High-Dynamic-Range Imaging

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1 Overview

While High-Dynamic-Range Imaging is a relatively new concept, much work has already been done in the field. From the simple averaging and combining of images, to legitimate inverse linearization of correlated pixels and development of HDR images, many different approaches have been taken.

For this project, research was done of existing work, a simple user-controlled manual process was developed, and a slightly more advanced automated process was designed. The most time by far was spent looking into existing work, and learning more about the actual mathematics behind the HDR imaging process.

An interesting side note is the public’s concern with the ethical considerations of HDR imaging, and how this concern might potentially slow down the scientific advancement. John Long from NPPA/The Voice of Visual Journalists had this to say about the matter: “Autochrome was a total mystery and marvel when it was introduced, but over time color became ‘normal’. HDR could eventually be like that. There are many computer techniques that could become normal in future years....”

2 Literature Search

When researching existing work on high-dynamic-range imaging, or HDR imaging, there are several misleading papers and documents that exist. In many cases, work has been done, and labeled as “HDR”, when really it is just heavy post-processing without any actual image combinations. Some of the most impressive images found were a combination of legitimate HDR imaging, followed by quality post-processing.

In the paper “Recent Advances in High Dynamic Range Imaging Technology”, an excellent summary is given of the human visual system (HVS), and its capabilities when it comes to viewing images. As technology has advanced, so has the progression of displays that best suit the HVS. For several decades, 3 log units of dynamic range has been achievable. The next step beyond this is what is being chased, and is where HDR imaging comes in. In his publication “A wide field, high dynamic range, stereographic viewer” G. Ward develops an idea of projecting a digital image as an LED backlight to extend the HDR concept to video.

An article found in the ACM Transactions on Applied Perception journal, ”Generating stereoscopic HDR images using HDR-LDR pairs” suggests an alternative attempt at pairing HDR imaging and Stereoscopic imaging. The method was based on exploiting the high luminance features of the LDR image, and creating a stereo effect from the combination with an HDR image.

3 Manual User Selection

The idea behind the manual selection was that the user would be able to select how heavily weighted each image would be in a basic weighted average of the images. It was intended to be simple, easy to use, and quickly repeatable. It would provide a clearly displayed, quality output for the user.
A GUI was made using GUIDE in MATLAB. This GUI is shown in figure 1 below. The user can adjust the slider for each image, based on how much they want it to contribute to the final resulting image.

![GUI for Manual Selection](image1)

**Fig. 1: GUI for Manual Selection**

In MATLAB, the “get(handles)” function was used to collect the values from the user-adjusted sliders. These values were then used to adjust the influence each initial image had. A basic weighted average was then taken of the three images, and the resulting image was displayed to the user. An example of some selected weights with the resulting image is shown in figure 2 below.

![Result of Manual Selection](image2)

**Fig. 2: Result of Manual Selection**

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**4 Automated Process**

The automated process involves combining weighted averages of the images which is done by thresholding the intensities of the center image. There are 5 images selected for the HDR function created for this project. The 3rd image is the image taken at normal exposure, with images 1 and 2 at higher exposure levels and images 4 and 5 at lower exposure levels. Thresholds were created at 85 and 170 which are 1/3 and 2/3 of the maximum intensity of 255.

At values below the minimum threshold, the pixel intensities were weighted towards the higher exposures of images 1 and 2, and above the maximum threshold pixel intensities were weighted towards the lower exposures of images 4 and 5. The pixel intensities in between the thresholds was weighted towards images 2, 3 and 4. The formulas used for the weighted averaging are shown in Figure 3. This method of weighted averages is useful because it pulls the intensity values for the pixels from the images that have the most contrast at that intensity level.

\[
\begin{align*}
a &= 0.6; \\
b &= 0.2; \\
\text{Ip1} &= (a \cdot I1 + b \cdot I2 + b \cdot I3) \\
\text{Ip2} &= (b \cdot I1 + a \cdot I2 + a \cdot I3) \\
\text{Ip3} &= (b \cdot I1 + a \cdot I2 + b \cdot I3)
\end{align*}
\]

**Fig. 3: Equation for Weighted Averages**

**5 Results**

Figure 4 shown below is an example result of the automated process. It shows a comparison between the image with default exposure and the HDR image created.
Fig. 4: Result of Automated HDR Imaging