GeoWeb 2.0 applications could support the Geodesign process

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ABSTRACT. *The emergence of Web 2.0 is materialized by new technologies (APIs, Ajax, etc.), by new practices (mashup, geotagging, etc.) an, by new tools (wiki, blog, etc.). It is primarily based on the principle of participation and collaboration. In this dynamic, the web mapping with spatial character or simply called Geospatial Web (or Geoweb) evolves by strong technological and social changes. Participatory GeoWeb 2.0 is materialized in particular by mashups among wikis and géobrowsers (ArgooMap, Geowiki, WikiMapia, etc.). The new applications resulting from these mashups are moving towards more interactive forms of collective intelligence. The Geodesign is a new area, which is the coupling between GIS and design, allowing a multidisciplinary team to work together. As it is an emergent term, the Geodesign has not be well defined and it requires innovative theoretical basis, new tools, media, technologies and practices to fit its complex requirements. In this document, we propose some GeoWeb 2.0 tools and technologies that could support the Geodesign process. The main contributions of the present research are firstly identifying the needs, requirements and constraints of Geodesign process as an emergent fuzzy field, and secondly offering new supports that are best meeting to the collaborative dimension of this process.*

RÉSUMÉ. *L'émergence du Web 2.0 se matérialise par de nouvelles technologies (API, Ajax, etc.), de nouvelles pratiques (*mashup*, geotagging, etc.) et de nouveaux outils (wiki, blog, etc.). Il repose principalement sur le principe de participation et de collaboration. Dans cette dynamique, le Web à caractère spatial et cartographique c'est-à-dire, le Web géospatial (ou GéoWeb) connaît lui aussi de fortes transformations technologiques et sociales. Le GéoWeb 2.0 participatif se matérialise en particulier par des* mashups *entre wikis et géobrowsers (ArgooMap, Geowiki, WikiMapia, etc.). Les nouvelles applications nées de ces* mashups *évoluent vers des formes plus interactives d'intelligence collective. Mais ces applications ne prennent pas en compte les spécificités du travail collaboratif, en particulier la gestion de traçabilité ou l'accès dynamique à l'historique des contributions. Le Géodesign est un nouveau domaine fruit de l'association des SIG et du design, permettant à une équipe multidisciplinaire de travailler ensemble. Compte tenu de son caractère émergent, le Géodesign n'est pas assez défini et il requiert une base théorique innovante, de nouveaux outils, supports, technologies et pratiques afin de s'adapter à ses exigences complexes. Les principales contributions de ce papier sont d'une part d'identifier les besoins, les exigences et les contraintes du processus de*

Geodesign collaboratif, et d'autre part de proposer des solutions géomatques répondant au mieux à la dimension collaborative du processus.

KEYWORDS: *Web 2.0, GeoWeb 2.0, Geodesign, Wiki, GIS.*

MOTS-CLÉS : *Web 2.0, GéoWeb 2.0, Géodesign, Wiki, GIS.*

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1. Introduction

Over time, geomatics and other sciences have evolved at every level: technology, concept, data, tools, applications, and so on. Indeed, there has been an expansion of professional geomatics (technical geomatics reserved for land management experts) to mass geomatics (ubiquitous geomatic and context-aware or spatial intelligence) (Roche, 2004). There is also the emergence of new forms of mass participation such as Public Participation in Geographical Information Systems (PPGIS) and Voluntary Geographic Information (VGI) (Goodchild, 2007; Kuhn, 2007; Roche, 2008). PPGIS provide a unique approach to engage the public in decision making, integrating local knowledge, complex spatial information, while allowing participants to act dynamically and reciprocally, to analyze alternatives (Sieber, 2006).

Through the democratization of the Internet and the establishment of international standards under the auspices of W3 and ISO, consumers become active and produce information. They can present their local problems and participate in the sustainable development planning of their community or region such as the case of FixMyStreet, built by MySociety (an application to help citizens to post, view, or discuss local problems: https://www.fixmystreet.com/). The citizen becomes more actively engaged in his community in order to improve his local services and the development of his sector (Rumbu, 2015). The concepts of participation, interaction and user generated content came into being with the new concept of Web 2.0. In recent neologism, participants in the production process are both users and producers, or simply said "produsers" (Budhathoki *et al.*, 2008, Coleman et al., 2009). "This Web innovation is fueling collective intelligence" (Joliveau, 2008a). Web 2.0, referred to as the Social Web, is more of an exchange platform where users become active actors (Mericskay, 2013).

As Geodesign is an emerging and multidisciplinary field, no real consensus has yet emerged regarding its definition. In fact, neither its specific characteristics, nor the requirements that it imposes in terms of use, supports or adapted approaches, nor even its own needs are not yet very clearly determined.

The need for an innovative theoretical base, new tools, supports, technologies and practices is now a prerequisite for meeting the complex requirements of Geodesign. Jack Dangermond at the first Geodesign Summit in 2010, talked about the importance of thinking of "new process, new ideas, new framework, new infrastructure, new generation of technologies, new platform". In addition, in 2012, a special issue of the

International Journal of Geomatics focused on exploring Geodesign as a new emerging field for geographic information science, its new methods and technologies. The different Geodesign summits, organized annually around the world (USA, Europe, and China) aim to build new concepts, new tools, new technologies, new practices; to share these and exchange between practitioners and researchers in order to better understand and work together more effectively.

2. Web 2.0 and GeoWeb 2.0

GeoWeb 2.0 as Web 2.0 is known a transformation, materialized by new technologies, new practices, new tools, etc. Participatory GeoWeb 2.0 materializes in particular by mashups between wikis and geobrowsers. New applications from these mashups are evolving into more interactive forms of collective intelligence and support for participatory decision making. GeoWeb 2.0 inherits new Web 2.0 principles such as collaboration, participation, sharing, exchange, openness, interaction, communication, and more.

2.1. Web 2.0

The concept of Web 2.0 since its emergence in 2004 has introduced its own terminology (Peter *et al.*, 2014, Marouf and Benslimane, 2014; Venanzi *et al.*, 2014, Davis, 2013; West, 2009; DIGIMIND, 2007; Masetti-Zannini, 2007; Leuf and Cunningham, 2001) including tools, technologies (wiki, web-blogs), approaches, concepts (Folksonomy, Crowdsourcing, Tags), data, files, formats (RSS). The Wiki is Wiki Wiki Web server called simply means "fast" in Hawaii, origin of Ward Cunningham. It is an extensible free collection of linked web pages and a hypertext system for storing and modifying information. It is also a database. The wiki is a collaborative and democratic space. In fact, it invites all users to edit through a WYSIWYG interface and create new pages, link pages and collaborate. The wiki has benefits for personal use and shared use such as information exchange, collaboration, building collective knowledge and updates. Nevertheless, it has the disadvantage of being too open and unstructured.

Web 2.0 offers a considerable number of new applications such as online office automation, employment, e-commerce, geolocation, news broadcasting, entertainment, multimedia document sharing, education and research online, library 2.0 (DIGIMIND, 2007).

2.2. GeoWeb 2.0

The Web with a spatial and cartographic dimension is named Geospatial Web or GeoWeb. The Geospatial Web concept was first introduced by Dr. Charles Herring in his US DoD paper in 1994 (Herring, 1994). GeoWeb, or the Geographic Web, is a term that describes the content and geographic applications available on the World Wide

Web (Euvrard, 2007). With the emergence of Web 2.0, GeoWeb has taken new trends. It in turn becomes GeoWeb 2.0 by inheriting the new principles of Web 2.0 such as collaboration, participation, sharing, exchange, openness, interaction, etc. (Fisher, 2008).

In the wave of GeoWeb 2.0, we have heard about several terms related to online mapping such as geospatial web or GeoWeb (Scharl and Tochtermann, 2007), GeoWeb for participatory urban design (Pak and Verbeke, 2014), GIS 2.0 (Jekel, 2007), Neogeography (Turner, 2006; Kahle, 2015), Volunteered Geographic Information or VGI (Goodchild, 2007), cartographic wiki or wikification of SIG (Hây, 2008), GeoVue (Hudson-Smith and Crooks, 2008), DigiPlace (Zook and Graham, 2007), cartography 2.0 (Hây, 2008), spatial crowdsourcing or geocollaboration (Hopfer and MacEachren, 2007), Geowiki "adapting a wiki Geographical domain" (Priedhorsky and Terveen, 2008; Guptill, 2007) cartography maps 2.0 (Crampton, 2008), web mapping 2.0 (Haklay *et al.*, 2008), geomatics 2.0 (Joliveau, 2008b), territories 2.0 (Guillaud, 2008) and Geoinformation 2.0 (ESRI, 2006).

The spatial revolution on the geographic Web consists of "reading - writing Web" (Crampton, 2008). Driven by technological developments, the digital map has benn changed. It becomes interactive, dynamic, multimedia and above all connected by its networking. The map in cartography 1.0 is an informative and communicative tool produced by expertise and consumed by everyone. However, the map in Mapping 2.0 is an interactive and participatory tool, produced and consumed by users (Hây, 2008). Simply said, Mapping 2.0 is changing the development context for digital mapping where the anyone can create his own maps through existing mapping services online.

GeoWeb 1.0 was static, individual and central, while GeoWeb 2.0 is dynamic, participatory and distributed (Maguire, 2007b). The new GeoWeb is positioning itself as a platform for the collective exchange of geolocated content that is gradually being formed through user-generated practices, tools, and content (Crampton, 2008; Haklay *et al.*, 2008).

GeoWeb has also introduced its own terminology (Hây, 2008; Pugin, 2008; Pornon and Noucher, 2007; Crooks *et al*., 2014; Maguire, 2008a; Turner, 2006; Sharl and Tochtermann, 2007; Ayers *et al.*, 2007), including tools (API, Mapplets), technologies (Ajax), approaches (POIs, widgets), processes (geoparsing, geotagging, geocoding, geolocation), data, files, formats (GPX, GeoRSS, KML, microformats, etc.) and standards (WMS, SLD, GML, SFS, SLD, SFS, SLD, CS-W, WCS, Open LS, SOS, SPS, WPS).

3. Geodesign

3.1. Context and definition

During a specialist meeting untitled "Spatial Concepts for GIS and Design" organized by the NCGIA in 2008, the term Geodesign is launched. Since then, many pioneers have been trying to provide definitions, concepts, reflections, tools by organizing summits every year at Redlands.

Like most new emerging terms, Geodesign is defined by several professionals (referred to as Geodesigners) with no consensus yet emerging. Several definitions have been proposed in Geodesign summits of ESRI USA, which we recall the most cited:

– Jack Dangermond (2010), President of ESRI: "Geodesign is a vision for using geographic knowledge to actively and thoughtfully design."

– Diana Sinton (2010) of the University of Redlands: "A planning approach to spatial design and methods and spatial knowledge of human and natural geographic contexts."

– Michael Flaxman (2010), MIT: "a set of techniques and enabling technologies for integrated planning, including project conceptualization, analysis, design specification, stakeholder participation and collaboration, design creation, simulation, and evaluation (among other stages). Geodesign is a design and planning method which tightly couples the creation of design proposals with impact simulations informed by geographic contexts".

– Carl Steinitz (2010), Harvard University: "Geodesign is geography by design".

Abukhater and Walker (2010): according to Smart Growth's definition: "Geodesign is the art and science of geospatially enabled sketching and modeling". It turns out that Geodesign is an art because it incorporates elements of sketching and design. It is a science because it incorporates the elements of modeling and analysis.

– Eric Miller (2008): "Geodesign is the thought of process comprising the creation of entities in our geo-scape".

– Batita *et al.* (2016): "a process that harness the creativity from design and the rationality from GIS to improve a multidisciplinary team analysis, making rapid and iterative scenario for rapid feedbacks and decision making within a consensus with public involvement".

From these definitions and conferences' proceedings, we have tried to identify a set of characteristics of the Geodesign process:

– Iteration: The Geodesign process is iterative and occurs spontaneously. In addition, the Geodesigners look for either a quickly return, or a new scenario (Miller, 2008).

– Collaboration: In most cases, the Design/Geodesign process is organized around a multidisciplinary team who collaborate and work together. Collaboration in such process involves sharing ideas, strategies, proposed solutions, assessments, implementation and preconception strategies in a distributed spatial and temporal environment (Miller, 2014). collaborative technologies in complex Geodesign projects become the tools that can make or break the success of a project (Miller, 2014). This dimension of collaboration also contains a set of characteristics, according to Miller (2014): communication between stakeholders, the sharing of different data sources (maps, animations, reports, values, etc.), the co- creation. Like urban design, Geodesign relies on process flexibility and fit with the creative dimension (Forester, 1999), decision-making that is based primarily on mediation and consensus (Miller, 2014) and interaction (Goodchild, 2010) raises the interactive dimension of Geodesign, considering all Spatial Decision Support Systems - SDSS solutions as a subset of Geodesign. SDSSs are interactive systems designed to support group work and spatial collaborative decision making).

– Deliberation: the spatial design and particularly the urban design is based on the deliberative approach. In addition, designers find their solutions through talking. In analyzing this type of process, Roche (2009) has shown that the design process sometimes has open and unstable elements whereas GIS is characterized by stable and firm representations.

– Participation: Controlled public involvement in such a process is possible (Abukhater and Walker, 2010; Ervin, 2011). The emergence of Web 2.0 and applications such as online mapping have dramatically changed the way geospatial data is used (Jankowski and Nyerges, 2001). The use, creation and analysis of geospatial data was once the realm of experts (Jones, 2011): it is the top-down approach (Goodchild, 2007). Technological advances have led to the democratization of geospatial data, and maps are now being produced by anyone without necessarily knowledge of geospatial data. Producers and consumers are no longer distinguishable. Residents through their local experiences and knowledge can suggest solutions in their territories. Therefore, the residents are experts, too, in their own way; they know better their history, values and culture of where they live (Abukhater and Walker, 2010).

– Ambiguity management: The creative side of Geodesign comes from the ambiguity that increases at each stage of the process while GIS is specifically designed to mitigate it (Roche, 2009). Ambiguity, fuzziness and vagueness are the main factors of uncertainty (Devillers and Jeansoulin, 2006). As a result, we can describe Geodesign as a certain process. Two types of ambiguity have been recognized: discord and nonspecificity (Devillers and Jeansoulin, 2006). Given the lack of a collaborative approach to managing geospatial data uncertainty that addresses the quality of this data, Grira (2014) has been working on its management and has implemented a collaborative approach to manage uncertainty on data quality.

– Multi-theme: A multi-theme process means a process that deals with several themes or themes, such as population, road network, cycling network, zoning, etc. Moreover, Ervin (2008) has highlighted that GIS with Design is a multicriterion and multidimensional process.

– Multi-actors: Participants in a Geodesign process can come from various professional backgrounds: civil engineering, urban planner, surveyor, surveyor, architect, environmentalist, etc., in addition to often involving elected officials.

– Multi-scale: The Geodesign covers a variety of scales, ranging from design, urban planning, community planning, city and town planning and regional planning, to mega-planning regions (Abukhater and Walker, 2010).

3.2. Is Geodesign a new concept?

Geodesign is a new term driven by new definitions, but it's not a new concept. Geodesign describes the integration of GIS and spatial design. The first combination between GIS and design was originally designed by and for the space designer community in the 1960s at Harvard University, at the Laboratory for Computer Graphics, but gradually the GIS largely based on their specific technical directions have been abandoned by this community. This concept was (re) updated in December 2008 at the "NCGIA Specialist meeting" in Santa Barbara on "Spatial Concepts in GIS and Design". This meeting was extended by the first Geodesign Summit which took place in Redlands in January 2010. Until that date, many editions took place at the same place. The last event took place on January 24-26, 2019. The overall objective of the Geodesign Summit is to help GIS and Design professionals (architects, landscape architects, landscape ecologists, urban and regional planners, planners of the environment, civil engineer, etc.) to find innovative solutions to the most pressing challenges of the fusion of design with GIS. More specifically, these summits aim to:

– Identify new geospatial features, tools and technologies necessary to support the Geodesign process,

– Encourage the development of Geodesign projects in the real world.

– Develop communication efforts for Geodesign, to include publication of articles, case study books, journals, etc.

– Provide a forum for discussion among peers.

3.3. Geodesign with "d" vs GeoDesign with "D"

Geodesign with a small "d" design that takes a simple design view in the sense of formulating a problem with the objectives and constraints, collecting the data, running a search for the solution and setting it implemented. The geodesign process with a small "d" does not consider the complexity of the process generated by the disagreements of different stakeholders, the difficulties to decide together, feedback loops that modify objectives, constraints and data (Goodchild, 2010). This complex process is treated in GeoDesign with a large "D".

3.4. Elements of Geodesign process

Although Geodesign as a discipline has recently been launched, it includes at least four basic elements (Abukhater and Walker, 2010):

– Sketching or sketching potential sketches and plans with a few parameters and few details while maintaining a form of ambiguity of the lines (Roche, 2009). In a process such as Geodesign, sketching is quite often participatory. As a result, it provides a collective brainstorming environment.

Figure 1. A tag cloud with terms related to Geodesig (Batita et al.*, 2019)*

– The use of appropriate software to evaluate the usefulness of scenarios.

– Fast feedbacks give an idea of medium-short term results.

– Iterations or repetitions adjusting the work along the project have several advantages: It encourages creativity, strengthens group work, and simplifies complex systems.

3.5. Geodesign system

Ervin (2011) described the Geodesign system by identifying fifteen components that are interdependent and essential: environment, elements, configuration, constraints, collaboration tools, versioning, level of abstraction, management of diagrams, text/media hyperlinks, modeling tools/scripts, time management, simulation tools, dashboards, and coach design methods.

To summarize and simplify this section, Figure 1 summarizes the main supports, components, ideas, elements, technologies, dimensions and founders related to Geodesign.

4. GeoWeb 2.0 concepts relevant to the Geodesign process

In this section, we propose an overview of the basic concepts of GeoWeb 2.0 in order to highlight their specificities, their strengths and their relevance to the Geodesign requirements and then draw up a state of the art of existing technologies. Indeed, we present the notions of wiki including the management of traceability, the removal, the principles of navigation in the contributions, the management of the spatial entity including the geometric, graphical and attribute components with the argumentation, the data quality, and decision-making by consensus.

"Wiki Wiki Web server" approach or simply said "wiki". This term is defined in the first chapter, and in the following section, we describe its features.

The wiki is the main part of technological innovations of Web 2.0. And a first social aspect of Web 2.0 is the notion of participation and collaboration (Pugin, 2008). Moreover, the wiki is designed to support a group of users not necessarily in the same territory, and asynchronously, to create, collaborate and share information (West, 2009). Indeed, thru wikis, people can build the content of the same page without losing the previous versions (Leuf and Cunningham, 2001). Through the wiki, it is possible to keep track of the sequence of changes (Pugin, 2008). In order to simplify things, let us put the wiki concept into action by the most famous and largest online encyclopedia Wikipedia. Users are themselves the producers of the pages. If an error is dragged by chance, certainly other Internet users will correct it. This collaborative work initiative is a good illustration of the capacity of amateurs to collaboratively produce knowledge (Mericskay, 2013). This is a true example of collective intelligence.

Collective Intelligence (CI) refers to "the cognitive abilities of a community resulting from multiple interactions among members of a group". It is defined as "a shared intelligence or group intelligence that results from the collaboration and competition of individuals". According to Tapscott and Williams (2007), collective intelligence is a massive collaboration based on the four principles: openness, peering, sharing and acting globally.

However, group effects limit the collective intelligence by conformism, fear, closure, lack of procedure, ideological homogeneity because it feeds on group interactions. This fact makes the process more complex and here we see the importance of GeoDesign with "D" to overcome the problems generated such as disagreements of different stakeholders, the difficulties to decide together, feedback loops that modify objectives, constraints and data.

Consulting several literatures related to the wiki (Leuf and Cunningham, 2001, Ebersbach *et al.,* 2008; West, 2009; Peter *et al*., 2014), allowed us to reveal its main features: editing (What You See Is What You Get – WYSIWYG editing), link, historicity, diff, recent changes, sanbox, and search.

In short, the wiki is editable by anyone at any time, following a multipage and nonlinear construction. Through the Wiki, it is easy to manage the traceability of contributions and navigate the history. Applying the spatial component to the Wiki content management system enables the production of interactive, collaborative, participatory mapping applications. Based on the technologies and principles of GeoWeb and Web 2.0, online mapping applications appear under different nominations such as GIS wikification, neogeography, mashups, spatial forums, etc. As a result, geolocated content can be modified, enriched, updated and deleted by anyone in synchronous or asynchronous mode. However, the voluntary geographic information generates a big problem regarding the data quality.

The spatial entity includes the geometric component (shape and location), the graphical component (iconography) and the attribute component while adding the argument (why did we edit?). These arguments constitute the main components of the external qualifications of contributions.

In most applications mentioned above, the validation of contributions is usually done by vote. However, the model of reconciliation of contributions of the wiki model is better used in support to establish a differentiated consensus (Noucher, 2009). The latter will be a better solution in decision-making in a Geodesign project within a multidisciplinary team.

5. State of the art of existing technologies

The state of the art presented in this section aims to identify the existing mainstream mapping applications, academic projects, geomatic solutions and Geodesign solutions that could be useful and effective for Geodesign process. Essentially, we identify four types of applications that we distinguish from each other depending mainly on who implemented them and why they were implemented while remaining in the same context of this research:

1) GeoWeb 2.0 applications based on a consumer-oriented wiki content management system: WikiMapia, OpenStreetMap (OSM).

2) Academic projects: ArgooMap, GeoDeliberator, GeoGig and WikiGIS.

3) ESRI products: CommunityViz, GeoPlanner, CityEngine and ArcGIS online.

These solutions do not really constitute an exhaustive synthesis, but offer a representative panel of the situation:

1) WikiMapia and OSM are some of the most famous and popular GeoWeb 2.0 applications;

2) The concepts of ArgooMap, GeoDeliberator, WikiGIS and GeoGig are important to support some dimensions of Geodesign process;

3) ESRI products are essential to mention, because they are made specially to support the Geodesign noting that this term is emerged and maintained by the same company.

5.1. GeoWeb 2.0 Applications

5.1.1. WikiMapia

The 2.0 collaborative mapping applications are multiple and huge, but the most significant example is Wikimapia. It is a voluntary “gazetteer” produced by volunteers to provide descriptions of places that may be useful to others (Goodchild, 2007). This Mashup was born following the convergence between Google Map, a little collaborative GeoBrowser and the most famous encyclopedia Wikipedia where the space component is absent.

This site launched in May 2006 by two Russian programmers Alexander Koriakine and Evgeniy Saveliev, is intended to "map the planet Earth" seen by satellite. It is more specifically a Web 2.0 project (http://en.wikipedia.org/wiki/WikiMapia), aimed at maintaining an interactive, editable, free, complete, multi-language map, and updated for the whole world.

The WikiMapia site is a collaborative mapping service providing an interactive web map built from the Google Maps API. The content of WikiMapia is managed under a Creative Commons (CC) license, that is, the site offers its data for sharing, transformation, changes, etc

5.1.2. OpenStreetMap

Like Wikimapia, the OSM database is continuously built collaboratively. It is indeed a contribution of the Neogeography where the voluntary users can intervene and collaborate according to the terms of the project of free Creative Commons licenses. OSM provides free and open geographic data of road networks, POIs, nodes, relationships, etc. from all over the world, it is founded in July 2004 by Steve Coast of University College London[1].

OSM contributors can follow three contribution methods for acquiring new data in the field: 1) satellite images provided by Yahoo! Maps and Bing Maps; 2) loading of available official data sources such as the cadastre or; 3) collecting traces and downloading to the OSM server. Then, they incorporate the new data by editing the content of the central OSM database (Brando Escobar, 2013). Every month, hundreds of amateur cartographers, for example, gather around the world to organize data in an organized and user-friendly way during cartographic campaigns called mapping parties (Haklay and Weber, 2008; Mericskay, 2013). For the representation of geographical features, OSM defines four basic elements: nodes (point with geographical positions), paths (polyline) or polygon (if polyline closed), relations and tags. These are used to store the metadata of objects. All contributions are released under a free license, but in September 2012, the open database license of the Open Data Commons was adopted to consider the data itself rather than its representation. OpenStreetMap stores a complete copy of the current state of an object when it is updated. Data produced by OSM is increasingly used by professionals, and several works such as Eckle and Albuquerque (2015), Arsanjani *et al.* (2013), Kebler *et al.* (2011a), Kebler *et al.* (2011b), Trame and Kebler (2011) are interested in designing methods and metrics to evaluate the quality, accuracy and coverage of this contributory data.

In examining GeoWeb 2.0 applications, several limitations emerge such as:

- The absence of metadata useful for qualifying the data produced,
- Limited to the requirements of spatialized collaborative work or geocollaboration,

1. http://en.wikipedia.org/wiki/OpenStreetMap

– Incapacity of ensuring the traceability of the spatio-temporal evolutions of the geometric objects created by the users (localization, form, descriptive attributes, graphic attributes),

– Access to the contribution's history via a time browser,

– They also do not have tools for comparing versions and displaying geometric differences,

– The validation of the contributions is done by vote.

5.2. Academic applications

Unlike the neogeographic projects mentioned above, participatory mapping projects developed by professionals do not follow the same logic of openness. Indeed, the data published by the contributors in this context belong entirely to the companies, for example an amateur who updates the data of Google Maps does not own the information that he has created (Mericskay, 2013).

5.2.1. Geodeliberator

GeoDeliberator is an initiative of "Penn State University's" College of "Information Science and Technology" and 'State College Borough Government' led by Guoray Cai and Jack Carroll. GeoDeliberator is a geographic decision support tool based on Web 2.0 technologies and implemented on AJAX. It provides an effective communication and analytical platform for enriching dialogues among different stakeholders in spatial decision-making processes. It facilitates online interactions. This kind of visual discussion tool can encourage the public to actively participate and express their views in environmental processes (Cai and Yu, 2009). In fact, the Geodeliberator is a prototype developed to explore the potential and use of geospatial annotation technology.

Geodeliberator facilitates the citizen engagement, deliberation process, and collective decision-making (Kropczynski, 2015).

5.2.2. ArgooMap

Argument map is another cartographic application, based on participatory GeoWeb and Web 2.0 technologies implemented by professionals (Rinner, 2001; Rinner *et al.*, 2008). ArgooMap is an initiative of Ryerson University in Toronto. This application (based on the "Google Maps API"), defined by its designers as an online map discussion forum, is built around the conceptual model of argumentation maps introduced by Rinner in 1999 (Rinner, 1999). The user can post comments on a map. Following a wiki-type architecture, a series of geolocated discussions take place.

This type of tool is based on GeoWeb and Web 2.0 technologies (Rinner *et al.*, 2008) and combines the production of geographical objects (points, lines, polygons) and discussion forums. This type of application appears interesting for the collective production of geographic content (Rinner, 2001). In this type of application, each created spatial object is attached to a series of comments that allow users to explain why they have placed a point at that point, drawn a zone in such a way. Another interesting feature for actors involved in several remote locations, the instant discussion, allows users to contribute collectively to the map while discussing synchronously to justify their actions. Both types of approaches allow the iterative refinement of participant-generated information through synchronous or asynchronous dialogue (Mericskay, 2013). ArgooMap operates under the Gnu General Public License (GPL) which is open source software. It is therefore available to all if Google Maps remains valid.

5.2.3. GeoGig

Geogig presents many new useful features, although it is still under development and unstable (version 1.2). It is a distributed version control system (DVCS) specifically designed to manage geospatial data. It inherits the concepts used in distributed version control of the Git. All versions are stored, available and can be used. It can display the differences between the two entries using the "diff" command. As you add new data to the repository database, GeoGig creates new versions that define the history of the repository. GeoGig stores the full set of objects that comprise each version (Holmes, 2012; Marin, 2014). Browsing the history is possible and it shows what has happened since the entity was created, while answering some questions such as "who edited this feature?", "Since when does this feature exist?" Or "how many changes did a person make in the last month?" It is implemented in Java and is available under an open source BSD license. It is designed to facilitate collaboration between users sharing the same spatial data. This application is accessible through the Command Console on Command Line. The resulting file could be viewed on QGIS or ArcGIS.

5.2.4. WikiGIS

Batita *et al.* (2012) defined WikiGIS as: "a collaborative platform 2.0, supported by a wiki that insures traceability of geographical contributions of participants while insuring the quality of produced data in a dynamic visualization and analysis. The WikiGIS has powerful features for editing and design of sketch mapping and in geoprocessing. It thus offers a simple and quick access to the process of Geodesign".

The WikiGIS concept was introduced by Stephane Roche in 2006 (Ciobanu *et a*l., 2007; Roche *et al*., 2012) and it is designed and developed by Wided Batita (Batita *et al*., 2012, 2014, 2016, 2019; Batita, 2016).

The basic concepts of WikiGIS are (Batita *et al.,* 2012):

1) A Web 2.0 application based on wiki track editing; dynamic management and consulting contributions. The data may be modified, enhanced, updated or even deleted.

All user contributions are archived and can be viewed dynamically with the historical content;

2) A documented traceability of users' contributions to ensure not only the argued documentation of the design process, but also access to this process;

3) The WikiGIS ensures not only the traceability of geometric, graphical and descriptive components of a feature, but also the relationships between different geometric features (topology, intersection, inclusion, etc.) over time. For example, a user can draw a line directly next to an existing line drawn by another user. These two lines could be aggregated in the future because of their common attribute, much like the extension of a road;

4) An ergonomic and simple mapping interface (GeoWeb 2.0) for easy viewing and navigation in space-time versions of contributions;

5) Any contribution is considered as an opinion;

6) These arguments are the main components to qualify external contributions;

7) All previous versions of an opinion are considered as an integral component of the object (not as a different object).

Thru the alloment of Saint Pierre Municipality, we explored the potential of WikiGIS mainly for supporting the collaborative dimension of Geodesign process. By combining the principles of iteration and traceability that are specific to wikis with the geospatial data analysis capabilities, WikiGIS becomes a comprehensive tool to support collaboration in an iterative process.

5.3. ESRI products

Since the emergence of Geodesign in 2010, ESRI has continued to improve and invent technologies to make and support it. Recently, several applications have emerged such as ArcGIS 10.3, ArcGIS Pro, Web AppBuilder, StoryMaps, Collector, and so on. In this sub-section, we will not explore all ESRI products, but we limit to some products that potentially meet the needs of Geodesign such as ArcGIS Online, CommunityViz, CityEngine and GeoPlanner.

5.3.1. ArcGIS Online

Following the trend of GeoWeb 2.0, ESRI has developed its own consumer maps via ArcGIS Online. Szukalsk (Szukalsk, 2012) showed the usefulness of ArcGIS online in Geodesign. In fact, it is a collaborative online platform where ArcGIS subscribers can use online services such as base maps, geocoding services, etc. This platform is intended for either personal use or business use.

ArcGIS Online aims to make maps, analyze data, and to share and collaborate. . By the example of Kentucky, Szulask (2012) showed how to explore the map and extract all the necessary information. He showed how to manipulate the map: zoom in, adding symbols, opening Excel, creating graphs, overlapping layers, managing the metadata of an object, etc. He showed how to share geographic content with other users. For diff function, side by side is proposed. By zooming in, both maps will be synchronized. The story maps take place in this platform. Indeed, it possible to analyze changes over time through presentations and to forecast a future state.

5.3.2. CommunityViz

It is developed by Placeways in partnership with the Orton Family Foundation, and in 2017, the software was purchased by City Explained, Inc. CommunityViz is an extension of ArcGIS, a decision support tool based on GIS, used in different areas such as urban planning, land use planning and the Geodesign (Walker and Daniels, 2011). With CommunityViz Scenario 360, users perform their own analyzes across multiple scenarios using custom formulas, indicators, and tables dynamically updated in real time as the user makes changes to the map or calculations. Users can later export their data to Google Earth or ArcGIS Explorer.

There are two parts in 3D scenario: Export and Viewer. The first part is an ArcGIS extension for creating 3D scenes, while the second part is used to explore scenes created by 3D Export scenario.

5.3.3. CityEngine

Among the innovations in 3D GIS and Geodesign technology, we mention the CityEngine product. It is an autonomous software that makes available to users of architecture, urban planning, spatial planning, etc. GIS simulation and production of 3D content. CityEngine is developed by Pascal Mueller at ETH Zurich. With this software, the user can build as many flexible and fast scenarios as he wants. The most realistic virtual 3D visualization possible in the design phase will prevent costly mistakes in the construction phase. Publishing the 3D model online allows you to share, collaborate and interact with others in the same and / or different domains. CityEngine supports CAD and GIS formats; which allows to export geospatial data from ArcGIS and OSM.

5.3.4. GeoPlanner

GeoPlanner brings the power of ArcGIS Online and a Geodesign workflow to ground planning activities with a JavaScript-based web application that allows users to create, analyze, and report planning scenarios in support of more enlightened decision-making. Indeed, a GeoPlanner project usually contains several scenarios created by different members of the team. To assess a scenario, the diff function is available according to evaluation criteria by means of analysis tools. The GeoPlanner application provides a Consensus tool to help designers and planners visualizing the degree of consensus with respect to the proposed scenarios. This tool identifies the areas of consensus planning and disagreement. To highlight the differences between two scenarios, we can compare them either side by side or by sliding the layer (swipe layer).

The ESRI products selected in this section are considered the ultimate solutions to fit almost all the needs of Geodesign process. Indeed, the management of the traceability of the geographical entity is well maintained, the collaboration of the users who come from different disciplines is well managed. Comparing the products, GeoPlanner is the best product so far as it better manages the traceability of an object and provides a consensus tool to help designers in decision making. Nevertheless, ESRI products require expertise to manipulate them and their licenses are too expensive. The navigation in the history is not yet well developed.

6. Discussion

There are many solutions that respond relatively well to the Geodesign process such as ESRI products. Nevertheless, these products are expensive and need an expertise to use. Indeed, we aim in this research to show the relevance of some features of GeoWeb 2.0 technologies in the Geodesign process, including mainly the management of traceability.

Some features are very useful in Geodesign process such as:

– A Web 2.0 application with wiki functionality applied to editing, managing and dynamically consulting contributions. All user contributions are archived, and are dynamically searchable through content history *via* a time browser,

– Documented traceability of user's contributions guaranteeing the documentation (reasoned) of the design process, but also access to this process,

– Any contribution is considered an opinion: the sum of a geometric entity (these three components) and an argument (who, where, when, why, with what intention and on what basis). These arguments constitute the main components (metrics) of external qualification of contributions,

– The contribution-opinion reconciliation model (wiki model) used to support the establishment of a differentiated consensus.

– The assessment of data quality,

– The multimedia component to support the argumentation,

– The ability to compare two versions and display the differences.

Web 2.0 application are so important tools for Geodesign process by traceability management and how we navigate in the history via a temporal navigator. Other functionalities have been suggested to support it like deltification, decision making by consensus, multimedia hyperlinks supporting the arguments and data quality measures.

In this Table 1 below, a benchmarking study among the solutions mentioned above to highlight their weaknesses and strengths regarding the features useful for Geodesign process:

Table 1. Benchmarking study

Criteria	Features	GeoWeb 2.0		Academic projects				ESRI products			
		OSM	Wiki Mapia	Geodeliberator	ArgooMap	Geogig	WikiGIS	ArcGIS Online	CityEngine	CommunityViz	GeoPlanner
Web 2.0 Applications				x		x		x	x	x	x
Contribution	Geometric				x						
	Attributary										
	Icon			x		x					
	Argument	x	x	x	x	x			x	x	x
	Multimedia	x	x	x	x	x		x	x	x	x
Traceability management	Versionning	x	x	x	x			x	x	x	x
	Temporal Navigator	x	x		x	x		x	x	x	x
Data quality				-	-	-					
Deltification	Geometric Diff	x	x	x	x			x			
	Textual Diff	x		x	x			x	x	x	x
Consensus validation		x	x	x	x	x		-	-	-	
Expertise on GIS non requested								x	x	x	x
Costless								x	x	x	x
Technical aspects	Language	HTML5 application using D3.js	HTML page and KML file	Ajax	API	Web API	HTML and Javascript	Google Earth and KML-KMZ			
	Platform	Collaborative mapping	Google Maps API	Geosptial annotaton	Argumrntion Map	Distributed Version Control System	Open Layer and Geoserver	ArcGIS extensions			
	License	Open Data Base	Creative Common		Gnu General Public	BSD Open Source	Mock-up	Proprietary			

7. Conclusion

The Geodesign process is considered as an iterative, collaborative, participatory, interactive, deliberative, uncertain, multi-scale, multi-stakeholder and multi-topic process. This process needs new technologies and tools and supports.

Sketch, Geomatic simulation solutions, Integration of three-dimensional design tools in GIS, the interaction of environmental models and GIS, Spatio-temporal GIS, Augmented Reality, SOLAP could be useful to support such process.

This study confirms that ESRI products met the needs of the Geodesign process. Nevertheless, these tools are not open to the public, their licenses are expensive and require expertise to handle them.

The purpose of this study is to show that GeoWeb 2.0 solutions and technologies such as OSM, WikiMapia, GeoDeliberator, ArgooMap and Geogig could partially answer the needs of Geodesign process. Indeed, the new cartographic applications "collaborative" GeoWeb 2.0 such as OSM and WikiMapia remain quite limited in terms of the requirements of collaborative spatial work or geocollaboration. Geodeliberator, WikiGIS and Geogig are not online platforms. They are applications under development, but their approaches fit many Geodesign requirements and they are promotor tools with big potential.

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