RIADE, ACS, GRASS strikes again:-) research, business and free software

NVIZ site management: variable attribute (size/color), LUTs, picking and multimedia

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ABSTRACT

This is a **second article** related to the project RIADE that we (the ACS GRASS Free Software Development Team) presented on the previous edition of the GRASS meeting, hence the title :-)

After our previous development regarding the **Flythrough** and **Time Series** management, we have turned our attention to further enhancements of **NVIZ**, the GRASS 3D visualization tool, in the belief that **3D visualization** of **multiple variable** at the same time can be a **key factor** for unveiling hidden behavior and exploiting new results in research.

Here we present the development of **new features** that we have added after our previous work. These are mainly related to the enhancements of the **NVIZ *site* management** that allows:

1) to visualize **each point** in a **different attribute** (color, size, marker) depending on **associated data**, in order to visually get immediate spatial patterns for one ore more variables at the same time;
2) to manage color and size **Look Up Tables** (LUTs) to be used by one or more sites, in order to exploit time series of different variables with the same size or color schemes to understand effective variations;
3) to access the information stored in the **associated database** directly by **picking** the objects of interest;
4) to access **external multimedia data** related to the objects of interest as a **hyperlink**;
5) to customize **highlighting** of the selected 3D site points.

RIADE (*Ricerca Integrata per l'Applicazione di tecnologie e processi innovativi per la lotta alla DEsertificazione*) (Integrated Research for the Application of innovative processes and technologies for fighting Desertification) is a project co-financed by MIUR (Minister for Education, University and Research) for developing an integrated and technologically innovative information system for monitoring desertification processes in South Italy, with the aim to promote interventions for the safeguard of the territory.

ACS is the **technological partner** of the RIADE consortium, that includes also **ENEA** (Agency for New technology, Energy and Environment) and Desertification Research Group (**NRD**) of the University of Sassari (**UNISS**).

This work shows once again how the free software can represent a **convenient (business) opportunity** for a private Italian firm that mainly develops **software on commission**.

Introduction

RIADE (*Ricerca Integrata per l'Applicazione di tecnologie e processi innovativi per la lotta alla DEsertificazione*) (Integrated Research for the Application of innovative processes and technologies for combating Desertification) is a project co-financed by MIUR (Minister for Education, University and Research) for developing an integrated and technologically innovative information system for monitoring desertification processes in South Italy, with the aim to promote interventions for the safeguard of the territory.

Despite the considerable patrimony of experience and knowledge related to desertification, only rarely the results of studies have been turned into structured and integrated systems. This is largely due to focusing on local conditions or on individual processes rather than on their complex interaction. In the effort for understanding a phenomenon that involves geology, soil science, climatology, hydrogeology, agronomy and forestry, interdisciplinary synergy is a key issue. A more holistic and systematic approach to desertification through an integrated project such as RIADE has been developed.

RIADE is a three-years research project (2002-2005) carried out by Advanced Computer Systems A.C.S. S.p.A., ENEA (National Agency for New Technology, Energy and Environment) and the Desertification Research Group (**NRD**) of the University of Sassari (**UNISS**), whose scope is to realize a structured and complex system for combating desertification. It shall provide a set of products for desertification modeling and forecast but also a decision making system for supporting the public administration in the environmental planning processes.

The project starts with the selection of a set of service-case areas, covering the Sardinia, Basilicata, Puglia and Sicily regions. In fact the Regions of South Italy are considered to be mostly at risk of desertification, where the phenomenon represents a real environmental emergency, which strongly influences the socio-economical development of the areas.

Among the requirement of the RIADE project, there was the need to manage very heterogeneous data geographically and temporally organized, to visualize in 4D (3D + time).

The choice of the software tools to use and develop has fallen on GRASS for its technical features, for its integration with PostgreSQL, PostGIS e QGIS and also because, being free software, it decreases the problems and costs linked to the licenses of the proprietary software for the final users (mostly public researchers).

The features included in the GRASS distribution and in the other chosen modules didn't solve all the project requirements. ACS task has been to build an *end to end* solution, by integrating all the packages and implementing the missing functions, so that the user could see an homogeneous environment, in which the data could automatically and seamlessly flow, regardless of the different data formats, and could be selected and visualized in 4D (3D + time).

After our previous development regarding the Flythrough and “Time Series” management(1), we have turned our attention to further enhancements of NVIZ 3D visualization in the belief that 3D

visualization of multiple variable at the same time can be a key factor for unveiling hidden behavior and exploiting new results in research.

In NVIZ the term *site* indicates a GIS object whose data are associated to points in space. A site is displayed as a set of points that have all the same representation (color, size and marker). In fact, the current version of NVIZ does not allow to represent the site values with different colors/sizes/markers within the same file. To overcome this limitation, we have focused on the possibility of associating the graphical attributes (colors/sizes/markers) to the point values (extracted from the database associated to the site), using a convenient user interface. Furthermore we have developed functions that allow picking a single point, to access its associated database record, and finally, if a special field is present, clicking on it will open multimedia data associated with that point.

So we have added the following set of new features:

1) **Site fields/attributes management**: each point can be visualized with a different attribute (color, size, marker) depending on associated data, in order to visually get synoptic display of one ore more variables at the same time.
2) **Look Up Tables (LUTs) management**: to manage color and size Look Up Tables (LUTs) to be used by one or more sites, in order to exploit time series of different variables with the same size or color schemes to understand effective variations.
3) **Object picking for database access**: to access the information stored in the associated database directly by picking the objects of interest.
4) **Hyperlink for external multimedia access**: to access external multimedia data related to the objects of interest as a hyperlink .
5) **Highlight**: Finally as a side feature, we have added the "Highlight" panel that allows to personalize how highlight works in the 3D space.

1 Site fields/attributes management

- It is possible to have color and/or size associated to each point of the site linked to field values
- It is possible to have more than one variable shown for each point of the site
- It is possible to have different marker shapes for each field (one remarkable: histograms)

Each point a different color and size:

it is possible to have a different color and/or size associated to each point of the site linked to field values. To accomplish this task the user needs to have access to the list of the associated fields and then establish an association between several couples of value and attribute (color or size). The minimum is two, between which the system interpolates linearly, while if there are more, it piecewise interpolates between the given values. Outside the minimum and maximum, the values are kept constant as the last

one. This happens if the fields type is numeric. If it is alphabetic, a constant attribute is kept until it changes in the LUT.

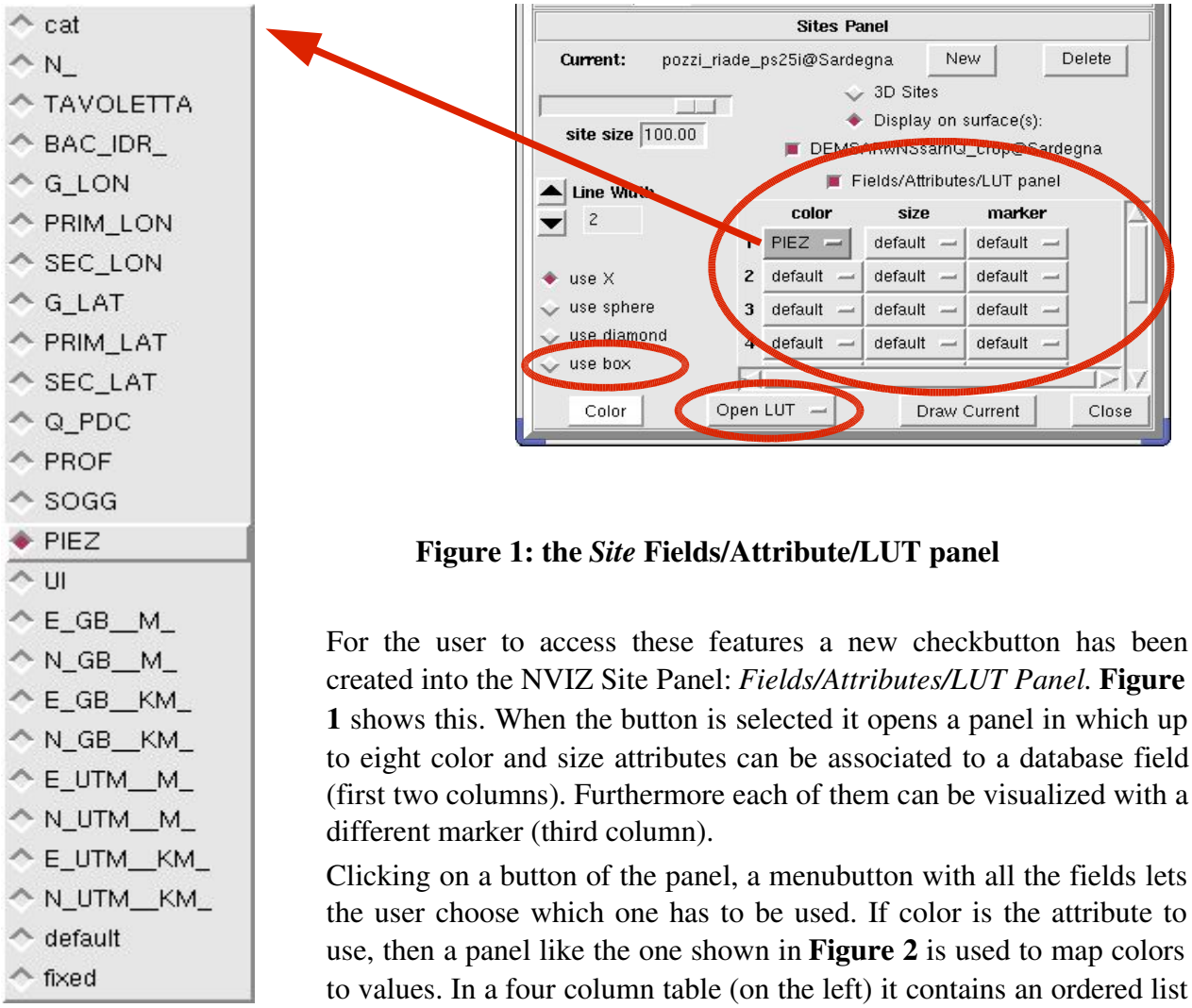


Figure 1: the *Site* Fields/Attribute/LUT panel

For the user to access these features a new checkbutton has been created into the NVIZ Site Panel: *Fields/Attributes/LUT Panel*. **Figure 1** shows this. When the button is selected it opens a panel in which up to eight color and size attributes can be associated to a database field (first two columns). Furthermore each of them can be visualized with a different marker (third column).

Clicking on a button of the panel, a menubutton with all the fields lets the user choose which one has to be used. If color is the attribute to use, then a panel like the one shown in **Figure 2** is used to map colors to values. In a four column table (on the left) it contains an ordered list of (1) a progressive number; (2) all the values found for that field (numeric or alphabetic); (3) an editable color square button column; (4) a non-editable color square labels column.

The user can associate a color to each value (third column), then, after pressing the *Apply* button, see the interpolated results in the fourth one.

The resulting Look Up Table (LUT) can also be viewed on the bottom-right part of this window in a more compact form.

In case we are dealing with size, instead of color, the fourth column and the compact LUT are absent,

but the procedure is the same.

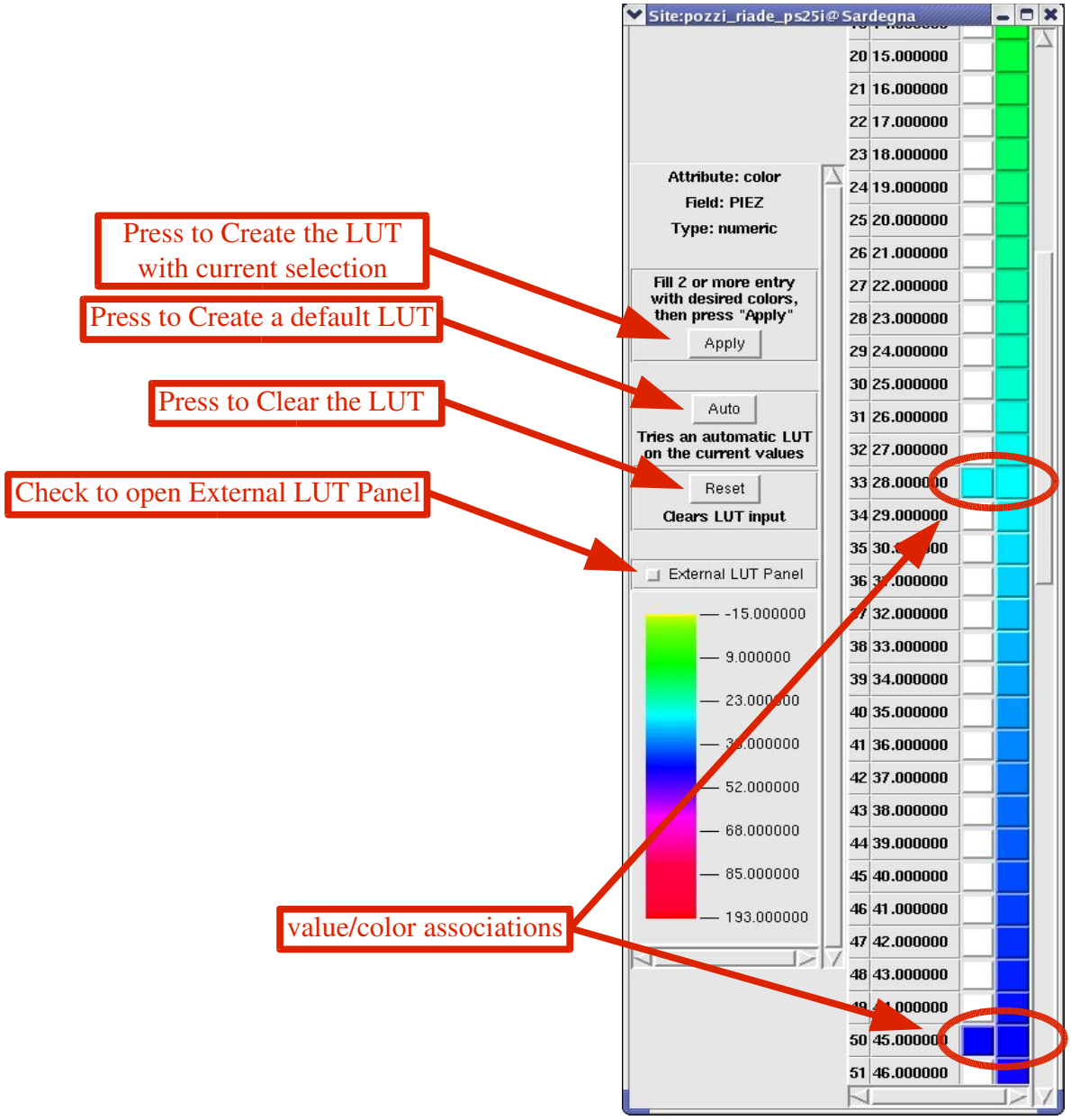
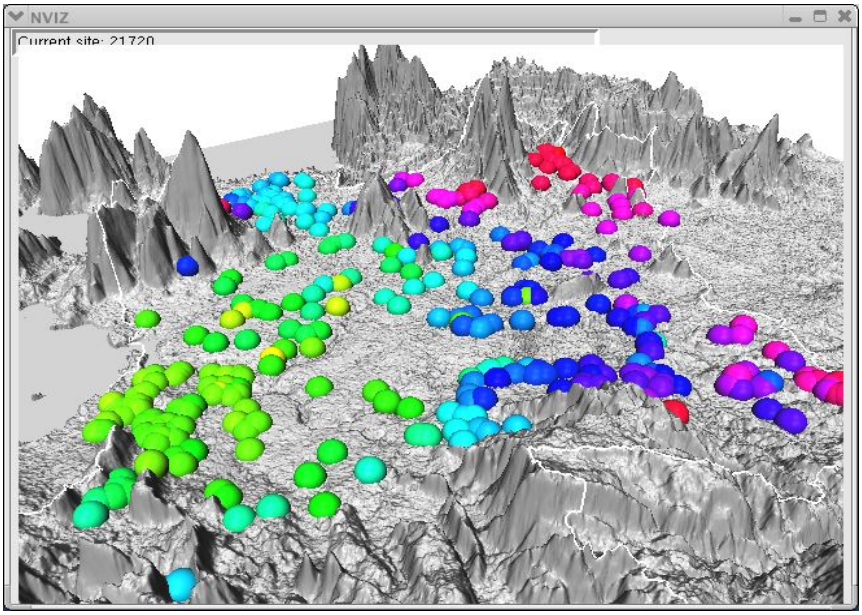


Figure 2: color *Site* Attribute panel

More than one variable for each point:

it is possible to have more than one variable shown as a separate (equal or different) marker for each point of the site. In particular one remarkable multiple representation not present before, has been added: histograms.



In **Figure 3 and 4** we can see examples of variable color and color+size attributes. In the following figures multiple variable examples are shown.

Figure 3: site with variable color attribute

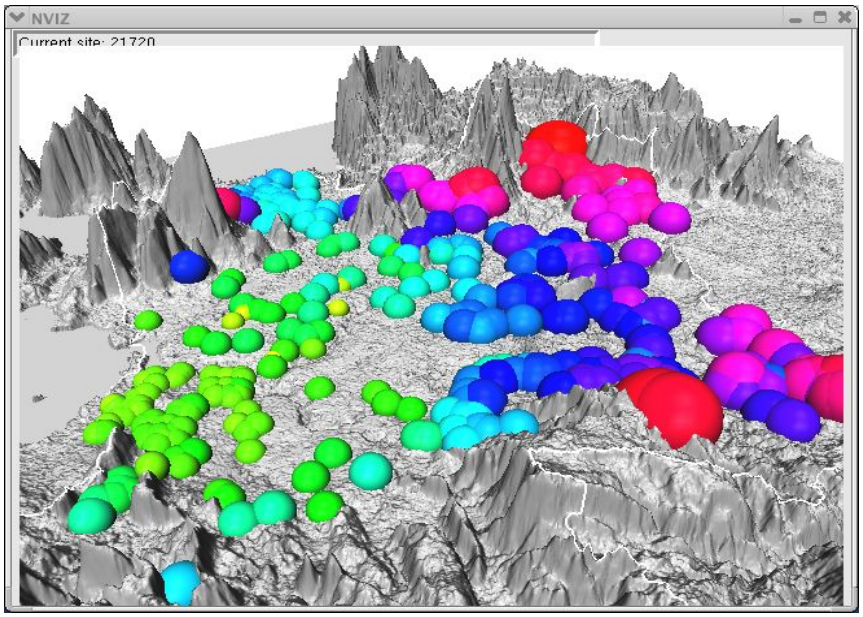


Figure 4: site with variable color and size attributes

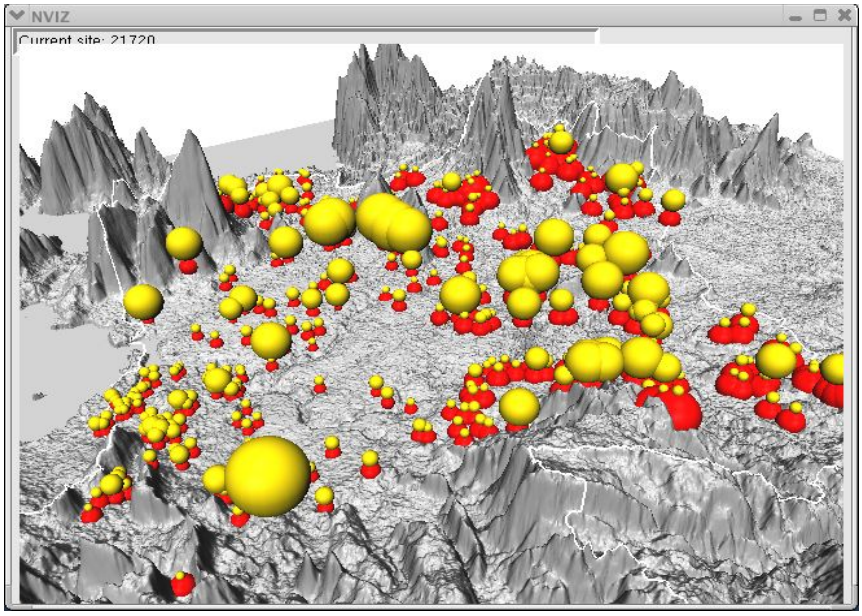


Figure 5 shows a way of visualizing two variables each one with a fixed color, but variable size and sphere marker.

Figure 5: site with two variable size attributes, each one fixed color and sphere marker

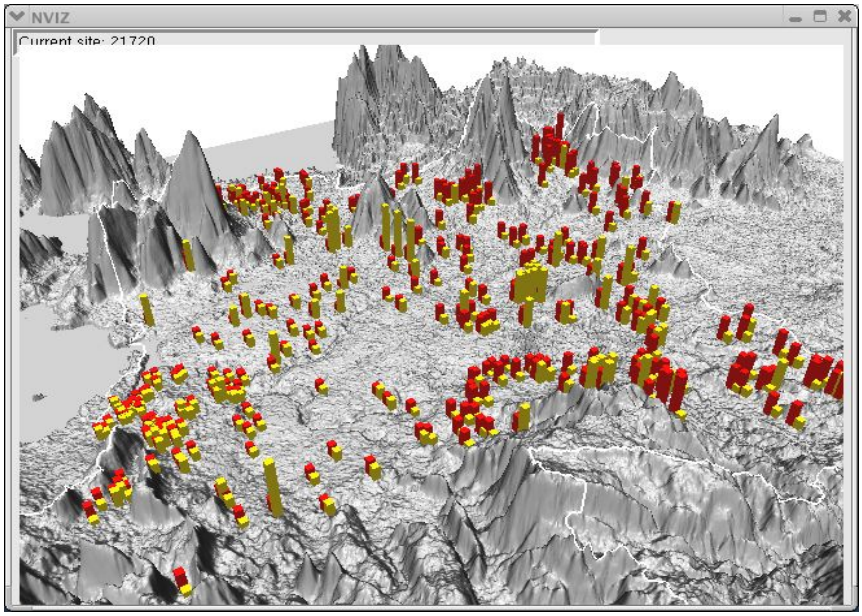


Figure 6 shows the same as the previous, but histograms markers: *histograms* are a new visualization (box) added to *X, sphere,and diamond* by ACS for simplifying multi-variables visualization (see **Fig 1**).

Figure 6: same as Figure 5, but with box marker (histograms)

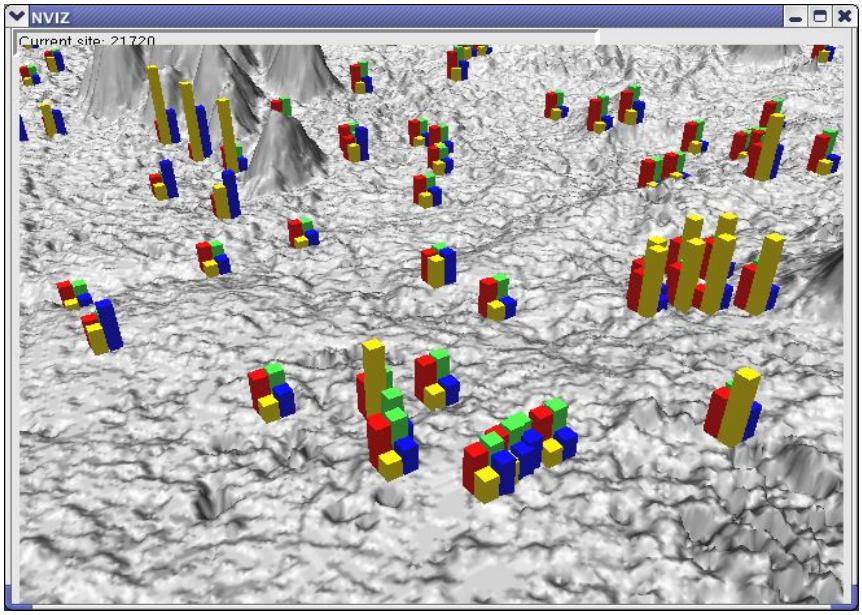


Figure 7 shows an example of the histograms visualization with four different variables.

Figure 7: same as Figure 6, but with four variables

Finally the user has a useful *Auto* button, to create a default LUT and a *Reset* button to clear everything and restore the initial state, in case anything goes wrong.

2 Look Up Tables (LUTs) management

- **LUT creation and mixing**: It is possible to create a LUT (color and size) from each site field values, to extract and combine LUTs coming from different sites into a single one and to save/load them to/from file.
- **One LUT for multiple sites**: It is possible to use an external unique LUT with different site fields/attributes in order to show variable variation with a single LUT (color or site)

In order to fulfill these tasks several functions have been created:

- **Extract a LUT** (color or size) from each site field value
- **Combine LUTs** coming from different sites into a single one.
- **Save and load LUTs**. To/from file.
- **Use an external unique LUT** with different sites fields/attributes in order to show variables variation with a single LUT (color or site)

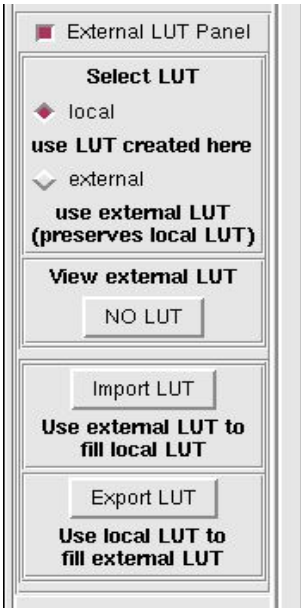
The most remarkable choice we have made is the philosophy behind the creation of a unique shared LUT among several site fields/attributes. We have had a pragmatic approach. Instead of building a LUT from scratch and then verify if it works or not, we have decided to start from actual real site

fields/attributes, and then incrementally extend to the others of the series we want to share the LUT with. So we create a LUT for the first site fields/attributes, and then we "Export" it. We "Import" it in the second and, if needed, add the extra values-attributes LUT entries. And so on up to the last site fields/attributes. At this point we save the LUT and for each of the sites involved we use it as an "External" LUT. Due to this approach we have no command to directly edit a LUT: we have first to "Import" it in a site fields/attributes, edit it as a "Local" LUT, and then to "Export" it again.

This way if a user learns how to do a LUT for a single site, he is already able to do it for multiple sites.

Hereafter we report in details how a LUT (color or size), that can be created for a site fields/attributes, can be then "exported", saved on a file and eventually be used by the same or other site fields/attributes so there is no need to repeat the same work each time, and furthermore the LUT is ready for further use.

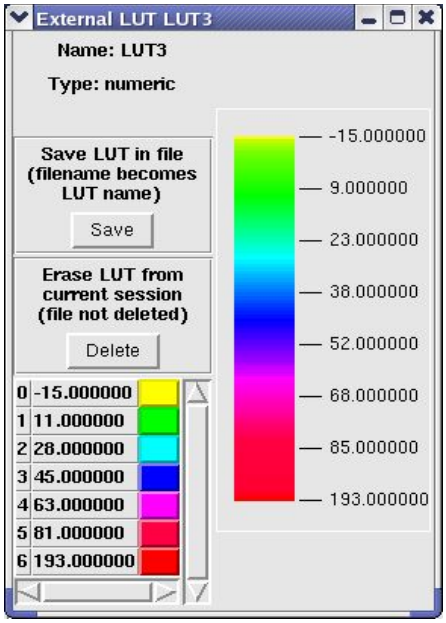
The External LUT Panel



In the *site/attribute* panel (**Figure 2**), used for LUT creation, there is a checkbutton "*External LUT Panel*" that opens the command panel that allows to manage the external LUTs (**Figure 8**). The panel is divided into four sections:

1) **Local or External LUT**: when local is selected, the LUT in the current site fields/attributes is used, while when external is selected, an external one is used. This is needed when we want a group of sites to use the same LUT. So we have to make all of them point to the same, but external, LUT.
2) **View External LUT**: when an external LUT is selected, its name is on the button in this section. When this button is pressed the external LUT is shown in a window like the one in **Figure 8**.
3) **Import LUT**: allows to choose an external LUT and copy it to a LUT of the current site fields/attributes. This is needed to create a LUT that is shared among different site/attribute couples.
4) **Export LUT**: exports the current LUT to an external one that can be managed with the window shown in **Figure 8**.

Figure 8: External LUT panel



The External LUT Window

The External LUT window presents 4 different sections:

1) **Name** and **Type**: the name is *LUTn*, where n is a progressive number, but the name becomes the filename as soon the LUT is saved on a file. The Type is numeric or alphabetic (alphabetic LUT are not interpolated, but constant value is kept between one value and the next).
2) Commands: **Save** on file and **Delete** from current session.
3) **LUT values**: the couples between color/size and the associated value that in fact are the LUT that is saved on a file.
4) **Interpolated LUT**: the same as the one in the site/attribute panel, it is the interpolation of the LUT couples. This section is absent when *size* is considered instead of *color* attribute.

Figure 9: The External LUT Window

3/4 Object picking for db access and Hyperlink for external multimedia

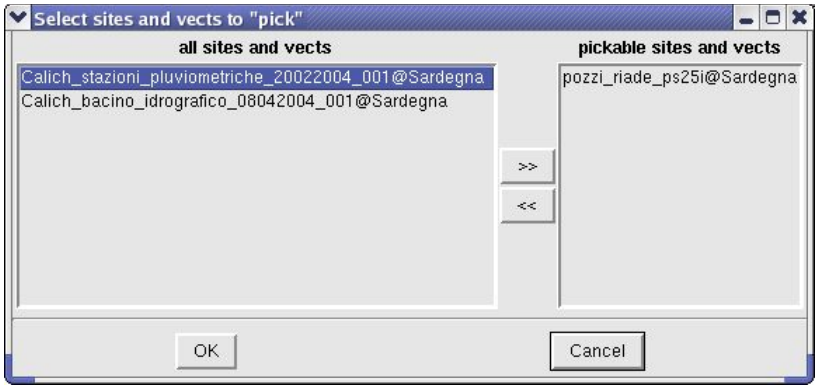
Picking is the feature that allows to point and click an object in the 3D space and get information stored into the associated database. It is similar to the "what's here" feature already present in NVIZ, but with more expanded user interface and a remarkable useful function that allows to associate external multimedia information, such as documents, pictures, movies, etc. and launch external viewer to access them.

If a special field (named MULTIMEDIA by default, but changeable) is found in the point record. its value is shown in the picking window as a button. This field must contain a file name or a directory name. If it is a file, it will be open with a proper viewer (association between files and viewer is made in a configuration file). If it is a directory name, a list will be shown as a popup menu with all the files in the directory. Releasing the mouse on one menu item, will launch the viewer for that file.

In this way we can have a link between a single point and multimedia data such as a document, a picture, a movie, an HTML page, etc.

Figure 10: the Pick Panel

In order to access the new features, the "Pick" panel has been added to



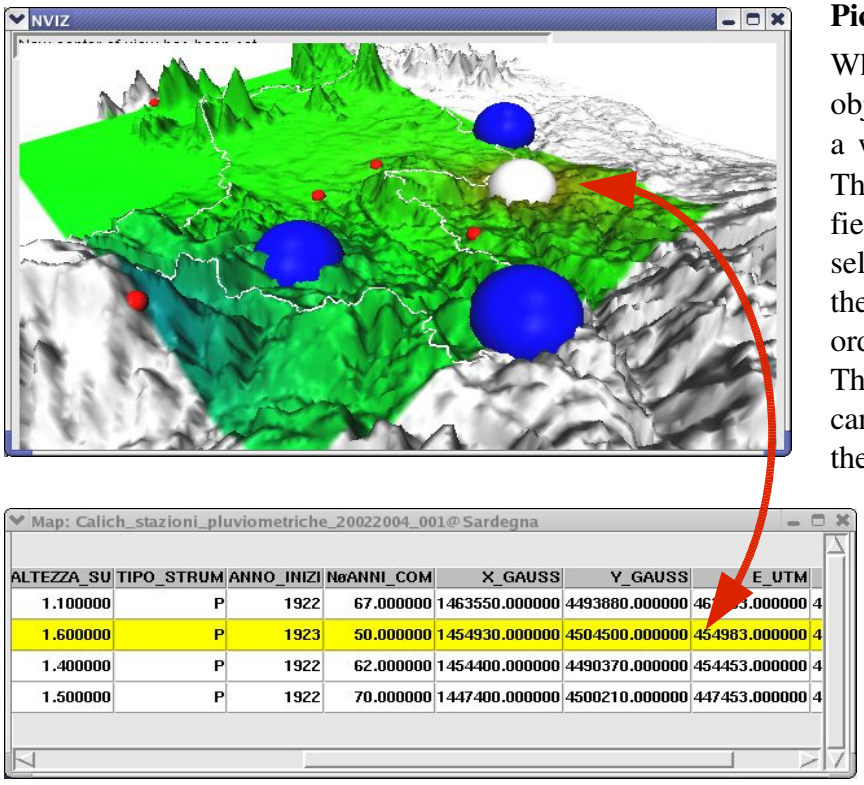
the list of available panels.

It allows to add and remove maps from the list of "pickable" objects: pressing the button "*Add/Remove Map to pick*" opens the window in **Figure 11.**

Figure 11: select 'Pi ckable" sites

The Pick panel then allows to:

- change "maxdist": side of the square centered on the pick point in which to look for objects;
- enable/disable picking (the pick checkbutton)
- show which site points have associated hyperlink (very useful during a demo-:)



Picking an object

When picking is allowed and the object contains associated information a window is opened as in **Figure 12** The window shows a table with all the fields of the picked object and the selected object is highlighted both in the 3D space and in the window, in order to maintain a visual correlation. The highlight works on both sides: we can select an object in the table or in the 3D space, and the corresponding one is highlighted on the other side.

Figure 12: Picking an object

5 Site highlight

Just as a side feature, we have added the "Highlight" panel that allows to personalize how highlight works in the 3D space. When an object has to be highlighted we can choose to change its color, size and marker. The default is only white color.

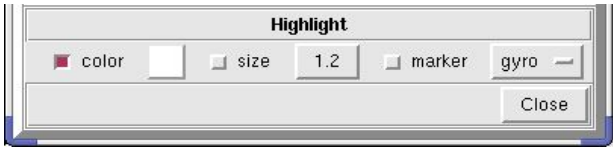
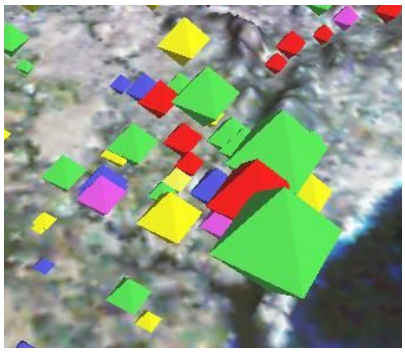
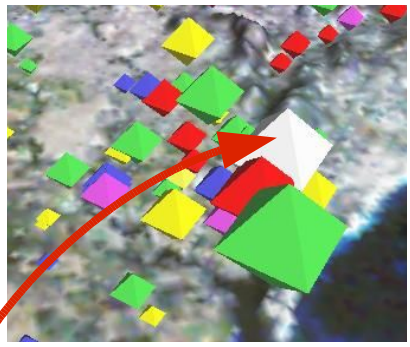


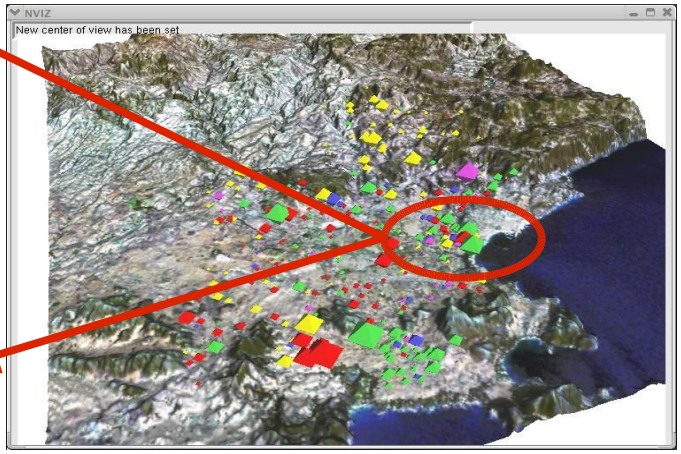
Figure 13: Highlight Panel

6 Conclusion: a practical example in the RIADE project





Here is an example of application of the above functions for the RIADE project. In these images we see the distribution of water wells in the test area Nurra (Sardinia). Each diamond represents one groundwater wells. Their size is proportional to the *electrical conductivity* and their color indicates water use: blue for *residential*, green for *agriculture and cattle*, yellow for *industry*, red for *not used* and purple for *unknown.*



Map: Calich_censimento_pozzi_05082004_001@RVAnurra

S	USO	UNI_IDROG	DATA_1_CAM	LIV_DIN	LIV_PIEZ_M	LIV_STAT_M	LIV_DIN_M_	QUOTA_PIEZ	PRELIEVO_D	T_xC	COND_MS_CM	
**	inutilizzato	***	20031218.000000	NO	0.000000	0.700000	***	78.300000	CAMPIONATORE	14.800000	0.980000	6
**	***	***	20031216.000000	NO	0.000000	0.340000	***	50.660000	CAMPIONATORE	16.000000	8.150000	7
1	giardino	***	20031021.000000	***	0.000000	0.000000	***	0.000000	RUBINETTO	22.000000	2.140000	7
**	***	***	20031021.000000	NO	0.000000	4.390000	***	0.610000	CAMPIONATORE	19.600000	1.380000	7
**	irrigazione e manutenzione cam	***	20031022.000000	NO	0.000000	6.360000	***	2.640000	RUBINETTO	18.300000	1.540000	7
0	industriale	***	20031021.000000	***	0.000000	0.000000	***	0.000000	RUBINETTO	20.000000	2.190000	7
**	Zootecnico	***	20031021.000000	NO	0.000000	4.300000	***	0.700000	RUBINETTO	19.000000	6.570000	7

Figure 14: Water wells distribution in the area of Nurra

Higher conductivity is found near evaporitic rocks, but also along the coast due to intrusion of salty water from the sea typically associated to over-exploitation of the wells. In our representation, for example, a diamond big and green can show a case of mismanagement, because salinized water is used to irrigate fields.

This example shows how with these new displaying tools we have an immediate picture of where concentrate our attention: we go to the "green and big" and, by picking on it, we can immediately explore the database with alphanumeric values and verify our hypothesis.

Aknowledgements

We thanks all the GRASS, NVIZ and QGIS community and especially developers that inspired our work and helped us to avoid to rewrite a huge amount of code.

Many thanks to RIADE students that helped us to test this prototype producing some really helpful test data.

Many thanks to all RIADE researcher that allowed to populate DB with significant data.

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Impostazione di una rete di monitoraggio delle acque sotterranee ed individuazione di indicatori di qualita' a mbientale per la lotta alla desertificazione

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(4) http://grass.itc.it – GRASS Home pace

(5) http://www.qgis.org – QGIS home Page

(6) http://www.postgis.org – PostGis Home Pace