Nouvelattar Of the Share Modelling Group

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CNR - Consiglio Nazionale delle Ricerche Istituto di Matematica Applicata e Tecnologie Informatiche - Genova

EDITORIAL



Welcome to the third issue of the Newsletter Of the Shape MOdelling Group! As usual, you will find here the recent achievements and new challenges of the SMG from the point of view of financed projects, research and networking activities.

Even after its end, the FOCUS K3D project keeps demonstrating its impact on the research community. Promoted by FOCUS K3D, the Computer&Graphics journal (Elsevier) will host a special issue on "Semantic 3D Media and Content" with the aim to provide an up-to-date view of the open issues in knowledge-intensive 3D media, and trace future research and technological directions.

The SMG keeps contributing to the diffusion of its research results both within other scientific domains and towards the general public. Besides the participation to the newborn Network of Excellence "GaLA", whose objective is to gather, integrate, harmonize and coordinate research on Serious Games, in these last six months the SMG has taken part to another EU-promoted initiative called "The Researcher's Night" by organizing the workshop "We will meet you in the virtual reality".

Fundamental research, however, remains the central activity of the group which has recently contributed to various aspects of geometric modelling and analysis. In this third issue we summarize some of the main results regarding 3D shape matching, shape retrieval, analysis of geometric objects having 3 or more dimensions, spectral shape analysis, topology-based surface tiling.

We are proud of the impact that our work has on the community, and are very happy to announce that AIM@SHAPE's Shape Repository counts 2.835.868 visits since its birth in August 2004, that the famous "bimba" model (a sort of symbol of AIM@SHAPE) became the cover page of ACM Transaction on Graphics, and that the work on the extension of scalar functions from surfaces to volumes (see NoSMoG #1, pg. 16) has been invited for presentation at SIGGRAPH 2010.

Also, we are pleased to note that the network of collaborations of the group is continuously growing, while existing partnerships are kept alive through several mechanisms, including bilateral cooperation agreements, visit exchanges, co-training of students and, clearly, financed projects. As usual, a part of this newsletter is dedicated to the description of recent actions of this type.

Enjoy your reading!

> Marco Attene

SMG: The Shape Modelling Group @ CNR-IMATI-Ge



The Shape Modelling Group (SMG) is a research team of the Institute of Applied Mathematics and Information Technology, branch of Genova (IMATI-Ge), of the Italian National Council of

The mission of the group is to advance research in the field of geometric modelling and computer graphics. Geometric modelling has been a key research topic at IMATI-Ge for several years. Geometric modelling is a set of mathematical and computer science techniques which relate to different fields, such as geometry, computational topology and computer graphics. The main aim is to describe the shape of an object or

phenomenon, through the definition of geometric primitive entities and the classification of the reference context. A "shape" is here intended as an entity having both a specific geometry and a meaning

Currently the research activities of the SMG are grouped into two main research units:

In the first research activity, fundamental research is performed on algorithmic and computational methods for shape modelling, processing, analysis and retrieval, using geometric and topological approaches. To this aim, new models for the representation of topological and geometrical information are defined, and new tools for the classification and recognition of shape features and topological structures

In the area of multidimensional media knowledge, the aim is to define a new modelling paradigm, based on the formalisation of several aspects related to the shape, which can be used to formalise the geometric form of an object (geometric model) as well as the set of contexts, or views, which could use

The research target of the SMG is to broaden the role of traditional modelling by the definition of new strategies for shape representation and analysis, in order to highlight the semantic level that better reflects the perception of shapes. Other topics of research are related to the fields of computer graphics, industrial design, reverse engineering, and geographical information systems.

> Bianca Falcidieno ≻

> > Head of the SMG

SMG Website: http://www.ima.ge.cnr.it/ima/smg/home.html





FOster the Comprehension, adoption and USe of Knowledge intensive technologies for coding and sharing 3D media content in consolidated and emerging application communities (EU FP7 Coordinated Action)



FOCUS K3D has promoted the adoption of semantics in 3D content modelling and processing. In the last year of the project the main activities were the organisation of 5 thematic workshops for each Application Working Group and a final conference on Semantic 3D Media, and the definition of a research roadmap.

After the conference, a special issue on Semantic 3D Media and Content has been launched by the international journal Computers & Graphics, Bianca Falcidieno and Ivan Herman editors. The goal of this special issue is to collect papers on perspective applications of 3D content, a rapidly emerging new form of media in the semantic multimedia panorama and an extremely challenging context of application of semantic multimedia. The issue is promoted by the FOCUS K3D project, and it is expected to provide an up-to-date view of the open issues i knowledge intensive 3D media, and trace future research and technological directions.



> B. Falcidieno

Project website: http://www.focusk3d.eu

Consortium: **CNR-IMATI-GE** (IT), CERETETH (GR), EPFL (CH), FHG (DE), INRIA (FR), MIRALab (CH), SINTEF (NO), UU (NL).

Project coordinator: Bianca Falcidieno

GaLA - Game and Learning Alliance

The GaLA motivation stems from the acknowledgment of the potentiality of Serious Games (SGs) for education and training and the need to address the challenges of the main stakeholders of the SGs European landscape (users, researchers, developers/industry, educators). A foundational fault issue in this context is the fragmentation affecting the SG landscape. The GaLA NoE aims to gather, integrate, harmonize and coordinate research on SGs and disseminating knowledge, best practices and tools as a international reference point in the TEL area. The other two key focuses of the project are the support to deployment in the actual educational and training settings and the fostering of innovation and knowledge transfer through research-business dialogue.

The NoE activities and resources to be integrated in a long-term view will consider: a strong integration among leading researchers, users and business; a strong concern on the current standards of education in order to favour a real uptake and scaling of the educational games initiatives; sustainability; the identification of key issues through multidisciplinary teams, who will put always the users – learners and teachers - and stakeholders in the centre; the promotion of research and development team forces organized in thematic areas; a strong coordination with EU TEL activities, offering a specialized focus and expertise on SGs.

> C. E. Catalano

> FP7 ICT-2009.4.2: Technology-enhanced learning > IMATI's contact person: *Bianca Falcidieno*

> Consortium: University of Genova (coordinators), CNR-IMATI-GE and other 29 partners (IT, FR, RO, DK, UK, ES, A, P, NL, FL, DE, NO, IR, CH)



Researchers' Night 2010 – Researchers on the rock

"Researchers on the Rock" aims at reinforcing the public recognition of the researchers, of their work and strong contribution to our society. All the activities planned address to the public at large and can involve different targets of people: families, schools, association members and tourists without barriers concerning the people cultural background and age.

The Researchers' Night Project promoted by the EC will take place contemporarily in more than 220 cities in Europe on the 24th September 2010. During the Night, the CNR-IMATI will organize the workshop "We will meet you in the virtual reality": researchers will invite participants in the room devoted to the origin of Genoa to enjoy the basic steps of a realistic virtual environment creation by transposing real objects and people into the digital world. This is a common practice in developing realistic simulations of life in ancient times which visitors can explore with an immersive experience. Researchers will also set up a small corner equipped with their laser body scanner: participants will see how human faces and small objects can be acquired and reproduced in a computer, analyzed and modified to fit a virtual scene, which can be navigated in 3D.

In this occasion, the CNR-IMATI will take on stage the preliminary results of a collaboration with Comune di Genova and Museo Civico di Archeologia Ligure concerning the digitalization of the "Tavola di Polcevera", a bronze tablet dating back to 117 B.C. The 3D data (nearly 25.000.000 points and 100 range images) have been acquired from the relic with our 3D Scanner V910 Konica Minolta and textures have been captured as high resolution digital images. Range image registration and texture mapping will provide a complete and detailed 3D model of the Tavola to be displayed interactively to the large public outside the Museum at high resolution and without any risk of damage.

The reconstructed model could be further annotated to link additional multimedia information according to the "semantic 3D media" paradigm fostered by the former EC project FOCUS K3D in many application fields among which Archaeology and Cultural Heritage.

> M. Mortara and C. Pizzi

- > Project cofunded by the European Commission
- > Coordinators: Museo di Archeologia Ligure (Italy)
- > IMATI's Contact Person: Corrado Pizzi

> Consortium: Comune di Genova, Museo di Archeologia Ligure, CNR, Palazzo Oddo, IIT, Festival della Scienza, Università degli Studi di Genova, Università degli Studi di Pisa, Giardino Letterario di Albenga



Object Detection

Fast 3D object detection in shape models and scenes

Fast part-in-whole matching between a template object and a target model is obtained by extracting off-line only the shape descriptor of the template, while the description of the target is dynamically and adaptively extracted during the matching process

We tackled the problem of detecting relevant objects in the target model or scene using an innovative framework that combines the advantages of part-in-whole matching with very promising time and quality performances. As a reference scenario, we consider a set of 3D models stored in a library of objects (template models) considered relevant for a specific application context. The goal is to detect the occurrences of the template models in the target model (e.g. a 3D scene). The proposed part-in-whole method combines the use of a particular class of local shape descriptors with an original matching schema that we call the Fast Reject. Differently from existing part-in-whole approaches, the Fast Reject schema requires only the shape descriptor of the template model to be extracted off-line, while the descriptor of the target is computed through an adaptive procedure during the matching process. The approach adopted is inspired by search strategies used in computer vision and pattern recognition, such as the cascade detector (Viola and Jones, 2001) or the coarse-to-fine strategy (Fleuret and Geman, 2001). To our knowledge extent, similar strategies were not applied in a systematic manner to the context of 3D object matching, while the gain in performance they achieve prompts for a wider use in computer graphics.

The Fast-reject schema works as follows: at the beginning of the process, only a small region of the template is searched within the scene by looking for matching portions of its descriptor; due to the reduced size of the query, such a search is extremely fast. Afterwards, a slightly bigger piece of the template is searched. This time, however, the search space is not the whole scene, but only a subset for which the first run produced a good match. Then, an even bigger region of the template is searched among the good matches of the second run, and so on, until the whole template is considered and possibly matched. The Fast-reject can be implemented based on a wide class of shape descriptors, including well-known approaches such as the spherical harmonics transforms (Kazdan et al., 2003).

When compared to the state of the art, the Fast-reject schema proves to be a faster approach without quality loss. Furthermore, there is no need to pre-process the target to compute its descriptor(s), which makes the method suitable for object detection within dynamic scenes. Finally, we foresee that in the future the use of voxel-based descriptors (e.g. spherical harmonics transforms) prompts the development of parallel implementations of the Fast-Reject that may lead to even realtime recognition systems.

> M. Attene

> M. Attene, S. Marini, M. Spagnuolo and B. Falcidieno. "The Fast Reject Schema for Part-in-Whole 3D Shape Matching". In Procs of 3DOR, May 2, 2010, Norrköping, Sweden, pp. 23-30, 2010.



The user selects a feature and the system detects all the occurrences in the model

Matching Distances

Effective approximation of the 2-dimensional matching distance

Some new approximation results about the 2-dimensional matching distance are presented, leading to the formulation of an algorithm for its computation (up to an arbitrary input tolerance)

Size Functions are aimed to provide mathematical and computational tools able to code salient shape characteristics. The main idea behind them is to take into account the topological features of a shape with respect to some geometric properties conveyed by real functions defined on the shape itself thus defining a discrete and proven stable descriptor, made up of a multiset of points in the Euclidean plane.

Since real data are characterized by two or more properties, a single real function is not enough to properly code the shape properties: these considerations have recently drawn the attention to the study of a multidimensional setting, where the term multidimensional is related to considering measuring functions taking value in R^k. Despite the growing efforts, differently from what happens in the 1dimensional situation, a complete and discrete stable descriptor seems not to be available in the multidimensional setting.

The arising computational difficulties have been faced following different strategies, but not completely solved. As a partial theoretical solution, it has been proven that, when k>1, there exists a foliation in half planes such that the restriction of a k-dimensional Size Function to these half-planes turns out to be 1dimensional. This allowed the definition of a stable matching distance between k-dimensional Size Functions. Unfortunately, it was not clear how many and what half-planes to choose to have a reasonable approximation of the matching distance, thus lacking of an efficient algorithm for the estimation of the multidimensional matching distance.



Recently, we have successfully solved the problem in the 2dimensional case. We have proven new theoretical results about the 2-dimensional matching distance, which allow us to bound the variation of the matching distance values on different halfplanes. As a by-product, we have developed an algorithm which takes as input an arbitrary (representing tolerance the maximum error we are disposed to accept in the evaluation of the matching distance between 2dimensional Size Functions) and gives as output an approximation of the 2-dimensional matching distance up to the input tolerance. Experimental results on 3D meshes the effective computational efficiency of the algorithm to decimate the number of calculations required to approximate the matching distance.

> 5. Biasotti



The distribution of the 2-dimensional matching distance between two models over the half-plane foliation. Value are ordered in increasing value from blue to red

> S. Biasotti, A. Cerri, P. Frosini e A. Cerri, 2-dimensional matching distance for surface mesh comparison, IN: 7th Int. Conference on Curves and Surfaces, Avignon, , June 24th - 30th, 2010

Reeb Graphs of Solids

Volumetric shape description based on Reeb graph

Extended Reeb graphs are mainly used to describe surfaces and their application domain spans from shape segmentation to retrieval and visualization. Recently, their definition has been extended to volume data and an algorithm for their computation has been provided

Reeb graphs are compact shape descriptors that convey topological information related to the level sets of a function defined on the shape. They have been mainly used to describe surfaces and their application domains span from shape segmentation to comparison and visualisation.

Recently, we have addressed the extraction of a Reeb graph description from volume data. Even if efficient algorithms for the computation of the Reeb graphs from volume and higher dimensional data already exist in the literature, they do not explicitly store information on which part of the volume is related to graph nodes and arcs neither describe these sub-parts. To overcome this limitation, we have extended to volume data the so-called Extended Reeb Graph (ERG), originally introduced in 2000 for terrain models.

The ERG of volume data is extracted through a finite set of iso-surfaces of a given realvalued function f defined over a tetrahedral mesh. Dealing with iso-surfaces instead of isocontours, the extension of the ERG to volumes is not straightforward and is based on a shape classification based on the analysis of the volumes bounded by the iso-surfaces of f. To do that, we have introduced the concept of critical volume thus making the ERG able to deal with vertices that corresponds to degenerate configurations of critical points. To incorporate also geometric quantities in the shape descriptor, we have coupled the elements of the graph (nodes and arcs) with geometric attributes that describe the sub-parts of the volume induced by the iso-surface decomposition.

As possible application of our descriptor, we foresee shape decomposition and parameterization; moreover, we think it is particularly suitable for shape similarity and sub-part correspondence because of the structural decomposition of the volumes.

> 5. Biasotti



ERG from two volume models

> S. Biasotti, B. Falcidieno, M. Spagnuolo. Extended Reeb graph description of volume data, IN: 7th Int. Conference on Curves and Surfaces, Avignon, June 24th – 30th, 2010.

Scalar functions

Topology- and error-driven extension of scalar functions from surfaces to volumes

On July 29th 2010, the paper "Topology- and error-driven extension of scalar functions from surfaces to volumes" has been presented by Giuseppe Patane' (CNR-IMATI) at SIGGRAPH 2010, Los Angeles – California, in the Technical Session "Surface Fields"

The behaviour of a variety of phenomena measurable on the boundary of 3D shapes is studied by modelling the set of known measurements as a scalar function f:M-->R, defined on a surface M. Furthermore, the large amount of scientific data calls for efficient techniques to correlate, describe, and analyze this data. In this context, we focus on the problem of extending the measures captured by a scalar function f, defined on the boundary surface M of a 3D shape, to its surrounding volume. This goal is achieved by computing a sequence of volumetric functions that approximate f up to a specified accuracy and preserve its critical points. More precisely, we compute a smooth map g:R3-->R such that the piecewise linear function h:=g|M:M-->R, which interpolates the values of g at the vertices of the triangulated surface M, is an approximation of f with the same critical points. In this way, we overcome the limitation of traditional approaches to function approximation, which are mainly based on a numerical error estimation and do not provide measurements of the topological and geometric features of f. The proposed approximation scheme builds on the properties of f related to its global structure, i.e. its critical points, and ignores the local details of f, which can be successively introduced according to the target approximation accuracy.

> G. Patané



Hierarchy of surface-based approximations $(f_i)_i$ and volume-based extensions $(g_i)_i$ of a scalar function f:M \rightarrow R, defined on a 3D shape M. The computation of the hierarchy is guided by the critical points and topological features of the input function

> Patanè G., Spagnuolo M., Falcidieno B. Topology- and error-driven extension of scalar functions from surfaces to volumes. ACM Transactions on Graphics, Volume 29, Issue 1, 2009

http://www.ge.imati.cnr.it/ima/personal/patane/PersonalPage/Patanes_Home_Page/B est_results/ACM_TOG_2009.html

Spectral Shape Comparison

Feature Selection for Enhanced Spectral Shape Comparison

In the context of 3D matching, objects are represented by shape descriptors that capture the most significant shape characteristics of the object. The information coded by the descriptor can be filtered such that it maximizes the intra-class similarity and the inter-class dissimilarity.

In the context of 3D shape analysis and matching, the spectrum of the Laplace-Beltrami operator has been widely studied in the recent years because it provides a descriptive and large feature vector able to characterize the input shape. It is well suited for shape matching tasks due to its isometry-invariance properties, its robustness to local noise and sampling, and its shape-intrinsic definition and multi-scale organization.

While there is an evidence of the close relationship between shape features and eigenvalues, the best way to use the spectrum for shape characterization has not been identified yet. We argue that statistical methods are the most appropriate to correlate sub-sets of the spectrum to classes of 3D shapes and to have a grasp on the semantics captured by the eigenvalues. In this context, our main contribution is the application and comparison of three feature selection approaches to the Laplacian eigenvalues: namely, (i) the first k eigenvalues, by varying k on the cardinality of the computed spectrum; (ii) the Hill Climbing technique; and (iii) the AdaBoost algorithm.

The obtained results confirm the hypothesis that the Laplacian spectrum contains unnecessary information for shape matching and classification. Indeed, the appropriate selection of a set of eigenvalues strongly improves the classification results and the retrieval efficacy.

> 5. Marini

> Marini S., Patané G., Spagnuolo M., Falcidieno B. ``Feature Selection for Enhanced Spectral Shape Comparison". In: 3DOR10 - Eurographics Workshop on 3D Object Retrieval 2010 (Norrköping, Sweden). pp. 31 - 38. M. Daoudi, T. Shreck, M. Spagnuolo, I. Pratikakis, R. Veltkamp, T. Theoharis (eds.). The Eurographics Association, 2010.



The relevant eigenvalues; the x-axis represents the classes and the the y-axis the eigenvalues

Shape Retrieval

3D Shape Retrieval Based on Best View Selection

Comparison of 3D shapes can be reduced to comparing their images; a single view of a model is sufficient to achieve good performance if it is the view in which the relevant shape features are maximally exposed

Nowadays 3D models are easily accessible through general-purpose or domain-specific sources, in consolidated professional domains - CAD, medicine - as well as in emerging ones - bioinformatics, cultural heritage, serious games- as highlighted by the FOCUS K3D project. Therein lies the need to develop retrieval engines able to provide users with 3D data in a fast and accurate way.

In the retrieval pipeline a query model is matched against all the entries of a database and the most similar objects are returned to the user in a ranked list. Among the works on 3D retrieval, the abstraction modality based on 2D views as representations of 3D models is gaining momentum; firstly because it is supported by the natural relationship between the two types of representation (images correspond to projections of 3D objects). Secondly, it allows one to query a 3D engine using a 2D image, thus uncoupling the representation format of a resource from the query modality by which to find it.



and the silhouette). Then, size functions are used as shape descriptors

Besides these advantages, using a view-based approach raises the question of which and how many images should be taken into account. Conversely to the majority of methods which use a set of images, we propose new approach which is based on a single view only. The underlying assumption is that

the selected image should be the maximally informative one, i.e. the best view where the relevant shape features are maximally exposed. Involving semantics in the view selection process allows us to store and process a single image for each model, whereas keeping the most relevant shape information. The best view selection is carried out basing on a previous result of our group on the automatic identification of semantically relevant views (M. Mortara, M. Spagnuolo "Semantics-driven best views of 3D shapes", Computers&Graphics 33(3): 280-290, 2009). Once the best view has been selected, we describe it by using both region-based and contour-based image descriptors. Descriptors invariant to rigid transformations and isometries are employed to avoid normalization procedures and deal with articulated and deformable objects.

Thanks to the use of a semantics-grounded view and invariant and informative shape descriptors, we reach on many shape categories a comparable or even better retrieval performance than state-of-the art methods using multiple views.

> M. Mortara

> D. Giorgi, M. Mortara, M. Spagnuolo "3D Shape Retrieval Based on Best View Selection". Proc. Of the ACM Workshop on 3D Object Retrieval, 25 October 2010, Firenze. To appear

Topological Segmentation

Tiling surfaces with cylinders using n-loops

An optimization approach to subdivide surfaces into tubular regions

This research activity is carried on in collaboration with LIMOS (UMR 6158 CNRS, Université Blaise Pascal). The aim is to provide several generic methods to manipulate a surface, and to subdivide it taking into account both geometry and topology.

In this work, we especially focused on subdividing surfaces into tubular regions, that is a significant question in various applications. Even if specific approaches have been described in several domains, most of the times topological properties are not explicitly handled, and the segmentation remains mainly driven by the geometry.



In this work, we present an original approach to describe the topological and combinatorial nature of a tiling of a surface with cylinders. For this, we first introduce m-cellular complexes, a framework allowing the flexible description of cuttings and tilings. Then we describe n-loops, an extension of the loops for producing tilings with cylinders.

Computational issues of n-loops are then addressed, using both topological and geometrical properties of the surface. We introduced an optimization process, using simulated annealing, in order to adjust the location of the n-loops in the given surface.

Finally, we propose two applications, first tiling a surface with large quadrangles patches, and segmenting surfaces then with possible protrusions. This second use of our framework produces a segmentation that handle the protrusions by translating this geometric properties into topology.

> J.-M. Favreau

> Jean-Marie Favreau, Vincent Barra, Tiling surfaces with cylinders using n-loops, SMI 2010

Relevance Feedback

Relevance Feedback with Multilevel Relevance Judgements for 3D Retrieval

Relevance feedback techniques help understanding the semantics of similarity for an observer, in the context of a specific query. Hence, they attempt to solve the semantic gap between description and meaning, between retrieval system and user. This research proposes a new relevance feedback technique, studied to take into account the peculiarities of 3D objects

3D shape retrieval is a complex interaction process between a user and the 3D content. In the last years, the semantic gap has been brought into focus, that is, the gap between visual data information and the meaning of data for a user. To fill the semantic gap, we have to "include a human in the loop", that is, to make the user an active player in the search process. The fundamental technique that allows the user to take part in the retrieval pipeline is relevance feedback. By relevance feedback, the user can feed the system with his/her thoughts via the repetition of three steps: s/he submits a query, which is answered by a list of items; then s/he gives feedback about the relevance of some of the items; the system refines its answer, so that it better fits the user's similarity concept.

Relevance feedback was introduced in the 1970s for text document retrieval. In the 1990s it became a widely adopted methodology for query refinement in image retrieval. In the last few years it started drawing the attention of the 3D retrieval community. Many techniques were imported from the research in Computer Vision. However, most of the proposals dealing with images rely on the assumption that a feature space is given, i.e., objects can be manipulated as (usually low-level) feature vectors. Also, 3D models are different from images, for they portrait the complexity of the 3D world, whereas they do not suffer from the sensory gap. Hence, 3D shapes can be analyzed not only according to low level features, but also according to high-level geometric and topological properties. This implies there are many types of 3D descriptors, such as graphs, skeletons, weighted points sets and suchlike. This suggests going beyond the state of art and developing new techniques which take into account the specific needs and opportunities of the 3D scenario.

In this research, we devise a new relevance feedback technique to support 3D retrieval. We propose a continuous, numerical scale for relevance judgements, instead of a small, usually binary (relevant/non-relevant) number of predefined relevance levels. In addition, our method combines multiple descriptors by working in the space of dissimilarities, thus being independent of the nature of the descriptors themselves, which can be feature vectors, graphs and so on. Finally, our technique does not require neither parameter optimization nor statistical learning procedures.

The first results of this activity were published in the Proceedings of the Eurographics Workshop on 3D Object Retrieval 2009 (3DOR09). A journal version is now available, which includes new insights, new experiments, and comparisons with other techniques.

>D. Giorgi



The scale of similarity nuances: from highly relevant to definitely not relevant

> D. Giorgi, P. Frosini, M. Spagnuolo, B. Falcidieno: 3D Relevance feedback via multilevel relevance judgements. The Visual Computer, Special Issue on 3DOR09, to appear

3D Classification

3D Classification via Information Theory and Feature Selection from Unattributed Graphs

Shape classification plays an important role in organizing and retrieving models in 3D databases. A joint research between IMATI and the University of Alicante demonstrates the feasibility of multiclass classification based on purely structural spectral features, with features selected via an information-theoretic criterion

Classifying a 3D query object means assigning the object to the most appropriate class of models in a database. Classification can be used to attach a semantic label to unknown query models, as well as to speed-up the retrieval process.

Shape classification is often supported by statistical learning techniques such as Feature Selection. The latter is used to select a subset of relevant features describing 3D objects in order to build robust classification algorithms. Despite the huge literature about Feature Selection in Pattern Classification, there are few studies about this topic in structured patterns, namely, when features are computed on non-attributed graphs (pure structure).

In collaboration with Francisco Escolano and Boyan Bonev, University of Alicante, we proposed an information-theoretic filter for feature selection in a multiclass problem, to be applied to spectral features extracted from unattributed Reeb graphs of 3D objects. We analysed the role of different features during the selection process, so as to draw conclusions about which spectral features are most important for the classification problem. This research has been presented at two international conferences, namely ICPR 2010 (IAPR International Conference on Pattern Recognition, Turkey, August 23-26) and SSSPR 2010 (Joint IAPR International Workshops on Structural and Syntactic Pattern Recognition, Turkey, August 18-20). The main contribution of this research is that it demonstrates the feasibility of multiclass classification based on purely structural spectral features, while emphasizing the role of different features and analysing the dependence of classification performance on the precision of the feature selection criterion. On similar topics, cf. the work by S. Marini et al. (page 11).

> D. Giorgi

> B. Bonev, F. Escolano, D. Giorgi, S. Biasotti: Information-theoretic Feature Selection from Unattributed Graphs. Proceedings ICPR 2010, International Conference on Pattern Recognition, Turkey, August 23-26, 2010.

> B. Bonev, F. Escolano, D. Giorgi, S. Biasotti: High-dimensional Spectral Feature Selection for 3D Object Recognition Based on Reeb Graphs. Proceedings SSSPR 2010: Structural, Syntactic and Statistical Pattern Recognition, LNCS 6218, pp. 286-295, 2010.



From 3D models to unattributed graphs, graph features and feature selection

Applications to Material Sciences

Computational geometry tools for Material Science and Geology

Fundamental theory and algorithms studied by computational geometry proved to be extremely useful to model and analyze the crystallization of molten substances

Material research and engineering try to understand the characteristics of complex materials by studying the interrelationship of composition, microstructure and process conditions represented in "phase diagrams". The calculation of phase diagrams is one of the main objectives of computational thermodynamics. Roughly speaking, a mixture of pure components constitutes a thermodynamic system that may exist is different aggregation states (phases) depending on temperature (T), pressure (P) and composition (X). Depending on its initial configuration, a system may change dynamically in order to attain an equilibrium state. For example, ice tends to pass from solid to liquid at ambient P and T. A phase diagram is a chart describing how the various phases of a system depend on thermodynamic parameters such as T, P, and X. To offer a rationale in the interpretation of phase stability in complex systems, it is common practice in Material Science (ceramurgy, glass technology, slags industry) and Geology (petrology, geochemistry, mineralogy) to represent the limiting regions that define the T-X condition of incipient crystallization. Such a region is a hypersurface called the "liquidus", and using simplicial meshes to represent it appears to be particularly appropriate. In practice, the liquidus is evaluated at a finite set of points, and modeling it through a simplicial mesh allows to provide an intuitive interpolation among the samples which is particularly flexible, both in terms of topology and in terms of availability of analysis and processing tools which are based on such a representation.

Existing theoretical models make it is possible to calculate the so-called "Gibbs free energy" for each phase and for each T-X condition. Starting from this information, we have implemented an algorithm that computes convex hulls to derive a sampling of the liquidus hypersurface for chemical systems with an arbitrary number of pure components. After having interpolated such samples using a simplicial mesh, if we are given an initial composition and temperature, descent tracking techniques can be used to predict which stable state would be reached if the melt is left free to cool down.

Our current research is focused on the study and development of algorithms to compute descent paths on simplicial meshes of arbitrary dimensions and topology. Computing such paths for high-dimensional liquidus hypersurfaces is of fundamental importance, as it makes it possible to understand the behaviour of molten materials such as magma bodies which, in turn, helps geologists in understanding eruption mechanisms.

> M. Attene



> M. Natali, M. Attene, G. Ottonello. "Computational geometry tools to model and analyse the crystallization of molten substances". Technical Report IMATI-CNR n° 08/2010.

collaborations and

Instituto Superior Técnico, Universidade Técnica de Lisboa, Portugal

Tiago André Cardoso Lourenço spent two weeks as visiting student at the IMATI, within the bilateral research project entitled "Advanced techniques for the retrieval of 3D shapes", between the CNR and the Fundaçao para Ciência e a Tecnologia (FCT). During his stay Tiago worked on the integration of software tools on shape analysis and processing, developed by IMATI in the ShaDe WB system. ShaDe WB is a system that Tiago is developing as part of his master's thesis and aims to help researchers working in the area of analysis, comparison and retrieval of three-dimensional objects, that allows the researchers to study and compare object description techniques with minor effort.

> 5. Marini

> Contact persons at Instituto Superior Técnico: Prof. Joaquim A. Jorge

National Institute for Space Research (INPE), São José dos Campos, Brazil

Dr. Sergio Rosim has been a visiting researcher at CNR-IMATI from April 1st to 30th. His research expertise is on digital terrain modelling and analysis for hydrological application. In particular at INPE he is leading a group for the developing a hydrological system, called TerraHidro which is currently employed in the Brazilian drainage network management.system. His stay at IMATI aimed to identify topics of interest for a bilateral collaboration between the two institutes: his main objective has been to analyse the research expertise of CNR-IMATI helpful to bring improvement within TerraHidro system. In particular three main research topics have been considered of interest for the collaboration. (i) the study of Reeb graph to improve the cartographic generalization of drainage according to different work schedules in TerraHidro, (ii) the activity on geographic metadata management within a spatial data infrastructure in order to improve data sharing of large volume of data within TerraHidro system, (iii) the application of parallel and distributed processing to handle of large amounts of spatial data.

> M. De Martino

> Contact persons at INPE: Dr. Sergio Rosim

Fak. II: Institut fuer Mathematik, Technische Universitaet Berlin.

May 2010, the 21th, Dr. Bruno Benedetti visited our lab and delivered the lecture: *La teoria di Morse discreta e la congettura di Poincaré (Discrete Morse theory and the Poincaré conjecture).* Dr. Benedetti discussed on Discrete Geometry and topology from a combinatorics point of view. In particular, he presented some recent results on the definition of discrete Morse functions over manifold with boundaries and on the characterization of locally constructible 3-spheres.

> 5. Biasotti

> Contact persons at Fak II: Dr. Bruno Benedetti

Escuela Politecnica Supeiror- Universidad Autónoma de Madrid (UAM), Spain

Last April Michela Spagnuolo and Daniela Giorgi paid a visit to Dr. Simone Santini, a member of the Department of Computer Engineering at UAM (Universidad Autónoma de Madrid). Simone Santini is the author of many articles about the role of semantics in multimedia analysis; his interests include image and video retrieval, multimedia annotation and interface design. The subject of the visit has been the way semantics and user context can take part in the query formulation phase of 3D search engines. The latter is a hot research topic, which will form the basis for a collaboration between UAM and IMATI.

> D. Giorgi

> Contact persons at UAM: Dr. Simone Santini

COLLABORATIONS and

VISIT EXCHANGES

The Australian e-Health Research Centre, CSIRO.

During one month, Jean-Marie Favreau visited the Australian e-Health Research Centre, at Brisbane. This visit took place in a long-term research activity involving IMATI, the French laboratory LIMOS (UMR 6158 CNRS, Université Blaise Pascal) and the Biomedical Imaging team of the Australian e-Health Research Centre. The aim of this project is to work on the Alzheimer's disease, exploiting information from several medical images, including MRI. During the visit, several specific questions related to the topology of the structures extracted from MRI scan have been explored, in order to facilitate the computation of the cortical thickness.

> J.-M. Favreau

> Contact persons at CSIRO: Prof. Olivier Salvado

Laboratoire d'Informatique, de Modélisation et d'Optimisation des Systèmes, Université Blaise Pascal, Clermont Ferrand, France.

Professor Vincent Barra and Dr. Gaëlle Loosli visited the Shape Modelling Group in order to start a collaboration on topics related to statistical methods for shape characterization and classification, and to consolidate the already on going collaboration on shape analysis based on topological properties of scalar functions.

The main research interests of Professor V. Barra, deal with the paradigm of machine learning with particular attention to supervised and unsupervised classification, while the research activity of Dr. Gaëlle Loosli is mainly focused on Kernels Machines and online learning. During their visit they discussed topics related to dimension reduction, features selection, machine learning and validation.

> 3. Marini

> Contact persons at Université Blaise Pascal: Prof. Vincent Barra

GISIG (Intnl. Group of Geographic Information System), Genoa, Italy.

IMATI is collaborating with GISIG within the EU project NESIS coordinated by GISIG itself. NESIS is a Thematic Network funded by the Competitiveness and Innovation framework Programme (CIP) - Information and Communication Technologies (ICT) - Policy Support Programme (PSP) of the European Commission (Agreement n. 225062, starting date 1st May 2008, duration 30 months). NESIS refers to the SEIS (Shared Environmental Information System) initiative of the European Commission and the European Environment Agency. It focuses on the ICT issues of implementing SEIS by gathering information on what is the current e-infrastructure that SEIS will be built upon, and by proposing an ICT roadmap and guidelines for the technical implementation of SEIS. At this aim it deals also with Good Practices, the analysis of which represents a relevant activity to support the definition for SEIS of the ICT roadmap as well as of its guidelines. IMATI is involved in the project activity as member of the Working Group of the project due to his know-how on ICT. In particular the activity which she is performing is related to the definition of a methodology for the analysis of good practices based on Business Process Model: the outcome is the identification the most relevant processes for the ICT roadmap for SEIS as well as technological services, tools, standards, and other relevant components of SEIS, helpful to implement the ICT guidelines for SEIS.

> Web Site: NESIS - http://www.nesis.eu/



Workshop on "Physical Melts reactivity and phase topology", June 16, 2010, Dip.Te.Ris, Uniersity of Genova

Invited talk given by Marco Attene on "Computational Geometry - Models and tools to support the computation and visualization of phase diagrams"

The workshop has been organized within the context of the national PRIN project "Physical and chemical properties of volatile-bearing silicate melts" with the twofold objective of (1) training Earth science PhD students and (2) provide an opportunity for researchers to share up-to-date knowledge in the field. Marco presented the Shape Modeling Group and summarized some basics concepts and algorithms of computational geometry that proved to be useful in the calculation and analysis of phase diagrams.

> M. Attene

Summer Internship on topological correction of volumes

During 6 weeks, Quentin Fortier from the ENS de Lyon (licence) performed an internship cosupervised by Jean-Marie Favreau and Marco Attene on topological correction of volumes. The aim of this work is to provide a theoretical framework that produces minimal cuts on volumes, according to specific topological constraints.

Several ideas have been explored, including a min-cut/max flow approach, in order to generalize the ideas previously explored by Jean-Marie Favreau on surfaces.

> J.-M. Favreau

Analysis of multi-dimensional data through the discretization of topological and differential descriptors and properties

Erika Montani. Laurea Thesis. Department of Mathematics, University of Genova. Supervisors at IMATI: Franca Giannini and Marina Monti

On July 28th Erika Montani discussed her Master thesis in Applied mathematics at the University of Genova. The thesis has been carried out in collaboration with prof. Jean Philippe Pernot from ENSAM in Aix en Provence. In the thesis Erika Montani developed measures and methods for the evaluation and modification of aesthetic properties of curves. The considered aesthetic properties are those identified within the European project FIORESII: concavity/convexity, s-shaped, acceleration and straightness. In particular, it has been developed an operator for the modification of curves to achieve a specified straightness value while satisfying possible pointwise constraints on position, curvature and tangent. The values of the straightness evaluated between curvature critical points have been exploited to propose an extension of the Leyton shape grammar curve's name to further characterised curves within the same class category.

> F. Giannini

ORGANIZATION

Shape Modeling International, SMI 2010

June 21-23, 2010. Arts et Métiers ParisTech, Aix-en-Provence, France. www.smi2010.lsis.org

Shape Modeling International provides an international forum for the dissemination of new mathematical theories and computational techniques for modeling, simulating and processing digital representations of shapes and their across a wide range of fields.

The technical programme has included three keynote talks of K. Polthier, M.P. Cani and A. Shamir.

Ten selected papers have been published in the issue 34(3) of Computers & Graphics (Elsevier), while the SMI Proceedings contains 18 full papers and 14 extended abstracts.

SMI'10 has honoured the memory of P. Bézier, former student of the Arts et Métiers ParisTech engineering school, who would have been 100 years old in 2010 !

CNR-IMATI has been involved in the organization of SMI 2010: B. Falcidieno and M. Spagnuolo are respectively conference and programme chairs.

> M. Spagnuolo and B. Falcidieno



Workshop: Matematica, Forma e Immagini 2010

March 18-19, 2010. Genova, Italy. http://www.dima.unige.it/~robbiano/mat-form-immag/

The workshop was jointly organized by Bianca Falcidieno from CNR-IMATI Genova, Lorenzo Robbiano, from the Department of Mathematics of the University of Genova (DIMA), and Alessandro Verri, from the Department of Computer Science of the University of Genova (DISI). The aim was to set up presentations and informal discussions to ease the interaction among research groups which make strong use of mathematical tools to deal with images and shapes. The workshop was subdivided in three very interesting half-day sessions, coordinated by Michele Piana (DIMA), Bianca Falcidieno and Alessandro Verri.

Further material available at: http://www.ge.imati.cnr.it/ima/smg/training.html

> F. Robbiano

FG60 – Computational and Geometric Topology

June 17-19, 2010. Bertinoro (FC) – Centro Residenziale Universitario

http://fg60.dm.unibo.it/index

Bianca Falcidieno sat on the Scientific Committee of FG60, a conference in honour of Prof. Massimo Ferri (University of Bologna) and Carlo Gagliardi (University of Modena and Reggio Emilia) on their 60th birthday. This event brought together pure and applied mathematicians working on Topology and Shape Analysis. B. Falcidieno gave a talk entitled "Computational Topology and Semantics for 3D Shape Analysis and Description", illustrating how Mathematics has been



exploited at IMATI over the years in order to solve problems grounded on Computer Graphics.

> D.Giorgi

Bianca Falcidieno - Research Director

Bianca Falcidieno is a Research Director of the National Research Council (CNR) of Italy, responsible for the Genova Branch of the CNR National Institute of Applied Mathematics and Information Technology (CNR IMATI-GE) and the President of the Research Area for the CNR in Genova.

She has been leading and coordinating research at international level in advanced and interdisciplinary fields (such as computational mathematics, computer graphics, multidimensional media and knowledge technologies), strongly interacting with outstanding industrial and social application fields: from industrial design to geographic information systems, from manufacturing to semantic web.

She is presently taking part in more than ten European and Italian research projects and she has been the coordinator of the FP6 Network of Excellence AIM@SHAPE, aiming at representing and processing knowledge related to multi-dimensional media. Since 2008, she is the coordinator of the FP7 Coordination Action FOCUS K3D, whose main aim is to promote the adoption of best practices for the use of semantics in 3D content modelling and processing.

She is the author of more than 200 scientific refereed papers and books. She is currently editor-in-chief of the International Journal Shape Modelling and Chair of the IEEE Conference SMI'10 (Shape Modelling International).

For the 80th CNR anniversary, Bianca Falcidieno was included in the 12 top-level researcher women in the CNR history.

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Michela Spagnuolo - Senior Researcher

Michela Spagnuolo is currently senior researcher at IMATI-CNR Genova. Her research interests are related to computational topology for shape understanding, classification and retrieval, and shape-based approaches to modelling and processing digital shapes.

She authored more than 120 reviewed papers in scientific journals and international conferences, edited a book on 3D shape analysis, and was guest-editor of several special issues. She is currently programme chair of the EG workshop on 3D Object Retrieval and of the IEEE Shape



Modelling International 2008 (SMI). She is member of the steering committee of SMI, and was programme chair for the Semantic and digital Media Technology, SAMT'07.

Her current interests include shape analysis techniques, shape similarity and matching, and computational topology. She was responsible for EC and national projects of CNR-IMATI-GE and is currently responsible of the research unit on "Advanced techniques for the analysis and synthesis of multidimensional media".

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Franca Giannini - Senior Researcher

Franca Giannini is a senior researcher at IMATI. She graduated in applied mathematics from the University in Genoa in 1986. Since then, taking into account the evolution of the available technologies and changes in working processes, she has concentrated on different issues for the specification of tools and methodologies for 3D geometric model representation, analysis and synthesis. In particular, her focus is the development of shape processing and modelling tools adaptable to the application needs by exploiting contextual knowledge. She has participated and been responsible for IMATI in several national and international projects carrying on strong collaboration with both international research institutions and

companies, such as industrial CAD developers, and end users companies. Since 2001 she is supervising PhD students in co-tutelle with the French Universities INPG and ENSAM. She is currently in charge of the project Multimodal and Multidimensional Content and Media of the Department ICT of CNR. She is co-author of two patented software for automatic feature recognition for hybrid solid representation. The results of her research activity have been published in more than 80 reviewed papers presented in international conferences and journals. Her current research interests include multidimensional media modelling and understanding and related knowledge formalisation in applications contexts.

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Chiara Eva Catalano - Researcher

Chiara Eva Catalano is a researcher at IMATI-CNR Genoa and joined the group since 1998. She took a degree in Mathematics in 1997 at the University of Parma and got a Ph.D. in Mechanics and Machine Design in May 2004 at the University of Genoa. Her research interests include geometric and feature-based modelling for industrial design and semantics in 3D modelling for applications.

In the first years the research activity focused on different problems of aesthetic engineering, particularly related to an efficient 3D freeform surface manipulation with styling shape constraints. In the PhD thesis, subdivision surfaces have been proposed as an alternative geometric representation in the styling phase, able to overcome some drawbacks of NURBS traditionally used in CAD.

In parallel, the applied nature of her research called for enhancing the pure geometric modelling with the semantics of specific contexts. In the frame of aesthetic engineering, she worked on feature-based approaches to preserve the design intent in the digital model. With the active participation to AIM@SHAPE techniques for knowledge formalisation, such as ontologies, have been studied to encode the contextual knowledge to the geometric description for a more efficient information retrieval and reuse. Currently, she is strongly involved in the FOCUS K3D project, which has been disseminating the results obtained in AIM@SHAPE in specific applied contexts. Along the years she had the opportunity to collaborate with several well-known research institutes in an interdisciplinary perspective, as the publications show.

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Marco Attene - Researcher

Since 1999 Marco Attene has been collaborating with IMATI, and there he is currently a member or the research staff. Marco holds a Laurea degree (M.Sc. equivalent) in Computer Science, a Doctoral degree (Ph.D equivalent) in Electronic and Computer Engineering, and a Research Management Diploma.

His research deals mainly with the treatment of 3D simplicial meshes. His earliest studies (1999-2003) were focused on mesh reconstruction from point clouds and parametric representations. Then, he worked on surface remeshing, with applications to shape analysis and geometry compression (2003-2005). Since 2006, he has been working on segmentation and semantic annotation of 3D shapes, with particular care to the treatment of explicit solid representations.

Marco contributed to the conception and implementation of several projects.

Within the scope of the EU FP6 AIM@SHAPE NoE, he coordinated an international team of experts for the definition of metadata to describe 3D shapes currently at the basis of the popular AIM@SHAPE Shape Repository. Marco manages six sourceforge software projects involving experts from the University of Genova and from the SMG at IMATI, and he is leading the activities of a research contract committed to IMATI by the University of Genova. Marco served as program committee member for several international conferences, and has been member of the organizing board of SMI'01 (IEEE Shape Modelling International Conference), of SAMT'07 (Intnl. Conf. on Semantic and Digital Media Technology 2007) and of the "Stability on watertight models" track of the SHREC 2008 international contest on 3D shape retrieval.

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Marina Monti - Researcher

Marina Monti has been graduated in Mathematic at the University of Genoa. Until the end of 1985 she's involved as researcher in the project CADME at the Politecnico of Milano and she is interesting mainly in geometric modelling. Until 1998 she's employed in high tech companies in the R&D department, where she is working mostly in the fields CAD and PDM tools.

In 1998 she starts working at IMA–CNR exploiting her knowledge in product representation in industrial design to the problematic of collaborative and distributed design, working within funded European research projects. She works at the extension of the concept of free form feature for styling by exploring the relationships between product shape and aesthetic character, to extract and formalize this knowledge in order to improve modelling tools for styling.



She actively participates to a research funded by ISPESL-DIPIA for the

analysis of PLM models of chemical plants for the identification and evaluation of critical configurations using the HAZOP and checklist approaches. Within the collaboration with ISPESL, she is tutor of a research grant focused on knowledge technology applied to the management of standards, engineering codes and normative which rule design, manufacturing and operations in industry to ensure reliability and safety. She acts as reviewer of several international journals and conferences and as proposal evaluator for the European Commission. She also acted as international expert for the Council of Physical Sciences of the Netherlands Organization for Scientific Research. She is co-author of more than 40 international journals and reviewed conference papers.

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MHO IS MHO

Monica De Martino - Researcher

Silvia Biasotti - Researcher

Monica De Martino is a researcher at CNR-IMATI-GE where she is leading research activity related to the knowledge technology for Geographic Information Management. She graduated from the Department of Mathematics, University of Genova in 1992. She started her research activity on image processing and surface modelling as guest researcher for almost one year at I.N.R.I.A, Sophia Antipolis, France. Then she has been working at IMATI-GE where she has been involved in National and International Projects working on spatial data processing and analysis and their application. Successively she has been extended her research

expertise to the Knowledge Management field: her specific scientific expertises are on Metatada Analysis, Ontology knowledge exploitation, Semantics Analysis. In particular she has contributed in the design and development of innovative methods for semantic similarity and granularity assessment. Currently she is addressing her interest in the study of new approaches to access to distributed metadata employing Semantic Web technology in the Web of Data. Most of her research results has been carried on and validated within European project: recently she has been scientific responsible for CNR-IMATI-GE of EU projects related to Geographic Information (INVISIP), to Spatial Data Infrastructure (IDE-UNIVERS and Nature-SDIplus) and she is participating to the eContentplus Thematic Network eSDI-Net+.

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Silvia Biasotti got a degree in Mathematics, a PhD in Mathematics and Applications and a PhD in Information and Communication Technologies, all at the University of Genoa. She joined IMATI-CNR in 1998; since then, her research activity focuses on computational topology, with the aim of developing mathematical tools for applications related to visual media, computer graphics and simulation arising in different scientific domains. She tackles the problem of finding shape descriptions that are mathematically well-defined and able to keep the salient characteristics of a shape, without forgetting the computational aspects. Main application domains of her research are multidimensional media analysis and

synthesis and 3D content knowledge representation and retrieval. In particular, she defined and developed tools applied to: analysis and generalization of DTM; automatic object alignment; 3D shape recognition; and model retrieval from CAD repositories.

She is principal investigator of the CNR project "Topology and homology for the analysis of digital shapes" and is involved in national and international projects where she collaborates with research teams in an international scenario, among them, the AIM@SHAPE EU FP6 project. She authored more than 50 reviewed scientific papers, published in international journals and conferences, and served as committee member of several conferences. She has been teacher at several master and PhD courses at the Univ. of Genoa and lecturer in international schools.

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Giuseppe Patané - Researcher

Giuseppe Patanè is researcher at CNR-IMATI (2001–today). He received a Ph.D. in "Mathematics and Applications" from the University of Genova (2005) and a Post–Lauream Degree Master in "Applications of Mathematics to Industry" from the "F. Severi National Institute for Advanced Mathematics" (2000).

From 2001, his research and teaching activities have been focused on the definition of paradigms and algorithms for modelling and analyzing digital shapes and multidimensional data. One of the main aspects underlying his work is the balance between pursuing a mathematically rigorous understanding of continuous models and providing algorithms for shape modelling and analysis. Digital shapes include data that represents a real, virtual, or multidimensional object; in this last case, the multidimensionality is intrinsic to the dimension of the data (i.e., 2D images, 3D shapes, volumetric and time-depending data) and the types of signals and



information concurring to the description of a phenomenon or a shape (e.g., spatial coordinates, timedepending shapes and functions). His current activities, which deal with the definition of hierarchical paradigms for modelling and analyzing digital shapes and multidimensional data, are organized along three main avenues.

- 1. Topological and geometric modelling of digital shapes.
- 2. High-level and semantic analysis of digital shapes.

3. Definition of a unified paradigm for modelling and analyzing d-dimensional data and their attributes.

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Simone Marini - Researcher

Simone Marini is a researcher at the IMATI-CNR, Genova. He obtained the degree in Computer Science in December 1999 and the Doctoral degree in Electronic and Computer Engineering in April 2005, both from the University of Genova. He has been member of the European Network of Excellence AIM@SHAPE and he is involved in several international projects and collaborations. His main research interests are 3D shape similarity and ontological representation of scientific concepts related to the domain of 3D shape. The research activity on the similarity, is mainly focused on the investigation and development of methodologies for the comparison of structural representations encoded by graphs. In particular he approached the problem of partial and global matching of 3D shapes by investigating the use of structural representation. He formalized and developed a new



methodology that combines geometric and structural information of the matched objects, by quantifying their overall shape similarity and also by providing explicit information on similar and dissimilar sub-parts of the objects. He also investigated the problem of 3D shapes classification through the generation of creative prototypes, that is shape descriptors able to summarize geometric and structural features shared by the members of a given class of 3D objects. Finally, the research activity on the knowledge representation relies on the conceptualization of specific scenarios relevant for the Computer Graphics community.

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Riccardo Albertoni - Researcher

Since 2002 Dr. Albertoni has been investigating the issues and applications of metadata analysis to compare and select multidimensional resources. In the early stage of his research activity Dr. Albertoni focused on the geographical metadata analysis to select optimal datasets for users' planning task within the European project INVISIP (IST 2000-29640). Then Dr. Albertoni's research moved toward the exploitation of semantics in metadata analysis. Dr. Albertoni applied his research in the domain of Multidimensional media within the EU-funded Network of excellence AIM@SHAPE (FP6 IST NoE 506766) where he focused on ontology driven metadata to document the acquisition and processing pipeline of multidimensional media. Such a research experience has afterwards turned out in an independent investigation aimed to exploit ontology driven metadata analysis tools. In particular, he has focused on the context-dependent semantic granularity and similarity assisting the

the context-dependent semantic granularity and similarity assisting the browsing and the comparison of heterogeneous and multidimensional data resources. In 2008 Dr. Albertoni has been selected within the NATO Research Assistant Programme for a grant concerning the adoption of ontology driven metadata at NATO Undersea Research Centre (NURC). In this context, Dr. Albertoni investigated Open Geospatial Consortium specifications and Linked Data technology paving the way for documenting data resources collected during NURC's sea trials. The originality of Riccardo Albertoni's research are attested by about 20 peer reviewed papers and numerous memberships in program committees of international conferences.

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Michela Mortara graduated in July 1999 in Computer Science from the University of Genova and since then she is member of the Shape Modeling Group at IMATI-CNR Genova. She started her research activities on 2D shape analysis for polygon morphing and surface reconstruction from planar sections, with a particular focus on the structural aspects of shapes. Then she moved to the 3D setting, focusing on morphological analysis, curvature estimation, skeleton extraction and segmentation of 3D objects. In May 2004 she got a Ph.D. in Robotics. From 2004 to 2008 she joined the AIM@SHAPE Network of Excellence working on analysis and

structuring of 3D shapes as a mean to devise the semantics (meaning or functionality) of shapes and their parts. In this framework she developed a method to automatically identify human body parts, compute anthropometric measures and locate standard landmarks on human body models which received the 2006 Computers&Graphics best paper award, with further applications in the construction of control skeletons for animation. Recently she started a new activity on semantic rendering and on the automatic selection of the best view of 3D object based on their visible salient features.

Since 2008 she is actively involved in the FOCUS K3D project which aims at promoting the adoption of CG and Knowledge technologies in several application domains; in particular, she follows the Gaming and Simulation, Medicine and BioInformatics activities.

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Michela Mortara - Researcher

Daniela Giorgi - Researcher

Daniela Giorgi graduated cum laude in Mathematics in 2002, then joined the ARCES Centre of Excellence at the University of Bologna. In 2006 she got a PhD in Computational Mathematics from the University of Padova. Since then she has been a member of the SMG at IMATI-CNR, Genova. Her research interests concern computational topology techniques for describing and retrieving images and 3D models. Her scientific profile shows her to have strong mathematical expertise (differential geometry, Morse theory, topology) together with in-depth knowledge in computational fields (computer graphics, image and 3D processing). She is the author of 28 peer-reviewed international publications in high-level journals (such as ACM Computing Surveys, Pattern Recognition) and conferences. She has been involved in many international projects, including the French-Italian Galileo project on image recognition (2003-2005) and the FP6 NoE AIM@SHAPE. During the latter, she was in charge of the Watertight Models Track (2007) and the Classification of Watertight Models Track (2008) of the



SHREC (SHape REtrieval Contest) event. She has been a lecturer at international schools and conferences. She is a reviewer for international journals, and serves on the Programme Committee of the Eurographics Workshop on 3D Object Retrieval (2009, 2010) and the ACM Multimedia International Workshop on 3D Object Retrieval (2010).

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Francesco Robbiano - Research assistant

Francesco Robbiano graduated cum laude in April 2002 in Computer Science from the University of Genova and since then he is member of the Shape Modeling Group at IMATI. He started his research activity with the implementation of a system for recognition and completion of form features in the CAD context. Since 2004, within the AIM@SHAPE Network of Excellence, his focus shifts to 3D object description. His work is mainly devoted to the design of ontologies, with special attention on the Shape Acquisition and Processing domain. These ontologies provide a formal characterization of 3D objects in specific usage domains and are the building blocks of the so-called Digital Shape Workbench. Meanwhile, the development of a Digital Library of scientific references is under his responsibility.



In 2006, he starts his activity as a PhD student in Electronic and Computer

Engineering and Telecommunications. He contributes to the developing of the ShapeAnnotator, an interactive software tool which goal is to let the user integrate different techniques for shape segmentation, and annotate the detected parts with concepts expressed in a given ontology. Two publications on major journals arose from this work. In his research activity, he considers more and more important the role of the user in the description phase: by taking into account the context of the user, the description can be tuned to the user needs. He got the PhD in April 2010, with the thesis "Description of 3D objects based on concepts, content and context", a work which is aimed to a tout-court description of 3D objects, centered on the role of the user.

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Jean-Marie Favreau – Post-doctoral fellow

Since 2009, Jean-Marie Favreau is a post-doctoral research assistant at the IMATI-CNR, Genova. He obtained the Master degree of Mathematics (1st year) in 2003 at the University of Nantes (France), and the Master degree of Computer Science (2nd year) in 2005 at the ENS de Cachan (Rennes, France). In 2009 he got a PhD in Computer Science from the Blaise Pascal University (Clermont-Ferrand, France).

He started his research activities on manipulation of

surfaces, focusing on cutting and tilings problems, driven by the topological properties and the geometrical information of surfaces. His work is strongly linked to applications, from medical imaging to computer graphics, integrating into the algorithms specific constraints related to the application domains. Recently, he focuses not only on surfaces, but also on volumic descriptions of 3D objects, with the aim to improve cutting methods, in particular in the context of brain segmentation and surface reconstruction.

He's the originator of a new partnership between IMATI-CNR and the LIMOS (UMR 6158 CNRS, Blaise Pascal University) focusing on fuzzy methods for object manipulation: segmentation, structured modeling, and shape retrieval.

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Visiting Students and Past collaborators

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UPCOMING EVENTS

Upcoming Events



Researchers' Night

Genoa and Albenga, Italy, September 24, 2010 http://www.palazzooddo.it/public/ Manifestazioni/2010/2010 09 24 Researchers' Night (La Notte dei Ricercatori).htm **Pacific Graphics 2010** Hangzhou, China, September 25-27, 2010 http://www.zjucadcg.cn/pg2010/index.html VisWeek 2010 (VIS, INFOViS, VAST) Salt Lake City (USA), October 24-29, 2010 http://vis.computer.org/VisWeek2010/ Int. Workshop on 3D Object Retrieval Firenze (Italy), October 25, 2010 http://www-rech.telecom-lille1.eu/acm3dor/program.html ACM Multimedia 2010 Firenze (Italy), October 25-29, 2010 http://www.acmmm10.org/ Eurographics Italian Chapter Conference 2010 (EG-IT 2010) Genova (Italy), November 18-19, 2010 http://www.eg-it.org/egit2010/ 5th Int. Conference on Semantic and Digital Media Technologies, SAMT 2010 Saarbruecken, Germany, December 1-3, 2010 http://www.samt2010.org/ **SIGGRAPH ASIA** Seoul, South Korea, December 15-18, 2010 http://www.siggraph.org/asia2010/ ViISIGRAPP 2011 (International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications) Algarve, Portugal, March 5-7, 2011

http://www.visigrapp.org/

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HOW TO REACH US



We are located in CNR's "Research Area of Genova" Torre di Francia, Via De Marini 6, Genova.





Bus number 1, 2, 7, 20, 30 (Via di Francia - WTC stop)

Genova Piazza Principe" railway station (10 mins by bus 20 or 30) 😯

🖻 Genova "Cristoforo Colombo" airport (20 mins by taxi)



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