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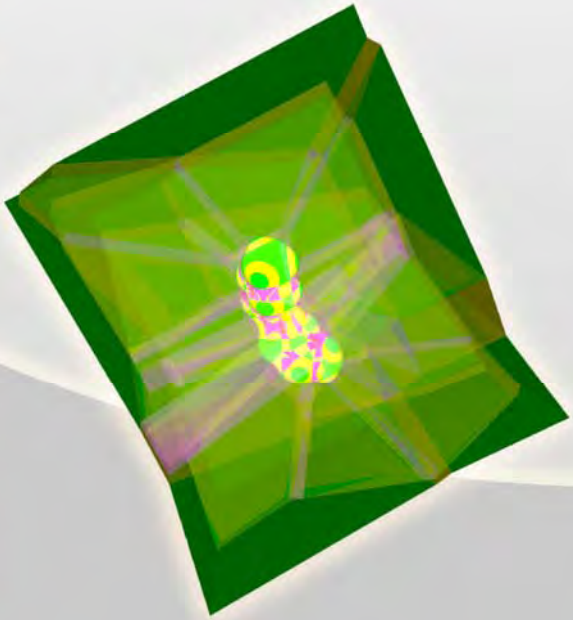
Newsletter Of the Shape MOdelling Group

Issue 5, September 2011

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



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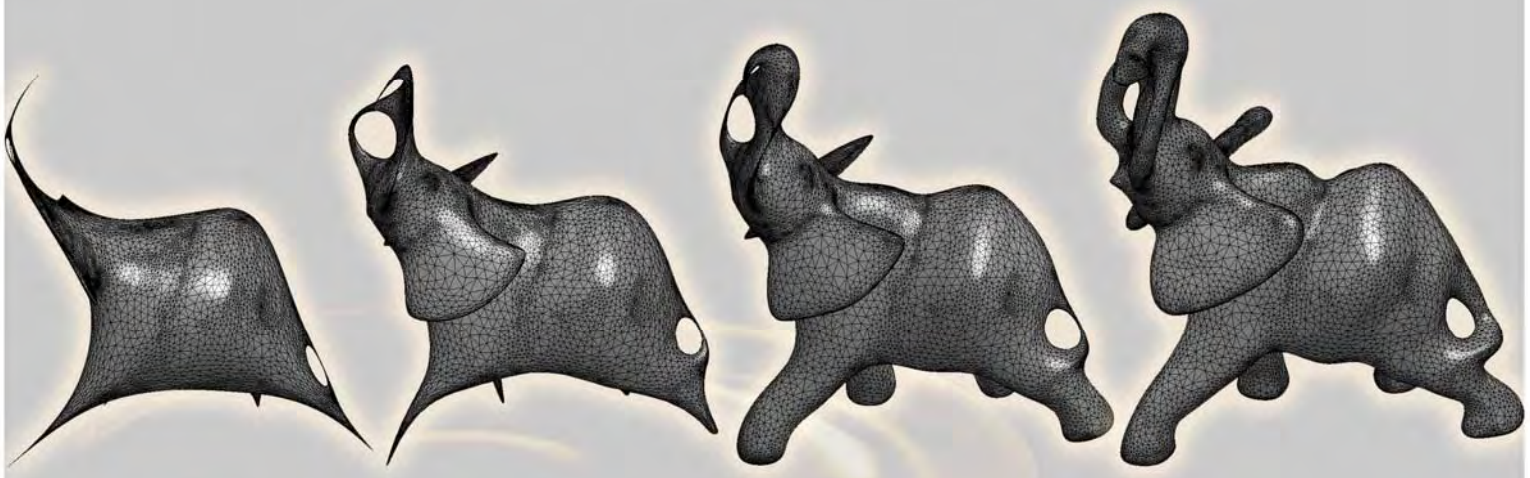


imati

CNR - Consiglio Nazionale delle Ricerche

Istituto di Matematica Applicata e Tecnologie Informatiche - Genova

EDITORIAL

Geometric modeling and computer graphics have plenty of applications, and for years the Shape Modeling Group has been exploiting its competences for applied research in areas related to terrain and environmental modeling, cultural heritage, scientific visualization, product design, security and many others. In the latest months, however, the group is more and more active in the field of bio-medicine and related applications. Besides the still ongoing collaboration with the Italian Institute of Technology on bio-molecule analysis and understanding, the SMG has recently become part of two important initiatives: a European project on multi-scale biological data visualization and analysis, and a new regional consortium studying medical devices and information technology for biomedicine. Material science represents another area where geometric modeling has shown its potential, and in this field the group has become partner of a newborn national project funded by the Italian Ministry of Education and Research.

As expected, projects trigger research, and this fifth issue of the Newsletter of the Shape Modeling Group includes a rich section dedicated to our most recent results. The visionary research roadmap drafted within the FOCUS K3D project has become a journal paper, just as the results of our research about object recognition and description. Furthermore, a new approach to define the connectedness of shapes has been defined and presented at the Shape Modeling International conference in Israel. Other important results originated from our research on semantics-oriented 3D modeling for industrial design, on size functions for robust 3D model comparison, and on semantic similarity to analyze resources exposed as Linked Data.

In these months the group has also concluded several training activities: our student Ruding Lou successfully defended his PhD thesis on modification of semantically enriched FE mesh models, while Federica Sciacchitiano defended her Bachelor's thesis on singularities in free-form curves and Jerome Pellettier discussed his master thesis on characterization and modification of curves based on aesthetic criteria.

Once again, enjoy your reading !

> Marco Attene

SMG: the Shape Modelling group @ CNR-IMATI Ge

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 Research (CNR).

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 associated.

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

- Advanced techniques for 3D digital shapes analysis and synthesis
- Coding, elaboration and restitution of multidimensional media knowledge

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 are developed.

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 this model (semantic model).

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**

Highlights

The SMG entered the new European project MultiScaleHuman! >More on page 5

Two new national projects will support our research > More on page 7

A lot of our training activities are giving the expected results! >More on page 17

EUROPEAN

PROJECTS

MultiScaleHuman - Multi-scale Biological Modalities for Physiological Human Articulation

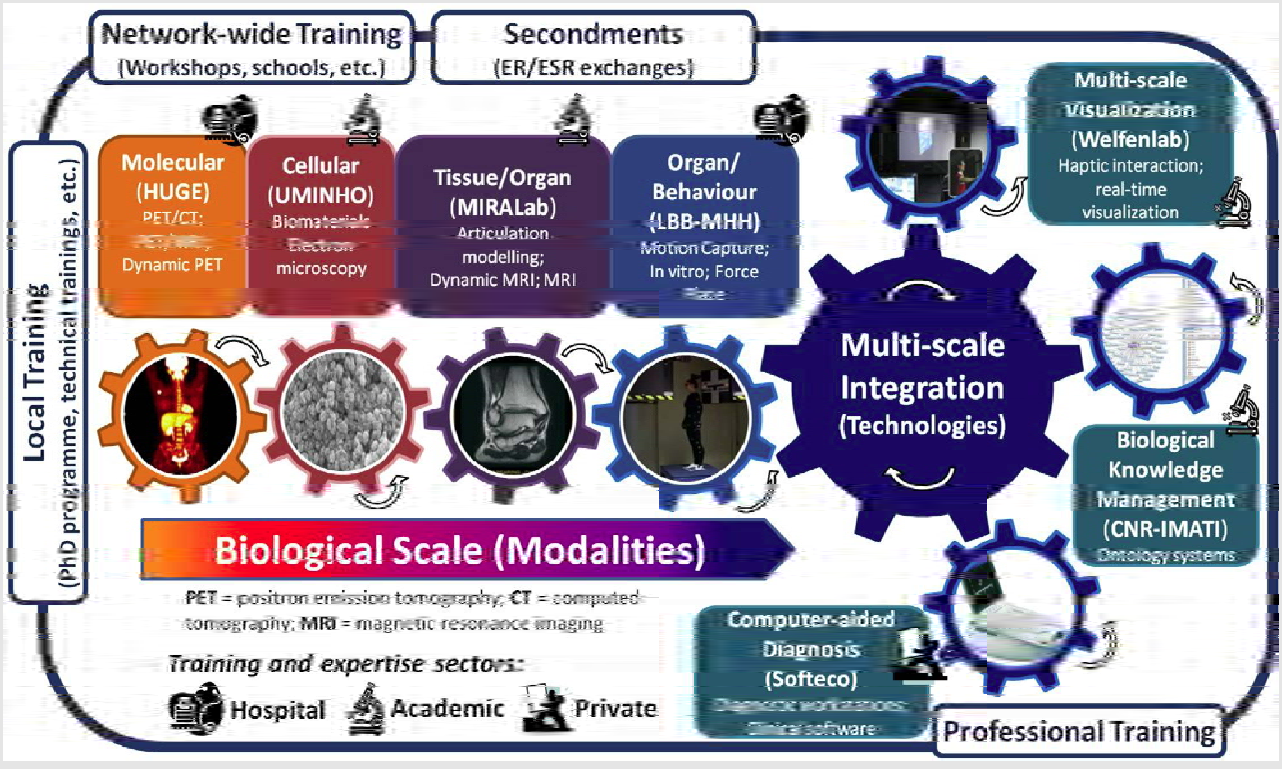
Musculoskeletal diseases (MSD) and related disorders are often considered as an inevitable consequence of aging and they account for the largest fraction of temporary and permanent disability. In this context, the goal of Multi-scale Biological modalities for physiological human articulation (MultiScaleHuman) is to research by training a body of early stage researchers (ESR) and experienced researchers (ER) in the creation of a multi-scale biological data visualization and knowledge management system for improved understanding, diagnosis and treatment of physiological human articulation. MultiScaleHuman will narrow its ambitious research towards a very important and challenging healthcare problem of MSD and related disorders. This will be achieved through initiating a network of ESR/ER with training provided from a three-sector-research consortium which involves academic (education), hospital (social actors) and private (industry) sectors. MultiScaleHuman will provide a unique training program, from technical to complementary skills learning by fully exploiting the training opportunities that Marie Curie ITN provides and by building a consortium of partners that brings multi-disciplinary skills in the understanding and treatment of physiological articulations in MSD and related disorders.

> G. Patanè

> FP7, People Programme, Initial Training Network *> Duration: Oct 2011 – Oct 2015*

> Coordinator: *Universite de Geneve (CH)* > IMATI's contact person: Michela Spagnuolo

> *Consortium*: UNIVERSIDADE DO MINHO, GOTTFRIED WILHELM LEIBNIZ, UNIVERSITAET HANNOVER, CONSIGLIO NAZIONALE DELLE RICERCHE, SOFTECO SISMAT SRL, LES HOPITAUX UNIVERSITAIRES DE GENEVE, UNIVERSITE DE GENEVE (Coordinator), MEDIZINISCHE HOCHSCHULE HANNOVER



MultiScaleHuman research and trainina activities

EUROPEAN PROJECTS

GaLA – Games and Learning Alliance

http://www.galanoe.eu

GaLA gathers cutting edge of European Research & Development organizations on Serious Games, involving 31 partners from 14 countries. The Network aims at favouring a strong integration among leading researchers, developers and users of serious games. The project will identify key issues in the adoption and development of Serious Games and draw a roadmap for future research on the topic. A strong concern is the current standards of education, in order to favour a real uptake and scaling of the educational games initiatives.

To integrate and cross-fertilize the different knowledge and expertise of the diverse groups of professional involved in GaLA, the first Alignment School took place in Edinburgh, 20-23 June 2011, organized by the Heriott-Watt University.

The week-long event included a range of keynote speakers, game demos, workshops and lectures, and M. Mortara gave the talk "Computer Graphics recipes for analyzing and enhancing shape information-Endowing 3D shapes with Semantics in Virtual Worlds" (available on the GaLA web site).

Concerning the IMATI's coordination of the Special Interest Group (SIG) on Serious Games for Humanities and Heritage, an on-line survey is being conducted to understand the needs and expectation of the various actors in the field (see below). In addition, the paper "Serious Games for Cultural Heritage: the GaLA Activities " has been accepted and will be presented at the International Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST) 18-21 October 2011, Prato, Italy.

Online survey link: http://www.galanoe.eu/index.php?option=com_sfg&formid=7

> M. Mortara

Some Serious Games in Humanities and Heritage: Travel in Europe (virtual tourism), Roma Nova (historical reconstruction) and The Gargas Caves (virtual archaeology).

> FP7 - IST ICT, Technology Enhanced Learning

> Duration: Oct 2010 – Sep 2014

> IMATI's Contact Persons: Bianca Falcidieno and Michela Mortara

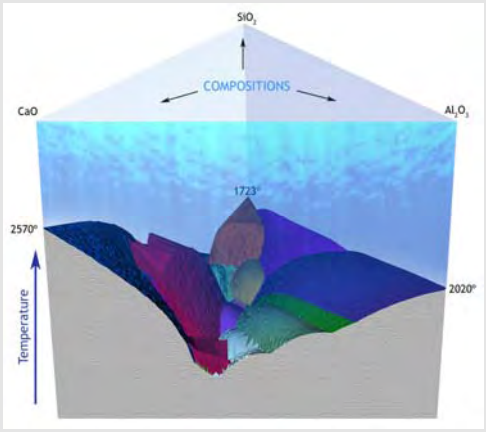
> Consortium: UNIGE (CH, coordinators), IMATI-GE-CNR and other 29 partners from *IT, FR, RO, DK, UK, ES, PT, NL, FN, DE, NO, IR, CH and AU.*

NATIONAL

Topology of phase diagrams and lines of descent

The fruitful collaboration between the SMG and the Department of Earth Sciences of the University of Genova (see NoSMoG #2, pg. 8) has given birth to a new national research programme (PRIN) on "Topology of phase diagrams and lines of descent" where computational geometry and material sciences are put together to study the evolution of magma bodies within the Earth's mantle.

The objective of the research unit at IMATI is to develop innovative methods for modeling and analysing simplicial complexes in arbitrary dimensions, with the aim of using these combinatorial structures to represent all the variables characterizing a thermodynamic system. The research program takes into account the topological, the morphological and the computational aspects related to the processing of geometric models of high dimensionality. Open issues related to Morse complexes and descending manifolds will be tackled, and algorithms to partition high-dimensional simplicial meshes will be designed. Besides scientific publications, we plan to develop a library for the simplicial representation of hyper-surfaces equipped with processing and analysis tools.



> M. Attene

> Funding org.: MIUR - Italian Ministry for Education & Research, PRIN programme

> IMATI's contact person: Marco Attene > Duration: Oct 2011- Oct 2013

Politecmed - Medical Technologies in Liguria

The goal of POLITECMED is to strengthen the industrial results and advance technological research in the field of medical devices and information technology in biomedicine and related applications/fields. In particular, POLITECMED seeks to consolidate a structured network of relationships, technical and scientific cooperation among public sector, industrial research, and industries active in Liguria, in order to facilitate and optimize future investments in Research and Development. To this end, both private companies and public members of POLITECMED will be co-financed by institutional bodies such as Regione Liguria. Furthermore, their activities will be focused on technology transfer actions quantifying the impact on the socio-economic area in terms of employment and economic benefit. In POLITCMED, CNR-IMATI will be responsible for promoting technology transfer activities through collaboration and exchange of know-how between industry and research partners. To this end, the CNR-IMATI activities will include (i) the identification of the main research results and technologies available among the members of POLITECMED; (ii) the organization of outreach activities concerning the main topics of POLITECMED; (iii) the integration of the Partners know-how; and (iv) the development of possible collaborations with research laboratories and industries outside the Consortium.

> G. Patanè

> Funding org.: *Regione Liguria – Regional Center for Research and Innovation*

> IMATI's contact person: Bianca Falcidieno & Franca Giannini > Duration: Jul 2011- Jul 2014

> Consortium: Esaote, O.M.S. Ratto, Softeco Sismat, Fos, Esacontrol, SY. O. Srl System and Org., SIIT, Univ. of Genova, CNR

PROJECTS

Semantics & 3D Media

RESEARCH

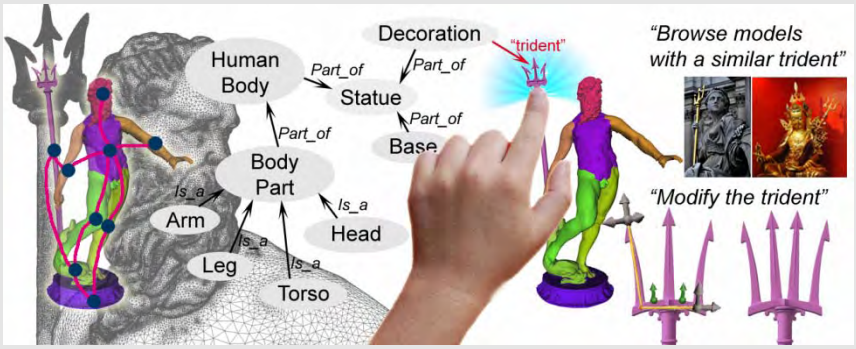
Semantics and 3D media: Current issues and perspectives

We identified four grand challenges representing a roadmap towards semantic 3D media. Interdisciplinary research efforts including computer graphics and semantic web are needed to foster the development of the 3D Internet and its applications.

The popularity of 3D media is currently not confined to the leisure sphere but it increased in many fields ranging from the entertainment market to the industrial product modelling, to health, biology, art, virtual tourism, and more. While problems related to the representation of the geometry of 3D shapes have been largely solved by the CG community, tools for coding, extracting, sharing, and retrieving the semantic content of 3D media are still far from satisfactory: interdisciplinary research efforts are needed to foster the development of the 3D Internet and its applications. The final result of the FOCUS K3D project was presenting its vision of the future and, without offering any off-the-shelf solution, giving an overview of the various aspects of semantics required to optimise tasks and processes related to 3D content in different application domains. We identified four grand challenges, which represent a roadmap towards semantic 3D media. They are defined in the following.

- Derive symbolic representations of 3D media mainly addresses the path from physically born objects to symbolic 3D models in the digital world, where a symbolic representation does not encode only the geometry but also the properties and the structure of the object in accordance with the context of use.
- Goal-oriented 3D model synthesizing consists in including knowledge in the model so that the whole conception cycle (which comprises modelling and simulation) ultimately becomes solely driven by the targeted end goal.
- Documenting the 3D life cycle is essentially related to 3D semantic annotation, which is the process by which a text-based piece of information is linked to the object and its parts and stored for subsequent uses; such associated text is conceived to be meaningful in some context and used to understand and store the information about the object that is not explicit or not contained in the geometric data.
- Semantic visualisation and interaction is meant as the set of processes controlling how the system presents the 3D content to the user and how the user is able to receive, search, retrieve, and exploit it. For each grand challenge, we outlined many open issues to motivate both the fundamental and the application-oriented research communities and find new innovative solutions. For details, please refer to the paper published on Computer & Graphics.

> C.E. Catalano



Semantic 3D Media in action

> C.E. Catalano, M. Mortara, M. Spagnuolo, B. Falcidieno, Semantics and 3D media: Current issues and perspectives, Computers &Graphics, vol 35 issue 4, August 2011, pp. 869-877

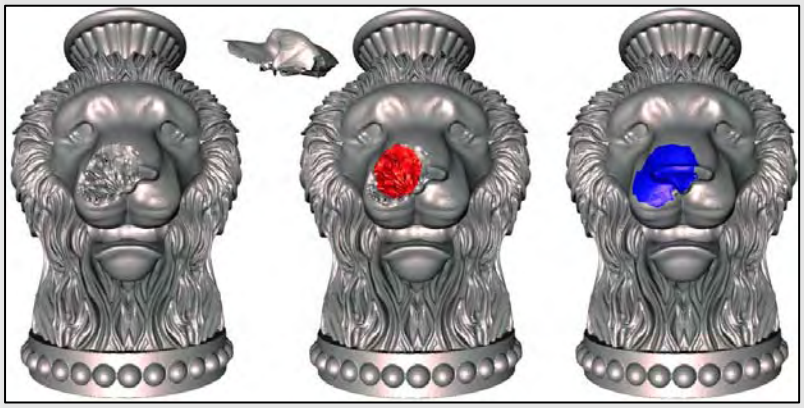
Shape Matching and Docking

Part-in-whole 3D shape matching and docking

A new approach to efficiently recognize instances of template shapes within target 3D models or scenes. Also useful to quickly analyze a target model and find appropriate binding sites with a complementary shape with respect to the template (3D shape docking).

The location of relevant parts in a 3D target model (e.g. a 3D complex scene) is often approached through part-in-whole shape matching, where various regions of the target model are compared with a given template model: the parts which are sufficiently similar to the template are tagged as relevant.

Typically, local descriptors of various regions in the target shape are computed offline, so that at query time it is sufficient to compare them with the template's descriptor. Although this approach is efficient for retrieval purposes, it might become inappropriate when the target model changes dynamically (e.g. 3D video). Thus, we tackle 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 performance gain obtained by the proposed approach is due to its capability to exploit the layered structure of a class of local shape descriptors. Roughly speaking, the Fast Reject schema is based on an iterative algorithm that initially analyzes a large number of small surface regions. At each iteration the number of regions decreases, by discarding portions of the target model that do not resemble the template model. At the same time, the remaining regions grow in order to add new information to the matching process.

This work builds on and extends previous ideas (see NoSMoG #3, pg. 7), with a significant innovation represented by a new curvature-tensor shape descriptor and by an adaptation of the framework. Based on the new shape descriptor, the adapted Fast Reject schema can be used to detect sites in the target whose shape is complementary with respect to the shape of the template, and thus can tightly accommodate it.

> 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 the Eurographics Workshop on 3D object retrieval (3DOR), May 2, 2010, Norrköping, Sweden, pp. 23-30, 2010.

> M. Attene, S. Marini, M. Spagnuolo and B. Falcidieno. “Part-in-whole 3D shape matching and docking”. The Visual Computer (to appear). DOI: 10.1007/s00371-011-0622-7..

RESEARCH

Shape Characterization

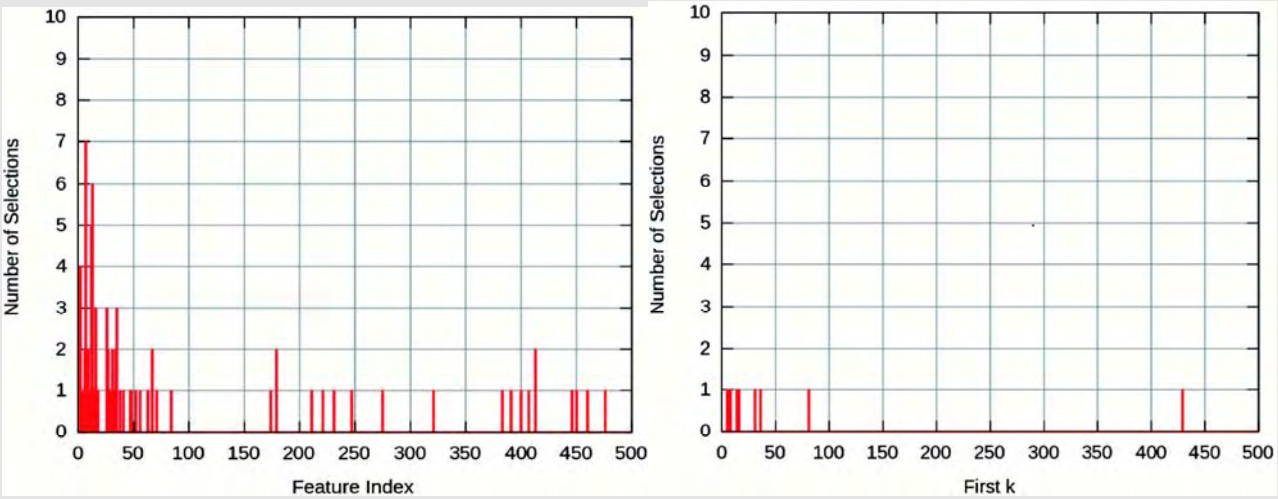
RESEARCH

Spectral Feature Selection for Shape Characterization and Classification

We have developed a framework for selecting the Laplacian eigenvalues that are more relevant to characterize and classify 3D models, represented as both triangle meshes and point clouds

We have recently developed a framework for selecting the Laplacian eigenvalues of 3D shapes that are more relevant for shape characterization and classification. In our work, we have demonstrated the redundancy of the information coded by the Laplacian spectrum and discussed the shape characterization capability of the selected eigenvalues. The feature selection methods used to demonstrate our claim are the AdaBoost algorithm and Support Vector Machine. The efficiency of the selection is shown by comparing the results of the selected eigenvalues on shape characterization and classification with those related to the first k eigenvalues, by varying k over the cardinality of the spectrum. Our experiments, which have been performed on 3D objects represented either as triangle meshes or point clouds, show that working directly with point clouds provides classification results that are comparable with respect to those related to surface-based representations. Finally, we have discussed the stability of the computation of the Laplacian spectrum to matrix perturbations.

> G.Patanè



These two examples show that only a subset of the Laplacian eigenvalues, which have been selected with the AdaBoost algorithm (left) and the first k eigenvalues (right), are necessary to discriminate among shapes belonging to the same class of human shapes. In both cases, we have used 10 bootstrap iterations.

> S. Marini G. Patané M. Spagnuolo B. Falcidieno. Spectral Feature Selection for Shape Characterization and Classification. The Visual Computer Journal. In press.

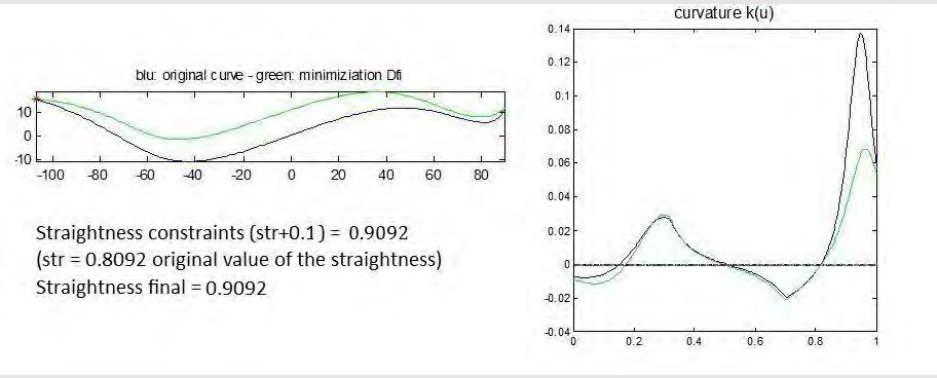
Industrial Design

Semantic oriented 3D modeling for industrial design

Definition and implementation of semantic operators for curve deformation based on a shape characterization specific to the industrial design context

To better simulate the way designers work, specific tools are needed to handle directly specific shape features meaningful for the design intent, without focusing on the underlying mathematic representation. For this purpose it is fundamental to identify proper higher-level shape descriptors as well as the corresponding manipulation techniques. This research activity is aimed at extending the semantic-oriented modelling tools for the creation and deformation of free form digital shapes developed in the collaboration between the Institute IMATI of the Italian National Council of Research in Genoa and the Laboratory LSIS - Ecole Nationale Superieure d'Arts et Metiers of Aix-en-Provence [1]. Semantic operators for curve deformation based on a shape characterization that is specific to the industrial design context are defined and implemented. The work grounds on the innovative approach suggested by the European FIORES-II project [2] for the intent-driven modelling tools for direct shape modification and on the multi-layered architecture proposed by the European Network of Excellence AIM@SHAPE for the definition of semantic-oriented 3D models. In particular the research proposes the use of meaningful aesthetic features for the evaluation of planar curve signature and for their intent-driven direct modification.

By providing functionalities for the evaluation of aesthetic properties of styling features, a semantic-driven deformation directly acting on the styling features modifying their property values becomes possible. In particular, the research focuses on the straightness aesthetic property implementation and exploits this property for achieving a qualitative curve description. Method for preserving the curve signature during curve modification are proposed as well, aimed at guaranteeing shape tuning according to the wished property values.



Possible future steps are the implementation of the other aesthetic properties, such as tension, and sharpness, in order to allow an easier satisfaction of the designer's requirements. Moreover, since in the industrial design process there is the need to manipulate a set of consecutive curves (for example the curves constituting the profile of a car), the evaluation of the aesthetic properties on a set of consecutive curves has to be addressed as well.

[1] V. Cheutet, C.E. Catalano, J.P. Pernot, B. Falcidieno, F. Giannini, J.C. L_eon, 3D sketching for aesthetic design using fully free-form deformation features. Comput. Graph. 29, 2005, pp.916-930.

[2] F. Giannini,M. Monti, G. Podhel, Aesthetic-driven tools for industrial design, Journal of Engineering Design, 17 (3), 2006, pp. 193-215

> M. Monti

> Giannini F. , Montani E., Monti M. , Pernot JPP, Semantic Evaluation and Deformation of Curves Based on Aesthetic Criteria, Computer-Aided Design & Applications, Vol. 8, No 3, 2011 pp 449-464.

RESEARCH

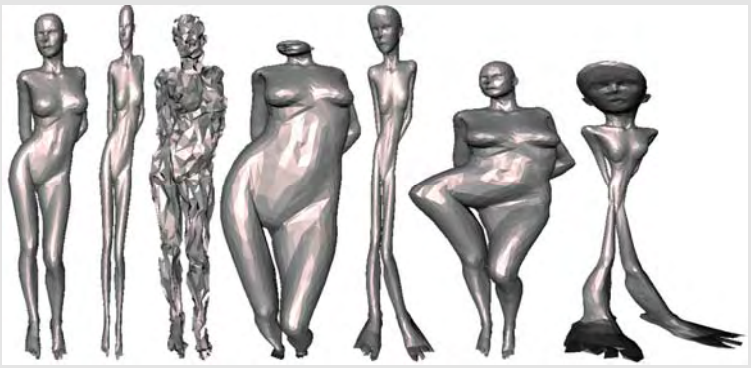
Shape Comparison

RESEARCH

Robustness and modularity of 2-dimensional size functions for 3D model comparison

Describing and comparing 3D shapes are challenging issues in Computer Graphics. To this end, Size Theory and Persistent Homology offer both theoretical and computational tools. We show how they enable the deformation-invariant comparison of 3D objects according to multi-dimensional properties

The main idea of Persistent Topology – which includes Size Theory and Persistent Homology – is to represent a shape by a pair (X, ϕ), where X is a topological space and $\phi : X \to R$ is a continuous real-valued function. A number of descriptors have been introduced to describe pairs (X, ϕ) – such as Size Functions – and successfully used for comparing images and 3D models [1]. Nonetheless, a single real-valued function ϕ may not be enough to cope with complex shape description problems. These considerations drew the attention to the study of a multidimensional setting, where the term multidimensional, or equivalently k-dimensional, is related to considering functions taking value in R^k, that is, $\phi : X \to R^k$, and the subsequent extension of shape descriptors to this case. The concept of k-dimensional size functions was introduced in [2], along with the k-dimensional matching distance to compare them.



A recent line of research deals with how to use the k-dimensional matching distance in practice, namely, how to approximate it so as to obtain a good compromise between computational cost and quality of results. An algorithm was presented in [3] which approximates the k-dimensional matching distance when k = 2, up to an arbitrary error threshold. In the work presented here, we show how the cited algorithm can support 3D shape comparison by tuning computational costs and accuracy of results in applications. As a further contribution, we show the robustness of our framework with respect to non-rigid shape deformations, as well as to other classes of shape deformations, such as non-metric-preserving transformation.

[1] Biasotti S., De Floriani L., Falcidieno B., Frosini P., Giorgi D., Landi C., Papaleo L., Spagnuolo M.: Describing shapes by geometrical-topological properties of real functions. ACM Computing Surveys 40 (4), 12:1-87, 2008

[2] Biasotti S., Cerri A., Frosini P., Giorgi D., Landi C.: Multidimensional Size Functions for Shape Comparison. Journal of Mathematical Imaging and Vision 32 (2), 161-179, 2008

[3] Biasotti, S. Cerri, A. Frosini P., Giorgi D.: 2-dimensional matching distance for surface mesh Comparison. 7th Int. Conference on Curves and Surfaces, Avignon, June 24th – 30th, 2010.

> D. Giorgi

> Biasotti, S., Cerri, A., Giorgi, D.: Robustness and modularity of 2-dimensional size functions – An experimental study. In: Proceedings CAIP 2011 – 14th International Conference on Computer Analysis of Images and Patterns, Seville, Spain, LNCS 6854, Ainhoa Berciano et al. Eds. (2011), 34–41.

Weighted Topology

Weighted topology for model representation

Dealing with huge data and physical limitations it is necessary to define geometric representations that couple data abstraction with a robust modelling of data imprecision. Our novel perspective is to weaken the connectedness of shapes to model abrupt topological changes as smooth transitions

Recent advances on data acquisition and storage are generating geometric models made of millions of elements. These models are generally affected by errors due to physical limitations of the digitalization techniques used. All these facts ask for model representations that are both simpler than the original model (and therefore abstract the original model) and able to deal with the data uncertainty.

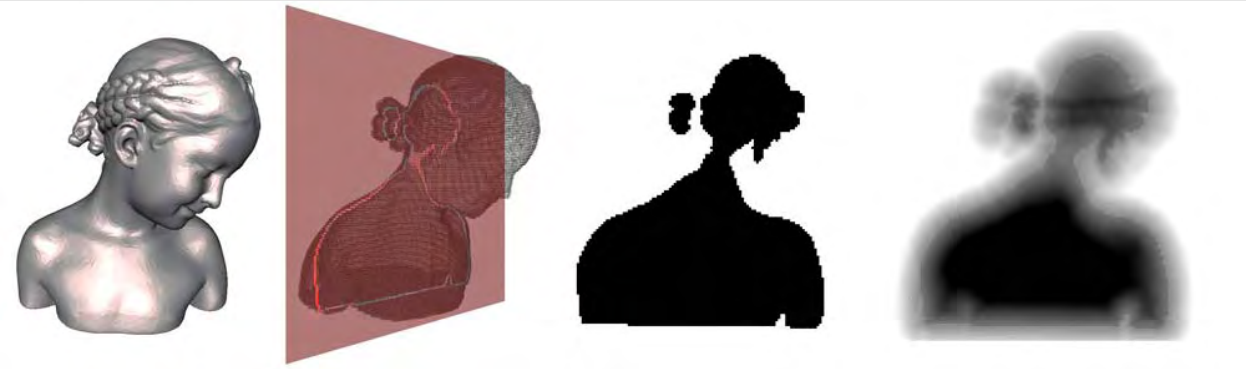
As first fact, we have observed that standard models used to represent solid objects that are strongly based on how points are connected to each other are not enough to face relatively small variations of the geometry that induce abrupt changes in topology. To overcome these limitations we have introduced the concept of weighted topology to model a 3D object whose connectivity and metric depend on a novel notion of weighted arc-length. The idea is to weight the arc-length between any two points of a solid object so that it takes into account that a given part of the object may be either weakly or strongly connected to another part. In practice, the connectedness between any pair of points of the solid is a number in the range [0,1], where the extremes 0 and 1 indicate that the two points are respectively disconnected or connected.

Weighted topology is related to fuzzy connectedness and it can be used to effectively characterize the space occupied by blurred solids. In turn, a blurred solid can be used as an approximated model to describe an object along with a set of possible small modifications of its shape that may also induce changes in topology.

This new model is useful to treat problems which are intrinsically not robust to small topological changes. As possible application domains of the model we have considered (1) the extension the applicability domain of existing segmentation algorithms, and (2) the improvement of the performances of a shape descriptor in a 3D object retrieval scenario. In the future we plan to investigate further application areas ranging from mesh processing to advanced shape analysis.

> S. Biasotti

> M. Attene and S. Biasotti. Geometric models with weighted topology. Computers & Graphics, Vol. 35, N. 3, pp. , 2011.



Rasterization of the “bimba” model over a cut plane and blurred shape

RESEARCH

Bio-informatics

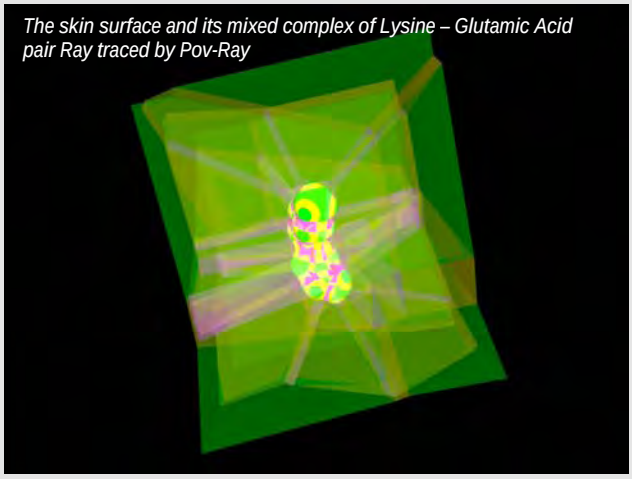
RESEARCH

Molecular surface definition in Biophysical modelling of electrostatics problems

The definition of a physically sound and computationally efficient molecular surface is a very interesting and long standing problem, especially in the implicit solvent continuum modelling of biomolecular systems, but also in the molecular graphics field; this work analyses the most widely used molecular surfaces

Traditionally, the simplest molecular models represent classical atoms as hard spheres whose radius, namely the van der Waals radius, indicates the distance from the nucleus at which the atomic repulsion begins its influence. The union of these hard spheres is the so-called van der Waals volume and the relative enclosing surface is termed the van der Waals surface (VDWS). This surface separates regions that can be reached by an ideal infinitely small external probe from inaccessible ones. If the molecule is immersed in a real solvent, considering a finite size probe makes more sense, since very small invaginations are actually not accessible.

Searching for a universal definition of the Molecular Surface (MS) is an ill-posed problem, since different MSs can suit different applications; for instance, real-time visualization needs speed, while the robustness of the model, the accuracy and the interpretability of the achieved results are crucial aspects in contexts where physical quantities, such as the electrostatic potential, are sought. However, the computational cost has to be kept minimal in any application where large systems are involved, e.g. to screen structural databases or to perform Molecular Dynamics runs.



The skin surface and its mixed complex of Lysine – Glutamic Acid pair Ray traced by Pov-Ray

We have recently investigated the possibility that some MS definitions developed in the Computer Graphics and Applied Mathematics fields can valuably contribute to Physics and Biochemistry oriented applications. We have mainly focused on the so-called Skin and the Blobby surfaces, and evaluated their possible adoption when estimating the electrostatic reaction field energy of bio-molecular systems. Lee and Richards' MS is kept as a reference and several figures of merit have been considered in this study.

We found that Skin surface seems to suit better the biophysical soundness than the blobby surface, and further analysis has to be performed to evaluate if a new definition can exploit the advantages of both.

Remarkably, the same methods developed for surface rendering, such as ray tracing for the Skin, can be beneficial to surface computation in electrostatics problems. Indeed, an efficient ray tracing-like technique on GPUs could be used to sample an implicit surface such as the Skin.

> S. Decherchi

> Invited Poster at Clemson Delphi Workshop, 4-6 April 2011.

Semantic Similarity

Semantic Similarity to Analyse Resources exposed as Linked Data

An application to habitats and species exposed as SKOS/RDF Linked Data Datasets

The increasing interest for Linked Data is affecting the way information is published, managed, and reused. However, the large part of achievements in this field still focuses on how to publish and share data rather than on tools to exploit the published Linked Data.

We propose the context dependent semantic similarity assessment developed in our previous research [1] as a building block to analyse Linked Data. In particular, in the reported activity, we have considered habitats and species, and we made them available as Linked Data within the European project NatureSDIPlus, to compare their annotated geographic resources.

Once more, the theoretical framework of semantic similarity based on (a) context dependence formalization of similarity criteria and (b) asymmetric similarity assessment, has been proved flexible and effective enough to support in complex analysis task. Besides, in that experience, we have also demonstrated our similarity as headway in exploiting Linked Data resources.

We have formalized different contexts in order to tailor the similarity assessment comparing (i) habitats according to the species that they host, (ii) species according to habitats they live into, and (iii) habitats with respect to their position in their taxonomic hierarchy.

Each of these contexts results in a different similarity assessment.

As overall considerations, we think it is worth remarking that:

- the different contexts provide means to rank and browse habitats and species according to specific features, that paves the way for defining a browsing customized with respect to specific user's views;
- the more datasets are interlinked, the higher are the potential contexts we can define, that enables new ways to sift data satisfying specific user's needs;
- the asymmetry in the similarity assessment emphasises the containment between compared elements, that is a powerful tool making explicit patterns which are pivotal for a deeper comprehension of data.

We expect semantic similarity will be combined with other search tools (e.g., facet search, information visualization and visual analytics components) in order to support powerful exploratory searches.

[1] Albertoni R., De Martino M.; Asymmetric and context-dependent semantic similarity among ontology instances, Journal on Data Semantics X, LNCS Vol.4900, Springer Verlag, pp 1-30, (2008)

> R. Albertoni

> Albertoni R., De Martino M.; Semantic Technology to Exploit Digital Content Exposed as Linked Data, eChallenges e-2011, 26-28 October 2011 Florence, Italy,

> Albertoni R., De Martino M., Semantic Similarity Assessment to Browse Resources exposed as Linked Data: an Application to Habitat and Species Datasets, abstract and presentation at INSPIRE conference 2011, 27 June 2011 – 1 July 2011, Edinburgh, Scotland.

RESEARCH

COLLABORATIONS and VISIT EXCHANGES

Computer Graphics and Multimedia Group
RWTH, Aachen University
Germany

The SMG and the Computer Graphics Group at RWTH started a collaboration on mesh repairing. Mesh repairing is a key component of modern application pipelines and tool chains that deal with 3D models. In recent years, indeed, polygon meshes have established as a standard representation in more and more application areas, while many upstream processes yield imperfect output meshes that are not compatible with the input requirements of other processes further down the pipeline. These facts motivated the proliferation of numerous algorithms to fix mesh defects.

Both the SMG and the Computer Graphics Group at RWTH are world-leading teams on this subject, and the first objective of their collaboration is about systematizing and classifying the existing mesh repairing algorithms into a survey paper. The manuscript has already been accepted for publication in the ACM Computing Surveys. Connected to the survey, a new web-site has been published with a list of software tools that perform repairing tasks and are freely available on the Web (http://www.meshrepair.org).

> M. Attene

> *Contact person at RWTH: Prof. Leif Kobbelt*

School of Remote Sensing and Information Engineering
Wuhan University
China

A new synergy has been established between the SMG's work on shape segmentation and the research undertaken by Dr. Xuan Sun and Prof. Qingquan Li on the analysis of building models. A first result of this collaboration is represented by a paper on "Automated Abstraction of Building Models for 3D Navigation on Mobile Devices" by X. Sun, B. Yang, M. Attene, Q. Li, S. Jiang, appeared in the IEEE GRSS Procs. of the 19th International Conference on Geoinformatics, Shanghai (China), 24-26 June, 2011. In this work, complex models of both modern and traditional buildings are abstracted so that they can be efficiently visualized on low-end mobile devices to implement interactive 3D city maps.

> M. Attene

> *Contact persons at Wuhan University:* Xuan Sun and Qingquan Li

TRAINING

Bachelor thesis: Singularities in free-form curves

On July 20th 2011, at the department of mathematics of the University of Genova, Federica Sciacchitano discussed her Bachelor's Thesis entitled “Singularities in free-form curves”. The thesis provides a survey of the types of curves generally adopted in Computer Graphics and Computer-Aided Design. In addition it analyses the singularities of 2D curves and implements a method for their evaluation.

Supervisor at IMATI: Franca Giannini

> F. Giannini

PhD thesis: Modification of semantically enriched FE mesh models: Application to the fast prototyping of alternate solutions in the context of industrial maintenance

PhD Thesis defended by Ruding Lou on June 21st, 2011. Joint PhD. Department of Mechanical Engineering, University of Genova Supervisors at IMATI: Franca Giannini, Bianca Falcidieno. Arts et Mètiers ParisTech: Supervisors Jean Philippe Pernot, Philippe Veron. Industrial Supervisors at EADF: Raphael Marc, Alexei Mikchevitch.

The virtual product behavior simulation in the context of product design solution optimization consists in a loop of four steps: CAD modeling, meshing, semantics enrichment and FEA. In order to accelerate the process during evaluating several product design solutions this thesis has focused on improving the loop by reducing the meshing and semantics enrichment steps. Concretely the proposed loop consists in semantically enriched FE meshes modification and FEA. For showing the feasibility of the optimized loop four instances of the semantically-enriched mesh operators are prototyped: merging, cracking, drilling and filleting. Candidate for the prize of thesis Pierre Bézier d’Arts et Métiers ParisTech.

> F. Giannini

Master Thesis: Characterization and modification of curves based on aesthetic criteria

Master Thesis at the Arts et Métiers – LSIS Laboratory, Aix-en-provence.2010-2011, Candidate: Jerome Pelletier. Supervisor: Jean-Philippe Pernot, External supervisors: Franca Giannini , Marina Monti

On June 22nd Jerome Pellettier discussed his Master thesis at the Arts et Métiers – LSIS Laboratory in Aix-en-provence. The thesis illustrates the research activity that has been carried out in collaboration with IMATI institute in Genoa: in particular a survey has been proposed to a sample of person in order to evaluate the feelings elicited by a set of curves and investigating if and how lay people perception of some aesthetic properties of curves differ from stylist perception.

> M. Monti

Internship: Categorisation of CAD models based on thin part identification

During his 3-moths internship at IMATI, Cédric Petton defined conditions for the classification of CAD parts according to specific characteristics that might generate problems during the creation of mesh model for FEA. Two categories have been considered: objects having an overall thin shape, objects with some ifeatures particularly thin with respect to the overall object shape. Various shape descriptors have been defined/selected and combined for the object-category association. A prototype for their identification has been implemented in Mathematica and integrated as plug-in in CATIA.

> F. Giannini

Master de Research - KIMP Arts et Mètiers ParisTech.

Supervisors: Franca Giannini (IMATI) and Jean Philippe Pernot (Arts et Mètiers ParisTech)

WHO IS WHO

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 Modeling 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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WHO IS WHO

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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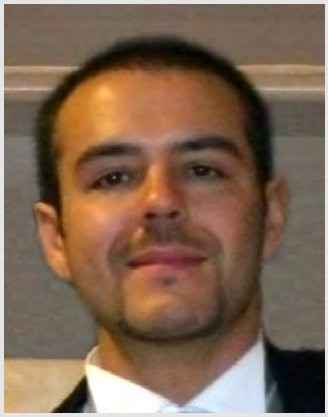

Marco Attene - *Researcher*

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 re-meshing, 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 has managed six sourceforge software projects involving experts from the University of Genova and from the SMG at IMATI, and led 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 is involved in academic research since 1999 when she joined IMATI, after 14 years of experience in research and development departments of CAD companies, where she managed several international projects. Her main scientific activities focus on geometric modelling, product model representation and management, and knowledge technologies. Main industrial application fields are mechanical design, industrial design and process plant. Working in research departments both industrial and public, she participated to several international funded projects, thus being involved both in the development of industrial products and in international research projects.

She acted as reviewer of several international journal and conferences. She also acted as international expert for the European Commission and for European Organizations for Scientific Research. She has published extensively in high profile journals and conferences and is co-author of more than 40 international journals and reviewed conference papers.

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WHO IS WHO

Monica De Martino - *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 - *Researcher*

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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WHO IS WHO

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, time-depending 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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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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WHO IS WHO

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 in metadata analysis tools. In particular, he has focused on 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 - *Researcher*

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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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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Sergio Decherchi – *Post-doctoral fellow*

Sergio Decherchi obtained the "Laurea" degree summa cum laude in Electronic Engineering in 2007 from Genoa University, Italy. Since 2005 he started collaborating with the Department of Biophysical and Electronics Engineering of Genoa University, where he completed a PhD in Electronic Engineering on Machine Learning and Data Mining in 2010. His main research area is computational intelligence and in particular statistical learning theory. The main addressed theme during PhD where the role of the hypothesis space in regularized learning algorithms (i.e. kernel methods). Other themes studied are: semi supervised learning, model selection, digital hardware implementation of intelligent systems; applicative domains, among others, include text mining and digit recognition. Other interests are on Biophysics and Number Theory. S. Decherchi published 20 papers in refereed conferences and journals. He is in the program committee of the CISIS conference series (Springer LNCS proceedings), reviewer for several IEEE and Elsevier journals and for the conferences IJCNN and ISCAS both from IEEE.

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UPCOMING EVENTS

Upcoming Events

VIEW, 12th International Computer Graphics Conference

October 25 - 28, 2011 (Turin, Italy)

VAST 2011: International Symposium on Virtual Reality, Archaeology and Cultural Heritage

October 18th-21st 2011 (Prato, Italy)

The 4th International Conference on Motion in Games 2011

November 13, 2011 (Edinburgh, UK)

VRST 2011: The 17th ACM Symposium on Virtual Reality Software and Technology

November 22 - 24, 2011 (Hong Kong, China)

SIGGRAPH Asia 2011

December 13 – 15, 2011 (Hong Kong, China)

ICPRAM 2012: First International Conference on Pattern Recognition Applications and Methods

February 06 - 08, 2012 (Algarve, Portugal)

GRAPP 2012: International Conference on Computer Graphics Theory and Applications

February 24 - 26, 2012 (Rome, Italy)

HOW TO REACH US

We are located in CNR's "Research Area of Genova"

Torre di Francia, Via De Marini 6, Genova.

Highway gate GENOVA OVEST (5 mins walking, about 300 m)

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)

Editorial Board