Orthoimage or map visualization in use in geoportals
Case study on the French Geoportal

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ABSTRACT: This paper sets out the results of a statistical analysis of a survey on a panel of 45 cartographic websites using the API of the French Géoportail. Existing design choices, such as favored base maps, transparency levels of the displayed layers, scale visualization, have been studied from mixed representations in use. They have also been faced to the aim of the related applications, the user's tasks (data visualization and interaction) and their resulting uses in order to define general trends about mixed representations.

KEYWORDS: fitness for use, mixed cartographic representation, geoportals, map, orthophoto

Introduction

Various and heterogeneous geographic data are currently available. Users are able to access topographic maps, orthoimagery, thematic vector data, relief (DTM), etc. (Bianchin 2007). These representations provide different views of the real world: they are comparatively more or less realistic, synthesized, abstract, symbolized, hierarchically organized, etc. Different features of the real world appear in these representations: roads or buildings are located on topographic maps whereas tree species or agricultural crops may also be identified in orthoimagery. These geographic data are provided by national mapping agencies (NMA) such as the French IGN[1], the USGS[2]; industrial/private companies such as Google[3], Microsoft[4]; or participative communities such as OpenStreetMap[5] (OSM). Users can visualize these data through geoportals and can also load them through web services in cartographic applications.

Online cartographic applications invite us to reconsider the concept of "base map" in the context of interactive digital maps (Feyt, 2011). The glossary term of the Open Geospatial Consortium[6] defines base maps as "Spatial data sets that provide the background upon which more specific thematic data is overlaid and analyzed". These layers appear as self-sufficient, do not need anything else to be displayed in a

[1] http://www.ign.fr/
[2] http://www.usgs.gov/
[3] http://maps.google.fr/
[4] http://www.bing.com/maps/
[5] http://www.openstreetmap.org/
[6] http://www.opengeospatial.org/

cartographic application and are able to provide a topographic context to overlaid data. For example, the cartographic API OpenLayers[7] distinguishes base layers from overlays regarding user interactions. Base layers are mutually exclusive layers: it is impossible to visualize two base layers at the same time. Moreover, they define the projection of the map and are displayed under the overlays: they are supposed to provide the necessary information to locate efficiently these overlays on the map. However, mixed cartographic representations emerged in cartographic applications (Raposo, Brewer, 2011). In this paper, a mixed cartographic representation is defined as a representation mixing together different data types or sources by superposition, transparency, merging, etc. Different research works aim at designing new mixed cartographic representations: pseudo-natural maps from OSM data in order to unit cartographic abstraction with natural appearance (Jenny, 2012) or maps inspired by artistic stylized views of the Earth in order to approach realism (Patterson, 2002). Two examples of mixed representations are the Google Maps hybrid representation which superposes road vectors and toponyms on an imagery background and the possible representation in the geoportal of the Swiss federal administration mixing aerial imagery with a color map (Cf. Figure 1[8]). Interactive tools are increasingly integrated into online cartographic applications which allow users to navigate through different data and to modify their visualization. This trend leads us to reconsider the status of base maps: is a base map still a base for the representation if it could be changed? For instance, the Swiss geoportal provides a cursor tool allowing users to navigate from two base maps (Cf. Figure 1), and in doing so, to design mixed representations by transparency:

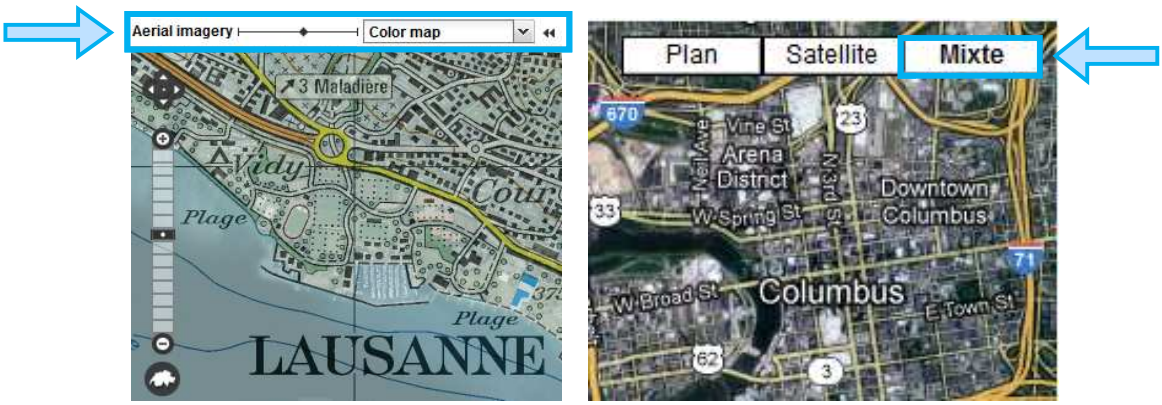


Figure 1 : Mixed cartographic representations from: a) the Swiss geoportal, b) Google Maps

This paper aims to study mixed representations in use in cartographic applications. At first sight, it may sound inconsistent to mix base maps together because of their supposed self-sufficient amount of data. Why are base maps mixed? We wonder if mixed base maps are the result of a technical opportunity or a popular trend, or a really efficient new cartographic representation. The case study presented here focuses first on how base maps are mixed, and second on the resulting efficiency of these representations according to the tasks they are designed for. The first part describes a statistical survey on a panel of carto-websites. The second part provides results about mixed representations while the third part analyses them according to the interactivity and the theme of the websites.

[7] http://openlayers.org/
[8] http://map.geo.admin.ch

Survey on representations mixing orthoimages and map visualizations

Our approach consists in a web survey which aims at analyzing existing mixed representations, their associated personalization tools and the uses of these applications, in order to question the fitness for use of the resulting cartographic applications but also to identify the potential shortcomings of these representations.

Panel of surveyed cartographic applications

The Géoportail[9] (i.e. the French Geoportal) provides to developers an OpenLayers based cartographic API to add dynamic maps on websites. Our survey panel is made of 45 websites randomly selected among these using the API (Application Programming Interface) of the Géoportail (Cf. list in Annex 1). Every website contains a cartographic application allowing an Internet user to visualize a map and most often to interact with it. The Géoportail infrastructure allows webmasters to access geographic data services such as imagery, topographic maps coming from IGN, geological maps coming from BRGM[10], relief and elevation, cadastral parcels, administrative units, transport networks, buildings, hydrography, and institutional partnership data. The choice of this case study based on the French geoportal was guided by the wealth of geographic data provided by the geoportal and the possibility for us to cross observed information with a database recording statistics about the uses of the different layers in the cartographic applications.

Variable sets studied during the survey panel

In order to describe existing representations in our survey panel, we have identified five main sets of variables to analyze: general information, the default base map, the loaded thematic data, the available interactive tools and statistics about the use of these representations as detailed below. In the one hand, most of these variables focus on default choices made by webmasters in order to estimate the potential fitness for use of mixed representations regarding some tasks or user profiles. Default choices mean the parameters of the visualization seen at the first visit of the websites, i.e. the characteristics of the cartographic representation that the webmaster has chosen to propose to the final user of the website[11]. For instance a default choice for a website could be to display an orthoimage or a scan of a map as the base map of the cartographic application. In the other hand, these variables mostly concern two aspects of cartographic user interfaces: some variables describe the design choices of the webmaster whereas other variables describe the resulting interface and cartographic visualization offered to the user. Some variables are then the result of others. For instance, a layer is visible or not by the user depending on if the webmaster defines that this layer is available, displayed, at the top of the layer superposition, and opaque. Furthermore some variables concern interactive tools to modify the representation. Therefore, *what the user sees* is both the result of *what the webmaster designs* and *what the user clicks*.

[9] http://www.geoportail.gouv.fr

[10] France's leading public institution in Earth science applications for the management of surface and subsurface resources and risks : http://www.brgm.fr/

[11] Two of our selected websites have not always the same default choices because they register the visualization parameters of the last users' visit letting them to design their own mixed cartographic representation.

First of all some general information about each website are collected together in order to be able to identify and describe the websites: their name, their URL address and the websites' affiliated organism. In this group of variables, the general theme (hiking, sustainable development, history, real estate, transport, culture, geomatics, tourism, etc.) and the target audience (either a professional public or a general public or both) is also identified among some categories we propose in order to have a first idea on the aims of the websites. Some technical information is also collected about our websites: the API language and version number.

The second set of variables aims at describing default base maps. Collected variables register which base map is available (topographic map, orthoimagery, both of them, etc.) in the cartographic application and how it is designed (displayed or not, more or less transparent, above or below other layers, etc.). These variables aim to define what cartographic representation is visible for the final user. Moreover, the default scale and the size of the cartographic visualization are listed as relevant parameters of the visualization.

The third set of variables focuses on the thematic data. We look at loaded vector thematic layers coming from the Géoportail (hydrography, administrative units, buildings, etc.) but also from webmaster personal database with their structure (uploaded file or web service format) and their geometric type (point, line or polygon). We also analyze whether the user is able to load its own structured data in the cartographic application.

The fourth set of variables lists available interactive tools in order to quantify how the user is able to modify, personalize or adapt the cartographic visualization. Variables enumerate the tools which modify the order of the layers, their transparency level, their visibility and the size of the map. Moreover, the digitization tools are listed as well as the export and import functionalities.

The last set of variables contains statistics processed from an internal IGN database. For each selected website, visits and loaded data have been counted limiting the study to the uses of January 2012. Specific access to the different resources provided by the geoportal has also been collected in order to accurately quantify the uses of the users.

Descriptive statistics about Géoportail visualizations in use

Several descriptive statistics are calculated from the different collected variables. Main results are provided here aiming at analyzing, first, default choices in cartographic representations and, second, available interactive tools.

Mixing topographic map and orthoimagery visualizations

Default base maps are observed for each selected cartographic application. Figure 2 shows the proportions of the different displayed base maps. Some applications use simultaneously different cartographic APIs (Géoportail, GoogleMaps, OSM …), involving that non IGN base maps are observed by default. It should be noted that GoogleMaps and OSM APIs are used when a relief representation is needed. An elevation layer is available through the Géoportail but not with a shaded representation.

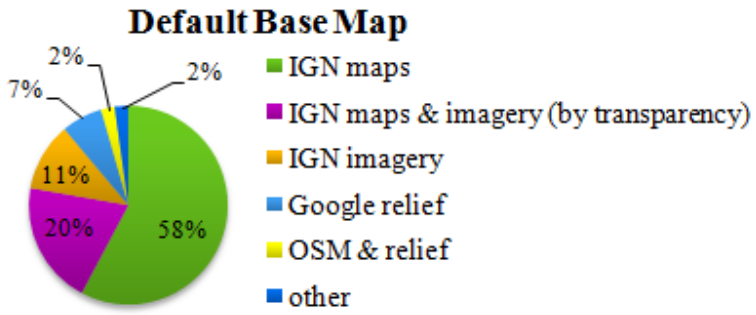


Figure 2: Default base maps of the selected cartographic applications

It is noteworthy that topographic maps are predominantly displayed (by 58% of the cartographic applications) as default base maps. This could be explained by the accuracy of these reference cartographic sources which fits for hiking activities, by the cartographic quality of these representations and by the originality of the displays of unusual base maps for online cartographic applications. Another relevant result is that only topographic maps and imagery background are displayed by default as base maps. The Géoportail though provides other layers that could be used as original base maps such as geological maps or old maps as Cassini which are sometimes available but never displayed by default.Figure 2 shows that 20% of the selected cartographic applications display a mixed cartographic representation by default, mixing IGN maps and IGN orthoimagery by transparency. Once again, we note that mixed representations are only designed mixing topographic map and imagery. The other potential base maps provided by the Géoportail are not used by default to provide mixed representations. Conducting the survey, we note that even though these mixed representations use the same base maps, they are heterogeneous. First, the order of superposition of these base maps is variable: a majority of the selected cartographic applications (49%) display the imagery layer as a background under the map layer whereas 18% of the selected cartographic applications display the topographic map under the imagery. Remaining cartographic applications (33%) does not present a layer superposition, i.e. their base map is fixed or only can be switched among base maps[12]. Second, existing mixed representations of our survey panel present different levels of transparency of both base maps.

Table 1 shows some examples within the survey panel which involve different ways of mixing topographic maps and orthoimagery base maps. The column on the right shows examples where the IGN topography maps are used as background layers. The column on the left shows examples where the IGN orthoimagery is used as background layer. Each row of the table shows different transparency levels from not mixed representations to representations where both base maps are transparently displayed. It appears that existing representations are visually heterogeneous. Representations 1 and 2 display a unique base map. Representations 3, 4, 5 and 6 design mixed representations giving priority to a given base map but adding another one more or less transparently. Particularly, representations 4 and 5 depict mixed representations with a very visible orthoimagery layer providing land occupation information: it highlights that different design choices could create very similar representations. Finally some representations, 7 and 8, display both base maps

[12]For instance: http://www.planorando.com.

with transparency. This design choice fades the mixed background: it allows adding some thematic information but it reduces the readability of both base maps.

	IGN Map backgroung under transparent imagery layer		IGN Imagery backgroung under transparent map layer	
Not mixed representations - one opaque base map - the other one totally transparent	 [13]	**1** Map 100% Imagery 0%	 [14]	**2** Imagery 100% Map 0%
Not much mixed representations - one opaque base map - the other one is very transparent	 [15]	**3** Map 100% Imagery 50%	 [16]	**4** Imagery 100% Map 30%
Mixed representations - one opaque base map - the other one is transparent	 [17]	**5** Map 100% Imagery 80%	 [18]	**6** Imagery 100% Map 70%
Faded Mixed representations - both base maps are transparent	 [19]	**7** Map 50% Imagery 30%	 [20]	**8** Imagery 70% Map 60%

Table 1: Samples of mixed representations

In order to evaluate which way of mixing base maps is more frequently used, we have collected the default transparency level for the topographic map and the imagery layer. These transparency levels are summarized by Figure 3 for the twenty-eight cartographic applications of our survey panel where both base maps are available. Faded mixed have been removed because they are too specific and should be studied separately.

[13] http://www.geml.fr/observations/09/index.php
[14] http://www.camping-frankrijk.nl/campingluchtfoto.asp?CampingID=456736
[15] http://www.parc-naturel-chevreuse.fr/balade-autour-de-paris.html#balades.titre
[16] http://www.wikimaginot.eu/visu.php?id=13872
[17] http://www.openrunner.com/
[18] http://www.valroc.net/html/geo_sentiers21/sage.html
[19] http://www.grande-traversee-alpes.com/gta-gr5/preparez-votre-itinerance/les-etapes?troncon_id=44
[20] http://www.parc-naturel-chevreuse.fr/index.php?id=593&plan=27

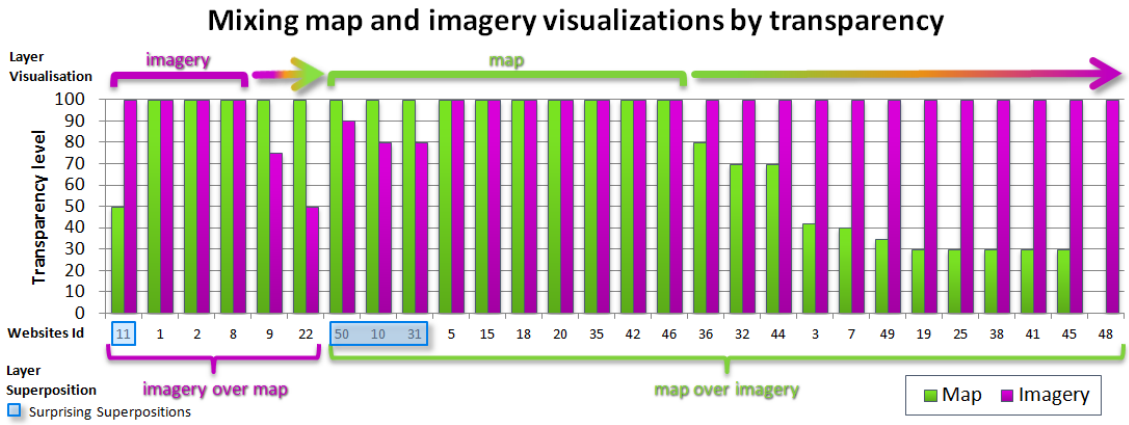


Figure 3: Transparency level of superposed topographic map and imagery base maps.

Figure 3 shows the different combinations of transparency level, the superposition order of the base maps at the bottom, and the resulting visualization for the user at the top. 50% of the representations of Figure 3 actually offer a not mixed representation: they are pointed out at the top Figure 3 by the "**map**" and "**imagery**" inserts. Four of these not mixed representations portray an opaque imagery background and ten portray an opaque topographic map base map. Among these not mixed representations, four are the result of an surprising superposition of layers by the webmaster[21]: for instance, the website 11 displays a transparent map but overlaid by an opaque imagery implying the invisibility of the map for the user. In consequence, these four cartographic applications offer wasted mixed representations. Twelve of the representations (43%) of Figure 3 (pointed out by the right arrow) display a transparent map over an opaque imagery background, like representation 4 or 6 of Table 1, whereas only two (pointed out by the left arrow at the top) of them (2%) display a transparent imagery layer over a topographic map in background, like representation 3 or 5 of Table 1. The diversity of the couples of transparency levels shows that for the time being there is no consensus on the design of cartographic representation in between topographic maps and orthoimagery. However, it is possible to extract general trends about mixed cartographic representations. On the one hand, maps are more often offered as default opaque base maps representations according to Figure 1 and. On the other hand, among the emerging mixed representations, Figure 3 shows that imagery is displayed with priority as a background layer over which topographic map is superposed. Furthermore, as few as three cartographic applications display faded representations, like representation 7 or 8 of Table 1, where both base maps are transparent by default. This could be explained by the difficulty to design a mixed representation by transparency using two traditional base maps together.

Adding thematic information through complementary vector layers

Mixed representations display together some base maps and sometimes thematic vector data are also superposed in addition. Webmasters have the possibility to choose which layer will be available in their cartographic application. Figure 4 shows the availability of the different resources of the Géoportail. For instance, cadastral parcel are available in 22% of the cartographic applications of our survey.

[21] They are pointed in blue in Figure 3.

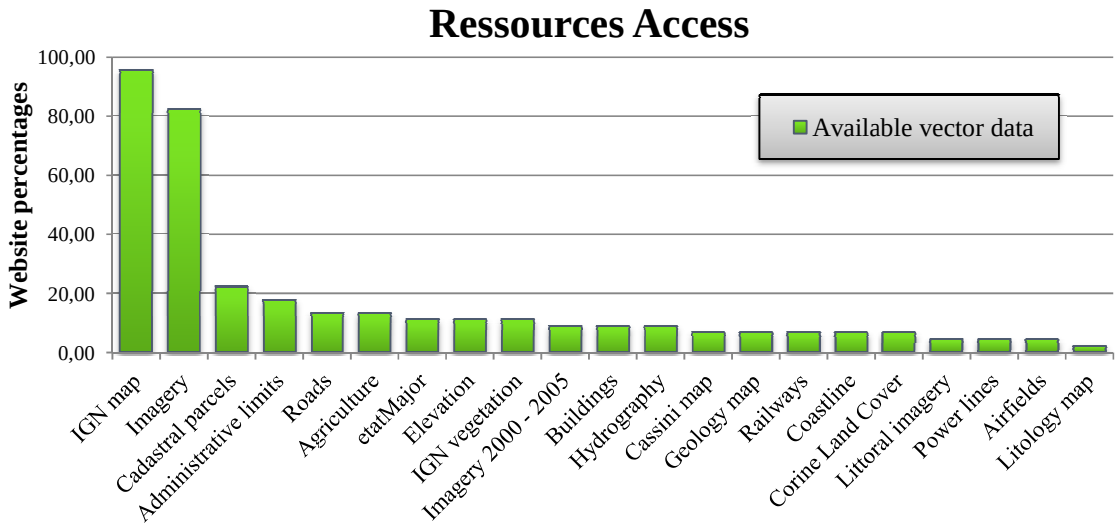


Figure 4: Availability and use of Géoportail data resources

IGN topographic maps and orthoimagery are available in the majority of the cartographic applications of our survey panel (respectively in 95% and 82%). The other resources are sometimes loaded, beginning with administrative information like cadastral parcels, administrative limits and roads. We wonder if this complementary information is available regarding the objective of the website or if webmasters provide as much information as they can to enrich their cartographic application. Figure 5a) shows that a large majority of cartographic applications (69%) only display base maps. Moreover, Figure 5b) shows that the added vector layers are not distributed uniformly through different sites: some webmasters have chosen to provide all the Géoportail resources in their cartographic application.

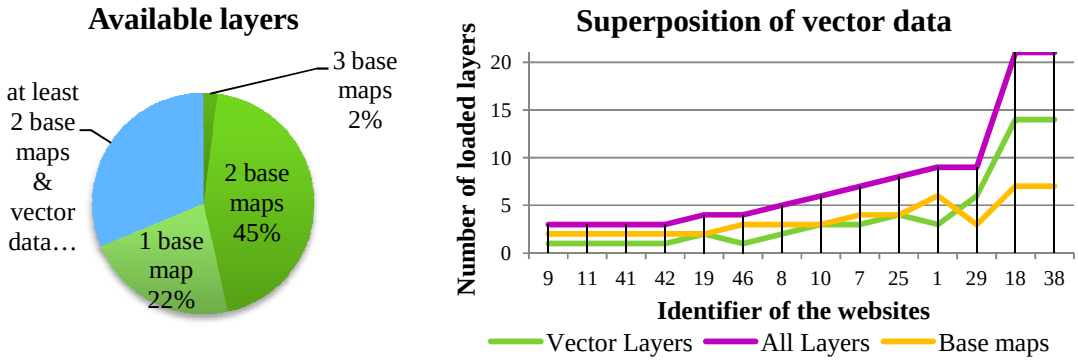


Figure 5: Available quantity of information in the selected cartographic applications

Default scale of the survey panel cartographic representation

Displayed data sets (base maps and thematic information) build up the cartographic representation but this is also defined by the scale of the visualization. The default map scales of our survey panel range from 1:4 000 to 1:8 000 000. Moreover, 20% of the cartographic applications of our survey panel do not have a fixed default scale. The scale of these cartographic applications is adaptive, for instance to hiking trails.

The Géoportail map layer provides a tile pyramid constituted by IGN different maps depending on the scale of the visualization. The proposed maps are the reference one from IGN at each scale (Cf. Table 2).

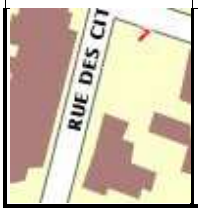
City Map	Topographic Map	Road Map	Road Map	Political Map	Physical Map
Very Large Scales	Large Scales	Medium Scales	Small Scales	Very Small Scales	Very Small Scales
					

Table 2 : IGN Map Type according to the scale visualization

Table 2 illustrates that very different IGN map types (information and graphic legend) are available through the map pyramid of the Géoportail. We wonder if webmasters choose the default scale consistently to user tasks or to their targeted geographical spaces.

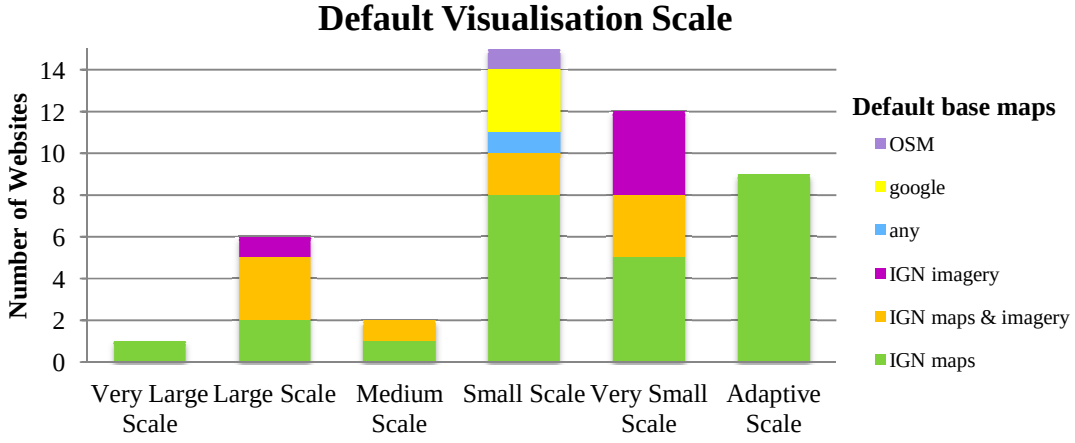


Figure 6 : Default visualization scale depending on the default base maps

First, Figure 6 shows that maps are chosen as default base map for nearly half of the representations for every scale whereas imagery backgrounds are only depicted at large or very small scales. Mixed representations are also offered by default regardless of the default scale visualization from large to very small scales. Moreover, Figure 6 shows that 20% of the cartographic applications offer an adaptive scale (last bar of Figure 6 a)) whereas 80% (remaining applications) offer a fixed scale. Cartographic applications offers adaptive scales when the visualization is dynamically build depending on user's interactions. For instance, websites dedicated to hiking planning widely provide trekking lists: the cartographic application will be generated depending on the chosen trek and its scale will be adapted to the extent of the whole trek. Figure 6 shows that small and very small scales are used in majority (60% of the visualizations). Designing these

representations, webmasters clearly favor the visualization of the maximum extent of the targeted territory (and consecutively the interest of the whole targeted audience). For instance, the official website of the French order of land surveyors[22] provides legal information about the land register for the whole French territory; that is why its cartographic application is by default on a scale of 1:8 000 000. Figure 6 shows also that medium, large and very large scales are not frequently used (20% of all the visualizations). We assume that adaptive and large scales have probably been chosen according to a given user task whereas large and very large have probably chosen because of the big extent of the resulting visible territory. Figure 6 indicates that webmasters mostly favor their targeted audience rather than the efficiency of the visualization when defining the default scale of the cartographic application despite that they surely use the Géoportail because of the availability of reference topographic maps.

Facing cartographic representations to uses and users

We wonder if the existing cartographic representations of our survey panel are consistently designed according to the main aim of the related website. Different aspects of the aim of the studied websites are first studied: the theme of the website, the targeted audience, the user tasks (data visualization, data interrogation) and the available interactive tools. The accesses to the different layers have also been processed from the statistical database of the Géoportail as they convey the effective uses of the related cartographic applications. Then the main aims of the websites and the resulting uses have been faced to the design default choices studied below.

Aspects of the carto-website main aims

Our survey panel contains very different websites according to their theme as shown by Figure 7 even though a majority of the survey panel (53%) is dedicated to different trekking activities. The targeted audience of the survey panel is the general public (87%) in majority; only 7% of the survey panel is only dedicated to a professional audience.

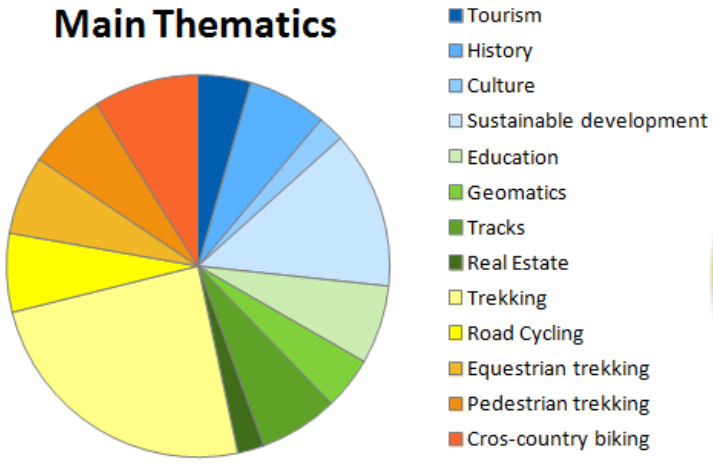


Figure 7: Main themes of our survey panel

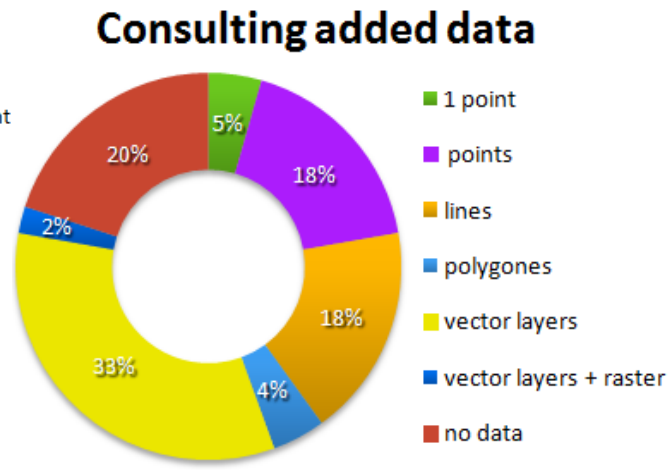


Figure 8: Superposed data to Géoportail base maps

[22] http://www.geofoncier.fr/carto/

During the visit of the websites, users are widely stimulated by different tasks: they are sometimes invited to observe, interrogate, import, symbolized or export data. Figure 8 shows that a majority of the cartographic applications (80%) provide their own data to visualize through more or less complex vector layers. Moreover, 73% of the websites allow the user to query data by click or mouse over interactions which widely open popups providing attributes information. However, only 13% of the websites allows users to load personal data and a very few of them offer to modify their symbolization.

As said above, the current cartographic representation for the user is not only the result of the webmaster design choices but furthermore of its own interaction on the cartographic application. In consequence, it is relevant to study how webmasters make users able to modify the cartographic representation in order to understand the relative significance of the studied default choices and the potential of these applications to offer personalization. Interactive tools studied on our survey panel allow the user to personalize the base map in choosing the visible layers among available layers, in ordering these layers and in modifying their transparency level. Figure 9 shows that a large majority of our survey panel applications provides these three interactive tools. Therefore, users are widely able to create their own mixed cartographic representations. In particular it is possible for them to design faded mixed representations in order to highlight their own data.

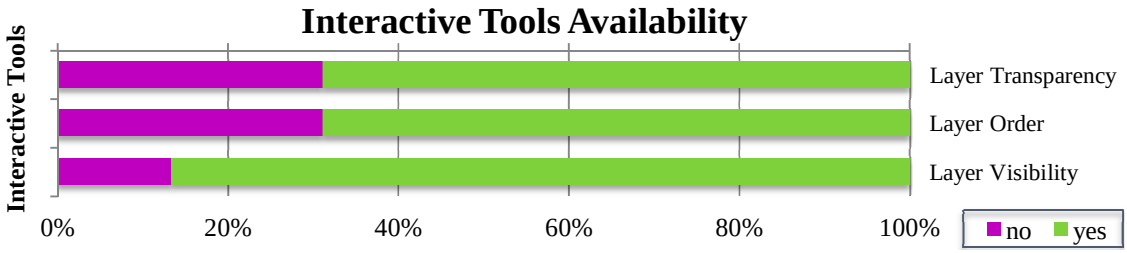


Figure 9: Interactive tools to personalize the base map

Resources' uses

Uses have been processed for each websites distinguishing different layers and for the month of January 2012: they have been calculated by the number of sessions that have loaded a layer divided by the number of sessions that have visited the website in order to identify first which sites involve the use of a given layer and second for a given site which layer is relatively more used than the others.

Consistency between website aims, resulting uses and design choices

All the compiled variables have been analyzed by a multiple correspondence analysis[23] (MCA). The default base map, scale, map type and base maps transparency levels have been selected as active variables conveying the default design choices whereas the main theme, the availability of interactive tools, the user tasks have been studied as supplementary variables. Uses have been faced to the results as quantitative supplementary variables.

[23] Data have been processed using the free software R. (Cf. http://www.r-project.org/)

Both illustrations of the Figure 10 shows the MCA first factor map which both axes explain almost 40% of the variance between the different studied cartographic applications regarding active variables, i.e. the representation design. Figure 10 a) shows the repartition of the categories of the qualitative variables: active variables in red such as "MapType_Topo", "MapType_road", "MapType_world", "MapType_adaptive", "MapType_null", which are the categories of the "MapType" variable, and illustrative variables in green. Figure 10 b) shows the quantitative variables which above all convey the uses of the different available layers and the global "Attending" of the websites.

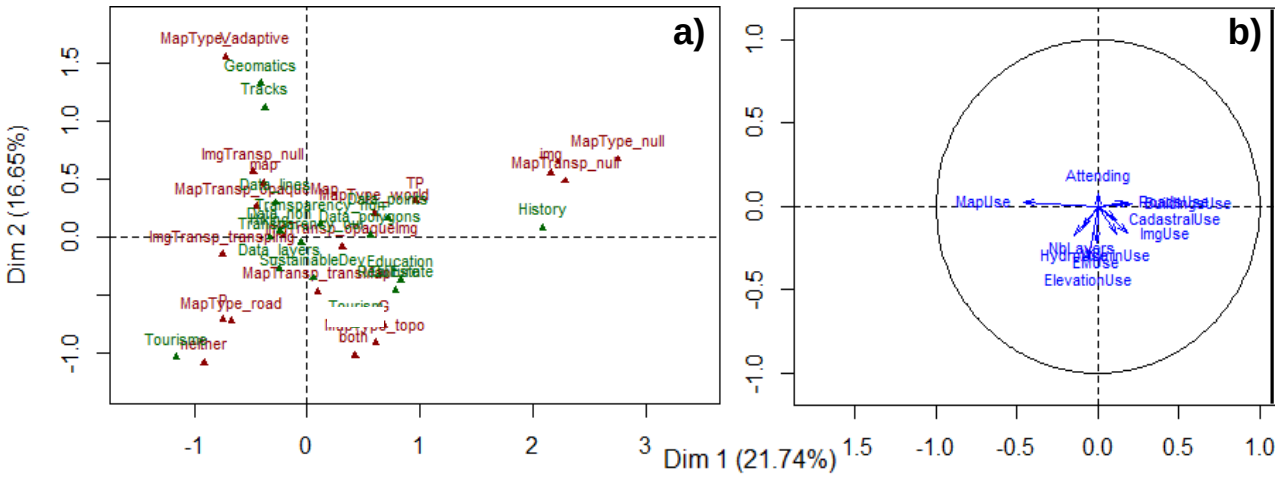


Figure 10: MCA Factor Map; Result of the multiple correspondence analysis of the survey.
a) MCA active and supplementary qualitative variables. b) MCA supplementary quantitative variables.

The common first axis (on the abscissa) conveys the opposition between cartographic applications which depict topographic maps (depicted by the "MapTransp_opaque" category of the map transparency variable, the "map" category of the default base map variable, etc.) and those using imagery background layers (depicted by the "MapTransp_null" category of the map transparency variable, the "img" category of the default base map variable, etc.). Mixed representations are located in between of this axis whereas cartographic representations that portray another default representation (superposed vector layers, Google Maps or OSM relief representations which are depicted by the "neither" category of the default base map variable) are closer to applications favoring map representation. The common second axis (on the ordinate) focuses on whether cartographic applications are adaptive or not: the scale and thus the map type could be adaptive or fixed by default by the webmaster.

Looking at Figure 10 a), in the one hand, it is noteworthy that "History" dedicated websites favor cartographic representations with a background layer whereas "Touristic" or "Hiking" websites favor map like representations. In the second hand, "Geomatics" and "Tracks" dedicated websites offers scale adaptive cartographic applications.

Looking at Figure 10 b) it is obvious that the map and the imagery layers are more loaded respectively in cartographic applications which favor map like representations and imagery background layer. Therefore, it is noteworthy that the cadastral parcels, the roads and the administrative limits (respectively depicted by the "CadastralUse", "RoadUse" and "AdminUse" variables) are more used superposed to an imagery background layer.

Conclusions

This paper sets out the results of a statistical analysis of a survey on a panel of 45 cartographic websites using the Géoportail API. Existing design choices have been studied from mixed representations in use and faced to the aim of the related applications and their resulting uses. This study draws general trends about mixed representations: topographic map are mostly used opaque whereas imagery layers are often used as background layers, scale is mostly defined regarding the targeted geographic space, and specific vector data are frequently superposed to an imagery background.

The emergence of mixed cartographic representations becomes manifest in the light of this survey of online cartographic applications. However, the high diversity of existing designs highlights the difficulty of defining an ideal mixed cartographic representation by consensus. The inconsistency of the superposition by transparency of traditional base maps initially designed as self-sufficient is clearly identified as a persistent scientific bottle-neck to design efficient mixed cartographic representations. The design of these new representations can not only be a succession of superposition order and transparency level considerations. Therefore, main results of the survey will be used in our PhD thesis, focusing on representations between abstraction and realism, in order to make sophisticated mixed cartographic representations. We assume that these representations could be used as new base maps. For instance, they could use efficient parts of available base maps in order to create in between representations that portray the “best” of each initial base maps without losing the readability of the remaining parts.

The high availability of interactive tools questions predefined traditional base maps: the user is increasingly invited to personalize the visualized representation. The base map thus becomes more adaptive and more dynamic depending on the user needs, the territory, the scale, and the application aim. One of the foreseen research issues of our PhD thesis is that the base map could change through the depicted territory using different symbolizations of the superposed features depending on their local graphic environment. Finally, we wonder who should make the map and especially the base map. *In between cartographic representations* and *interactive navigation tools* through these representations could thus be a way to invite the user to participate to the conception of the base map. The objective of both hopefully forthcoming results of our PhD these aims at guiding the user by available cartographic expertise. Thereby, the cartographer will offer an opportunity to the user to browse safely in between cartographic representations without the risk of damaging the readability of available base maps.

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Annexes

Annex 1: Sites Panel

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