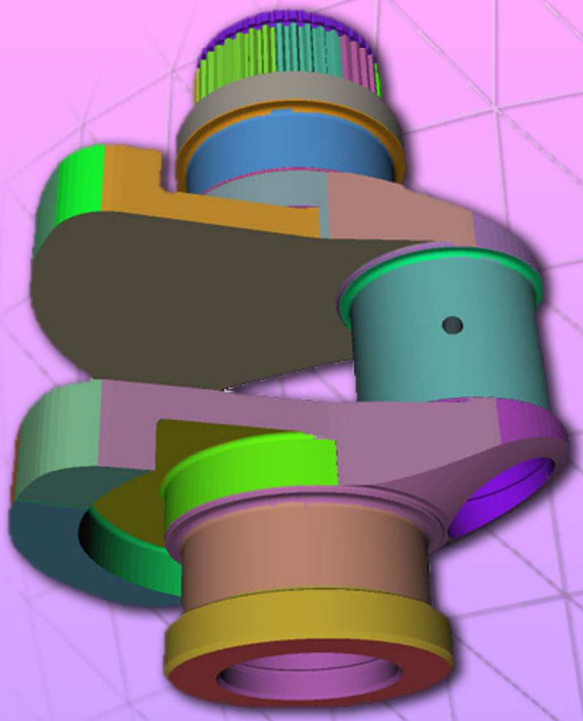
NOSMOG

Newsletter Of the Shape MOdelling Group

Issue 2, March 2010



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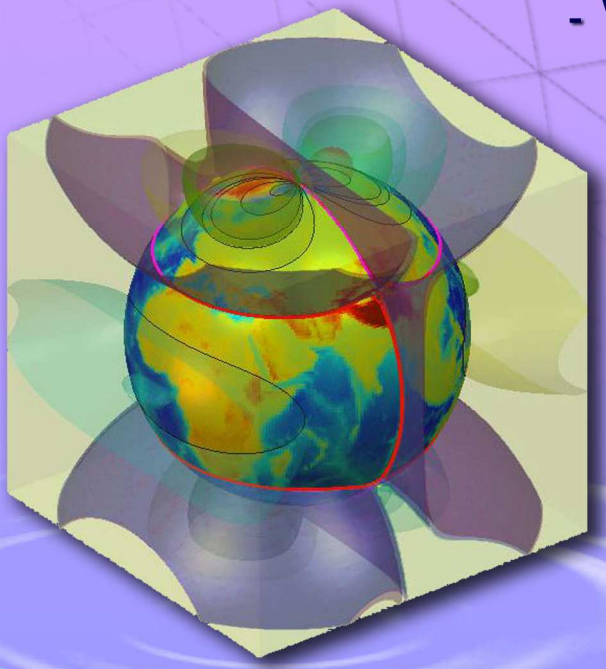

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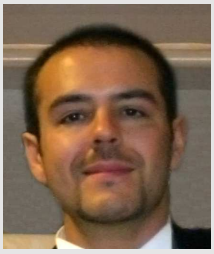
Istituto di Matematica Applicata e Tecnologie Informatiche - Genova

EDITORIAL



Now that the FOCUS K3D European project is finished, it is time to collect the results and make them produce new challenging research. The Shape Modeling Group at IMATI is proud to have coordinated such a successful project and to have delineated, with the help of the FOCUS K3D consortium, a "research roadmap" that identifies high-level goals and long-term challenges that the Computer Graphics community should face in the upcoming years.

In this second issue of the Newsletter Of the Shape MOdelling Group, we summarize these grand challenges along with all the other recent activities and research results of the group. While highlighting the connections between each single activity and the aforementioned long-term goals, we also try to provide insights about current and future work of the SMG in new and interesting areas. So, we draw attention to the fact that Semantic Web and Linked Data technologies are becoming more and more widespread, and connecting the "world of shapes" to such a "world of distributed data" is perceived by the community as a crucial step towards a really pervasive use of 3D; herewith, we describe the participation of the SMG to important European initiatives to reach this objective. Furthermore, we show that the marriage between Computational Geometry and Knowledge Technologies (promoted by the SMG through AIM@SHAPE and FOCUS K3D) has triggered interesting collaborations within related areas such as robot vision and query formulation in 3D search environments, but also within unexpected contexts such as drug design, medicine and Earth sciences.

Clearly, the center of gravity of the SMG activities remains the study of 3D shapes, where the group keeps on performing both fundamental and applied research at an international level. The second part of this newsletter is dedicated to these aspects. Within the group the most recent activities include the study of the Laplace-Beltrami and the heat diffusion operators, but also the development of algorithms to automatically repair digitized 3D models, or to intelligently cut a surface to make it developable on the plane. These studies are also used to define abstractions of the shapes that can be used as "signatures" to perform retrieval or classification tasks, with applications in areas such as molecular docking and face recognition.

The research activities of the group take advantage of a network of fruitful collaborations that are kept alive through several mechanisms, including bi-lateral cooperation agreements, visit exchanges, co-training of students and, clearly, financed projects. Hence, a significant part of this newsletter is dedicated to the description of recent actions of this type.

> Marco Attene

SMG: the Shape Modelling group @ CNR-IMATI Ge

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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**

FOCUS K3D

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 promotes 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.

The research road map envisaged by FOCUS K3D is an attempt to synthesize the vision of the project on semantic 3D media, after an extensive discussion with a variety of users in the four application domains we selected. We identified high-level goals that represent the long-term challenges that the Computer Graphics community should face as new targets for new and disruptive research, with a strong need to breach the borders of a single discipline and call for a truly multi-disciplinary effort. The five grand challenges are: Derive Symbolic Representations (i.e. how to derive semantic models from acquired data), Goal-oriented 3D Model (i.e. how to embed knowledge and function in the modelling and simulation processes), Documenting the 3D Lifecycle, Semantic Visualisation and Interaction, Standards. Within each of these high-level challenges, we also identified a number mid-term challenges that, without being exhaustive, could be the required building blocks for making further important research advancements.

The Digital Shape Workbench (DSW)

Developed under the EU FP6 NoE **AIM@SHAPE** coordinated by IMATI (www.aimatshape.net) the DSW has become a reference workbench for the research community at global level, providing high quality and documented models, tools and bibliographic resources that can be browsed by concept through ontologies. The DSW had nearly 2.500.000 visits from all over the world and more than 1.000.000 downloads since its first release in March 2006. At present the Shape Repository of the DSW contains 1180 shapes approximately. The DSW is still maintained and continuously updated with new resources (e.g. by domain specific shapes under the FP7 FOCUS K3D project).

After the experience of FOCUS K3D and as reflected by the research road map, the path towards really effective semantic 3D content is still complex, but doable. As the research road map tries to convey, we believe that the potential of semantic multimedia technologies could be fully exploited in 3D and knowledge intensive application areas, where the processes deal with contents of multiple form and type, the processing workflows are guided by knowledge and semantics, and the working environment is usually distributed. Computer Graphics is ready to answer these challenges, but it needs a more close connection with Knowledge Management, Machine Learning, and Cognitive Modelling.

The research roadmap has been already presented at the FOCUS K3D final conference on Semantic 3D Media, which wanted to provide interesting insights on novel ideas and applications in the emerging research field of semantic 3D media and content.

The programme featured six keynote talks by outstanding experts in the area of the Semantic Web and in the application domains considered in FOCUS K3D: Medicine, Bioinformatics, Archaeology and Cultural Heritage, Gaming and Simulation, CAD/CAE and Virtual Product Modeling. Moreover, the presented research road map has been discussed with the participants during a panel session. Technical sessions on the five application domains and project presentations completed the programme. Further information about the 5 Thematic workshops and the final conference can be found at www.focusk3d.eu, where the complete road map will be downloadable soon.

> C.E. Catalano and M. Mortara

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

Consortium: **CNR-IMATI-GE** (Italy), CERETETH (Greece), EPFL (Switzerland), FHG (Germany), INRIA (France), MIRALab (Switzerland), SINTEF (Norway), UU (The Netherlands).

Project coordinator*: Bianca Falcidieno*

PROJECTS

Spatial Data Analysis

PROJECTS

Network for promotion of cross border dialogue and exchange of best practices on Spatial Data Infrastructures (SDI's) throughout Europe

The objective of eSDI-Net+ is to bring together existing SDI key players and target users in a Thematic Network to be established as a platform for communication and exchange between different stakeholders involved in the creation and use of SDI's. The network promotes high-level decisions, technical discussion and information exchange, in order to increase awareness concerning the importance of GI enrichment and of SDI's for GI reuse, to allow an integrated view of the experts and to permit the creation of integrated guidelines, standards, and implementation of best practices. The main outcomes of the project are the identification of criteria for SDI good practices and the SDI best practice awards assigned during a conference organised by the project in November 2009.

IMATI-CNR is involved in the project as technological partner in order to support network discussion for the identification of the technical components relevant for the identification and analysis of best practices. In particular considering that within eSDI-Net+, multicultural and multilingual aspects in accessing digital GI content are addressed, IMATI-CNR contributes with his experience on knowledge management technology to identify SDI aspects related to semantic interoperability between digital collections and services in order to facilitate access and use of the digital content in a multilingual context.

> M. De Martino

> Project website: http://www.esdinetplus.eu/ Scientific responsible for IMATI: *Bianca Falcidieno*

Best Practice Network for SDI in Nature Conservation

NATURE-SDI*plus* aims at establishing a Best Practice Network dealing with a cluster of the data themes listed in the Annexes I and III of the INSPIRE Directive (2007/2/EC) and focused on the nature conservation issues. The project contributes to the implementation of the INSPIRE Directive with targeted reference to the following cluster of data themes of the INSPIRE Annexes Protected Sites (Annex I) Biogeographical regions (Annex III) Habitats and biotopes (Annex III) Species distribution (Annex III)

Projct Objectives are: (1) To establish a Network on Geographical Information for nature conservation in order to share experiences and good practices, to stimulate the community of nature conservation stakeholders at improving, the harmonisation, the exploitation and the access to their datasets. (2) To evaluate common metadata profile and data model for the addressed data themes in supporting the INSPIRE Directive implementation at EU level. **Project Outcomes** are: (1) An analysis of the usability and the accessibility of data. These results are used to develop the NATURESDI*plu* European metadata profile and data model for datatsets on nature conservation and for multilingual and multicultural tools for a simpler and standardised access to spatial data. (2) A geoportal, as a demonstration infrastructure, that is compliant with the INSPIRE principles and supported by web services, provides the data accessibility as main gateway to available datasets and services and an open Network of stakeholders dealing with geoinformation for nature conservation.

IMATI-CNR has been involved in the project for his expertise on technology for knowledge management and semantics analysis of spatial data. In particular IMATI has been responsible of the activity related to the multicultural and multilingual issues in spatial data sharing. The result of his activity has been a semantic based framework exploiting Semantic Web technology to face with multicultural/multilingual issues in data interoperability. In particular the implemented framework is going to be employed in the development of the NATURE-SDI*plus* European metadata profile enriched by semantics and data model for datasets on nature conservation. Moreover the framework is employed to facilitate spatial data search a metadata annotation at geoportals level.

> M. De Martino

> Project: cofunded by EU programme eContentplus

> Websites:http://www.nature-sdi.eu , http://linkeddata.ge.imati.cnr.it:2020/

> Consortium: 30 partners (IT, AT, ES, GR, BE, DE, LT, UK, PT, CZ, HU, PL, NPD, CY, SE, FR, SK, INT) coordinated by **GISIS** (IT)

> Scientific responsible for IMATI: *Monica De Martino*

Shape Retrieval and Recognition

Advanced techniques for three-dimensional shape retrieval

In this joint research project, we aim at investigating new tools for shape characterization and indexing, and new approaches to formulate queries in a 3D search environment. To this end we intend to combine knowledge of both teams in the areas of shape analysis and retrieval. The Portuguese team has already been working on a framework for retrieval of 2D drawings, images and graphics, as well as on research on 3D retrieval based on shape similarity and semantic characterization. The Italian team has been developing internationally recognized research on 3D analysis and classification. So, by combining the complementary skills of both research groups, we are creating a better critical mass in the area of 3D retrieval.

Therefore, from the proposed bilateral cooperation several outcomes are expected. From a scientific perspective, we plan to deepen the reciprocal knowledge and define together a detailed set of requirements that an advanced search engine for 3D retrieval should have. Moreover new algorithms for shape description and indexing and new paradigms for query formulation will be studied.

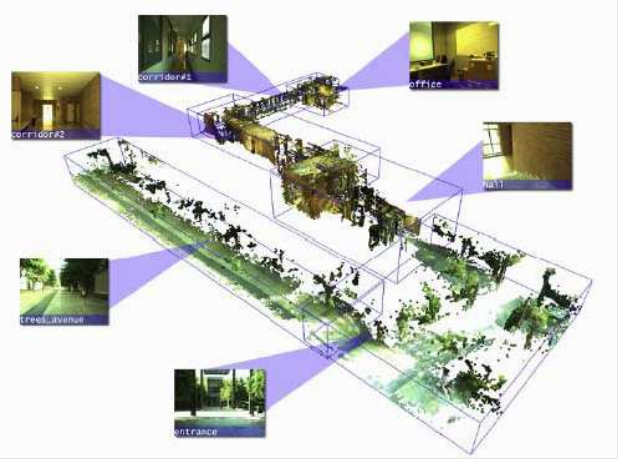
> S. Marini

> Project and partners: *bilateral cooperation with the Instituto de Engenharia de Sistemas e Computadores Investigação e Desenvolvimento em Lisboa (Portugal)*

> Scientific responsible for IMATI: *Michela Spagnuolo*

HL-SLAM: Hybrid Metric-Topological Slam Integrating Computer Vision and 3D Laser for Large Environments

Simultaneous Localization and Mapping (SLAM) is a technique which robots and autonomous vehicles use to build a map of the environment they are moving in, while at the same time keeping track of their current position. The HL-SLAM project aims to develop new hybrid SLAM techniques which are able to combine visual 2D information with 3D information coming from stereo or 3D laser scanning. In other words, the project plans to complement Computer Vision-based analysis (appearance and stereo) with 3D point cloud analysis.



The involvement of IMATI in the project is concerned with 3D data characterization, feature extraction, segmentation and recognition. In particular, IMATI contributes to the project with techniques to describe 3D object and scenes via computational topology techniques.

IMATI participates in the HL-SLAM project with D. Giorgi as an invited researcher. In the context of the project activity, she visited the University of Alicante on December 2008. The project coordinator Prof. F. Escolano visited IMATI on February 2010.

> D. Giorgi

> Project: *international project funded by the Spanish Ministry of Science and Education.*

> Partners: *Univ. of Alicante (ES - coordinator), INAOE (Mexico) and IMATI*

> Scientific responsible for IMATI: *Daniela Giorgi*

PROJECTS

Semantics and Computational Geometry

PROJECTS

An Open, Ubiquitous and Adaptive Chronic Disease Management Platform for COPD and Renal Insufficiency

CHRONIOUS (http://www.chronious.eu/) is a European project aimed at defining an open platform to manage and monitor patients with chronic diseases during their daily life through the implementation and deployment of a platform that will be worn by the patients.

The project team envisages an adaptive and ubiquitous chronic disease management system that offers continuous monitoring to patients by using several sensors either in a form of a wearable solution or scattered in the patient's living environment and a series of "intelligent" services to healthcare providers and organisations that aid them in the monitoring of their patients. For medical professionals, several services are going to be provided by the CHRONIOUS platform. First, healthcare professionals are provided an intelligent access to certified healthcare information that is indexed in a meaningful and structured way through dedicated ontologies, so as to save time when searching and to retrieve more focused information. This new approach, in which IMATI is mainly involved, uses ontologies combined with medical thesauri (e.g. http://www.nlm.nih.gov/mesh/meshhome.html) to provide focused and cross-lingual information retrieval. The use of domain-specific ontologies is an appealing approach to allow users to express information requests at a higher level of abstraction with respect to keyword-based access.

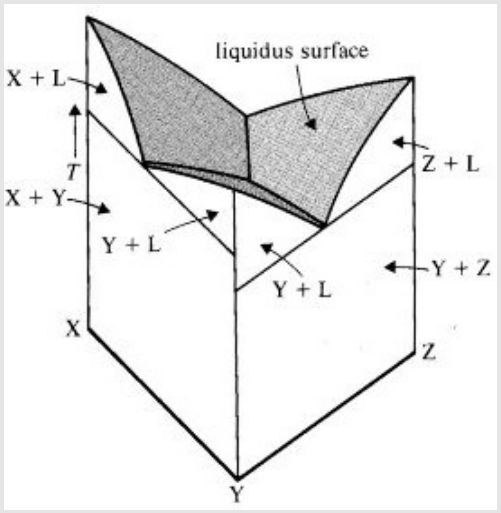
Furthermore, IMATI is also involved in the specification of Decision Support services for professionals involved in the Chronic Disease Monitoring and Management Process that exploits the massive amount of data recording and information available at different sites of the process (health history, hospitalization data), in order to discover correlations between daily activity processes that are not yet known.

> S. Marini

> Project: EU FP7 ICT-2007.5.1 (2008-2012) Website: http://www.chronious.eu

> Coordinator: **TESAN S.p.A** (IT) Scientific responsible for IMATI: *Franca Giannini*

Study and development of computational geometry and shape analysis tools to support the computation of ternary and quaternary phase diagrams



In this research contract, the competences of the SMG on computational geometry and shape analysis are put to the service of Earth and Material Sciences. The context of the project, indeed, deals with the study of a computational tool able to depict the thermochemical features of complex silicate melts.

In such a context, the representation and analysis of the so-called "liquidus" turns out to be particularly important: roughly speaking, the liquidus is a hyper-surface describing the melting temperature of a composite material as a function of the relative amount of its constituting pure elements. Thus, in a binary system (i.e. a material made of two pure elements) the liquidus is a curve, in a ternary system it is a surface, and so on.

The objective of this research is to support the computation and analysis of the liquidus using geometry-based techniques. While traditional methods derive the liquidus using numeric approximation techniques, the approach we propose is based on the analysis of a convex hull, which appears to be much more robust and reliable. Furthermore, once all the samples of the liquidus are computed, they can be interpolated through a simplicial complex to produce a continuous model which is suitable for further analysis. We plan to validate this model by computing descent lines describing the behaviour of the melt as its temperature decreases.

> M. Attene

> Project and partners: *research contract committed to IMATI by Dip.te.ris-University of Genova.*

> Scientific responsible for IMATI: *Marco Attene*

Mesh Repairing

Automatic repairing of polygonal and tetrahedral meshes

When designing algorithms for geometric processing and analysis, researchers often assume that the input conforms to several requirements. On the other hand, both synthesized and digitized meshes typically exhibit several defects, and thus are not appropriate for a widespread exploitation

Digital 3D shape models are crucial in many sectors such as industrial design, gaming, simulation and medicine, to cite a few, and their impact on forthcoming multimedia-enabled systems is foreseen to grow significantly. Moreover, significant advances in 3D acquisition technologies have brought a gradual change in the way 3D models are produced and handled, and currently digitized models are becoming more and more widespread.

Although producers of 3D digitizers try to make their tools as flexible as possible, each specific application context has its own requirements that define the class of supported 3D models. In industrial design, for example, several downstream applications assume that the mesh does not contain degenerate, or nearly degenerate elements. In computer graphics, numerous shape analysis tools expect the input mesh to enclose a solid; such tools typically fail if the mesh has holes, or provide unpredictable results if the input has self-intersections. Also, several algorithms are defined only for input meshes with manifold connectivity.

Thus, repairing simplicial meshes is particularly important, and the SMG provided significant contributions in this area. In the past, we worked on an interactive system called ReMESH that helps the user in the task of identifying and fixing geometric errors on polygon meshes (see NoSMoG N. 1, pp. 11).

After having used ReMESH extensively to fix digitized models, we have identified a rather common pattern in the sequence of the repairing operations employed. Thus, we have developed an algorithm that replicates such a sequence of operations automatically, and hence is able to fix digitized models with surface holes, degenerate elements, self-intersections and non-manifold connectivity, without requiring any user intervention. This makes the algorithm particularly appropriate to automatically fix big shape repositories.

The model of a chair repaired through our new algorithm

Another contribution in this area is represented by two novel algorithms to fix tetrahedral meshes so as to turn them to valid manifolds. In medical applications, CT or MRI scans of a patient generate raster 3D images from which one can extract the shape of a particular tissue (e.g. an organ or a bone). This procedure may generate volumetric simplicial meshes whose suitability for specific applications (e.g. for surgical simulation) is often based on the fact that they are manifold.

Our novel algorithms are able to automatically correct the topology and, if necessary, the geometry of a tetrahedral mesh so that it can be exploited in a much wider set of contexts.

> M. Attene

> Marco Attene, Daniela Giorgi, Massimo Ferri and Bianca Falcidieno. "On converting sets of tetrahedra to combinatorial and PL manifolds". Computer-Aided Geometric Design, Vol. 26, No. 8, pp. 850-864, 2009.

> Marco Attene. "A lightweight approach to repairing digitized polygon meshes". The Visual Computer, 2010 (to appear – DOI: 10.1007/s00371-010-0416-3).

> Software: MeshFix V1.0 – http://meshfix.sourceforge.net

RESEARCH

3D Face Recognition

RESEARCH

3D Face Recognition via Multidimensional Scaling and Spherical Harmonics

Face recognition is needed to build advanced security systems in high-risk areas such as airports. Most techniques analyse 2D data, i.e. images acquired by cameras. Recently, the research community has started focusing on 3D data, as 3D models are highly informative, less sensitive to illumination, and independent of the subject's pose

In the context of the MultiTrust project, the company Elsag Datamat and IMATI worked together on face recognition for security systems. The reference scenario was people identification at airport checkpoints. The project purpose was to assess the potential of 3D-based techniques to overcome the typical limitations of 2D-based methods in non-controlled situations: sensitivity to changes in illumination; lack of robustness with respect to occlusion of landmark points such as pupils; sensitivity to changes in facial pose. In all these cases, the analysis of 3D data is expected to help filling the sensory gap, and to add fundamental information about three-dimensional face features which can be lost after projection on an image.

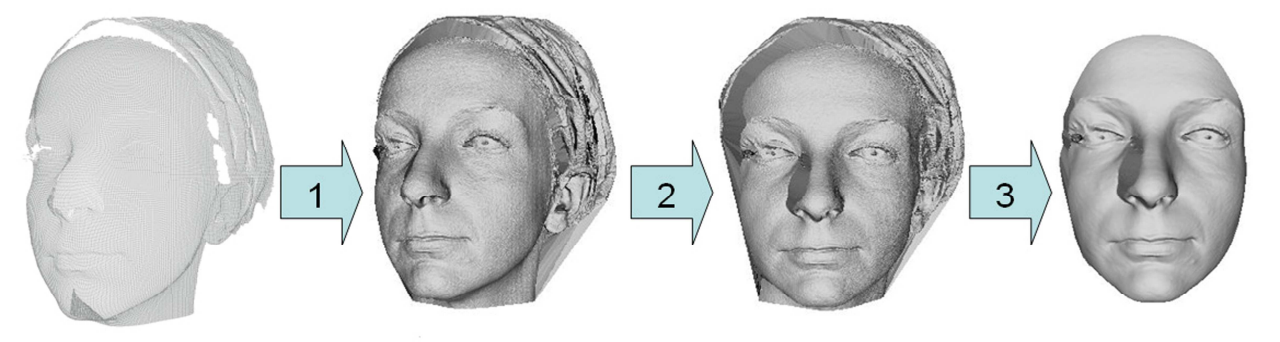
According to the reference setting, IMATI built a representative database of 3D face models, covering the different cases that might occur in real situations, such as changes in pose, expression, illumination. The database was built using laser scanning, during two scanning sessions at different time intervals to simulate time effects. The acquired faces were pre-processed so as to obtain smooth triangular meshes. Although very small, the database has proven to be useful to verify different assumptions.

On this database several face recognition algorithms were tested. We implemented an improved version of a well-known state-of-the-art 3D approach, namely the method based on Multidimensional Scaling proposed by Elbaz and Kimmel (2003, IEEE Trans. on PAMI) and refined by Bronstein, Bronstein and Kimmel (2005, IJCV). After deriving a face signature invariant to facial expressions following the original method, we proposed a variant on the technique for comparing signatures, based on Spherical Harmonics. The performance of this technique was compared with the performance of a widely used 2D-based commercial system, revealing better results on our database.

The outcome of the project has been presented at an international conference on security and surveillance systems (IEEE AVSS 2009) and at a national workshop on workplace safety.

In our future activity, we plan to devise multi-modal algorithms for face recognition, integrating 2D and 3D data so as to achieve a higher trustworthiness degree of results.

> D. Giorgi



From a raw point cloud obtained via laser scanning to a smooth 3D mesh

> D. Giorgi, M. Attene, G. Patanè, S. Marini, C. Pizzi, S. Biasotti, M. Spagnuolo, B. Falcidieno, M. Corvi, L. Usai, L. Roncarolo, G. Garibotto: *A critical assessment of 2D and 3D face recognition algorithms*. Proceedings AVSS 2009: 6th IEEE International Conference on Advanced Video and Signal Based Surveillance, pp. 79-84, 2009

> D. Giorgi, M. Attene, G. Patanè, S. Marini, C. Pizzi, S. Biasotti, M. Spagnuolo, B. Falcidieno, L. Usai: *Riconoscimento di volti con tecniche 3D per controlli di sicurezza*. Atti Scienza e Tecnica Rendono Sicuro il Lavoro, Bragatto & Monti (a cura di), ISPESL CNR, Genova, ISBN 978-88-904413-1, 2009

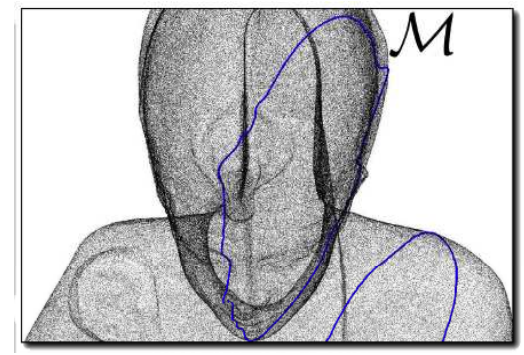
Point-sampled Surfaces

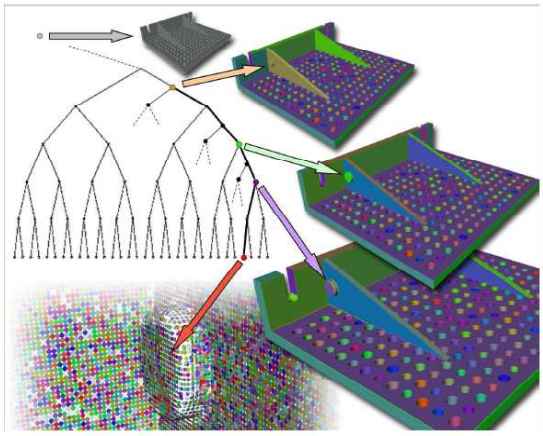
Contouring, segmenting, and abstracting point-sampled surfaces

This research focuses on the definition of a unified paradigm for contouring, segmenting, and abstracting point-sampled surfaces; main applications include shape analysis and comparison, surface reconstruction and editing

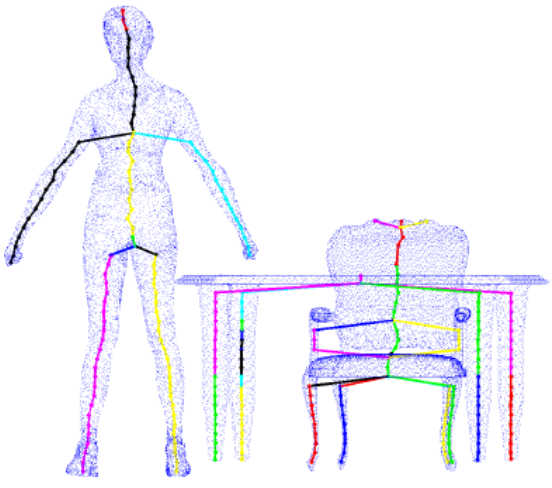
Recent advances in 3D acquisition technologies have brought a gradual change in the way 3D models are produced and handled. Today, precise digitized models are extremely complex, and it is not rare to deal with objects made of millions of elements (e.g., points, triangles, etc). Such a complexity prompted the development of algorithms to analyze, partition, and abstract large models.

In this context, we have proposed a novel framework for the definition, contouring, and visualization of scalar functions on unorganized point sets, which are sampled from a surface in 3D space. Given a map $f:M \rightarrow R$, defined on a point set M, the idea behind our approach is to exploit the local connectivity structure of the k-nearest neighbor graph of M and mimic the contouring of scalar functions defined on triangle meshes through moving least-squares and implicit modeling. Furthermore, these techniques have been used to define the scalar function underlying f and study their numerical stability and approximation accuracy.





Then, we have focused our research on hierarchically segmenting point sets in useful shape parts, with the aim of reducing the gap between a huge development of mesh-based techniques and a relatively low attention on multi-resolution decompositions of point sets. The proposed hierarchical representation $H(M)$ of a point set M codes the surface underlying M through patches of various shape and size, which form a hierarchical atlas. If M belongs to the class of regular models, which were defined by Varady et al. for reverse engineering, then $H(M)$ captures the most significant features (i.e., planes, spheres, cylinders, cones, torii) of M at all the levels of detail. In this case, $H(M)$ is exploited to interactively select regions of interest on M, intuitively re-design the model, and approximate the input point sets through idealized manifold meshes.



Finally, we have defined a skeletal representation, called Point Cloud Graph, that extends the definition of the Reeb graph to arbitrary point clouds obtained from m-dimensional manifolds embedded in the d-dimensional space. In R^3, the Point Cloud Graph converges to the Reeb graph of the underlying manifold as the point cloud becomes denser. The resulting algorithm is easy to implement and the graph representation yields to an effective simplification of the data. Finally, the experimental results have shown that our approach is flexible and robust to non-uniform point distributions.

> G. Patanè

> Patanè G. *Analysis and Segmentation of Point-Sampled Surfaces*. CNR-IMATI Tech. Report N. 02/2007.

> Attene M., Patanè G. *Hierarchical Structure Recovery of Point-Sampled Surfaces*. Computer Graphics Forum (to appear)

> Natali M., Biasotti S., Patanè G., Falcidieno B. *Graph-based representations of point clouds*. CNR- IMATI Technical Report N. 09/2009.

RESEARCH

Spatial Data Sharing

RESEARCH

Advanced Knowledge Organization Systems for Spatial Data Sharing

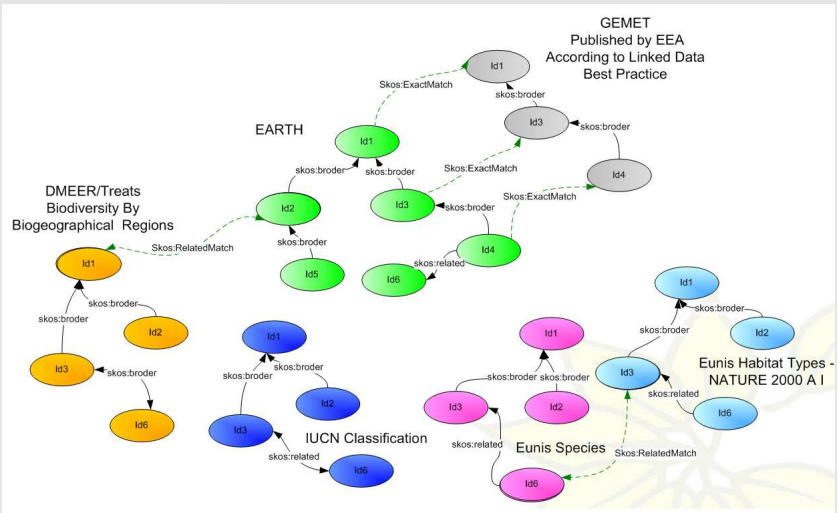
Different Knowledge Organization Systems solutions are proposed to share knowledge among different user communities/countries operating in the Geographic application domain. This activity aims at promoting Semantic Web/Linked Data technology to empower the usability of such systems and overcome their limitations to improve search for spatial data and metadata indexing

Data sharing is affected by multilingual and cultural barriers in the use and reuse of geographical data at international level. It requires the need to use geographic data in a standardised way and with a common nomenclature both in a multicultural and a multilingual context. Knowledge Organization Systems KOS (thesaurus, classification and taxonomy) solution is proposed to share standard technological and scientific terms of geographic data understandable by different user communities operating in the Geographic field. In the current state of play more that one KOS may be available for a given competency, moreover terminologies adopted have often a national origin, so they are not uniform in all the countries and often even stakeholders from the same country can adopt different terminology in everyday practice.

IMATI-CNR has developed a best practice methodology exploiting Linked Data technology to face with multicultural/multilingual issues in sharing geographic information in a Spatial data Infrastructure. In particular it addresses two specific issues: "data resource annotation and publication" and "Information search and retrieval". The proposed methodology has been applied for data on Nature Conservation within an EU project "NATURE-SDIplus".

The outcome is a Common Thesaurus Framework where different well known KOS referring to a specific topics (e.g. nature conservation) are shared and assembled with the intent of providing an integrated result for the different faced of the topic: within the framework, thesauri can be just added or if needed linked with other thesauri internal or external to the framework. The result is a dynamic environment where a new thesaurus can be added or further extended and two different thesauri may be interlinked.

The framework fulfils the requirements of "modularity" to preserve future updates for existing terminologies, "openness" to add as separated modules new concepts keeping separated the original KOS, "exploitability" to be adopted and enriched by third party system by encoding the KOS in a standard and flexible format, "interlinking" to harmonize the term usage by linking terms and concepts among different KOS. To meet these properties, Semantic Web technology have been adopted for the implementation: SKOS model to encoding a thesaurus according to semantic web\W3C recommendations and Linked Data best practice to publish the thesaurus in machine understandable format.



Common Thesaurus framework for Nature Conservation: structure and contents

> M. De Martino

> The Common Thesaurus Framework is published at http://linkeddata.ge.imati.cnr.it:2020

> "A joint initiative to support the semantic interoperability within the GIIDA project", P. Plini, S. Di Franco, V. De Santis, V. Felice Uricchio, D. De Carlo, S. D'Arpa, M. De Martino, R. Albertoni, Ci4DM Congress Proceeding, Torino, 3-5 February 2010.

Topological Segmentation

Topological segmentation of surfaces and volumes using applicative constraints

Subdividing surfaces into tubular regions using scalar functions to detect the boundaries — using fuzzy data from segmentation on medical images to detect and correct unwanted junctions

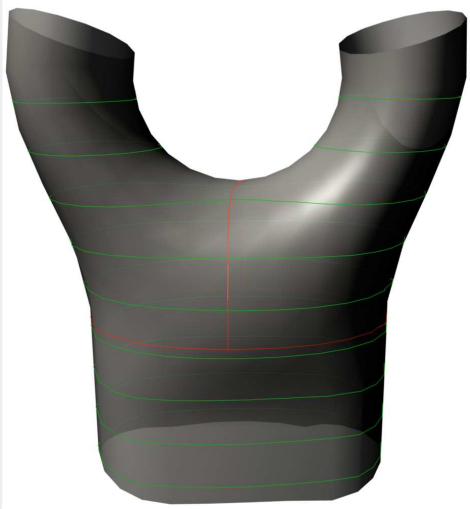
RESEARCH

Segmentation of surfaces into cylinders

Subdividing surfaces into tubular regions is a significant question in various applications, and specific approached has been described in several domains. However, most of the time topological properties are not globally handled.

In a previous work, we introduced an original cutting structure, called n-loops that allows to produce cylindrical regions with good combinatorial and topological properties: each boundary of the cylinders contains exactly two points with more than two adjacent cylinders. An n-loop is defined by 2 points called base-points, and n non-homotopic paths joining the two base-points. Even if the topology of the surface induce the number of n-loops to produce a tiling in cylinders, the location of the n-loops depends on various parameters: the geometry of the surface, but also the applicative context.

In this work, we describe a method to adjust the location of the n-loops using a continuous scalar function defined on the triangulated mesh, and designed by piecewise-linear interpolations on triangles using given values on the vertices. A such function can be computed by handling various properties as geometry, topology, or specific properties form the applicative context.



A 3-loop computed using a scalar function on the input surface

Detection of α-junctions on volumes

Topological manipulation of surfaces has been used to correct data resulting from medical images, for example by removing topological noise. In this context, we described the α-junctions as the shortest non-separating loops, that corresponds to unwanted junction. However, this definition refers to surface properties of the volume, but the final cut can be seen as a volumetric correction.

In this work, we plan to extend the cutting ideas for volume data, with the aim to find the cuttings of minimal surface. In our previous works, we modified the geodesic distance introducing some applicative or geometric information.

We plan to perform here the same kind of modifications, by introducing on the data structure values computed from the geometry and/or the applicative context (e.g. the values computed by a fuzzy segmentation process in an MRI).

> J.-M. Favreau

> J-M. Favreau, S. Biasotti, V. Barra, M. Spagnuolo. "N-loop computation using scalar function", Curves and Surfaces, Avignon, 2010

Modification of FEM Meshes

RESEARCH

Transferring FEM semantic data in CAD-less mesh modification

Avoiding the re-insertion of Finite Element Analysis (FEA) semantic data is a key issue to make more efficient the behaviour evaluation of product shape alternatives. This can be obtained by providing suitable tools that modify the product shape directly acting on the semantically enriched FE model

This research activity is carried on in collaboration with ENSAM in Aix-en-Province and EDF in Paris. It is aimed at defining methods and tools for the direct shape modification of Finite Element Meshes, either 2 or 3D, while preserving and possibly updating the associated semantic information.

Nowadays, most of the numerical simulations are carried out by successively performing the following steps: CAD model definition or modification, conversion to a mesh model and enrichment with semantic data relative to the simulation (e.g. material behaviour laws, boundary conditions), Finite Element simulation and analysis of the results. Classically, the semantic data (e.g. materials, boundary conditions) are attached to the mesh through the use of groups of geometric entities sharing the same characteristics. Thus, any modification of the CAD model always implies an update of the mesh as well as an update of the attached semantic data. This is time-consuming and not adapted to the context of industrial maintenance and, in general, when CAD models are not available.

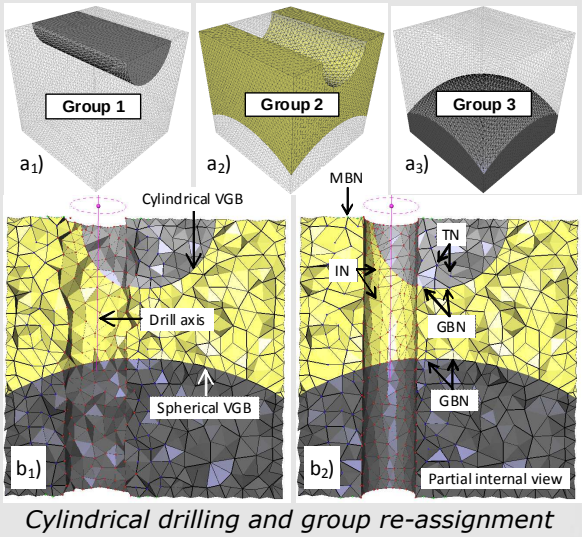
To overcome these limits, we propose a CAD-less prototyping framework working directly at the level of meshes enriched by semantics expressed as mesh groups. In this way, the number of steps necessary for FE model preparation stage can be reduced. The idea is to remove the "hard" steps of CAD modification, re-meshing and FE model preparation by bringing necessary local modifications directly onto the meshes while maintaining and potentially propagating the associated semantic data. We foresee various operators, such as union, crack insertion, drilling, …, for direct modification of enriched FE mesh models mechanically tuned (i.e. physically validated). Devising the mesh modification operators that take into account and preserve the presence of FE semantic data (i.e. reassign the elements of the modified mesh to the corresponding groups such that the geometrical shape of the groups is the same of the original ones) allow the complete re-use of semantic enriched 3D models. Obviously, the preservation and propagation rules are context and semantic dependent. For example a material law can be directly propagated, whereas for pressure information the correct propagation depends on the context such as the resulting shape characteristics and the cause of the pressure.

The proposed mesh operators simultaneously act at the geometric level, corresponding to the low level mesh elements, and at the structural one, corresponding to the groups expressing the link to the semantics by collecting mesh elements characterized by semantic data. The operator behaviour is driven by the semantics themselves, including the outer shape of the operands (i.e. of the operated mesh and of the modifying tool) as well as the shape of the groups' boundaries. All of this information is transformed into a set of constraints that drive a mesh deformation engine that is applied to guarantee the mesh quality required in FEA.

>F. Giannini

> R. Lou, F. Giannini, J-P. Pernot, A. Mikchevitch, B. Falcidieno, P. Véron, R. Marc, *Towards CAD-less finite element analysis using group boundaries for enriched meshes manipulation*, Proc. of Int. Design Engineering Technical Conferences & Computers and Information in Engineering Conference, IDETC/CIE 2009, August 30 – September 2, 2009, San Diego, CA, USA

> R. Lou, F. Giannini, J-P. Pernot, A. Mikchevitch, B. Falcidieno, P. Véron, R. Marc, *Direct Modification of FEM meshes preserving group information*, Proc. of TMCE 2010, I. Horváth, F. Mandorli and Z. Rusák (eds.) April 12–16, 2010, Ancona, Italy



Cylindrical drilling and group re-assignment of a 3D mesh

Spectral Analysis

Spectral analysis of 3D shapes and multi-dimensional data

Numerical properties of the Laplacian and the heat kernel matrix have been exploited to analyze, characterize, and compare 3D shapes through high-level signatures and associated feature spaces

In digital geometry processing and shape modelling, the Laplace-Beltrami and the heat diffusion operator, together with the corresponding Laplacian eigenmaps, harmonic and geometry-aware functions, have been used in several applications, which range from surface parameterization, deformation, and compression to segmentation, clustering, and comparison. In this context, our research has been focused on the following activities.

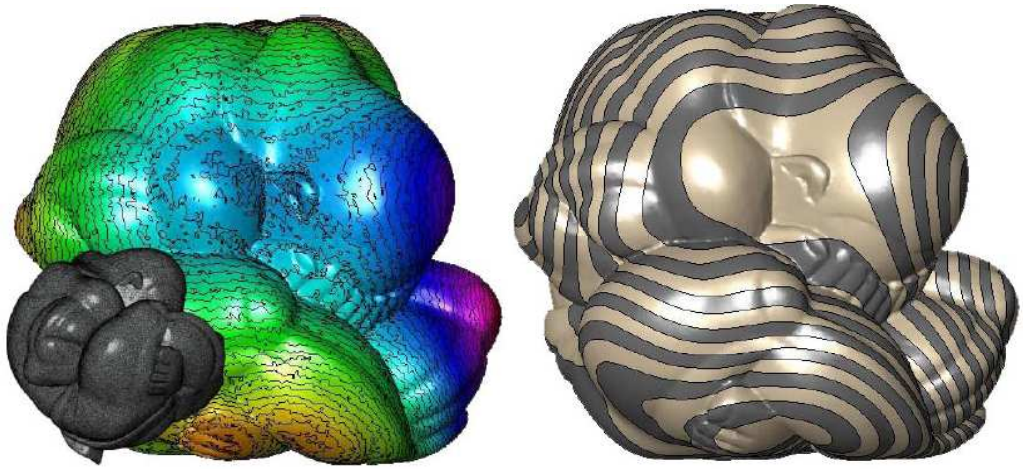
(1) We have improved the results of previous work on the study of the spectral properties of the Laplacian eigenfunctions through the analysis of the numerical aspects behind the computation, robustness, and applications of mesh Laplacian operators. More precisely, the perturbation theory related to the eigenvalue problem has been used to address the numerical (in)stability in the computation of the Laplacian eigenfunctions and show at which extent it affects the analysis of the input surface. Then, the spectral properties of the Laplacian matrix have been exploited to introduce the Tikhonov regularization, the feature and scale-based spaces associated to triangulated surfaces. Finally, these concepts have been characterized through the analysis of their main properties and applications.

(2) We have derived a novel discretization of the heat kernel, which is linear, stable to an irregular sampling density of the input surface, and scale covariant. With respect to previous work, this last property makes the kernel particularly suitable for shape analysis and comparison; in fact, local and global changes of the surface correspond to a re-scaling of the time parameter without affecting its spectral component.

(3) We have studied the feature spaces and scale spaces that are induced by the proposed Laplace-Beltrami operator and heat kernel on surfaces, respectively. These spaces have been used to provide a multi-scale approximation of scalar functions defined on 3D shapes.

(4) We are investigating the selection of the Laplacian eigenvalues and the definition of novel signatures for shape comparison. The shape can be represented by manifold as well as non-manifold triangle meshes; specializations to point-sampled surfaces are currently under investigation.

> G. Patanè



Level-sets of a noisy scalar function and its smooth approximation, which has been computed through the discrete heat kernel

> Ruggeri M. R., Patanè G., Spagnuolo M., Saupe D., Spectral-driven isometry-invariant matching of 3D shapes. In: International Journal of Computer Vision. May 2009.

> Patanè G, Falcidieno B. Multiscale feature spaces for shape analysis and processing. In Proc. Shape Modeling International (SMI) (2010). To appear".

> S. Marini, G. Patané, M. Spagnuolo, B. Falcidieno. *Enhanced spectral shape comparison*. EG Workshop on 3D Object Retrieval, 2010. To appear.

RESEARCH

Shape Approximation

RESEARCH

Shape approximation based on differential properties of real functions

We are addressing the problem of surface approximation through the use of iso-contours and flow paths of a real function. Our results confirm that this approach is suitable for progressive surface simplification, transmission, and reconstruction

This research activity addresses the problem of surface approximation through the iso-contours and portions of flow paths of a real function defined on a closed triangle mesh.

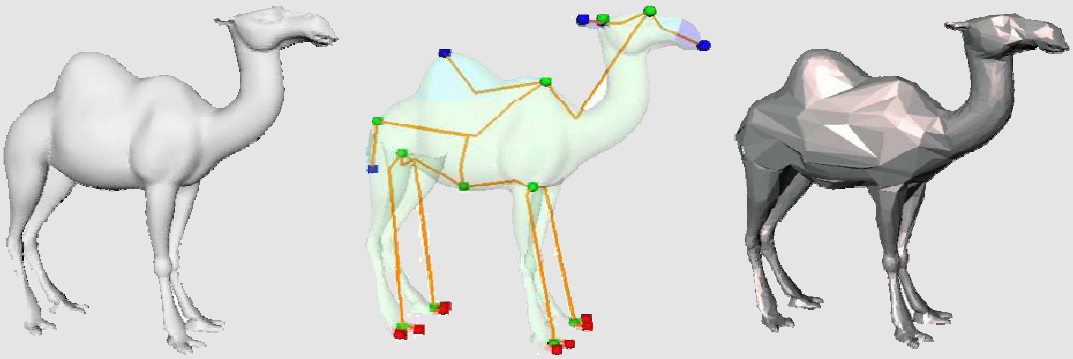
The idea behind this approach is to define a shape chartification suitable for surface approximation and able to approximate each chart on the basis of its boundary samples. In case the chartification is too rough and/or the shape samples are sparse, the charts are automatically refined and their boundary re-sampled until the approximation error is smaller than a user-defined threshold.

The innovation of this approach lies both on (i) the definition of an iterative refinement of the shape into a set of patches and (ii) the tiling approach, which is able to manage non-planar and non-parallel lines. To ease the tiling process, we determine a set of correspondences among the boundary components. through the computation of the flow paths of the input function. The union of these correspondences forms a set of guiding lines for the tiling, meaning that they are constraints used in the approximation process.

The coding of the patches is supported by the Reeb graph and contains the rules to properly tile, stitch them, and reconstruct the original shape while preserving its topology. In particular, all the information (contour samples, attachments between contours, tiling rules) needed to compute the approximated surface is opportunely coded in a file.

The method is geometry-aware by definition as the nodes of the Reeb graph are representatives of the main shape features, which belong to the approximated shape already at the initial iteration steps. The points of the reconstructed shape belong to the original surface, their total number is highly reduced, and the original connectivity is replaced by a set of patches which preserves the global topology of the input shape.

> S. Biasotti



From left to right: original surface, Reeb graph, and approximated model

> S. Biasotti, G. Patané, B. Falcidieno, M. Spagnuolo and G. Barequet *Shape Approximation by Differential Properties of Scalar Functions*. Computers&Graphics, Elsevier, Vol. 34, N. 3, 2010

> S. Biasotti. G. Patanè, M. Spagnuolo, B. Falcidieno and G. Barequet, *Adaptive Shape Chartification*, IMATI Technical Report 02/09, July 2009.

COLLABORATIONS and VISIT EXCHANGES

Drug Discovery and Development Research Unit The Italian Institute of Technology (IIT). Genova, Italy.

The Italian Institute of Technology (IIT) is a Research Foundation, founded in 2003, to promote scientific excellence in "Humanoid" technology with a focus of 4 key technological platforms (Robotics, Neurosciences, Nanobiotechnologies and Drug Discovery & Development). The Drug Discovery and Development Research Unit of the IIT is dedicated to the discovery of new medicines through an interdisciplinary effort that spans Medicinal Chemistry, Pharmacology, Computational Chemistry, NMR Discovery, Analytical Discovery and Structural Biophysics. The SMG collaborates with the Drug Discovery unit exploiting its expertise in geometric modelling to devise new semantics-oriented representations of molecular surfaces where the shape could be associated to the various molecule properties like toxicity and reactivity.

> M. Mortara

> Contact persons at IIT: Walter Rocchia and Andrea Cavalli

Centrum voor Wiskunde en Informatica (Center for Mathematics and Computer Science), Amsterdam, Netherlands.

Francesco Robbiano visited CWI in November 2009 for 21 days (CNR – Short Mobility Programme). During his interactions with the members of the Interactive Information Access research group, and in particular with Ivan Herman, some requirements and needs have been pinpointed, among which: users of a 3D search engine should be enabled to express their context; content-based retrieval should support semantic web approaches; a shared naming scheme should be used to reference parts of objects; big ontologies should be elected to demonstrate 3D annotation.

The visit provided a good bridge towards the Semantic Web community and prompts for any collaboration involving user-based studies, presentation of data, user interfaces and annotation, especially when the aim is to connect to the linked data on the web.

> F. Robbiano

> Contact persons at CWI: Lynda Hardman and Ivan Herman

Centre of Excellence ARCES (Advanced Research Centre on Electronic Systems) – University of Bologna. Italy.

ARCES was established in 2001 as an interdepartmental Centre of Excellence in the ICT area, and it soon became the first academic structure of the University of Bologna in the collection of external funds. IMATI has a long-running collaboration on shape description and retrieval with the members of the ARCES group on Mathematical Methods in Pattern Recognition. The collaboration dates back to the 1990s, and has been strengthened by the participation in the project MACROGeo funded in 2003 by the Italian Ministry of Research. Among the many joint publications, we mention Describing shapes by geometrical topological properties of real functions, published in 2008 in ACM Computing Surveys. Lately, IMATI and ARCES have been working together on a new distance between 3D objects.

> D. Giorgi

> Contact persons at ARCES: M. Ferri, P. Frosini, C. Landi, A. Cerri and B. Di Fabio

COLLABORATIONS and VISIT EXCHANGES

Digital Enterprise Research Centre (DERI)- National University of Ireland, Galway.

Riccardo Albertoni visited DERI between November and December 2009 for 21 days (CNR – Short Mobility Programme). A scientific collaboration to compare multidimensional media according their linked data descriptions has been established. A first prototypic result has been obtained combining the semantic similarity previously developed at IMATI with SINDICE, the DERI's semantic web index. In this prototype SINDICE is exploited to retrieve the non-authoritative descriptions of multidimensional media whilst IMATI's semantic similarity analyses the retrieved descriptions enabling a context dependent sift and ranking of multidimensional media.

> R. Albertoni

> Contact persons at DERI: Giovanni Tummarello

Institute for Mathematics, University of Vienna. Austria.

Philipp Harms was a visiting PhD student at the Shape Modelling Group from September 2009, the 14th to October 2009, the 9th.

His research interests in shape analysis include Riemannian metrics on shape space and their differential geometric properties. His aim is to find metrics on the shape able to distinguish different shapes and their characteristics.

During his stay at IMATI he addressed the problem of surface design and reconstruction from arbitrary cross sections. He studied the wellposedness and uniqueness of the solution, investigating the existence and the computation of surfaces with minimal Willmore energy or other functionals depending on principal curvatures.

> S. Biasotti

Technion - Israel Institute of Technology.

October 2009, the 6th, Michael Bronstein visited our lab and delivered the lecture:

ShapeGoogle: geometric words and expressions for invariant shape retrieval

Michael Bronstein discussed how to apply modern methods in computer vision to problems of non-rigid shape analysis. Feature-based representation and metric learning methods have recently gained popularity in computer vision, while remaining largely unknown in the shape analysis community. He showed analogous approaches in the 3D world applied to the problem of non-rigid shape retrieval in large (Internet-scale) databases. This will allow the community to adopt methods employed in search engines for efficient indexing and search of shapes.

> S. Biasotti

TRAINING

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

Alessandra Massa. Laurea Thesis. Department of Mathematics, University of Genova. July, 25, 2009. Supervisors at IMATI: Giuseppe Patané and Bianca Falcidieno

The thesis has discussed and compared computational methods for the topological analysis of volumetric data through the critical points of scalar functions. As main tool, we have considered the Morse theory in the continuous case, which have been exploited to define new topological descriptors for data analysis and characterization in the discrete setting. As main application, we have considered medical and volumetric data sets, which are commonly used in scientific visualization.

> G. Patané

Shape Descriptors from Point Clouds

Mattia Natali. Laurea Thesis. Department of Mathematics, University of Genova. July, 22, 2009. Supervisors at IMATI: Silvia Biasotti and Bianca Falcidieno

This thesis defines a description framework, which extends the concept of Reeb graph to point clouds. Our description deals directly with the point cloud without considering any support mesh, is flexible with respect to the shape characteristics the user want to emphasize, is robust with respect to noise and non-uniform samplings, is able to deal with multiple shapes and is computationally efficient (O(nlogn)). As possible application domains we foresee medical imaging; simulation; shape recognition and retrieval; and scientific visualization.

> S. Biasotti

Analysis and develpment of techniques for curve evaluation and deformation based on aesthetic criteria

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

The thesis is aimed at developing measures and methods for the evaluation and modification of aesthetic properties of curves based on the Leyton's grammar. Such measures are aimed developing aesthetic similarity comparison of curves in industrial design. The considered aesthetic properties are those identified within the European project FIORESII: concavity/convexity, acceleration, flatness and, tension. Whereas Leyton's grammar is aimed at describing and manipulating curves in terms of their curvature critical points.

> F. Giannini

Shape Recognizer

Aurelian Bargier*. Internship at IMATI – student from Arts et Mètiers ParisTech Aix en Provence, France. Supervisors: Franca Giannini (IMATI) and Jean-Philippe Pernot (ENSAM)*

During this internship stage methods for the clustering of mesh elements in partitions whose nodes are on basic surfaces like planes, spheres and cylinders have been studied and developed. The developed tools have been integrated within the XDS environment to support the development of direct FEA model modifications.

> 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 will include keynote talks of K. Polthier, M.-P. Cani and A. Shamir. SMI'10 will honour the memory of P. Bézier, former student of the Arts et Métiers ParisTech engineering school, who would have been 100 years old in 2010 ! Selected papers will be published in the issue 34(3) of Computers & Graphics (Elsevier).

CNR-IMATI supports the Arts et Métiers ParisTech and the Lab. of Information and Systems Sciences (LSIS) in the organization of SMI'10: B. Falcidieno and M. Spagnuolo are respectively conference and programme chairs.

> M. Spagnuolo and B. Falcidieno

EG workshop on 3D Object Retrieval, 3DOR 2010

May *2, 2010.* Norrköping, Sweden. http://www-rech.telecom-lille1.eu/3dor/

3DOR'10 is the third Eurographics Workshop on 3D Object Retrieval, organized as a co-event of EuroGraphics 2010. The aim is to stimulate researchers from different fields (computer vision, computer graphics, machine learning and human-computer interaction) who work on the common goal of 3D object retrieval, to present state-of-the-art work in the field and thus provide a cross-fertilization ground that will stimulate discussions on the next steps in this important research area. The popularity of the topics pushed by 3DOR is also demonstrated by the success of the call for a Special Issue of IJCV on 3D Object Retrieval subsequent to the workshop. Since last year, the results of the SHREC "3D Shape Retrieval Contest", unique benchmarking for 3D retrieval, is co-located with the 3DOR events. Michela Spagnuolo is a program chair of 3DOR 2010.

> M. Spagnuolo

FOCUS K3D Conference on Semantic 3D Media and Content

Feb *11-12, 2010. INRIA Sophia Antipolis - Méditerranée, France*. http://www.focusk3d.eu

The conference on Semantic 3D Media organized by the project FOCUS K3D (coordinated by IMATI-Ge) wanted to provide interesting insights on novel ideas and applications in the emerging research field of semantic 3D media and content.

The programme featured six keynote talks by outstanding experts in the area of the Semantic Web and in the application domains considered in FOCUS K3D: Medicine, Bioinformatics, Archaeology and Cultural Heritage, Gaming and Simulation, CAD/CAE and Virtual Product Modeling. Key event of the programme has been the presentation of the research road map envisaged by FOCUS K3D that has been discussed with the participants during a panel session. Technical sessions on the five application domains and project presentations completed the programme.

> M. Mortara

La Scienza e la Tecnica Rendono Sicuro il Lavoro

Oct *29-30, 2009.* Palazzo S. Giorgio, Genova (Italy). http://www.ispesl.it

In the process industries a huge knowledge about processes, substances, equipment had been developed in past decades. The knowledge underlying all the activities is mostly well defined and formalized; nevertheless accident rates has not been decreasing anymore for about ten years. That is not for a lack of knowledge, but because it has been ignored or distorted, or badly applied. Fast personnel turn-over, ageing manning, foreign employees, extensive sub-contracting are contributing in these "losses of knowledge". The conference organized by ISPESL and CNR-IMATI aims at illustrating research trends and industrial demand for stimulating collaborations to create advanced knowledge based tools exploiting all the existing safety knowledge.

> M. Monti

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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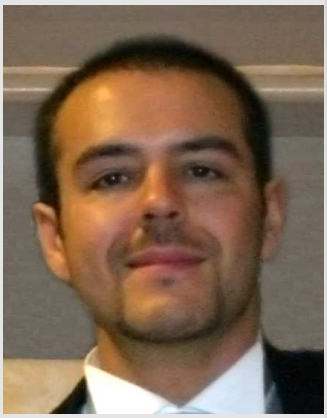
WHO IS WHO

Marco Attene - *Researcher*



Since 1999 Marco Attene has been collaborating with IMATI, and there he is currently a member or the research staff. From the University of Genova, Marco received a Laurea degree (M.Sc. equivalent) in Computer Science in 1998 and a Doctoral degree in Electronic and Computer Engineering in 2004.

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.

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 five sourceforge software projects involving experts from the University of Genova and from the SMG at IMATI.

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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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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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, my 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 my 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). My 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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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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WHO IS WHO

Daniela Giorgi - *Researcher*

Daniela Giorgi graduated cum laude in Mathematics in 2002, and 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 research fellow 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 an author of 23 peer-reviewed international publications in high-level journals (such as Pattern Recognition, ACM Computing Surveys) and conferences. She has been involved in many international projects, including the French-Italian project Galileo on image recognition (2003-2005) and the NoE FP6 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. Thanks to her skills in computational topology and 3D analysis, she has been invited to research in a project on robotic navigation funded by the Spanish Government. She has been a lecturer at international schools. She is a reviewer for international journals, and serves on the Programme Committee of the Eurographics Workshop on 3D Object Retrieval (2009, 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. 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. The title of the PhD thesis (the discussion is foreseen for spring 2010) is "Description of 3D objects based on concepts, content and context", and is aimed to a tout-court description 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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UPCOMING EVENTS

Upcoming Events

EG Workshop on 3D Object Retrieval (3DOR 2010)
Norrkoping (Sweden), May 2, 2010
http://www-rech.telecom-lille1.eu/3dor/

Eurographics 2010
Norrkoping (Sweden), 3th to 7th of May, 2010
http://www.eurographics2010.se

Computer Graphics Theory and Applications (GRAPP) 2010
Angers, France, 17 - 21 May, 2010
http://www.grapp.org

Computer Animation and Social Agents (CASA 2010)
Saint-Malo, France, May 31 - June 2, 2010
http://casa2010.inria.fr

Computer Graphics International 2010
Nanyang Technological Univ., Singapore, June 8-11, 2010
http://cgi2010.miralab.unige.ch

Shape Modeling International (SMI 2010)
Aix-en-provence, France, 21-23 June 2010
http://www.smi2010.lsis.org/

Symposium on Geometry Processing
Lyon, France, July 5-7, 2010
http://sgp2010.liris.cnrs.fr

Siggraph 2010
Los Angeles, CA (USA), 26 - 30 July 2010
http://www.siggraph.org/s2010

ACM Symposium onSolid and Physical Modeling 2010
Haifa, Israel, September 1-3, 2010
http://www.cs.technion.ac.il/~spm2010/

Pacific Graphics 2010
Hangzhou, China, September 25-27, 2010
http://www.zjucadcg.cn/pg2010/index.html

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)

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