



MINISTERIO
DE CIENCIA
Y TECNOLOGÍA

SECRETARÍA DE ESTADO
DE POLÍTICA CIENTÍFICA
Y TECNOLÓGICA

DIRECCIÓN GENERAL
DE INVESTIGACIÓN

SUBDIRECCIÓN GENERAL
DE PROYECTOS DE INVESTIGACIÓN

JORNADAS DE SEGUIMIENTO

PROYECTOS EN TECNOLOGÍAS DE LA INFORMACIÓN

DESCRIPCIÓN DE RESULTADOS

Referencia del proyecto: TIC1998-0973-C03-01

Título: CAD integrado para sistemas de iluminación y luminarias

Investigador principal: Juan Carlos Torres Cantero

Dirección de contacto: Dpto. Lenguajes y Sistemas Informáticos
ETS. Ing. Informática
Av. Andalucía 38
18071 Granada

email: jctorres@ugr.es

Datos sobre el grupo investigador:

¿Se trata de un proyecto coordinado? SI

Referencia del proyecto: TIC1998-0973-C03-02

Investigador principal: Francisco José Serón Arbeola

Dirección de contacto: Dpto. Informática
Centro Politécnico Superior
Universidad de Zaragoza
C/ María de Luna, 3
E-50015 Zaragoza

email: seron@posta.unizar.es

Referencia del proyecto: TIC1998-0973-C03-03

Investigador principal: Jordi Regincós Isern

Dirección de contacto: Departament d'Informàtica i Matemàtica Aplicada
Universitat de Girona
Campus Montilivi
Escola Politècnica Superior
E-17071 Girona

email: jordi.regincos@ima.udg.es

1. PROJECT OBJECTIVES

The three groups have been working for several years on realistic rendering, and have developed their own rendering platforms (ALEPH, SIR y GIRT). These platforms can be used for the precise, in the physical sense, lighting computation of complex scenes. In this project we try to investigate the use of these platforms on industrial applications, which implies taken into account specific features, that are different for every application field.

The main goals of this project are

- To investigate the application of these techniques to the computer aided design of illumination systems and luminaries.
- To investigate the application of realistic rendering to others applications, including non-conventional ones.
- To improve the rendering platforms. Including new type of objects, increasing the rendering efficiency, improving the characterisation of the reflection process and investigating the benefices of distributed architectures.

To get these goals the project proposed to developed several application prototypes, with the purpose of evaluating the possible use of the technology in specific fields, and a parallel effort devoted to improve the systems Itself. The applications chosen fall in both areas of illumination systems design and luminaries design, and includes classic illumination application as well as novel ones. The application fields chosen were:

- Design of public illumination systems, analysing the perturbation on environment with fog/smoke and vegetation occlusions of the illumination field.
- Design of virtual scenarios.
- Design of emergency illumination systems.

- Design of passive luminaries
- Design of car headlights.
- Analysis of luminaries, and automatic design of luminaries.
- Acoustic rendering.

For most of this applications we had industrial partners or contact from which we got information on the requirements. Anyway, the goal was to evaluate the possibility of deigning and building real applications that satisfy the requirements, and not to implement whole applications.

The work on the improvement of the rendering process has had the following goals:

- Increase the domain of scene objects.
- Increase efficiency:
- Formalisation and measurement of material properties.
- Development of rendering algorithms for participative media and other natural phenomena.

2. LEVEL OF SUCCESS

This section contains a list of the major objectives actually accomplished, indicating the main problems found, and the proposed solutions to solve them. A more detailed description of the result can be found in the summary report.

2.1 Rendering scenes with fog and other natural phenomena.

We have modelled three types of phenomena: the absorption of light intensity by the medium, the emission of light by the medium, and the scattering that produces a directional energy redistribution. We can simulate elastic and inelastic scattering.

We have modelled also the refraction of light in anisotropic dielectric media, using the construction of Huygens

2.2 Automatic design of Luminaries

A design of a general CAD platform for luminaries has been elaborated, and a initial solution of the inverse problem has been proposed. A tool for the Analysis of scene complexity has been developed. Tools for the analysis of the illumination has been also developed.

2.3 Optical properties formalisation and measurement.

A system for the measurement of the BRDF (Bidirectional reflectance distribution function) has been designed and build.

2.4 Simulation of passive luminaries.

A characterisation of passive luminaries has been done and an initial model of the phenomena has been designed. This model is been simulated using ALEPH in order to evaluate the accuracy of the results.

2.5 Analysis of perturbation in the illumination field.

Two different systems are available at this moment. One is based on classic radiosity calculations, while the other is based on Monte-Carlo raytracing.

2.6 Support for new applications.

We have solved the acoustic, physics-based simulation of virtual architectural environments, including closed and half-opened environments, using Monte-Carlo inverse raytracing .

We have specified and implemented software for the generation of complex architectural environments. From 2D plan on DXF format, 3D models are generated on MGF or Maya formats. These work has been shared with project TIC98-0586-C03-02.

We have also implemented geometric editors to enter the scene geometry to the rendering process.

A different aspect investigated on this field has been the development of applications usable through internet. The effort here has gone in two different directions. The first approach has been to make the render available through the network as a remote rendering system. The second one investigate the possibility of building a distribute rendering system using Atlas. We have developed some extensions to Atlas and are now implementing a broadcast mechanism to select the rendering hosts.

2.7 Design of car's headlights.

Due to the new trend of using headlights with completely transparent diffusers, that don't affect the radiance energy distribution of these headlights, we have focused our research on the design of reflectors, modelled as B-spline parametric surfaces. A test bed has been developed simulating the measurement process carried out in the optic laboratory. In order to validate the method we need to compare our results with real data. We will try to get these data from Valeo S.A.

2.8 Design of emergency illumination systems.

A prototype system has been designed, limited to environment without stairs. The prototype have proved the possibility of computing interactively these kind of illumination systems.

2.9 Virtual reality techniques.

We have used volumetric visualisation to study the 3D structure of the illumination of a luminaries. The software developed has been adapted to visualise luminaries in EULUM and INDAL.

2.10 Improving the efficiency of rendering algorithms.

A new method to estimate luminance on a large mesh of small polygons has been developed, and a new method to compute the inclusion test of a 2D point within the convex hull of a set of points, without computing the convex hull.

2.11 Rendering surfaces and volumes.

A new methods to ray-trace b-spline surfaces, which are well suited to deal with the specific problems that arise in designing headlights, has been designed and tested. New representation schemes for solid and volumes have been proposed.

3. RESULTS

This section summarise the results obtained in: personal training, participation in others projects, co-operation with other groups, and the list of publications. The list of goals accomplished

can be found in section 2. A separate document, including a summary of the main results has been elaborated.

3.1. Personal

Most of the people involved on the projects, within the three groups have not got the PhD. For most of them their PhD research is part of their duties in this project. During this three years project some of them have finished their PhD, and a lot of them are actually finishing it. The PhD developed in this period, totally or partially included in this projects are:

Toni Sellarès, *Structural and Algorithmic Aspects of Geometric Projections*, Universitat Politècnica de Catalunya, 2000. Advisors: Ferran Hurtado and Xavier Pueyo.

Martín Perandrés, Domingo: *Alhambra: un modelo para la producción de animación bidimensional*. Universidad de Granada, 1999. Advisor: Juan Carlos Torres

Jorge Revelles Moreno, *Formalización y optimización de métodos de optimización para síntesis de imágenes*, Universidad de Granada, Noviembre 2001. Advisor: Carlos Ureña

Guillermo Gutiérrez Pérez, *Proyecto Aleph: propagación de la luz en medios no homogéneos*. Centro Politécnico Superior de Zaragoza. Noviembre 2001. Advisor: F. J. Serón.

Pedro Miguel Latorre Andrés: *Modelos físicos de iluminación: Simulación por computador*. Centro Politécnico Superior de Zaragoza. Junio de 2001. Advisor: F. J. Serón.

Adriane Borda Almeida da Silva: *Los saberes constitutivos del modelado geométrico y visual. Desde las instituciones científicas y profesionales a las escuelas de arquitectura*. Un análisis de transposición didáctica. Centro Politécnico Superior de Zaragoza. Octubre de 2001. Advisors: J. Arlegui, F. J. Serón.

Alfredo Pina Calafí: *Modelado de un insecto virtual*. Centro Politécnico Superior de Zaragoza. Marzo de 2001. Advisor: F. J. Serón.

Several PhD thesis are in progress: Gustavo Patow, Miquel Feixas, Pedro Cano, Francisco Velasco, Miguel Lastra, Marcelino Cabrera, Francisco Conde, Vicente del Sol, Eva Cerezo, Alberto Turón, Juan Antonio Magallón

Jordi Regincós did a postdoc stage at IRISA (France)

3.2. Industrial relationships

Our partner Kinora, has provided an architectural model that has been incorporated in our test data sets.

Valeo provided information on the testing and measuring process used for lamps.

Zemper provided information on the design and simulation of emergency illumination systems.

The Girona Group have had some meetings with C&G Carandini people in order to discuss the following problems:

- Design of optical sets using inverse computation of reflectors.
- How the reflector design can increase or decrease the lamp heating.
- Visibility problems due to sharp light changes: intensity changes (as can occur in tunnels), or glaring.

The Zaragoza Group has had several contractual activities involving the transference of technology in relation to some of the results obtained in this project:

Industrias Derivadas del Aluminio S. A. (INDAL S. A.)

Two agreements have been signed so far via OTRI of the University of Zaragoza, to develop the radiosity calculation modules for its interior, exterior and projection illumination calculation system, named INDALWIN. Those modules apply directly the results obtained in this project.

GRUPOLUX empresa Tecnoluz Ensayos y Calibraciones S. L., and the Applied Optics Group of the University of Zaragoza

The goal of the collaboration is to gather together the knowledge and tools developed by the Grupo de Informática Gráfica Avanzada with the knowledge and lab instruments of the Applied Optics Group of the University of Zaragoza and with the calibration labs and the knowledge of the Spanish lighting market supplied by the company Tecnoluz Ensayos y Calibraciones S. L..

The common goal is to offer a productive, physics-based simulation environment that allows for the generation of synthetic imagery of great realism and fidelity.

Things done so far:

- Several simulations have been performed by the consortium. It is the intention of the group to offer an industrial service for the simulation of lighting. The relation with the university groups is via OTRI of the University of Zaragoza. One agreement have been signed so far via OTRI of the University of

Zaragoza, to develop the radiosity calculation modules for its interior, exterior and projection illumination calculation system, named EUROLUXOR.

– A TIC project has been granted (Ref. TIC2000–0426–P4–02)

Audiomarket Multimedia, currently named *Absolut Media Arte y Comunicación SA*, located in Zaragoza, is very interested in all the aspects relating the precise simulation of sound.

The company has presented several projects so far, relying on the working group from the University of Zaragoza in charge of the simulation of both light and sound. The awarding of one of them is imminent.

D. Fermín Gómez Laguna is working with the company in areas related with the RAVEL system. The group was granted a scholarship to Help the Exchange of Research Personnel between Industries and Public Research Centers, which was given to D. Fermín Gómez Laguna.

3.3. National and international projects participation

Esprit Open LTR 35.772 SIMULGEN project. Our group (Prof. Xavier Pueyo) is the leader of this project. It deals with the illumination simulation in generic environments, and some applications such as car luminaries design. The benefits of this project are clear: some results from generic problems can be incorporated in the current TIC–0973 project and car luminaries design has a close relationship with the reflector design covered in the TIC project.

The co–operation with prof. Poulin has been carried out in the context of a Generalitat de Catalunya mobility program (AIRE). This co–operation has included the study of problems related to bulb overheating.

Jordi Regincos has visit for 8 months the SIAMES (Syntehse d'Image, Animation, Modelisation et Simulation) in the Institute de Recherche en Informatique et Systemes Aleatoires (IRISA), Rennes (France), participating in the TMP PAVR (a Platform for Animation and Virtual Reality) European project, getting theoretical and practical in immersive virtual reality environments.

TIC98–0586 "Realidad virtual aplicada al diseño cooperativo en ingeniería de sistemas de elevada complejidad." in cooperation with the Universitat Politecnica de Catalunya has some common aspects of interest. As said in this report, some models are shared with this project, as well as the software developed for generating these models.

"Cálculo y visualización con SICARA 3D del proyecto de iluminación del hall del Auditorio Teide en Gran Canaria". Lledo S.A. 24/07/00 –31/07/00.

"Cálculo y visualización con ALEPH++del proyecto de iluminación de un hotel de 5 estrellas en Vitoria". Lledo S.A. 19/06/00 – 18/07/00

"INDALWIN–exteriores, sistema de cálculo de iluminación basado enRadiosidad". INDAL, S. A., 1999

"Visualización de datos provenientes de simulación del comportamiento aerodinámico de un deflector de humos". Compañía de Gas Española 1999

3.4. Cooperation with others groups.

Professor Pierre Poulin. Dept Informatique et Recherche Operationelle. Universite de Montrial (Canada). Diseño inverso de reflectores y analisis de comportamiento de elementos para la prevención del calentamiento de las lámparas.

Professors Alvar Vinacua and Pere Brunet. Dpto. de Lenguajes y Sistemas Informáticos. Universidad Politécnica de Catalunya. Especificación del modelo geométrico de los reflectores y estudio de las técnicas de optimización. Generación de modelos geométricos complejos.

Professors Alvar Vinacua and Marta Freiren, from the UPC, co–operated in the development of an Atlas interface for the rendering platforms.

Professor Francisco Feito, from the University of Jaén, design of the hyper–patches model.

3.5. Publications

M. Feixas, E. Acebo, Ph. Bekaert and M. Sbert, An Information Theory Framework for the Analysis of Scene Complexity, **Computer Graphics Forum (Proc. Eurographics '99)**, 18(3):C95–C106

M. Feixas, E. del Acebo, Ph. Bekaert and M. Sbert, Information Theory Tools for Scene Discretization. **Proceedings of the Tenth Eurographics Workshop on Rendering**, Granada, Spain, June 21–23, 1999, pp. 103–114

J. A. Magallón, F. J. Serón: Visualización del entorno de Simulación de la iluminación y visualización fotorrealista ALEPH, en el proyecto de iluminación de las fachadas del Ecmo. Ayuntamiento de Valladolid. **Research–Reportt RR–99–07**, System Engineering and Computer Sciences, Dpto. Ingeniería Eléctrica e Informática, Centro Politécnico Superior, Universidad de Zaragoza. (1999).

- Cabrera, M.; Torres, J.C.; Gea, M. Towards User Interfaces Prototyping from Algebraic Specification **VI Eurographics Workshop on Design, Specification and Verification of Interactive Systems**, DSV-IS '99 Pp: 55–69 Braga, Portugal. 1999.
- Martín, D.; Torres, J.C. Virtual lights: a method for expressive visualization 20th **Annual Conference of the European Association for Computer Graphics EUROGRAPHICS'99–Short papers**. Milano, 1999
- Cano, P.; Velasco, F.; León, A.: Diseño Orientado a Objetos de una Arquitectura para Modelado y Visualización de Volúmenes. **IX Congreso Español de Informática Gráfica (CEIG'99)** Jaen, 16–18 Junio 1999.
- F.A. Beltrán, J.R. Beltrán, Nicolas Holzem, Adrian Gogu: Matlab Implementation of Reverberation Algorithms. **Proc. Digital Audio Effects Workshop '99** pp 91–96. Trondheim (Noruega), Diciembre 99
- E. Cerezo, A. Pina, F. J. Serón: Motion and Behaviour Modelling: State of the Art and New Trends. **The Visual Computer**, vol. 15, nº 3, pp. 124–146, 1999.
- F. Gómez, F. Serón, M. P. Navarro, M. C. Pastor: Rapid Prototyping from Computed Tomography to Manufacture a Skull–Tumour Model. **Second World Manufacturing Congress. International Symposium on Manufacturing Technology (ISMT'99)**, pp. 389–395, 1999. I.S.B.N.: 3–906454–19–3. Editores: S. Nahavandi & M. Saadat Editorial: ICSC Academic Press, Canada/Switzerland
- A. Pina, F. J. Serón: Creando Vida Artificial. Aplicación para el control de Actores Sintéticos. **VIII Conferencia de la Asociación Española para la Inteligencia Artificial**. pp. 1–8, 1999. I.S.B.N.: 931170–0–5 Editores: J. C. Torres, F. Feito
- J. A. Magallón, F. J. Serón, G. Gutiérrez, D. Gutiérrez: Generación por ordenador de los modelos tridimensionales correspondientes a las distintas etapas de la Catedral de la Seo. **XI Congreso Internacional de Ingeniería Gráfica**. pp. 85–98, 1999. Asociación de Expresión Gráfica en la Ingeniería.
- F. Garbajosa, F. J. Serón: Simulación del crecimiento de vegetales basado en el sistema de Lindermyer mediante el uso del interface gráfico RenderMan. **XI Congreso Internacional de Ingeniería Gráfica**. pp. 504–512, 1999. Asociación de Expresión Gráfica en la Ingeniería.
- P.P. Vázquez and F. Pérez, Virtual Occluders for Computing Cheap Soft Shadows for Raytracing, **Actas XX Congreso Español de Informática Gráfica, CEIG'00**, pp. 107–120, Castelló, June 28–30, 2000.
- J. Rigau, M. Feixas and M. Sbert, Visibility Complexity of a Region in Flatland, **Eurographics'00 short paper**, Interlaken, Switzerland, August 20–25, 2000.
- G.Patow; J.R.Jimenez; A.Vinacua; X.Pueyo, Diseño de Conjuntos Ópticos de Luminarias, **Actas del CEIG2000, Comunicaciones cortas**, pp.383–383, Castellon, Junio 2000.
- Ureña, C: Computation of Irradiance from Triangles by Adaptative Sampling. **Computer Graphics Forum**, 19 (2) Pp: 165–171. Junio, 2000
- Torres, J.C.; Conde, F.A.: A fast algorithm to decide the inclusion of a point in the Convex–Hull of a 2D point set. **Journal of Graphics Tools**, December 2000. 5(4), pp. 25–32.
- Revelles, J.; Ureña, C.; Lastra, M. An Efficient Parametric Algorithm for Octree Traversal **8th International Conference in Central Europe on Computer Graphics, Visualization and Interactive Digital Media –WSCG'2000–** Pp: 212–219 Plzen, Czech Republic. 2000.
- Cano, P.; Torres, J.C. Octrees Modificados: una extensión a Octrees clásicos. **II Jornadas Andalúses de Informática Gráfica**. Pp: 1–10. Sevilla, Noviembre 2000.
- Revelles, J.; Ureña, C.: Formalización de Optimizadores Basados en Indexación Espacial. **II Jornadas Andalúses de Informática Gráfica**. Pp: 89–97. Sevilla, Noviembre 2000.
- García, A.L.; Conde, F.A.; Torres, J.C. Modelado de Sólidos usando Hiperparches **II Jornadas Andalúses de Informática Gráfica** Pp: 53–6. Sevilla, Noviembre 2000.
- Jaume Rigau, Miquel Feixas, Mateu Sbert, Scene Visibility Complexity in Flatland, **IliA 00–03–RR, 02/04/00**.
- Jaume Rigau, Miquel Feixas, Mateu Sbert, Visibility Complexity of Animation in Flatland., **IliA 00–05–RR 05/05/00**.
- E. Cerezo, F. J. Serón Imágenes sintéticas de escenas submarinas: una aproximación al problema. **Congreso Español de Informática Gráfica CEIG'00**. pp. 121–142, 2000. I.S.B.N.: 84–8021–314–0. Editores: R. Joan, I. Navazo, R. Quirós

- J. A. Magallón, F. J. Serón: Proyecto ALEPH: Simulación realista de la iluminación en entornos arquitectónicos complejos mediante técnicas basadas en Radiancia. **VIII Congreso Español de Expresión Gráfica en Arquitectura**, EGA'00. pp. 87–92, 2000. Editors: M^a I. Ruiz, J. Regot, E. Redondo
- F. J. Serón, J. A. Magallón, E. J. Sobreviela: Diseño y validación de un sistema de cálculo de Radiosidad para interiores y exteriores. **Research–Reportt RR–00–06**, System Engineering and Computer Sciences, Dpto. Ingeniería Eléctrica e Informática, Centro Politécnico Superior, Universidad de Zaragoza. (2000).
- F.A. Beltrán, J.R. Beltrán: Virtual Space Reverberation Simulation Using a Multispeaker System. **CREATE Symposium: Sound in Space**. Lugar de celebración: Santa Barbara, CA (USA), Marzo 2000.
- A. Pina, E. Cerezo, F.J. Serón: Computer Animation: From Avatars to Unrestricted Autonomous Actors. (A survey on replication and modeling mechanisms). **Computer&Graphics**, vol. 24, nº 2, pp. 297–311, 2000.
- J. A. Magallón, D. G. Pérez, F. J. Serón: OVDG. Sistema de representación de vuelos virtuales basado en datos topográficos reales. Aplicación a la cuenca del Ebro. **XII Congreso Internacional de Ingeniería Gráfica**. CD–ROM, 12 pp., 2000. I.S.B.N.: 84–8448–008–9, D.L.: VA–450–2000. Editores: Asociación de Expresión Gráfica en la Ingeniería.
- J. I. Pulido, F. Gómez, F. J. Serón: Prototipado rápido a partir de imagen médica para la fabricación de estructuras biológicas complejas. **VI Congreso Internacional de Mecánica Aplicada e Computacional**. pp 263–272, 2000. I.S.B.N.: 972–8021–61–5. Editores: Universidad de Aveiro (Portugal).
- J. Rigau, M. Feixas, and M. Sbert, Visibility Complexity of Animation in Flatland, **Proceedings of the 9th Winter School on Computer Graphics and CAD Systems** (Plzen, Czech Republic), pp. 2:352–359, 2001
- J. Rigau, M. Feixas, P. Bekaert, and M. Sbert, View–Dependent Information Theory Measures for Pixel Sampling and Scene Discretization in Flatland. **Proceedings of the 17th Spring Conference on Computer Graphics** (Budmerice, Slovak Republic), pp. 231–238, 2001.
- Cabrera, M.; Gea, M.; Torres, J.C. User profiles to customize the user interface. **UIA–HCI'2001** Pp: 471–475 New Orleans (USA), 2001
- Conde, F.; Torres, J.C. A Simple Validity Condition for B–Spline Hyperpatches **Eurographics'2001 Short papers**. Manchester (UK), 2001F.
- Velasco, J.C. Torres: Cells Octree: A New Data Structure for Volume Modeling and Visualization. **6th International Fall Workshop on Vision, modeling and visualization 2001**. November 21 – 23, 2001. Stuttgart, Germany
- Martín, D.; Torres, J.C. Un marco general para las Transformaciones No Lineales Exendidas Jerárquicas. **XI Congreso Español de Informatica Gráfica (CEIG'2001)**. Pp: 165–178. Girona, Julio 2001.
- Velasco, F.; Torres, J.C.: Uso de Octrees de celdas para visualización de volúmenes. **XI Congreso Español de Informatica Gráfica (CEIG'2001)**.Pp: 99–111. Girona, Julio 2001.
- Revelles, J.; Ureña, C.: A Formalization of Ray Casting Optimization Techniques. **XI Congreso Español de Informatica Gráfica (CEIG'2001)**. Pp: 85–98. Girona, Julio 2001.
- C. Ureña, M. Lastra. Density Estimation on the Tangent Plane for Radiosity. Talk at: **Dagstuhl Seminar on Stochastic Methods in Rendering**. Dagstuhl–Wadern, Germany, 10–15 June, 2001.
- E. Cerezo, F. Serón: Simulating Underwater Scenes. A first pproximation. **9th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision**, pp. 395–402, **2001**. Editors: Nadia Magnenat Thalman, Vaclav Skala. University of West Bohemia, Plzeu, Czech Republic.
- F. J. Serón, R. Rodríguez, A. Pina, E. Cerezo: Adding Support for High–Level Skeletal Animation. **IEEE Transactions Visualization and Computer Graphics**, (*in press*).

Papers in review proccess

- Cano, P.; Torres, J.C.: Representation of Polyhedral Objects using SP–OCTREES. **10th International Conference in Central Europe on Compuer Graphics, Visualization and Computer Vision 2002**. Plzen, Czech Republic
- Cano, P.; Torres, J.C.: Progressive Transmission and Edition of Solids using Space Decomposition Hierarchical Schemes. **Solid Modeling 2002**. Germany, 2002