




aion: An R Package to Represent Archaeological Time Series

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Summary

Numerous R packages have been developed to describe, analyze, and model temporal data in the context of archaeological studies in the broadest sense. These packages encompass various functionalities, including handling radiocarbon data (e.g., *Bchron* by Haslett & Parnell (2008) or *rcarbon* by Crema & Bevan (2021)), Optically Stimulated Luminescence dating (Luminescence by Kreutzer et al. (2012)), Bayesian chronological modeling (*ArchaeoPhases* by Philippe & Vibet (2020)), using paleoenvironmental proxies (e.g., *shoredat* by Roalkvam (2023)), or other temporal data (e.g., *kairos* by Frerebeau (2023)). This multitude of packages underscores the significance of computational approaches in archaeology (Schmidt & Marwick, 2020). However, it also presents a major challenge as each package employs its own representation of temporal information. Consequently, exchanging data between different packages within the same data workflow becomes even more arduous. *aion* is designed to provide a consistent framework for representing archaeological time series.

Statement of need

R ships with a lot of functionality useful for time series, in particular in the base stats (*R Core Team*, 2023), or in the zoo (Zeileis & Grothendieck, 2005) packages¹. However, these features are not adapted to most archaeological time series. Archaeological data is typically collected through field excavations or surveys, resulting in irregularly spaced observation times. Although several packages can handle irregular time series, the way they represent dates means they cannot easily be used for archaeological series. These are indeed defined for a given calendar era and more importantly they can involve dates very far in the past.

aion provides a system of classes and methods to represent and work with such time series. This package does not provide tools for temporal analysis or modeling. Instead, it offers a system of classes and methods to represent and work with archaeological time series. This API can be extended and used by other specialized packages (see *kairos* v2.0 as an example).

Functionality

In base R, dates are represented by default as the number of days since 1970-01-01 (Gregorian), with negative values for earlier dates. *aion* uses a different approach: it allows to create date vectors represented as *rata die* (Reingold & Dershowitz, 2018), i.e. as number of days since 01-01-01 (Gregorian). This allows to represent dates independently of any calendar and makes calculations and comparisons easier.

¹See the CRAN Task View about time series analysis: <https://cran.r-project.org/view=TimeSeries>.

37 The *rata die* vector provides the internal time representation of the *aion* time series (note that
 38 the era (Roe, 2022) package allows to work with numeric vectors that represent year-based
 39 time scales). The `fixed()` function allows to create such a vector from dates that can then be
 40 converted back into dates (or years) of a particular calendar.

41 In *aion* a time series is represented by an S4 class that inherits from the base array. A time
 42 series object can be created with the `series()` function that returns an $n \times m \times p$ array, with
 43 n being the number of observations, m being the number of series and with the p columns
 44 of the third dimension containing extra variables for each series. This array comes with an
 45 extra time slot that store the observations times expressed in *rata die*. It be created with the
 46 `series()` function.

47 All output produced by *aion* can be formatted with (virtually) any calendar, as long as the
 48 calendar has been defined and the associated conversion methods are available. *aion* natively
 49 supports both Julian and Gregorian calendars (with the most common eras for the latter,
 50 e.g. Before 2000, Before Present, (Before) Common Era...) and allows to create custom
 51 calendars.

52 Acknowledgements

53 The inspiration for this package comes from the *era* package by Joe Roe.

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