

Package ‘Amelia’

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Title Amelia II: A Program for Missing Data

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Depends R (>= 2.0.0), foreign, utils

Description Amelia II “multiply imputes” missing data in a single cross-section (such as a survey), from a time series (like variables collected for each year in a country), or from a time-series-cross-sectional data set (such as collected by years for each of several countries). Amelia II implements our bootstrapping-based algorithm that gives essentially the same answers as the standard IP or EMis approaches, is usually considerably faster than existing approaches and can handle many more variables. Unlike Amelia I and other statistically rigorous imputation software, it virtually never crashes (but please let us know if you find to the contrary!). The program also generalizes existing approaches by allowing for trends in time series across observations within a cross-sectional unit, as well as priors that allow experts to incorporate beliefs they have about the values of missing cells in their data. Amelia II also includes useful diagnostics of the fit of multiple imputation models. The program works from the R command line or via a graphical user interface that does not require users to know R.

License GPL (>= 2)

URL <http://gking.harvard.edu/amelia>

Suggests tcltk, Zelig

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amelia-package	<i>Amelia II: A Program for Missing Data</i>
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Description

Uses a bootstrap+EM algorithm to impute missing values from a dataset and produces multiple output datasets for analysis.

Details

Package:	amelia
Type:	Package
Version:	1.0
Date:	2006-03-03
License:	See Manual

You can use the package in one of two ways: either by invoking the `ameliagui()` command and running the program from a graphical interface or by loading in your data and then running the `amelia` function on the data.

If you use the GUI in Windows, makes sure that you run R under a Single Window Interface (SDI) as it will try to grab focus from the GUI if you don't.

Author(s)

James Honaker, Matthew Blackwell, Gary King

References

King, Gary; James Honaker, Anne Joseph, and Kenneth Scheve. "Analyzing Incomplete Political Science Data: An Alternative Algorithm for Multiple Imputation", *American Political Science Review*, Vol. 95, No. 1 (March, 2001): Pp. 49-69.

africa

Economic and Political Indictors in 6 African States

Description

Data on a few economic and political variables in six African States from 1972-1991. The variables are year, country name, Gross Domestic Product per capita, inflation, trade as a percentage of GDP, a measure of civil liberties and total population. The data is from the Africa Research Program. A few cells are missing.

Usage

africa

Format

A data frame with 7 variables and 120 observations.

Source

Africa Research Program <http://africa.gov.harvard.edu>

amelia

AMELIA: Mutiple Imputation of Incomplete Multivariate Data

Description

Runs the bootstrap EM algorithm on incomplete data and creates imputed datasets.

Usage

```
## Default S3 method:
amelia(x, m = 5, p2s = 1, frontend = FALSE, idvars = NULL,
       ts = NULL, cs = NULL, polytime = NULL, intercs = FALSE,
       lags = NULL, leads = NULL, startvals = 0, tolerance = 0.0001,
       logs = NULL, sqrts = NULL, lgstc = NULL, noms = NULL, ords = NULL,
       incheck = TRUE, collect = FALSE, arglist = NULL, empri = NULL,
       priors = NULL, autopri = 0.05, emburn = c(0,0), bounds = NULL,
       max.resample = 100, ...)

## S3 method for class 'amelia':
amelia(x, m = 5, p2s = 1, frontend = FALSE, ...)
```

Arguments

<code>x</code>	either a matrix, data.frame or a object of class "amelia". The first two will call the default S3 method. The third a convenient way to perform more imputations with the same parameters.
<code>m</code>	the number of imputed datasets to create.
<code>p2s</code>	an integer value taking either 0 for no screen output, 1 for normal screen printing of iteration numbers, and 2 for detailed screen output. See "Details" for specifics on output when <code>p2s=2</code> .
<code>frontend</code>	a logical value used internally for the GUI.
<code>idvars</code>	a vector of column numbers or column names that indicates identification variables. These will be dropped from the analysis but copied into the imputed datasets.
<code>ts</code>	column number or variable name indicating the variable identifying time in time series data.
<code>cs</code>	column number or variable name indicating the cross section variable.
<code>polytime</code>	integer between 0 and 3 indicating what power of polynomial should be included in the imputation model to account for the effects of time. A setting of 0 would indicate constant levels, 1 would indicate linear time effects, 2 would indicate squared effects, and 3 would indicate cubic time effects.
<code>intercs</code>	a logical variable indicating if the time effects of <code>polytime</code> should vary across the cross-section.
<code>lags</code>	a vector of numbers or names indicating columns in the data that should have their lags included in the imputation model.
<code>leads</code>	a vector of numbers or names indicating columns in the data that should have their leads (future values) included in the imputation model.
<code>startvals</code>	starting values, 0 for the parameter matrix from listwise deletion, 1 for an identity matrix.
<code>tolerance</code>	the convergence threshold for the EM algorithm.
<code>logs</code>	a vector of column numbers or column names that refer to variables that require log-linear transformation.
<code>sqrts</code>	a vector of numbers or names indicating columns in the data that should be transformed by a square root function. Data in this column cannot be less than zero.
<code>lgstc</code>	a vector of numbers or names indicating columns in the data that should be transformed by a logistic function for proportional data. Data in this column must be between 0 and 1.
<code>noms</code>	a vector of numbers or names indicating columns in the data that are nominal variables.
<code>ords</code>	a vector of numbers or names indicating columns in the data that should be treated as ordinal variables.
<code>incheck</code>	a logical indicating whether or not the inputs to the function should be checked before running <code>amelia</code> . This should only be set to <code>FALSE</code> if you are extremely confident that your settings are non-problematic and you are trying to save computational time.

<code>collect</code>	a logical value indicating whether or not the garbage collection frequency should be increased during the imputation model. Only set this to <code>TRUE</code> if you are experiencing memory issues as it can significantly slow down the imputation process.
<code>arglist</code>	an object of class "ameliaArgs" from a previous run of Amelia. Including this object will use the arguments from that run.
<code>empri</code>	number indicating level of the empirical (or ridge) prior. This prior shrinks the covariances of the data, but keeps the means and variances the same for problems of high missingness, small N's or large correlations among the variables. Should be kept small, perhaps 0.5 to 1 percent of the rows of the data; a reasonable upper bound is around 10 percent of the rows of the data.
<code>priors</code>	a four or five column matrix containing the priors for either individual missing observations or variable-wide missing values. See "Details" for more information.
<code>autopri</code>	allows the EM chain to increase the empirical prior if the path strays into a nonpositive definite covariance matrix, up to a maximum empirical prior of the value of this argument times n , the number of observations. Must be between 0 and 1, and at zero this turns off this feature.
<code>emburn</code>	a numeric vector of length 2, where <code>emburn[1]</code> is the minimum EM chain length and <code>emburn[2]</code> is the maximum EM chain length. These are ignored if they are less than 1.
<code>bounds</code>	a three column matrix to hold logical bounds on the imputations. Each row of the matrix should be of the form <code>c(column.number, lower.bound, upper.bound)</code> . See Details below.
<code>max.resample</code>	an integer that specifies how many times Amelia should redraw the imputed values when trying to meet the logical constraints of <code>bounds</code> . After this value, imputed values are set to the bounds.
<code>...</code>	further arguments to be passed.

Details

Multiple imputation is a method for analyzing incomplete multivariate data. This function will take an incomplete dataset in either data frame or matrix form and return `m` imputed datasets with no missing values. The algorithm first bootstraps a sample dataset with the same dimensions as the original data, estimates the sufficient statistics (with priors if specified) by EM, and then imputes the missing values of sample. It repeats this process `m` times to produce the `m` complete datasets where the observed values are the same and the unobserved values are drawn from their posterior distributions.

The function will start a "fresh" run of the algorithm if `x` is either a incomplete matrix or data.frame. In this method, all of the options will be user-defined or set to their default. If `x` the output of a previous Amelia run (that is, an object of class "amelia"), then Amelia will run with the options used in that previous run. This is a convenient way to run more imputations of the same model.

You can provide Amelia with informational priors about the missing observations in your data. To specify priors, pass a four or five column matrix to the `priors` argument with each row specifying a different priors as such:

```
one.prior <- c(row, column, mean, standard deviation)
```

or,

```
one.prior <- c(row, column, minimum, maximum, confidence).
```

So, in the first and second column of the priors matrix should be the row and column number of the prior being set. In the other columns should either be the mean and standard deviation of the prior, or a minimum, maximum and confidence level for the prior. You must specify your priors all as distributions or all as confidence ranges. Note that ranges are converted to distributions, so setting a confidence of 1 will generate an error.

Setting a priors for the missing values of an entire variable is done in the same manner as above, but inputting a 0 for the row instead of the row number. If priors are set for both the entire variable and an individual observation, the individual prior takes precedence.

In addition to priors, Amelia allows for logical bounds on variables. The `bounds` argument should be a matrix with 3 columns, with each row referring to a logical bound on a variable. The first column should be the column number of the variable to be bounded, the second column should be the lower bounds for that variable, and the third column should be the upper bound for that variable. As Amelia enacts these bounds by resampling, particularly poor bounds will end up resampling forever. Amelia will stop resampling after `max.resample` attempts and simply set the imputation to the relevant bound.

If each imputation is taking a long time to converge, you can increase the empirical prior, `empri`. This value has the effect of smoothing out the likelihood surface so that the EM algorithm can more easily find the maximum. It should be kept as low as possible and only used if needed.

Amelia assumes the data is distributed multivariate normal. There are a number of variables that can break this assumption. Usually, though, a transformation can make any variable roughly continuous and unbounded. We have included a number of commonly needed transformations for data. Note that the data will not be transformed in the output datasets and the transformation is simply useful for climbing the likelihood.

Please refer to the Amelia manual for more information on the function or the options.

Value

An instance of S3 class "amelia" with the following objects:

<code>imputations</code>	a list of length m with an imputed dataset in each entry. The class (matrix or data.frame) of these entries will match x .
<code>m</code>	an integer indicating the number of imputations run.
<code>missMatrix</code>	a matrix identical in size to the original dataset with 1 indicating a missing observation and a 0 indicating an observed observation.
<code>theta</code>	An array with dimensions $(p + 1)$ by $(p + 1)$ by m (where p is the number of variables in the imputations model) holding the converged parameters for each of the m EM chains.
<code>mu</code>	A p by m matrix of of the posterior modes for the complete-data means in each of the EM chains.
<code>covMatrices</code>	An array with dimensions (p) by (p) by m where the first two dimensions hold the posterior modes of the covariance matrix of the complete data for each of the EM chains.

code a integer indicating the exit code of the Amelia run.
 message an exit message for the Amelia run
 iterHist a list of iteration histories for each EM chain. See documentation for details.
 arguments a instance of the class "ameliaArgs" which holds the arguments used in the Amelia run.

Note that the `theta`, `mu` and `covMatrcies` objects refers to the data as seen by the EM algorithm and is thusly centered, scaled, stacked, tranformed and rearranged. See the manual for details and how to access this information.

Author(s)

James Honaker, Gary King, Matt Blackwell

See Also

For imputation diagnostics, [missmap](#), [compare.density](#), [overimpute](#) and [disperse](#).
 For time series plots, [tscsPlot](#). Also: [plot.amelia](#), [write.amelia](#), and [ameliabind](#).

Examples

```
data(africa)
a.out <- amelia(x = africa, cs = "country", ts = "year", logs = "gdp_pc")
summary(a.out)
plot(a.out)
```

ameliabind

Combine multiple runs of Amelia

Description

Combines multiple runs of `amelia` with the same arguments and data into one `amelia` object.

Usage

```
ameliabind(...)
```

Arguments

... two or more objects of class `amelia` with the same arguments and created from the same data.

Details

`ameliabind` will combine multiple runs of `amelia` into one object so that you can utilize diagnostics and modelling on all the imputations together. This function is useful for combining multiple runs of `amelia` run on parallel machines.

Note that `ameliabind` only checks that they arguments and the missingness matrix are identical. Thus, it could be fooled by two datasets that are identical up to a transformation of one variable.

Value

An object of class `amelia`.

See Also

`amelia`

`AmeliaView`

Interactive GUI for Amelia

Description

Brings up the `AmeliaView` graphical interface, which allows users to load datasets, manage options and run `Amelia` from a traditional windowed environment.

Usage

```
AmeliaView
```

`combine.output`

Combine Multiple Amelia Output Lists

Description

This function combines output lists from multiple runs of `Amelia`, where each run used the same arguments. The result is one list, formatted as if `Amelia` had been run once.

Usage

```
combine.output(...)
```

Arguments

... a list of `Amelia` output lists from runs of `Amelia` with the same arguments except the number of imputations.

Details

This function is useful for combining the output from `Amelia` runs that occurred at different times or in different sessions of R. It assumes that the arguments given to the runs of `Amelia` are the same except for `m`, the number of imputations, and it uses the arguments from the first output list as the arguments for the combined output list.

compare.density *Compare observed versus imputed densities*

Description

Plots smoothed density plots of observed and imputed values from output from the `amelia` function.

Usage

```
compare.density(output, var, col = c("red", "black"), scaled = FALSE,
  lwd = 1, main, xlab, ylab, legend = TRUE, frontend = FALSE, ...)
```

Arguments

<code>output</code>	output from the function <code>amelia</code> .
<code>var</code>	column number or variable name of the variable to plot.
<code>col</code>	a vector of length 2 containing the color to plot the (1) imputed density and (2) the observed density.
<code>scaled</code>	a logical indicating if the two densities should be scaled to reflect the difference in number of units in each.
<code>lwd</code>	the line width of the density plots.
<code>main</code>	main title of the plot. The default is to title the plot using the variable name.
<code>xlab</code>	the label for the x-axis. The default is the name of the variable.
<code>ylab</code>	the label for the y-axis. The default is "Relative Density."
<code>legend</code>	a logical value indicating if a legend should be plotted.
<code>frontend</code>	a logical value used internally for the Amelia GUI.
<code>...</code>	further graphical parameters for the plot.

Details

This function first plots a density plot of the observed units for the variable `var` in `col[2]`. The the function plots a density plot of the mean or modal imputations for the missing units in `col[1]`. If a variable is marked "ordinal" or "nominal" with the `ords` or `noms` options in `amelia`, then the modal imputation will be used. If `legend` is `TRUE`, then a legend is plotted as well.

References

Abayomi, K. and Gelman, A. and Levy, M. 2005 "Diagnostics for Multivariate Imputations," *Applied Statistics*. 57,3: 273–291.

See Also

For more information on how densities are computed, [density](#); Other imputation diagnostics are [overimpute](#), [disperse](#), and [tscsPlot](#).

 disperse

Overdispersed starting values diagnostic for multiple imputation

Description

A visual diagnostic of EM convergence from multiple overdispersed starting values for an output from `amelia`.

Usage

```
disperse(output, m = 5, dims = 1, p2s = 0, frontend = FALSE, ...)
```

Arguments

<code>output</code>	output from the function <code>amelia</code> .
<code>m</code>	the number of EM chains to run from overdispersed starting values.
<code>dims</code>	the number of principle components of the parameters to display and assess convergence on (up to 2).
<code>p2s</code>	an integer that controls printing to screen. 0 (default) indicates no printing, 1 indicates normal screen output and 2 indicates diagnostic output.
<code>frontend</code>	a logical value used internally for the Amelia GUI.
<code>...</code>	further graphical parameters for the plot.

Details

This function tracks the convergence of `m` EM chains which start from various overdispersed starting values. This plot should give some indication of the sensitivity of the EM algorithm to the choice of starting values in the imputation model in `output`. If all of the lines converge to the same point, then we can be confident that starting values are not affecting the EM algorithm.

As the parameter space of the imputation model is of a high-dimension, this plot tracks how the first (and second if `dims` is 2) principle component(s) change over the iterations of the EM algorithm. Thus, the plot is a lower dimensional summary of the convergence and is subject to all the drawbacks inherent in said summaries.

For `dims==1`, the function plots a horizontal line at the position where the first EM chain converges. Thus, we are checking that the other chains converge close to that horizontal line. For `dims==2`, the function draws a convex hull around the point of convergence for the first EM chain. The hull is scaled to be within the tolerance of the EM algorithm. Thus, we should check that the other chains end up in this hull.

See Also

Other imputation diagnostics are `compare.density`, `disperse`, and `tscsPlot`.

`freetrade`*Trade Policy and Democracy in 9 Asian States*

Description

Economic and political data on nine developing countries in Asia from 1980 to 1999. This dataset includes 9 variables including year, country, average tariff rates, Polity IV score, total population, gross domestic product per capita, gross international reserves, a dummy variable for if the country had signed an IMF agreement in that year, a measure of financial openness, and a measure of US hegemony. These data were used in Milner and Kubota (2005).

Usage`freetrade`**Format**

A data frame with 10 variables and 171 observations.

Source

World Bank, World Trade Organization, Polity IV and others.

References

Helen Milner and Keiko Kubota (2005), "Why the move to free trade? Democracy and trade policy in the developing countries." *International Organization*, Vol 59, Issue 1.

`missmap`*Missingness Map*

Description

Plots a missingness map showing where missingness occurs in the dataset passed to `amelia`.

Usage

```
missmap(obj, legend = TRUE, col = c("wheat", "darkred"), main,  
        y.cex = 0.8, x.cex = 0.8, y.labels, y.at, csvar = NULL, tsvar = NULL, ...)
```

Arguments

<code>obj</code>	an object of class "amelia"; typically output from the function <code>amelia</code> , a matrix or a dataframe.
<code>legend</code>	should a legend be drawn?
<code>col</code>	a vector of length two where the first element specifies the color for missing cells and the second element specifies the color for observed cells.
<code>main</code>	main title of the plot. Defaults to "Missingness Map".
<code>x.cex</code>	expansion for the variables names on the x-axis.
<code>y.cex</code>	expansion for the unit names on the y-axis.
<code>y.labels</code>	a vector of row labels to print on the y-axis
<code>y.at</code>	a vector of the same length as <code>y.labels</code> with row numbers associated with the labels.
<code>csvar</code>	column number or name of the variable corresponding to the unit indicator. Only used when the <code>obj</code> is not of class <code>amelia</code> .
<code>tsvar</code>	column number or name of the variable corresponding to the time indicator. Only used when the <code>obj</code> is not of class <code>amelia</code> .
<code>...</code>	further graphical arguments.

Details

`missmap` draws a map of the missingness in a dataset using the `image` function. The columns are reordered to put the most missing variable farthest to the left. The rows are reordered to a unit-period order if the `ts` and `cs` arguments were passed to `amelia`. If not, the rows are not reordered.

The `y.labels` and `y.at` commands can be used to associate labels with rows in the data to identify them in the plot. The y-axis is internally inverted so that the first row of the data is associated with the top-most row of the missingness map. The values of `y.at` should refer to the rows of the data, not to any point on the plotting region.

See Also

[compare.density](#), [overimpute](#), [tscsPlot](#), [image](#), [heatmap](#)

overimpute

Overimputation diagnostic plot

Description

Treats each observed value as missing and imputes from the imputation model from `amelia` output.

Usage

```
overimpute(output, var, legend = TRUE, xlab, ylab, main,
           frontend = FALSE, ...)
```

Arguments

output	output from the function <code>amelia</code> .
var	column number or variable name of the variable to overimpute.
legend	a logical value indicating if a legend should be plotted.
xlab	the label for the x-axis. The default is "Observed Values."
ylab	the label for the y-axis. The default is "Imputed Values."
main	main title of the plot. The default is to smartly title the plot using the variable name.
frontend	a logical value used internally for the Amelia GUI.
...	further graphical parameters for the plot.

Details

This function temporarily treats each observed value in `var` as missing and imputes that value based on the imputation model of `output`. The dots are the mean imputation and the vertical lines are the 90% percent confidence intervals for imputations of each observed value. The diagonal line is the $y = x$ line. If all of the imputations were perfect, then our points would all fall on the line. A good imputation model would have about 90% of the confidence intervals containing the truth; that is, about 90% of the vertical lines should cross the diagonal.

The color of the vertical lines displays the fraction of missing observations in the pattern of missingness for that observation. The legend codes this information. Obviously, the imputations will be much tighter if there are more observed covariates to use to impute that observation.

See Also

Other imputation diagnostics are `compare.density`, `disperse`, and `tscsPlot`.

plot.amelia

Summary plots for Amelia objects

Description

Plots diagnostic plots for the output from the `amelia` function.

Usage

```
## S3 method for class 'amelia':  
plot(x, which.vars, compare = TRUE, overimpute =  
      FALSE, ask = par("ask"), ...)
```

Arguments

x	an object of class "amelia"; typically output from the function <code>amelia</code> .
which.vars	a vector indicating the variables to plot. The default is to plot all of the numeric variables that were actually imputed.
compare	plot the density comparisons for each variable?
overimpute	plot the overimputation for each variable?
ask	prompt user before changing pages of a plot?
...	further graphical arguments.

See Also

[compare.density](#), [overimpute](#)

summary.amelia *Summary of an Amelia object*

Description

Returns summary information from the Amelia run along with missingles information.

Usage

```
## S3 method for class 'amelia':  
summary(object, ...)
```

Arguments

object	an object of class <code>amelia</code> . Typically, an output from the function <code>amelia</code> .
...	further arguments.

See Also

[amelia](#), [plot.amelia](#)

tscsPlot	<i>Plot observed and imputed time-series for a single cross-section</i>
----------	---

Description

Plots a time series for a given variable in a given cross-section and provides confidence intervals for the imputed values.

Usage

```
tscsPlot(output, var, cs, draws = 100, conf = .90,
         misscol = "red", obscol = "black", xlab, ylab, main,
         pch, ylim, xlim, ...)
```

Arguments

output	output from the function <code>amelia</code> .
var	the column number or variable name of the variable to plot.
cs	the name of the cross-section to plot.
draws	the number of imputations on which to base the confidence intervals.
conf	the confidence level of the confidence intervals to plot for the imputed values.
misscol	the color of the imputed values and their confidence intervals.
obscol	the color of the points for observed units.
xlab, ylab, main, pch, ylim, xlim	various graphical parameters.
...	further graphical parameters for the plot.

Details

The `cs` argument should be a value from the variable set to the `cs` argument in the `amelia` function for this output. This function will not work if the `ts` and `cs` arguments were not set in the `amelia` function.

write.amelia	<i>Write Amelia imputations to file</i>
--------------	---

Description

Writes the imputed datasets to file from a run of `amelia`.

Usage

```
write.amelia(obj, file.stem, extension = NULL, format = "csv", ...)
```

Arguments

<code>obj</code>	an object of class "amelia"; typically output from the function <code>amelia</code> .
<code>file.stem</code>	the leading part of the filename to save to output The imputation number and extension will be added to complete the filename. This can include a directory path.
<code>extension</code>	the extension of the filename. This is simply what follows <code>file.stem</code> and the imputation number.
<code>format</code>	one of the following output formats: <code>csv</code> , <code>dta</code> or <code>table</code> . See details.
<code>...</code>	further arguments for the <code>write</code> functions.

Details

`write.amelia` writes each of the imputed datasets to a file using one of the following functions: `write.csv`, `write.dta`, or `write.table`. You can pass arguments to these functions from `write.amelia`.

If you were to set `file.stem` to "outdata" and the `extension` to ".csv", then the resulting filename of the written files will be

```
outdata1.csv
outdata2.csv
outdata3.csv
...
```

and so on.

See Also

[write.csv](#), [write.table](#), [write.dta](#)

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