

whitepaper

# Hyperinflation in contrast-land

Now and then crazy things happen in the world of digital image processing. Remember the introduction of the first digital photography camera, and the battle for megapixels that came with it? You had only just bought your 6MP camera (and were very happy about your holiday pictures from Hawaii); and some manufacturers were already trying to convince you that their 12MP model would have made the vacation even better. That 'pixel-inflation' led to absurd numbers where super hi-res devices were combined with plastic lenses; resulting in a net performance that made it look your pictures in Hawaii were taken under water (our apologies if your Hawaii pictures were actually taken underwater).

The same has happened (in a 2nd wave) with electronic displays (both direct view and projection based). Remember the trend from 'HD ready' or 'full HD' to 'UHD'? Actually, that journey is still ongoing. On the camera side, resolutions beyond UHD are already being tested: it's probably just a matter of time before that next pixel-inflation hits the display world.

Recently a new trend has started: this time, a contrast-inflation. Most people have a good feeling about what contrast ratio is (if not, watch this video<sup>1</sup>) but the new talk of the town is '**dynamic range**': '**extended dynamic range**' (EDR) and '**high dynamic range**' (HDR). To avoid this becoming another hyper-inflation, we'd like to share some facts and insights.

'Dynamic range' is very similar to 'contrast ratio': the former is used more often for capturing devices (the human eye, cameras) while the latter is used more often for visualization devices (displays, electronic and other). Historically, contrast ratio has always been interpreted as a global parameter. Dynamic range is used in displays to indicate more local variations: e.g. the relative difference between a bright white spot in one corner; a dark black area in the other. Note that this is purely about perception: you could quantify local variations with a contrast ratio as well.

Then what about 'extended' and 'high'? As far as we know (if we're wrong, please send us your corrections) there are no standards defining where 'normal' ends, and where 'extended' or 'high' begins. Some people refer to the definition of f-stops from cameras. But actually, everything higher than the industry or market standard can lawfully claim to be XDR or HDR. Note that this is exactly what some manufacturers are already doing today: "10% better than standard? Let's call it HDR!"

It is important to note that we do not doubt the fact that contrast ratio is a very important image quality metric. It helps define how much detail you can resolve in an image. It is an important contributor to how natural a digital image looks. More contrast is better: no doubt about it.

Two very important questions are:

- Is the contrast that I perceive only defined by the technology that I use?
- Does adding more contrast add an equal amount of enhanced image quality?

We will answer these questions below.

## The law of diminishing returns

On the topic of the first question, an interesting paper was presented on the 2015 NAB Show, by Peter Ludé, titled: 'How black is black?'<sup>2</sup>. In this paper, the author zooms in on the use of **High Dynamic Range projectors in a digital cinema environment**. Digital cinema is probably where the best content formatting meets the best image processing. As such, it's a good reference case for HDR. Four different contributing factors are identified in the paper as defining the perceived image quality on screen. Two are technology-defined, two have nothing to do with the projector or screen technology, but are 100% defined by ambient parameters. An **'auditorium contrast'** is defined and measured in the paper to be around 650:1. The presented model puts the different parameters in parallel and proves that ambient parameters can bring a 1500:1 sequential contrast (inherent to the projector) down to 354:1!

This confirms findings that date back more than 20y: the **ambient environment is THE critical defining parameter for the perceived contrast ratio**. Light sources in the room, reflective properties of items in the room, ... all have a bigger impact on what you'll finally experience than the display in the room. This puts things in perspective when manufacturers start promoting contrasts of 10,000:1; 100,000:1 ... 1 million to 1 anybody? Those are pure theoretical values, only reproducible in perfectly controlled dark room environment. As soon as you put it into a real environment the relative difference is sequentially minimized. Local safety regulations might force you to place Exit signs; your customer probably appreciates some aisle lighting not to stumble off the stairs. And are you really going to ask everyone in the room to wear a black shirt? A lot of testing and modelling is going on in different R&D labs around the globe to better quantify this effect for different set-ups and configurations. As this data becomes publically available, it should help in keeping the contrast-inflation under control.

This understanding of ambient parameters also helps answering the second question above. Since the contribution of ambient parameters is so dominant, it levels out the perceived contrast ratio to a lower level. Independent of whether you start from a theoretical contrast of 10M:1 or 1M:1; the net result will be close to the dominant defining factor in the auditorium contrast. Then you come to an interesting commercial discussion where you invest significantly more in HDR because you assume you will get significantly more contrast ratio; but you end up with marginally better image quality. Is it at that moment the best investment to make? Don't forget that in the image quality puzzle, contrast ratio is just 1 contributor. **Brightness, uniformity, color gamut, 3D quality and resolution** are at least as important. Given the above, it might bring a higher return on investment for you to invest in higher brightness or better 3D. The law of diminishing returns plays much less in these parameters; while – as explained above – it has a high impact on perceived contrast ratio.

## Conclusion

The world of electronic display systems is being confronted with a new trend: an inflation of contrast ratio to so-called 'extended dynamic range' and 'high dynamic range'. In this context, it is important to understand the impact of ambient parameters on the perceived contrast ratio. Recent studies have shown that these parameters are dominant. More research and development is going on in this domain and will help users understand the real added value of investment in higher contrast.

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