


(j) star

Figure 1: "database" images

(a) airb (b) rcar (c) flag

Figure 2: "external" images

Model / Image	air2	bre1	air4	leds	air3	fire	star	air1	lbug	bre2
air2	1.00	0.20	0.06	0.11	0.13	0.14	0.07	0.05	0.05	0.24
bre1	0.25	1.00	0.07	0.30	0.25	0.14	0.30	0.05	0.10	0.32
air4	0.06	0.06	1.00	0.21	0.22	0.24	0.16	0.12	0.02	0.08
leds	0.14	0.30	0.25	1.00	0.25	0.31	0.27	0.17	0.09	0.17
air3	0.17	0.26	0.28	0.26	1.00	0.44	0.22	0.13	0.06	0.26
fire	0.18	0.14	0.30	0.32	0.43	1.00	0.19	0.15	0.07	0.22
star	0.09	0.27	0.17	0.25	0.20	0.17	1.00	0.09	0.08	0.16
air1	0.06	0.05	0.14	0.15	0.12	0.14	0.09	1.00	0.02	0.05
lbug	0.06	0.10	0.02	0.09	0.06	0.07	0.09	0.03	1.00	0.13
bre2	0.27	0.28	0.09	0.15	0.22	0.19	0.16	0.04	0.11	1.00

Table 1: RGB intersections within database

Model / Image	air2	bre1	air4	leds	air3	fire	star	air1	lbug	bre2
airb	0.26	0.28	0.20	0.27	0.42	0.37	0.20	0.09	0.07	0.36
rcar	0.16	0.13	0.35	0.37	0.31	0.33	0.18	0.11	0.08	0.18
flag	0.09	0.15	0.14	0.19	0.18	0.25	0.18	0.20	0.09	0.15

Table 2: RGB intersections against external images

Model / Image	air2	bre1	air4	leds	air3	fire	star	air1	lbug	bre2
airb	0.39	0.33	0.23	0.35	0.49	0.32	0.23	0.09	0.09	0.49
rcar	0.12	0.13	0.60	0.37	0.22	0.49	0.21	0.15	0.07	0.20
flag	0.12	0.14	0.15	0.20	0.22	0.28	0.14	0.17	0.09	0.15

Table 3: YUV intersections against external images

1.3.1 "... what are the conversion formula's..."

The formula for RGB to YUV conversion is straightforward (source: Wikipedia):

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.14713 & -0.28886 & 0.436 \\ 0.615 & -0.51499 & -0.10001 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{1}$$

1.3.2 Description of YUV model

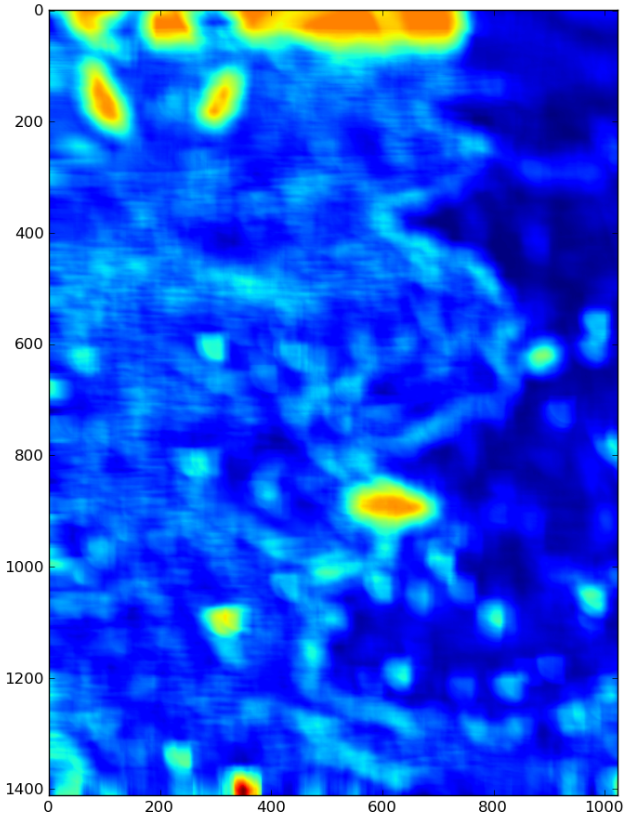
The YUV model is a European (PAL) standard and the equivalent of the US (NTSC) standard, YIQ. The model was created for the broadcasting industries of the 20th century as a means to efficiently transmit colour video signals. The YUV model takes certain characteristics of human colour perception into account to reduce the bandwidth needed to transmit chrominance (as opposed to luminance) components of the image.

1.3.3 Effect of YUV model on histogram intersections

A quick comparison of the intersection tables for RGB and YUV shows apparently non-linear differences in the way intersections are evaluated for these two colour models.

For instance, the YUV model appears to better reflect the similarity between the fire truck and red car. One could speculate that the YUV model better accounts for the perceived similarity of the red vehicles, where perhaps the RGB model "notices" the difference between the two reds more "literally".

Interestingly, the YUV model shows a significantly higher value between "air4" and the red car, than the RGB model. The YUV implementation would appear to lend greater weight to the similarity between the respective gray sea background and gray asphalt background.



(a) where's Waldo?

Figure 3: expectation heatmap: Waldo's location

2 Colour back projection

2.1 Colour back projection exercise

Refer to the application (menu option 3) and source code. Note that the number of bins can easily be adjusted within `menu()`.

It is also worth noting that the expected location returned by our implementation corresponds to a sailor near the bottom of the image. His trouseres feature a similar colour pattern to Waldo's, but larger. This suggests that tweaks to the convolution kernel's size in our implementation should result in improved results.