

REVIEW ARTICLE

Ideas on technoscience and digital experimentation in geography

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ABSTRACT

This paper carries out an analysis and reflection on how technoscience reaches Geography through Geographic Information Technologies, how it impacts the production of geographic knowledge and how it derives in the possibility of digital experimentation in the discipline in an environment called geo-digital reality. It is shown that advances in GIT have allowed overcoming old limitations, enriching more and more the observations made by Geography, and it is also highlighted the promising future of digital experimentation in Geography through all the possibilities offered by current technological developments.

Keywords: Technoscience; Geography; Geographic Information Technologies; Digital Experimentation

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1. Introduction

The present great technical-cultural revolution characterized by the emergence of digital technologies and their omnipresence, has allowed abundance in the generation, access and management of information, as well as greater interactivity, and all these are achieved through new forms of information coding such as: Hypertexts, multimedia, virtual reality, augmented reality, 3D, web 2.0, artificial intelligence, digital geographic information, etc. This leads to a new background or reality, in which sciences such as Geography supported by geotechnologies are active parts.

In this scientific and social context, the demand for spatial information is gradually growing and the sciences that capture, analyze and produce digital geographic information are becoming more and more important, which is why Geography can be considered to be in the eye of the hurricane. The use of geo-graphic information technologies (GIT) is increasing in scientific and professional Geography, as these tools have a great impact. Geographic information systems (GIS), digital cartography (DC), global navigation satellite systems (GNSS) and satellite images have shown great progress, allowing studies which can be carried out with greater coverage, more accurate and real-time.

In this article, there is an analysis and reflection on how technoscience enters geography through GIS, how it affects the production of geographic knowledge, and how it arises in the possibilities of digital experimentation in an environment called geo-digital reality.

2. Technoscience and geography

The contemporary technoscience developed during the second half of the 20th century and the first decades of the 21st century can be con-

sidered as a process where the production of scientific knowledge is characterized by the marked presence of technical instruments (with high levels of technologization), allowing, among other things, a greater speed and quantity in the production of knowledge for applied purposes, which in most cases serves to solve specific problems¹. The analysis of the current technoscientific revolution implies the complex interactions between science, technology, society, politics, economy and nature; however, for the purposes of this paper, we will only focus on the repercussions of technoscience on the production of scientific knowledge, especially geographic knowledge.

One of the characteristics of technoscience today is its tendency to develop the production of knowledge in controlled environments like laboratories, as Medina points out:

Technoscientific research is increasingly concerned with processes provoked and controlled in laboratories by the researcher himself as reproducible effects of constructions which, in turn, are technological results of scientific production, such as electrical and radioactive generators, particle accelerators, lasers or recombinant DNA^[1].

In all these areas of knowledge, large-scale projects (mega-projects) have been developed, which are directed and financed by national governments, governmental or international associations, giving way to the well-known great science or mega-science (big science). We need to stress that many of the great scientific discoveries in these fields would not have been possible without these mega-projects. One of the examples that can be pointed out is the “large hadron collider” located on the French-Swiss border², whose contributions will radiate the fields of physics, medicine, electronics, computer science, and others.

¹It is important to clarify that technoscience is not only a process of the current era, as Medina points out one might think that the current interweaving of science, technology, society and nature that constitutes the core of what is called technoscience is unique to our time, but the truth is that it has existed in different forms throughout the scientific traditions^[1].

²At CERN, the European Organization for Nuclear Research, physicists and engineers are investigating the fundamental structure of the universe. They use the world’s largest and most complex scientific instruments to study the building blocks of matter: the fundamental particles. (<http://home.cern/>).

According to specialists in the field, technoscience is a second phase closely linked to mega-science. The latter still exists, but there has been a mutation since the eighties that has to do with the genome project, or with companies such as Microsoft, Intel or Google. The same author assures that the difference between technoscience and macrosience lies in the fact that the former involves highly innovative small companies which is capable of generating relevant technoscientific advances, and the latter refers to big science.

Thus, the development of technoscience can be considered in different areas of knowledge, such as technophysics, technobiology, technogeology, technoastronomy and also social technosciences like technoeconomics and, technosociology. In other words, the proposal of technoscience implies a transformation that does not reach all disciplines at the same time, but that sooner or later will affect all scientific and engineering disciplines.

In the particular case of geography, the process of technical-scientific transformation is due to the confluence of several factors. For Ruiz, it is due to a coincidence of factors that, although individually have great strength as creators of change, when combined they multiply their capacity^[2]. These change-generating factors are of a theoretical and methodological nature (within Geography) and technological. With regard to the latter, the advances in data capture and the possibilities of processing them would stand out, allowing the generation of a multiplicity of information outputs or products, as well as the great progress in the means of exchanging and communicating information.

In order to detail how the different developments that led to current geotechnologies occurred over time, a timeline was drawn (**Figure 1**) that allows a chronological understanding of the appearance of each of these factors that have contributed to minimize the differences between the real world and the geo-digital world or the world represented³.

³Regarding the process of recreating the real world, Moreno clarifies that geographic reality (GR) is transmuted into digital reality (DR), replacing it in the process of solving knowledge problems. This DR is not a complete recreation of the former, but a partial one, which implies instituting limits to the observable different from those of the SR^[7].

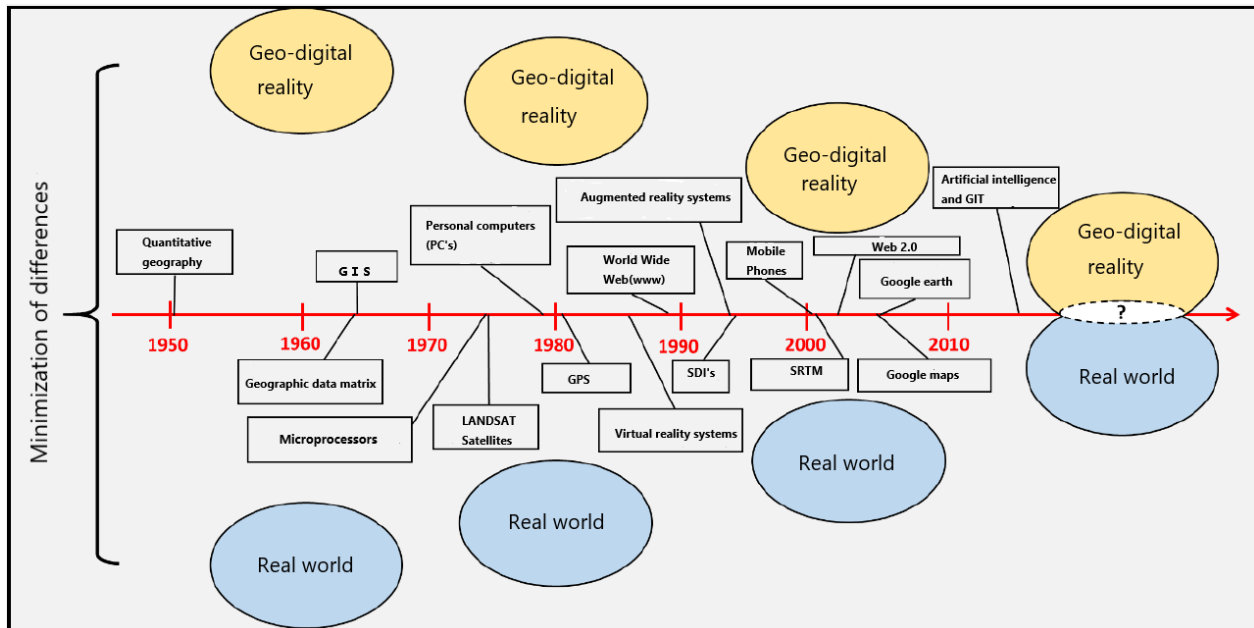


Figure 1. Minimization of the differences between the “real world” and the “geo-digital or represented reality”.
Source: Own elaboration.

2.1 Geographic information technology

One of the first aspects to be highlighted and that provided the basis for the subsequent automation of methods and techniques that are present in many of today’s geographic information technologies (GIT), is the development of the quantitative approach that began in the 1950s in Geography. In this regard, Buzai^[3-5] stated that the first impression when applying GIT allows conclusion that they support their development in already established paradigms, such as the rationalist and quantitative ones.

Another of the great milestones with repercussions in the development of GIT is Brian Berry’s geographic data matrix^[6] to which Ruiz explains:

With the matrix, Berry established a working method that made it possible to collect the locations of objects or phenomena occurring in the territory by means of their coordinates, as well as to store them in an orderly manner together with their descriptive data, i.e., their attributes. In order to represent the changes experienced by these objects or phenomena over time, the author proposed the creation of various temporal matrices that would store the state of these elements at each moment^[2].

This procedure can be seen later in the data

models used in geographic information systems (GIS). It can also be affirmed that many of the contributions developed within the quantitative geography approach will be operationalized automatically and digitally in GIT.

Another factor contributing to the accelerated development of geo-technologies in the era of the so-called information revolution is associated with the dizzying progress of electronics and informatics. Some of the most outstanding aspects are the appearance of the first microprocessors (introduction of the large-scale integration circuit) in the mid-1970s, which in turn will facilitate the appearance of desktop personal computers (PC) in the late 1970s, which will have an impact on the development of desktop GIS⁴ and consequently on its massive use.

Also, at the beginning of the 70’s, the capture, quantity and quality of spatial information will be revolutionized, when satellite platforms such as the LANDSAT series⁵ are put into orbit. In this regard, Flores makes the following description:

⁴According to Olaya desktop GIS continue to maintain their position as fundamental applications, and to speak generically of a GIS generally implies speaking of a desktop application before other types of applications^[13].

⁵Stuff in Space (<http://stuffin.space/>) is a real-time 3D map of objects in Earth orbit, allowing to visualize the positions of satellites for different purposes.

The development and improvement of state-of-the-art technologies, oriented to the capture (survey), handling and visualization of huge volumes of information, have originated amazingly efficient tools, among which, it is worth mentioning several remote sensing systems (LANDSAT, SPOT, RADAR, etc.), digital image processing (DIP), global positioning systems (GPS), spatial information systems (GIS-IIS-WIS), two and three dimensional computer graphics and computer aided cartography (CAC)^[8].

The impact of GIT is so great that they have made it possible to carry out studies where the speed and quantity of data transmitted and processed was unimaginable decades ago. A concrete example is the integrated permanent surveillance systems with stations that record in real or near-real time and allow constant monitoring of air pollutants (chemical and biological) in urban areas⁶. When complemented with a GIS, the possibilities multiply, integrating pollution, atmospheric, socioeconomic and epidemiological variables, and thus generating predictions through spatio-temporal evaluations.

These advances and innovations occurred within the framework of the information revolution, led Müller^[9] to affirm that in the last 20 years more changes have occurred than between Ptolemy and the computer. The aforementioned transformations had such a great impact that they gave way to the emergence of what some authors called geoinformatics, defined as the discipline or branch of knowledge that, in an interrelated manner, studying the nature and structure of geographic information, the procedures, techniques and methods for its capture, storage, processing, analysis, graphing and dissemination or communication^[10].

The impact of the above mentioned has arisen a theoretical discussion within Geography by theoretical geographers. The first steps in this direction were taken by Dobson^[11] with the mention of the term “automated geography”. Although it is not the

subject of this paper, it is important to clarify that this discussion on geotechnology has led to different positions, on the one hand there are those who claim that geotechnology is not a new paradigm of Geography but that geotechnology generates a geographic paradigm or way of seeing the geographic reality that Geography offers to the rest of the disciplines^[3-5,12]. On the other hand, there are those who claim that GIT are enabling a new mode of knowledge production, called as technoscience in general or geotechnological paradigm/praxis in Geography^[7,14,15].

2.2 Internet, virtual reality, augmented reality and associated geotechnologies

Another of the advances in recent decades that has undoubtedly generated great changes is the internet⁷, in the case of Geography, Capel emphasizes that it has been one of the disciplines that has experienced the greatest impact with the transformations of the Internet, which has opened up new possibilities for dissemination and has given new uses to the new geographic information technologies^[16]. Ruiz describes it as the epicenter of the geographic explosion, it has become a veritable hotbed of territorial resources that official institutions, private companies or individuals generate and deposit in it for public use. “Geographic ubiquity is everywhere”^[2].

Of all the possibilities that have been generated with the advent of the internet in Geography, one of the most outstanding at present are the spatial data infrastructures (SDI)⁸, which in general terms can be considered as a GIS on the Internet, a more complete concept would be the one developed by

⁷ The evolution of the Internet is such that as the so-called broadband spreads, the contents of the web cease to be merely textual and become progressively audiovisual, and hypertext gives way to hypermedia. Moreover, it is no longer necessary to download content for later consumption; with broadband it can be enjoyed directly online through the web, at any time and as many times as you want^[18].

⁸The United States Spatial Data Infrastructure, known as NSDI (National Spatial Data Infrastructure structure), is the first large-scale SDI to be implemented. It was created in April 1994 as a result of the enactment of Executive Order 12906, which calls for progress in the construction of a national spatial data infrastructure coordinated among federal, state and local governments, the private sector and academia.

⁶Currently, the Municipality of Madrid has a Monitoring System that consists of 24 automatic remote stations that collect basic information for atmospheric monitoring through analyzers that record gas and particle levels (<http://www.mambiente.munimadrid.es/opencms/opencms/calai re/SistemaIntegral/SistVigilancia/index.html>).

the SDI of Spain:

A spatial data infrastructure (SDI) is a computer system integrated by a set of resources (catalogs, servers, programs, applications, web pages...) that allows access to and management of geographic data sets and services (described through their metadata), available on the internet, which complies with a series of norms, standards and specifications that regulate and guarantee the interoperability of geographic information. It is also necessary to establish a legal framework that ensures that the data produced by the institutions will be shared by the entire administration and that encourages citizens to use them^[17].

It should also be noted that SDI have not been the only on-line alternative to visualize geographic information at present, there are also applications called virtual globes, where the best known is the Google Earth, these are means that allow access to geographic information to a larger number of users, as they do not require high levels of specialization to use them.

The so-called virtual reality (VR), although it is not a recent technology, since in mid-1986 systems of this type began to be offered, through monitors placed in a helmet that allowed people to have the perception of simulated environments in computers, with a real appearance. Its beginnings were in the field of entertainment and video games⁹, currently its potential is being exploited in many other areas, such as medicine, archeology, military training and flight simulations. VR provides disciplines such as Geography with great possibilities by allowing the study of a specific geographic space without the need for direct contact, reaching levels of representation of the real world that are very close to the real world. Among other utilities, it is being used for the previous planning in the office before the development of field activities, allowing to optimize the work and the resources used.

In this line, it is also possible to find today the so-called augmented reality (AR), which in our opinion is a clear example of how the border between the real world and the geo-digital world

⁹City VR is an example of a game where the user can explore cities from other perspectives. Allowing to touch and feel the skyscrapers, walking like a giant.
(http://store.steampowered.com/app/517990/City_VR/)

is beginning to blur, since this technology is able to complement the perception and interaction with the real world, providing the user with a real scenario augmented with additional computer-generated information. In this way, physical reality is combined with virtual elements having a mixed reality in real time^[19]. In this much broader definition, we observe the appearance of concepts of great importance in AR environments such as interaction and mixed reality or real time.

Within the levels of AR that currently exist¹⁰, we can already find applications in electronic devices that allow locating points of interest on a real world image by means of GPS and compass (**Figure 2**).

Finally, one of the most recent proposals involves the combination of GIT and artificial intelligence (AI). The so-called AI that is gaining momentum every day, is now also beginning to join GIT to address some of society's most important challenges, such as climate, water, agriculture and biodiversity management¹¹.

3. Digital experimentation in Geography.

The analysis and reflection of this section will begin with the following statement made by the philosopher of science Wagensberg: Scientific progress follows, more or less elastically, the progress of the capacity to observe and experiment^[20]. In the case of the ability to observe, it has been demonstrated in the preceding lines, over the last 60 years, how the science of Geography has overcome great limitations in the ability to carry out its observations,

¹⁰According to Rice a level 3 of AR will be available, at this level, we must detach ourselves from the monitor or display to move to lightweight, transparent wearable displays (of a scale like glasses). Once AR becomes VA (augmented vision), it is immersive. The overall experience immediately becomes more relevant, contextual and personal^[19]. The same author even states that there will be a level 4, where we will end up using contact lens displays and/or direct interfaces to the optic nerve and brain. At this point, multiple realities will collide, blend together and we will end up with Matrix^[19].

¹¹Esri's mapping technology, coupled with Microsoft Azure, has been able to produce geographic analysis in a matter of minutes, allowing the Chesapeake Conservancy to visualize exactly where a plantation is most effective (<http://obrasurbanas.es/microsoft-esri-inteligencia-artificial/>)

showing this ability to observe can be much more precise, faster and on a larger spatial and temporal

scale through technoscience.



Figure 2. Examples of augmented reality and geolocated data. On the left image of a cell phone capturing a panoramic view of the street using a camera and superimposing the digital street map. On the right image of a cell phone capturing the panorama and displaying places, landmarks and objects in 3D.

Source: Left image was from Glogger, 2009. Image on the right was taken from: <https://www.androidcentral.com/lg-and-wikitude-team-launch-3d-augmented-reality-browser>.

Regarding the ability to experiment, if we understand the concept of experiment as the study in which one or more independent variables (supposed antecedent-causes) are intentionally manipulated to analyze the consequences that the manipulation has on one or more dependent variables (supposed consequent-effects), within a control situation for the researcher^[21]. Then, in this sense, it would be difficult to manipulate variables in the object of study of Geography (geographic space), or in its field of action (territory). Thus, the question arises: Is it possible to avoid the limitations of experimentation in Geography? The answer to this question may be affirmative if we take into consideration that we can count on information that does not refer directly to the real world, but to a simulated world. As Wagensberg clarifies: Although the complexity of the real world prevents us from observing and experiencing it, we can observe and experience a simulated world^[20].

In this case the term “simulation” is taken as equivalent to “digital experimentation”, the experimentation that can be developed in a geo-digital environment, making use of the technologies described above, and the computing capabilities that are currently available. As it has been demonstrated, the progress and possibilities of geographic information technologies are almost infinite. Currently

the field of simulation in Geography (digital experimentation) is becoming increasingly important, especially in the field of urban Geography. It can be stated that, never before has the suite of geo-spatial technologies and socio-economic data collection schema been so powerful and of such potential^[22]. The future of the possibility of experimenting with computers and generating scientific knowledge in Geography is increasingly promising:

Meta-modeling, using more than one model to measure confidence in results, is becoming more commonplace for now in climate science and increasingly in social science models. And lastly, geo-computation, high-performance and grid computing are on the edge of creating computationally tractable answers to previously unsolvable modeling and simulation problems^[22].

Digital experimentation will make it possible to anticipate problems, and thus contribute to land use planning, and perhaps contribute knowledge to improve the quality of life.

Final considerations

The contemporary technoscience developed during the second half of the 20th century and the first decades of the 21st century in many disciplines, also affected Geography, which is impacted through GIT in the production of geographic knowledge.

This scientific knowledge is characterized by the marked presence of the multiplicity of digital geo-technologies, which are allowing among other things to produce at a higher speed and greater quantity geographic knowledge, which decades ago was impossible to generate. Advances in GIT and the combination with other technologies have contributed to the minimization of the differences between the real world and the represented geo-digital world.

There are also other possibilities, such as the case of generating information through digital experimentation, which can have an applicative character, allowing to anticipate problems in the geographic space, predicting the result in given circumstances or at least reducing the levels of uncertainty.

Conflict of interest

The author declared no conflict of interest.

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