

OUTLINE OF MY PAST AND CURRENT RESEARCH ACTIVITIES

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Currently I am Director of GraphiTech, Center for Advanced Computer Graphics Technologies, located in Trento, Italy, which has been founded as joint venture between the INI-GraphicsNet Foundation, the Cultural Institute of Trento (Istituto Trentino di Cultura now Fondazione Bruno Kessler) and the University of Trento (Università degli Studi di Trento). In GraphiTech, thanks to an outstanding research group, I am caring on research in different, but very much related, areas. Some keywords which could be used to describe my work are: Design Theory, Computer Aided Design, Visualisation Technologies, Intelligent and Multimodal Interfaces and Interactions, Technology Transfer, Science and Technology Policy

At the beginning of my research career my interests were focused on the application of virtual reality technology to computer aided design, advanced 3D interaction techniques and computer supported co-operative work in engineering applications. The research was conducted with the aim of assisting the product development process and the product lifecycle with modern information and communication technologies as, for instance, Virtual-Augmented and Mixed Reality, CSCW (Computer Support Cooperative Work) and Shape Semantics.

Initially I started from the assumption that, despite the wide spread adoption of sophisticated software tools for mechanical design, serious difficulties were still encountered during the styling phase of the design process when free-form surfaces have to be modelled according to the functional product constraints and requirements. Many software have tried to tackle this issue, however products developed so far for geometrical modelling were not nearly as user-friendly as the ones commonly employed for mechanical design. As a matter of fact, in this domain traditional input-output interfaces, like mouse, keyboard and monitor are not suitable for a deep interaction between user and software. On the other hand, interfaces used in virtual reality systems, like gloves and head-mounted displays, could be much more effective because they allow exploring 3D space in a more intuitive way. Therefore the aim of my research has been to search and test methods, instruments and software applications that could allow industrial designers to model surfaces in the easiest and most natural way.

With respect to this domain I have contributed to the development of various software platforms. In particular, I have led the implementation and I have developed part of the SpaceDesign system, a complete re-implementation of the ARCADE system. I have started and coordinated the development of the SmartSketches user-centred system which has introduced computer-based tools in the initial stages of product design within mixed reality environments. To this end, the system has provided innovative multimodal user interfaces combining sketches, gestures and speech among others, to accomplish design tasks in different contexts, ranging from small tablets to large-scale displays and immersive environments.

Within this application domain, briefly, I have been working on the following scientific area:

- ❖ User and Cognitive Task Analysis of Multimodal Interfaces.
- ❖ Visual languages and multimodal input to describe model constraints.
- ❖ Extended virtual and augmented environments for design.
- ❖ Efficient search algorithms to match sketches against multimedia databases.
- ❖ Intelligent user interfaces for product design.
- ❖ Interactive building of precise 3D models from sketches.
- ❖ Usability studies and Empirical Evaluation of Multimodal interfaces.

Specifically as far as Free-Form Surface Design in Immersive Environments is concerned, I have been working on:

- Extended Design Environments ranging from personal design assistants, through desktop monitors, to the CAVE.
- Novel 3D interaction techniques to create and manipulate free-form surfaces in virtual environments in conjunction with different input and output devices.
- Mathematical models and representation schemes for free-form surfaces, together with the algorithms for rendering these surfaces.

Meanwhile, I had the opportunity to specialize myself in the application of IT in the domain of cultural heritage, with the aim to connect different culture through New Technology as well as develop instruments for the re-qualification of the archaeological, architectural and monumental patrimony. Definitely, the possibility to visit an archaeological landscape or site and at the same time experiencing its reconstruction interactively makes the all experience more engaging, culturally enriching and entertaining for visitors. In fact archaeological sites and ancient monuments

are usually perceived by not specialists as fragmented, partial, and difficult to interpret and comprehend, and out of the contemporary age context. This results in a frustrating and limiting experience for most of the people. The curators of archaeological sites have been trying to respond to this making available to the public textual information, drawings showing how the site looked like in ancient times, and physical models of ancient monuments. These are all very limited attempts to fill the lack of information and context that most of the visitors experience, which have also required from the expert point of view a significant amount of time with questionable results. Visitors are in need for interactive and mobile tools from where to access data on demand about the cultural background of the site, artistic aspects, historical context and other valuable information that would enrich their experience. At the same time visitors of one archaeological site require to relate their visit to other culturally similar or related archaeological sites, so that to built a wide picture of cultural and stylistic interrelations between various sites.

Similarly to other research field, I mainly growth my experience on this domain trough the leading medium-size projects funded by European community as well as by public and private institutions, with highly interdisciplinary and geographically distributed teams. The experience I had in this scientific domain permeates and influences all my research vision, with ultimate goal to support the vision of a culturally interconnected cyber world.

Later, my research activities is evolved and enriched within two main research areas, semantic-based shape representations and semantic-oriented tools to acquire, build, transmit, and process shapes with their associated knowledge. I foresee a new generation of shapes in which knowledge is explicitly represented and, therefore, can be retrieved, processed, shared, and exploited to construct new knowledge. On that regard the research on "*Blueprints image retrieval using sketch and spatial information*" has been an activity conducted for the specific purpose of implementing an environment capable of analysing and extracting features typical of the automotive design and styling. This activity deals not only with low-level image descriptions, e.g. curve alignment, but also with information at the semantic-level, e.g. spatial relations among objects. This approach leads to the solution of Image Retrieval problems at a higher, semantic level instead of dealing with low level issues as it is done in other traditional methods. Techniques and algorithms from CAD and Pattern Recognition are integrated in a suitable way to produce a flexible, accurate and fast method for Image Retrieval using Sketch and Spatial Information. This research and implementation activity reflects, and deals with various low level aspects such as Shape alignment, Shape segmentation, Shape matching and Shape Descriptors.

Further I addressed the efficient and effective use of large size displays and lightweight near-to-the-eye displays within the product development process. I have been interested in improving interaction with lightweight near-to-the-eye screens and tiled stereoscopic large-size displays. To do so I have studied how the improvements on interaction process can be coupled to developments at the hardware level, resulting in the development of unique stereoscopic head mounted displays (HMD) using emerging display technologies such as LCOS and OLEDs. On the software level improvements comprise the fidelity of the content to be displayed (rendering quality), the interfacing between the user and the displays through innovative 2D/3D interaction techniques for mixed realities and advanced tracking systems. The achievements of this research are being integrated into a collaborative mixed-reality product-development environment within two application scenarios: the car industry and architectural design. Specifically as far as my specific interests in the following topics are concerned, I have worked on the following research issues:

- To improve user interaction with innovative displays through new interaction metaphors and tracking approaches (e.g. large area tracking for mobile users).
- To integrate and demonstrate the benefits of combined use of large-scale displays with near-to-the eye screens within innovative collaborative mixed reality environments.

In the last years, this vision has evolved to more recent research interest addressing issues such as the visualization of very large amount of multidimensional data to be made interactively available to a user looking for decision support. Within this topic my focuses are in the area of interactive visualization and intelligent complexity reduction for strategic activities. These include investigating methodologies and developing ITC platforms to support the discovery of unexpected patterns with respect to prior knowledge. In this scientific domain I am paying a specific attention to a wide range of issues dealing with environmental security and its implications for economic, cultural and political instability.

In this context, I am fascinated about the potentiality, yet unexpressed, on the use of geographic information to describe, assess and visually depict physical features and geographically referenced activities on the Earth to support the processes of control, monitoring and planning of a territory.

It is widely acknowledged that geospatial information has immense applicability across a vast spectrum of human endeavours. Examples include oil and gas exploration, weather forecasting and

tracking, aviation, satellite ground systems, environmental planning, disaster management, public administrations (e-government), civil planning and engineering, and all fields of e-science. All such activities entail gathering significant amounts of data and other critical information that must be stored, accessed and managed. Within this scenario my research activity faces the increasing number of large repositories of geospatial data stored in different locations and in various formats. To address this problem I am focusing on standards to distribute geospatial information. In this field still many unresolved issues are critically important in the context of a rapidly emerging global need to migrate data from technically or physically isolated repositories to increasingly open environments. Within this scenario initially I am focused on the development of a system architecture based on OGC-compliant web services, including Geo-Visual Analytics tools that ensure interactive and interoperable access to automatic or semi-automatic processing functionalities. This is done both at low level processes, i.e. to pre-processing or geo-reference data, as well as high-level processes, necessary for instance to provide automatic feature recognition, to ensure extraction of thematic maps, to assess risk etc. Ultimately in the near future I wish to investigate Geo-Visual Analytics techniques to index, filter, integrate data acquired through available enterprise business intelligence processes. This research work and development so far on this domain performed by my research group, GraphiTech, it has been directly acknowledged by NASA.