A Tutorial Proposal for ICME2007

1. Contact Information

Guoping Qiu
School of Computer Science
The University of Nottingham
Jubilee Campus
Nottingham NG8 1BB
United Kingdom

Email: qiu@cs.nott.ac.uk
Phone: +44 115 8466507
Fax: +44 115 9514254

2. Tutorial Title

High Dynamic Range Imaging – The Future of Digital Photography and Video

3. Rationale

Throughout the history of imaging science, there has been constant quest for more advanced technologies to provide better and more real visual experiences for the consumers. The invention of colour has forever changed the imaging industry and the introduction of digital technology has made imaging ubiquitous. Now a new imaging technology has started to emerge which has the promise of bringing a new revolution in digital imaging. This new technology is called high dynamic range imaging, or HDRI for short.

Almost all of today's image and video file formats, e.g., jpeg, mpeg, etc, use 8 bits per colour channel. This means that they can record a luminance dynamic range of less than 2 orders of magnitude. Yet, the real world scenes humans experience every day have far higher luminance dynamic ranges. For instance, a scene showing both shadows and sunlit areas will have a dynamic range exceeding 100,000:1.

Human visual system is capable of simultaneously perceiving light intensities over a range of 4 orders of magnitude, and with adaptation, its sensitivity can stretch to 10 orders of magnitude.

Therefore, it is clear that current image file formats are poor representations of real scenes and only record a fraction of the contrast that humans are capable of perceiving.

Conventional computer monitors and other reproduction media such as printing papers have limited dynamic ranges, often less than 2 orders of magnitude. This is why traditionally there is little reason to represent images with more than 8 bits per colour channel. On the image capture side a similar argument can be made. Most cameras limit their outputs to eight bits per colour channel.

However, the situation is slowly changing. In recent years, a new research area generally referred to as high dynamic range imaging (HDRI) has been gathering momentum. In HDRI, the image files record the actual colour and dynamic range of the original scene rather than the limited gamut and dynamic range of the monitor or other reproduction media. This means that image processing, manipulation, display and other operations will no longer be limited by the number of bits used to represent each pixel.

HDRI will have widespread applications in the field of multimedia including, digital cinema, digital photography, computer games, etc., and will open up many new possibilities, including dramatically improving the visual realism of digital photography and video.

As current technology can already produce high enough spatial resolution but lacks dynamic range of the pixels, many have advocated that the future of digital photography and video will be high dynamic range imaging. It has been argued that the significance of the transition from low dynamic range imaging to high dynamic range imaging can be compared to that of the transition from black and white television to colour television. In the next decades, the imaging industry will inevitably move to HDRI which will affect all aspects of imaging research, including capturing (sensor, camera), storage (compression, coding) and reproduction (rendering, tone-mapping, printing and display).

Researchers have already started to develop methods for capturing, storing and displaying high dynamic range images where displaying often involves compressing the high dynamic range (many bits) using spatial processing. Research papers in HDRI frequently appear in conferences such as ACM Siggraph, Eurographics, and computer vision conferences such as IEEE CVPR. Up to now, most research activities in HDRI seem to be performed by researchers in the computer graphics community. We believe that HDRI will have an important role to play in creating new and richer multimedia content, the multimedia community should and will embrace the new emerging field and will be able to contribute to its development as much as the computer graphics community.

Whilst there has been marked increase in research activities in HDRI, research papers are scattered in various conference proceedings and journals. Researchers new to HDRI often don't know where to start because the field is really in the very early stage of development. The rationale of the tutorial is therefore:

- High dynamic range imaging has clearly started to emerge as a new research field
- HDRI holds the promise to bring about exciting new developments in digital imaging and multi-(visual) media content creation and presentation.
- Whilst there have been much activities in the computer graphics community, there have been relatively few researchers in the multimedia signal processing community performing HDRI research.
- Thus, the proposed tutorial will be a timely introduction of this new exciting technological trend to the multimedia research community. It will educate future researchers in HDRI thus promoting research in new technologies for multimedia content creation and presentation.

4. Potential Audience

Potential audience may include graduate students, researchers, engineers and practitioners in multimedia signal processing including content creation. Content providers, camera manufacturers, display equipment makers, photographers, digital artists, graphical art designers and computer game makers.

5. Pre-requisites

There is no pre-requisite. It will be an introductory tutorial suitable for audience with basic knowledge of digital imaging and photography.

6. Content Outline

The tutorial will begin by discussing the weaknesses of current (low dynamic range) image and video formats and the limitations of conventional reproduction media such as video monitors. It will then introduce the vision and potential of high dynamic range imaging. Subsequently, it will introduce topics in all stages of the high dynamic range imaging pipeline including, capture, processing, coding/compression, and display. It will conclude by discussing potential applications of HDRI technology. Emphasis will be on image processing perspective of HDRI. Indicative topics include:

(i) Introduction

(ii) HDR image and video acquisition.

- Introduction to HDR image and video acquisition issues
- Multiple exposure techniques
- High dynamic range cameras

(iii) High dynamic range image processing

- Introduction to image processing issues in HDR image and video
- HDR image and video file formats
- Noise removal/filtering
- Lossless coding of HDR image and video
- Lossy coding of HDR image and video
- Backward compatible high dynamic range MPEG/JPEG compression
- HDR compression quality measures

(iv) HDR image and video display/reproduction

- Introduction to HDR image and video reproduction issues
- Tone mapping for HDR image and video
- Global tone reproduction curve based techniques
- Local tone reproduction operator based techniques
- Hardware techniques and equipment for the display of HDR image and video.

(v) Applications of HDRI and summary.

7. Length of Tutorial

3 Hours

8. Lecturer

Guoping Qiu

Guoping Qiu is a Reader (Associate Professor) in Visual Information Processing in the School of Computer Science and Information Technology, the University of Nottingham, UK. Before joining Nottingham in 2000, he was a Lecturer (Assistant Professor) in the School of Computing, the University of Leeds, UK (1999 – 2000); and the School of Mathematics and Computing, the University of Derby, UK (1993 – 1999).

He received his BSc in Electronic Measurement and Instrumentation from the University of Electronic Science and Technology of China in 1984 and his PhD in Electronic Engineering from the University of Central Lancashire, UK in 1993. He has been performing research in fields related to image processing for more than 15 years and has authored more than 100 publications.

His research interests include high dynamic range imaging. He has been performing research in HDRI since 2002. He has developed several successful tone-mapping operators for displaying high dynamic range images. In August 2006, his paper on HDR image tone mapping using optimization received a Best Paper Award at the 18th International Conference on Pattern Recognition (ICPR2006). Apart from publishing academic papers on HDR imaging, with his industrial collaborators, he has filed a patent on HDRI. He is currently a consultant for a company helping the development of HDRI products. His research group at Nottingham is currently developing advanced tone mapping, coding and compression techniques for high dynamic range image and video data. He is the lead guest editor of a Special Issue on High Dynamic Range Imaging for the Journal of Visual Communication and Image Representation, scheduled to be published in 2007.

His publications directly related to the subject area of the proposal include

1. G. Qiu, J. Guan, J. Duan and M. Chen, "Tone mapping for HDR image using optimization – A new closed form solution", ICRP 2006, 18th International Conference on Pattern Recognition, 20 - 24 August 2006, Hong Kong (**Best Paper Award**)
2. G. Qiu and J. Duan, "Hierarchical Tone Mapping for High Dynamic Range Image Visualization", VCIP2005, Visual Communication and Image Processing, 12 - 15 July 2005, Beijing, China
3. G. Qiu and J Duan, "An optimal tone reproduction curve operator for the display of high dynamic range images", ISCAS2005, IEEE International Symposium on Circuits and Systems, 23 - 26 May 2005, Kobe, Japan
4. J. Duan, G. Qiu and G. D. Finlayson, "Learning to display high dynamic range images", CGIV'2004, IS&T's Second European Conference on Color in Graphics, Imaging and Vision, Aachen, Germany, April 5-8, 2004
5. J. Duan and G. Qiu, "Fast Tone Mapping for High Dynamic Range Images", ICPR2004, 17th International Conference on Pattern Recognition, Cambridge, United Kingdom, 23 - 26 August 2004
6. J. Guan and G. Qiu, "Image Contrast Gain Control by Linear Neighbourhood Embedding", Technical Report, Report-VIPLAB-02-2005, School of Computer Science and Information Technology, University of Nottingham, November 2005
7. J. Duan, M. Bressan, C. Dance and G Qiu, "Histogram adjustment for high dynamic range image mapping", US Patent filed by Xerox Research Centre Europe (XRCE), May 2006

His publication in general areas of image processing include

1. K-W Sze, K-M Lam, and G. Qiu, "A new key frame representation for video segment retrieval", IEEE Trans. on Circuits and Systems for Video Technology, Vol. 15, No.9, pp. 1148-1155, 2005
2. G. Qiu, "Embedded colour image coding for content-based retrieval", Journal of Visual Communication and Image Representation, Volume 15, Issue 4, December 2004, Pages 507-521
3. G. Qiu, "Colour image indexing using BTC", IEEE Transactions on Image Processing, vol. 12, no.1 pp. 93 -101, 2003
4. G. Qiu and K-M Lam, "Frequency layered color indexing for content-based image retrieval", IEEE Transactions on Image Processing, vol. 12, no.1 pp. 102 -113, 2003
5. G. Qiu, "Indexing chromatic and achromatic patterns for content-based colour image retrieval", Pattern Recognition, vol. 35, pp. 1675 – 1686, August, 2002
6. G. Qiu, "MLP for adaptive postprocessing block coded images", IEEE Transactions on Circuits and Systems for Video Technology, vol. 10, pp. 1450 - 1454, December, 2000
7. G. Qiu, "Inter-resolution look-up table for improved spatial magnification of images", Journal of Visual Communications and Image Representation, vol. 11, pp. 360 - 373, Academic Press, November 2000
8. G. Qiu, "A progressively predictive image pyramid for efficient lossless coding", IEEE Transactions on Image Processing, Vol. 8, No.1, pp. 109 – 115, 1999
9. G. Qiu, "An Improved Recursive Median Filtering Scheme for Image Processing", IEEE Transactions on Image Processing, Vol. 5, pp. 646-648, 1996
10. G. Qiu, "Functional Optimisation Properties of Median Filtering", IEEE Signal Processing Letters, Vol. 1, No. 4, pp. 64-65, 1994