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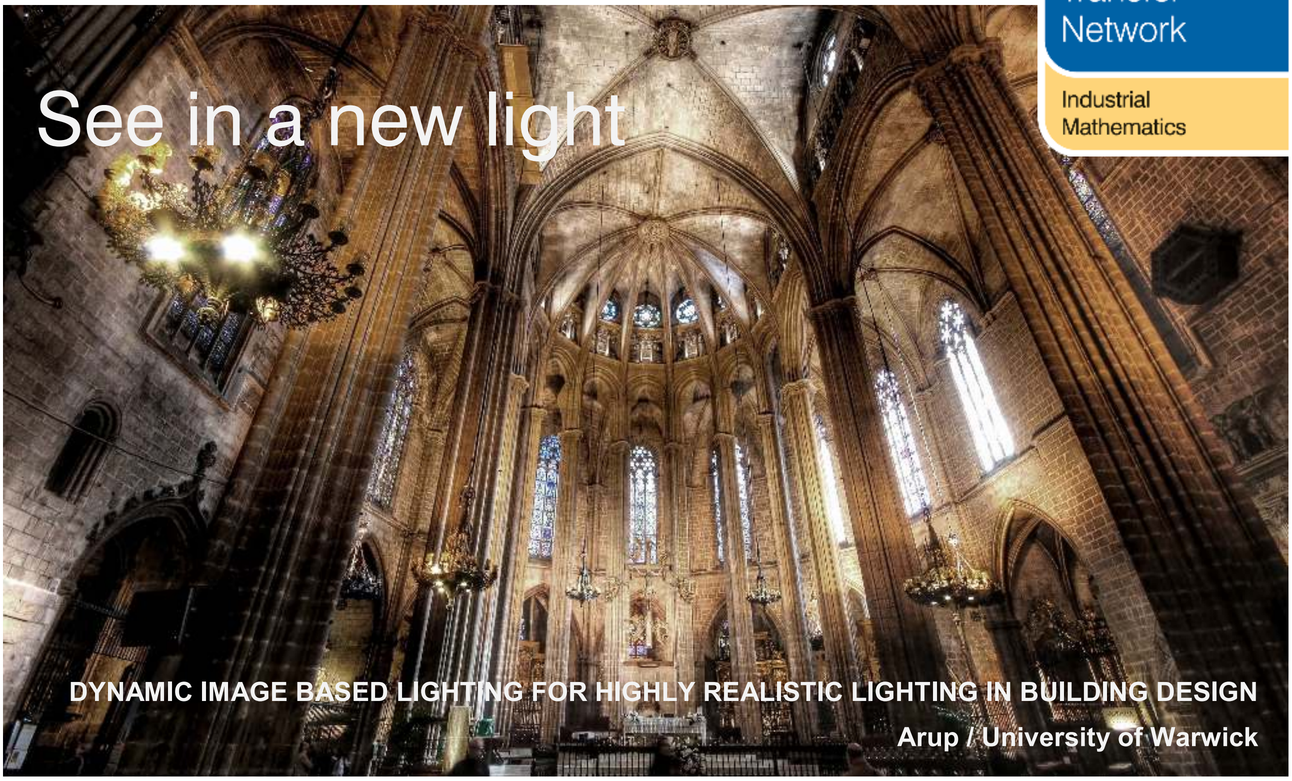
Industrial Mathematics



See in a new light

DYNAMIC IMAGE BASED LIGHTING FOR HIGHLY REALISTIC LIGHTING IN BUILDING DESIGN

Arup / University of Warwick

The need

Image Based Lighting (IBL) is a technique for artificially re-lighting real world or synthetic objects. The project sought to develop a new mathematical approach to IBL to cope with the dynamic nature of the lighting captured by the HDR video camera. Standard IBL uses only static information from a 360-degree panoramic HDR image, assuming that light sources are located at an infinite distance. In the new approach, we wanted to exploit dynamic information from film clips recorded by the HDR video camera to capture real world conditions, where light sources change over time.

Additionally, the project sought to integrate this into Arup's existing visualisation system in order to significantly improve the fidelity of images used for building design.

The outcomes

Dynamic IBL will play a key role in improving the visual fidelity of computer generated imagery for the building design process. Such high-fidelity rendering techniques are physically based and thus require a robust mathematical foundation in order to deliver the desired perceptual equivalence between the real scene and its virtual counterpart. HDR video produces large amounts of data (417 gigabytes (GB) are required to store each second of video), therefore all elements of the processing pipeline must deliver high performance.

The new mathematical method developed from the project can then be used to define algorithms for IBL using images or videos. Of particular interest are temporal IBL algorithms applicable to the newly acquired HDR video. An additional challenge encountered during the internship was to create interoperability between the PAR and Rhinoceros3D software systems and to extend the PAR so as to run on Arup's computing cluster.

This challenge served as a stimulus to explore other areas of current related research at Warwick Digital Laboratory on high fidelity rendering on shared resources, and was a key element in resolving this issue.

"This experience has given us excellent insights into the range of knowledge and capabilities at University of Warwick and we are excited about future research work and collaboration with them."

Steve Walker
Arup

Technical summary

High Dynamic Range (HDR) imagery is a novel way to capture, store, process, and visualise pictures and videos. It allows the representation of all real world luminance levels without limits in terms of quantisation and range. For example, when a picture of an indoor scene with bright light coming in through a window is taken using conventional imaging, this picture will show only the interior of the room clearly with a blank window or, conversely, the scene through the window will be clearly depicted with a dark interior. HDR imaging allows the capture of all radiance information within the scene, from the interior room detail to the bright day-lit landscape outside the window, due to the fact that the range is not 'clamped' and quantisation of light levels is encoded using a representation of real values. Using these images, it was possible to improve the IBL technique so that the lighting for Arup's models of buildings looks more natural.

The mathematical approach to temporal IBL was to extend a spatial sampling technique to the temporal domain. This was achieved by modifying the median cut algorithm into a new scheme called *'quad cut'*. This new sampling scheme is less prone to flickering, although this can still be present. To reduce flickering, temporal filtering of generated samples was applied in an efficient way by splitting and merging samples. These algorithms were developed in Matlab.

The integration of this algorithm into Arup's system included the production of a working 'pipeline' that connects Rhinoceros3D (a NURBS modelling package) and a physically based renderer (PAR) developed at the University of Warwick. This involved extending the PAR in order to be compatible with Rhinoceros3D. Furthermore, an input/output (I/O) mechanism to connect them was developed.

"The main benefit of the internship was the opportunity to work on a rendering system in a real-world situation outside the academic software-developing world where important, practical details are not always considered."

Francesco Banterle
University of Warwick

"This Industrial Mathematics Internship has enabled leading edge academic research results to be transferred to solve a challenging real industrial problem. We look forward very much to working with Arup on many other exciting projects in the future."

Alan Chalmers
University of Warwick

This project was part of the programme of industrial mathematics internships managed by the Knowledge Transfer Network (KTN) for Industrial Mathematics. The KTN works to exploit mathematics as an engine for innovation. It is supported by the Technology Strategy Board, in its role as the UK's national innovation agency, and the Engineering and Physical Sciences Research Council, in its role as the main UK government agency for funding research and training in engineering and the physical sciences.

EPSRC
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Project Details

Partners
Arup
University of Warwick

Project investment
£12,000

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