HDRchitecture: Real-time Stereoscopic HDR Imaging for Extreme Dynamic Range

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Figure 1: EyeTap welding helmet causes the eyes themselves, to, in effect, become both cameras and displays by providing exact POE (Point-of-Eye) capture for a stereo headup display.

1. BACKGROUND ON HDR

The history of HDR (high dynamic range) imaging in digital photography goes back 19 years, as Robertson et al. state[2]:

> "The first report of digitally combining multiple pictures of the same scene to improve dynamic range appears to be Mann[1]."

HDR combines multiple differently exposed pictures of the same subject matter to be able to see a much greater dynamic range than is possible in a single exposure.

2. REALTIME HDR VIDEO

In this demonstration, we present extreme HDR adapted for use in GlassEyes^{TM} (EyeTap) electric arc welding helmets, as well as for a general-purpose seeing aid.

Our "WeldCam HDRchitecture" (abbreviated "HDRchitecture") system uses one or more cameras, and optional active illumination systems, that can be used by welding schools and professionals to inspect welding in real-time. We present HDRchitecture as either a fixed camera system (e.g. for use on a tripod), or as a stereo EyeTap cybernetic welding helmet (see Figure 1) that records and streams live video to observers, nearby or remote. By capturing a dynamic range of more than a million to one, we can see details that cannot be seen by the human eye or any currently existing commercially available cameras.

We present a highly parallelizable and computationally efficient HDR reconstruction and tonemapping algorithm for extreme dynamic range scenes. In comparison to existing HDR work, our system runs in real-time, and requires no user intervention or fine-tuning of parameters. It renders images with a high image quality up to 1920x1080 resolution. HDRchitecture uses FPGAs, GPUs, or multi-core CPUs for real-time (30 to 120 frames/sec) stereoscopic HDR processing.

Figure 2: (Left) State-of-the-art digital cameras can not capture extreme dynamic range of TIG welding. The electric arc is overexposed, yet the surroundings are underexposed. (Right) Single frame from the real-time HDR video glasses. Our system captures 120 frames/sec.

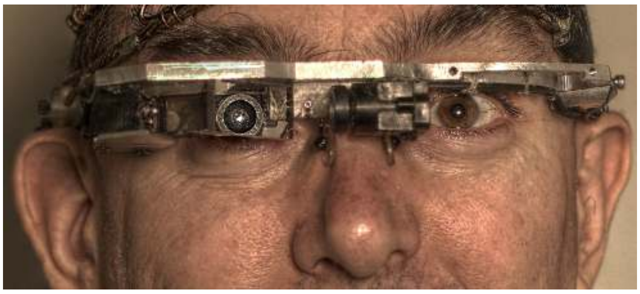

Figure 3: HDR technology developed for welding can be used for everyday life. Augmediated^{TM} Reality and HDR Cearable Computing, etc, http://eyetap.org/publications

Our initial FPGA-based hardware configuration fits inside a shirt pocket, and can be built into ordinary eyeglasses if desired. There are two HDMI camera inputs, one for the left eye, and the other for the right eye, as well as HDMI outputs fed back to the left and right eyes, after processing of the video signals. The circuit board facilitates processing by way of a Xilinx FPGA, but our approach also works with Altera FPGAs.

A goal of the demonstration is to show the development of HDR eyeglasses as a general-purpose seeing aid for everyday life (Fig 3).

3. REFERENCES

[1] S. Mann. Compositing multiple pictures of the same scene. In *Proceedings of the 46th Annual IS&T Conference*, volume 2, 1993.

[2] M. Robertson, S. Borman, and R. Stevenson. Estimation-theoretic approach to dynamic range enhancement using multiple exposures. *Journal of Electronic Imaging*, 12:219, 2003.

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