band-limited (ie it has a local action, a single source of light is blurred into a small spot, wherever the source is located).

These properties result in a strong structure of the matrix of the linear system, which turnsoutto beatwo-level band Toeplitz matrix. A band matrix has non-zero elements only on a few diagonals around the principal one, and a Toeplitz matrix has equal elements on each diagonal. A two-level band Toeplitz matrix is a block matrix which presents these two structures (band and Toeplitz form) both at the block level and inside each block. Circulant preconditioners, frequently applied to Toeplitz matrices, can be easily modified in order to cope with the noise. However, in the caseof band Toeplitz matrices, a band preconditioner would be preferable, since it could be inverted with the same cost of a CG iteration. We have recently proposed a two-level band preconditioner, which is effective for image reconstruction problems with the above properties and has a computational cost per iteration linear with respect to the number of pixel of the image. Figure 2 shows an example of a synthetic medical image (the 2D Hoffman phantom) blurred by the instrument used for acquisition and corrupted by noise. Figure 3 shows the image reconstructed by applying a few iterations of a preconditioned CG method.

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Shape Geometry and Aesthetics

by Franca Giannini and, Marina Monti

FIORES-II is a research project of the European Commission that aims at investigating and identifying the links between emotional shape perception and geometry, in order to facilitate communication between designers and CAD operators and to create more user friendly tools for aesthetic design.

The market success of industrial products strongly depends on their aesthetic character, i.e. the emotional reaction that product is able to evoke. To achieve their aim designers have to act on specific shape properties, but at present they are not directly supported in this by existing digital tools for model definition and manipulation, mainly because of the still missing mathematical formalisation of the properties themselves. The European project FIORES-II (GRD1-1999-10785-Character Preservation and Modelling in Aesthetic and Engineering Design), started in April 2000, aims at investigating and identifying the links between emotional shape perception and geometry and to create, through their mathematical formalization, more user friendly tools for aesthetic design

Relationships Between a Physical Form and its Emotional Message

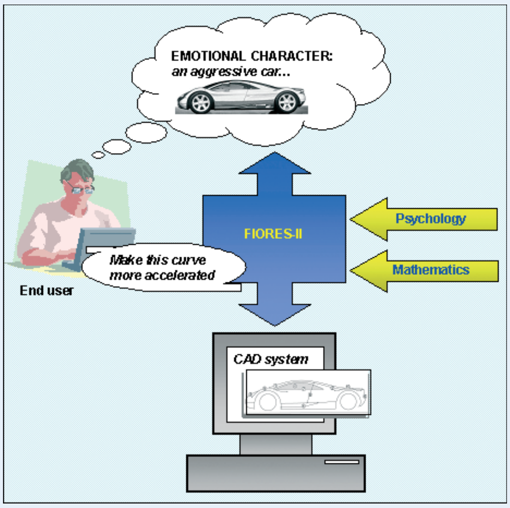
In order to develop modelling tools for allow designer to quickly attain the desired emotional message, it is necessary to understand the procedures they follow to achieve their objectives. Within the FIORES-II project, design activities in different industrial fields have been analysed in depth and the language used in different phases of the design cycle has been studied. It emerged that the terms strictly related to emotional values (eg dynamic, aggressive, etc.) that express the objectives, iethe character, to be achieved by the end product are mainly used when designers talk with marketing people. On the other hand, during the creation and modification of the digital model, designers communicate their aesthetic intent using a more detailed and restricted set of terms corresponding to shape properties. In this phase they provide instructions on which elements and properties have to be changed to realise their objective (eg making a curve a bit more accelerated, or decreasing the tension of …) and to fulfil marketing directives. This second set of terms represents the first link between low-level geometric properties and the high level features of a product. Therefore, in order to identify links between message and geometric shape, we envisage a two-level mapping: the first level links geometric properties with design terms; the second links these latter to the emotional message.

Starting from the above considerations, major focus has been devoted to mathematically formalise the most used terms of the Language of the Trade (ie Acceleration, Tension, Convexity, Concavity, Lead in, Crispness, Sharpness, Softness, Crown), with the objective to develop modelling tools which are fundamental for:
- direct shape modification with a stronger semantic control that offered by classical methods
- specification of the aesthetic properties in objective terms
- aesthetic feature modification.

The development of these tools implies the solution of the following problems for each term:
- definition of its meaning from the design viewpoint: what shape does the designer expect when the modifier value changes for the entity considered? Which geometric properties are affected by the modifier?
- specification of the mathematical function producing the expected shape modification and the related application domain
- identification of the parameters to be provided by the user or specified automatically for character preservation, plus the specification of which parameters can be used within an optimisation process and how

- valuation metrics for the modifier for testing purposes.

As an example, to illustrate how the above points have been mathematically solved, the convexity property is shortly described. Traditionally a curve is convex/concave, if the curvature (ie the second derivative) along the curve has the same sign. In our case, it has a more specific meaning. From the interviews done to the end-users, it comes out that judging a curve more or less convex depends on several factors: the symmetry, the roundness, the curvature variation..... Many of these factors depend in turn on mathematical properties that can be calculated on the curve and that have to be combined to define a suitable measure criterion, which has to be continuous and derivable. To take into account the aspects that are implicitly judged by the users, we included in it mathematical properties such as curve's length, area included in the curve, coordinates of the gravity centre, momentum of inertia of the lamina with respect to the axes of the coordinate system local to the curve, etc. The combination of these properties (by means of the Minkowsky measure and with the adoption of weights to better calibrate it) provided a measuring criterion corresponding to the user feedback in a quite satisfying way.



The FIORES-II framework.

The theoretical specification of the tools is almost complete and the implementation of a software prototype is currently under development.

It has not been easy to acquire a full understanding of how designers perceive shape and then to translate this into mathematical formalism. Even if some of the terms used have a direct mathematical counterpart, the meaning is not always the same. For example, not all the curves in which the second order derivative increases are necessarily perceived as accelerating curves. Moreover, different shapes may be perceived as having the same property value. This means that several variables contribute to a single property, thus requiring a further level of interpretation to give a formal description of their interdependencies.

The preliminary results confirm the validity of the approach not only from the point of view of user interest but also from a scientific perspective, linking different disciplines such as mathematics and perceptual psychology.

Link:
Project home page:
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Angry * (-1) = Surprised!

by Aldo Paradiso

Facial animation systems allow reproduction of facial expressions on synthetic faces where most of the time expressions are designed by hand. In order to avoid building manually the very large set of expressions humans are able to recognize, why not generate new expressions by combining existing, even very different ones?

The Algebra of Expressions consists of a set of operators and related properties defined over a set that is a generalization of the MPEG-4's Facial Animation Parameters. It may be used to describe, manipulate, and generate in a compact way facial expressions, and adopted as a tool to further study and better understand the role of emotions conveyed by facial expressions and their relationships.

Existing animation tools allow defining facial expressions for human-like or cartoon-like synthetic faces, which are then employed for several purposes in Human-Computer interaction. Most of the tools are designed to build expressions manually, acting on low-level parameters. An example is given by MPEG-4 based tools, where each facial expression is coded as an ordered sequence of 68 integer numbers, called Facial Animation Parameters (FAPs). Parameters 3-68 (that is, 66 of them) act on points defined on a synthetic face (feature points). Each FAP represents a displacement of the associated point with respect to its original position. By displacing a point a deformation of its surrounding area is produced, resembling muscle deformations, and acting on several points facial expressions are created. A neutral expression has all zeroes values; all other expressions have some FAP different from zero. However, the human face can generate around 50.000 distinct facial expressions, which correspond to about 30 semantic categories. Clearly the human face is extremely expressive. Is it possible to cover this amount by defining a minimal