



Modelling Pre- and Protohistorical Iconographic Compositions. The R package decorr

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Abstract

Pre- and Protohistorical societies are characterised by the absence of a writing system. Writing is known to be one of the most rational symbolic system with i) a clear distinction between signified and signifier – specially in alphabetic and binary writings –, ii) the development of the signified on a horizontal, vertical or boustrophedon axis. In illiterate societies, testimonies of symbolic systems mostly come from iconography (ceramic decorations, rock-art, statuary, etc.) and signs are displayed mostly as discontinuous figures which can have different relationships one with another.

To understand meaningful associations of signs, geometric tools, graph analysis and statistical analysis offer great tools to recognize iconographical patterns and to infer collective conventions. We present the **decorr** R package which grounds methods and tools to analyse ancient iconographical systems.

Keywords: Iconography, Graph Theory, Network Analysis, Spatial Analysis, R.

1. Introduction: Count data regression in R

The introduction is in principle “as usual”. However, it should usually embed both the implemented *methods* and the *software* into the respective relevant literature. For the latter both competing and complementary software should be discussed (within the same software environment and beyond), bringing out relative (dis)advantages. All software mentioned should be properly `\cite{}`d. (See also Appendix B for more details on `BIBTEX`.)

For writing about software JSS requires authors to use the markup `\proglang{}` (programming languages and large programmable systems), `\pkg{}` (software packages), `\code{}` (functions, commands, arguments, etc.). If there is such markup in (sub)section titles (as above), a plain text version has to be provided in the `LATEX` command as well. Below we also illustrate how abbreviations should be introduced and citation commands can be

■ employed. See the L^AT_EX code for more details.

Shared methods, to study iconography from Prehistory and Protohistorical times (here for Europe, from ca. 10,000 BC to ca. 500 BC), are really few. Most of the times, studies are site dependend or periode dependend (Leroi-Gourhan 1992). Even in the retriected framework of the study, statistics are also really few. Indeed, the variability of iconographic expressions, as the inherent difficulties of iconology formalization, have made such methods difficult to apply. Since, today a large of archaeological studies on iconographical contents are oriented towards "more scientific" domains like the characterisation of the chaine operateire (from raw material to the shaping), characterisation of raw material (geologic nature of the supports, pigments, etc.), use-wear analysis, radiocarbon dating, etc. Iconographic studies lacking of basic units like CaCO₃ to indicate a limestone panel, a-Fe₂O₃ to indicate use of hematit in a painting, etc. For most elaborated studies on iconography per se, a rational starting point is to considered a graphical unit as the smallest constitutive element of a composition, even with geometric and abstract composition the spliting of the iconographical content into isolated graphical units is hard. From this starting point, it is quite common to read a study where a decoration is considered as the organisation of graphical units into figures, organisation of figures into patterns, organisation of patterns into motives, on so on, until the total recomposition of the graphical content. Wheter, the graphical unit has an intrinsic content (its shape, color, orientation, size, etc.), the other levels of the analysis are uniquely link to the spatial organisation of the graphical units. As linguistic, or any formal system, iconography can be seen as spatial features related one with the other depending on rules of proximities. An iconographical composition can be "read" as a spatial distribution of features with intrinsic values (the signs) possibly having meaningful relationships one with another depending on their pairwise spatial proximities. Just like `art <- paste0("a","r","t")` means "art" and not "rat" with R. Difficulties come from the fact that spatial relations between graphical units are not linear, just as the Saussurian prime principle of the signifier De Saussure (1989), but multi-directional and the direction of the interactions of pairwise graphical units can be in any order (Fig. 1)

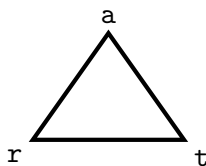


Figure 1: Potential spatial relations between graphical units during Prehistory

In this article we present the R package **decorr**

2. The R package decorr

The **decorr** can be downloaded on GitHub.

2.1. Function index

2.2. Function `listdec()`

This function store graphs in a list.

2.3. Function `xxx`

xxx

The basic Poisson regression model for count data is a special case of the GLM framework `?`. It describes the dependence of a count response variable y_i ($i = 1, \dots, n$) by assuming a Poisson distribution $y_i \sim \text{Pois}(\mu_i)$. The dependence of the conditional mean $E[y_i | x_i] = \mu_i$ on the regressors x_i is then specified via a log link and a linear predictor

$$\log(\mu_i) = x_i^\top \beta, \quad (1)$$

where the regression coefficients β are estimated by maximum likelihood (ML) using the iterative weighted least squares (IWLS) algorithm.

Note that around the `{equation}` above there should be no spaces (avoided in the \LaTeX code by `%` lines) so that “normal” spacing is used and not a new paragraph started.

R provides a very flexible implementation of the general GLM framework in the function `glm()` (`?`) in the **stats** package. Its most important arguments are

```
glm(formula, data, subset, na.action, weights, offset,
    family = gaussian, start = NULL, control = glm.control(...),
    model = TRUE, y = TRUE, x = FALSE, ...)
```

where `formula` plus `data` is the now standard way of specifying regression relationships in R/S introduced in `?`. The remaining arguments in the first line (`subset`, `na.action`, `weights`, and `offset`) are also standard for setting up formula-based regression models in R/S. The arguments in the second line control aspects specific to GLMs while the arguments in the last line specify which components are returned in the fitted model object (of class ‘`glm`’ which inherits from ‘`lm`’). For further arguments to `glm()` (including alternative specifications of starting values) see `?glm`. For estimating a Poisson model `family = poisson` has to be specified.

As the synopsis above is a code listing that is not meant to be executed, one can use either the dedicated `{Code}` environment or a simple `{verbatim}` environment for this. Again, spaces before and after should be avoided.

Finally, there might be a reference to a `{table}` such as Table 1. Usually, these are placed at the top of the page (`[t!]`), centered (`\centering`), with a caption below the table, column headers and captions in sentence style, and if possible avoiding vertical lines.

3. Illustrations

For a simple illustration of basic Poisson and NB count regression the **quine** data from the **MASS** package is used. This provides the number of **Days** that children were absent from school in Australia in a particular year, along with several covariates that can be employed as regressors. The data can be loaded by

| Type | Distribution | Method | Description |
|----------------|--------------|----------|---|
| GLM | Poisson | ML | Poisson regression: classical GLM, estimated by maximum likelihood (ML) |
| | | Quasi | “Quasi-Poisson regression”: same mean function, estimated by quasi-ML (QML) or equivalently generalized estimating equations (GEE), inference adjustment via estimated dispersion parameter |
| | | Adjusted | “Adjusted Poisson regression”: same mean function, estimated by QML/GEE, inference adjustment via sandwich covariances |
| | NB | ML | NB regression: extended GLM, estimated by ML including additional shape parameter |
| Zero-augmented | Poisson | ML | Zero-inflated Poisson (ZIP), hurdle Poisson |
| | NB | ML | Zero-inflated NB (ZINB), hurdle NB |

Table 1: Overview of various count regression models. The table is usually placed at the top of the page ([t!]), centered (**centering**), has a caption below the table, column headers and captions are in sentence style, and if possible vertical lines should be avoided.

```
R> data("quine", package = "MASS")
```

and a basic frequency distribution of the response variable is displayed in Figure 2.

For code input and output, the style files provide dedicated environments. Either the “agnostic” {CodeInput} and {CodeOutput} can be used or, equivalently, the environments {Sinput} and {Soutput} as produced by Sweave() or knitr when using the render_sweave() hook. Please make sure that all code is properly spaced, e.g., using `y = a + b * x` and *not* `y=a+b*x`. Moreover, code input should use “the usual” command prompt in the respective software system. For R code, the prompt `"R> "` should be used with `"+"` as the continuation prompt. Generally, comments within the code chunks should be avoided – and made in the regular L^AT_EX text instead. Finally, empty lines before and after code input/output should be avoided (see above).

As a first model for the `quine` data, we fit the basic Poisson regression model. (Note that JSS prefers when the second line of code is indented by two spaces.)

```
R> m_pois <- glm(Days ~ (Eth + Sex + Age + Lrn)^2, data = quine,
+   family = poisson)
```

To account for potential overdispersion we also consider a negative binomial GLM.

```
R> library("MASS")
R> m_nbin <- glm.nb(Days ~ (Eth + Sex + Age + Lrn)^2, data = quine)
```

In a comparison with the BIC the latter model is clearly preferred.

```
R> BIC(m_pois, m_nbin)
```

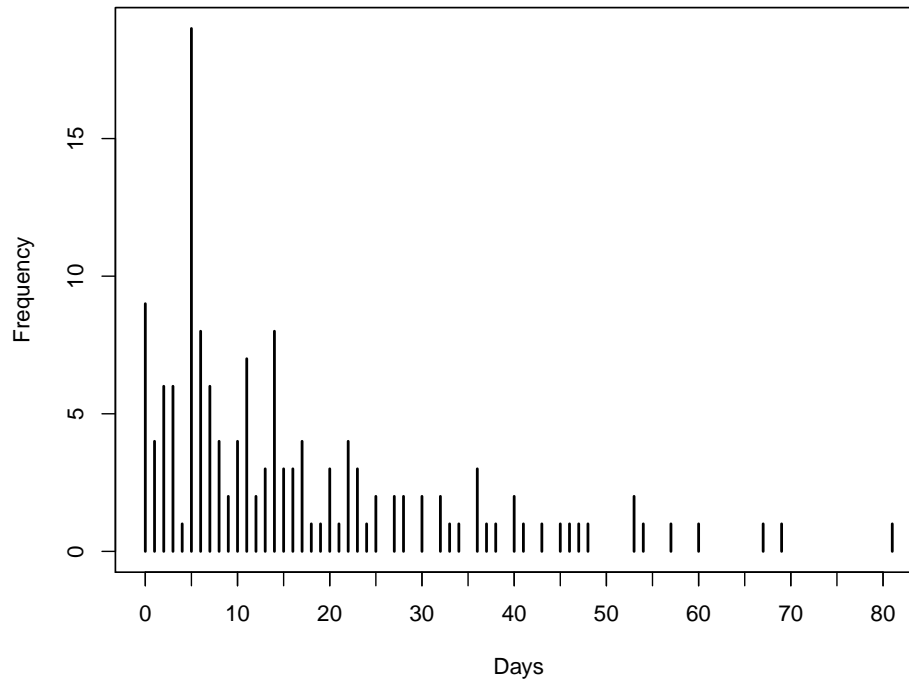


Figure 2: Frequency distribution for number of days absent from school.

```

      df      BIC
m_pois 18 2046.851
m_nbin 19 1157.235

```

Hence, the full summary of that model is shown below.

```
R> summary(m_nbin)
```

Call:

```
glm.nb(formula = Days ~ (Eth + Sex + Age + Lrn)^2, data = quine,
       init.theta = 1.60364105, link = log)
```

Deviance Residuals:

| Min | 1Q | Median | 3Q | Max |
|---------|---------|---------|--------|--------|
| -3.0857 | -0.8306 | -0.2620 | 0.4282 | 2.0898 |

Coefficients: (1 not defined because of singularities)

| | Estimate | Std. Error | z value | Pr(> z) |
|-------------|----------|------------|---------|-------------|
| (Intercept) | 3.00155 | 0.33709 | 8.904 | < 2e-16 *** |
| EthN | -0.24591 | 0.39135 | -0.628 | 0.52977 |
| SexM | -0.77181 | 0.38021 | -2.030 | 0.04236 * |
| AgeF1 | -0.02546 | 0.41615 | -0.061 | 0.95121 |
| AgeF2 | -0.54884 | 0.54393 | -1.009 | 0.31296 |
| AgeF3 | -0.25735 | 0.40558 | -0.635 | 0.52574 |

| | | | | |
|-------------|----------|---------|--------|------------|
| LrnSL | 0.38919 | 0.48421 | 0.804 | 0.42153 |
| EthN:SexM | 0.36240 | 0.29430 | 1.231 | 0.21818 |
| EthN:AgeF1 | -0.70000 | 0.43646 | -1.604 | 0.10876 |
| EthN:AgeF2 | -1.23283 | 0.42962 | -2.870 | 0.00411 ** |
| EthN:AgeF3 | 0.04721 | 0.44883 | 0.105 | 0.91622 |
| EthN:LrnSL | 0.06847 | 0.34040 | 0.201 | 0.84059 |
| SexM:AgeF1 | 0.02257 | 0.47360 | 0.048 | 0.96198 |
| SexM:AgeF2 | 1.55330 | 0.51325 | 3.026 | 0.00247 ** |
| SexM:AgeF3 | 1.25227 | 0.45539 | 2.750 | 0.00596 ** |
| SexM:LrnSL | 0.07187 | 0.40805 | 0.176 | 0.86019 |
| AgeF1:LrnSL | -0.43101 | 0.47948 | -0.899 | 0.36870 |
| AgeF2:LrnSL | 0.52074 | 0.48567 | 1.072 | 0.28363 |
| AgeF3:LrnSL | NA | NA | NA | NA |

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(1.6036) family taken to be 1)

Null deviance: 235.23 on 145 degrees of freedom
 Residual deviance: 167.53 on 128 degrees of freedom
 AIC: 1100.5

Number of Fisher Scoring iterations: 1

Theta: 1.604
 Std. Err.: 0.214

2 x log-likelihood: -1062.546

4. Summary and discussion

■ As usual ...

Computational details

■ If necessary or useful, information about certain computational details such as version numbers, operating systems, or compilers could be included in an unnumbered section. Also, auxiliary packages (say, for visualizations, maps, tables, ...) that are not cited in the main text can be credited here.

The results in this paper were obtained using R 3.4.1 with the **MASS** 7.3.47 package. R itself and all packages used are available from the Comprehensive R Archive Network (CRAN) at <https://CRAN.R-project.org/>.

Acknowledgments

All acknowledgments (note the AE spelling) should be collected in this unnumbered section before the references. It may contain the usual information about funding and feedback from colleagues/reviewers/etc. Furthermore, information such as relative contributions of the authors may be added here (if any).

References

- De Saussure F (1989). *Cours de linguistique générale*, volume 1. Otto Harrassowitz Verlag.
- Leroi-Gourhan A (1992). *L'art pariétal: langage de la préhistoire*. Editions Jérôme Millon.

A. More technical details

Appendices can be included after the bibliography (with a page break). Each section within the appendix should have a proper section title (rather than just *Appendix*).

For more technical style details, please check out JSS's style FAQ at <https://www.jstatsoft.org/pages/view/style#frequently-asked-questions> which includes the following topics:

- Title vs. sentence case.
- Graphics formatting.
- Naming conventions.
- Turning JSS manuscripts into R package vignettes.
- Trouble shooting.
- Many other potentially helpful details...

B. Using BibT_EX

References need to be provided in a BibT_EX file (`.bib`). All references should be made with `\cite`, `\citet`, `\citep`, `\citealp` etc. (and never hard-coded). These commands yield different formats of author-year citations and allow to include additional details (e.g., pages, chapters, ...) in brackets. In case you are not familiar with these commands see the JSS style FAQ for details.

Cleaning up BibT_EX files is a somewhat tedious task – especially when acquiring the entries automatically from mixed online sources. However, it is important that informations are complete and presented in a consistent style to avoid confusions. JSS requires the following format.

- JSS-specific markup (`\proglang`, `\pkg`, `\code`) should be used in the references.
- Titles should be in title case.
- Journal titles should not be abbreviated and in title case.
- DOIs should be included where available.
- Software should be properly cited as well. For R packages `citation("pkgname")` typically provides a good starting point.

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