Project Report

Of

Group 5

On topic

“Sub-pixel based image processing”

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Definition of Sub-pixel:

A single picture element (a "pixel") of an LCD screen is actually composed of three "sub-pixels": one red, one green, and one blue (R-G-B). Taken together this sub-pixel triplet makes up what we've traditionally thought of as a single pixel.

Our eye sees a single pixel like this: 

But a magnifying glass reveals it as: 

This means that an LCD screen boasting a horizontal resolution of 800 whole pixels is actually composed of 800 red, 800 green, and 800 blue sub-pixels interleaved together (R-G-B-R-G-B-R-G-B ...) to form a linear array of 2400 single-color sub-pixels.

When our eye sees a solid white line:

What's actually being displayed is:

The human eye doesn't 'see' closely spaced colours individually since our vision system deliberately mixes these three primary colours in combination to form intermediates. Our eyes only register these three colours and perceive all others as combinations of these.

NOTE: Sub-pixel meaning here is the individual channel of a pixel (i.e. R, G and B), not the intensity value of the positions between pixels.

Sensor array pattern for different display technologies:

Before beginning with the processing in sub-pixel domain, we should quickly review different sensor pattern used in current display technologies for handling colour information. CRT monitors generally uses Bayer pattern sensor. The sensor patterns for CRT and LCD display are given in fig. (1).

It can be noticed that there are twice as many green pixels as red or blue on this representation of a CRT(Bayer pattern sensor).

Not all LCD's have the same linear ordering of R-G-B sub-pixels. (Some are B-G-R.)

If image on the left looks better than the image on the right, then you have RGB display pattern, otherwise you have BGR pattern. If you are viewing it on CRT then please ignore this part.

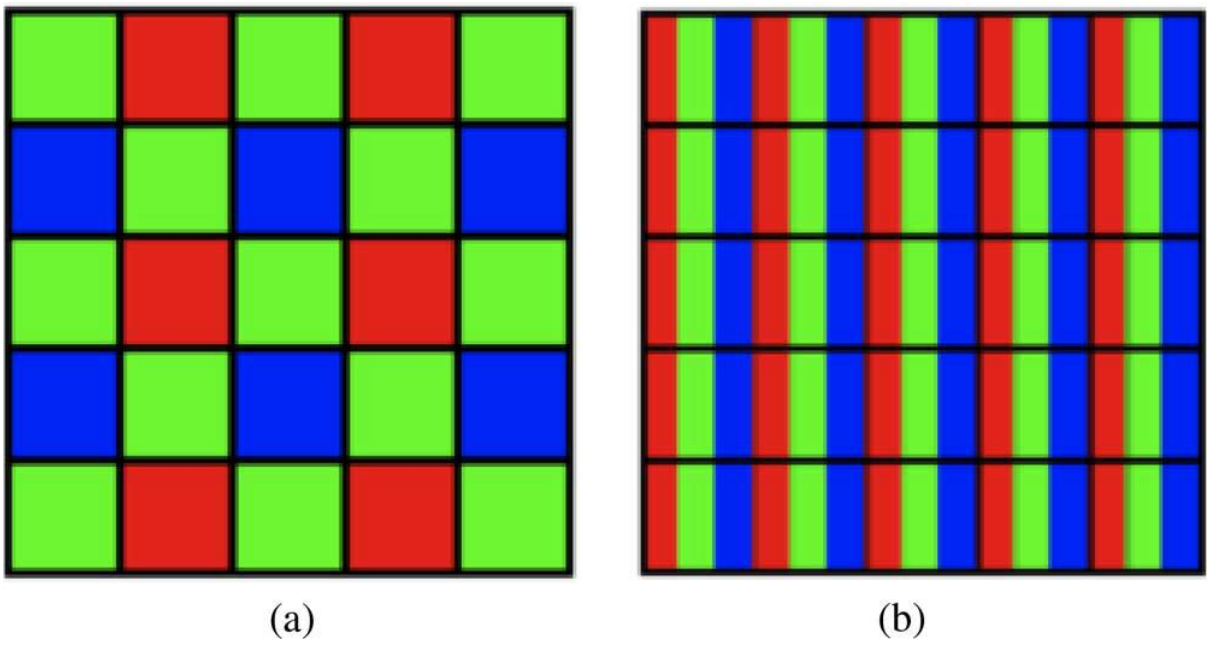


Fig.(1) (a). Sensor pattern for CRT display (b). For LCD display

Sub-pixel Rendering

After reading basics about sub-pixel and display technologies, we started working on most used application of sub-pixel based processing “Sub-pixel Rendering”. In this section we will summarize the term “Sub-pixel Rendering”, show some of the applications and finally mention some important patents and facts regarding it.

We have already explained the RGB pattern in a LCD display

This means that if we were to treat the actual sub-pixels individually -- ignoring their differing colours for the moment -- we would have three times the horizontal resolution from our existing LCD display panels!

Definition: Sub-pixel rendering is a way to increase the apparent resolution of a computer's liquid crystal display (LCD) or organic light-emitting diode (OLED) display by rendering pixels to take into account the screen type's physical properties – Wikipedia

For example suppose we wish to draw an object with a sloping diagonal edge, then the CRT display will display it as fig(2.a). We can improve the same diagonal edge by drawing the diagonal edge with some non-white pixels we can produce a much smoother edge as in fig.(2b). Even though the pixels along the diagonal edge are non-white, our eyes still perceive them as absolutely white and the perceived image by our eye will look like fig.(2c).

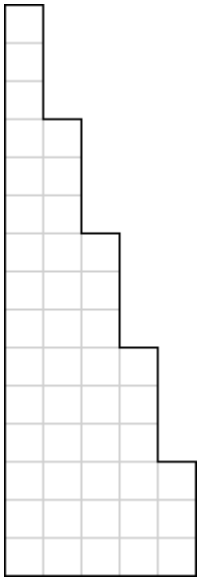


Fig. 2a

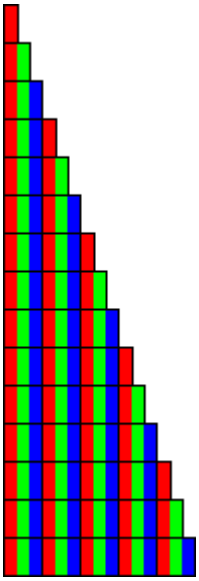


Fig. 2b

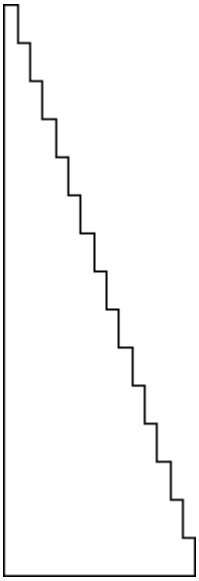


Fig. 2c

Here are some of the widely used applications of Sub-pixel rendering:

1. Rendering small typefaces on digital display
   making small font character clear and sharp
2. Font Character Kerning
   'Kerning' is the process of managing the spacing between characters. As you may have noticed in some cases(especially small font size) if we move two characters together by one pixel and they're too close, move them back apart and now they're too far apart. This problem can be solved at sub-pixel level.
3. Font Emboldening
   Sometimes 'bold' seems too bold (way more than it should be) and at other times it doesn't seem to do very much at all. This can be solved at sub-pixel level.
4. Font Italicizing
   Improving clarity and sharpness of italic character by the means of sub-pixel processing.

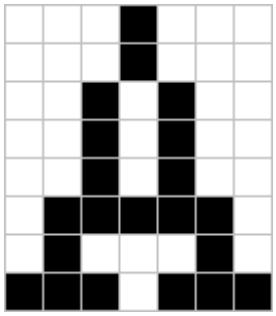


Fig. 3a

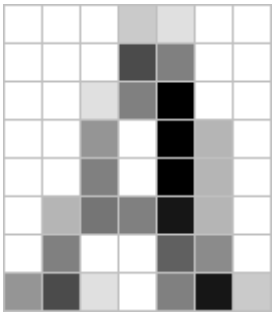


Fig. 3b

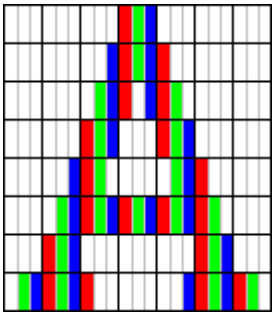


Fig. 3c

Fig. 3a is a 8 point regular (non-italics, non-bold) capital 'A' rendered in Microsoft's standard Times New Roman font, it is vastly less clear and sharp. Fig. 3b is an attempt to correct it by anti-aliasing filter and Fig. 3c is the solution by sub-pixel rendering

Microsoft's November 1998 Comdex announcement of it's "breakthrough" new display technology, dubbed 'ClearType' was regarded by many as the most important event of the show.

Although Sub-pixel rendering is a great topic with lots of scope, but we figured out that it's more cantered towards improving resolution of fonts in digital media and belongs to Computer Graphics rather than Image Processing. Our work in this project will be focused on the other application of Sub-pixel based processing, i.e. Down-sampling, Image demosaicking etc.

Down-sampling using sub-pixel based techniques:-

Down-sampling is to shrink a high resolution image such that the visual distortion introduced is reduced.

Methods proposed in literature

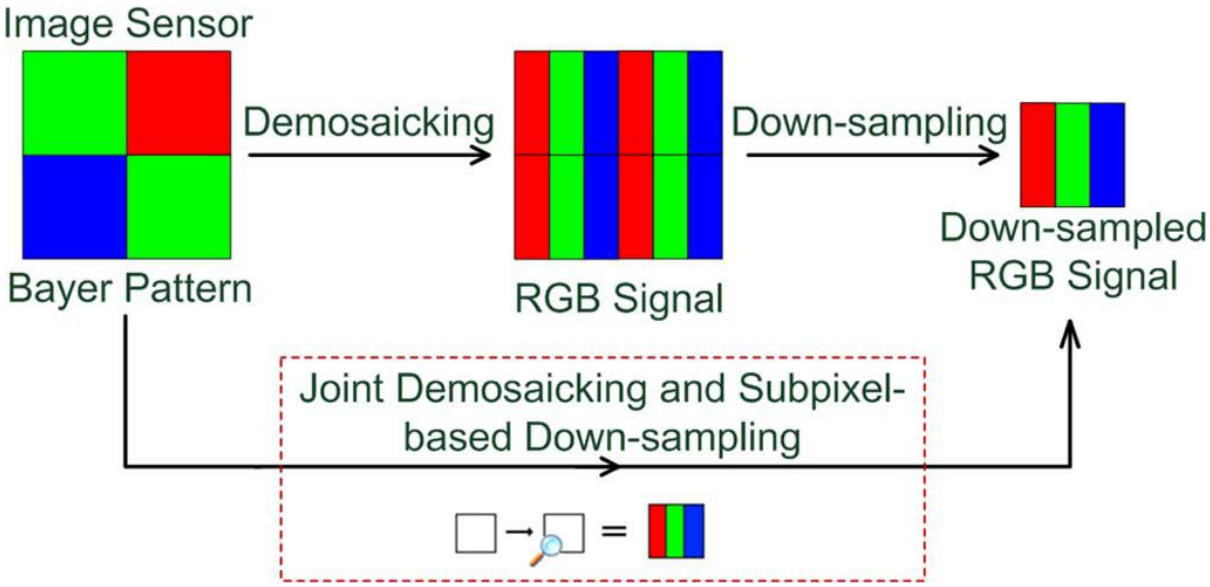
1. Direct Pixel-based Down-sampling (DPD)
   Incurs severe aliasing artifacts in regions with high spatial frequency
2. Direct Sub-pixel-based Down-sampling (DSD)
   Chrominance Distortion
3. Adaptive Sub-pixel-based Down-sampling scheme Using Edge Detection
4. Sub-pixel based Down-sampling via Min-Max directional Error

Joint Demosaicing and Sub-pixel based Down-Sampling:-

Art of constructing full colour image from Bayer colour filter array is called demosaicing.

A digital camera with a single sensor and Bayer color filter array (CFA) requires demosaicing to reconstruct a full color image and down-sampling to display it on a low resolution LCD screen. The two steps, demosaicing and down-sampling, influence each other.

The colour artifacts introduced in demosaicing may be magnified when followed by down-sampling. Simultaneous demosaicing and down-sampling can lower the overall introduced antifacts. This simultaneous demosaicing technique is explored by *Lu Fang* in her paper "Joint demosaicing and sub-pixel based Down-Sampling for Bayer Images: A Fast frequency-Domain Analysis Approach". This work was referred to us by *Anubha ma'am.*



Results:

Sub-pixel is a field which deals the individual channel of an Image and try to do enhancement at that level, the results are rarely visible for natural image and very much application specific. In our final demo we will be showing results on a colour CRT and LCD for showing exact enhancement.