HDR-Panorama

Design challenges for mobile solutions

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Abstract

This paper provides an overview of Ittiam's HDR-Panorama solution for consumer devices like smartphones and tablets. This advanced technology enables capture of high quality panorama images covering a high dynamic range of luminance. In addition to ensuring faithful capture of shadow and highlight regions, the intelligent computational photography techniques ensure seamless stitching resulting in beautiful panoramic images. Solutions for HDR-Panorama involve significant algorithmic and computational challenges. This paper describes the critical challenges addressed by Ittiam's HDR-Panorama solution.

Figure 1 - Overview

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Introduction

The dynamic range of the human eye is several times higher than the capture systems in a smartphone. High Dynamic Range (HDR) technologies use advanced computational photography techniques and combine exposure bracketed shots to generate a higher dynamic range image from a given capture system to achieve the same. Similarly, panorama images on mobiles create stunning landscape images that match and often exceed the field of view of the human eye. Panorama images, created by capturing multiple images of the scene and using intelligent stitching algorithms, significantly enhance the imaging experience. Hence, HDR imaging and panorama have become an essential part of mobile devices today.

Ittiam's HDR-Panorama solution, the first of its kind on mobile devices, extends HDR techniques to panorama images by combining two key technologies (HDR and Panorama) to create a rich imaging experience on mobile devices. Ittiam's solution takes advantage of the improvements in the capture technology of smartphones and captures multiple exposure bracketed images. These images are first combined to create a high dynamic range representation and then stitched seamlessly to create HDR-Panorama images.

Challenges with mobile HDR-Panorama

Capture process

Typical panorama images are created by capturing multiple images of the scene by moving the capture device in an arc about an axis, and then stitched seamlessly to generate the image. To enable this, the successively captured images should have enough overlap. Although this can be achieved through a manual process, it is usually neither user friendly nor optimal. This results in the need for intelligent capture systems that guide the user and ensure that the images are captured automatically when the optimal overlap point is reached.

HDR-Panorama solutions have to address the additional challenge of capturing exposure bracketed shots at each capture point of the panorama to ensure a higher dynamic range. While advances in the capture technology have ensured faster capture of exposure bracketed shots, the capture module must possess the intelligence to extract maximum details while capturing the dynamic range and remain consistent across shots. Designing such an intelligent capture module is a key challenge in generating high quality HDR-Panoramas.

Ittiam's HDR-Panorama solution includes such an intelligent capture system which selects the optimal exposure for the exposure bracketed shot to capture maximum dynamic range for the system. The capture process is automated by a user guidance system which uses a combination of sensor technology and image processing to guide the user through the capture process for optimal overlap across successive images.

Stitching process

There are several challenges in the panorama stitching process:

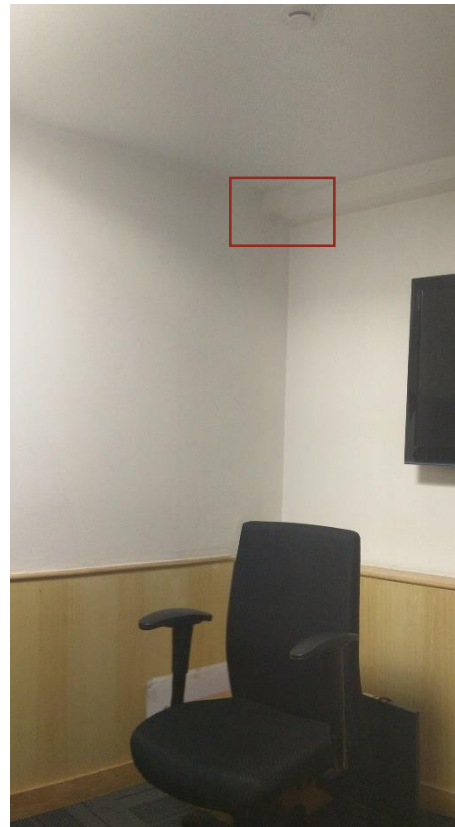1. *Image registration:* HDR-Panorama solutions involve 2 steps of image registration. The first step ensures that the bracketed shots at each capture point in the panorama are registered correctly. This is necessary to counter the hand movements that are common during the use of a mobile camera. The second step registers the successive images by exploiting the overlap

region across shots. Since the camera moves in a pan motion across shots, the employed image registration methods need to work under such transformations.

2. *Disparity/Parallax issues:* Despite the best image registration methods used, all the areas across two images may not be aligned due to hand movements. Hand movements cause the camera center to shift and lead to parallax issues in the stitched images. The movements also cause blurring and ghosting in the final panorama and the stitching algorithm has to be intelligent to minimize these effects.
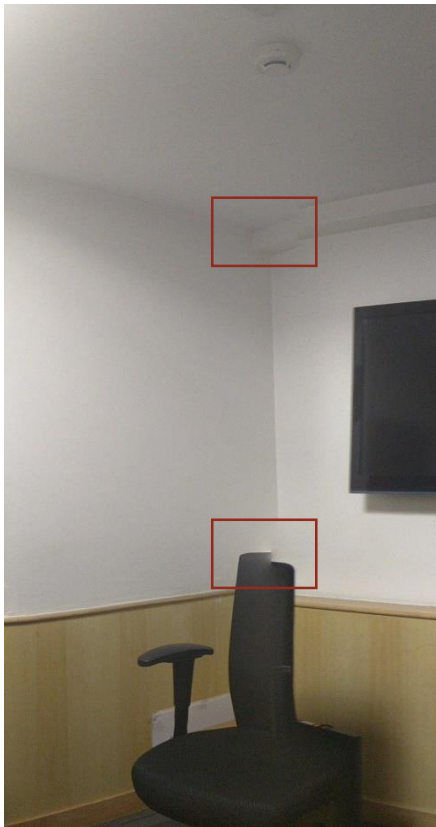
(a) Severe disparity issues   (b) Disparity issues minimized

Figure 2 - Disparity issues indicated in red block

3. *Photometric variations:* The images of an object captured at different angles can acquire different photometric properties. Due to the typical arc motion in a panorama capture, overlapping regions of the scene between two successive captures encounter such differences and cause significant problems in stitching. In case of a HDR-Panorama, this problem is further multiplied due to the sparse nature of HDR data.

4. *Exposure changes:* The exposure levels of successive images in a panorama could change with the lighting conditions of the scene resulting in variations in intensity.

| (a) Before exposure compensation | (b) After exposure compensation minimized |

Figure 3 - Exposure variation across the pan

Ittiam has developed an efficient stitching algorithm which addresses the above issues. Ittiam's image registration module is fine-tuned and customized to handle 2 levels of registration: (i) Registration of the exposure bracketed images and (ii) Registration between successive shots of a panorama. The registration module also ensures that any disparities are minimized across the overlapping regions.

Ittiam's solution uses the radiance domain to stitch the data. In addition to providing a high dynamic range, this also helps in efficient handling of the exposure changes across the panorama. Advanced blending methods ensure that the challenges posed by photometric variations and sparseness of the HDR data are suitably addressed. The solution uses multi-scale blending techniques which ensure that different frequency bands in the image are appropriately blended to create seamless images.

Tone mapping process

The stitched image obtained from the process described above is in the HDR domain (16 bit) and has to be converted to the display range (8-bit). The process of converting HDR data to display friendly LDR images is called *tone mapping*. The challenge in this task is to fit the higher range of details in the image to show both shadow and highlight scenes of images in the limited LDR range. When mapping the entire luminance range of an HDR image to a limited number of display levels, reduction in contrast is observed which reduces the detail perception of the scene. On the other hand, local tone mapping can retain the contrast in the image since small sections of the image get to use all the display levels. However, local tone mapping often leads to visually perceptible intensity reversals that manifest as halos in the image. Ittiam's HDR imaging algorithms produce tone-mapped images with good contrast while avoiding perceptible intensity reversals as shown in images below. Ittiam's solution provides multiple tone mapping presets which vary from natural to dramatic effects to cater to the preferences of diverse users.

Figure 4 - Panorama image

Figure 5 - HDR-Panorama image with "Dramatic" tone mapping preset

Figure 6 - Panorama image with "Natural" tone mapping setting

Figure 7 - Panorama image

Figure 8 - HDR-Panorama image with "Dramatic" tone mapping preset

Figure 9 - HDR-Panorama image with "Bleach" tone mapping preset

Computational power and memory usage

HDR-Panorama solution includes several computationally intensive modules like image registration, blending and tone mapping. Since the solution is targeted at consumer grade devices like mobiles and tablets, the implementation should limit processing requirements to ensure longer battery life. Ittiam's solution has been specifically designed and optimized for an embedded platform with constrained resources. Its efficient multi-threaded implementation ensures that the images are processed in the background in parallel with the active capture process. This has the additional benefit of ensuring low delay between shots. Ittiam's optimized implementation that combines maximizing the device's SIMD capabilities with GPU acceleration of various modules ensures that the power consumption is always kept under check.

Another important aspect for an application running on consumer devices is the memory consumption. Since exposure bracketed shots have to be captured and processed at every point in the panorama, the memory requirements are high. Further, the algorithms need data to be stored in the radiance domain which is memory intensive. To address these challenges, Ittiam's solution has been intelligently designed for maximum re-use of memory across modules thereby keeping the memory requirements to a minimum.

Key features of Ittiam's HDR-Panorama

- A novel solution enabling capture of panoramas with high dynamic range on mobile devices.
- A true HDR solution. The panorama image is built in the HDR domain and tone mapped to the display range.
- Offers 7 stops of dynamic range over the native camera and uses advanced scene analysis techniques.
- Seamless panorama images from handheld devices using advanced image registration and blending techniques
- Offers a variety of tone mapping presets including natural, lively, dramatic, black & white and bleach to suite different user preferences and uses patent pending algorithms.
- Fast processing through GPU acceleration and maximizing the SIMD capabilities of the device.

Availability at Ittiam

Ittiam's HDR-Panorama is available as a software solution and extensively verified on both Android and iOS platforms across multiple devices. The solution can be integrated into the device platform by either chipset manufacturers or mobile OEMs. It can also be integrated into mobile photography applications. For more details please contact mkt@ittiam.com.

Conclusion

HDR photography is generally considered an art. Today, it has become a default feature on most mobile devices. Extending the HDR to panoramas can provide a very exciting solution that delivers mind blowing panorama images. However, such a solution pose many challenges in implementation on mobile devices. An avid photographer with keen interest in HDRs judiciously chooses the scene specific exposures for each of the constituent images in the panorama, stitches the constituent images, generates the high dynamic range representation and then chooses the tone-mapping to be applied and selectively enhances the contrast, color and other parameters in an image to arrive at a visually appealing HDR-Panorama image. Ittiam's HDR-Panorama solution does not require any manual intervention and automatically handles everything from selection of exposure bracketing, deciding the capture positions of the panorama to generating the final tone-mapped output. By providing different versions of the tone-mapped output, Ittiam's HDR-Panorama solution enables a camera phone user to arrive at artistic images with minimal effort and without ever having to use external software on a desktop or PC.

References

1. https://en.wikipedia.org/wiki/High-dynamic-range_imaging
2. https://en.wikipedia.org/wiki/Tone_mapping
3. https://en.wikipedia.org/wiki/Panorama
4. https://en.wikipedia.org/wiki/Binocular_disparity
5. http://www.ittiam.com/products/software-ips/imaging/

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