

# Package ‘sandwich’

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**Title** sandwich: Spatial Interpolation Based on Spatial Stratified Heterogeneity

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**Depends** R (>= 3.5.0), sf, ggplot2, gridExtra, geodetector, dplyr, caret, lwgeom

**Suggests** rmarkdown,  
knitr,  
MASS

**Description** This package enables the implementation of Sandwich model-based mapping in R.  
It provides functions to output the summarized statistics, the interpolated surface,  
and the standard error and confidence interval maps.

**License** GPL (>= 2)

**URL** <http://www.sssampling.cn/>, [https://github.com/linyuehzzz/sandwich\\_spatial\\_interpolator](https://github.com/linyuehzzz/sandwich_spatial_interpolator)

**BugReports** [https://github.com/linyuehzzz/sandwich\\_spatial\\_interpolator/issues](https://github.com/linyuehzzz/sandwich_spatial_interpolator/issues)

**LazyData** false

**RoxygenNote** 7.1.1

**VignetteBuilder** knitr

**Encoding** UTF-8

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bc	<i>Breast cancer incidence in mainland China</i>
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### Description

The bc dataset consists of two csv files:

- bc\_sampling\_ssh: Breast cancer incidence at 242 sampling units in mainland China, where the SSH stratum ("SSHID") and reporting unit ("GBCODE") that each sample falls into are specified. The sampling attribute is "Incidence".
- bc\_reporting\_ssh: The county-level administrative divisions in mainland China ("GBCODE"), where the weights of each intersecting stratum ("W1" and "W2") are specified.

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hs	<i>Heshun human population</i>
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### Description

The hs dataset consists of four sf objects:

- hs.sampling: Human population of 312 sampling villages within the Heshun region, China, which serves as the sampling layer.
- hs.ssh: A zonation map with 5 strata that serves as a candidate SSH layer.
- hs.ssh2: A zonation map with 6 strata that serves as another candidate SSH layer.
- hs.reporting: The administrative division of 10 townships in Heshun county that served as the reporting layer.

### References

Li, L., Wang, J., & Wu, J. (2012). A spatial model to predict the incidence of neural tube defects. *BMC Public Health*, 12(1), 951. doi:[10.1186/1471-2458-12-951](https://doi.org/10.1186/1471-2458-12-951)

### Examples

```
library(sf)
library(ggplot2)
data("hs.sampling")
summary(hs.sampling$Population)
ggplot(data=hs.sampling) + geom_sf(aes(color=Population))
```

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jl	<i>Jilin rodent density dataset</i>
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### Description

The jl dataset consists of four sf objects:

- `jl.sampling`: Rodent density at 627 sampling quadrats in Jilin, China, which serves as the sampling layer.
- `jl.ssh`: A classification map with 8 strata that serves as a candidate SSH layer.
- `jl.ssh2`: A zonation map with 11 strata that serves as another candidate SSH layer.
- `jl.reporting`: The administrative division of 10 counties in Jilin that served as the reporting layer.

### References

Liu, T., Wang, J., Xu, C., Ma, J., Zhang, H., & Xu, C. (2018). Sandwich mapping of rodent density in Jilin Province, China. *Journal of Geographical Sciences*, 28(4), 445-458.. doi:[10.1007/s11442-018-1483-z](https://doi.org/10.1007/s11442-018-1483-z)

### Examples

```
library(sf)
library(ggplot2)
data("jl.sampling")
summary(jl.sampling$Shushu)
ggplot(data=jl.sampling) + geom_sf(aes(color=Shushu))
```

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<code>load.data.shp</code>	<i>Load shapefiles into sf</i>
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### Description

`load.data.shp` converts shapefiles into a list of sf objects.

### Usage

```
load.data.shp(path, sampling.file, ssh.file, reporting.file)
```

### Arguments

<code>path</code>	Directory of the shapefiles.
<code>sampling.file</code>	Name of the sampling layer, minus extension (.shp). The sampling layer should be a point feature that contains an attribute that is to be interpolated.
<code>ssh.file</code>	Name of the SSH layer, minus extension (.shp). The SSH layer should be a polygon feature.
<code>reporting.file</code>	Name of the reporting layer, minus extension (.shp). The reporting layer should be a polygon feature.

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load.data.txt	<i>Load text files into data frames</i>
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### Description

load.data.txt converts text files into a list of data frames.

### Usage

```
load.data.txt(path, sampling_ssh.file, reporting_ssh.file)
```

### Arguments

sampling_ssh.file	Name of the file linking sampling and SSH layers. Each row denotes a sampling unit. At least two columns need to be included in this file: value of the sampling attribute and the stratum each sampling unit falling into.
reporting_ssh.file	Name of the file linking reporting and SSH layers. Each row denotes a reporting unit. The weights of each stratum should be specified in the columns.
path	Directory of the shapefile.

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plot.ci	<i>Plot confidence interval for the mean</i>
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### Description

plot.ci plots the lower and upper bounds of the confidence interval for the mean value of each reporting unit.

### Usage

```
plot.ci(object)
```

### Arguments

object	An sf object generated from the sandwich.ci function.
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plot.mean	<i>Plot Sandwich estimates</i>
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**Description**

plot.mean plots the mean value of an attribute for each reporting unit estimated by the Sandwich model.

**Usage**

```
plot.mean(object)
```

**Arguments**

object	An sf object generated from the sandwich.model function.
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**References**

Wang, J. F., Haining, R., Liu, T. J., Li, L. F., & Jiang, C. S. (2013). Sandwich estimation for multi-unit reporting on a stratified heterogeneous surface. *Environment and Planning A*, 45(10), 2515-2534. doi:[10.1068/a44710](https://doi.org/10.1068/a44710)

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plot.se	<i>Plot standard error of the Sandwich estimates</i>
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**Description**

plot.se plots the standard error of the estimated mean value for each reporting unit.

**Usage**

```
plot.se(object)
```

**Arguments**

object	An sf object generated from the sandwich.model function.
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**References**

Wang, J. F., Haining, R., Liu, T. J., Li, L. F., & Jiang, C. S. (2013). Sandwich estimation for multi-unit reporting on a stratified heterogeneous surface. *Environment and Planning A*, 45(10), 2515-2534. doi:[10.1068/a44710](https://doi.org/10.1068/a44710)

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sandwich	sandwich: <i>Spatial Interpolation Based on Spatial Stratified Heterogeneity</i>
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### Description

The package `sandwich` provides tools to interpolate a spatially stratified heterogeneous population with high accuracy, even when its spatial autocorrelation is weak. These tools allow the calculation of critical summarized statistics such as Geodetector  $q$ . They also enable the visualization of the interpolated surface as well as the standard error and confidence interval maps.

### Author(s)

Yue Lin, Chengdong Xu, and Jinfeng Wang

### References

Wang, J. F., Haining, R., Liu, T. J., Li, L. F., & Jiang, C. S. (2013). Sandwich estimation for multi-unit reporting on a stratified heterogeneous surface. *Environment and Planning A*, 45(10), 2515-2534. doi:[10.1068/a44710](https://doi.org/10.1068/a44710)

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sandwich.ci	Calculate confidence interval for the mean
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### Description

`sandwich.ci` calculates the confidence interval for the mean value of each reporting unit.

### Usage

```
sandwich.ci(object, level=.95)
```

### Arguments

<code>object</code>	An sf object or a data frame generated from the <code>sandwich.model</code> function.
<code>level</code>	The confidence level required. By default, <code>level = .95</code> .

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sandwich.cv	<i>Perform k-fold cross validation</i>
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### Description

sandwich.cv performs  $k$ -fold cross validation to evaluate the overall model accuracy and outputs the average root mean square error (RMSE).

### Usage

```
sandwich.cv(object, sampling.attr, k=10, type="shp", ssh.id.col=NULL,
reporting.id.col=NULL, ssh.weights=NULL)
```

### Arguments

object	When type="shp", object is a list of 3 sf objects generated by load.data.shp, including a POINT sf object used as the sampling layer, a POLYGON sf object used as the SSH layer, and a POLYGON sf object used as the SSH layer. When type="txt", object is a list of 2 data frames generated by load.data.txt, including a file linking sampling and SSH layers linking reporting and SSH layers and a file.
sampling.attr	A string denoting the name of the attribute in the sampling layer to be interpolated.
k	The number of folds ( $k > 1$ ). By default, $k = 10$ .
type	A string denoting the type of input data. type="shp" denotes shapefiles, and type="txt" denotes text files. By default, type="shp".
ssh.id.col	A string denoting the column that specifies which stratum each sampling unit falls into in the file linking sampling and SSH layers.
reporting.id.col	A string denoting the column that specifies which reporting unit each sampling unit falls into in the file linking sampling and SSH layers.
ssh.weights	A list that specifies the strata in the SSH layer and their corresponding columns of weights in the file linking reporting and SSH layers.

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sandwich.model	<i>Perform Sandwich model-based mapping</i>
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### Description

sandwich.model estimate the mean value of an attribute and its standard error for each reporting unit using the Sandwich method documented by Wang et al. (2013).

### Usage

```
sandwich.model(object, sampling.attr, type="shp", ssh.id.col=NULL, ssh.weights=NULL)
```

**Arguments**

object	When type="shp", object is a list of 3 sf objects generated by load.data.shp, including a POINT sf object used as the sampling layer, a POLYGON sf object used as the SSH layer, and a POLYGON sf object used as the SSH layer. When type="txt", object is a list of 2 data frames generated by load.data.txt, including a file linking sampling and SSH layers linking reporting and SSH layers and a file.
sampling.attr	A string denoting the name of the attribute in the sampling layer to be interpolated.
type	A string denoting the type of input data. type="shp" denotes shapefiles, and type="txt" denotes text files. By default, type="shp".
ssh.id.col	A string denoting the column that specifies which stratum each sampling unit falls into in the file linking sampling and SSH layers.
ssh.weights	A list that specifies the strata in the SSH layer and their corresponding columns of weights in the file linking reporting and SSH layers.

**References**

Wang, J. F., Haining, R., Liu, T. J., Li, L. F., & Jiang, C. S. (2013). Sandwich estimation for multi-unit reporting on a stratified heterogeneous surface. *Environment and Planning A*, 45(10), 2515-2534. doi:[10.1068/a44710](https://doi.org/10.1068/a44710)

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ssh.data.shp	<i>Prepare shapefile data for Geodetector</i>
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**Description**

ssh.data.shp joins a candidate SSH layer to an existing layer.

**Usage**

```
ssh.data.shp(object, ssh.lyr, ssh.id, ssh.name=NULL)
```

**Arguments**

object	A POINT sf object to be joint. Its geometry should be consistent with the sampling layer, but it may have additional attributes from the SSH layer(s).
ssh.lyr	A POLYGON sf object used as the candidate SSH layer. Its strata ID will be linked to object.
ssh.id	A string denoting the attribute name of strata ID in the SSH layer.
ssh.name	A string denoting the new attribute name assigned to the strata ID in the output object. If NULL, the attribute name will be the same as that in the old SSH layer.

**See Also**

[geodetector R package](#)



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ssh.data.txt	<i>Prepare text data for Geodetector</i>
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**Description**

ssh.data.txt prepare the input from text files for the geographical detector model.

**Usage**

```
ssh.data.txt(object)
```

**Arguments**

object	A list of 2 data frames generated by load.data.txt, including a file linking sampling and SSH layers linking reporting and SSH layers and a file.
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**See Also**

[geodetector R package](#)

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ssh.test	<i>Calculate Geodetector factor detector q-statistic and interaction detector</i>
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**Description**

ssh.test calculates the factor detector  $q$ -statistic and the interaction detector in the geographical detector model described by Wang et al. (2010). The  $q$ -statistic measures the SSH of the sampling attribute in terms of a given stratification, which can be used for the selection of an SSH layer for Sandwich model-based mapping. The interactive effects indicate whether a combination of two stratifications enhances the SSH of the sampling attribute.

**Usage**

```
ssh.test(object, y, x, test="factor", type="shp")
```

**Arguments**

object	A POINT sf object linking the attributes of the sampling layer and the strata ID in the SSH layer(s) generated from ssh.data.
y	A string denoting the name of the explained variable (sampling attribute) in object.
x	A string denoting the name(s) of the explanatory variable(s) (stratification(s)) in object.
test	A string denoting the type of test. test="factor" denotes the factor detector, and test="interaction" denotes the interaction detector. By default, test="factor".
type	A string denoting the type of input data. type="shp" denotes shapefiles, and type="txt" denotes text files. By default, type="shp".

**References**

Wang, J. F., Li, X. H., Christakos, G., Liao, Y. L., Zhang, T., Gu, X., & Zheng, X. Y. (2010). Geographical detectors-based health risk assessment and its application in the neural tube defects study of the Heshun Region, China. *International Journal of Geographical Information Science*, 24(1), 107-127. doi:[10.1080/13658810802443457](https://doi.org/10.1080/13658810802443457)

**See Also**

[geodetector R package](#)

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