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Gaining layered objects into image rendering

Using layered objects and parallel processing technologies as basis for analyzing and controlling streamed objects in real-time

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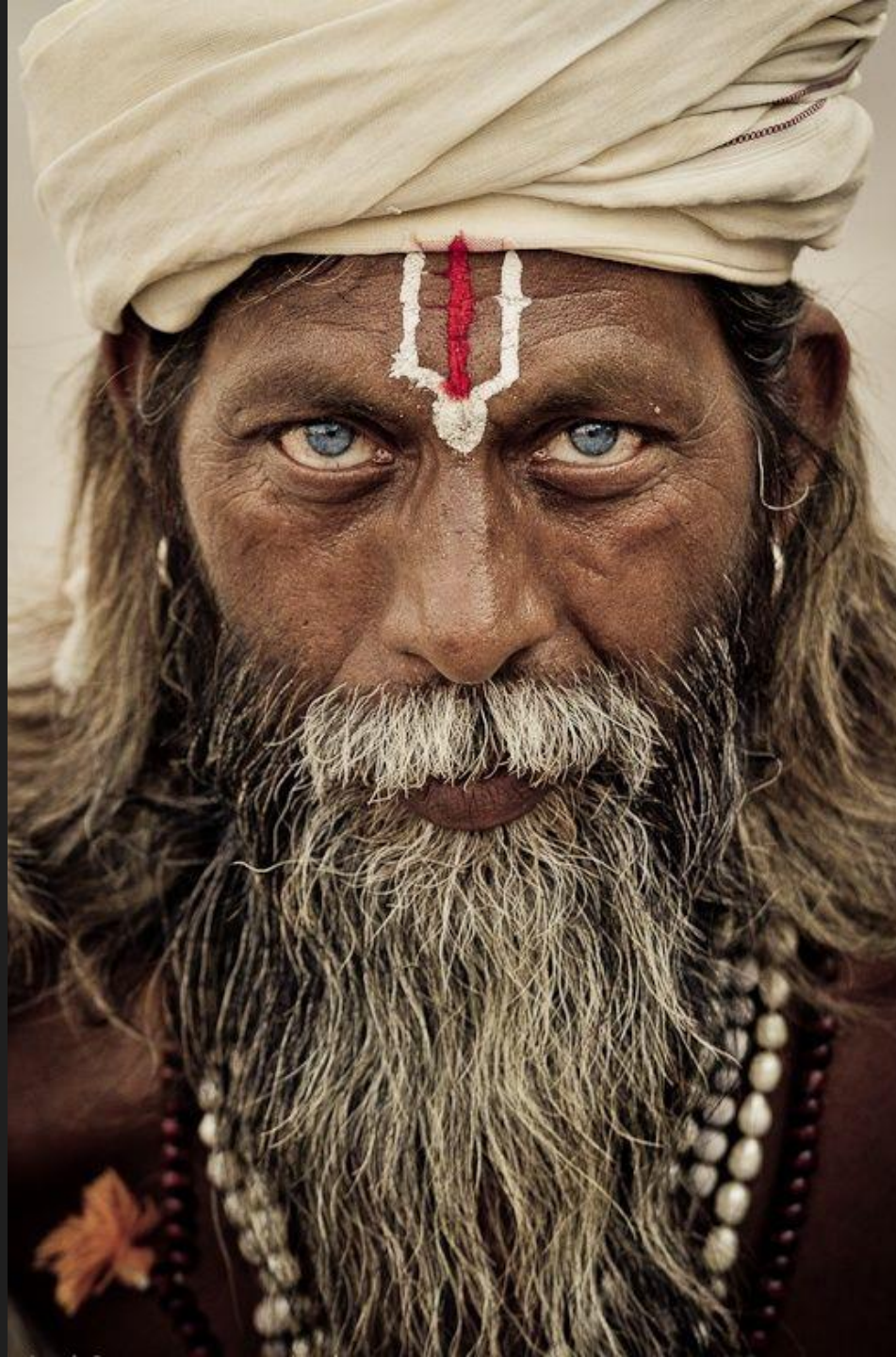

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Introduction

Purpose

The purpose of this paper is to describe new ideas in real-time rendering for high-resolution video streaming and utilization of GPU as a key element for achieving the goal of real-time complex image processing. These ideas are based upon review of the physics of the problem and thorough analysis of applicable technological approaches.

Understanding real-time image processing

Processing images in real time poses an additional challenge on top of the existing problems of image processing – hard limit on processing time. This limit imposes low maximal resolutions which enable complex processing at 30 frames per second on CPU. Parallel computations executed on GPU are capable of processing higher resolutions, but often at the cost of complexity of the processing.

Understanding image processing on hand-held devices

Today's availability of High Resolution video camera in every hand-held device raises a huge technical challenge when trying to apply real-time streaming technology or object manipulation techniques, especially when preserving the original input's high resolution is desired. Hand-held devices have limited memory and computational abilities, which are not suitable for processing large quantities of data simultaneously.

Scope of objects in image processing

What is an image?

In the scope of image processing, an image is a two dimensional array of bytes representing luminance and chrominance as perceived by the camera sensor. Since the data is represented as numbers, image processing is essentially mathematical manipulations on the image matrix.

Classification of image properties

Image properties which are a target for processing can be divided into several categories, each with its own set of mathematical operations used to produce desired results.

Graphical object	Definition
Bits per pixel	Number of bits per color channel of each pixel
Palette	Range and order of available colors for the image
Outline	Result of edge detection algorithms such as Sobel and Canny
Color properties	Light, contrast, temperature, saturation, etc.

Scope of objects in image processing

Understanding GPU parallel processing

Real-time processing of large amount of visual data requires parallel processing, which is done by the GPU. The time benefit of processing each pixel of the image parallel to others comes at the cost of limited computational complexity for each iteration, because many image processing algorithms rely on previous pixels being post-process. Increasing the number of iterations to add complexity, reduces the time spared by parallel processing; this is especially true for high resolutions.

Definition of complex image filters for GPU

The main demand of parallel processing is for the mathematical formula to manipulate image data to be written as a calculation on a single pixel. When an algorithm requires processed data from previous pixels, the processing of the image on GPU will be done in at least two steps, prolonging processing time. Many of the image processing approaches require the properties of the image (see above) to be processed sequentially, thus forcing many iterations of parallel processing.

Layered Model in real-time

Layered modeling of graphical objects

Reproduction of a complex image effect from a standard (non-real-time) image processing software as an algorithm which can run in real-time requires replacing each masking layer defined in the software with reciprocal mathematical formulas. This task often borders the impossible, due to exponential complexity of the functions.

Defining a complex graphical object

Since even the most complex mathematical formulas are built from simple arithmetical parts, it is possible to optimize a specific algorithm for a specific image effect in order to reduce the required number of iterations to an acceptable amount and enjoy real time processing of high resolution images. Dividing the image to logical processing parts prior to processing enables to define the structure of the formulas and optimize the algorithm in real time.

Layered Model in real-time

Create and Compile GL programs

By mixing and matching parts of pre-optimized mathematical formulas, we create complex image filters without increasing number of iterations per processed image. Handheld implementations of OpenGL can compile programs for GPU during run-time, thus enabling real time generation and application of effects.

Layered Model in real-time

Code Example

```
//pseudo code

Xmix()
{
                    on (GL Frame)
                    {
                    get all frame properties
                    For each property
                    {
                              apply mathematical formula
                    }
                    generate OpenGL C code
                    optimize computations
                    compile OpenGL code
          }
}
```


Summary

The paper presented a summary of the needs for advanced real-time rendering algorithm designed for parallel processing when approaching high-resolution streaming technology.

Thank you

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