



Project-Team FRV Sense

# ***Fast Rendering and Visualization Sense***

*Rennes*

| *Activity Report*

*2014*



## 1 Team

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## 2 Overall Objectives

### 2.1 Objectives

The different topics that will be addressed by the team are:

1. Real-time rendering and global illumination algorithms exploiting the performances of the new GPUs (Graphics Processing Units);
2. Color and visual perception;
  - Color appearance models
  - HDR and tone mapping
3. Inverse lighting and image aesthetics

Our objectives for the these topics are:

- Real-time rendering and global illumination

The main objective is real-time global illumination computation. This is a real challenge that want to take up all the researchers involved in 3D movie and game video as well as virtual reality applications. We want to make available to artists a tool for photorealistic real-time rendering.

The global illumination problem (called GI from now on) has been intensively studied over the last decades. Many approaches (path tracing, bidirectional path tracing, photon mapping, etc.) have been proposed to solve it. As the GI problem is mathematically expressed with an integral equation, most of these methods use a Monte Carlo algorithm with an importance sampling defined on the integral domain. However, in certain cases, the importance sampling strategy does not guaranty satisfying results in a reasonable computation time. Indeed, this sampling strategy is efficient if the probability density function (pdf) used to generate samples is proportional to the integrand. In the GI context, this pdf is not known and it is challenging to define an efficient function which takes into account all the problems to be solved. As a solution Veach<sup>[Vea97]</sup> proposed to use the Metropolis-Hasting light transport (MLT) algorithm which has the ability to build an arbitrary probability density by random walking. This random walk is managed by an importance function which gives the relative importance between different states of a Markov Chain. However, in GI, this importance function is often designed in the image space and precomputed. We proposed a MLT-based GI method that uniformly distributes the resulting estimation error over all the computed image. Our method does not rely on a fixed scalar function but updates it after each pass which consists in generating an amount of photons from the light sources. The new importance function is evaluated in the 3D space rather than in 2D.

For global illumination we have also proposed another integration procedure known as Bayesian Monte Carlo integration (BMC)<sup>[O'H87]</sup>. As opposed to importance sampling methods, BMC does not require the samples to be drawn from a predefined pdf and does take into account samples location. The price to pay for this is a higher computational cost per samples but in a recent paper[?], we have shown that this cost can be kept to the same level as for importance sampling with a suboptimal solution. Compared to the usual combination of importance and stratified sampling procedures, our proposed BMC method allows a 23% decrease in the number of samples for the same noise level. However, these results have only been obtained for the computation of the diffuse component in the final gathering step of a photon mapping renderer and cannot be easily extended to the implementation of a full global illumination renderer. Our approach will allow to analyze for which rendering step or for which effect the use of BMC could be beneficial and then experiment solutions. A first objective will be to deal with the rendering of the glossy component. An important aspect of this work will be the integration of prior knowledge. We think that BMC can provide a very powerful framework for very efficient rendering methods.

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[Vea97] E. VEACH, *Robust Monte Carlo methods for light transport simulation*, PdD Thesis, Stanford University, 1997.

[O'H87] A. O'HAGAN, "Monte-Carlo is fundamentally unsound", *The Statistician* 36, 2/3, 1987, p. 247-249.

We are also working on QMC (Quasi Monte Carlo) applied to GI. We have proposed several metrics to evaluate the performance of sampling the hemisphere.

- Color and visual perception
  - Color appearance models and tone mapping
 

Our main objective is to propose approaches allowing to combine global illumination engines and visual perception based algorithms in order to compute perceptually realistic images. We have already proposed a robust and real-time model of visual attention which mixes top-down and bottom-up approaches in the context virtual reality<sup>[HBO<sup>+</sup>10,HLC<sup>+</sup>10]</sup>. We have also proposed and evaluated methods to enhance visual feedback by adding a depth of field blur in VR applications<sup>[HLCC08]</sup>. In the short-term, our work focuses onto three topics:

    - \* the creation of a robust and real-time chromatic adaptation algorithm (estimate of white balance) in the context of global illumination;
    - \* the enhancement of tone mapping algorithm using our visual attention model;
    - \* the proposal of new tone mapping techniques for dynamic scenes;

Once we will be able to evaluate the perceptual realism of the rendered images, then in the long-term, one challenge will be to inverse the perceptual models and let the artist/designer specify some constraints on image appearance and perception. The rendering parameters will be tuned to satisfy these constraints. Note that a high level model of constraints can be used by an artist to enhance the visual perception of 3D scenes.

### 3 Scientific Foundations

#### 3.1 Global Illumination

**Keywords:** Global illumination, relighting, bayesian Monte Carlo, multi-view rendering, image-based rendering, color appearance model, high dynamic range.

To achieve realistic rendering, one has to compute global illumination accounting for: multiple reflections and refractions, sub-surface scattering (within skin, marble), multiple scattering in participating media (smoke, fire, dust, clouds), chromatic adaptation, tone mapping, etc. It is well known that global illumination computation is demanding in terms of computing and memory resources. This is why the team members have already proposed new solutions based

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[HBO<sup>+</sup>10] S. HILLAIRE, G. BRETON, N. OUARTI, R. COZOT, A. LECUYER, “Using a Visual Attention Model to Improve Gaze Tracking Systems in Interactive 3D Applications”, *Computer Graphics Forum*, 2010.

[HLC<sup>+</sup>10] S. HILLAIRE, A. LECUYER, R. CORTE, T., R. COZOT, G. BRETON, “A Real-Time Visual Attention Model for Predicting Gaze Point During First-Person Exploration of Virtual Environments”, *in: VRST 2010*, 2010.

[HLCC08] S. HILLAIRE, A. LECUYER, R. COZOT, G. CASIEZ, “Depth-of-Field Blur Effects for First-Person Navigation in Virtual Environments”, *Computer Graphics and Applications*, 2008.

on irradiance/radiance caching methods implemented on the GPU to speed up the different computations involved in global illumination and rendering algorithms[2, ?].

Radiance caching has also been used to simulate multiple scattering within participating media[?]. Indeed, we proposed a technique for efficiently rendering participating media with irradiance caching scheme using Monte Carlo ray tracing. Our approach extends the original algorithm for surfaces to volumes rendering. Our method allows us to adjust density of cached records according to illumination changes and to store both direct and indirect contributions in the records but also multiple scattering due to medium. To achieve this, we proposed an adaptive shape for records depending on geometrical features and irradiance variations. In order to avoid a too high density of cached records where it is not necessary (for example away from the observer inside a medium with high absorption and scattering properties) a new method is proposed to control the density of the cache during the addition of new records. This volume density control is depending of the interpolation quality with the existing records and the photometric characteristics of the participating media. Limiting the number of records in the volume can accelerate both the computation pass (computation of irradiance and gradients may be time-consuming for a record) and the final rendering pass by limiting the number of searches in the cache. Moreover, storing all contributions in records is of high importance, especially in the case of scenes having many light sources with complex geometry as well as wide surfaces exposed to daylight or again for animation rendering. Finally, instead of using an expensive ray marching to find records that cover the ray, we gather all the records along ray which contribute to the in-scattered radiance. With these different techniques, pre-computing and rendering passes are significantly speeded-up.

We have brought several contributions to global illumination: radiance cache, participating media, Metropolis Light Transport, etc. Moreover, we proposed a novel approach to progressive photon mapping for scenes containing surface and volume objects. Our method allows to handle scenes with specular and refractive objects as well as homogeneous and heterogeneous participating media.

### 3.2 Bayesian and Quasi Monte-Carlo methods for image rendering

**Keywords:** Sampling, likelihood principle, Monte Carlo.

Most global illumination rendering methods are based Monte-Carlo importance sampling but, as pointed out by OHagan in 1987<sup>[O'H87]</sup>, this procedure suffers from two inconsistencies that we will briefly present in the following. Firstly, the estimator depends on some arbitrary choice of the sampling density which violates the Likelihood principle. Secondly, this procedure ignores sample location and thus wastes important information. Although solution exists to alleviate these problems, it still remains true that choosing the right sample distribution is a difficult problem and that Monte Carlo importance sampling does not allow to easily take into account prior knowledge on the data. This leads to a waste of samples which is further increased by the fact that samples location is not exploited. Furthermore, samples reuse from one integral computation to another is difficult since samples must be drawn from a predefined probability density function (pdf).

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[O'H87] A. O'HAGAN, "Monte-Carlo is fundamentally unsound", *The Statistician* 36, 2/3, 1987, p. 247-249.

QMC integration is now extensively used in computer graphics (see e.g. [SEB08]). Keller has shown in [Kel13] that QMC techniques can be applied in a consistent way to deal with a wide range of problems (anti-aliasing, depth of field, motion blur, spectral rendering, etc.). However, few applications have been reported in the literature specifically addressing hemispherical sampling with a view of computing the illumination integral. Unlike the unit square sampling case, no explicit construction of optimal point sets for spherical sampling is known and generally the spherical point sets are generated by lifting point sets from the unit square to the unit sphere through an equal-area transform. Although such point constructions are not proved to be optimal, recent results from the numerical analysis literature suggest that both (0, 2)-sequences and Fibonacci lattices lifted to the sphere are quite close to optimality in terms of discrepancy [ABD12].

Nevertheless their performance is not exactly equivalent: several authors have shown that spherical Fibonacci (SF) lattices are particularly well-suited to sphere sampling compared to other low-discrepancy point sets. Furthermore, similar point structures arise spontaneously in nature so as to implement a best packing strategy on the sphere (e.g. packing of seeds in the sunflowers head [Vog79]), a clear indication that these structures have intrinsically good spherical uniformity properties. We introduced theoretical aspects on QMC spherical integration that have never been used in the graphics community [5]. In concrete terms, we define worst case integration error (w.c.e.), spherical cap discrepancy (s.c.d.) and an inter-samples distance-based energy metrics, which allows to assess the quality of a spherical samples set for spherical integration.

### 3.3 Color, Visual Perception and Inverse Lighting

**Keywords:** Color appearance model, visual perception, tone mapping, white balancing, high dynamic range.

**Color appearance models and visual perception** Global illumination algorithms provide, as results, physically based values that need to be transformed into displayable RGB images. This transformation could seem straightforward. But the human visual system does not perform a direct transformation, rather it involves some local and global adaptation operations, takes into account the viewing conditions and some cognitive tasks. To give the same

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visual perception as that of a user immersed in a 3D virtual world, this transformation into images of these physical values must take into account the features of the human visual system (HVS) as well as the characteristics of the display device. The main key features of the human visual system to be accounted for are the luminance adaptation, the chromatic adaptation, the focus point (at which the user is looking) and the depth of field. On the display device side, we have to take into account the luminance range, the color range, the size of the screen and if necessary the stereo features.

Chromatic adaptation consists in recovering the color appearance of objects as if the user was within a 3D scene (as if he sees directly the scene). But color appearance for the human visual system does not depend only on the spectral radiance of the stimulus, but it also takes into account the viewing conditions. Color appearance models allow to model the perception of color stimulus according to the viewing conditions through colorimetric and photometric quantities such as: brightness, lightness, chroma, saturation, colorfulness, and hue of the stimulus [KJF07,Fai05]. Many works also deal with chromatic adaptation. They belong to different research fields: computer graphics, color science, computer vision, etc [Fai91b,Fai91a,VK70,WW09]. Colors are perceived as constant even though the illuminant color changes. Indeed, the perceived color of a diffuse white sheet of paper is still white even though it is illuminated by a single orange tungsten light, whereas it is orange from a physical point of view. Unfortunately global illumination algorithms only focus on the physics aspects of light transport. The output of a global illumination engine is an image which has to undergo chromatic adaptation to recover the color as perceived by the HVS. We proposed a new color adaptation method [3],[?] well suited to global illumination. This method estimates the adaptation color by averaging the irradiance color arriving at the eye. Unlike other existing methods, our approach is not limited to the view frustum, as it considers the illumination from all the scene. Experiments have shown that our method outperforms the state of the art methods.

The conversion of the HDR (High Dynamic Range) luminance range of the images (computed using a global illumination algorithm) to LDR (Low Dynamic Range) images displayable onto LDR display devices is called Tone Mapping. This topic has been widely addressed by the computer graphics community. A complete state of the art of tone mapping algorithms can be found in [RWD<sup>+</sup>10]. While many solutions have been designed over the last decade, only few of them can cope with video sequences. Indeed, these TMOs tone map each frame of a video sequence separately, which results in temporal incoherency. Two main types of temporal incoherency are usually considered: flickering artifacts and temporal brightness in-

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coherency. While the reduction of flickering artifacts has been well studied, less work has been performed on brightness incoherency. We proposed a method that aims at preserving spatio-temporal brightness coherency when tone mapping video sequences. Our technique computes HDR video zones which are constant throughout a sequence, based on the luminance of each pixel. Our method aims at preserving the brightness coherency between the brightest zone of the video and each other zone. This technique adapts to any TMO and results show that it preserves well spatio-temporal brightness coherency. We validate our method using a subjective evaluation. In addition, unlike local TMOs, our method, when applied to still images, is capable of ensuring spatial brightness coherency. Finally, it also preserves video fade effects commonly used in post-production.

**Inverse Lighting** As many phenomena are accounted for by global illumination algorithms, it is difficult to know beforehand what the resulting image will look like. For instance, we would like an object of a scene to be bright, with a lot of contrast, while we would like the background of the scene to be dark and uniform. Answering such specifications can be a time-consuming and tedious effort if it is not done automatically. Thus, a trial-and-error approach is not satisfactory. To obtain a satisfactory result automatically, the user has to express his aesthetic intent by providing a set of target values for properties of the final image. The goal is to change iteratively the parameters of the 3D scene to fit the specification. There are a lot of parameters to take into account. Among them are: position, size, luminance of the light sources, reflectance of the materials, distribution of the objects in the scene. The methods used to compute these lighting parameters to fit a set of constraints are called inverse lighting methods. In these methods, an objective function that accounts for the target parameters is defined to express the intent of the user. The objective function expresses the distance between the current lighting design and the desired result. To find the optimal set of parameters, an objective function has to be minimized. There are many ways to express the aesthetic intent, as there are many possible aesthetics.

We designed a new inverse lighting framework. Given a set of target parameters provided by the user, we set up a platform that can render a scene with global illumination techniques and allows to minimize the objective function to find the desired parameters (light source size, position, luminance) to meet the user's intent.

### 3.4 Automatic computation of cinematographic sequences

**Keywords:** 3D Graphics, Realism, Animation, Cinematography.

Automatically computing a cinematographically consistent sequence of shots over a set of actions occurring in a 3D world is a complex task which requires not only the computation of appropriate shots (viewpoints) and appropriate transitions between shots (cuts), but the ability to encode and reproduce elements of cinematographic style. Models proposed in the literature, generally base on finite state machine representations, provide limited functionalities to build sequences of shots and are no designed in mind to generate sequences reproducing a given cinematographic style, nor do they allow to perform significant variations in style over the same sequence of actions. In collaboration with Marc Christie (member of the Mimetic

team at INRIA Rennes Bretagne Atlantique) we first proposed an expressive automated cinematography model that can compute significant variations in terms of cinematographic style, with the ability to control the duration of shots and the possibility to add specific constraints on the desired sequence. Second, we parametrized the model in a way that facilitates the application of learning techniques so as to reproduce elements of style extracted from real movies by using a Hidden Markov Model representation of the editing process. The proposed model is both more general than existing representations, and proves to be more expressive in its ability to precisely encode elements of cinematographic style. Results comparing our model with state-of-the-art finite state machine representations illustrate these features. The next step is to add some lighting constraints which would influence the determination of shot sequences.

## 4 Application Domains

### 4.1 Applications

**Participants:** all participants.

The applications of our works are:

- Lighting simulation: fast and physics-based;
- High quality video games: real-time, high realism, perception-based, help game designers to choose lighting and material properties interactively, stereoscopic and autostereoscopic;
- 3D movies: interactivity, high photorealism, perception-based, help for artists to choose lighting and material properties interactively, stereoscopic and autostereoscopic;
- Virtual and augmented reality: high realism, fast, stereoscopic and autostereoscopic.

## 5 New Results

### 5.1 Camera placement and Cinematography

**Participants:** Billal Merabti, Marc Christie, Rémi Cozot, Kadi Bouatouch.

The important advances in the quality and performances of 3D rendering allow to create 3D animated sequences in real-time with the aim to generate in real-time movies of cinematographic quality. However, the integration of 3D cinematographic elements (camera placement, light source placement, actor placement) requires the formalization of a knowledge that exists empirically in industry and in the literature. The approach that we adopt is to study, from real data (movies), the combination of framing, lighting and placement of actors, given elements of cinematographic style (duration of framings, their frequency, transition between framings, etc.) Our approach will provide an efficient computational model allowing the placement of actors,

camera and light sources, with the aim of automatic staging satisfying elements of specified styles.

In collaboration with Marc Christie (member of the Mimetic team at INRIA Rennes Bretagne Atlantique) we first proposed an expressive automated cinematography model that can compute significant variations in terms of cinematographic style, with the ability to control the duration of shots and the possibility to add specific constraints on the desired sequence. Second, we parametrized the model in a way that facilitates the application of learning techniques so as to reproduce elements of style extracted from real movies by using a Hidden Markov Model representation of the editing process. The proposed model is both more general than existing representations, and proves to be more expressive in its ability to precisely encode elements of cinematographic style. Results comparing our model with state-of-the-art finite state machine representations illustrate these features. The next step is to add some lighting constraints (expertise of the FRVSense team) which would influence the determination of shot sequences.

This work has been partially published at WICED 2014, Workshop on Intelligent Cinematography and Editing [8]. A more detailed paper has been submitted to a journal.

## 5.2 Global Illumination

**Participants:** Adrien Gruson, Remi Cozot, Mickael Ribardiere, Kadi Bouatouch.

The global illumination problem (called GI from now on) has been intensively studied over the last decades. We have proposed and implemented different approaches (path tracing, bidirectional path tracing, photon mapping, etc.) to solve this problem. As the GI problem is mathematically expressed with an integral equation, most of these methods use a Monte Carlo algorithm with an importance sampling defined on the integral domain. However, in certain cases, the importance sampling strategy does not guaranty satisfying results in a reasonable computation time. Indeed, this sampling strategy is efficient if the probability density function (pdf) used to generate samples is proportional to the integrand. The pdf is not known and it is challenging to define an efficient function which takes into account all the problems to be solved. As a solution, Veach et al. [Veach 1998] proposed to use the Metropolis-Hasting light transport (MLT) algorithm which has the ability to build an arbitrary probability density by random walking. This random walk is managed by an importance function which gives the relative importance between different states of a Markov Chain. However, in GI, this importance function is often designed in the image space and precomputed. We proposed a MLT-based GI method that uniformly distributes the resulting estimation error over all the computed image. Our method does not rely on a fixed scalar function but updates it after each pass which consists in generating an amount of photons from the light sources. The new importance function is evaluated in the 3D space rather than in 2D, which drastically improve the quality of the generated images. This work has been submitted to a conference.

In collaboration with the computer graphics group of the university of central Florida (USA) we have also proposed a Discrete Ordinate Method for Polarized Light Transport Solution and Subsurface BRDF Computation. This work has been presented at Graphics Interface conference [6], an extended version of the paper has been published in the journal: Computers

& Graphics [3].

### 5.3 Quasi Monte Carlo

**Participants:** Ricardo Marques, Christian Bouville, Kadi Bouatouch.

Quasi-Monte Carlo (QMC) methods exhibit a faster convergence rate than that of classic Monte Carlo methods. This feature has made QMC prevalent in image synthesis, where it is frequently used for approximating the value of spherical integrals (e.g. illumination integral). The common approach for generating QMC sampling patterns for spherical integration (used in global illumination) is to resort to unit square low-discrepancy sequences and map them to the hemisphere. However such an approach is suboptimal as these sequences do not account for the spherical topology and their discrepancy properties on the unit square are impaired by the spherical projection. So, we are interested in directly sampling the hemisphere for global illumination purposes.

QMC (Quasi Monte Carlo) are extensively used in rendering algorithms but among the many possible techniques proposed in the literature, it is very difficult to predict what will be their performances when applied to rendering. As the benefits of QMC compared to classic Monte Carlo depend on the integrand smoothness, this factor must necessarily be taken into account in a performance criterion. Furthermore, most QMC techniques are originally designed for sampling the unit square or the unit cube whereas the illumination integral is fundamentally a hemispherical integral. Our goal is thus to propose a theoretical framework that enables to predict the performances of QMC techniques applied to global illumination to compute the illumination integral. For this purpose, we use a spherical Fourier analysis of the illumination integral considering both diffuse and glossy reflection cases. We show that the integration error can be broken down into two distinct components which have been described as zonal and anisotropic. We then define a performance criterion that uses the Sobolev spaces theory to characterize the smoothness of integrands in the frequency domain. The proposed theoretical framework is applied to various QMC techniques so as to analyze and predict their performances. These predictions are confirmed by experimental global illumination results. This work has been submitted to the journal ACM TOG..

### 5.4 Inverse Rendering

**Participants:** Adrien Gruson, Rémi Cozot, Kadi Bouatouch.

In computer graphics, lighting plays an important role in the appearance of a scene. A change in the configuration of light sources can lead to different aesthetics in the final rendered image. Lighting design becomes increasingly complex when using sophisticated global illumination techniques. We proposed a new approach to automatically design the lighting configuration according to the aesthetic goal specified by the user as a set of target parameters. Target parameters are used to set up an objective function which is minimized so that the final image, rendered using optimal light parameters, meets the requirements set by the user. The objective function is a sum of terms which depend on user-defined target parameters. It is simple to add new terms to address specific styles. Our results show that this method can be

used to automatically design a lighting configuration that will give to the final image a classic photographic look.

This work has been published at Pacific Graphics conference [7] and an HDR (Habilitation a Diriger Des Recherches) [10].

## 5.5 Style Transfer

**Participants:** Hristina Hristova, Olivier Le Meur, Rémi Cozot, Kadi Bouatouch.

Transferring features, such as light and colors, between input and reference images is the main objective of many recent research works. Current state-of-the-art methods focus mainly on the complete transfer of the light and color distributions. However, they do not grasp in a good manner some image style specifications. We proposed a local method for carrying out a transfer of style between two images even of highly different styles. Our method performs the partitioning of both images into Gaussian distributed clusters by considering their main style features. These features are automatically determined by the classification step of our algorithm. Moreover, we present several novel policies for input/reference cluster mapping, which have not been tackled by previous methods. To complete the style transfer, for each pair of corresponding clusters, we apply a parametric color transfer method and a chromatic adaptation transform. Results as well as an evaluation by two objective metrics show that the proposed method obtains visually pleasing and artifact-free images, respecting the reference style.

This work has been submitted to a conference.

## 5.6 HDR Imaging

**Participants:** Ronan Boitard, Mickael Ribardiere, Rémi Cozot, Kadi Bouatouch.

Several TMOs have been proposed over the last decade, from the simple global mapping to the more complex one simulating the human vision system. While these solutions work generally well for still pictures, they are usually less efficient for video sequences as they are source of visual artifacts. Only few of them can be adapted to cope with a sequence of images. In this paper we present a major problem that a static TMO usually encounters while dealing with video sequences, namely the temporal coherency. Indeed, as each tone mapper deals with each frame separately, no temporal coherency is taken into account and hence the results can be quite disturbing for high varying dynamics in a video. We have proposed a temporal coherency algorithm that is designed to analyze a video as a whole, and from its characteristics adapts each tone mapped frame of a sequence in order to preserve the temporal coherency. This temporal coherency algorithm has been tested on a set of real as well as Computer Graphics Image (CGI) content and put in competition with several algorithms that are designed to be time-dependent. Results have shown that temporal coherency preserves the overall contrast in a sequence of images. Furthermore, this technique is applicable to any TMO as it is a post-processing that only depends on the used TMO. This work gave rise to a paper in a journal [2], a conference [5], and a workshop [4] and a PhD [1].

## 6 Contracts and Grants with Industry

### 6.1 Contracts

We were part of a project, named Nevex, with industrial partners such as: Technicolor, TF1, and other companies involved in HDR acquisition and display. This project is concerned with the design of a complete High Dynamic Range chain: acquisition, compression, transmission and display. We have also two CIFRE grants with Technicolor.

## 7 Other Grants and Activities

### 7.1 International Collaborations

We have several collaborations with other laboratories and universities: University of Central Florida (UCF) in Orlando (US), Technical University of Prague (Czech Republic), University of Minho in Braga (Portugal), University of Pretoria (South Africa). Within the framework of these collaborations, several PhD students have been or are jointly supervised.

We are also in an european COST action (HDRi IC-1005) whose leader is the university of Warwick, England.

### 7.2 National Collaborations

## 8 Dissemination

### 8.1 Involvement in the Scientific Community

Most of the team members have published in:

- high level journals: IEEE Trans. Visualization and Computer Graphics, IEEE Comp. Graphics and Applications, Computer Graphics Forum, Journal of Graphics Tools, The Visual Computer, etc.
- and high level conferences: EGSR, Pacific Graphics, IEEE Virtual Reality, Computer Graphics International, Web3D, etc.

They have been reviewers for several conferences and symposia such as: Siggraph, Eurographics Pacific graphics, etc., and for journals such as: ACM TOG, IEEE TVCG, The Visual Computer, Computer Graphics Forum, etc.

Kadi Bouatouch is an associate editor of the journal The Visual Computer. He has also been external examiners for several PhD in Europe (England, Germany, Belgium, The Netherlands, Spain, Cyprus) and the United States (UCF, Utah). He was also the co-chair of the second international conference and SME workshop of the IC-1005 HDRi cost action in 2014.

Christian Bouville and Kadi Bouatouch have been the co-chairs of the Web3D'2003 conference which has been held in Saint Malo, France. We have also founded the Eurographics Workshop on Rendering in 1990. This workshop became EGSR (EuroGraphics Symposium on Rendering) in 2003.

We gave a tutorial [9] at the Eurographics'2014 conference in Strasbourg. Its title is: Bayesian and Quasi Monte Carlo Spherical Integration for Illumination Integrals. We also gave, in 2014, a tutorial within the framework of the Training School of the IC-10005 HDRi cost action. .

## 8.2 Teaching

Kadi Bouatouch is Professor at ISTIC, university of Rennes 1. He gives courses on programming (Mathematica, JAVA) and on computer graphics. He is responsible for Digital Image track of the Master of computer science delivered by the university of Rennes 1.

Rémi Cozot is an assistant professor at ESIR, university of Rennes 1. He gives courses on programming (JAVA, C++) and on computer graphics.

## 9 Bibliography

### Major publications by the team in recent years

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