Computers Programs

VOLCANIC DANGER: HOW MATHEMATICAL MODELS CAN HELP

Destroyed in one of the most famous volcanic eruptions in history, that of Vesuvius in A.D. 79, the Roman cities of Pompeii and Herculaneum testify to the fact that volcanoes represent a danger for the populations near them. Vesuvius is not an isolated case. Many other active volcanoes are located in densely populated areas, such as certain regions of Japan, Indonesia, the Caribbean and Latin America. The historic process of settlement in volcanic zones should not surprise us since it is precisely the ash and lava fragments that make the soil in these areas particulary fertile.

It is of primary importance to be able to evaluate the danger of volcanoes, whether for planning urban development in volcanic areas or for estimating the real danger facing already existing settlements.

A useful tool for this purpose is mathematical-numerical modeling. This is a quantitative approach, which is put into practice with the help of informational aids in conjunction with more traditional qualitative methods consisting, for the most part, of reconstructing the history of the volcano through the analysis of emitted materials.

A model is defined as a set of data relating to a certain system, in our case a volcano, which is gathered in order to understand the functioning of that system. The creation of such a model is divided into designing its structure, that is the definition of the boundaries of the system and the identification of the extent of the attributes and the activity which characterize it; and defining and researching the data, that is the values which its attributes can assume. In the case of mathematical models, a system and its attributes are represented by mathematical variables and the activities are described in terms of mathematical functions which bring the diverse variables together. In general, these functions are a formal transcription of physical laws: for example, the conservation of the mass, the quantity of motion or of energy. If the form of these equations is too complicated, it is impossible to find an analytic solution with mere pen and paper. One must resort to the proper calculating instruments, whence the term "mathematical-numerical modeling." By applying a model to a certain system, it is possible, if the values of the attributes are known from an initial point in time ("input data"), to determine their evolution in time and space ("output data").

Mathematical-numerical methodology proved to be so useful in all scientific disciplines in general that Kenneth Wilson, the 1982 Nobel Prize winner in Physics, felt it necessary to coin the official term "Computational Physics" for a third methodology of scientific inquiry in addition to analytical studies with paper and pencil and experimental research.

In Pisa, collaboration between IBM Research Center and the National Volcanology Group of CNR has developed mathematical-numerical models which simulate the dynamics of a volcanic eruption. One can thus study the factors which influence the flow of the volcanic material but which cannot actually be observed directly (such as the behavior of a volcano, the pressure in the magma chamber, the mobile properties of magma, etc.) and then apply the re-

sults to the volcanic risk, in order to determine how they influence the danger of the eruption, especially in terms of the extension and thickness of the deposits left on the ground.

This technique has been applied to Vesuvius. This entails the evaluation of the danger of falling ash and particles in a possible future eruption of the volcano. The point of departure is the determination that the "size" and the "explosivity" of an eruption of Vesuvius increases according to the time the volcano has been at rest. An eruption today, given the present rest period of some 50 years, would be of a middle magnitude, the most violent, in any case, since the eruption of 1631. Among the various types of eruption that can be expected, ash and particles would be thrown up in the air in the form of a column above the volcano following the eruption. They would then take the shape of a mushroom cloud. In this case, the ash and particles would be carried from the mushroom by the wind and dispersed by the turbulent movements of the atmosphere, eventually falling back onto the ground as a result of gravity. Thanks to the mathematical model, already used to simulate the fall of volcanic materials in famous eruptions of the past, such as those of Vesuvius in 79 and Mount St. Helens (USA) in 1980, it has become possible to calculate the ground distribution of the ash and particles by changing the input data of the model, especially the profile of the wind at altitude. The illustration shows the results obtained employing wind statistics gathered for 10 years in the region under examination. This is a calculation of the probability of having on a ground concentration higher than the fixed threshold of 200 kg per square meter (the load related to the collapse of buildings).

The type of the quantification of danger not only is new for Vesuvius but also constitutes an original approach from the methodological point of view.

Finally it should be emphasized that the models developed at Pisa can also be used to simulate, in time and space, the evolution of a particular real eruption and thus to create a map of the danger related to an eruption today.

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COMPUTERS AND THE EXPLOITATION OF CULTURAL ASSETS: THE EXPERIENCE OF THE NEAPOLIS PROJECT

The heightened interest of the public in cultural assets has brought to light the substantial lack of informational systems capable of satisfying the cognitive needs of an ever-increasing number of persons. In fact, in most cases, current methods of popular communication do not include systematic and organic ways of improving understanding of the manifold cultural importance of each archaeological, architectural, historical or artistic discovery. For this reason, a strategy should be elaborated to exploit these cultural assets as a whole, a strategy which permits true "appreciation," meaning the active and conscious acquisition of knowledge.

However, such a goal is difficult to achieve, partly because of the "multidimensional" nature of these historical phenomena which may be analyzed from various interpretative and disciplinary viewpoints, and partly because of the numerous differences among the potential recipients of this message (culture, interests, age, free time, etc.).

This is a real obstacle in the creation of educational systems which, by using traditional media systems, satisfy the requests of an extremely heterogeneous public. It is, in fact, difficult to portray a typical user upon which to base the structure, language and content of this product.

This is where the potential of computer systems can offer a positive alternative and an efficient way of transmitting information about these cultural phenomena to the public at large. The integrated and diversified treatment of texts, images, diagrams, animations, sounds and simulations permits the creation of extremely flexible instruments that adapt to the most varied methods of information (exhibitions, museums, archaeological areas and parks, visitor centers, etc.).

These possibilities are also boosted by the obvious advantages offered by electronics in the form of a dynamic and interactive access to data. An unlimited opportunity for each individual to personalize his "journey" through this information, by choosing from a vast range of possibilities which are at the root of the most novel and qualified forms of com-

munication. For this reason, the interactive approach is the characteristic element of many of the educational and informative systems in the exhibition and realized by "Progetto Neapolis."

"Hypermedia" products were therefore preferred to other systems, thanks to the perfect development of all the communicative potentials of the computer and also because they fulfilled all the requirements of this particular exhibition. One characteristic of these so-called hypermedia is that they produce a mass of information, both in written and graphic form, that does not follow a linear pattern, but instead branches out on various levels into a complex network of logical interrelationships.

This allows the user to carry out transverse and multidirectional links according to the capabilities of the human brain, with the added advantage of easy access to a large number of different types and forms of data.

THE DAEDALUS SYSTEM: "THE LABYRINTH UNDER THE ASHES" POMPEII AND EVERYDAY LIFE IN HYPERMEDIA

The section of the exhibition that illustrates the various aspects of Pompeian life "crystalized" by the eruption in A.D. 79 envisages two computer systems: *Introducing Pompeii* and *Artifacts in Action*. Based on a similar hypermedia approach, the two programs are, however, substantially different in their structure and specific communication patterns.

Introducing Pompeii presents the visitor with a general outline of a complex sociocultural system such as a Roman city during the first century A.D., while *Artifacts in Action* places the exhibited objects in a precise context. The joint interpretation of the two hypermedia allows the visitor to comprehend various aspects of antiquity by establishing an «informative path" not conditioned by fixed models but determined by the user himself.

The basic computer structure of *Introducing Pompeii* is that of an introductory book on Pompeii, divided into eight chapters, each dealing with general subjects (general historical outline, Pompeii and the area around Vesuvius, the urban structure of the city, its socioeconomic reality, its political, administrative and religious organization, everyday life, artistic expressions and the history of the excavations). These sections are divided into a total of 50 essays, written in a similar style, each briefly illustrating one topic; their succession permits a traditional, linear method of interpretation, similar to that of an "electronic book".

This interpretation is a possible alternative to the "hypertextual path," which is the most important educational and informative aspect of this system, and is implemented by "steering" through the topics according to the relationships that are proposed each time.

The system called *Introducing Pompeii* may be explained as a "graph" in which the "points" represent the minimum units of information (texts and images) and the "curves" the interrelated logical links which cross the topics like a "labyrinth" of possible paths of knowledge (for example: from social classes to public monuments, to construction techniques, or from the history of town planning to residential architecture, pictorial subjects or religious rites).

Artifacts in Action is quite different. The goal of this program is to provide the visitor with information on the objects exhibited; information conceived as the immediate answer to basic demands for knowledge concerning each single object: What is it? What was it used for? Where was it used? How was it made? At the same time, we tried to illustrate the articulated system of relationships in which the object participated, by proposing a partial reconstruction of its original context. The inspirational principles of the system have consequently determined the elaboration of an informative model divided into several, hierarchically identifiable, logical levels. Another important difference with *Introducing Pompeii* is the use of a segmented compositional syntax, in the form of texts of varying length and stylistic approach.

The "hypermedia" path is based on an entry interface made up of images illustrating various groups of objects exhibited and divided into six topics (the home and furnishings, food, work and technology, society, religion, decoration). From the first link in the informative chain, which always consists in a short explanation of the "chosen" object, multiple ramifications of topics are available. The latter, by illustrating various aspects of ancient civilization inspired by the chosen object, with emphasis on the "entry" topic, aims at progressively answering the widest possible range of questions.

The possibility of continuously making personal choices (from lists, symbols and dia-

Tecnica elettronica di ripristino dell'immagine applicata al restauro di una parete affrescata della casa VI, 17 (Ins. Occid.), 42.
Electronic reconstruction of an image applied to a frescoed wall of house VI, 17 (Ins. Occid.), 42.

grams) allows the visitor subjectively to choose and vary the depth of the information, follow a whim to explore a special subject. Progressing through logical associations, the visitor appears to be "accompanied" by the objects exhibited, which "act" on his request, as veritable witnesses of the past. A bronze pitcher, for example, leads to information on Roman tableware, the way in which banquets were held, the type of food consumed and the preparation of particular dishes; in the same way, a hydraulic valve is the cue to a brief outline of water distribution, public fountains, grottoes, gardens and ornamental sculptures.

Both systems, as all the other hypermedia products presented here, operate from a PS/2 workstation with two 8514 color monitors modified into touch-screen versions. The construction of the screens depend on the form, number and arrangement of the texts and images.

Cross links between the various points is shown within the screens by using words, bands or images of different colors which, once activated, permit hypertextual connections.

THE REDISCOVERY OF THE ANCIENT CITY: "DIGGING IN PROGRESS"

Two and a half centuries of almost continuous archaeological excavations, aimed at the rediscovery of an entire ancient city, represent a historical and human adventure, complex and rich in meaning. Apart from the progressive acquisition of knowledge on the material reality of a community that lived 2000 years ago, a number of cultural phenomena have constantly interacted with the progress of the archaeological excavations. In particular, the reactions to the finds made in the Vesuvian region are reflected in the customs and artistic culture of Europe in the eighteenth and nineteenth centuries.

The specific goal of the system *Digging in Progress* is to provide the visitor with a certain number of references which enable him to understand this articulated phenomenon. The internal structure of the program, which corresponds to the informative requirements of the exhibition, is based on a chronological grid divided into six periods (from 1749 to the present day), in turn divided into four thematic sections. The proposed periods reflect political and historical changes as well as the succession of archaeologists, and in this way illustrate the numerous ways of approaching the multifaceted experience of excavation in the Vesuvian area, the principal discoveries, the work of the various "experts" and the work methods and documentation techniques.

The way in which the history of the excavations is presented may be described simply as a "checkered" pattern, to be used according to the following two divisions: one is based on a chronological sequence and the other elaborates each given aspect according to the period in time; for each topic it is possible to visualize explicative monographic studies (biographies, lists, flashbacks, etc.).

The entry interface to the program offers the immediate cartographical visualization of that sector of Pompeii involved in the excavations relating to the "chosen" period. As far as the images which support the texts are concerned, for each chronological period, we chose to present the contemporary iconographic documentation, so as to render visually evident the evolution of the representation and survey techniques of the archaeological discoveries (from engravings to photogrammetry).

THE SHELL, THE MASK AND THE DIVINITY IN THE POMPEIAN ROOM: "IMAGES ON WALLS"

Since the initial period of the rediscovery of Pompeii and Herculaneum, the wall paintings found there, and which are an almost unique witness to the production of the Roman school thanks to their number and excellent state of preservation, are also the spark which rekindled the interest of scholars and the public at large. The problems related to these wall paintings, the iconographic, historical and artistic aspects as well as the technical, compositional and functional ones, are some of the most debated subjects within the extensive scientific bibliography gathered over two and a half centuries of study and research. The considerable contribution of the most varied media structures has even brought about a sort of identification, in collective memory, of the Vesuvian cities with the images painted on the walls of their houses. Therefore, in the framework of the exhibition, the physical and integral reconstruction of a painted room undoubtedly represents one of the most important moments of communication.

The system *Images on Walls* aims at illustrating this complex phenomenon – object of the computerized cataloguing of the Neapolis Project – through the exemplification of certain "guiding" elements which then provide a brief panorama of the phenomenon itself. To reach this goal, the visitor is provided with several guidelines to Pompeian painting: technique, formal aspects, social communication. The hypermedia *Images on Walls* is then divided into various thematic paths, aimed at explaining the compositional elements of a painted wall, from the point of view of the pattern and syntax of the decoration as well as the iconographic themes themselves. In short, we attempted to provide the visitor with certain basic tools to decode the wall decorations of Pompeii, and favor the perception of the phenomenon through

the visitor's own personal experience, free from the influence of a preliminary filter of historical and artistic biases. This reconstruction takes place as the result of the computerized hypermedia path, so that the dynamic visualization of the image assumes a particular educational and communicative importance. Numerous iconographic interfaces also fuel the interest of the user by making the interactive dialogue more stimulating.

AN ELECTRONIC VISIT TO THE HOUSE OF THE MENANDER AND THE HOUSE OF THE VETTII: "WALKING ON VIDEO"

One of the systems operating at the exhibition, *Walking on Video*, allows the visitor to take an "electronic tour" of two important Pompeian houses: the House of the Menander and the House of the Vettii.

This system is characterized by a considerable degree of interaction, determined by the initial cartographic interface which represents the plan of the chosen house around which it is possible to walk by acting directly on the video. The elaboration of this tour can become a progressive personal "discovery" for the visitor. In fact, in each room, one can select a wall and then visualize its pictorial designs or particular architectural configurations. One can also ask for more information furniture or objects found during the excavations.

The texts vary according to the level of investigation chosen each time: from an introductory summary of the house, to a study of the characteristics of each room (typology, structure, function), to the details of pictorial decoration.

In fact, *Walking on Video* fulfills two goals: it offers an "interactive guide" to the monument and transmits concise data on more general aspects of Pompeian life (for example, residential architecture, wall decoration and household furniture). The possibility of using a cartographic base with subsequent enlargements, as well as directly questioning walls and graphic symbols, visualizing images and texts, represents the application, in education, of the methodological systems developed in the framework of the integrated Neapolis System.

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