A dedicated Geographic Exploration Interface for the monitoring of worldwide Farm Animal Genetic Resources

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1. Introduction

Within the branch of agriculture, livestock sector is presently facing important stress due to modern farming. Artificial selection and controlled reproduction, combined with natural selection, gene flow, and genetic drift processes, gradually lead to a general loss of genetic diversity among species and breeds, which may potentially cause damaging effects like loss of breeding stock (Bruford et al. 2003). Consequences are of global concern and sustainable solutions have to be found to optimally conserve livestock genetic resources diversity as we are confronted to an accelerating extinction crisis (Luikart et al. 2003).

To face the thread, the Environment Programme of United Nations (UNEP) wrote the Convention on Biological Diversity (Rio Earth Summit 1992) and charged nations to identify and monitor their biodiversity, to share the resulting data, and to integrate the conservation and sustainable use of biological resources into national decision-making. On this basis, Food and Agriculture Organization (FAO) initiated a global strategy for the management of Farm Animal Genetic Resources (FAnGR) aiming at conserving livestock biodiversity. Since then, many research projects on FAnGR produced genetic data characterizing livestock worldwide, but also socio-economic and environmental data describing the places where the species and breeds are raised.

One of the 13 priority areas of action for conserving the world's FAnGR is to gather all the collected information in an internationally accessible information system to carry out global surveys of the molecular genetic diversity of the major livestock species (FAO 2006). An increasing proportion of these genetic data is georeferenced giving the opportunity to make use of geographic information to facilitate the management and to enrich the analysis of FAnGR. Analyses carried out in the framework of a European project called ECONOGENE (www.econogene.eu) well illustrate this approach.

In this paper, we propose a dedicated Geographic Exploration Interface (GEI) on the Internet able to exploit genetic, socio-economic and environmental data to watch over the global state of FAnGR, and to support conservation decisions. This research comes within the scope of GLOBALDIV, a european project for the dissemination of current advanced and integrated methodologies for the characterization, evaluation prioritization and conservation of livestock genetic resources (www.unicatt.it/zootecnica/globaldiv).

2. Online dedicated geographic exploration interface

New interactive visualization tools are presently developed in the GIScience community to deal with large, complex datasets and concurrently sizeable and complicated analytical tasks (Dykes et al. 2005). The goal of these systems is to establish connections between different categories of information (in our case: genetic, socio-economic and environmental data) to grant experts access to integrated views. Interactive and dynamic maps or graphics are increasingly used to explore information across disciplines.

2.1 Coordinated and multiple views in exploratory visualization

Geovisualization (MacEachren and Taylor 1994) considers the interactive and dynamic representation of geographical data for exploration, analysis, explanation and presentation purposes (DiBiase 1992). The field of GIScience provides the scientific community with concepts, methods and technologies to support the visual exploration and communication of spatial phenomena. Both interactivity and dynamics allow end-users to interact with the interface in order to conduct their exploration, to manage the multiplicity of representation forms and scales, and also to expand their field of perception to new views. Several web, desktop or mixed solutions like GeoVista Studio, SOLAP, or CommonGIS, exist under the designation Geographic Exploration Systems GES (Dykes 2005) on the one hand, and Interactive Atlases IA (Hurni 2004) on the other hand (Pointet 2007).

2.2 FAnGR experts as end-users

Experts interact with geographical exploration tools in the context of problem solving activities, and this endows information and its processing with meaning. The characteristics of end-users and their concern are therefore important and have to be taken into account to adjust the solution. FAnGR specialists, as end-users, have a commanding expertise of the investigated theme but were never confronted with spatial data and analysis. The design of an online GEI deals with the challenge of providing experts with a message to be complex in content and simple in use.

2.3 Communication interface

The constraints identified place the adapted solution half-way between the GES and the IA. The ongoing development of an online dedicated GEI is based on a progressive design process in which Geographic Information specialists and third party discipline experts are taking part (Pointet 2007).

This application is a coordinated and multiple views exploratory visualization interface allowing users to rapidly and interactively browse and query multiple dynamic views (graphs, tables, maps, etc.). It consists of a Graphical User Interface GUI on top of analysis and representation components, constituting an application implemented on the Internet. Mouse and keyboard are used to navigate in thematic, temporal, and spatial spaces. In order to keep to the progression of the user's exploration and to restrict the amount of transfered information, data are dynamically retrieved and aggregated from the remote database. The selected technology is based on a SVG graphical interface coupled with a Javascript interactivity and rendering engine, allowing an AJAX retrieval of information from a spatial database. The information is dynamically dispatched to the various representations (fig.1).

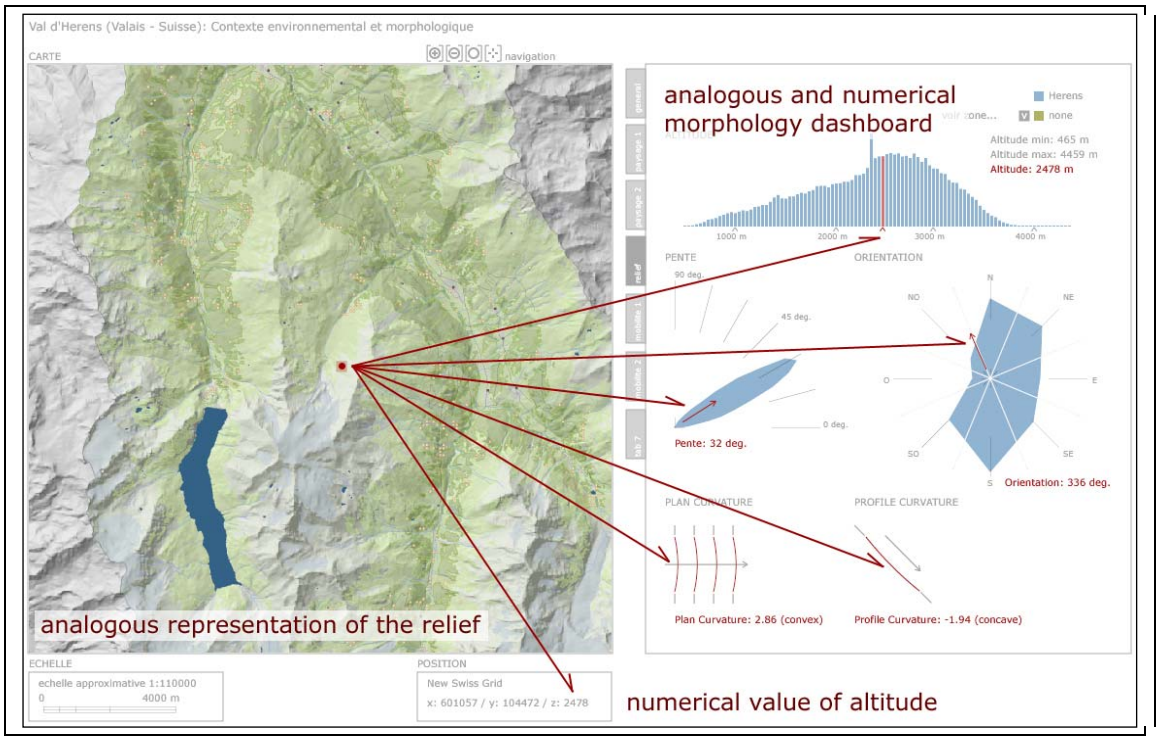

Figure 1. Overview of the dedicated Geographical Exploration Interface and its visualization elements (map, graphs, symbols and text) here applied to geomorphology. Changing the cursor location over a Digital Elevation Model dynamically displays local altitude, slope, orientation and curvature inside interactive graphs.

3. Discussion

Conservation decisions should be informed by optimum combination of information on functional genetic diversity. But current decision aids are focused primarily on genetic diversity only, while they might consider other factors, such as social and cultural value of different breeds. The solution we propose here is particulary well suited to provide such a transversal multidisciplinary view to experts. It makes it possible to *analyse*, *represent* and *communicate* data of different types and from different disciplines (genetics, socio-economics, geoenvironmental), placing them in a spatial framework in order to draw a complete picture of diversity in the context where it is to be conserved.

3.1 Expansion of the role of representation elements

The proposed interface highlights a shift to new roles for the representation components. The visualization elements (maps and graphs) are primarily informative, and also interactive. Moreover, “analogical” and “numerical” representations are coordinated and grouped in a single digital interface to take advantage of the evocative nature of the former and of the reinforcing character of the latter. This expansion of roles implies changes in the way users interact with the information, empowering their interpretation through iterative exploration of visual elements.

3.2 Favouring the integration of spatial analysis and GIS

In addition to the service provided to the field of FAnGR, the application described in this paper also addresses a recognized major drawback in GIScience which is the lack of integration of spatial analysis and Geographic Information Systems (Goodchild 1992; Marble 2000). Despite a slight improvement (new reasonably priced GIS, open source GIS), this lack of integration persists in desktop applications, or more precisely the integration is often still detained by the cost of additional modules containing spatial analysis intelligence.

On the Internet, this integration remains infrequent. An overwhelming number of WebGIS solutions only show and represent information. The dedicated GEI presented here is a first step towards the incorporation of spatial intelligence, before concretely offering online spatial analysis services as described in the next section.

3.3 Towards online computational geoservices

The interface we present here is one among several applications to be developed at the intersection of genetics and GIScience (Joost 2006). The GEI can be improved with the addition of different useful tools like classification algorithms, correlation processing, or discretization capacities for example. But our main ambition is to transpose advanced spatial analysis functions in order to offer online computational geoservices, to start with applications dedicated to population geneticists. A first project is to be launched in Landscape Genomics, a recent field aiming at detecting signatures of (natural) selection within the genome of animals and plants.

4. References

Bruford MW, Bradley DG, Luikart G, 2003, DNA markers reveal the complexity of livestock domestication. *Nature*, 11(4):900-910.

DiBiase D, 1992, Animation and the Role of Map Design in Scientific Visualization. Cartography and Geographic Information Systems, 19: 201-214, 265-266

Dykes J, MacEachren A, Kraak M, 2005, *Exploring Geovisualization.* Elsevier Science, Amsterdam, Netherlands.

FAO, 2006, Options and Strategies for the Conservation of Farm Animal Genetic Resources. Domestic Animal Diversity Information System (DAD-IS), Rome, 2006 (http://dad.fao.org/).

Goodchild MF, 1992, Geographical information science. *International Journal of Geographical Information Systems*, 6 (1):31-45.

Hurni L, 2004, Vom analogen zum interaktiven Schulatlas: Geschichte, Konzepte, Umsetzungen, *Wiener Schriften zur Geographie und Kartographie*, 16, 222.

Joost S, 2006, The geographic dimension of genetic diversity: a GIScience contribution for the conservation of animal genetic resources. PhD thesis no 3454, Ecole Polytechnique Fédérale de Lausanne (EPFL).

Luikart G, England PR, Tallmon D, Jordan S, Taberlet P, 2003, The power and promise of population genomics: from genotyping to genome typing. *Nature*, 12(4):981-994.

MacEachren A, Taylor F, 1994, *Visualization in Modern Cartography*. Elsevier Science, New York, USA.

Marble D, 2000, Some thoughts on the integration of spatial analysis and Geographic Information Systems. Geographical Systems, 2:31-35.

Pointet A, 2007, Rencontre de la science de l'information géographique et de l'anthropologie culturelle: Modélisation spatiale et représentation de phénomènes culturels. PhD thesis no 3789, Ecole Polytechnique Fédérale de Lausanne (EPFL).