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Virtual reality: The non-temporal cartographic animation and the urban (large) scale projects

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Abstract The evolution of digital technology has placed cartography in a dialog on questions concerning the new abilities, its form and prospective. The cartographic presentation in three dimensions has as a basic feature: the simulation with the "natural" ability of understanding the space.

One of the problems that arose in virtual environments refers to the use of scale in relation to the analysis and the study of space. This relation of geographic analysis and cartographic tools is strictly defined in traditional cartography, but in the virtual cartographic environment the rules of optical understanding and measurement of space are defined by an arbitrary free moving of the sight, that prescribes the natural vision and therefore the perception of the specific space.

In close relation with the cartographic motion is the cartographic visualization of the time and the relevant techniques: splitting of time, creation of motion frames, timing, rapidity, motion pattern, etc.

The specific work describes, through specific examples that focus mainly on urban areas, methodological and technical approaches concerning the concept of time and scale problems in virtual cartography, but mainly contributes in the ongoing scientific dialogue concerning the theoretical documentation of Virtual Cartography.

Finally,we regard Computational Intelligence as a comprehensive and effective algorithmic platform for mechanisms of Virtual Reality.

Keywords Cartographic animation · Time · Cartographic visualization · Virtual reality · Scale · Computational Intelligence

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1 Cartographic animation: an overview

Major changes affected the cartography, as a scientific field, during the last decade. The new scientific and social changes, in parallel with the rapid evolution of technology in geoinformatics and in relation with a serious inflow of new georeferenced (spatial) data, have a major contribution in these changes. These digital technologies are a part of wider changes and evolutions in representation and processing of georeferenced information that are topics in close relation with the scientific visualization and Virtual Reality. A special type of dynamic representation, within the framework of geoanalysis, is the cartographic animation that permits the representation of complex spatial evolutionary procedures.

The cartographic animation is defined as "*a graphic art that occurs in time*", and it is "*a dynamic visual statement that evolves through change in the display*"[1].

The first application in cartographic animation is referred only some decades ago. It is known by the early of sixties, as a scientific object and a technique, but only very recently became an alternative applicable cartographic technique. In practice even earlier, late of thirties, the film metaphor influenced the presentation of maps and therefore the cartographic animation. A Disney animation from 1940 depicted the invasion of Poland by Germany in the previous year, using motion symbols (such as arrows) over a map (Peterson M, 2000) (Fig. 1)[2].

The cartographic animation is not an accidental invention based on the rapid evolution of hardware and software but its scientific origins refer to a wider scientific field: *the visualization*. The first concept in the hierarchical route of understanding the cartographic animation is the Scientific Visualization.

[1] Peterson, M., "Cartographic Animation", http://www.odyssey.ursus.maine.edu/gisweb/spatdb/gis-lis/gi94078.html (last visit 19/5/2002)

[2] Πηγή http://maps.unomaha.edu/AnimArt/ActiveLegend/Peterson.html (τελενταια επισκειψη ιστοσελιδαζ12/5/2002)

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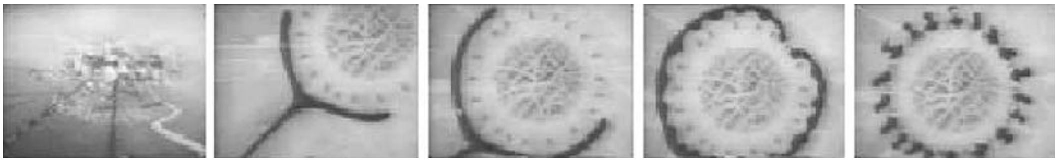


Fig. 1 Five frames from the production of Disney Studios depicted the invasion of Poland by Germany

A. The *scientific visualization* is the transformation of numeric and symbolic data, and information, into geometric images that been produced by an electronic computer (Rhyne T, 1999). The scientific visualization is based in a series of application and techniques from relevant fields, such as image processing, CAD, user's interfaces development, etc. Additionally, the relevant research is focused on color rendering, 3D graphics, time series animation, computer interoperability, etc.
B. The *cartographic visualization*, also known as geographic visualization (Peterson M, 2000), is the second concept affecting the mental route of defining the cartographic animation and it is the form of visualized information that emphasized on the development and assessment of visual methods, targeting to support the research, the analysis, the synthesis, and presentation of georeferenced information (MacEachren A). The geographic visualization combines the development of theory, tools and methods and also stresses on understanding the way of using tools and methods to boost the mind and to support the decision-making process.
C. The *cartographic animation*, having basic elements of visualization, is the interaction and animation on maps. A significant point is that tries to embody the time in maps showing not only "where" the objects are, but also "when" they will be, and, even more important, how they will move and behave. The basic purpose in cartographic animation is the visualization of "changes".

2 Basic questions upon the conventional time

The conventional and traditional representation of time and motion, through static maps, is a very difficult procedure and the main constrain (or the basic challenge) is that the representation of reality is feasible only through a symbolic way. An answer, in that effort of time representation, is the specific type of animation that tries to simulate the abilities of human eyesight.

A key-point in the whole process of representing the time-motion is its fragmentation in individual maps (moments) in such way so to be able to represent individual time-moments giving the impression and the ability of understanding the changes. The applications must be very significant, and to describe in a reliable way, the natural dynamic system of the reality (Castagneri J). The most well-known time-representation method is the production of a set of maps, each of them representing an individual time moment.

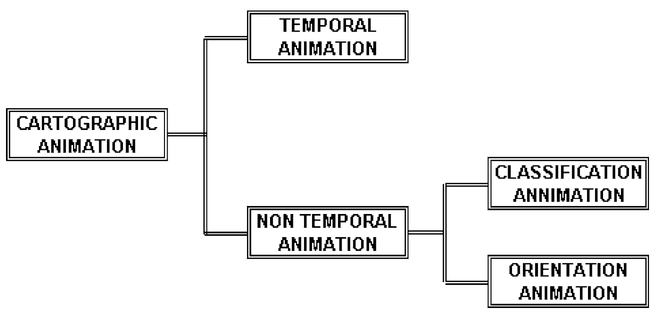
However the use of time-series georeferenced data requires a special attention and handling. For example, trying to reproduce a time-series, that starts the middle ages and ends in the current century, we have to plan the distribution of information according to a qualitative balancing approach that is a selected reduction of available materials, in case of oversupply by choosing specific representative frames, and enrichment of materials, in case of lack by producing new frames. This process targets in the production of an integrated and time-consistent series of images describing the evolution of a spatial phenomenon.

3 Forms and types of animation

There are two types of cartographic animation: temporal and non temporal. The basic difference among them is that, in the first case, each frame shows an individual time-moment, while, in the second case, each frame shows an individual aspect (Sandercock M, 1999).

Non-temporal cartographic animation. In the non-temporal cartographic animation the changes been caused by other variables that might include visually temporal-data, but in a non-temporal way, representing different, but relevant, groups of spatial data or representing data in a different generalization level.

There are three different types of non-temporal data: a) the changes concern the data (Changing time), b) the changes are relevant to the representation (Changing data), and c) the changes concern the representation (Peterson M).



Types of cartographic animation

Our approach is referred to the last two cases, where the changes are relevant to the representation itself (Changing Data). There are three distinctive types of cartographic animation:

- *Fly-Through*, probably the most common in non-temporal cartographic animation,
- *Graphic zoom*, where, as in the previous case, there are no changes on attributes. The zooming in a static picture or photograph is a typical example, and
- *Spatial trends*, with limited concern in this case.

The other case that the changes concern the way of representation is referred to the level and degree of map abstraction. The process of introducing motion (animation) into a map is relevant to the map abstraction process. The abstraction of the reality makes maps strong tools but at the same time difficult in interpretation. The cartographic abstraction is divided into four types:

- *Cartographic zoom* with the relevant spatial information fluctuation.
- *Animation – classification*, where each frame represents a different classification schema.
- *Animation–generalization*
- *The sound*, also, can be a part of cartographic animation

4 Techniques of cartographic animation

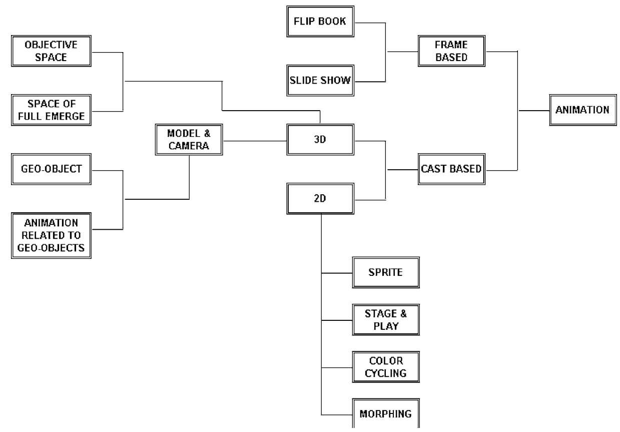
According to Dorling [3] there are three types of animation: 1) Pan and zoom in static 3D images, 2) Time series animation with planar images, and 3) the use of animation for exploring 3D objects.

Acevedo [1] gives a variation of the same schema: 1) Planar animation, 2) 3D perspective animation with a constant viewpoint, and 3) 3D perspective animation with mobile viewpoint. Apart of the above classifications, the basic types of animation techniques are classified in two main categories: Frame-based animation and cast-based animation.

The *frame-based animation* is the simpler of these two techniques. Each frame been produced by a painting, graphics, mapping or GIS software (Peterson M). A huge amount of individual frames is required to produce some seconds of animation in such way that the rapid succession of these frames produces the illusion of changes (animation).

The second type of *cast-based animation* is related to the typical technique of producing motion. It splits the map in different layers, such as background (landscape), road network, building blocks, etc. Each frame is possible to include many layers. This technique is more accurate, flexible, needs less amount of RAM, but it demands specialized and more complex software.

Gersmehl [7] defines two big categories, the first is referred to 2D animation (Sprite, Stage & Play, Color Cycling, Morphing) and the second to 3D animation (Model & Camera). From these techniques the more suitable for large (urban) scale models animation are the following:



- *Stage & play*. This method is based on the changes of viewpoint and not on the changes of time. The most known usage of this method is the fly-through, a basic application is the production of preplanned movies, and a more sophisticated application is the virtual flights.
- *Model & camera*. This method is based in 3D spatial attributes. The role of the specific software is very important. There are software based only in one technique (such as PowerPoint) and other having more abilities (Macromedia Director, 3D Studio Max and Viz AutoDesk, Adobe Premiere, etc.)

5 From 3D to Virtual Reality

The representation of reality, in conventional planar maps, includes the overstepping, in which the users know very well its difficulties, of representing the real 3D nature of a landscape using a planar tool: the map [4]. In Virtual Reality the characteristics of cartographic visualization are extended with the use of advanced tools: moving in the 3rd and 4th dimension, creation of illusion of gravity independence, and animation with the ability of spatial immersion.

Virtual Reality techniques produce user interacting environments that are very close to the complexity of the real world. The interaction degree is in close relation with the H/W and S/W abilities. In some cases the needs require condition of full immersion that means simulation of, as much as possible, different senses: vision, hearing, motion and touching. In these cases the used systems require the maximum of devices: head mounted display (HMD), loudspeakers, moving platforms, data gloves, etc.

Virtual Reality is a type of dynamic cartography (Sandercock M, 1999) and as it is mentioned before and if we adopt the Dorling's [3] classification, consisting of three types of animation: 1) Pan and zoom in static 3D images, 2) Time series animation with planar images, and 3) use of animation for exploring 3D objects, then it is easy to classify the Virtual Reality as a component of the last case.

The Virtual Reality has stronger analytical ability, for spatial data, that the conventional cartography has [4]. It emphases in the natural role of cartography by giving the ability of producing new ways of spatial data visualization, not only for informative purposes and users interaction, but also to extent the static model of the map into a dynamic environment with embedded interaction tools and decision making.

However we have to consider, and not to ignore, the abilities and the limits that the software and hardware put and also the limitations of representing the landscape perspective.

6 Techniques for simulating the reality

The Virtual Reality systems are varied according to their potentialities that are relevant to the abilities and requirements of hardware and software. There are various types of Virtual Reality. In general there are two types: systems that offer the ability of immersion and systems that not. The second one, the Desktop VR, is very common and most of the users have experience of developing or using relevant applications. These two types are not close systems, their applications are not dedicated to one or to the other type but are operational (more or less) in both types. We can define the following types of virtual reality (VR):

Full or immersive VR. It is based in fully simulated environments. In this case the VR requires from the user to be a subject within an environment that stimulate the vision, the hearing, the motion and the touch. Additional, a lot of researches are taking place in other fields, such as smelling, targeting the full substitution or simulation of all senses.

Usually there is a full simulation by using moving platforms, but more often we met full non-temporal simulation, that means the user has the ability of free moving (free change of viewpoint), while the interaction between the various commendatory components has major interest (the user has the ability to add or to remove specific components).

Transparent VR. It this case, pictures (various types of photographs) of the real world are used as a background and the georeferenced information is appeared over on it. One of the most known examples is the appearance of landscape model on the airplanes' cockpit. Applications of the specific technique are very common in the entertainments and war industry (Flight simulations).

Projection VR. It is a participial experience where the graphics representations are in large scale. It is a version of semi-immersive VR where the illusion is achieved into a big room-sized cube having screen is all sides (CAVE: Cave Automatic Virtual Environment). The users ware lightweight stereo glasses and are moving by using a portable device. Similar are the systems and the projections in a planetarium.

Desktop VR. This is the most common, non-immersive, type of VR because it is possible to be in an ordinary personal computer. The most GIS and CAD software provide this ability and the relevant tools.

7 The virtual cartography

The planar representations of georeferenced information play an important, and well-defined, role in spatial sciences and, rightly anymore, the cartographic visualization is considered as a conventional, more or less, approach by the majority of sciences. The static planar map is one of the oldest communication means (maps turned to stone or clay, approximately 4,500 years ago in Mesopotamia and then switching to paper some time later, Paterson M), and it has a lot of restrictions and limitation on visualizing the necessary spatial information (Parsons E, 1994). The most often restrictions are, the representation of 3D reality in planar surfaces, difficulties in representing dynamically changed phenomena, inability of shifting from constant scale and generalization, difficulty of representing time series, etc.

On the other hand it is necessary to examine the wider framework of information diffusion and production. The rapid evolution of digital technology, the Internet, the World Wide Web, thrust a new communication status quo. The new abilities for information processing and diffusion are strictly depended from this evolution and are under its control, approval and condition. The 3D cartographic animation is anymore a common practice, as the information society needs it and also exists the proper technological background (hardware and software).

As the conventional cartography has a long time tradition and a well and strictly defined theoretical and technological documentation and framework, it has a hesitant approach and confrontation against the animated and interactive cartography. On the other hand, the ordinary practice documents that the cartographic animation stands critical and renegotiates the stable principles of conventional cartography, in users as well as in experts level. We might say that the cartographic animation is a revolutionary approach concerning the cartographic information diffusion and expectations.

8 Main factors of urban scale projects and requests from Virtual Reality

In urban geography [2] the representation of a city is defined by two meanings: *the site and the situation*. The situation is referred in the place that a city possess in relation to the large geographical sets, namely the main traffic axes, the mountains, the waters, the visible economic activities, the adjacent cities, etc. The dimension of city's development and type is an attribute of the specific situation.

The site concerns the physical characteristics of the city's situation (geographical place) and been changed through the time in relation to the other morphological characteristics of the city (e.g. shape)

The quality of cartographic animation, in real conditions, is a privilege of rather expensive computer systems (McCullagh MJ). But this is the one side of the truth, the other side is that the rapid evolution equip the average user with marvelous visualization tools and techniques, such as the VR.

However the VR doesn't demand extra computational power only from the computer, but there are two other crucial factors having major importance and involvement in producing cartographic animation for large (urban) scale projects.

It is a common finding that only the small scales secure the equivalence, in the analysis level, between the landscape (terrain) and the urban complex. The development of a digital terrain model, having high resolution, is a high demanding process, but the same stands also for the development of a 3D model of a city. The coexistence of DTM and the city model (grid, basic infrastructures, buildings, etc.), mainly in large scales of digitization, requires effective lighten of the model. The enrichment of resolution, of one of these two factors, requires the lightening of the other or the reduction of the reference area (a classic case is the MS Flight simulation where the cities do not have many details or if this happens–as in the case of Los Angeles–then it concerns only a part of the city).

9 Handling the motion's "degree of freedom"

A basic characteristic of Virtual Reality is the ability of full navigation into a simulation of reality, wherein the user has the ability of traveling into the virtual world, having the maximum potential level of spatial perception and understanding. The ability of full navigation raises a set of new problems that, in the conventional cartography, are stable principles.

Some of these "stable" practices and principles, such as the orientation, need an overall revision by the average user demanding difficult decisions. It is very difficult to someone, in a virtual environment, to have the obvious help that the North arrow of a conventional static map offers. In virtual environments, as in ordinary daily reality, the north orientation is an attribute with a limited contribution, as it is changing every moment according to the viewpoint motion.

The same non-stable meaning and contribution has also the "map-scale". This environment permits the full freedom of motion with a consequence of full elasticity of scale. The stable scales in different maps of the conventional cartography, are not valid anymore and the perception of the scale is very close to the perspective ability of human vision. But simultaneously this is a problem, as the representation of city requires specific scales, limited from 1:1,000 to 1:10,000, as they have to emerge the specific characteristics of site and place, and not to permit the user to "move" in the range of other scales such as the architectural or geographical scale. As the different types of scales are strictly defined (information, generalization, etc.), in close relation of the desirable scope, the choice and definition of the proper scale is a real challenge, within these environments having the characteristic of scale elasticity.

Within the same theoretical framework, even the meaning of scale seems to be abstract, a fact that supports the research of metric rationalization of space as long as the 3D spatial models have different scale if they are close to the observer (viewpoint) or far from him.

The existence of a coordination index on the monitor, giving continuously the coordinations of the viewpoint movements, during a virtual navigation, would be an answer but this is absolutely indicative as long as the user doesn't observe vertically down but scans the space under an angle. Additionally information upon the observation lens angle is needed (normal, type of wide-angle, etc.)

Another solution would be the conventional computation of scale in relation of a specific gravity point (centroid) of the map (the deformations and distances variant in every point within a 3D space) but in this case it is not possible to compute all the necessary factors in an accurate and reliable way. Such factors are the resolution (aperture width) of software that produced the final result (e.g.: 256×243, 320×240, 512×486, etc). Additionally the monitor's resolution, that varies from user to user, makes fuzzier the computation demanded complex algorithms. As it seems the potential answers are not in conventional approaches but in a new methodological framework. The software of virtual flights use navigations tools of common aircrafts such as, flight height, observation angle, navigation speed, compass, etc. and that make us to think that we have to change dramatically the way of reading a map. That means the guidance of basic characteristic of Virtual Reality: the navigation ability.

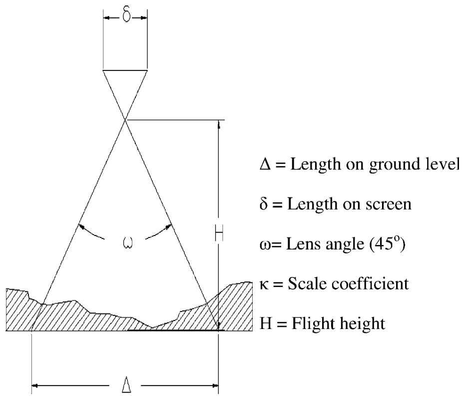
An answer to that, is the limitation of motion within an area where the scale has a specific maximum and minimum, according to the spatial analysis of processing, examining and observing urban areas. The implementation of such model is feasible by creating specific fields that limited the motion of viewpoint and would compute as follows:

CASE A: Animation in constant radius.

The observer is moving over a specific surface of sphere where its radius corresponds to a specific scale (see "computation of flight observation height")

CASE B: Animation in variable radius with controlled variation field.

If the observer wishes to move in a variable radius (e.g. between 1:10,000 and 1:1,000) then it has to compute the radius of a second globe and the motion of viewpoint will be limited between the void of two globes.



$$\left.\begin{aligned} \varepsilon\phi\,\omega/2 = \frac{\Delta/2}{H} &\Rightarrow H = \frac{\Delta/2}{\varepsilon\phi\,\omega/2} \\ \frac{d}{\Delta} = \frac{1}{\kappa} &\Rightarrow \Delta = \delta\cdot\kappa \end{aligned}\right\} \Rightarrow H = \frac{d\,\frac{\kappa}{2}}{\varepsilon\phi\,\frac{\omega}{2}}$$

Computation of flight observation height

10 Computational intelligence (CI)

CI [3] is a well-established paradigm that seamlessly combines three main technologies aimed at the development of intelligent systems, that is granular computing, neural networks and evolutionary optimization. As in the design of such systems, we have to address various challenging issues such as knowledge representation, adaptive properties and learning abilities and structural developments, CI has to a cope with each of them. With regard to the properties of intelligent systems being supported by CI, we can envision two general points of view. These properties can be sought as *intrinsic* to any intelligent systems or they can be *extrinsic* to them. In the first case, we are concerned with the features that are crucial to the design of the systems, which usually do not manifest externally so by analyzing the performance of the system we cannot say whether a specific technology has been utilized. Essentially, we are not concerned about that. The extrinsic properties are dominant and become of a paramount relevance when dealing with communication of intelligent systems with others or facilitating an effective interaction with human users. This aspect is extremely relevant in providing the user a sense of intelligent and user-friendly capabilities of the systems. Here we can stress that these capabilities are very diversified and could cover a vast territory. For instance, one can envision several interesting scenarios

- Coping with heterogeneous information. Quite often, in intelligent systems we may encounter information coming not only from sensors (in which case these are numeric readings) but also from users (in the form of linguistic evaluations) or being a result of some initial aggregation or summarization. Interestingly, these inputs are essential to the functioning of a system and cannot be ignored or downplayed. The heterogeneity of information requires special attention in the sense of the use of more advanced mechanisms of processing and representing such a mix of various pieces of evidence
- Establishing an effective, transparent, and customized communication with the end user when presenting the results of processing completed by a system. Here the notion of generality (abstraction) or granulation of information plays a pivotal role. A suitable level of granulation of information is essential to the effective communication and acceptance of a system (in whichever role we can envision the system to be utilized). This immediately leads us to the concept of adaptive and user-driven interfaces which become an essence to most interactive and human centric systems including tutoring architectures, decision-support systems, and knowledge-based architectures (including expert-like systems and their more advanced topologies).

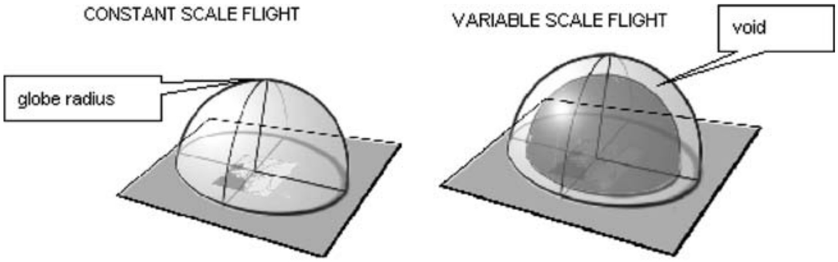
The term of CI being coined in the 1990s (quite commonly viewed as a synonym of soft computing) helps us establish a sound mapping between the technologies and their dominant role in meeting some specific requests of the domain. What is also very characteristic for CI today is a broad array of hybrid systems (called neurofuzzy systems, neuro-evolutionary systems, genetic fuzzy systems). They emerge as a result of an in-depth understanding of the benefits of individual technologies and their genuine complementarity.

In what follows, we briefly highlight the essence of the contributing technologies of CI, discuss their synergies and elaborate on the resulting architectures

Granular computing Granular information is everywhere. We granulate information all the time. We rarely reason on a basis of numbers. Our judgment is often triggered by some aggregates which in a nutshell are a result of abstraction.

Originally, CI embraced fuzzy sets as the key vehicle of information granulation. It is worth stressing that the other fundamental environments for describing granular information are readily available and a suitable choice depends upon a specific problem at hand.

Neurocomputing is inherently associated with adaptive and highly flexible systems – neural networks. The learning abilities of the networks (either through supervised or unsupervised learning) are in the heart of networks. The learning is exploited when building systems that can learn from data, adapt to the nonstationary environment including preferences of users) and help generalize to new, unknown situations. The spectrum of learning models, network architectures is impressive. Neural networks are highly distributed



Models of viewpoint motion

which make them fault tolerant and What has been said so far, it is definitely very encouraging. The drawback is with the lack of transparency of the networks. The distributed character of processing can be pointed at as the most prominent reason of this deficiency. Similarly, as no prior domain knowledge could be "downloaded" onto the network, its learning is carried out from scratch which by itself is not the most encouraging.

Evolutionary computing The principle of evolutionary computing cast in the setting of CI becomes a synonym of structural optimization, reconfigurability, combinatorial optimization, and variant selection usually completed in large and complicated search spaces. From its inception in the 1970s, evolutionary computing with all its variations of genetic algorithms, evolutionary strategies, genetioc programming, etc is aimed at the global, structural system optimization that is carried out in presence of a very limited and general information about the optimality criterion. With the growth of the topologies discussed in CI (and the growth being both present in terms of the plain dimensionality of the ensuing architectures as well as their increasing complexity).

From the above summary, it becomes apparent that the main agendas of these technologies are different yet highly complementary leading to the scenarios in which the advantages and limitations of each of them could be strengthened and compensated, respectively. This compensation effect is in essence a crux of the resulting synergy and helps develop interesting and useful linkages.

As stressed, there are a significant number of possible interactions between the contributing technologies in the realm of CI. Bearing in mind the main objectives of granular computing and neural networks, we can envision a general layered type of the model in which any interaction with the external world (including users) is dome through the granular interface (external layers) whereas the core computing part is implemented as a neural network or a neurofuzzy structure (in which case we may be emphasizing the logic facet of ongoing processing faculties).

11 CI in Virtual Reality

As discussed in the previous section in which we have outlined the foundations of CI, it becomes apparent that CI can be regarded as a comprehensive and effective algorithmic platform for mechanisms of Virtual Reality. As Virtual Reality is inherently human-driven and human oriented, it becomes beneficial to envision a number of essential pursuits

- The human-oriented character of granular computing becomes an evident asset in the setting of VR processes. The user can interact more "naturally" with the VR system not being confined to numbers but rather operate on perceptions and subjective views. This helps develop the most suitable perspective at the problem, navigate through different levels of generality (abstraction) thus enabling more intuitive mechanisms of tangible system-human interaction.
- The variable granularity of information we can easily capture through the concepts of fuzzy sets, rough sets and alike, helps us focus learning process on various users who come with different levels of knowledge so an adjustment to this level becomes necessary. The size of information granules reflects a level of abstraction which in turn implies a certain level of generality of the interaction processes
- Evolutionary mechanisms become of paramount relevance when it comes to gathering information through intensive and directed activities of VR. We can envision situations in which an effective and flexible mechanism requires a substantial level of structural optimization. This feature is well handled by genetic algorithms and genetic optimization

Learning in the VR environment by its very nature is a highly dynamic process. In order to capture its characteristics in an efficient manner and assure that the ensuing models are fully equipped with such abilities, we require mechanisms of learning. Neural networks are an ideal vehicle to meet this goal. The superb learning models involved in neural architectures and this deals both with supervised and unsupervised learning. The supervised learning is useful in mimicking some learning patterns of humans. Unsupervised learning goes beyond that and allows us to gain a general view at some global patterns of learning. The matter of reinforcement learning is another important option worth pursuing.

12 Results

The virtual worlds offer a significant advantage in spatial analysis by giving answers, through an obvious way, in a series of questions that the planar (2D) cartography has a natural difficulty of response. At the same time they put questions affecting the performance degree of reality. Are they right objects?

In any case, the Virtual cartography is only in a starting point. There is an evident need for theoretical and technical documentation of substantially topics that will build a set of stable principles and will form the theoretical and operational framework and background of Virtual cartography.

Until then, any type of scientific dialogue, referred to its substance and its factors, such as the virtual rendering, the interactions, the operability and the use of new means and devices, are not only necessary but also essential. There is only one presupposition: patience. We have to wait until the time of unanimous forming of an initial framework of common scientific acceptance that will lead the virtual cartography to be as reliable as the conventional cartography is.

The rapid and enormous technological evolution brought together different scientific fields in common questions and challenges. The Virtual Reality introduced into conventional cartography the Virtual Cartography, a technology that is in full growth and evolution. The abilities and perspectives are extremely promising but at the same time a lot of job must be done that requires a demanding and longtime involvement.

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