A PROCESS TO DESIGN CREATIVE LEGENDS ON-DEMAND

Sidonie Christophe, Anne Ruas
Laboratoire COGIT – Institut Géographique National, 2/4 avenue Pasteur
94165 Saint-Mandé cedex
http://recherche.ign.fr/labos/cogit/
{sidonie.christophe, anne.ruas}@ign.fr

Abstract
Current cartographic tools allow technically novice and expert users to make maps. However resulting legends may be of poor quality because of the lack of cartographic and visual perception knowledge. The purpose of our research work is to help users to select good sets of colours in order to build a legend that is *satisfactory* for them, i.e. that fit their tastes and needs, and *correct*, i.e. that respects cartographic rules. We propose a *design process* made up of three steps: identification of user's preferences on colours, proposition of suitable legends, and refinement of legends. Two strategies respecting this process are implemented with the help of *map samples* and *painters' palettes*.

Keywords: cartography, colours, legend design, cartographic constraints, painters' palettes, map samples, visual perception.

Introduction
Functionalities of cartographic rendering offered by current cartographic tools allow *technically* novice and expert users to make good and bad maps: problems of legibility and efficiency of the cartographic message conveyed by the map are often highlighted (Monmonnier 1991, Krygier & Wood 2005). In fact these tools do not offer help to users during their map design process. Moreover, they do not evaluate the quality of the cartographic productions. A main issue is the design of the map legend in terms of colours' selection: on the web, by default renderings of data are overlaid without any evaluation of the consistency of these overlaying.
In this paper we present research results from a PhD thesis in progress in the COGIT Laboratory where we are working on vector geographical data and on graphic representation of these data in particular. The main purpose of our research work is helping users to select good associations of colours to make a good legend. The aim of the work is to propose legends that best fit the user's needs while respecting some cartographic rules. For that, we evaluate both the design process and the legend in progress.
The paper starts with the specification of our purpose of helping users to make a legend and states that the main problem we have to solve is to correctly associate colours to users' themes. Then we propose a legend design process made up of three steps. Finally we present our prototype system and the implementation of strategies, with the help of map samples and painters' palettes, relying on this legend design process.

I- Helping users to make legends in selecting good colours

In this part we specify our purpose of helping users to make legends. We first analyse existing works related to legend design and then describe the main problem we have to solve.

Some works focusing on legend design:

- UMapIt (Unrestricted Mapping Interactive Tool) developed by the University of Laval allows users to personalize a map based on the following functions: selecting themes and objects within themes, selecting a geometric representation for an object – based on a multi-representational database-, modifying the symbol of a theme, modifying the symbol of an object (Bernier et al. 2005).
- Brewer (2003) proposes an online tool to help users in finding efficient colours for their thematic maps. The ColorBrewer[1] (Brewer 2005) produces a set of colour schemes adapted to users' needs, described with two criteria: the number of classes in the legend and the type of relation between the classes (sequential, diverging and qualitative). Once users have a colour scheme, the ColorBrewer applies it to a default map. This allows users to have a visual overview of what colours yield when they are associated in a legend. The ColorBrewer is made for users who need to make a nice thematic map, but have neither expertise nor time to analyse colour schemes and their suitability.
- Chesneau (2006) contributes to improve legends by evaluating and enhancing colour contrasts in a given map. Chesneau's tool calculates colour contrasts in existing maps and checks if they correctly render relations (association, difference, order) between themes. Besides it suggests new colour schemes. Improvements of the system as well as alternative processes are presented in (Buard & Ruas 2009).

These works are important steps in the on-demand legend design process domain. We state that users' help could be improved, mainly in adapting the propositions to various types of users, from novices to experts: novices do not know specific vocabulary of cartography, and may face difficulties to use these tools. Moreover we would like to propose to users many various legends according to their preferences, still efficient but original. The legend design process consists in finding colours to render themes in the legend and to associate them correctly. The Figure 1 shows the rendering of topographical data according to cartographic constraints: conventions and contrasts.

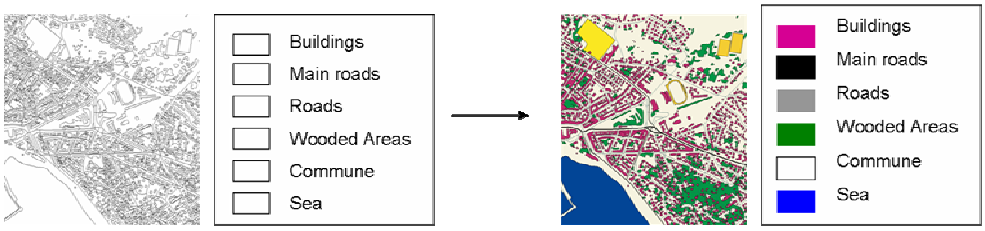

Figure 1 : Legend design process

[1] http://colorbrewer2.org/

According to the wide range of colours that exists, this problem has an infinite number of solutions. In order to restrict the number of possible solutions and to fit the users' needs, their preferences must be taken into account: they have preferential colours or more adapted to their needs. Moreover cartographic expertise should be used to assist in making good decisions about the suitability of one colour for a theme. So we consider our main problem to solve as the search of correct associations of colours to user's themes, according to user's and cartographic constraints.

II- Correct associations of colours to user's themes

The problem of making correct associations of colours to user's themes can be solved by a process that manages user's preferences and cartographic constraints together. We propose a process composed of three main steps, based on human-machine interactions: 1)- identification of user's preferences, 2)- proposition of suitable legends according to constraints, 3)- refinement of legends. Each step is supported by several interactions with the user, in order to converge towards best results.

1- Identification of user's preferences

The first step consists in identifying u*ser's preferences* i.e. that concern all preferences about colours the user may have. We want to obtain two types of user's preferences presented in Figure 2: "*I like this colour*" and "*I like / I do not like this colour for the road theme*", but also "*I have no idea*". These types of preferences give two types of user's constraints: a colour is approved/disapproved independently to a theme (*constraint on colour*) or a colour is approved/disapproved for a specific theme (*constraint on a theme*).

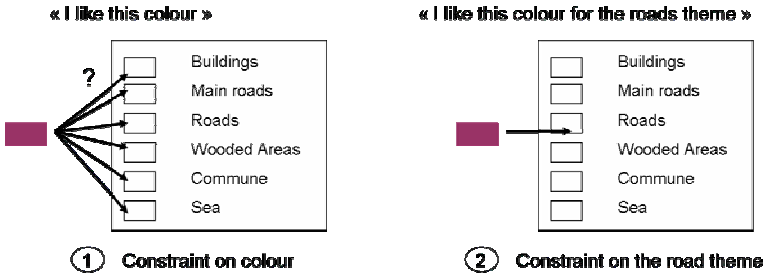

Figure 2 : Types of users' constraints

The system is not supposed to know the level of knowledge of the user and should work for novices and experts. The purpose is not to make them fill a complete form about their needs. We first assume that by default they do not know exactly what they want in terms of colour. In order to make this step of identification of preferences efficient, we propose to make users manipulate some specific objects allowing analogical reasoning that they could comment:

- *Map samples* are maps of the same zone with various legends that support cartographic rules (Dominguès & Bucher 2006)(Figure 3). It is easier to work

with map samples in order to have an idea of existing correct legends and to state on colour preference.

Figure 3 : Some map samples for urban/sea data types (Dominguès & Bucher 2006)

- *Painters' palettes* are extraction of harmonious colours from famous paintings (Christophe 2009)(Figure 4). Users may select colours independently to themes or colours for a specific theme.

Figure 4 : Some palettes coming from Matisse[2] and Le Titien[3] (Christophe 2009)

2- Propositions of suitable legends

The second step consists in proposing legends adapted to both user's constraints established during the previous step and some cartographic constraints. In order to integrate this knowledge, we represent them jointly in a set of constraints. Some fundamental cartographic constraints coming from graphic semiology have been identified (Robinson 1952, Bertin 1967, MacEachren 1995) and are used in the COGIT Laboratory for researches related to legend design and graphic semiology (Christophe 2008, Dominguès et al. 2009, Buard & Ruas 2009). All, some or none themes may be commented by the user, thus constrained. So we try to meet a situation where we have possible colours for all themes. Several cases appear:

- When we have user's constraints on each theme, we test each approved colour for a theme, according to the constraint "*Different themes have different hues*". Figure 5 shows an example of this situation: each theme has several approved colours and three different legends are proposed.

[2] Henri Matisse, *La Tristesse du Roi*, 1952, Centre Georges Pompidou, Paris, France, ©Succession H. Matisse

[3] Le Titien, *La Vierge au lapin*, ap. 1530, Musée du Louvre, Paris, France.

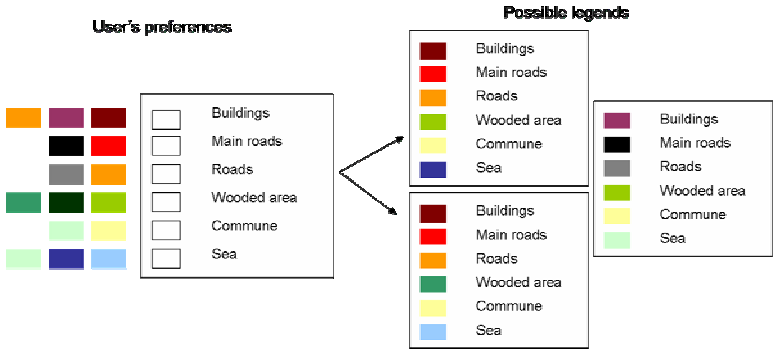

Figure 5 : To associate approved colours to corresponding themes

- When we have user's constraints on some themes, we find possible colours for the non-constrained themes. We first use conventional constraints: "*Sea is rendered by the Blue Family*", and "*Wooded area by the Green Family*". Then, "*Background should be clear enough*" so we find the clearest colours for it. For the other themes to set, if we do not have associated Colour Family, we apply constraints according to the relations between themes: in Figure 6, the roads theme should have a similar hue to the main roads theme, *to render an associative relation*. Once we have possible colours for all themes, we test all possibilities.

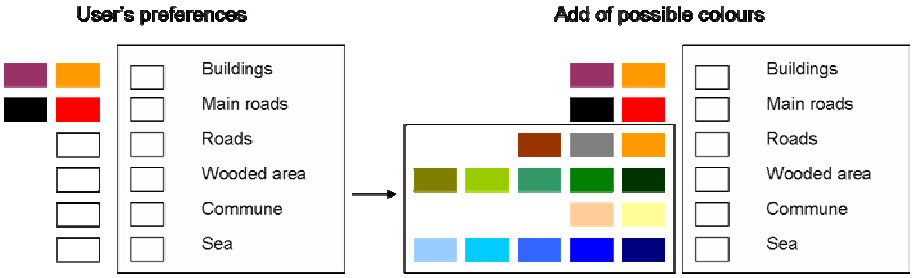

Figure 6 : To find possible colours for non constrained themes

- When we have user's constraints on colours, we set the approved colours to existing themes, according to the conventional and contrast constraints (Figure 7). Then we test all possibilities.

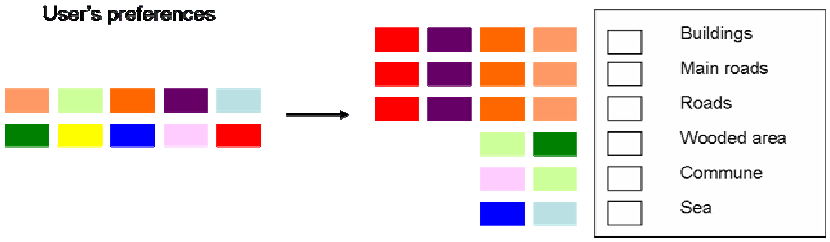

Figure 7 : To associate approved colours to correct themes

During this step, several recursive interactions may happen in order to propose various suitable colours and also the best combinations of colours, and finally to converge towards the most satisfactory proposed legends. Once we obtained these legends, the user may select some of them for refinement.

3- Refinement of some propositions

The third step consists in refining legends with the help of adapted palettes, in order to improve them. According to the theme to modify, a proposition of suitable colours is done. For instance, if the user tries to modify the current colour of the sea theme, we propose a palette of various values of the current hue, a palette of other conventional hues, i.e. various colours of the Blue Family. If the user was using a painter's palette during the first step, we propose available colours of this current palette.

III- Prototype System: COLorLEGend

In order to proceed well, a dialogue between the user and the system is implemented (Christophe 2008). A controller of dialogue manages the design process presented in the previous part, as *design strategies*. We present first the functionality of evaluation of the controller. Then we describe the implementation of the design process through two design strategies based on "Map Samples" and "Painters' Palettes".

Evaluation

At each interaction with the user the current constraints are evaluated:

- Detection of any inconsistency between constraints: if several constraints are inconsistent, the controller proposes to the user to choose one among them. For instance, the user may say that he likes a blue colour for the "sea" theme, while he may have said that he does not like this colour before.
- Detection of an over-constrained situation: the dialogue may also be unsolvable because of the current users' constraints: a relaxation of some constraints should be done, and the user has to validate which constraint has priority.

Measures of the good progress of the design are implemented. Three states are particularly computed by the system:

- The *user mark* measures his satisfaction, i.e. if his preferences are taken into account or not.
- The *cartographic mark* measures the respect of cartographic constraints.
- The *system mark* measures the good progress of the dialogue.

Thanks to the global monitoring of the design process, current constraints are permanently evaluated, and if something gets wrong, the controller is able to backtrack, to propose alternatives, to go to the next step.

Legend design Strategies

At the beginning of the dialogue, the controller proposes to the user to select one of two design strategies: the "*Map Samples*" one or the "*Painters' Palette*" one. These

strategies rely on the plan made up of three steps of legend design process. If something goes wrong during the process, the controller is able to stop the current strategy and to propose the other to improve the process. Strategies use the chromatic circle proposed by (Chesneau 2006, Buard & Ruas 2009) to handle cartographic constraints.

"Map Samples" Strategy

This strategy aims at proposing map samples to a user and makes him choose some colours of legend from several samples and put them together in new legends. Figure 8 presents the process of this strategy.

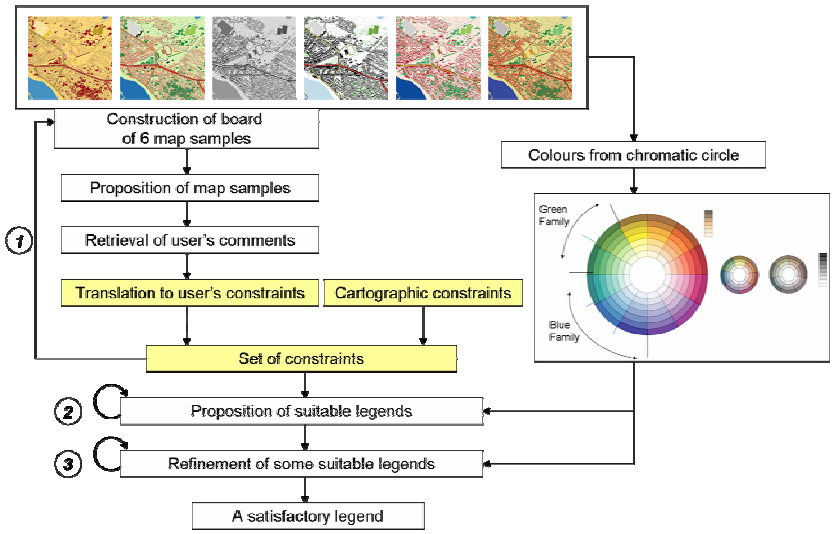

Figure 8 : "Map Samples" Strategy

During the step 1, a board of six map samples is proposed to the user: he can comment samples or colours. The strategy proposes suitable boards of samples again until he has entered all his preferences. User's preferences on colours are then translated into constraints. Figure 9 presents an example of colours approved by a user.

Figure 9 : Example of user's approved colours

During the step 2 conventional and contrast constraints are used first to verify user's preferences and then to apply them correctly. According to the preferences displayed in Figure 9, several possible legends are built. Two of them are presented in Figure 10.

Figure 10 : Two possible legends from map samples

The user can then select some of them that seem satisfactory for him, in order to improve them with the refinement tools of the step 3, until the validation of a most satisfactory one.

<u>"Painters' Palettes" Strategy</u>

The strategy based on painters' palettes aims at proposing several colours' palettes to the user, and makes him select some satisfactory colours among them: the user can select a palette, and comment one by one, the colours or the colours for a theme he likes or not. The system warns him if the selected colour is considered as not conventional for a theme. Figure 11 presents the all process of the strategy with the help of our "Derain palette".

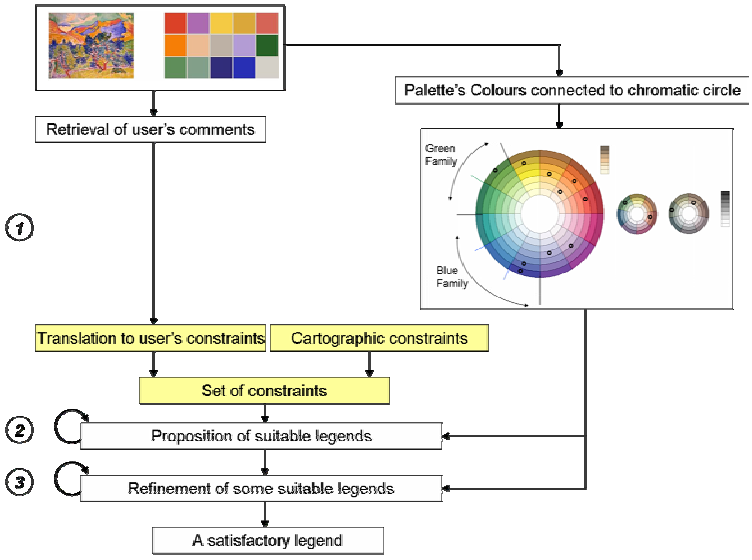

Figure 11 : "Painter's Palette" Strategy (with Derain)

Figure 12 presents three possible legends based on the Derain palette on an urban/sea zone. The first one is not conventional because of the colours of wooded areas and sea. With the help of chromatic circle, conventional constraints are applied and the two following legends are proposed. We notice that the system selects the clearest colour of the palette to render the background: this constraint could be considered as a limit between graphic and cartographic works. The other colours of the Derain Palette may all be used for the other themes.

Figure 12 : Three possible legends from the Derain palette on an urban/sea zone

Conclusion

Our main proposition to solve the correct association of colours to user's themes is a legend design process made up of three steps: identification of user's preferences on colours, proposition of suitable legends according to a set of user's and cartographic constraints, refinement of legends. We have implemented two design strategies relying on this plan, with the help of map samples and painters' palettes. These strategies take part to a global human-machine dialogue. A prototype COLorLEGend is implemented.
We have now to improve the interpretation of user's preferences on colours in taking into account the cartographic context of the colour, i.e. other contrasts of colours. We rely also on a cartographic representation knowledge base that we are building in the COGIT Laboratory. We are also working on characterization of colours' harmony in maps in order to propose more evaluation tools as contrast, harmony and cartographic marks. Tests of the prototype COLorLEGend are under progress.

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