

# Package ‘StructuralVariantAnnotation’

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**Type** Package

**Title** Variant annotations for structural variants

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**Description** StructuralVariantAnnotation contains useful helper functions for dealing with structural variants in VCF format. The packages contains functions for parsing VCFs from a number of popular callers as well as functions for dealing with breakpoints involving two separate genomic loci encoded as GRanges objects.

**License** GPL-3

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---

.constrict	<i>constrict</i>
------------	------------------

---

### Description

constrict

### Usage

```
.constrict(gr, ref = NULL, position = "middle")
```

### Arguments

gr	GRanges object
ref	reference
position	only 'middle' position is accepted.

### Value

A constricted GRanges object.

---

.isSymbolic                      *Determining whether the variant is a symbolic allele.*

---

**Description**

Determining whether the variant is a symbolic allele.

**Usage**

```
.isSymbolic(r, a)
```

**Arguments**

r                      Reference vector.  
a                      ALT vector.

**Value**

A logical list of which the length is the same with the input object.

---

.pairwiseLCPrefix              *vectorised pairwise longest common prefix Returns the length of the longest common prefix for each string pair*

---

**Description**

vectorised pairwise longest common prefix Returns the length of the longest common prefix for each string pair

**Usage**

```
.pairwiseLCPrefix(s1, s2, ignore.case = FALSE)
```

**Arguments**

s1, s2                      A pair of strings.  
ignore.case              Whether cases in the strings should be ignored.

**Value**

The length of the longest common prefix for each string pair.

`.svLen` *Returns the structural variant length of the first allele*

---

**Description**

Returns the structural variant length of the first allele

**Usage**

```
.svLen(vcf)
```

**Arguments**

vcf                    VCF object

**Value**

Structural variant lengths of the first allele.

---

`.testfile` *Testthat helper utility to locate files used for package tests*

---

**Description**

Testthat helper utility to locate files used for package tests

**Usage**

```
.testfile(filename, location = "extdata")
```

**Arguments**

filename              Name of the test file.  
location              Directory of the test file.

**Value**

Returns the file to be tested.

---

.testrecord                      *Loading a VCF containing the given records*

---

**Description**

Loading a VCF containing the given records

**Usage**

.testrecord(record)

**Arguments**

record                      string vector of record to write

**Value**

A VCF object.

---

.toVcfBreakendNotationAlt  
   *Converts to breakend notation*

---

**Description**

Converts to breakend notation

**Usage**

.toVcfBreakendNotationAlt(gr, insSeq = gr\$insSeq, ref = gr\$REF)

**Arguments**

gr                              GRanges object.  
insSeq                        insert sequence of the GRanges.  
ref                             reference sequence of the GRanges.

**Value**

breakendAlt or breakpointAlt depending on whether the variant is partnered.

---

<code>.unXStringSet</code>	<i>converts an XStringSet to a character</i>
----------------------------	--

---

**Description**

converts an XStringSet to a character

**Usage**

```
.unXStringSet(x)
```

**Arguments**

<code>x</code>	An XStringSet.
----------------	----------------

**Value**

A character.

---

<code>align_breakpoints</code>	<i>Adjusting the nominal position of a pair of partnered breakpoint.</i>
--------------------------------	--

---

**Description**

Adjusting the nominal position of a pair of partnered breakpoint.

**Usage**

```
align_breakpoints(vcf, align = c("centre"),
  is_higher_breakend = names(vcf) < info(vcf)$PARID)
```

**Arguments**

<code>vcf</code>	A VCF object.
<code>align</code>	The alignment type.
<code>is_higher_breakend</code>	Breakpoint ID ordering.

**Value**

A VCF object with adjusted nominal positions.

---

breakendRanges	<i>Extracting unpartnered breakend structural variants as a GRanges</i>
----------------	---

---

## Description

Extracting unpartnered breakend structural variants as a GRanges

## Usage

```
breakendRanges(x, ...)  
  
## S4 method for signature 'VCF'  
breakendRanges(x, ...)
```

## Arguments

x	A VCF object.
...	Parameters of <code>.breakpointRanges()</code> . See <code>breakpointRanges</code> for more details.

## Details

The VCF standard supports single breakends where a breakend is not part of a novel adjacency and lacks a mate. This function supports parsing single breakends to GRanges, where a dot symbol is used in the ALT field to annotate the directional information. Single breakends provide insights to situations when one side of the structural variant is not observed, due to e.g. low mappability, non-reference contigs, complex multi-break operations, etc. See Section 5.4.9 of <https://samtools.github.io/hts-specs/VCFv4.3.pdf> for details of single breakends.

## Value

A GRanges object of SVs.

## Methods (by class)

- VCF: Extracting unpartnered structural variants as GRanges.

## Examples

```
vcf.file <- system.file("extdata", "gridss.vcf",  
                        package = "StructuralVariantAnnotation")  
vcf <- VariantAnnotation::readVcf(vcf.file, "hg19")  
breakendRanges(vcf)  
breakendRanges(vcf, nominalPosition=TRUE)
```

---

breakpointgr2bedpe      *Converting breakpoint GRanges to BEDPE-like dataframe*

---

### Description

Converting breakpoint GRanges to BEDPE-like dataframe

### Usage

```
breakpointgr2bedpe(gr)
```

### Arguments

`gr`                    A GRanges object.

### Details

`breakpointgr2bedpe` converts a breakpoint GRanges to a BEDPE-formatted dataframe. The BEDPE format consists of two sets of genomic loci, optional columns of name, score, strand1, strand2 and any user-defined fields. See <https://bedtools.readthedocs.io/en/latest/content/general-usage.html> for more details of BEDPE format.

### Value

A BEDPE-formatted data frame.

### Examples

```
#converting a GRanges object to BEDPE-like dataframe
vcf.file <- system.file("extdata", "gridss.vcf", package = "StructuralVariantAnnotation")
vcf <- VariantAnnotation::readVcf(vcf.file, "hg19")
gr <- breakpointRanges(vcf)
breakpointgr2bedpe(gr)
```

---

breakpointgr2pairs      *Converts a breakpoint GRanges object to a Pairs object*

---

### Description

Converts a breakpoint GRanges object to a Pairs object

Converts a BEDPE Pairs containing pairs of GRanges loaded using to a breakpoint GRanges object.

### Usage

```
breakpointgr2pairs(bpgr, writeQualAsScore = TRUE, writeName = TRUE,
  bedpeName = NULL, firstInPair = NULL)
```

```
pairs2breakpointgr(pairs, placeholderName = "bedpe",
  firstSuffix = "_1", secondSuffix = "_2", nameField = "name",
  renameScoreToQUAL = TRUE)
```

**Arguments**

<code>bpgr</code>	breakpoint GRanges object
<code>writeQualAsScore</code>	write the breakpoint GRanges QUAL field as the score fields for compatibility with BEDPE rtracklayer export
<code>writeName</code>	write the breakpoint GRanges QUAL field as the score fields for compatibility with BEDPE rtracklayer export
<code>bedpeName</code>	function that returns the name to use for the breakpoint. Defaults to the sourceId, name column, or row names (in that priority) of the first breakend of each pair.
<code>firstInPair</code>	function that returns TRUE for breakends that are considered the first in the pair, and FALSE for the second in pair breakend. By default, the first in the pair is the breakend with the lower ordinal in the breakpoint GRanges object.
<code>pairs</code>	a Pairs object consisting of two parallel genomic loci.
<code>placeholderName</code>	prefix to use to ensure each entry has a unique ID.
<code>firstSuffix</code>	first in pair name suffix to ensure breakend name uniqueness
<code>secondSuffix</code>	second in pair name suffix to ensure breakend name uniqueness
<code>nameField</code>	Fallback field for row names if the Pairs object does not contain any names. BEDPE files loaded using rtracklayer use the "name" field.
<code>renameScoreToQUAL</code>	renames the 'score' column to 'QUAL'. Performing this rename results in a consistent variant quality score column name for variant loaded from BEDPE and VCF.

**Details**

Breakpoint-level column names will override breakend-level column names.

**Value**

Pairs GRanges object suitable for export to BEDPE by rtracklayer

Breakpoint GRanges object.

**Examples**

```
vcf.file <- system.file("extdata", "gridss.vcf", package = "StructuralVariantAnnotation")
bpgr <- breakpointRanges(VariantAnnotation::readVcf(vcf.file))
pairgr <- breakpointgr2pairs(bpgr)
rtracklayer::export(pairgr, con="example.bedpe")
bedpe.file <- system.file("extdata", "gridss.bedpe", package = "StructuralVariantAnnotation")
bedpe.pairs <- rtracklayer::import(bedpe.file)
bedpe.bpgr <- pairs2breakpointgr(bedpe.pairs)
```

---

```
breakpointGRangesToVCF
```

*Converts the given breakpoint GRanges object to VCF format in breakend notation.*

---

### Description

Converts the given breakpoint GRanges object to VCF format in breakend notation.

### Usage

```
breakpointGRangesToVCF(gr, ...)
```

### Arguments

<code>gr</code>	breakpoint GRanges object. Can contain both breakpoint and single breakend SV records.
<code>...</code>	For <code>cbind</code> and <code>rbind</code> a list of VCF objects. For all other methods <code>...</code> are additional arguments passed to methods. See VCF class in VariantAnnotation for more details.

### Value

A VCF object.

---

```
breakpointRanges
```

*Extracting the structural variants as a GRanges.*

---

### Description

Extracting the structural variants as a GRanges.

`.breakpointRanges()` is an internal function for extracting structural variants as GRanges.

### Usage

```
breakpointRanges(x, ...)
```

```
## S4 method for signature 'VCF'
breakpointRanges(x, ...)
```

```
.breakpointRanges(vcf, nominalPosition = FALSE,
  placeholderName = "svrecord", suffix = "_bp", info_columns = NULL,
  unpartneredBreakends = FALSE)
```

**Arguments**

x	A VCF object
...	Parameters of <code>.breakpointRanges()</code> . See below.
vcf	A VCF object.
nominalPosition	Determines whether to call the variant at the nominal VCF position, or to call the confidence interval (incorporating any homology present). Default value is set to FALSE, where the interval is called based on the CIPOS tag. When set to TRUE, the ranges field contains the nominal variant position only.
placeholderName	Variant name prefix to assign to unnamed variants.
suffix	The suffix to append to variant names.
info_columns	VCF INFO columns to include in the GRanges object.
unpartneredBreakends	Determining whether to report unpartnered breakends. Default is set to FALSE.

**Details**

Structural variants are converted to breakend notation. Due to ambiguities in the VCF specifications, structural variants with multiple alt alleles are not supported. The CIPOS tag describes the uncertainty interval of the around the position of the breakend. See Section 5.4.8 of <https://samtools.github.io/hts-specs/VCFv4.3.pdf> for details of CIPOS. If HOMLEN or HOMSEQ is defined without CIPOS, it is assumed that the variant position is left aligned. A breakend on the '+' strand indicates a break immediately after the given position, to the left of which is the DNA segment involved in the breakpoint. The '-' strand indicates a break immediately before the given position, rightwards of which is the DNA segment involved in the breakpoint. Unpaired variants are removed at this stage.

**Value**

A GRanges object of SVs.

**Methods (by class)**

- VCF: Extracting structural variants as GRanges.

**Examples**

```
vcf.file <- system.file("extdata", "vcf4.2.example.sv.vcf",
                       package = "StructuralVariantAnnotation")
vcf <- VariantAnnotation::readVcf(vcf.file, "hg19")
breakpointRanges(vcf)
breakpointRanges(vcf, nominalPosition=TRUE)
```

---

calculateReferenceHomology

*Calculates the length of inexact homology between the breakpoint sequence and the reference*

---

### Description

Calculates the length of inexact homology between the breakpoint sequence and the reference

### Usage

```
calculateReferenceHomology(gr, ref, anchorLength = 300, margin = 5,
  match = 2, mismatch = -6, gapOpening = 5, gapExtension = 3)
```

### Arguments

gr	reakpoint GRanges
ref	reference BSgenome
anchorLength	Number of bases to consider for homology
margin	Number of additional reference bases include. This allows for inexact homology to be detected even in the presence of indels.
match	see Biostrings::pairwiseAlignment
mismatch	see Biostrings::pairwiseAlignment
gapOpening	see Biostrings::pairwiseAlignment
gapExtension	see Biostrings::pairwiseAlignment

### Value

A dataframe containing the length of inexact homology between the breakpoint sequence and the reference.

---

countBreakpointOverlaps

*Counting overlapping breakpoints between two breakpoint sets*

---

### Description

Counting overlapping breakpoints between two breakpoint sets

### Usage

```
countBreakpointOverlaps(querygr, subjectgr, countOnlyBest = FALSE,
  breakpointScoreColumn = "QUAL", maxgap = -1L, minoverlap = 0L,
  ignore.strand = FALSE, sizemargin = NULL,
  restrictMarginToSizeMultiple = NULL)
```

**Arguments**

- querygr, subjectgr, maxgap, minoverlap, ignore.strand, sizemargin, restrictMarginToSizeMultiple  
See findBreakpointOverlaps().
- countOnlyBest Default value set to FALSE. When set to TRUE, the result count each subject breakpoint as overlapping only the best overlapping query breakpoint. The best breakpoint is considered to be the one with the highest QUAL score.
- breakpointScoreColumn  
Query column defining a score for determining which query breakpoint is considered the best when countOnlyBest=TRUE.

**Details**

countBreakpointOverlaps() returns the number of overlaps between breakpoint objects, based on the output of findBreakpointOverlaps(). See GenomicRanges::countOverlaps-methods

**Value**

An integer vector containing the tabulated query overlap hits.

**Examples**

```
truth_vcf = VariantAnnotation::readVcf(system.file("extdata", "na12878_chr22_Sudmunt2015.vcf", package = "Structurizr"))
crest_vcf = VariantAnnotation::readVcf(system.file("extdata", "na12878_chr22_crest.vcf", package = "Structurizr"))
caller_bpgr = breakpointRanges(crest_vcf)
caller_bpgr$true_positive = countBreakpointOverlaps(caller_bpgr, breakpointRanges(truth_vcf),
  maxgap=100, sizemargin=0.25, restrictMarginToSizeMultiple=0.5, countOnlyBest=TRUE)
```

---

elementExtract

*Extracts the element of each element at the given position*

---

**Description**

Extracts the element of each element at the given position

**Usage**

```
elementExtract(x, offset = 1)
```

**Arguments**

- x list-like object
- offset offset of list

**Value**

The element of each element at given positions.

---

extractBreakpointSequence

*Extracts the breakpoint sequence.*

---

### Description

Extracts the breakpoint sequence.

### Usage

```
extractBreakpointSequence(gr, ref, anchoredBases,
    remoteBases = anchoredBases)
```

### Arguments

gr	breakpoint GRanges
ref	Reference BSgenome
anchoredBases	Number of bases leading into breakpoint to extract
remoteBases	Number of bases from other side of breakpoint to extract

### Details

The sequence is the sequenced traversed from the reference anchor bases to the breakpoint. For backward (-) breakpoints, this corresponds to the reverse compliment of the reference sequence bases.

### Value

Breakpoint sequence around the variant position.

---

extractReferenceSequence

*Returns the reference sequence around the breakpoint position*

---

### Description

Returns the reference sequence around the breakpoint position

### Usage

```
extractReferenceSequence(gr, ref, anchoredBases,
    followingBases = anchoredBases)
```

### Arguments

gr	breakpoint GRanges
ref	Reference BSgenome
anchoredBases	Number of bases leading into breakpoint to extract
followingBases	Number of reference bases past breakpoint to extract

**Details**

The sequence is the sequenced traversed from the reference anchor bases to the breakpoint. For backward (-) breakpoints, this corresponds to the reverse compliment of the reference sequence bases.

**Value**

Reference sequence around the breakpoint position.

---

findBreakpointOverlaps

*Finding overlapping breakpoints between two breakpoint sets*

---

**Description**

Finding overlapping breakpoints between two breakpoint sets

**Usage**

```
findBreakpointOverlaps(query, subject, maxgap = -1L, minoverlap = 0L,
  ignore.strand = FALSE, sizemargin = NULL,
  restrictMarginToSizeMultiple = NULL)
```

**Arguments**

`query, subject` Both of the input objects should be GRanges objects. Unlike `findOverlaps()`, `subject` cannot be omitted. Each breakpoint must be accompanied with a partner breakend, which is also in the GRanges, with the partner's id recorded in the partner field. See `GenomicRanges::findOverlaps-methods` for details.

`maxgap, minoverlap` Valid overlapping thresholds of a maximum gap and a minimum overlapping positions between breakend intervals. Both should be scalar integers. `maxgap` allows non-negative values, and `minoverlap` allows positive values. See `GenomicRanges::findOverlaps-methods` for details.

`ignore.strand` Default value is FALSE. strand information is ignored when set to TRUE. See `GenomicRanges::findOverlaps-methods` for details.

`sizemargin` Error margin in allowable size to prevent matching of events of different sizes, e.g. a 200bp event matching a 1bp event when `maxgap` is set to 200.

`restrictMarginToSizeMultiple` Size restriction multiplier on event size. The default value of 0.5 requires that the breakpoint positions can be off by at maximum, half the event size. This ensures that small deletion do actually overlap at least one base pair.

**Details**

`findBreakpointOverlaps()` is an efficient adaptation of `findOverlaps-methods()` for breakend ranges. It searches for overlaps between breakpoint objects, and return a matrix including index of overlapping ranges as well as error stats. All breakends must have their partner breakend included in the partner field. A valid overlap requires that breakends on both sides meets the overlapping requirements.

See `GenomicRanges::findOverlaps-methods` for details of overlap calculation.

**Value**

A dataframe containing index and error stats of overlapping breakpoints.

**Examples**

```
#reading in VCF files
query.file <- system.file("extdata", "gridss-na12878.vcf", package = "StructuralVariantAnnotation")
subject.file <- system.file("extdata", "gridss.vcf", package = "StructuralVariantAnnotation")
query.vcf <- VariantAnnotation::readVcf(query.file, "hg19")
subject.vcf <- VariantAnnotation::readVcf(subject.file, "hg19")
#parsing vcfs to GRanges objects
query.gr <- breakpointRanges(query.vcf)
subject.gr <- breakpointRanges(subject.vcf)
#find overlapping breakpoint intervals
findBreakpointOverlaps(query.gr, subject.gr)
findBreakpointOverlaps(query.gr, subject.gr, ignore.strand=TRUE)
findBreakpointOverlaps(query.gr, subject.gr, maxgap=100, sizemargin=0.5)
```

---

isStructural

*Determining whether the variant is a structural variant*


---

**Description**

Determining whether the variant is a structural variant

**Usage**

```
isStructural(x, ...)

## S4 method for signature 'CollapsedVCF'
isStructural(x, ..., singleAltOnly = TRUE)

## S4 method for signature 'ExpandedVCF'
isStructural(x, ...)

## S4 method for signature 'VCF'
isStructural(x, ...)
```

**Arguments**

x	A VCF object.
...	Internal parameters.
singleAltOnly	Whether only single ALT values are accepted. Default is set to TRUE.

**Details**

The function takes a VCF object as input, and returns a logical value for each row, determining whether the variant is a structural variant.

**Value**

A logical list of which the length is the same with the input object.

**Methods (by class)**

- CollapsedVCF: Determining whether a CollapsedVCF object is a structural variant. Only single ALT values are accepted.
- ExpandedVCF: Determining whether a ExpandedVCF object is a structural variant.
- VCF: Determining whether a VCF object is a structural variant.

**Examples**

```
vcf.file <- system.file("extdata", "gridss.vcf", package = "StructuralVariantAnnotation")
vcf <- VariantAnnotation::readVcf(vcf.file, "hg19")
isStructural(vcf)
```

---

isSymbolic

*Determining whether the variant is a symbolic allele.*


---

**Description**

Determining whether the variant is a symbolic allele.

**Usage**

```
isSymbolic(x, ...)

## S4 method for signature 'CollapsedVCF'
isSymbolic(x, ..., singleAltOnly = TRUE)

## S4 method for signature 'ExpandedVCF'
isSymbolic(x, ...)
```

**Arguments**

x                    A VCF object.  
...                    Internal parameters.  
singleAltOnly        Whether only single ALT values are accepted. Default is set to TRUE.

**Details**

The function takes a VCF object as input, and returns a logical value for each row, determining whether the variant is a symbolic allele.

**Value**

A logical list of which the length is the same with the input object.

**Methods (by class)**

- CollapsedVCF: Determining whether a CollapsedVCF object is a symbolic allele. Only single ALT values are accepted.
- ExpandedVCF: Determining whether a ExpandedVCF object is a symbolic allele

**Examples**

```
vcf.file <- system.file("extdata", "gridss.vcf", package = "StructuralVariantAnnotation")
vcf <- VariantAnnotation::readVcf(vcf.file, "hg19")
isSymbolic(vcf)
```

---

 partner

*GRanges representing the breakend coordinates of structural variants  
#@export Partner breakend for each breakend.*

---

**Description**

GRanges representing the breakend coordinates of structural variants #@export Partner breakend for each breakend.

**Usage**

```
partner(gr, selfPartnerSingleBreakends = FALSE)
```

**Arguments**

`gr` GRanges object of SV breakends  
`selfPartnerSingleBreakends`  
 treat single breakends as their own partner.

**Details**

All breakends must have their partner breakend included in the GRanges.

**Value**

A GRanges object in which each entry is the partner breakend of those in the input object.

**Examples**

```
#reading in a VCF file as \code{vcf}
vcf.file <- system.file("extdata", "gridss.vcf", package = "StructuralVariantAnnotation")
vcf <- VariantAnnotation::readVcf(vcf.file, "hg19")
#parsing \code{vcf} to GRanges object \code{gr}
gr <- breakpointRanges(vcf)
#output partner breakend of each breakend in \code{gr}
partner(gr)
```

---

StructuralVariantAnnotation

*StructuralVariantAnnotation: a package for SV annotation*

---

## Description

StructuralVariantAnnotation contains useful helper functions for reading and interpreting structural variants calls. The packages contains functions for parsing VCFs from a number of popular caller as well as functions for dealing with breakpoints involving two separate genomic loci. The package takes a ‘GRanges’ based breakend-centric approach.

## Details

\* Parse VCF objects with the ‘breakpointRanges()’ and ‘breakendRanges()’ functions. \* Find breakpoint overlaps with the ‘findBreakpointOverlaps()’ and ‘countBreakpointOverlaps()’ functions. \* Generate BEDPE files for circos plot with ‘breakpointgr2pairs()’ function. \* ...

For more details on the features of StructuralVariantAnnotation, read the vignette: ‘browseVignettes(package = "StructuralVariantAnnotation")’

---

%na%

*Replaces the NA values in a with corresponding values in b*

---

## Description

Replaces the NA values in a with corresponding values in b

## Usage

```
a %na% b
```

## Arguments

a, b                    objects to be tested or coerced.

## Value

The altered object.

---

%null%

*Uses b if a is NULL*

---

**Description**

Uses b if a is NULL

**Usage**

a %null% b

**Arguments**

a, b                    objects to be tested or coerced.

**Value**

An un-null object.

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