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MINISTERIO DE CIENCIA E INNOVACIÓN

DIRECCIÓN GENERAL DE INVESTIGACIÓN

PROYECTOS I+D, ACCIONES ESTRATÉGICAS Y ERANETS

INFORME DE SEGUIMIENTO ANUAL

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Titulo del Proyecto: CAD BASADO EN EL MODELADO Y LA SIMULACIÓN DEL TRANSPORTE DE LUZ
Organismo: Universitat de Girona
Centro: Institut d’Informàtica i Aplicacions
Departamento: ---
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Fecha: 16 de Febrero de 2010

SR. SUBDIRECTOR GENERAL DE PROYECTOS DE INVESTIGACIÓN
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A. ACTIVIDADES REALIZADAS Y GRADO DE CONSECUCIÓN DE LOS OBJETIVOS PROPUESTOS

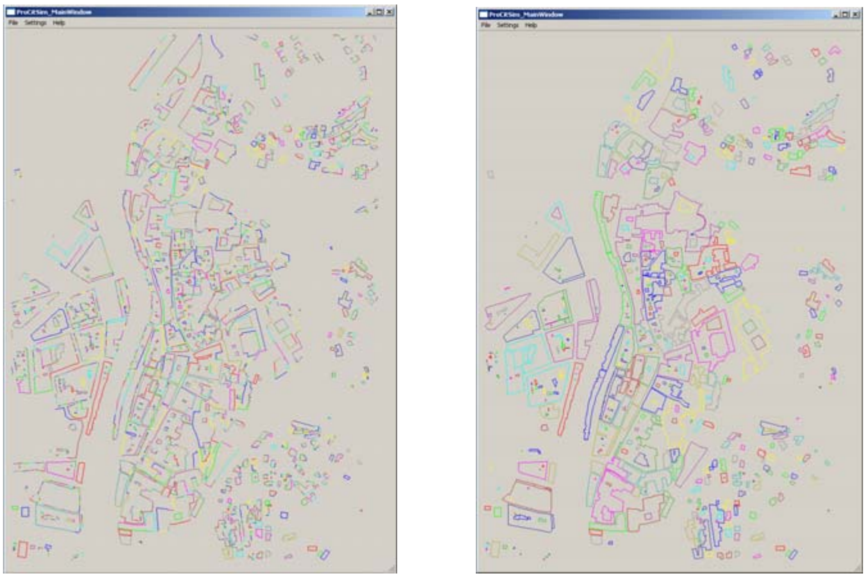
1. Describa brevemente las actividades realizadas en el pasado año de desarrollo del proyecto. Indique si existe algún resultado a que haya dado lugar el proyecto durante ese período.

Dado que, en las explicaciones para el resumen que hemos tenido que entregar recientemente para las jornadas de seguimiento del próximo 5 de Marzo, hemos entendido que podíamos aprovechar el trabajo allí llevado a cabo, por lo que copiamos a continuación la parte del resumen para las jornadas correspondiente al segundo año. Rogamos nos comuniquen si es necesaria su traducción al español.

Bloque 1. Modelado urbano.

Restructuring of cadastral city data

Our goal has been to create a hierarchic and robust data structure that represents, with the most possible fidelity, a modern city and its blocks of buildings.
From cadastral data of the city (provided by the local City Council), we process it and correct its errors (frequent mistakes and anomalies) in a uniform way. Consequently, we get structured data able to recognise the blocks and any interesting urban element from this data. This problem is complex because it is necessary to identify not just simple file elements from the input file, but also their connectivity and structure in the real world.



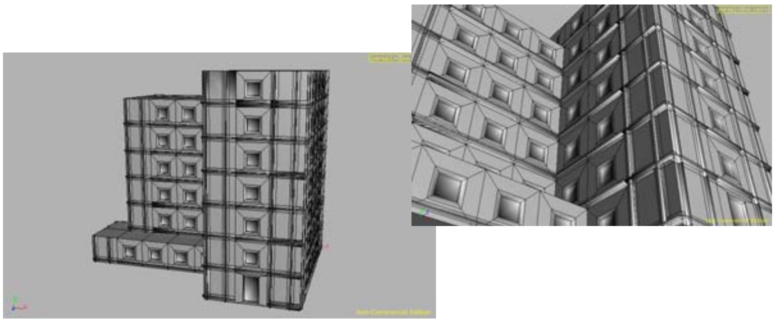
Non structured (left) input data and structured (right) result.

Synthetic Procedural City Modelling

We have continued and improved the implementation of the most effective solutions to date, using procedural tools based on rules. We have added new solutions, more efficient, flexible and user-oriented for urban modelling. In particular, we are currently working on hierarchic urban generation, something which will, in turn, let us employ a precise search system inside the city to localize landmarks and other unique architectural structures, like applying a set of specific rules to create a distinctive urban landmark.

Prototype for city generation: using pattern-based procedure.

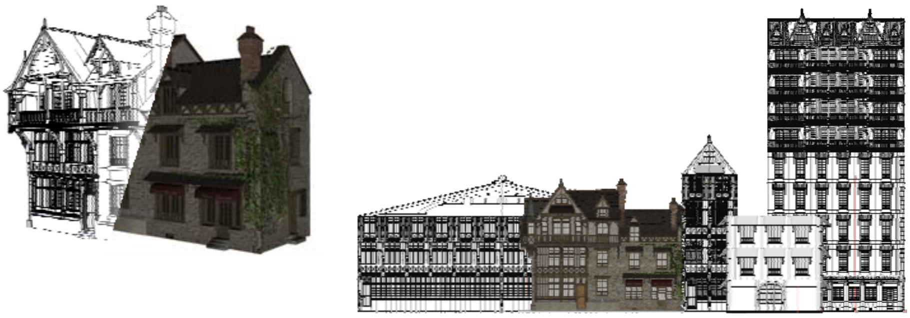
In http://ima.udg.edu/~dagush/projects/skylineEngine/ additional information is available.



Initial prototype for procedural building generation

User-Friendly Graph Editing for Procedural Buildings

In this part we have developed a simple and elegant interactive visual editing scheme for shape grammars, allowing the creation of rule-bases from scratch without text file editing and in a very user-friendly way [1]. Up to now, there was a disassociation between the rules and their application, resulting in a somewhat unnatural development process. Here we bridge this gap by providing a direct rule-based editing metaphor, which lets the user create new buildings without changing their workflow, in a much more direct and intuitive manner. This shift also opens the door to a whole series of possibilities, ranging from simple model verifications to full model editing through graph rewriting operations.



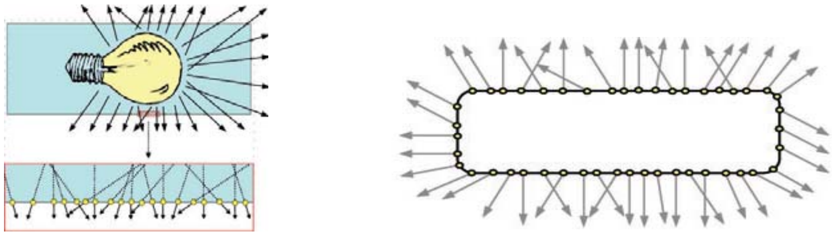
Generation of a variety of buildings (right) from a building template (left)

Bloque 2. Iluminación artificial.

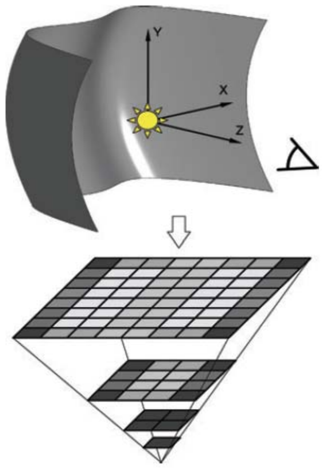
GPU Acceleration techniques for reflector design.

As stated in the previous report, this part was almost finish. The goals have been fulfilled and the results have been published in a international journal [2]. In this paper we present a new technique based in Quad-Tree Relief Mapping to represent the reflector as a mipmap height field (figure bellow) and then trace rays in an efficient way. We have extended the original technique to support multiple reflections and multiple ray orientations. Using this approach the lighting computations per reflector have been reduced to less than 1 second per reflector using 1 million particles to represent the bulb light emission.

- Implementation of a technique to compute the lighting distribution using near-field light sources.

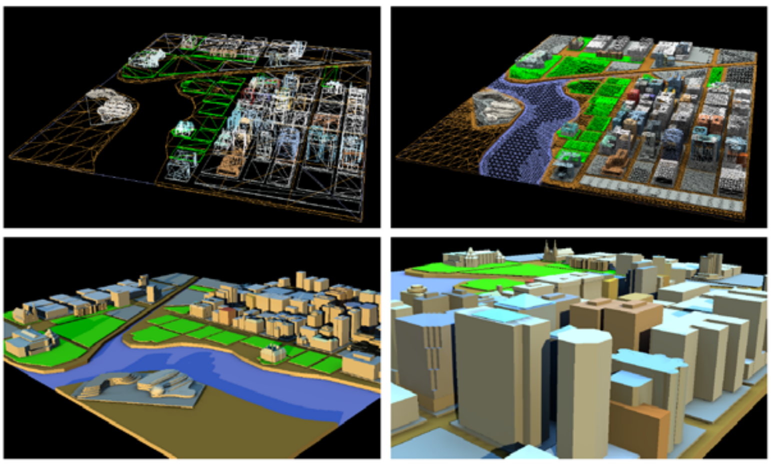


- Use of the rapid lighting distribution computation technique to guide the optimization process in inverse reflector design.



Bloque 3. Iluminación natural.

We have improved the first implementation a new method of interactive simulation that allows direct light to efficiently carry out an adaptive subdivision of the model. This has produced the necessary results to publish the proposed technique in an international event. The technique is based on the calculation of visibility through parallel projections from a set of directions from the sky, performed by hardware. The method enables interactive lighting visualizations with changing conditions of day and time, and editing the material characteristics of the model.



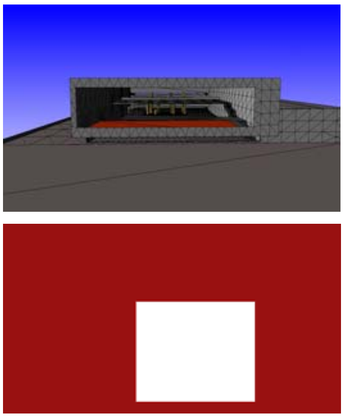
Results of applying the adaptive subdivision method to a urban model. Input model (8987 triangles, upper left), subdivided model (128309 triangles, top right), displayed with two different natural lighting conditions (bottom)

We have also keep on improving our tool to interactively visualize simulation results in light conductors systems under different sunlight date and time conditions, as well as on the evaluation and analysis of lighting architectural projects.

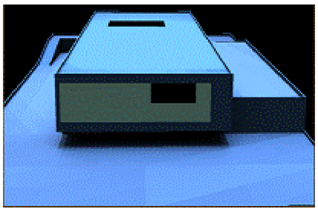
Bloque 4. Iluminación asistida.

We have improved our inverse daylighting model devoted to the design of building openings. Our objective is to compute opening shape from desired illumination conditions in the early stages of architectural design, using an inverse model [3].

The inverse daylighting model includes sky lighting as well as light reflected by surroundings, and therefore combines near-field and far-field light sources. Input data is a heterogeneous lighting distribution on indoor faces called “lighting intention”. Openings are considered as a set of intermediate anisotropic light sources. Therefore the geometric reconstruction problem is seen as a source emittance problem. A pin-hole model generates anisotropic light sources and computes light contribution on each indoor faces. An image metric evaluates the distance between this light contribution and lighting intention. Intermediate light sources which have the smallest distance are selected to be part of opening, and therefore define opening shape. This technique is intended to aid opening design in the early stage of architectural design. Our model is validated from test cases and illustrated by a case study in order to show the opening reconstruction process.



Lighting intention

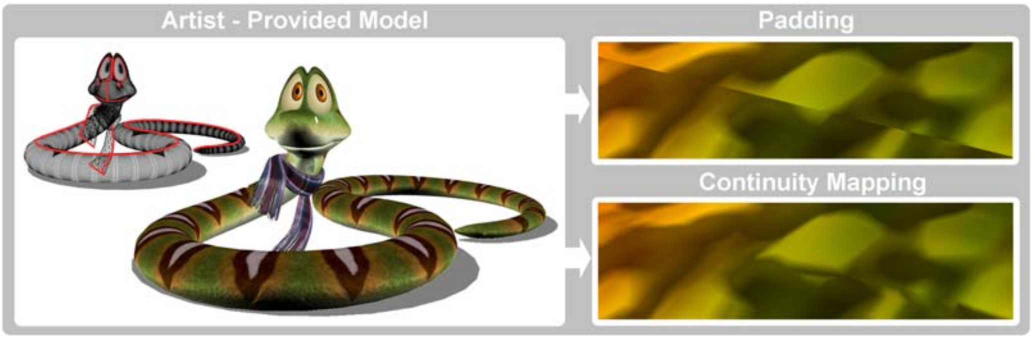


Final opening shape

Bloque 5. Visualización interactiva

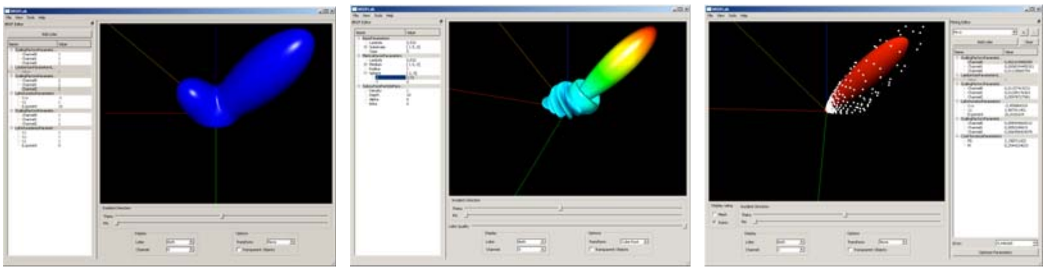
In this block we have done very significant advances on several operations/functions to deal with high quality and reliable realistic visualization at interactive rates:

- We developed two techniques (collectively known as *Continuity Mapping, CM*) that together make any multi-chart parameterization seamless: *Traveler's Map* is used for solving the spatial discontinuities of multi-chart parameterizations in texture space thanks to a bidirectional mapping between areas outside the charts and the corresponding areas inside; and *Sewing the Seams* addresses the sampling mismatch at chart boundaries using a set of stitching triangles that are not true geometry, but merely evaluated on a per-fragment basis to perform consistent linear interpolation between non-adjacent texel values [4].

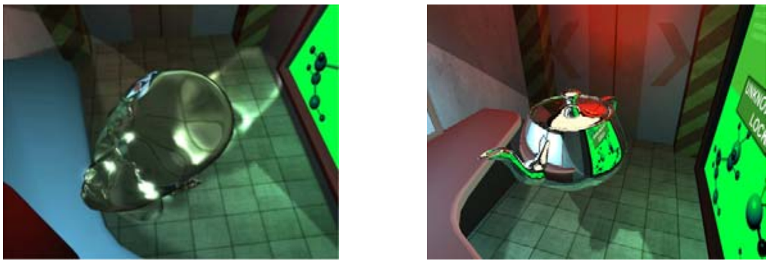


- Rendering of path-based surface detail in real-time (like the groves in the example of the figure below) [5].

- Development of a general system for designing BRDFs: BRDFLab [6]
  http://brdflab.sourceforge.net/



- GPU based reflection and caustic effects solving simultaneously two problems of previous methods: lost of caustic energy and insufficient caustic sampling [7].



References.

[1] "User-Friendly Graph Editing for Procedural Buildings", Gustavo Patow, Submitted.

[2] "Fast Inverse Reflector Design (FIRD)". Albert Mas, Ignacio Martín and Gustavo Patow. Computer Graphics Forum , Vol. 28 (8), pp. 2046-2056, 2009.

[3] “A Simulation Method for Inverse Daylight Opening Design in Buildings” G. Besuievsky and V. Tourre. Published in "Proceedings of IV Iberoamerican Symposium in Computer Graphics - SIACG, pp 39-47 , 2009

[4]"Continuity Mapping for Multi-chart textures", Francisco González, Gustavo Patow, ACM Transactions on Graphics (ToG), Volume 28, Issue 5, Texturing, Article No. 109, pp 1-8, 2009

[5]“Real-Time Path-Based Surface Detail”, Carles Bosch and Gustavo Patow, Computers & Graphics, 2010, accepted with minor revisions.

[6] “BRDFLab: A general system for designing BRDFs”, Adrià Forés, Carles Bosch, Sumanta Pattanaik, Xavier Pueyo. CEIG’2009, (seleccionado por el Comité de Programa para posible publicación en una revista internacional), 2009

[7]"Specular Effects on the GPU: State of the Art", Lászlo Szirmay-Kalos, Tamás Umenhoffer, Gustavo Patow, Lászlo Szécsi, Mateu Sbert, Computer Graphics Forum, Volume 28 (6), pp. 1586-1617. 2009.

2. Si ha encontrado problemas en el desarrollo del proyecto, coméntelos, especificando su naturaleza (de carácter científico, de gestión, etc).

There have not been significant deviations in the sense of introducing possible modifications of the global objectives neither in the quantity or quality of the results. Nevertheless some changes have been introduced in the work program due to incidences like the lack of some information and/ the evolution of graphics hardware providing new performances that suggest to change the strategy foreseen in the project’s proposal. We also had to invest some time to solve unforeseen problems related to the use of GPUs. Another important aspect that introduced some additional work is the lack of information on BRDFs and the difficulty of editing/designing them which is mandatory to be able to get realistic images representing real materials, so their interaction with light. In any case, we do not foresee relevant changes in the expected results of the project and we have obtained interesting research and technological results that were not expected.

Incidencia 1.
Task 2 of Block 2 has its milestones due to the 3rd year. However, since the work has already begun, we want to propose a change in its goals due to the results and the experience acquired in Task 1. Despite of the acceleration provided by the technique presented in [2], we have realized that there are accuracy problems in certain reflector setups. Specifically, reflectors with surfaces almost perpendicular to the height field direction are not very well represented. At the same time, there have been advances in GPU ray tracing availability that allow the use of triangulated surfaces as reflector representation without an extra computational cost.

Using pure ray tracing with triangle meshes has the advantage of getting rid of the restriction to represent the surface as a height field. Our experiments show that using new generation GPU ray tracers like OptiX (NVIDIA) make the use of general 3D surfaces for the reflectors possible.

Since the surface representation is no longer a problem, we propose to change the goal of Task 2. The main bottleneck now is the global optimization algorithm, especially when using a large number of parameters to control the surface. We have started to work in a new stochastic global optimization technique that allows exploring a large reflector space with lots of local minima.
The new milestones would be: Month 27: Analysis of stochastic techniques suitable to global optimization. Month 36: New stochastic technique for global optimization in inverse reflector design. Software and report.

Incidencia 2.
The mistakes and anomalies of cadastral data of real cities provided by the Local City Council are very frequent and more complex than expected. So we had to process and correct them in order to get structured data able to recognise the blocks and any interesting urban element from the

real input data. This unforeseen hard task is explained in the beginning of Block 1 report "*Restructuring of cadastral city data*".

Incidencia 3.
Due to the extra work done in other tasks (like the one described just above) and the fact that we hope to take advantage of current work of other parts of the project, we decided to postpone Task 1 of Block 4.

Incidencia 4.
We needed to face the problem of obtaining correct surface material and surface details (example: grooves) in order to be able to visualize our scene with the required degree of realism. Otherwise, the effort made on getting reliable light sources would be fruitless in the context of the project.

Incidencia 5.
Task 3 of Block 5 has not been achieved yet as a consequence of the additional, unforeseen, work we have done concerning interactive visualization. See report of Block 5 and its result