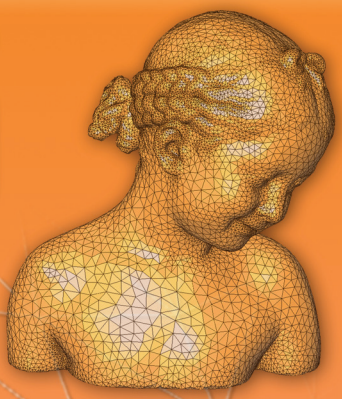
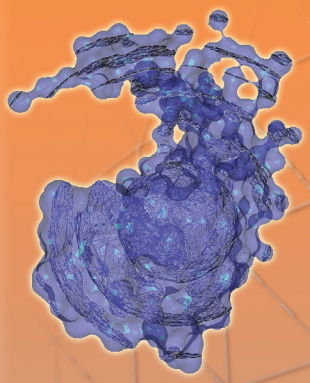
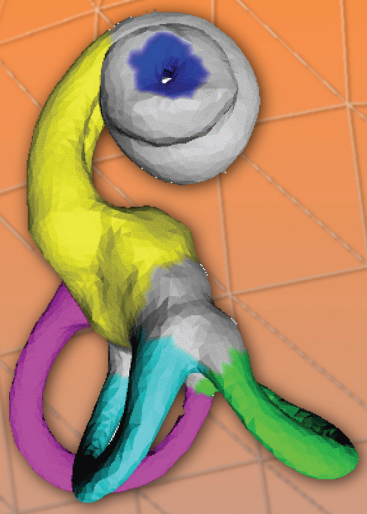
NOSMOG

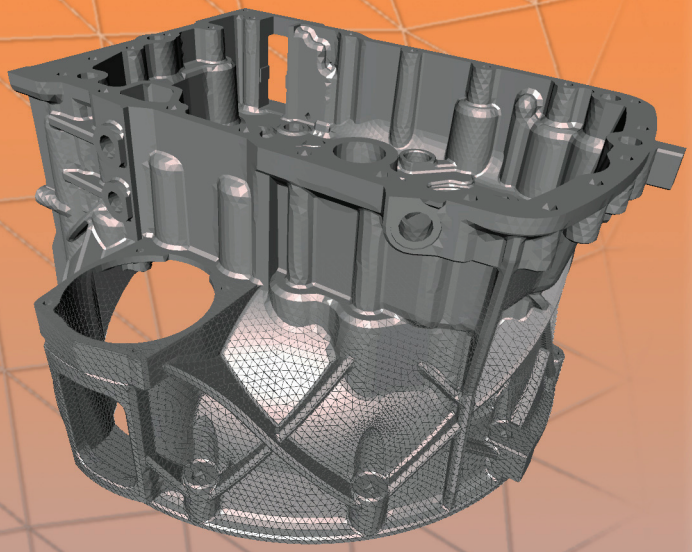
Newsletter Of the Shape MOdelling Group

Issue 1, September 2009









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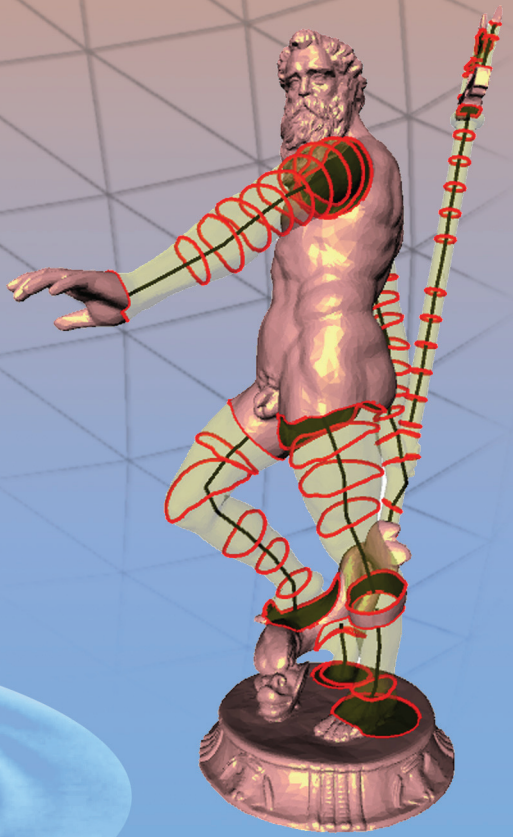

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CNR - Consiglio Nazionale delle Ricerche

Istituto di Matematica Applicata e Tecnologie Informatiche - Genova

EDITORIAL

Dear reader -

This brief editorial has the twofold objective of presenting the NOSMOG initiative itself and providing an outline of the specific contents of this first issue.

The idea of composing this newsletter originated from the need to provide a regular and constantly updated overview of the ongoing activities and the research results of the Shape Modelling Group (SMG) at IMATI. In its regular issues, NOSMOG is expected to become an important source of information for researchers and professionals interested in the activities of the SMG. Hopefully, this can be the starting point for the constitution of fruitful partnerships with academic and industrial groups.

Being in its first issue, this newsletter presents a sort of wrap up of the group along with its recent history. Thus, the following pages provide a summary of the principal activities that mostly contributed to the characterization of the team and to the definition of its characteristics of excellence. The group is introduced as a whole along with its main mission and its more specific research objectives, whereas activities are presented in terms of research projects, scientific and technological results. A section is dedicated to the presentation of the group's experience in organizing dissemination and training events. Finally, in this issue a particular space is devoted to the scientific profile of each member of the group.

To conclude, I would like to thank Bianca Falcidieno and Michela Spagnuolo for their encouragement in initiating this newsletter, and all my colleagues for having provided the contents and having demonstrated to be exceptionally tolerant to the boring requests of contribution.

Enjoy your reading !

> Marco Attene

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

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

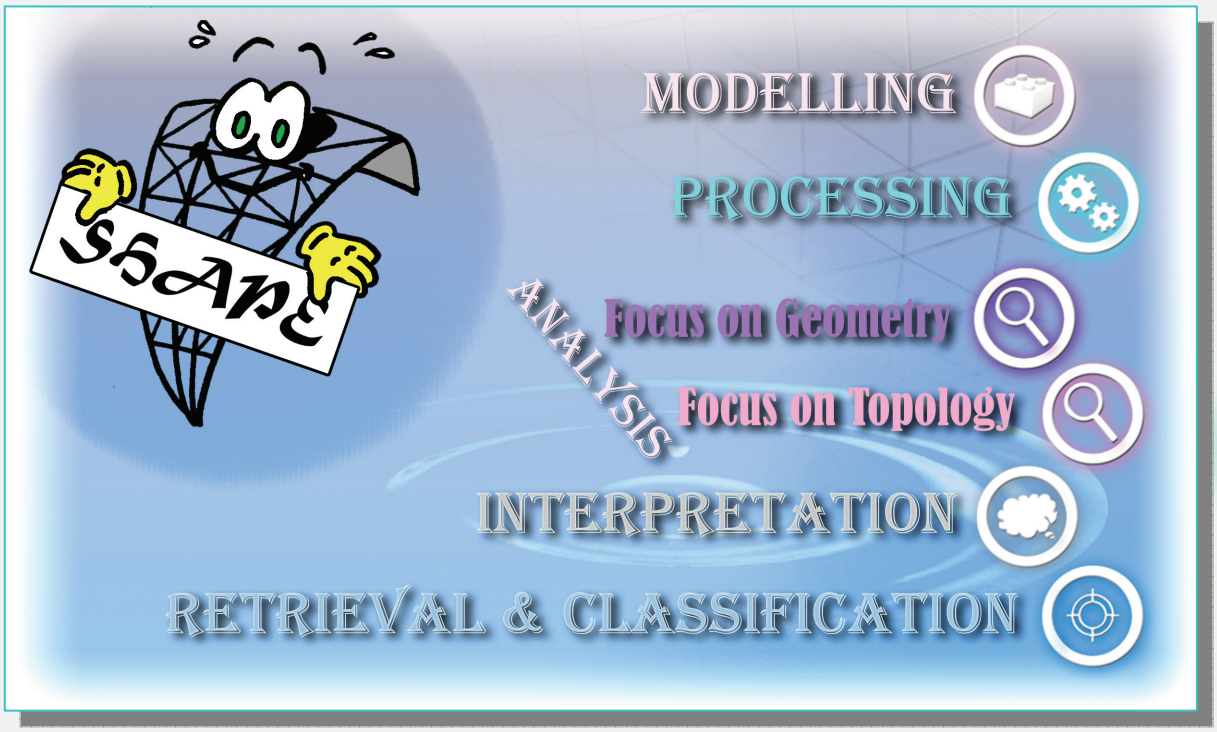
- Advanced techniques for 3D digital shapes analysis and synthesis
- Coding, elaboration and restitution of multidimensional media knowledge

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.

> B. Falcidieno

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



The research activities of the SMG span the whole digital shape lifecycle, ranging from the construction of the raw geometric model up to its highest-level interpretation

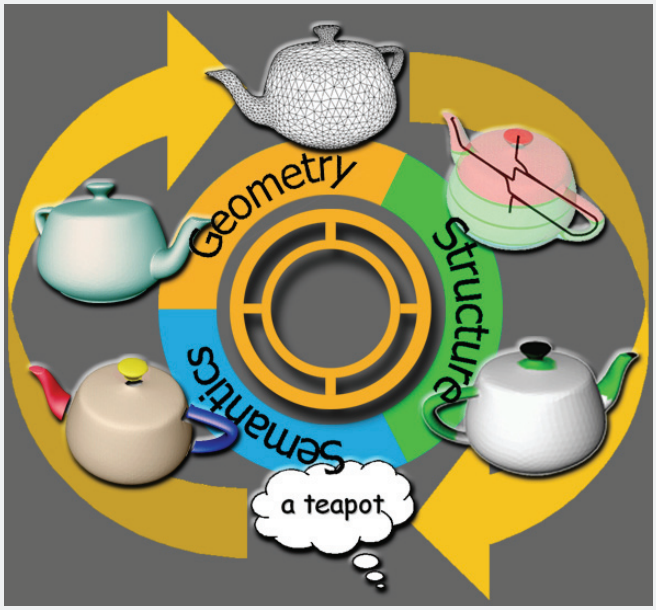
AIM@SHAPE

EU FP6 IST Network of Excellence

Advanced and Innovative Models And Tools for the development of Semantic-based systems for Handling, Acquiring, and Processing knowledge Embedded in multidimensional digital objects

The Mission of AIM@SHAPE has been to foster the development of new methodologies for modelling and processing the knowledge related to digital shapes. This knowledge is concerned with the geometry (the spatial extent of the object), the structure (object features and part-whole decomposition), attributes (colours, textures), semantics (meaning, purpose), and has interaction with time (morphing, animation). AIM@SHAPE has grown a new multi-disciplinary research field, which deeply integrates Computer Graphics and Vision with Knowledge Technologies and builds on using knowledge formalisation mechanisms (metadata and ontologies) for linking semantics to shape or shape parts. The innovation sought by AIM@SHAPE is to move towards digital representations of shapes which are able to model not only the visual appearance of objects but also their meaning or functionality in a given knowledge domain.

In the four years of activity (04-07), AIM@SHAPE pursued the introduction of knowledge management techniques in 3D content modelling, reusing and sharing. On the one hand, this required the development of tools able to extract semantics from 3D models (e.g. automatic or semi-automatic annotation tools), on the other hand it was necessary to build a common framework for reasoning, searching and interacting with the semantic content related to the knowledge domain.



Technological Results - The main technological result of AIM@SHAPE has been an integrated platform for modelling, processing and sharing multi-dimensional media, called the Digital Shape Workbench (DSW), which is an elaborated framework to store shapes, tools, and publications along with the knowledge related to them and expressed through the definition of general and specific shape ontologies. The success of this approach is documented by the popularity of the Shape Repository: about 1.900.000 accesses and 85.000 downloads by users coming from more than 100 countries!

Moreover, the DSW relies on a search engine able to provide significant results and reasoning functionalities, coupling a semantic-web approach with an innovative geometry-oriented retrieval mechanism for 3D media based on shape similarity assessment. The development of the DSW required the conceptualisation of specific domains and the precise characterization of the resources to be shared. AIM@SHAPE approached this issue with the definition of general ontologies for characterizing shapes, and with the definition of application-oriented ontologies.

Scientific Results - From a scientific perspective, AIM@SHAPE improved the understanding of the two main lifecycles of digital shapes: the first goes bottom-up from the acquisition of 3D objects up to the semantic level, while the second corresponds to the top-down design from a concept defining an object at the semantic level down to the geometric model. The AIM@SHAPE ambition was to revisit the lifecycles with focus on methods to preserve semantic content, to annotate automatically digital shapes, to interact with the semantics, and to maintain and update the semantics at the different stages of digital shape lifecycles.

> B. Falcidieno

- *Web page*: http://www.aimatshape.net
- *Digital Shape Workbench*: http://dsw.aimatshape.net

Consortium: **CNR-IMATI-GE** (Italy), DISI (Italy), FhG/IGD (Germany), EPFL (Switzerland), INPG (France), INRIA (France), ITI-CERTH (Greece), MPII (Germany), SINTEF (Norway), TECHNION (Israel), UNIGE (Switzerland), UU (Netherlands), WEIZMANN (Israel).

Project coordinator: Bianca Falcidieno

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

FOCUS K3D (Mar 2008 – Feb 2010) promotes the adoption of best practices for the use of semantics in 3D content modelling and processing. Its main goals are: (1) To build multi-disciplinary communities of researchers, professional users or producers of 3D content; (2) To carry out rigorous analyses in order to identify issues that currently inhibit a wider user participation in the production, reuse and sharing of 3D content; (3) To promote and evaluate the results achieved by recent and ongoing projects in the field of 3D media semantics representation and processing; (4) To identify promising future developments for a broader use of semantics and knowledge technologies related to 3D shapes.

The project focuses on four Application Working Groups (AWGs) that are characterised by a massive use of 3D digital resources not only related to visual aspects but involving also the representation of domain knowledge. They are CAD/CAE & Virtual Product Modelling; Medicine & Bioinformatics; Gaming & Simulation; Cultural Heritage& Archaeology. For each of these application scenarios, specific dissemination and take-up actions are planned to demonstrate how semantic 3D content can answer a number of open problems in the content production and processing chain in those domains. Moreover, the project addresses the needs of the different categories of both 3D content providers and users encouraging active participation by key market actors: (1) Professional developers of tools for 3D content creation and management (e.g. CAD systems, acquisition and reconstruction systems, reverse engineering, computer graphics programs); (2) Creators of digital 3D content (e.g. stylists, engineers, game designers, radiologists, archaeologists, bioinformaticians); (3) Publishers/dealers of 3D repositories on line, organisations collecting and distributing 3D models; (4) Scientists in Computer Graphics and Vision or in disciplines intensively using 3D modelling and simulation (e.g. mechanical engineering, environmental modelling, drug design).

The AWGs are coordinated by FOCUS K3D partners, who formulated ad hoc questionnaires and interviews, and promoted discussions to elaborate the requirements and desiderata of the various communities with respect to 3D content authoring and processing. Position papers have been solicited and discussed at the organised thematic workshops where academia and industry have been invited. The results achieved have been used to compile state of the art reports and to establish a methodology for an effective dissemination and exploitation to larger communities; finally, they will lead to the development of the roadmap for future research directions.

In order to be able to demonstrate in practice the advantages of using semantic 3D shapes, FOCUS K3D will use an adequate infrastructure support, as the one offered by the Digital Shape Workbench (DSW) of the AIM@SHAPE project (see page 4), which provides the functionalities for sharing 3D resources and accessing them via formalised knowledge, either as metadata or as ad hoc ontologies. To the extent of our knowledge, the DSW is unique in its role; however, any other existing infrastructure that offers the same functionalities could be used.

> C. E. Catalano

► 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*

EU FP7 Coordination Action

Multimodal and Multidimensional Content and Media

The CNR scientific network is composed by Departments, Institutes and research Units. The 11 Departments are the organisation units corresponding to the main technological and scientific research areas according to which CNR is organised, and have the role of planning coordination and results evaluation. Departments are in turn organised in research projects defined according to specific objectives and carried out by research groups of CNR institutes.

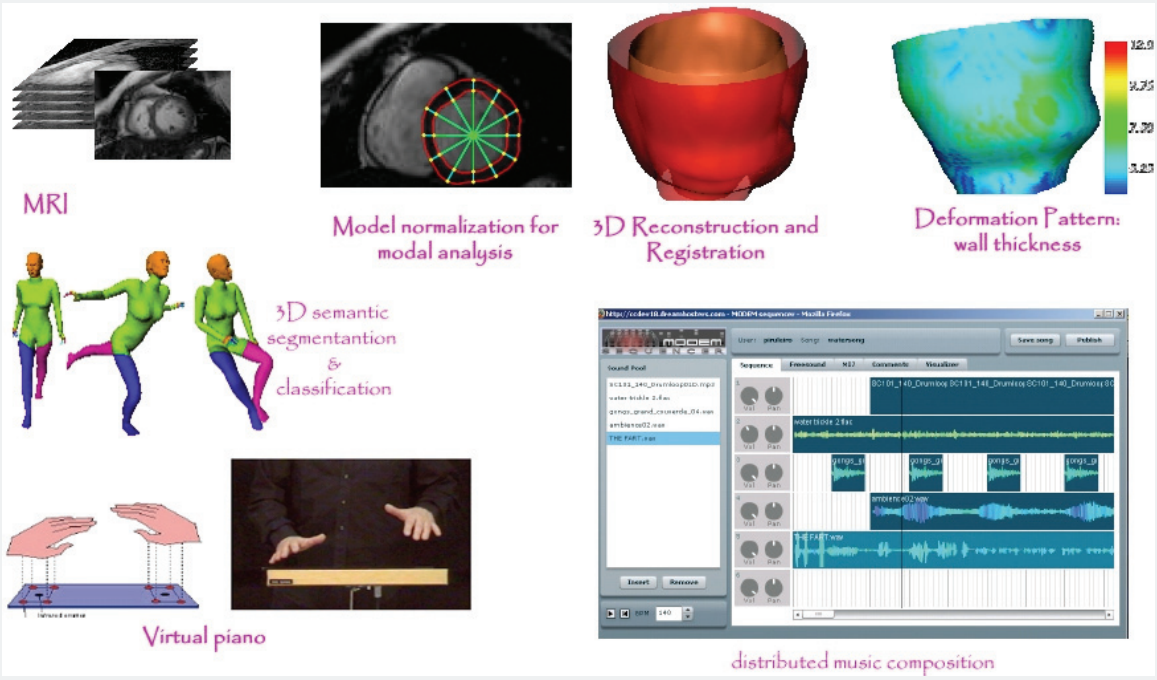
The Multimodal and Multidimensional Content and Media (2006-2011), is one of the 7 projects of the Information and Communication Technologies (ICT) department of CNR (http:// www.ict.cnr.it). The project is aimed at coordinating and integrating all the activities carried out by the CNR institutes on the creation, processing and context-dependent representation and restitution of multidimensional media content. Multidimensionality is either intrinsic to the datum type (e.g. 2D images and 3D shapes), or due to the multiplicity of types of signals and data concurring in the description of the same phenomenon, e.g. in the remote sensed data, the multidimensionality can be given by factors as space, scale, frequency and time. Similarly, multimodality is meant as the utilization both of one or more sources for the data acquisition and creation, as in the case of medical data, and of different tools and methods for the user interaction, that go beyond the traditional mouse and keyboard, thus providing a high degree of realism and immersion in virtual environments.

The main purpose of this project is the achievement of a radical improvement and innovation in the representation and fruition and retrieval of multidimensional media (images, videos, 3D models, sensor data, sound,…) aiming at the realization of "intelligent" contents, that should enable a contextual representation and presentation being readily comprehensible both for the field experts and for the analysis and evaluation instruments. At the same time, a more realistic multi-sensorial interaction is being provided, e.g. through virtual reality and haptic interaction; such interaction should guarantee easy access to any user, thus following the ambient intelligence and eInclusion approaches.

The adopted approach is the definition/integration of the different activities of multidimensional media acquisition, analysis, and synthesis, in an efficient and effective way, at different levels of abstraction and meaning, both in the analysis and synthesis process. Main application fields considered are environment, medicine, edutainment, industrial production and diagnostic, cultural heritage.

> F. Giannini

► *Web page*: http://mdm.ge.imati.cnr.it/



Involved CNR Institutes: **IMATI-GE**, IMATI-MI, ICAR-PA, CIB-NA, IDPA-MI, IEIIT-PI, IEIIT-TO, IFAC-FI, IMAA-PZ, IREA-MI, ISTI-PI.

Project coordinator: Franca Giannini

Free form features and aesthetic properties for styling product modelling

Today, even sophisticated modelling tools miss functionalities suited to creative users' mentality and able to support them in attaining models with the desired characters. Identifying form features and properties along with their modelling capabilities aid the development of such functionalities.

The use of free-form shapes has become mainstream to design complex products that have to fulfil both engineering requirements and aesthetic criteria. Even if today's CAD systems can easily represent free-form shapes by means of NURBS surfaces, their definition and modification still require a deep knowledge and a great skill in the manipulation of the underlying mathematical models. Moreover, current CAD systems hardly support both the modification of already existing models, possibly coming by scanning physical objects, and the initial shape definition phase, which is strongly characterised by uncertainty where shape alternatives need to be quickly produced and evaluated.

This research activity aims at overcoming such limitations by adopting the concept of free form features based on shape deformation tools acting on continuous, discrete and mixed geometric models. The research originated by our participation to the EU projects FIORES and FIORES II involving stylists and CAS operators from the main automotive and consumer appliances in Europe. The research has then been continued in collaboration with Jean Claude Léon from INPG and produced three PhD theses, two of them in co-tutelle with INPG. Through the collaboration with stylists a free form feature taxonomy for surface modelling and a set of aesthetic properties for curve evaluation and modification have been defined. Being the styling activity strongly curve-driven, the considered free form features are obtained through a set of surface deformation operations guided by the aesthetic key lines drawn by the designer, establishing a link between geometry and the stylist's intent.

The first implementation developed is based on a deformation technique applicable both to NURBS and tessellated representations. Such approach is founded on the Force Density Method and applied to a bar network coupled with the control network of the NURBS surface or with the mesh nodes. Due to this association, the correct position of the surface control points/nodes coincides with the new equilibrium configuration of the bar network depending on the given constraints, which may be curves, dimensions, relative positions, tangency conditions. Inaccuracies, planarity in some areas and sharp edges can be introduced to support uncertainty, without surface trimming, by changing the minimisation criteria for the geometric and mechanical parameters used or by adding new deformation constraints. Finally, an implementation of the styling features obtainable by generalised sweep operations has been provided on subdivision surfaces. They have been introduced as a unique geometric frame supporting different design stages since they bypass some of the transfer problems of NURBs, which make use of multi-patch and trimmed surfaces. The algorithm inserts sweep-like features according to the parameters and characteristics of the directrix and the section curves, exploiting the local refinement and smoothness properties of the subdivision.

> C. E. Catalano, F. Giannini

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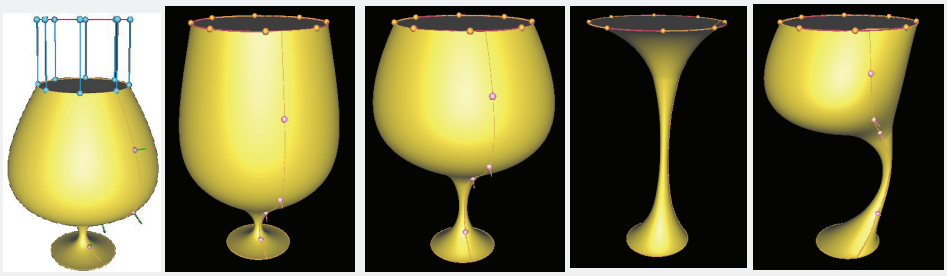

Examples of deformations to a target curve applying different minimizations (to the object or to its subparts)

Methods for effective CAD-FEM link in cooperative product development

Finite Element Analysis not only requires a representation conversion of CAD data but also time consuming shape adaptation processes. This research aims at developing methods to make more efficient the adaptation process and to identify when new analysis are really necessary to improve the overall product development activity.

This research activity has been carried out in collaboration with Prof. Jean-Claude Léon from INPG Grenoble (F) and has produced two PhD thesis in co-tutelle. It is aimed at defining methods and tools for more efficient integration of product design and structural analysis in cooperative product development.

During product life-cycle design several simulations and analysis have to be performed. Design and Finite Element Analysis (FEA) are two deeply different disciplines requiring different products descriptions and representations. In fact while in design provides a fully detailed description of the part, in FEA a simplified product shape has to be provided. Within a co-operative design environment several activities are run in parallel. Thus, designers may need to perform additional modifications even after an analysis has been already conducted on a given version of the CAD model. Such operation involves a questioning of the validity of the analyses already carried out. Reappraisal does not necessarily mean that a new analysis is required, but more exactly it is necessary to evaluate or quantify its impact on the validity of the results previously obtained. This evaluation is only possible through the availability of 1) a real interaction between both models 2) tools for the evaluation of the impact of the performed changes on the simulation results. In this research we deal with these two aspects.

Thus, a new topological model has been defined called HLT (High Level Topology) able to represent both manifold and non-manifold configurations typical of FE models containing idealized parts and of the geometric support of the analysis Boundary Conditions. It maintains the CAD semantics and handles the links with the polyhedral representation. Based on that, we have implemented a fully automatic tessellation and conformity set up processes and feature identification methods for the characterization of fillets and holes on the created polyhedral model. A new concept of simplification feature is proposed that combines the geometric (form features) and mechanical data (map of FE sizes) in order to characterize the concept of detail removed during the shape adaptation process and a set of simplification features categories is proposed according to their removal characteristics. To estimate the impact of the removed details over the analysis results an a posteriori criterion has been specified for linear static analysis. In the case where some shape simplifications are considered as exceedingly influencing the obtained analysis results, the shape of the simulation model can then be adapted by reintroducing the removed detail to provide more accurate results. Such criterion can also be applied to new features inserted in the design view to understand the validity of the already performed simulation over the new design version, thus reducing the modification-simulation loop cycles. The developed methods have been tested on some complex models and can be integrated in commercial systems.

> F. Giannini

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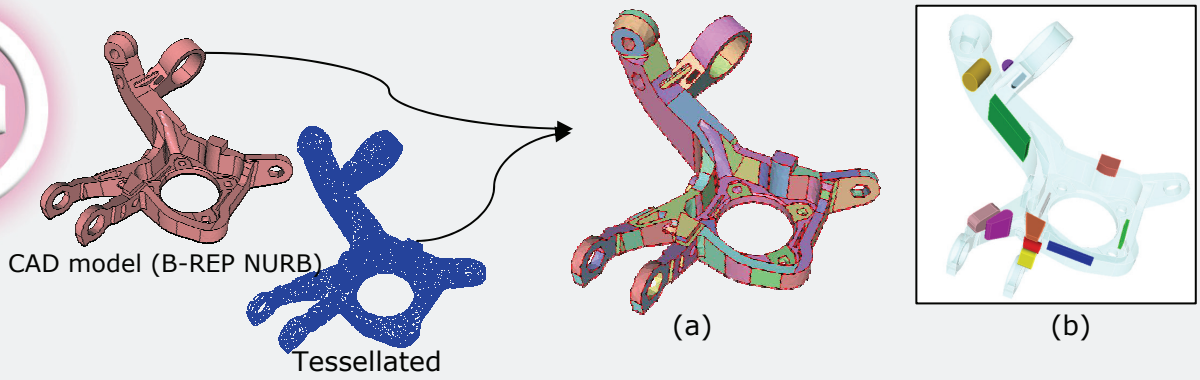

Example of a mixed representation of a product (a) and its simplified FE model with highlighted the removed details (b).

Fuzzy B-Splines: a surface model which encapsulates the uncertainty of data

Fuzzy B-Splines: a surface model which encapsulates the uncertainty of data

How to model and visualize the uncertainty due to noise in the data, to data reduction processes or approximation error.

Physical or scientific data, as collected or simulated by any experimental machinery, are likely to be affected by noise or uncertainty. Various sources of uncertainty exist: the resolution of the tool used to acquire data, the nature of the phenomena being analysed, the data reduction step needed to make data tractable, the data modelling itself. Traditionally, the quality of a model built on uncertain data is measured in terms of global numerical accuracy, such as upper bounds to error estimations, but local estimates of the possible deviation between the measured or approximated and the real data are not available. Therefore, users in the scientific domains lack tools to understand and manage the uncertainty inherent to the specific model, especially when doing analysis or in decision making processes and the presentation of uncertainty has been often separated from the presentation of the model itself.

In this field, we have proposed an innovative approach to uncertainty modelling using the arithmetic of fuzzy numbers. The solution devised integrates classical geometric techniques (B-spline approximation) with mathematical methods for uncertainty formalization (fuzzy set theory). Coding imprecise values using intervals is a satisfactory choice whenever there is no additional knowledge available on data behaviour and reliability. Intervals do not give any information, indeed, about the "degrees of membership" in the sense that every value within the interval is possible. In other words, in absence of any information, coding imprecise values as interval corresponds to assuming a uniform probability distribution over the interval, that is, a constant probability. A fuzzy number is defined making use of the interval analysis and relating two important concepts: confidence intervals and presumption levels. A confidence interval is an interval of real numbers that provides a representation for an imprecise numerical value by means of its sharpest enclosing range. A presumption level is an estimated truth-value about some knowledge.

Our approach starts reducing the original, and usually large, set of uncertain data to a smaller one whose elements are fuzzy numbers with suitable memberships function. Based on this, FBS generalize crisp B-splines and interval B-splines, by having its control points being defined by the set of reduced fuzzy numbers. The probability of the data distribution at each presumption level is represented by two shells which delimit the volume of variability of the data for that specific presumption level. Efficient algorithms for the computation of the different presumption levels of the approximating splines were also developed. Finally it is crucial to be able to interrogate the FBS model efficiently and robustly with respect to the requirements introduced previously, and a generalization of the Newton method to query the fuzzy spline model has been developed.

This work was done in collaboration with the Dept, of Mathematics and Informatics of the University of Catania, taking advantage of their library for the fuzzy arithmetic.

> M. Spagnuolo

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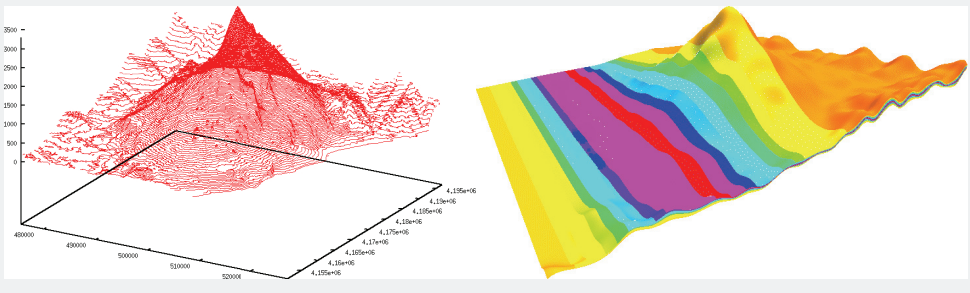

(a) *(b)*

The original data of the Mount Etna, kindly provided by the CNR, containing 72891 points, covering and area of approximately 6000x5400 meters (a); the FBS representation of the data set, where the same color identifies the shells corresponding to the same presumption level (b).

Surface chartification, parameterization and remeshing

In the context of geometry processing, our approach to shape chartification is based on the decomposition of the input surface into 0-genus or (almost) equilateral patches, and it is capable of addressing several applications such as parameterization, remeshing, and compression.

In the context of geometry processing, our research has been focused on shape chartification and local/global parameterization for surface remeshing and compression. The proposed approach is based on the decomposition of the input shape into 0-genus or (almost) equilateral patches. These types of constraints on the properties of each patch are mainly motivated by the target applications, which include parameterization, remeshing, compression.

In the topology-based decomposition, each patch is computed by studying the evolution of the critical points and the iso-contours of scalar functions intrinsically defined by the input surface (e.g., the Laplacian eigenfunctions). The resulting decomposition is independent of the surface discretization, stable to noise, and naturally follows the shape and extent of the protrusion of the input surface. For the lossy compression of manifold triangle meshes, our approach subdivides an original mesh P into simply and (almost) equilateral connected regions. From these patches, we generate a new mesh P', whose connectivity is fairly regular and can be compressed to less than a bit per triangle using the EdgeBreaker algorithm or similar compression schemes. Finally, the locations of the vertices of P' are compactly encoded with a new prediction technique, which uses a single correction parameter per vertex.

For the local parameterization of a manifold triangle mesh P with an arbitrary genus and boundary components, each patch of the topology-driven chartification has 0-genus and is parameterized using an extension of the barycentric coordinates' method. The chart decomposition and the parameterization are used to define a shape graph of the input shape, where each node represents one primitive and the arcs code the adjacency relationships among the primitives. The shape graph has been used for skeleton-based surface deformations. For global parameterization, the computation of the cut-graph and the generators of the topological handles of P is based on the iso-contours of a scalar function f:P→R, which cut the topological handles of P, and on the completion of the cut-graph on the planar domain. In this way, we define a family of cut-graphs that satisfy different constraints such as minimal length; minimization of the parameterization distortion; or interpolation of points as required by remeshing and texture mapping.

> G. Patané

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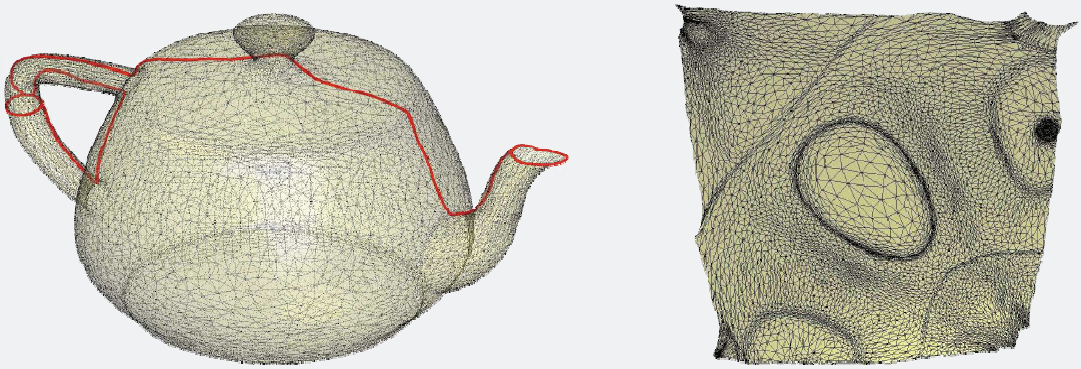


Input surface, cut graph (red curve), and planar parameterization.

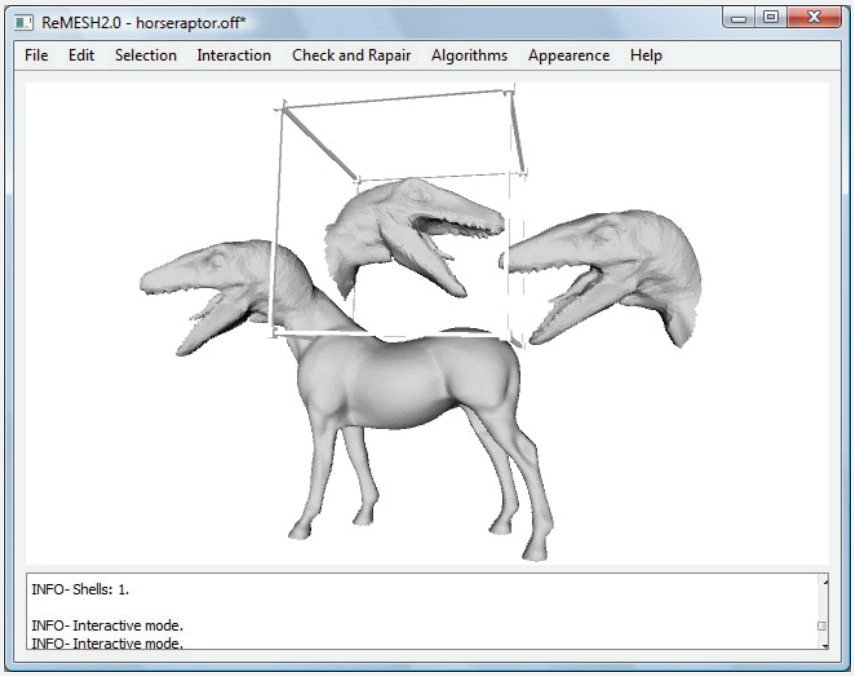
ReMESH: an interactive environment to edit and repair triangle meshes

ReMESH is an editor for polygonal meshes with advanced repairing features. It provides algorithms to filter out all the characteristic flaws present in digitized 3D models, has a powerful selection mechanism, copy and paste, undo, and all the other typical functionalities of an editor.

3D polygonal meshes obtained from acquisition of real-world objects may easily exhibit topological or geometrical defects, which often prevent subsequent processing and analysis to provide satisfactory results.

ReMESH is a user-friendly graphical tool which incorporates several mesh-repairing features, and allows to perform a kind of low-level editing which is often missing in most existing software packages. ReMESH provides "standard" repairing algorithms such as automatic conversion to manifold and oriented surfaces, elimination of unreferenced vertices, surface smoothing, hole filling, and so on.

The innovative aspects of the software, however, are due to an extensive set of advanced functionalities that make it possible to convert the raw result of a scanning session to a watertight manifold surface without self-intersections.



All the triangles which are nearly degenerate can be automatically removed; disconnected surfaces can be smoothly merged together; the topology of the surface can be simplified; intersecting triangles can be automatically selected and removed; chamfered sharp features can be reconstructed.

Besides the automatic procedures such as the aforementioned algorithms, ReMESH provides an interactive interface through which a user can modify the mesh at triangle level by simply clicking on the mesh and dragging the mouse. As for any standard editor, a selection mechanism is provided. In ReMESH, a selection is a collection of triangles, that is, the triangle is the atomic entity treated (just as characters for a word processor, or pixels for an image processor).

The first idea of ReMESH was born in 2004 to cope with a basic necessity of computer graphics researchers, namely, the possibility to use raw models as test cases for new algorithms that require high-quality models. During the development of a new algorithm, in fact, it is much easier to fix some rules for the early design phases and then relax them eventually. This is especially true in computer graphics: considering a 3D object represented by a watertight, manifold surface without degenerate or disconnected components makes things much easier.

The first public version of ReMESH was released in October 2004. From then, the project has been growing continuously, and ReMESH has been extensively used for several applications. Among them, a noticeable example is the popular AIM@SHAPE's Shape Repository (http://shapes.aimatshape.net), where most of the meshes that have been tagged as "high-quality" were edited through ReMESH. Another important application is the SHREC Shape Retrieval Contest (http://www.aimatshape.net/event/SHREC), where several certified datasets have been created through ReMESH. From 2008, ReMESH has become a sourceforge software project which currently counts more than 1800 downloads.

> M. Attene

- *Paper* - Marco Attene and Bianca Falcidieno. "ReMESH: An Interactive Environment to Edit and Repair Triangle Meshes". In Procs of Shape Modeling Internationl (SMI'06), IEEE C.S. Press, pp. 271-276, 2006.
- *Software* – http://remesh.sourceforge.net.

Hierarchical segmentation of 3D objects

Hierarchical Segmentation of 3D Objects

We convert a raw 3D object into a structured assembly of its relevant parts. Useful to recover design intent in digitized mechanical objects, to idealize 3D models, to enable "intuitive" 3D part selection, and to manipulate raw 3D models through interactive deformation and copy&paste-based editing.

Modern industry is spending more and more efforts in the exploitation of 3D acquisition devices for diverse applications (reverse engineering, quality control, 3D TV, medical imaging, …). Current 3D digitizers can easily produce huge volumes of precise data representing objects and scenes. To automatically "understand" such data it is important to recognize a high-level structure of each shape in terms of its relevant parts; representing shapes in terms of parts, with smaller parts hierarchically nested within larger parts, has been proved to be a central aspect of visual experience. Unfortunately, while a person looking at a rendered 3D model can easily perceive a decomposition of the surface into interesting sub-parts (primitive shapes, protrusions, handles, …), it turns out to be a rather hard task for a computer. Techniques that attempt to perform this operation are known as "shape segmentation" algorithms, and constitute a vibrant research area.

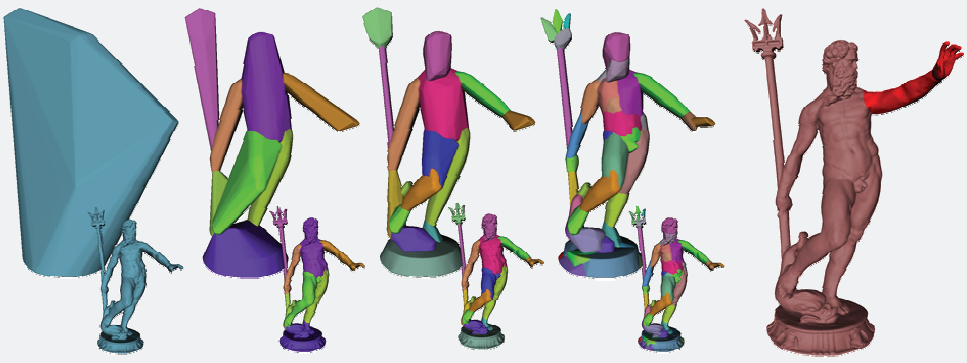
We have designed segmentation algorithms that produce hierarchies of 3D parts. In essence, a detailed input object is converted into a binary tree: each leaf corresponds to an atomic element of the input (eg. a triangle, a tetrahedron, …), the root represents the whole object, and intermediate nodes correspond to interesting parts eligible for selection, deformation, reusing, and so on.

To define what is interesting, we focus on two separate classes of objects: (1) reverse engineered mechanical shapes and (2) natural shapes. Note that the nature of relevant features is substantially different for these two categories. In a scanned engine, for example, it is probably useful to extract surface patches that correspond to design or structural elements (planes, fillets, through holes, …). In contrast, in a virtual character it is useful to know where an arm is attached to the torso, for example to perform plausible animation. Triangle meshes are used to represent 3D mechanical models. For this class of objects, the interesting parts are assumed to be connected sets of triangles that can be fairly approximated by either planar, spherical or cylindrical patches. The segmentation framework, however, is generic; this means that other primitive types can be easily plugged into the system (e.g. cones and torii). To treat natural shapes such as animals, plants or human bodies, we have developed an algorithm that exploits the intuitive notion of convex decomposition. Well-established cognitive theories state that humans tend to decompose complex shapes by cutting them along lines of deep concavity; this makes the resulting parts relatively convex. In our setting, we have defined a formal measure of convexity for objects represented through tetrahedral meshes. Then, we have used our segmentation framework to build hierarchies in which the captured parts are as convex as possible. This work started as an activity of the AIM@SHAPE project, and currently contributes to the achievement of the MDM project objectives.

> M. Attene

- M. Attene, M. Spagnuolo, B. Falcidieno. "Hierarchical Mesh Segmentation based on Fitting Primitives". The Visual Computer, 22(3): pp. 181-193, 2006.
- M. Attene, M. Mortara, M. Spagnuolo and B. Falcidieno. "Hierarchical Convex Approximation of 3D Shapes for Fast Region Selection". Computer Graphics Forum, 27(5): pp. 1323-1333, 2008.

- Software - http://efpisoft.sourceforge.net



Segmentations (bottom), convex approximations (top) and part deformation (right).

Morphological analysis and segmentation for understanding 3D shapes

The Tailor surface analysis and the Plumber segmentation into tubular features are described; among the applications the extraction of geometric and structural information implicitly encoded in a 3D model and its use to shape understanding for instance in the context of human body models.

This activity covers shape analysis, segmentation and abstraction, and belongs to the recent research trend at IMATI-GE/CNR that deals with the extraction of semantic information based on prior decompositions of shapes into building primitives whose meaning is defined by the underlining application context.

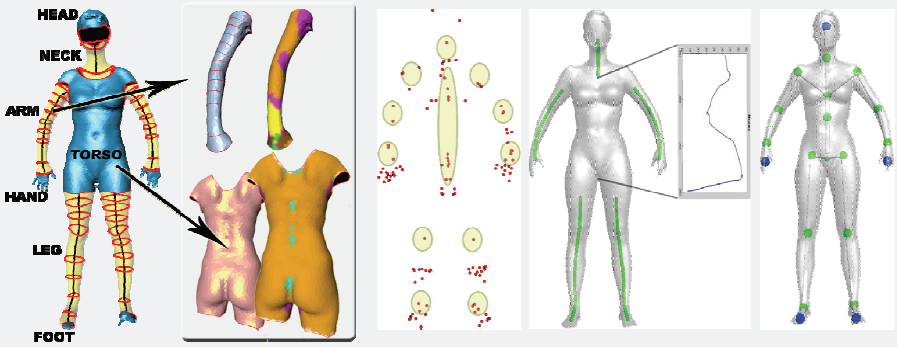
Understanding the implicit knowledge carried by a digital shape in unspecialized contexts is not a trivial task. In general, characterizing a shape amounts to construct a computational description of the most representative features of the shape, usually of a few basic types, possibly along with their relationships (structural decomposition). While in engineering the specification of relevant features is usually well defined (e.g. in CAD applications, see page 7), formalizing and recognizing features of free-form, scanned or organic shapes is particularly challenging. We tackled the problem defining a new multi-scale description of 3D objects based on geometric properties of the shape which are invariant under rotation, translation, and scaling. This morphological analysis approach is called *Tailor* and is able to capture the main features of a given surface discriminating between global and local ones. To be more specific, *Tailor* analyses the geometric and topological properties of neighbourhoods of variable size of the surface vertices to assign them morphological labels like *tip*, *pit*, *blend*, *limb*, *well*, *split* and a few others.

Based on the *Tailor* characterization, we developed the *Plumber* segmentation algorithm, which starts from *limb* regions to identify tubular features on complex shapes in a multi-scale fashion. Tubular and non tubular components are enhanced with geometric and structural attributes (e.g. volume, tube axis and cross sections) and organized into an abstract representation (the *Shape graph*) which can be used to automate complex tasks such as matching, retrieval, or comparison of shapes.

The segmentation method previously described has been exploited to extract the semantic content and of human body models from their geometry and structure, and from the knowledge pertaining to the domain. Reasoning on the relative sizes of the features and on the adjacency relations among them encoded in the *Shape graph* makes it possible to automatically recognize its relevant components (tubular features will identify *arms*, *legs*, *neck*, and *fingers*, non tubular parts will identify *torso*, *head*, *palm*, *fingertips* and *feet*) and compute further measures to devise higher level anthropometric information (e.g. the ratio volume/length gives a hint on the human limb fatness; the local variation of the associated *Shape graph* gives us precious information about the body posture). The automatic identification of human body parts, together with the detection of landmarks over the body surface based on the *Tailor* analysis, has been used to develop a knowledge-based automatic extraction of control skeletons for animation.

> M. Mortara

- M.Mortara, G.Patané, M.Spagnuolo, B.Falcidieno, J.Rossignac "Blowing Bubbles for the multiscale decomposition of triangle meshes" *Algorithmica* - special issue on shape algorithms. Vol 38, (1), pp. 227-248, Springer, 2003.
- M. Mortara, G. Patanè, "Plumber: a multi-scale decomposition of 3D shapes into tubular primitives and bodies". Proceedings of *ACM Symposium on Solid Modeling and Applications* SM'04 (Genova, Italy, 9-11 June 2004), pp. 339-344. G. Elber, N. Patrikalakis, P. Brunet (eds.). Eurographics Association, 2004.
- M. Mortara, G. Patané, M. Spagnuolo "From geometric to semantic human body models". *Computers&Graphics* vol.30 (2) 185 – 196, Elsevier 2006 (Best paper award).



Pipeline of the knowledge-based extraction of control skeletons for animation.

Best view of 3D shapes based on the visibility of meaningful features

How to automatically determine the pose of a 3D object that corresponds to the most informative view of the shape; useful for automatic thumbnail generation for large repositories or catalogues of 3D models.

The problem of automatically selecting the pose of a 3D object that corresponds to the most informative and intuitive view of the shape is known as the best view problem. In many applications, like the creation of thumbnails for huge repositories or catalogues of 3D models, it is necessary to capture a pleasant and informative image of an object; also, informative 2D views of 3D objects can be used to apply various Computer Vision techniques in the 3D setting, for instance for shape recognition and classification. Up to now, such snapshots are still manually captured with a quite time-consuming process.

Judging a set of views as the best ones for an object is obviously deeply related to the nature of human perception of 3D shapes, which has been matter of study for centuries and is still under debate. There is an agreement, however, that the best view is closely related to the semantics of a shape and/or of its salient components, in a specific context or application domain, and it should make it easier to recognize the 3D object according to its meaning or purpose.

A former work of our group in collaboration with the Israel Institute of Technology describes a number of different ways to measure the goodness of a view and compares several state-of-the-art view descriptors. The majority of prior work on this topic privilege views that expose as much of the geometric or topological complexity of the object as possible, making use of semantic information only implicitly. Conversely, in this research we argue that the best view should be evaluated taking into consideration the meaningful components, or features, of a 3D shape, that is, the quality of a view should be bound to the semantics of the displayed features.

To identify meaningful components, this research relies on the consolidate expertise of the group in the field of shape analysis and structuring. We tested a number of segmentation methods which target the recognition of different sets of features and are suited to different type of shapes: Fitting Primitives, Reeb Graph, Tailor and Plumber (see pages 12 and 13). Recently, also an annotation tool has been proposed that exploits a mixture of segmentation algorithms to support the user in selecting meaningful parts of 3D models (see page 21); this could be useful to manually select features of interest, maybe automatically propagating them to other similar shapes in a consistent way. At present, we developed a prototype that automatically captures thumbnails (500x500 pixels) of segmented 3D shapes and takes advantage on shape classification if available (the most suited segmentation method and saliency parameters can be tuned based on a-priori knowledge on shape characteristics). In our experiment, more than the 88% of the generated thumbnails for a database of 400 models were ranked as good views, while only the 3% were judged very poor and would require manual intervention. Further applications of this research include semantic rendering of 3D shapes and motion planning.

> M. Mortara

- M. Mortara and M. Spagnuolo: Semantics-driven best view of 3D shapes. *Computers & Graphics*, Vol 33, issue 3, June 2009.
- O. Polonsky, G. Patanè, S. Biasotti, C. Gotsman, M. Spagnuolo: What's in an image? *The Visual Computer* 21(8-10): 840-847 (2005).

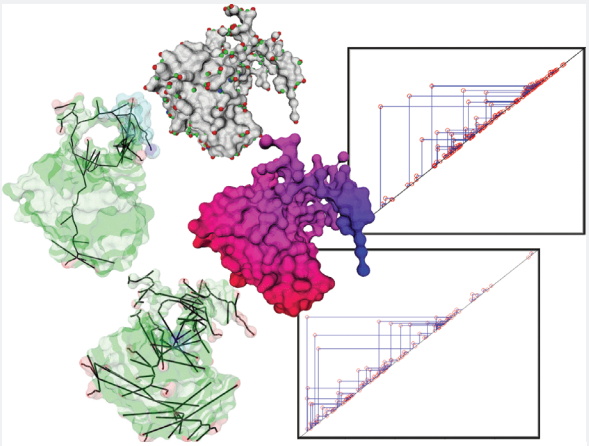
Best views computed on 3D models segmented by the Fitting Primitives algorithm

Computational topology techniques for shape description

Combining mathematical formalism with computational techniques, computational topology extends, creates, and deploys innovative solutions for the treatment of n-dimensional data. Its application crosses many fields dealing with huge and composite amounts of data, e.g. scientific simulations of real phenomena.

This research activity deals with computational topology, a recent branch of research that involves both mathematics and computer science, and tackles the problem of providing a suitable setting for formalizing and solving several issues related to shape analysis. Computational topology addresses the analysis of geometric shapes and the extraction of descriptions that synthetically represent digital shapes, preserving the topological properties and the salient characteristics. Since topology focuses on the qualitative properties of spaces, such as the connectedness and how many and what type of holes they have, topology is the best tool to describe the shape of a mathematical model at a high level of abstraction. Geometry, conversely, is mainly related to the quantitative characteristics of a shape. Integrating the classifying power of topology with the differentiating power of geometry enables us to extract information about shapes at different levels, taking into account global as well as local shape properties.

Our research focuses on methods for shape understanding that are rooted in Morse theory, ranging from one to high dimensional shapes and from single to multivariate mapping functions. For instance, we have proposed a computationally efficient algorithm to compute the Reeb graph and extended its original definition (the so-called Extended Reeb Graph, ERG) to analyze and characterize a triangle mesh with respect to the behaviour of a real and at least continuous function defined on the mesh. The surface model is characterized using a level set strategy, recognizing critical areas instead of critical points and coding the evolution of the contours in a graph-like structure. Our descriptions have been effectively applied to the analysis and generalization of digital terrain models (DTM); shape parameterization, segmentation and reconstruction. In addition, the simplicity of the structure (a graph in every dimension) and the natural link between the properties of the function and the original shape have led to a massive use of this descriptor for shape comparison and to the development of several shape matching and retrieval tools.



The model of a protein with some shape descriptions

Another result is the extension of the notion and computation of Size Functions to multidimensional data, both in terms of high dimensional data and multivariate functions. Since the beginning, the declared aim of size theory has been the development of a geometrical-topological framework for comparing shapes equipped with real functions describing the shape properties. In this sense, size functions provide a practical and manageable class of descriptors yielding a stable dissimilarity measure between shapes. With these premises, Size Functions have been extensively used in pattern recognition and computer vision, mainly for image retrieval and classification, and recently in the computer graphics domain, for the retrieval of 3D object.

> S. Biasotti

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- Biasotti S., Cerri A., Frosini P., Giorgi D., Landi C. Multidimensional Size Functions for Shape Comparison. In: Journal of Mathematical Imaging and Vision, vol. 32 (2) pp. 161 - 179. Springer, 2008.
- Biasotti S., Giorgi D., Spagnuolo M., Falcidieno B. Reeb graphs for shape analysis and applications. In: Theoretical Computer Science, vol. 392 (1-3) pp. 5 - 22. Computational Algebraic Geometry and Applications. Elsevier, 2008.
- Patanè G., Spagnuolo M., Falcidieno B. A Minimal Contouring Approach to the Computation of the Reeb Graph. In: Ieee Transactions on Visualization and Computer Graphics, vol. 15 (4) pp. 583 - 595. IEEE, 2009.

Approximation and analysis of scalar functions

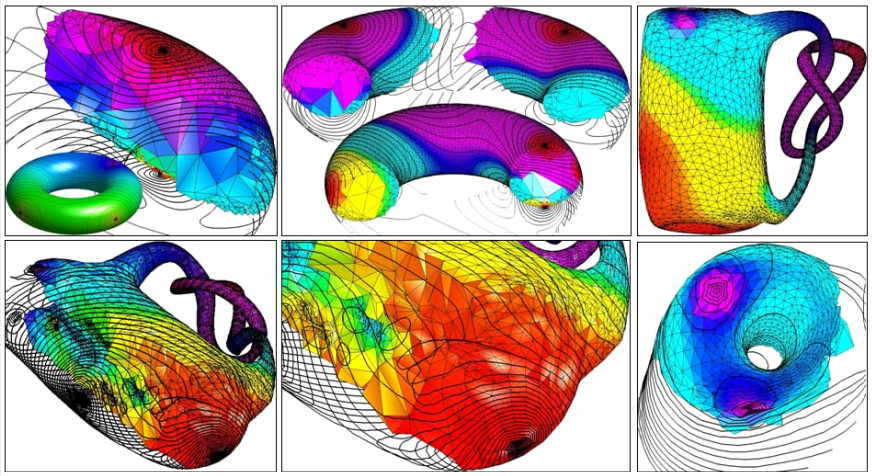
Approximation and analysis of scalar functions

Scalar functions, which have a central role for modelling and analyzing several properties of 3D shapes, can be characterized by combining different differential, numerical, and topological techniques in a unified framework.

Scalar functions are extensively used to model data in engineering, geographical applications, bio-sciences (e.g., medicine and bio-informatics) and are among the most frequent mathematical models used in scientific visualization. Indeed, the behaviour of a variety of scientific phenomena, measurable on the boundary of 3D shapes, is studied by modelling the set of known measurements as a scalar function $f: P \rightarrow R$, defined on a surface P.

In this context, our research focuses on the analysis of scalar functions defined on triangulated and point-sampled surfaces using differential, numerical, and topological techniques, which include the analysis of the critical points, the use of implicit approximation techniques, the computations of high-level shape descriptors such as the Morse complex and the Reeb graph. Recently, we have also addressed the problem of extending the measures captured by a scalar function f defined on the boundary surface P of a 3D shape to its surrounding volume. The approximation scheme, which is based on implicit modelling techniques, handles arbitrary scalar functions defined on surfaces represented by 2-manifold triangle meshes without imposing constraints on the sampling density and smoothness of f and P. The degrees of freedom on the choice of the basis functions (i.e., globally and compactly-supported radial basis functions) allow us to adapt the model parameters to specific problem constraints such as the number of input samples, the local accuracy, and the degree of smoothness of the final approximation.

Another important research activity is concerned with the definition of new classes of basis functions, which are intrinsically defined by the input surface and its local/global properties. These new functions are intended to support shape analysis, abstraction, and comparison. Among them, we have focused our attention on the harmonic functions, the eigenfunctions of the Laplace-Beltrami operator, and the spectral-driven basis functions. All these classes provide interesting insights into the structure and morphology of the input shapes and/or the underlying phenomena.



Level sets of a map defined on a surface and its volumetric approximation.

Since a low quality of the discrete representations of the input data, unstable computations, numerical approximations, and noise might produce functions with a high number of critical points, we have developed an algorithmic framework for smoothing an arbitrary scalar function, while simplifying its redundant critical points and preserving those that are mandatory for its description. Inserting constraints in the smoothing of f allows us to overcome the traditional error-driven approximation of f, which does not provide constraints on the preserved topological features. Finally, we have studied the comparisons of two or more functions by evaluating their “independency", that is, how much and where the measured properties differ.

> G. Patanè

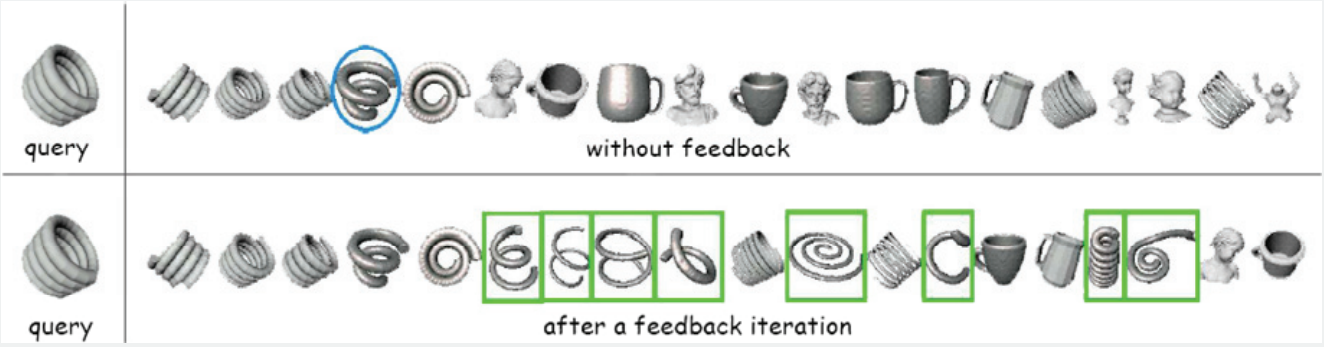
- Patanè G., Spagnuolo M. Falcidieno B. Topology- and error-driven extension of scalar functions from surfaces to volumes. ACM Transactions on Graphics. To appear, 2009.
- Patanè G., Falcidieno B. Computing Smooth Approximations of Scalar Functions with Constraints. Computer&Graphics. vol. 33 (3) pp. 399 - 413. Elsevier, 2009.
- Patanè G., Spagnuolo M., Falcidieno B. A minimal contouring approach to the computation of the Reeb graph. IEEE Transactions on Visualization and Computer Graphics. vol. 15 (4) pp. 583 - 595. IEEE Press, 2009.

Relevance feedback for 3D object retrieval

Relevance feedback plays a key role in 3D search engines, as it bridges the semantic gap between the user and the system. In this research, the inclusion of humans in the loop combines with high-level descriptors and a simple distance normalization procedure, to approximate subjective similarity.

Before devising 3D retrieval techniques, we should acknowledge that similarity is a cognitive process, depending on the observer: objects have a shape for the observer, in whose mind the perception of phenomena joins existing concepts and allows recognition and similarity assessment. This suggests 3D retrieval techniques should offer different viewpoints from which to observe objects, and these viewpoints should be combined to make a decision, as we do in our daily life: we observe something furry, with four legs, claws, and a tail, then decide it is a cat. Computationally, this turns into the need for shape descriptors which capture different high-level perceptual properties, and for smart techniques which select the descriptors that best fit the user's idea of similarity. A powerful technique for learning the user's similarity concept is relevance feedback.

Whereas relevance feedback dates back to the 1960s, it has only recently drawn the attention of the 3D community. The need for methods that go beyond the state of the art in related disciplines has soon come into evidence. In developing a new method addressing 3D objects, we started with the assumption that the observer uses a gauge of similarity values, spanning the nuances of similarity between what is felt relevant and what is not. This implies going beyond the traditional, "relevant/not relevant" binary categorization. The gauge is modelled as a pseudo-distance, i.e., as a distance without the property that two objects having zero distance are the same object. The goal is the approximation of the unknown user's pseudo-distance, according to a partial knowledge we have on some dataset examples.



Retrieval results with and without relevance feedback

The approximation gets started with a set of known pseudo-distances, computed by using complementary 3D shape descriptors. The user judgement, expressed via an easy interface, is used to penalize the distances that do not reflect the user perception, that is, the descriptors that perceive to be different the objects the user perceives to be similar. The basic idea is that similarity may emerge as the inhibition of differences, that is, as the lack of diversity with respect to the shape properties taken into account. The penalization of mistaken distances is done by a re-scaling procedure based on elementary but important properties of pseudo-distances, and guaranteed by an easy-to-prove approximation theorem. No optimization processes are required.

The fundamentals of this research are the multi-dimensional, parametric nature of shape descriptors - in line with our long-time studies (see page 15) – as well as the active role played by the user - the real focal figure in the 3D retrieval process (see also page 19). IMATI's attention to 3D retrieval is also witnessed by the organization of five tracks of the SHape REtrieval Contest (SHREC). Launched by AIM@SHAPE in 2006, the event now involves several research groups worldwide.

> D. Giorgi

► D. Giorgi, P. Frosini, M. Spagnuolo, B. Falcidieno: Multilevel relevance feedback for 3D shape retrieval. Proceedings 3DOR'09: Eurographics Workshop on 3D Object Retrieval, The Eurographics Association, pp. 45-52, 2009.

Shape matching and classification Using structural descriptors

Shape matching and classification using structural descriptors

Retrieval and classification of 3D content play a crucial role in applications for the organization and filtering of 3D data. Within this context structural descriptions are an intermediate step between geometry and semantics that allow for global and partial matching of 3D shapes.

There is a large consensus that shapes are recognised and coded mentally in terms of relevant parts and their spatial configuration, or structure. Relevant parts are obviously dependent on the application, meaning that it is possible to index an object with different features according to the context in which it has been asked to describe it. The difficulties in succeeding with this task depends on the fact that there is neither a single best shape characterization nor a single best similarity measure, for this reason it is appreciable to propose a framework for working on shape retrieval where different characterization methods can be plugged-in and tested, while keeping the same computational setting. Moreover, an important point is that the similarity between two shapes is assessed not only in terms of identical global match but it is based on the contribution of common features compared to those distinguishing them. Therefore, a retrieval system closer to the human perception of similarity should be able to assess similarity but also to identify the common parts (global and partial matching).

The problem statement only just described, has been approached by investigating and developing an original methodology for shape matching that combines geometrical and structural properties of the 3D shapes, with the aim of identifying sub-parts shared by 3D objects represented as polygonal triangle meshes.

The geometry and the structure of the shapes are coupled in a structural descriptor able to provide at the same time both a global and a local information of the shape: the Extended Reeb Graph (ERG). The ERG provides a flexible coding that can be adapted to the user's needs and to the context of applications. The matching framework for sub-part correspondence is achieved through a robust and efficient graph-matching technique, which builds the common sub-graphs between two shapes and highlights the maximal sub-parts having similar structure and geometry.

Within this matching framework, structural descriptors are also used to define and construct 3D shape prototypes, that improve the automatic classification of 3D content and search by summarizing key features of the members of a class, then classifying the query object into the class that the prototype most similar to the given query represents. Given a class of shapes, its prototype can be defined either in a selective or in a creative manner: In the first case, one or a set of few members of the class are chosen as the best representatives of the whole class. In the second case new models, possibly not belonging to the class, are generated as prototypes of the class. The investigated methodology builds creative prototypes of 3D object classes described by structural descriptors and the original prototype creation phase uses graph editing operations, which take into account both adjacency and attribute manipulation.

> S. Marini

- Marini S., Spagnuolo M., Falcidieno B. Structural Shape Prototypes for the Automatic Classification of 3D Objects. In: IEEE Computer Graphics and Applications, vol. 27 (4) pp. 28 - 37, 2007.
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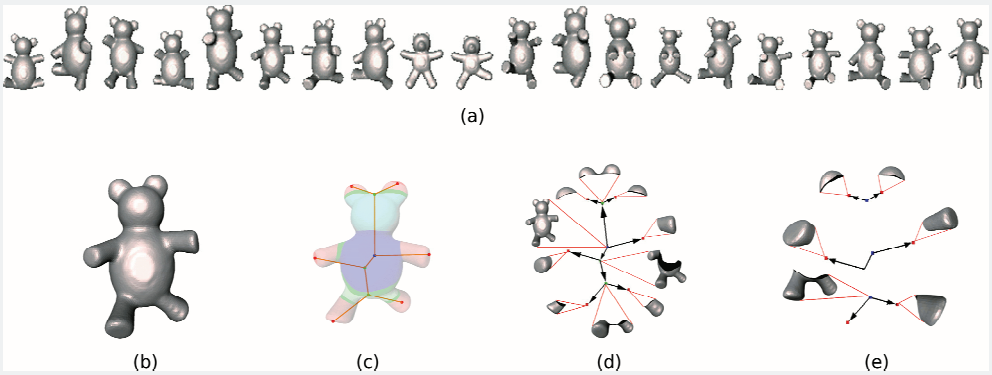
- Marini S., Spagnuolo M., Falcidieno B. From Exact to Approximate Maximum Common Subgraph. In: Procs. of Graph-Based Representations in Pattern Recognition - IAPR Intnl Workshop (Poitiers, France, 11-13 April 2005) pp. 263 - 272. L. Brun, M. Vento (eds.). (LNCS vol. 3434). Springer, 2005.



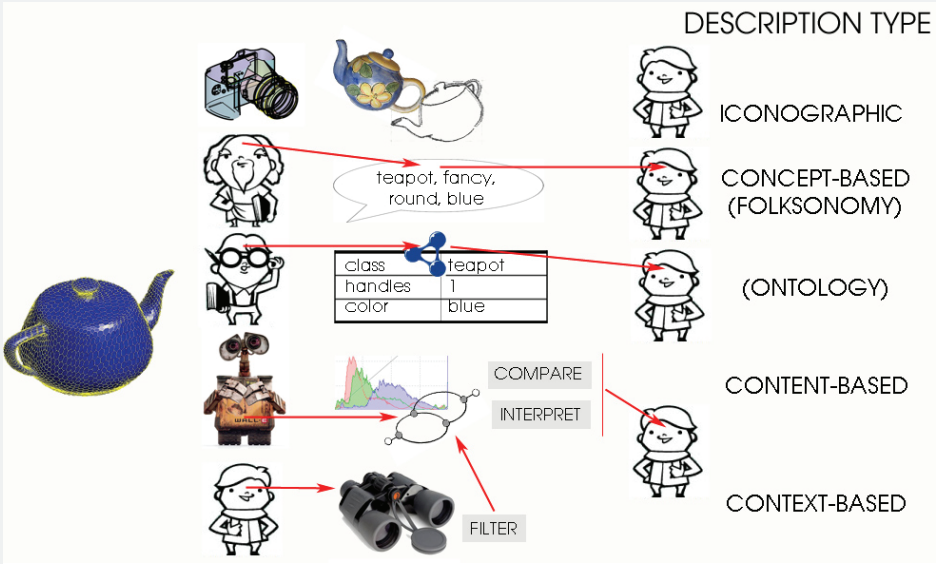
A class of shapes (a). A class member (b) displayed with its structural descriptor (c). The geometric attributes associated to the structural descriptor encoded as directed graph (d) and the corresponding prototype (e).

The user perspective on 3D object description

The description of 3D objects can be driven by concepts, content, context. Concept-based: annotation of objects with textual tags. Content-based: automatic methods to analyze their shapes. Context-based: emphasis on the perspective of the user and his specific requirements.

Whenever a resource is created, located or stored, usually it needs to be coupled with a description which synthesizes its main characteristics. The more meaningful the description is, the easier the retrieval and the usage of the resource will be. In particular we are interested in 3D objects, which are widely recognized as the upcoming wave of digital media. Our recent contribution is to focus on the role of the user (i.e. the consumer of the stored resource) in the description process.

Let us make an ordinary example: when we meet a girl we memorize her name and some relevant features that characterize her. If eventually a friend asks us to describe her, our description also depends on the context: if she is a candidate for a job, her attitudes and her experiences will be important, if we want to stress her beauty, some details about her appearance will be proper, if we have to sell her some clothes, her size will be the most relevant detail. The same patterns arise also in the domain of 3D digital objects, and it is possible to point out the main issues by referring to the simple example above.



Different approaches to description and the role of the user in the process

Annotation is the process of tagging a resource with concepts, which may be picked from an unstructured set of keywords (vocabulary), from a structured set of interconnected keywords (ontology, see also page 21) or by freely chosen keywords (folksonomy). This kind of approach is very straightforward, as concepts are highly descriptive: if a 3D object represents a teapot, the most descriptive information that can be used is the word "teapot" itself. Nevertheless, this approach often needs a human descriptor who explicitly annotates the resource beforehand, therefore it is largely dependant from the trustworthiness and the accuracy of the describing keywords. Description is doomed to be subjective/qualitative (e.g. pretty, tall) and may also refer to extrinsic features (not extractable by the analysis of the resource, e.g. name, address). Content-based approaches rely on a different perspective: the description is based on an analysis of the resource. The description is objective/quantitative, but it is limited to intrinsic features, and focuses just on some (relevant) characteristics of the resource. The assessment about the relevance of the above characteristics is arbitrary, as different descriptors capture different characteristics: some of them capture the overall shape, some others may capture the structure, the pose, the orientation or the volume of the object.

To overcome the arbitrariness issue the user should be enabled to implicitly (see page 17) or explicitly assess a priori the relevance of the different characteristics: by defining a context he is able to cast a viewpoint on the 3D shapes, thus selecting, filtering and weighting the diverse content-based descriptors, and dynamically combining them into the most appropriate context-based descriptor. Since the aim is to involve more and more the user in the process, it is possible to foresee that context-based descriptors will become the next major paradigm for object description.

> F. Robbiano

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Semantic analysis of metadata to search for multidimensional media

Semantic analysis of metadata to search for multidimensional media

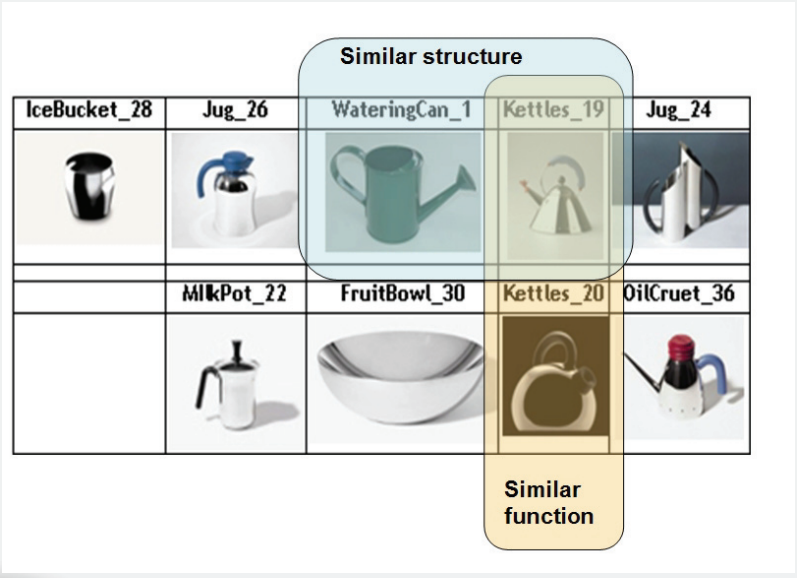
Methods of Semantic Similarity and Semantic Granularity to Compare and Browse Multidimensional Media Resources described by Ontology-driven Metadata.

The difficulties pertaining to content accessibility are mainly due to a poor overlap between the conceptual model employed by the seeker and the model defined by information providers. Ontology-driven metadata, which are information describing data organized according to ontologies, have recently been imposed to make explicit portions of both models. They provide the semantics of resources collected in repositories or directly available on the web. A full exploitation of such semantics by ontology-driven methods is of primary importance for application domains where resources need to be searched and selected (e.g., Geographical Information, Digital Library, Biomedical and Multimedia domains).

From our direct research experience within the European founded project AIM@SHAPE, we realize that the "standard ontology technology" provides reasoning facilities that are mainly useful to check the ontology consistency, but they still lack of effective tools for comparing and browsing the resources according their associated semantics. Thus, we have defined two powerful ontology-driven methods which overcome this limitations:

- "Semantic Similarity among ontology instances". It is a method aiming at identifying resources that are conceptually close but not identical taking into account their semantic description. It is the basics component for retrieving resources and further analysis such as the resource clustering.
- "Semantic Granularity". It is a method aiming at easing the browsing of any repository of resources described by an ontology: it organizes the resources according to different levels of abstraction, i.e. granularities, which can be exploited to browse the collection of resources in coarse or very fine grained views.

Both the methods are context dependent: they are parameterized according to the different criteria which might affect the comparison and the browsing activities in different application contexts. This offers flexible user-oriented tools which improve the decision making of the user as the methods can be explicitly tailored according to the specific user preferences. The two methods have been applied in different application domains. semantic similarity has been validated in two applications domains: to compare researcher staff and in the industrial design for retrieving 3D object according to their decomposition in parts or the their functionalities, Semantic granularity has been validated in the digital library domain to browse repository of scientific papers.



The results obtained so far are going to be extended for considering the metadata of Multidimensional Medial available in the "Web of Data". In particular, our current research is extending the aforementioned methods considering the ever growing amount of resources available within the linked data initiative (http://linkeddata.org/).

> R. Albertoni

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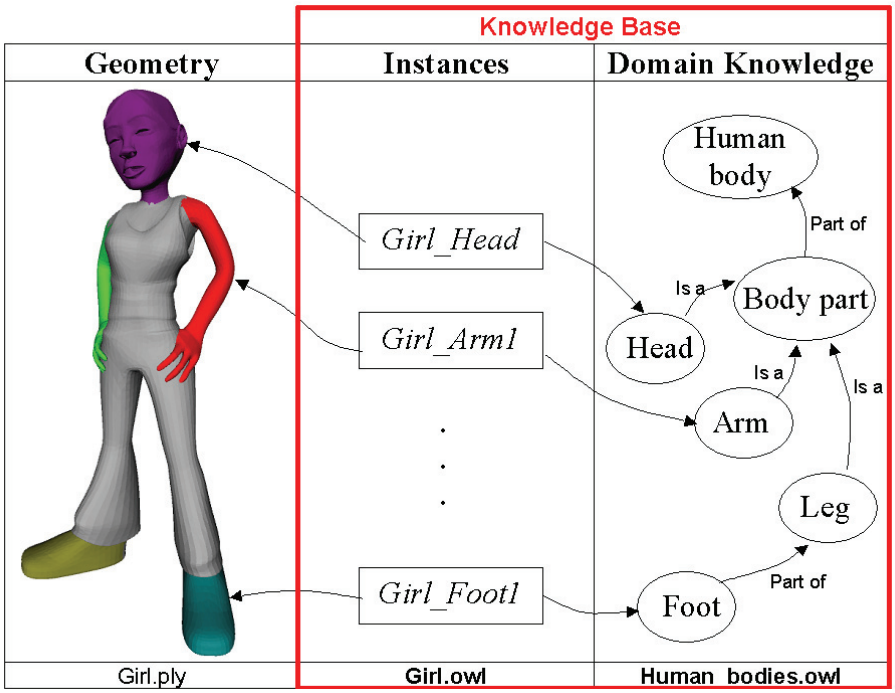
ShapeAnnotator: Characterization of 3D shape parts for semantic annotation

An interactive GUI for 3D feature extraction and semantic annotation of surface meshes. Several segmentation algorithms are provided to define characteristic parts of an object. Each part can be linked to formal semantics expressed in an ontology to enable easy reuse and flexible retrieval.

Digital models of 3D objects are nowadays recognized as the upcoming wave of digital content shared, distributed and even created over the Internet. In the last few years we have assisted to a significant growth of online repositories of 3D shapes which reveals the importance of making these resources more accessible and easy to share and retrieve. At the same time, 3D social networking and 3D mapping applications (e.g. Second Life, Google Earth) are having an impressive success.



Bridging geometry and semantics through the ShapeAnnotator

Key to an effective sharing of 3D media is the possibility to annotate 3D models with information about their semantics, or any other knowledge item, useful to characterize the objects and the context in which they are used. Recent research in multimedia and knowledge technologies demonstrated the potential of semantic annotations to support advanced sharing and interactions with multimedia, for example for search, reuse and repurposing.

Building on AIM@SHAPE's experience, we present a flexible and modular system for part-based annotation of 3D objects, called the "ShapeAnnotator". In our settings, 3D shapes are represented by surface meshes while annotation domains are formalized by ontologies: these are mainly implementation choices, while the whole framework has a larger applicability and is independent of the specific representation used both for the geometry and knowledge.

The novelty of the ShapeAnnotator relies on the concurrent use of a variety of shape segmentation tools to offer a rich set of operators by which the user can easily select the part he/she wishes to link to relevant concepts expressed by the ontology. The ShapeAnnotator acts therefore at two levels: it helps the user in the identification of relevant parts, or features, in the model, and it provides the software environment to annotate the parts with concepts that express their semantics.

Moreover, since the formalization of a concept may also involve the specification of metric parameters of the part (e.g. dimensions, length), the annotation step implements also a number of automatic services for the computation of these quantitative properties. This work started as an activity of the AIM@SHAPE project, and currently contributes to the achievement of the MDM project objectives.

> M. Attene

- *Paper* - M. Attene, F. Robbiano, M. Spagnuolo, B. Falcidieno. "Characterization of 3D shape parts for semantic annotation". Computer-Aided Design (2009), doi:10.1016/j.cad.2009.01.003
- *Software* - http://shapeannotator.sourceforge.net

Knowledge management for safety in industry

Definition of methods and tools to exploit the variety of data constituting the knowledge related to standards, engineering codes, normative and best practice which rule design, manufacturing and operations in industry to ensure reliability and safety (e.g. P&I diagrams, 3D models, textual documentation).

The most knowledge underlying the activities in industry, and in particular in the process industry, is perfectly defined and formalized; but, unfortunately accidents continue to happen and 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 forgotten, or distorted, or badly applied. Many issues, including fast personnel turn-over, foreign employees and extensive outsourcing , are contributing in these "losses of knowledge", which pose new risks in many industries. Advanced methodologies and tools for knowledge management could be very useful to exploit all the existing safety knowledge.

This research activity originates from a research funded by ISPESL. In the research ISPESL-B6402, the objective was the development of methods for supporting the identification of components or subparts of a plant representing possible critical configurations. A software prototype has been developed to demonstrate that the methods defined are able to exploit and interpret the variety of data constituting the plant design and stored in a CAD/PDM system to provide users with contextual browsing the plant data (P&I, drawing, 3D models) related to the identified possibly critical configurations.

Following this experience, the research activities focused on the management of standards, engineering codes and normative which rule design, manufacturing and operations in industry to ensure reliability and safety.

In particular the potentialities offered by KB technologies has been exploited to the design and certification of pressure equipments; a knowledge base has been defined, composed of an ontology, a set of logical axioms and logical rules, to support both the application of a specific safety normative in the first stages of the pressure vessels design process, and its verification a posteriori by inspection bodies. The case study is restricted to the VSR normative, as applied in Italy. However, the use of ontologies to model the application domain enables a straightforward extension to a wider domain and to other safety rules than VSRs.

> M. Monti

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Event organization

Among its activities, the Shape Modelling Group has also developed a long-standing experience in organising international scientific events such as conferences and workshops. Herewith, the most relevant are reported.

➢ **International Convention on Shape and Solids**

7-11 June, 2004, Genova, Italy

This convention brings together two important international events: the Shape Modelling International Conference (SMI) and the ACM Symposium on Solid Modelling and Applications (SM). SMI was launched for the first time in Japan in 1997 with the aim of engaging a rather multi-disciplinary community with common interests about shape modelling, but looking at the problem from a side view with respect to other specialized conferences. SMI is now an annual and circular event with the venue changing circularly from Asia to Europe, and to America. SM is primarily focused on the design, representation, transmission, analysis, visualization, and animation of informationally complete models of physical shapes and of their properties. Although much of the past research was concerned with models of manufactured parts or processes, the Symposium is seeking to expand the applications of solid modelling beyond CAD/CAM, to domains such as medicine, biology, and geo-sciences.

http://smism04.ge.imati.cnr.it/

➢ **1st International Workshop on Shapes and Semantics**

17 June 2006, Matsushima, Japan

This workshop aims at providing a forum for the dissemination of new and emerging fields engaged in the integration of Multidimensional Media with Knowledge and Content processing technologies. Focus of this first event will be on the dissemination of the most relevant results of projects funded by the European Commission and targeted at bridging the gap between semantics and digital media systems. The workshop offers an opportunity to projects, institutions and individuals to present ongoing research to industrial representatives and development engineers who could exploit the technology emerging from the projects.

http://www.aimatshape.net/event/shapes-and-semantics

➢ **International Conference on Semantic And digital Media Technologies**

5-7 Dec 2007, Genova, Italy

The international conference on Semantic And digital Media Technologies (SAMT) targets to narrow the large disparity between the low-level descriptors that can be computed automatically from multimedia content and the richness and subjectivity of semantics in user queries and human interpretations of audiovisual media - The Semantic Gap.

http://samt2007.ge.imati.cnr.it/

➢ **Eurographics 2009 workshop on 3D object retrieval**

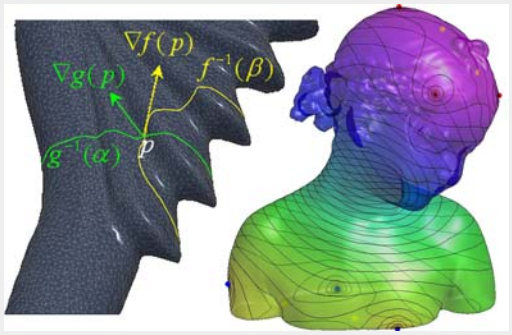
29 March 2009, Munich, Germany

The aim of this workshop 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.

http://3dor.ge.imati.cnr.it/About.html

Training Activities

The organization of training events is one of the activities of the Shape Modelling Group. Besides promoting several student/researcher exchanges with project partners and collaborating institutions, the SMG organizes university courses and international schools for PhD students and post-docs.



International Summer School on Computational Methods for Shape Modelling and Analysis

14-18 June, 2004, Genova, Italy

This school provided training courses aimed at PhD, PostDoc or researchers with either a computer science, informatics or mathematics background, and prior knowledge of geometric modelling techniques. The school focused on different aspects related to shape modelling, processing and analysis, and the final programme included training on remeshing techniques, computational topology, shape acquisition and reconstruction, shape interrogation, shape similarity and matching, skeletal structures and level of detail in mesh-based representations.

http://smism04.ge.imati.cnr.it/intro_school.html

International Summer School on Shape Modeling and Reasoning

18-22 June 2007, Genova, Italy

The International Summer School on Shape Modelling and Reasoning focused on representations and computational techniques for modelling and reasoning on digital shapes. The program consisted of invited lectures, given by leading international scientists in the field, who presented state-of-the-art techniques on shape modelling and reasoning, and brought complementary views of problems and solutions. The school has been co-organized by the SMG, the Department of Computer Science (DISI) of the University of Genova and the Israel Institute of Technology (TECHNION) within the scope of the EU FP6 Network of Excellence AIM@SHAPE.

http://shapesummerschool07.disi.unige.it/

Courses organized in cooperation with the University of Genoa

PhD course: Analysis of discrete surfaces

PhD in Information and Communication Technologies

years: 2006-2007 and 2007-2008.

Master course: Methods of analysis of discrete surfaces and their applications

Laurea in Applied Mathematics

years: 2005-2006, 2006-2007, 2007-2008, 2008-2009, 2009-2010.

The focus of these courses is to form young professionals and researchers able to exploit mathematics across different disciplines, mixing both theoretical and technological aspects. These courses present an overview of the recent results in the extension and the usage of mathematical in the computational setting, such as Morse theory, implicit shape representation, computational topology, discussing their application to a number of multidisciplinary domains, such as terrain modelling, product design and manufacturing.

http://www.ima.ge.cnr.it/ima/personal/patane/PersonalPage/IMATI-DIMA_Course/Corso.html

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'09 (Shape Modeling International) Beijing, China.

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

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Michela Spagnuolo

Senior Researcher

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

She authored more than 120 reviewed papers in scientific journals and international conferences, edited a book on 3D shape analysis, and was guest-editor of several special issues. She is currently programme chair of the EG workshop on 3D Object Retrieval and of the IEEE Shape Modelling International 2008 (SMI). She is member of the steering committee of SMI, and was programme chair for the Semantic and digital Media Technology, SAMT'07.

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

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Franca Giannini

Senior Researcher

Franca Giannini is a senior researcher at IMATI. She graduated in applied mathematics from the University in Genoa in 1986. Since then, taking into account the evolution of the available technologies and changes in working processes, she has concentrated on different issues for the specification of tools and methodologies for 3D geometric model representation, analysis and synthesis. In particular, her focus is the development of shape processing and modelling tools adaptable to the application needs by exploiting contextual knowledge. She has participated and been responsible for IMATI in several national and international projects carrying on strong collaboration with both international research institutions and companies, such as industrial CAD developers, and end users companies. Since 2001 she is supervising PhD students in co-tutelle with the French Universities INPG and ENSAM. She is currently in charge of the project Multimodal and Multidimensional Content and Media of the Department ICT of CNR. She is co-author of two patented software for automatic feature recognition for hybrid solid representation. The results of her research activity have been published in more than 80 reviewed papers presented in international conferences and journals. Her current research interests include multidimensional media modelling and understanding and related knowledge formalisation in applications contexts.

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Chiara Eva Catalano

Researcher

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

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

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

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Marco Attene

Researcher

Since 1999 Marco Attene has been collaborating with IMATI, and there he is currently a member or the research staff. 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 Patanè

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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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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Daniela Giorgi

Research assistant

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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List of projects

List of Projects

International

1) 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. Resp: Bianca Falcidieno (2008-2010)
2) eSDI-Net+ European Network on geographic Information Enrichment and Reuse Network for promotion of cross border dialogue and exchange of best practices on Spatial Data Infrastructures (SDI's) throughout Europe. Resp: Bianca Falcidieno (2007-2010)
3) SHALOM: SHApe modeLing and reasOning: new Methods and tools. Resp: Bianca Falcidieno (2006-2009)
4) IDE-Univers Infrastruscture de donnèes spatiales entre Universitès et Centres de recherche dans le Mediterranèe Occidentale. Resp: Monica De Martino (2006-2008)
5) Network of Excellence AIM@SHAPE: Advanced and Innovative Models And Tools for the development of Semantic-based systems for Handling, Acquiring, and Processing knowledge Embedded in multidimensional digital objects(Contract number FP6 IST NoE 506766). Resp: Bianca Falcidieno (2004-2007)
6) Research Agreement GVU/Gatech IMATI-GE/CNR Surface Analysis. Resp: Bianca Falcidieno (2002-2005)
7) INVISIP: Information Visualization for Site Planning. Resp: Monica De Martino (2001-2003)
8) ARION: An Advanced lightweight architecture for accessing scientific collections. Resp: Michela Spagnuolo (2001-2003)
9) Bilateral Agreement Laboratory 3S,Domaine universitaire, Grenoble (France) - IMATI-GE/CNR Free-form deformation for aesthetic and engineering design. Resp: Bianca Falcidieno (2001-2003)
10) European Project GROWTH: "FIORES II: Character Preservation and Modelling in Aesthetic and Engineering Design". Resp: Franca Giannini (2000-2003)
11) Bilateral Project IMATI-GE/CNR - University of Otago (NZ) Shape-based Meshing Techniques. Resp: Bianca Falcidieno (2000-2003)
12) CNR – CNPq (Brazil) Analysis of Digital Terrain Model for the detection of topographic features of interest for the environment protection. Resp: Bianca Falcidieno (2001-2002)
13) Enhancing Product Development Through Physical prototype Rapid e-Delivery. Resp: Franca Giannini (2001-2002)
14) Consultancy Research Contract "High-quality Terrain Modelling". Resp: Bianca Falcidieno - Michela Spagnuolo (1998-2002)
15) European Project Telematics "THETIS: A data management and data visualization system for supporting coastal zone management for the Mediterranean sea". Resp: Michela Spagnuolo (1998-2001)
16) European Project INCO "TAUTEM: Transfer and Advanced Use of Technologies for Manufacturing". Resp: Monica De Martino (1997-2001)
17) Eurepean Project BRITE/EURAM "FIORES: Formalization and Integration of an Optimized Reverse Engineering Styling workflow". Resp: Bianca Falcidieno (1997-2001)
18) European Project ESPRIT "COWORK: COncurrent project development IT tools for small-medium enterprises netWORKs". Resp: Franca Giannini (1997-2000)
19) Mediterraneo "Geometric features for industrial design". Resp: Franca Giannini (1996-2000)

National

1) Consultancy Research Contract MULTITRUST "Multibiometria per applicazioni di Sicurezza", Resp. Michela Spagnuolo (2007-2008)
2) Parco Scientifico e Tecnologico della Liguria, DOCUP (Ob. 2, mis.3.7): "studio di fattibilità di un sistema per l'ottimizzazione dei tagli subacquei supportato da una ontologia di processo". Resp. Bianca Falcidieno (2006-2007)
3) Contratto SIIT – "Salute": "Sistemi Intelligenti per la Gestione del Paziente nel Ciclo Diagnostico e Terapeutico". Resp. Bianca Falcidieno (2009-2010)
4) "Recognition of parts and components in virtual industrial plant represented in PDM-CAD-CAE models aimed at identifying critical configurations". Resp: Franca Giannini (2003-2005)
5) MACRO-GEO: Progetto di Ricerca FIRB "*MACROGeo: Metodi Algoritmici e Computazionali per la Rappresentazione di Oggetti Geometrici*". Resp. Bianca Falcidieno, 2003-2005

List of Representative publications

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- Albertoni R., Bertone A., De Martino M. *Semantic Analysis of Categorical Metadata to Search for Geographic Information*. In: DEXA '05 Procs, pp. 453 - 457, IEEE, 2005.
- Albertoni R., Bertone A., De Martino M. *Visualization and Semantic Analysis of Geographic Metadata*. In: GIR '05 Procs., pp. 9 - 16, IEEE, 2005.
- Albertoni R., Camossi E., De Martino M., Giannini F., Monti M. *Context Enabled Semantic Granularity*. In: KES 2008 Procs. p. 682-688. (Lect Notes in Artificial Intelligence). Springer, 2008.
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- Albertoni R., De Martino M. *Using Context Dependent Semantic Similarity to Browse Information Resources: an Application for the Industrial Design*. In: MAReSO 2007 Workshop Procs, pp. 58 - 72, 2007
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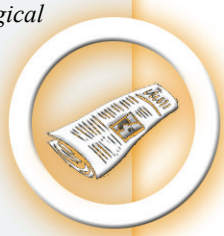

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News and upcoming events

Workshop on 3D Knowledge Technologies for Cultural Heritage Applications
12 September, 2009
Vienna, Austria
http://195.251.17.14/3d-knowledge-for-ch/

This workshop targets the scientific community working in the field of 3D graphics and knowledge technologies and aims to bring together researchers, 3D content creators/users and Cultural Heritage professionals.

Organized and sponsored by the EU FP7 Project Focus K3D

15th International Conference on Virtual Systems and Multimedia (VSMM 2009)
9-12 September, 2009
Vienna, Austria
http://www.vsmm2009.org/

Vision or Reality? Computer Technology and Science in Art, Cultural Heritage, Entertainment and Education

Organized by Vienna University of Technology (Austria)

2009 Joint Virtual Reality Conference of EGVE - ICAT – EuroVR
7-9 December, 2009
Lyon, France
http://jvrc09.inrialpes.fr/

JVRC09 will provide an opportunity for virtual reality researchers, engineers and users to interact, share new results and new applications, show live demonstrations of their work, and discuss emerging directions for the field.

Organized by INRIA (France)

3D Image Processing (3DIP) and Applications
17-21 January, 2010
San Jose, CA, USA
http://195.251.17.14/events/3d-image-processing-3dip-and-applications

Conference EI103 Part of program track on 3D Imaging, Interaction, and Measurement of IS&T / SPIE Electronic Imaging.

Organized by University of Lyon (France)

IS&T / SPIE Electronic Imaging SCIENCE AND TECHNOLOGY

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