A HIBAR Research Story:
How an Optics Innovation Made Television Images More Realistic

An interview with Professor Lorne Whitehead of the University of British Columbia (UBC), conducted by Professor Ben Shneiderman of the University of Maryland, May 2021. Prof. Shneiderman was a Peter Wall Institute for Advanced Studies International Visiting Research Scholar at the University of British Columbia during 2018.

Thanks, Lorne, for agreeing to this brief interview. Please tell me how you came to be involved in research that led to the widely used technology of high dynamic range displays. I'm especially interested in your perspective on the two dualities of HIBAR research, namely (1) synergy between aspects of the work that were basic research with those that were use-inspired and (2) synergy arising from the deep collaboration of non-university research partners with academic researchers. To start off, how did you become interested in this area of technology?

Like many HIBAR stories, this one took about 20 years from very early conception to large-scale impact. As background, I had long been interested in photography and I was frustrated that photographic prints could not capture the real world. People can easily perceive scenes with a large brightness (or luminance) range, where the brightest areas might be 100,000 times brighter than the dimmest. Yet, as photographers have long appreciated, neither a photographic print, (nor a television screen), could reproduce anywhere near that range of brightness. (This is why photographs of sunsets, chandeliers, and the lights of Broadway were seldom satisfying. To put this in numerical terms, most television screens and photos can accurately display a luminance ratio of only about 256 to 1.)

While I had long been aware of this problem, around 2000, it really hit close to home, and I decided I had to do something about it. You see, one of my research fields at UBC involved improving the "piping" of natural daylight into buildings, in order to save electricity. We had to be careful not to cause glare, so it was important to ensure that the design would yield a glare-free interior. It would be a very expensive mistake to discover this only after the construction was completed. By that time, computer modeling had advanced sufficiently to predict the luminance levels, but there was no practical way to *display* those predictions for people to observe, because of the low dynamic range of then-existing displays.

This was a really serious problem, which led me to devise a solution. The solution was a display device that was far too big and expensive for general use, but I reasoned that it would be warranted for this special professional need. The idea was to direct the image-forming light emitted by a large computer *projector* through a large lens system in order to brilliantly rear-illuminate an LCD display computer *screen*. The projector had a dynamic range of about 256 to 1, and so did the screen, so when superimposed, the predicted dynamic range of the brilliant image would be the multiple of their individual ranges: 65,536 to 1.

This was a fairly straight-forward creative applied research project - we got the required funding for it, we carried it out, and, as planned, it worked well! But, certainly it would never make a practical display - the display unit was 200 cm deep, and the cost, even in volume production, would be 10 times that of a normal television. With this high cost and large size, it would not become a standard approach for television. It was simply a good expensive solution to an important niche problem. If we had stopped there, everyone would have been very satisfied with that niche research success (which received the best paper award at the 2002 International Conference on Architectural Research).

This sounds like very applied research - but how did this become a HIBAR story? How did the work also take on a basic research character and how did it span the academic/societal divide?

In this particular example, I tackled the academic/societal divide first. In my previous daylighting research, I had interacted quite a lot with the Windows and Daylighting Laboratory at Lawrence Berkeley Laboratory, led by my friend Steve Selkowitz. They often carried out work of a HIBAR nature, which I admired. In the course of my project, it occurred to me that they might have given some thought to the HDR visualization problem, and I noticed a publication by Greg Ward, of that laboratory, on new file formats for representing High Dynamic Range data. On a hunch, I invited Greg to come and visit with my student, Helge Seetzen and me. It was a fateful meeting - since then the three of us have collaborated a great deal and remain good friends.

Furthermore, that collaboration ended up changing television! Here's how that happened: When we met that day, Greg shared how he had built a static HDR display by sandwiching together two transparencies and brightly backlighting the pair. Essentially this was a non-active version of our big HDR device - it couldn't play movies of course, but at least it was thin! Greg mentioned that he had a problem though - it was impossible to perfectly align the two pictures. However, he said he had solved it well enough by making the back image black and white, and slightly blurry. He said that surprisingly, that little bit of added blur in the rear image didn't seem to be a problem. That turned out to be a very critical piece of practical know-how.

Fortunately, I was also aware of some important developments in the lighting industry, by virtue of my long time interactions with Philips Corporation. As a result, I knew that white LEDs were likely going to become cost effective light sources, probably over a period of about 10 years. For this reason, I felt it wasn't unreasonable to ask the following question: "Could Greg's blurry monochrome back image be emulated by an electronically controlled array of white LEDs, without the consequent blur excessively denigrating the resultant HDR image? To answer this question, we needed to know how much blur in the rear image could be tolerated by the human vision system. This was a basic research question about human vision - the answer was not known at that time. So, we performed that required basic vision experiment, which led to a stunning discovery: Put simply, in the case of high dynamic range stimuli, a portion of the pattern can be surprisingly blurry, yet the blur itself was imperceptible! This is a result of an effect known as intra-ocular scatter and its unconscious suppression within the higher processing levels of the vision system.

This scientific understanding led to published research papers, and the list of collaborators gradually grew. The University of British Columbia funded the cost of the first patent application (US Patent #6,891,672, May 10, 2005), which enabled the attraction of seed capital. Helge and I launched a spin-off company, Brightside Technologies, with the help of two energetic, insightful and capable business leaders, Don Graham and Richard McKellar. I enjoyed and greatly value the collaboration with them. Their expertise and synergy with rest of the team was also very effective. This increased the patent portfolio and provide access to additional investment and partnership opportunities.

Helge Seetzen was at a suitable stage in his career to join Brightside Technologies as its Chief Technology Officer (while also completing his Ph.D. under my supervision), and the company explored commercial development and licensing opportunities. The attraction of this technology led to Dolby, the sound and visual display technology company, acquiring Brightside Technologies. Working within Dolby, the Brightside team benefited from Dolby's expertise, much-deserved reputation, and strong connections with commercial display manufacturing companies, leading to widespread uptake of this technology. This led to the incorporation of these technologies in an ever-increasing fraction of modern televisions screens. The latest development is that Apple's 2021 iPad display uses this technology to provide a world-leading brilliant beautiful display.

To recap, this breakthrough was a direct result of deep creative research partnerships that spanned the university/society divide, while the research itself spanned the range from very basic understanding to highly practical problem solving. It was that confluence of perspectives and understanding that led to a new way of enriching our lives with breathtakingly realistic brilliant moving images.

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