METU, Department Of Computer Engineering

Graduation Project
Proposal Form

Project Information

Title

An end to end real time high dynamic range video capture and display pipeline

Target

Public [ ] Restricted [X] (Group of the proposing students)

Proposer Information

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IP (Intellectual Property) Information

None

Project Description and Background Information

Description

Conventional image and video acquisition methods cannot capture the dynamic range of real world scenes. Such devices will output content with missing information such as saturated or completely dark pixels in bright and dark regions of the scene, respectively. High dynamic range imaging aims to overcome these limitations and capture the full content in a scene. HDR imaging poses mainly two challenges: acquiring and displaying HDR content.

There are several existing commercial products that operate on HDR content. However, these hardware are often inaccessible by researchers or end-users due to their extremely high price tag.

Our project aims to implement a real time HDR imaging pipeline (capture and display) using off the shelf products such as regular cameras and LCD displays, which will arguably cost only a fraction of a dedicated hardware solution.

Similar Products/Projects

There aren't any existing solution that provides both capturing and displaying HDR content, therefore we list acquisition and displaying products separately.

1. HDR Displays

- **Sim2 HDR Displays** [4]
  - Capable of displaying real HDR content
  - Uses an LCD panel to show the image and an LED panel to adjust the background illumination
  - Very expensive (> €25.000)
  - Not on retail
- **Samsung JS9500** [3]
  - Not an HDR display, but has 10 bits per channel input, which allows the display to output a much wider dynamic range than regular displays
  - Still expensive for a non-HDR display ($7.999)
  - On retail

2. HDR Content Acquisition

- **Arri Alexa Series** [5]
  - High end professional grade camera
  - Up to 4K resolution
  - Extremely high price point (> £39.000)
  - Uses custom CMOS sensor
  - On retail
- **Red Epic** [6]
  - High end professional grade camera
  - Up to 6K resolution @ 75 FPS
  - High price point (> $24.000)
  - Captures frames with alternating exposures to construct HDR images
  - On retail

Justification of the proposal

The purpose of our project is to present an affordable HDR imaging pipeline using off the shelf tools that are available to anyone. The pipeline will support capturing and displaying an high definition HDR video stream in real time.

High dynamic range imaging aims to capture the full contents of a real world scene, however without native HDR hardware, capturing HDR content is cumbersome and usually problematic in dynamic scenes and displaying HDR content in a low dynamic range monitor is not meaningful since the content needs to be compressed before display. Existing commercial products have unrealistic prices and often are not available to end users and most researchers.

The fundamental problem our project aims to solve is the cost and availability barrier of real time high definition HDR content acquisition and displaying.

Contributions, Innovation and Originality Aspects of the Project

Although there are existing products for capturing and displaying HDR content, our project aims to be the first all in one solution to provide high resolution real time HDR video capturing and previewing by utilising high performance GPUs.

The major downside of existing commercial products is their extremely high price points and being only exclusively available. Our project will be using off the shelf components available to anyone to build the pipeline.

Although there is some interest for development on HDR displays and cameras internationally, our project is the first national take for this area. Also, our project aims to provide the highest resolution video capture in real time internationally.

Technical Aspects of the Project

Our project consists of 3 units:

1. HDR Camera
2. Processing unit
3. HDR Display

- For the HDR Camera, we will be using multiple common DSLR cameras to capture LDR images with different exposure settings [1]. The cameras will be driven by the *processing unit* over USB or firewire to capture LDR images in synchronisation.
- Processing unit could be a laptop, desktop or possibly any computer with a GPU and is responsible for constructing HDR frames from the LDR inputs taken from the HDR camera. The captured images are directly transferred to the processing unit and are processed with a GPGPU program written in OpenCL to create the HDR frames to meet the very high throughput expectation.
- An HDR display can be built using a high power, variable background light with a regular LCD panel [2]. We will be using a projector with colour filters removed to achieve maximum and controllable brightness. Therefore, the HDR display has 2 video streams: one for brightness and one for colour, which will be driven by the processing unit. When an HDR frame is ready on the processing unit, the frame will be passed to an OpenGL program which breaks the image up to its brightness and colour counterparts and places them to their respective buffers which will be received by the HDR display. HDR display and the processing unit communicates over 2 DVI connections.

Targeted Output, Targeted User/Domain Profile

Our end product will consist of 3 major components: HDR camera, processing unit and the HDR display. The HDR camera will have multiple regular DSLR cameras. The processing unit is where the images from the LDR cameras are merged to construct HDR frames. The HDR frames are then displayed by the HDR display, which consists of a background light assembly and an LCD panel. The background assembly will be implemented using an off the shelf projector with its colour filters removed.

Our final product will be able to capture and display HDR video content at HD resolution in acceptable frame rates (> 24 FPS).

As discussed in the existing products section, there are high end professional grade equipment with astounding prices for HDR content. Such products are favoured by the professional film and TV industry by providing very high resolution frames at high FPS, which is a requirement for the said users. However, anyone who is interested in high quality videos outside of the said tight group is in our targeted users like amateur film producers, researchers and scientists.

Project Development Environment

We will be using several DSLR cameras to capture LDR frames. The captured frames must be delivered to the processing unit as soon as possible, therefore we will be using a high bandwidth connection like USB 3.0 or firewire for this communication.

For the display, we will be removing the colour filters of a projector as the backlight for an LCD panel. The GPU on the processing unit will be driving the projector and the LCD panel.

To maintain a real time system, operations to combine the LDR frames taken must be as fast as possible. A GPU will be used to fulfil this requirement. CUDA, OpenCL or Compute shaders of DirectX or OpenGL could be used to execute the construction of HDR frames on the GPU. Since OpenCL executes across heterogeneous platforms and several operating systems, it will be the language of choice to utilise the GPU. Along with OpenCL, C++ is the language to be used high performance and ease of interfacing with GPU APIs.

External Support

- We will be using multiple (up to 3 or 4) DSLR cameras for the HDR camera assembly.
- A projector for the backlight of the HDR display.
- An LCD panel for the colour filter of the HDR display.

No other hardware will be necessary.

Assoc. Prof. Dr. Ahmet Oguz Akyuz will be providing us with up to 5 DSLR cameras for the project.

References

[1]: Michel Bätz, Thomas Richter, Jens-Uwe Garbas, Anton Papst, Jürgen Seiler, André Kaup, High dynamic range video reconstruction from a stereo camera setup, Signal Processing: Image Communication, Volume 29, Issue 2, February 2014, Pages 191-202, ISSN 0923-5965, http://dx.doi.org/10.1016/j.image.2013.08.016. (http://www.sciencedirect.com/science/article/pii/S0923596513001331)
[2]: Helge Seetzen, Wolfgang Heidrich, Wolfgang Stuerzlinger, Greg Ward, Lorne Whitehead, Matthew Trentacoste, Abhijeet Ghosh, and Andrejs Vorozcovs. 2004. High dynamic range display systems. In ACM SIGGRAPH 2004 Papers (SIGGRAPH '04), Joe Marks (Ed.). ACM, New York, NY, USA, 760-768. DOI=http://dx.doi.org/10.1145/1186562.1015797 (http://anyhere.com/gward/papers/Siggraph04.pdf)
[3]: http://www.samsung.com/us/televisions-home-theater/tvs/4k-suhd-tvs/4k-suhd-js9500-series-curved-smart-tv-65-class-64-5-diag-un65js9500fxza/
[4]: http://hdr.sim2.it/
[5]: https://www.arri.com/camera/alexa
[6]: http://www.red.com/learn/red-101/hdrx-high-dynamic-range-video