

Photorealistic Image Synthesis and development of interfaces in computer games

TIC2001-2416-C03

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Abstract

We present here a report on the running project Photorealistic Image Synthesis and development of interfaces in computer games, project number TIC Síntesis de imágenes fotorrealistas en juegos por ordenador. TIC2001-2416-C03, financed by the Spanish Ministry of Science and Technology.

Introduction

We present here a report on the running project Photorealistic Image Synthesis and Development of Interfaces in Computer Games, project number TIC2001-2416-C03-01¹, financed by the Spanish Ministry of Science and Technology. This is a coordinated project between the University of Girona, University Jaume I, and University Pompeu Fabra. In this project the know-how of participant groups in areas of realistic rendering and multiresolution will be applied to the development of new techniques or to the adaptation of existing ones for their use in computer games. Given the closeness between the techniques used in computer games and the ones in virtual reality, the developed algorithms are likely to be also useful to the virtual reality field. Also, more realism demands the development of more sophisticated man-game interfaces.

The project is organized in three subprojects, Photorealistic image synthesis², Multiresolution modelling³ and Advanced interface design for computer games⁴, being respectively responsible for each subproject University of Girona (UdG), University Jaume I from Castelló (UJI) and University Pompeu Fabra from Barcelona (UPF).

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¹ The project was recently presented in Eurographics 2003, the most important conference of Computer Graphics in Europe.

² <http://ima.udg.es/iiia/GGG/TIC2001-2416-C03-01/>

³ <http://graficos.uji.es/proyecto.php?numero=16>

⁴ <http://www.tecn.upf.es/videojocs/>

Next we describe the project objectives in section 1, level of accomplishment in section 2, and results in section 3. Each section is divided into three subsections corresponding to each subproject.

1 Project Objectives

The project is a 3 year project, with start date 2001-12-01 and end date 2004-11-30. The total project funding: is ca. 170.000 euro, distributed in ca. 90.000 euro for the first subproject, ca.60.000 for the second one, and ca. 20.000 for the third one. In addition a 4 year PhD student fund was assigned to the first subproject. Around 6 people were involved with the first subproject, 4 people with the second and two with the third.

A first common task of all three projects was the selection of common 3D engine platforms where to develop upon. Due to the different nature of the subprojects, no common platform was found to suit all three subproject needs, and thus on one side the third subproject selected the Unreal platform, and on the other side the first and second subproject work both on Crystal Space and Fly3D platforms.

We present next the scientific objectives of each subproject.

Subproject number 1: Photorealistic image synthesis. University of Girona:

General objective:

To obtain new methods and adapt existing ones of photorealistic image synthesis for their application to computer games and virtual reality.

The subobjectives are the following:

Non-physical simulation of the global illumination. UdG1
Automatic computation of trajectories for exploration of virtual environments and reconstruction in Image Based Rendering. UdG2
Use of simplified environments for the acceleration of the illumination calculation. UdG3
Acceleration of global illumination computation (with hardware UdG6, parallelism UdG5, and coherence UdG4).

Subproject number 2: Multiresolution modelling. University Jaume I:

General objective: Increase the visualization speed of complex scenes using Multiresolution Modeling (MR)

The subobjectives are the following:

Comparison of existing multiresolution models UJI1
Full development of MOM (Multiresolution Ordered Meshes) UJI2

Development of new multiresolution models using connectivity information UJI3
Development of specific multiresolution models (trees and plants) UJI4

Subproject number 3: Advanced interfaces design. University Pompeu Fabra:

General objective: To determine requirements and development criteria to define new interfaces for computer games taking into account application and usability parameters.

The subobjectives are the following:

Analysis of Motion-Capture as input interface. UPF1
Interface studies on Augmented-Reality systems used as output-interface. UPF2
Video-capture as input/output interface. UPF3
Interactive narratives and their relation with Artificial Intelligence as a paradigm for the interaction between agents and characters in the game. UPF4
Artificial Intelligence topics and their relationship with computer games. UPF5

2 Level of Success



Fig.1 Screenshots showing results of the obscurances techniques (UdG), LOD trees (UJI) and camera positioning (UPF).

Subproject number 1: Photorealistic image synthesis. University of Girona:

The following objectives have been totally or in its majority accomplished: UdG1: Non-physical simulation of the global illumination, UdG2: Automatic computation of trajectories for exploration of virtual environments and reconstruction in Image Based Rendering, Acceleration of global illumination computation (with hardware UdG6, parallelism UdG5, and coherence UdG4). In this moment we are porting to 3D engines selected the obtained algorithms that run in real time. We have also begun to work on subobjective UdG3: Use of simplified environments for the acceleration of the illumination calculation. Also, due to the close relationship between the areas of

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the first (illumination, UdG) and second (modeling and geometry, UJI) subprojects we have been in close contact to incorporate the illumination algorithms and the ones for point-of-view selection to LOD and tree models. This should be done in the third year of the project.

The scientific results of our work can be found under the results section. Around thirty scientific publications have been produced, and four students have finished their PhD in the context of the projects (three of them have already read their dissertation).

Also, we will end in the third year the tasks still unfinished, mainly concerning to objective UdG3, and finish porting to the selected game engines the developed real time algorithms.

On the other hand, we have explored the application to virtual reality, and collaborated with project “Sistema de interacción inmersiva en entornos de realidad virtual”, TIC2001-226-C02-02 (headed by Dr. Xavier Pueyo) in an objective not explicitly contemplated in our project, such as porting the game engines with our illumination algorithms to virtual reality platforms.

Subproject number 2: Multiresolution modelling. University Jaume I:

The subproject developed in the University Jaume I, has four main objectives: the comparison of multiresolution models (UJI1), the complete development of MOM (UJI2), the research in models which exploit connectivity (UJI3) and the development of specific models for trees and plants representation (UJI4).

Regarding the first objective (UJI1), a survey and characterization of multiresolution models has been published in a scientific journal. At present time we are working in the development of a set of test to compare well-known multiresolution models. Implementations of the following models Progressive Meshes, View Dependent Progressive Meshes, Hierarchical Dynamic Simplification and Multi-Triangulation, have been done. Those models will be compared with the developed ones in our subproject Multiresolution Ordered Meshes, Multiresolution Triangle Strips and LOD Strips.

The second objective (UJI2) has been the extension of MOM. Nowadays, MOM is a completely developed model. We are working in its inclusion in the Fly3D engine.

We have developed two models which exploit connectivity (UJI3): MTS that has already been published and LOD Strips (actually in development). MTS has already been demonstrated in the Fly3D. The extensions of the models are planned for the rest of the year.

A multiresolution model for trees and plants representation has been developed (UJI4). It is in the process of integration with complex scenes formed by thousands of trees. The aim is to have

scenes of woods where the user can move in real time. Artistic representations of plants and trees in real time have been also developed. We are in close contact with UdG to incorporate their algorithms in our tree model.

Subproject number 3: Advanced interfaces design. University Pompeu Fabra:

The initial plan for the 36-month sub-project aimed to achieve the whole set of five main objectives, and we have been working in different levels in order to develop the most of each one of them, although we rescheduled the work putting stronger efforts in the two last topics, as we were not provided with the MCYT grant we requested for the planned personnel. In general terms, we have had different activities to support our initial goals although the results differ from the plan.

Instead of the planned two full-time research students we only had a single PhD student (Alejandro Ramírez), but we have additional researchers being involved with the tasks, even if they have only a partial dedication (Oscar Civit and Daniel Sánchez-Crespo). There has been also involvement of UPF researchers outside our Interactive Technologies Group and several internal seminars have been conducted on AI and videogames. The state of the art was reviewed and the main conclusions were:

- although games are increasingly using AI techniques, these are several years behind current research; significant advances might be achieved using state of the art AI techniques in current games related problems
- games simulation, especially behavioural simulation, seem to pose challenging problems to current state of the art research even in relatively simple settings; a test-bed on behavioural simulation simple enough but able to evolve could probably stimulate this type of research.

Interfaces (UPF1,UPF2,UPF3)

The funds obtained have allowed the Research Group to acquire diverse tools and hardware to experiment with interfaces. Ricardo Gadea, with a grant from the University's Audiovisual Institute, has been developing virtual-body installations, that allows us to experiment with a real-time data/physical interface (using vital signs, biofeedback). His work uses a virtual environment as a performance space for interactivity, using a new-interface approach to the control of visual elements, such as those used in interactive games, within a framework of a physical approach to interactive results.

The use of bio-feedback (sent through a wireless connection) to register body movements for real-time digital imaging and processes, allows to handle physical inputs (such as vital signs, cardiac activity, breathe, muscles, brain, heart) to control a 3D context. Spatial and temporal parameters are the result of a biological feedback.

Interactive narratives and AI (UPF4, UPF5)

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This is the subject of the ongoing work of the full time PhD student. The main visible result is the research report that focuses on the research possibilities of Interactive Storytelling (concretely in the potential of developing different cinematic tools within a storytelling system) with the intention to provide strong, advanced and coherent narrative capabilities in a virtual environment where stories are generated with virtual actors. The context of the proposal is a virtual scenario, developed with a game engine, where virtual actors and agents manage to generate a story that results from AI formalisms, such as planning techniques and state-machines. The application of the scenario is currently under development but it has already been tested and the first results are being obtained.

The basic idea behind the application is to use and explore the cinematic language, and its elements, since not only the language has different formalisms that make it adequate to be translated to a computer system, but it is successful among both users and spectators when they experience a story that is being told. One of the main strengths of the approach, in comparison to other ontologies, is that users need not to be familiar with the formalisms of such a language in terms of a knowledge of its principles, since they are already familiar with its results and effects in the overall storytelling process.

The project already has a minimal set of camera control, automatic camera positioning, angles, direction, and cinematic-oriented capabilities to the virtual scenario. The current camera controls allow basic film movements, such as dolly, zoom, panning and tracking, but we aim to continue the development of a broader film ontology. This initial framework provides a basic stage (within the game-engine environment, specifically Unreal Tournament) where the camera and some agents allow the creation of a basic cinematic experience, using simple AI (finite-state machines) to control the cinematic narrative elements, according to states and character descriptors within a single room.

The applications include computer-games and storytelling systems based in game engines, which make use of an improved interface to the visual experience. Although there are some approaches to camera control, we feel they lack the role it usually has in the cinematic context, and their results are far from achieving the suspension of disbelief of users and we aim at improvements in this area.

The following steps include the extension of the cinematic set (more and improved camera movements), as well as the development of improved character definitions, in order to have a minimal area to produce the final results: the camera and the story interrelated to provide storytelling capabilities from AI formalisms. As mentioned, a basic ontology for camera control has been developed, and its capabilities are being explored. Future steps include the use of more complex AI (developing an API to make use of techniques such as planning).

The objective of establishing a state-of-the-art in order to set a correct background for AI applications related to computer games has been fully developed. The state-of-the-art is now part of an internal report, and was also presented as part of a research report that led to obtaining the Advanced Studies Diploma by the current researcher on the subject.

The report mentions that even though computer games have traditionally implemented empirical solutions to many AI problems, are now turning to more traditional AI algorithms. After

introducing the role of AI in gameplay, the report reviews the main techniques used in current computer games such as finite-state transition networks, rule-based systems and search algorithms. The report includes the description of the implementation of AI in several commercial computer games, as well as an overall view of academic research in AI targeting computer games applications.

Other approach has been taken in the three chapters of Sanchez-Crespo's new book on games programming, fully devoted to AI applied to the games context.

Games techniques in another research context

Videogames techniques have been applied in an European research project to achieve real time molecular visualization and interaction; a whole engine (Molecular Open Inventor) has been modified providing a standardised support for researchers in the field.

Oscar Civit has started exploring the Physics based aspects of games. Both himself and Sánchez-Crespo are starting their PhDs this academic year.

3 Result indicators

Subproject number 1: Photorealistic image synthesis. University of Girona:

Publications related to the project:

1. Àlex Méndez, Mateu Sbert, Jordi Catà
Real-time obscurances with Color Bleeding (The Three Cubes Demo) Video Presentation, Eurographics 2003, Granada, Spain
2. Keller, T. Kollig, M. Sbert, L. Szirmay-Kalos
Efficient Monte Carlo and Quasi-Monte Carlo Rendering Techniques Tutorial, Eurographics 2003, Granada, Spain
3. M. Sbert, A. Iones, A. Krupkin, À. Méndez
Fast Realistic Lighting for Video Games
Speech proposal for Game Developers Conference 2004, San Jose, EEUU
4. F. Castro, M. Sbert, L. Neumann
Fast Multipath Radiosity using Hierarchical Subscenes
Enviado a la revista Computer Graphics Forum.
5. Görgy Antal, Roel Martínez, Ferenc Csonka, Mateu Sbert, László Szirmay-Kalos
Combining Global and Local Global-Illumination Algorithms,
Proceedings of Spring Conference on Computer Graphics SCCG 2003,
Bratislava, Slovakia, April 2003.
6. Àlex Méndez, Mateu Sbert, Jordi Catà
Real-Time Obscurances with Color Bleeding,
Proceedings of Spring Conference on Computer Graphics SCCG 2003,
Bratislava, Slovakia, April 2003.
BEST PRESENTATION AWARD
7. Pere-Pau Vázquez and Mateu Sbert
Bandwidth Reduction for Remote Navigation Systems Through View Prediction and Progressive Transmission.
Accepted for publication in Elsevier's Future Generation Computer Systems International Journal.
8. Pere-Pau Vázquez and Mateu Sbert
Perception-based illumination information measurement and light source placement.
Lecture Notes in Computer Science, 2003 (Proc. of ICCS'2003).

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9. Pere-Pau Vázquez and Mateu Sbert
Fast adaptive selection of best views.
Lecture Notes in Computer Science, 2003 (Proc. of ICCS'2003).
10. Pere-Pau Vázquez and Mateu Sbert
Automatic Indoor Scene Exploration.
Proceedings of 6th International Conference on Computer Graphics and Artificial Intelligence (3IA 2003).14-15 May 2003, Limoges, France.
11. Àlex Méndez, Mateu Sbert, Laszlo Neumann
Obscurances for ray-tracing,
EUROGRAPHICS 2003 Poster Presentation, Granada, Spain, 2003.
12. Roel Martínez, László Szirmay-Kalos and Mateu Sbert
A Multiple Depth Buffer Implementation for Radiosity
Computer Graphics and Geometric Modeling CGGM2003, Montreal, Canada, May 18-21, 2003.
13. J. Rigau, M. Feixas, and M. Sbert
Refinement Criteria for Computer Graphics using Convex Functions
Compositional Data Analysis Workshop, Girona, 15-17 Octubre 2003
14. J. Rigau, M. Feixas, and M. Sbert
New Contrast Measures for Pixel Supersampling
Advances in Modeling, Animation and Rendering. Proceedings of CGI'02 (Bradford, UK), pp. 439-451. Springer-Verlag London Limited, London, UK, 2002. ISBN 1-8523-3654-4.
15. J. Rigau, M. Feixas, and M. Sbert
Entropy-Based Adaptive Supersampling
The 13th Eurographics Workshop on Rendering, Poster Papers Proceedings (Pisa, Italy), pp. 63-70, 2002.
16. M. Feixas, J. Rigau, P. Bekaert, and M. Sbert
Information-Theoretic Oracle Based on Kernel Smoothness for Hierarchical Radiosity.
Short Presentations of Eurographics (Saarbrücken, Germany), pp. 325-333, 2002.
17. J. Rigau, M. Feixas, and M. Sbert
Information-Theory-Based Oracles for Hierarchical Radiosity
II International Workshop on Computer Graphics and Geometric Modeling (CGGM'2003) in the 2003 International Conference on Computational Science and Its Applications (ICCSA 2003) (Montreal, Canada), may-2003.
18. J. Rigau, M. Feixas, and M. Sbert
Entropy-Based Adaptive Sampling
Proceedings Graphics Interface 2003 (Halifax, Canada, June 11-13), pp. 149-157. Canadian Information Processing Society, 2003, ISBN 1-56881-207-8.
19. J. Rigau, M. Feixas, and M. Sbert
Refinement Criteria Based on f -Divergences.
Rendering Techniques 2003 (14th Eurographics Workshop on Rendering, Leuven, Belgium, June 25-27), pp. 260-269.
Per H. Christensen and Daniel Cohen-Or (eds.), Association for Computing Machinery, New York (NY), USA, 2003, ISBN 1-58113-754-0.
20. Mateu Sbert, Jaume Rigau, Miquel Feixas and László Neumann
Systematic Sampling in Ray Tracing
IVth IMACS Seminar on Monte Carlo Methods MCM 2003, 15-19 September 2003, Berlin
21. Mateu Sbert and Philippe Bekaert
Reusing Paths in Radiosity and Global Illumination
IVth IMACS Seminar on Monte Carlo Methods MCM 2003, 15-19 September 2003, Berlin
22. A. Iones, A. Krupkin, M. Sbert and S. Zhukov
Fast Realistic Lighting for Video Games
IEEE Computer Graphics & Applications may/june 2003
23. Pere Pau Vázquez, Miquel Feixas, Mateu Sbert and Wolfgang Heidrich
Automatic View Selection Using Viewpoint Entropy and its Application to Image-Based Modeling. Computer Graphics Forum
24. Philippe Bekaert, Mateu Sbert and John Halton
Accelerating path tracing by reusing paths
Rendering Techniques 2002 (Eurographics Workshop on Rendering), pp.125-134, ACM Siggraph Press
25. Mateu Sbert, Miquel Feixas, Jaume Rigau, Francesc Castro and Pere Pau Vázquez
Applications of Information Theory to Computer Graphics
Invited Talk, 3IA' 2002, Limoges, 2002
26. Roel Martínez, Laszlo Szirmay-Kalos and Mateu Sbert
A Hardware Based Implementation of the MultipathMethod

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CGI2002, Computer Graphics International, Bradford UK, July 1-5, 2002, Proc. of Computer Graphics International 2002, J. Vince and R. Earnshaw (eds.), Ed. Springer, ISBN 1-85233-654-4.
27. Pere-Pau Vázquez and Mateu Sbert
Automatic Keyframe Selection Techniques for High-Quality Image-Based Walkthrough Animation Using Viewpoint Entropy
International Conference of Central Europe on Computer Graphics, Visualization and Computer Vision, Plzen, Feb 4-8 2002
Also in Journal of WSCG, Volume 10, No.1, Pages 461-468, ISSN 1213-6972.
28. Pere-Pau Vázquez and Mateu Sbert
Bandwidth Reduction Techniques for Remote Navigation Systems
Lecture Notes in Computer Science, number 2330, pp. 249-257, 2002 (Proc. of ICCS'2002)
29. Pere-Pau Vázquez, Miquel Feixas, Mateu Sbert and Wolfgang Heidrich
Image-based Modeling Using Viewpoint Entropy
Computer Graphics International 2002, (CGI2002), 1-5 July 2002, Bradford, UK
30. Pere-Pau Vázquez, Miquel Feixas, Mateu Sbert and Antoni Llobet
Viewpoint Entropy: A New Tool for Obtaining Good Views for Molecules
D.Ebert, P.Brunet, I.Navazo (eds.)
Data Visualisation 2002 (Eurographics/IEEE TCVG \ Symposium Proceedings). May 27-29, 2002, Barcelona, SPAIN.

Also, three PhD students in the team have already read their dissertation and an additional one got already the approval of the PhD programme to be read. The four PhD's have been developed partly in the framework of the project. They are the following:

Miquel Feixas, *An Information-Theory Framework for the Study of the Complexity of Visibility and Radiosity in a scene*, december 2002, advisor: Mateu Sbert.
Francesc Castro, *Efficient Techniques in Global Line Radiosity*, december 2002, advisor: Mateu Sbert.
Pere Pau Vázquez, *On the Selection of Good Views and its Application to Computer Graphics*, may 2003, advisors: Mateu Sbert and Wolfgang Heidrich.
Roel Martínez, *Adaptive and Depth Buffer Solutions with Bundles of Parallel Rays for Global Line Monte Carlo Radiosity*, december 2003 (to be read), advisor Mateu Sbert.

In addition two new PhD students have started their PhD with subjects related to the project. One of them is Àlex Méndez, who has the grant assigned together with the project, and the other one is Jordi Rovira, who is employed in a game company.

Several BsC and MsC thesis are being done in the context of the project. Also, the posgraduate student Jordi Catá was contracted by the project. His duties were to install and evaluate software development kits for different consoles, to help to incorporate into Crystal 3D Space the obscurances algorithm and to evaluate this engine as a virtual reality platform. This last task has been done in collaboration with the project "Sistema de interacción inmersiva en entornos de realidad virtual", TIC2001-2226-C02-02, headed by Dr. Xavier Pueyo.

The american games company Saber Interactive, formerly Advanced Productions Inc., supports actively the project since its start. On one side it gives technical advice on performance requisits, on the other side it studies the incorporation into its games of the developed algorithms. In that case an IPR contract would be signed.

We have started a collaboration with the spanish games company Digital Legends Entertainment SL, a *spin-off* company from Ramon Llull University in Barcelona. An agreement on scientific collaboration has been signed in july 2003 between this company and the University of Girona. Our graphics group will develop several algorithms for Digital Legends and will study its

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implementation with graphics hardware. Digital Legends organised in Barcelona the “Jornadas sobre Ocio Digital” (workshop on digital leisure) and invited us to them. We consider the relationship with this company of strategical value.

We have also contacted Per Christensen from Pixar Animations Studios. This company works with a simplified version of the obscurances algorithm which could be very much improved with our new developments.

A collaboration has started with Dr. Qing-Xu from Tianjin University, in China. Dr. Qing-Xu wants to apply the algorithms developed to computer animation. A grant has been applied to the Chinese government and also to Tianjin University that will allow Mateu Sbert to visit for two weeks China in next spring.

The development of new algorithms in radiosity and global illumination have made possible to continue the collaboration with Dr. Philippe Bekaert, formerly at Max Plank Institute and now at Limburg University in Belgium. A Catalan-Flemish joint action, “Global illumination techniques for interactive applications” ACI2002-52, has been funded by Catalan government. On the basis of this collaboration our group has been invited to participate in a Flemish research framework led by the Computer Graphics and Computer Vision groups of the universities of Leuven and Limburg.

A collaboration has also started with Karol Myszkowski, Cyrille Damez and Vlastimil Havran from Max-Planck-Institut für Informatik to use the reusing paths algorithm in computer animation.

Mateu Sbert has coordinated a proposal, GameTools “Advanced Tools for Developing Highly Realistic Computer Games”, for the VIth framework within strategic objective IST-2002-2.3.2.7, “Cross media contents”, with 5 other universities and 6 companies. The preparation of this proposal has allowed to stablish strategical contacts with some of the involved companies and institutions, specially AIJU, Spanish Institute for the Toy, in Ibi, Alicante.

Mateu Sbert also participates in the proposal “Recodex: Modalities of Representation, Consultation and Exposition for Analogic Virtual Objects in Multidimensional Perception”, coordinated by Dr. Alessandro Zinna (Universities of Urbino and Limoges) and that has as objective the digitalization of the different elements of cultural heritage. University of Girona will be in charge of the Image-Based Rendering visualization techniques.

Relationships with the Computer Graphics group at Granada University have been also strenghted. Mateu Sbert has been invited to participate in the Software PhD programme that recently has obtained the quality mention of the Spanish Ministry of Education.

Subproject number 2: Multiresolution modelling. University Jaume I:

Publications related to the project:

- M. Chover, R. Vivó. ¿Hay vida en el ciberespacio?, Novática, ISBN/ISSN 0211-2124, (aceptado).
- C. Rebollo, I. Remolar, M. Chover, Visualización de terreno en tiempo real, Novática, ISBN/ISSN 0211-2124 (aceptado).

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- C. Campos, R. Quirós, J. Huerta, R. Vivó, E. Camahort, GreenArt: A Tool for Non-Photorealistic Rendering of plants and trees, (Poster) Eurographics 2003, The Eurographics Association, ISBN/ISSN 1017-4656, Granada, 2003.
- I. Remolar, M. Chover, J. Ribelles, Ó. Belmonte, View-Dependent Multiresolution Model for Foliage, Journal of WSCG, University of West Bohemia, ISBN/ISSN 1213-6972, Plzen(Czech Republic), vol. 11, num. 2, pp. 370-378, 2003.
- C. Campos, R. Quirós, J. Huerta, E. Camahort, R. Vivó, Visualización artística de escenarios naturales, XIII Congreso Español de Informática Gráfica, Universidade de La Coruña, ISBN/ISSN 84-9749-072-X, La Coruña, pp. 173-186, July, 2003.
- J. Ribelles, A. López, Ó. Belmonte, I. Remolar, M. Chover, Multiresolution modeling of arbitrary polygonal surfaces: a characterization, Computers & Graphics, ISBN/ISSN 0097-8493, vol. 26, num. 3, pp. 449-462, 2002.
- Ó. Belmonte, I. Remolar, J. Ribelles, M. Chover, C. Rebollo, Multiresolution Modelling Using Connectivity Information, Journal of WSCG, ISBN/ISSN 1213-6972, Plzen (Czech Republic), vol. 10, num. 1, pp. 71-78, 2002.
- M. Chover, Ó. Belmonte, I. Remolar, M. Chover, Web-based Virtual Environments for Teaching, EG/SIGGRAPH Workshop on CGE, Virtual Journal <http://virtual.inesc.pt>, ISBN/ISSN 0873-1837, Bristol, UK, 2002.
- I. Remolar, J. Ribelles, Ó. Belmonte, M. Chover, C. Rebollo, Modelado geométrico para visualización en tiempo real, Novatica, ISBN/ISSN 0211-2124, vol. 156, pp. 39-43, 2002
- I. Remolar, M. Chover, Ó. Belmonte, J. Ribelles, C. Rebollo, Eurographics'02 (Short Presentations), 140, 9, Geometric Simplification of Foliage, vol. 1017-4565, num. Saarbrücken (Germany), 397-404, 2002
- Ó. Belmonte, I. Remolar, J. Ribelles, M. Chover, M. Fernández, Efficient Implementation of Multiresolution Triangle Strips, Proc. of the Computational Science 2002 Conference (ICCS 2002). Workshop on Computer Graphics and Geometric Modeling, ISBN/ISSN 3-540-43593-X, Amsterdam (The Netherlands), vol. 2, pp. 111-120, 2002.
- C. Campos, E. Camahort, Ó. Belmonte, J. Huerta, 1st Ibero-American Symposium on Computer Graphics (SIACG 2002), 141, 9, Acceleration Techniques for Non-Photorealistic Rendering of Trees, vol. 972-98464-1-3, num. Guimaraes, Portugal, 173-180, July, 2002.
- J. Santonja, J. Linares, M. Chover, An image mapping system for simulating ceramic tiles on real photographs, ICCVG 2002 - International Conference on Computer Vision and Graphics, ISBN/ISSN 839176830-9, Zakopane - Poland, 2002.
- J. Linares, J. Santonja, M. Chover, Internet integration of an image mapping system, SIACG 2002 - 1st Ibero-American Symposium on Computer Graphics - Short papers, ISBN/ISSN 0873-1837, Guimaraes - Portugal, 2002.
- Ó. Belmonte, Técnicas de Aceleración para Visualizar Modelos Multirresolución, Tesis Doctoral, Dirigida por: Miguel Chover Sellés y Marcos Fernández Marín. Valencia, 2002.

A relationship with Virtual Market has been initiated. Virtual Market is a company related with the creation of virtual environments in the pottery industry.

Collaborations with the other groups involved in the project have continued and collaborations with the group of Computer Graphics of the Polytechnics University of Valencia and the University of Vigo have started. These collaborations can be appreciated in the publications originated by the project. Besides these collaborations, a relationship with Werner Purgathofer's group from the Technological University of Viena has been established.

UJI participates in the Vith Framework GAMETOOLS proposal related to the development of tools for the computer games industry.

Subproject number 3: Advanced interfaces design. University Pompeu Fabra:

The following information provides complementary results on the research areas, together with a general overview of the work done:

** Personnel undergoing training*

Alejandro Ramírez, student working full-time as a researcher for the Department of Technology in the area of interactive storytelling (related to videogames and AI applied to narratives and cinematic techniques). He has now the 100% of the academic credits, and is in the preparation of his thesis.

** Research Report: A Cinematographic Approach in Interactive Storytelling*

Research report presented by Alejandro Ramírez to obtain the Advanced Studies Diploma, part of the Ph.D. degree in Computer Science and Digital Communication.

** Videogames and AI: Seminar and reports*

There have been around ten meetings dealing with the use of AI in videogames context. Hector Geffner (ICREA/UPF) and Daniel Sanchez-Crespo seminars have resulted into some material internally available.

** "Inexpensive Caustics in Cg".*

Research paper about caustics (submarine illumination) in real time. Work developed by Daniel Sánchez-Crespo, a UPF researcher and professor, together with people from NVIDIA corporation,

** "Core Techniques and Algorithms in Game Programming"*

Book by Daniel Sánchez-Crespo, published by New Riders in America, Europe, Japan and Australia, 860 pages, in English, after 18 months of development. The book presents an overall synthesis on game-programming. Three full chapters are entirely devoted to the use of AI in a gaming context.

** Game Developers' Conference 2003 Internal Report*

Oscar Civit and Daniel Sánchez Crespo, as part of the research project activities, have attended the Game Developers' Conference (San José, California, USA) of this year, and have provided results and feedback on the core technologies and future advances.

** Undergraduate Final Project: High-Level 3D improvements*

Eduard Gonzalez and Sergi Gonzalez have developed graphical improvements in a molecular visualization engine from videogames elements and techniques.

** Undergraduate Final Project: Narrative Structures in a Virtual Environment*

Sergio García and Victor García have developed a virtual scenario capable of handling autonomous agents and a simple narrative based supported by autonomous camera and actions.