

Overview of ensemblVEP

Valerie Obenchain

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1 Introduction

Ensembl provides the facility to predict functional consequences of known and unknown variants using the Variant Effect Predictor (VEP). The `ensemblVEP` package wraps Ensembl VEP and returns the results as R objects or a file on disk. To use this package the Ensembl VEP perl script must be installed in your path. See the package README for details. Downloads:

<http://uswest.ensembl.org/info/docs/variation/vep/index.html>

Complete documentation for runtime options:

http://uswest.ensembl.org/info/docs/variation/vep/vep_script.html

To test that Ensembl VEP is properly installed, enter the name of the script from the command line:

variant_effect_predictor.pl

2 Results as R objects

```
> library(ensemblVEP)
```

The `ensemblVEP` function can return variant consequences from Ensembl VEP as R objects (`GRanges` or `VCF`) or write them to a file. The default behavior returns a `GRanges`. Runtime options are stored in a `VEPParam` object and allow a great deal of control over the content and format of the results. See the man pages for more details.

```
> ?ensemblVEP
```

```
> ?VEPParam
```

The default runtime options can be inspected by creating a `VEPParam`.

```
> param <- VEPParam()
```

```
> param
```

```
class: VEPParam
```

```
basic(0):
```

```
input(1): species
```

```
cache(3): dir, dir_cache, dir_plugins
```

```
output(1): terms
```

```
identifier(0):
```

```
colocatedVariants(0):
```

```

dataformat(0):
filterqc(0):
database(2): database, host
advanced(1): buffer_size

> basic(param)

$verbose
[1] FALSE

$quiet
[1] FALSE

$no_progress
[1] FALSE

$config
character(0)

$everything
[1] FALSE

$fork
numeric(0)

```

Using a vcf file from VariantAnnotation as input, we query Ensembl VEP with the default runtime parameters.

```

> fl <- system.file("extdata", "gl_chr1.vcf", package="VariantAnnotation")
> gr <- ensemblVEP(fl)

```

Consequence data are parsed into the metadata columns of the GRanges. To control the type and amount of data returned see the options in output(VEPParam()).

```

> head(gr, 3)

```

GRanges with 3 ranges and 12 metadata columns:

	seqnames	ranges	strand	Allele	Gene
	<Rle>	<IRanges>	<Rle>	<factor>	<factor>
rs58108140	1	[10583, 10583]	*	A	ENSG00000223972
rs58108140	1	[10583, 10583]	*	A	ENSG00000227232
rs58108140	1	[10583, 10583]	*	A	ENSG00000227232
	Feature	Feature_type		Consequence	cDNA_position
	<factor>	<factor>		<factor>	<factor>
rs58108140	ENST00000456328	Transcript	upstream_gene_variant		<NA>
rs58108140	ENST00000488147	Transcript	downstream_gene_variant		<NA>
rs58108140	ENST00000541675	Transcript	downstream_gene_variant		<NA>
	CDS_position	Protein_position	Amino_acids	Codons	
	<factor>	<factor>	<factor>	<factor>	
rs58108140	<NA>	<NA>	<NA>	<NA>	
rs58108140	<NA>	<NA>	<NA>	<NA>	
rs58108140	<NA>	<NA>	<NA>	<NA>	
	Existing_variation	DISTANCE			
	<factor>	<factor>			
rs58108140	<NA>	1286			
rs58108140	<NA>	3821			
rs58108140	<NA>	3780			

seqlengths:					
1					
NA					

Next we use a vcf of structural variants as input

```
> fl <- system.file("extdata", "structural.vcf", package="VariantAnnotation")
```

and request that a VCF object be returned by setting the *vcf* option in the *dataformat* slot to TRUE.

```
> param <- VEPParam(dataformat=c(vcf=TRUE))
```

An call to *ensemblVEP* results in an error.

```
> vcf <- ensemblVEP(fl, param)
2012-12-03 16:40:55 - Starting...
ERROR: Could not detect input file format
```

In most situations Ensembl VEP can auto-detect the input format. In this case, however, it cannot so we explicitly set the *format* option to 'vcf'.

```
> input(param)$format <- "vcf"
```

Try again.

```
> vep <- ensemblVEP(fl, param)
```

Success! When a VCF is returned, consequence data are included as an unparsed INFO column labeled *CSQ*.

```
> info(vep)$CSQ
```

```
CharacterList of length 6
[[1]] -||||intergenic_variant|||||
[[2]] deletion|ENSG00000233684|ENST00000430529|Transcript|intron_variant&nc_t...
[[3]] deletion|ENSG00000230448|ENST00000418420|Transcript|intron_variant&nc_t...
[[4]] insertion|ENSG00000134077|ENST00000515662|Transcript|coding_sequence_va...
[[5]] duplication|ENSG00000132155|ENST00000423275|Transcript|intron_variant&N...
[[6]] -||||intergenic_variant|||||
```

The *parseCSQToGRanges* function parses these data into a *GRanges*. When the rownames of the original VCF are provided as *VCFRowID* a metadata column of the same name is included in the output.

```
> vcf <- readVcf(fl, "hg19")
> csq <- parseCSQToGRanges(vep, VCFRowID=rownames(vcf))
> head(csq, 3)
```

GRanges with 3 ranges and 13 metadata columns:

	seqnames		ranges		strand
	<Rle>		<IRanges>		<Rle>
1:2827693_CCGTGGATGCGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	1		[2827693, 2827762]		*
2:321682_T/	2		[321682, 321682]		*
2:321682_T/	2		[321682, 321682]		*
1:2827693_CCGTGGATGCGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C					
2:321682_T/					
2:321682_T/					
1:2827693_CCGTGGATGCGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C					
2:321682_T/					
2:321682_T/					
1:2827693_CCGTGGATGCGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C					
2:321682_T/					
2:321682_T/					

	VCFRowID
	<integer>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	2
2:321682_T/	3
2:321682_T/	3
	Allele
	<factor>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	-
2:321682_T/	deletion
2:321682_T/	deletion
	Gene
	<factor>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	<NA>
2:321682_T/	ENSG00000233684
2:321682_T/	ENSG00000233684
	Feature
	<factor>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	<NA>
2:321682_T/	ENST00000430529
2:321682_T/	ENST00000436808
	Feature_type
	<factor>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	<NA>
2:321682_T/	Transcript
2:321682_T/	Transcript
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	
2:321682_T/	intron_variant&nc_trans
2:321682_T/	intron_variant&nc_trans
	cDNA_position
	<factor>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	<NA>
2:321682_T/	<NA>
2:321682_T/	<NA>
	CDS_position
	<factor>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	<NA>
2:321682_T/	<NA>
2:321682_T/	<NA>
	Protein_position
	<factor>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	<NA>
2:321682_T/	<NA>
2:321682_T/	<NA>
	Amino_acids
	<factor>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	<NA>
2:321682_T/	<NA>
2:321682_T/	<NA>
	Codons
	<factor>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	<NA>
2:321682_T/	<NA>
2:321682_T/	<NA>
	Existing_variation
	<factor>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C	<NA>

```

2:321682_T/<DEL> <NA>
2:321682_T/<DEL> <NA>
DISTANCE
<factor>
1:2827693_CCGTGGATGCGGGGACCCGCATCCCCTCTCCCTTCACAGCTGAGTGACCCACATCCCCTCTCCCCTCGCA/C <NA>
2:321682_T/<DEL> <NA>
2:321682_T/<DEL> <NA>
---
seqlengths:
  1  2  3  4
NA NA NA NA

```

The `VCFRowID` columns maps the expanded *CSQ* data back to the rows in the *VCF* object. This index can be used to subset the original VCF.

```

> vcf[csq$"VCFRowID"]

class: CollapsedVCF
dim: 27 1
rowData(vcf):
  GRanges with 5 metadata columns: paramRangeID, REF, ALT, QUAL, FILTER
info(vcf):
  DataFrame with 10 columns: BKPTID, CIEND, CIPOS, END, HOMLEN, HOMSEQ, IMPR...
info(header(vcf)):
  Number Type Description
BKPTID . String ID of the assembled alternate allele in the ass...
CIEND 2 Integer Confidence interval around END for imprecise va...
CIPOS 2 Integer Confidence interval around POS for imprecise va...
END 1 Integer End position of the variant described in this r...
HOMLEN . Integer Length of base pair identical micro-homology at...
HOMSEQ . String Sequence of base pair identical micro-homology ...
IMPRECISE 0 Flag Imprecise structural variation
MEINFO 4 String Mobile element info of the form NAME,START,END,...
SVLEN . Integer Difference in length between REF and ALT alleles
SVTYPE 1 String Type of structural variant
geno(vcf):
  SimpleList of length 4: GT, GQ, CN, CNQ
geno(header(vcf)):
  Number Type Description
GT 1 String Genotype
GQ 1 Float Genotype quality
CN 1 Integer Copy number genotype for imprecise events
CNQ 1 Float Copy number genotype quality for imprecise events

```

3 Write results to a file

In the previous section we saw Ensembl VEP results returned as R objects in the workspace. Alternatively, these results can be written directly to a file. The flag that controls how the data are returned is the *output_file* flag in the *input* options.

When *output_file* is an empty character (default), the results are returned as either a *GRanges* or *VCF* object.

```

> input(param)$output_file

character(0)

```

To write results directly to a file, specify a file name for the *output_file* flag.

```

> input(param)$output_file <- "/mypath/myfile"

```

The file can be written as a *vcf* or *gvf* by setting the options in the *dataformat* slot to TRUE. If neither of *vcf* or *gvf* are TRUE the file is written out as tab delimited.

```

> ## Write a vcf file to myfile.vcf:
> myparam <- VEPParam(dataformat=c(vcf=TRUE),
+                       input=c(output_file="/path/myfile.vcf"))
> ## Write a gvf file to myfile.gvf:
> myparam <- VEPParam(dataformat=c(gvf=TRUE),
+                       input=c(output_file="/path/myfile.gvf"))
> ## Write a tab delimited file to myfile.txt:
> myparam <- VEPParam(input=c(output_file="/path/myfile.txt"))

```

4 Configuring runtime options

The Ensembl VEP web page has complete descriptions of all runtime options. http://www.ensembl.org/info/docs/variation/vep/vep_script.html#running Below are examples of how to configure the runtime options in the *VEP-Param* for specific situations. Investigate the differences in results using a sample file from *VariantAnnotation*.

```

> fl <- system.file("extdata", "ex2.vcf", package="VariantAnnotation")

```

- Add regulatory region consequences:

```

> param <- VEPParam(output=c(regulatory=TRUE))
> gr <- ensemblVEP(fl, param)

```

- Specify input file format as VCF, add HGNC gene identifiers, output SO consequence terms:

```

> param <- VEPParam(input=c(format="vcf"),
+                   output=c(terms="so"),
+                   identifiers=c(symbol=TRUE))
> gr <- ensemblVEP(fl, param)

```

- Check for co-located variants, output only coding sequence consequences, output HGVS names:

```

> param <- VEPParam(filterqc=c(coding_only=TRUE),
+                   colocatedVariants=c(check_existing=TRUE),
+                   identifiers=c(symbol=TRUE))
> gr <- ensemblVEP(fl, param)

```

- Add SIFT score and prediction, PolyPhen prediction only, output results as VCF:

```

fl <- system.file("extdata", "chr22.vcf.gz", package="VariantAnnotation")
param <- VEPParam(output=c(sift="b", polyphen="p"),
                  dataformat=c(vcf=TRUE))
vcf <- ensemblVEP(fl, param)
csq <- parseCSQToGRanges(vcf)

> head(levels(mcols(csq)$SIFT))
[1] "deleterious(0.01)" "deleterious(0.02)" "deleterious(0.03)"
[4] "deleterious(0.04)" "deleterious(0.05)" "deleterious(0)"

> levels(mcols(csq)$PolyPhen)
[1] "benign"           "possibly_damaging" "probably_damaging"
[4] "unknown"

```

5 sessionInfo()

```

> sessionInfo()

```

```

R version 3.0.2 Patched (2013-12-18 r64488)
Platform: x86_64-apple-darwin10.8.0 (64-bit)

```

```

locale:

```

```
[1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
```

attached base packages:

```
[1] parallel stats graphics grDevices utils datasets methods
[8] base
```

other attached packages:

```
[1] ensemblVEP_1.2.2 VariantAnnotation_1.8.12 Rsamtools_1.14.3
[4] Biostrings_2.30.1 GenomicRanges_1.14.4 XVector_0.2.0
[7] IRanges_1.20.6 BiocGenerics_0.8.0
```

loaded via a namespace (and not attached):

```
[1] AnnotationDbi_1.24.0 Biobase_2.22.0 biomaRt_2.18.0
[4] bitops_1.0-6 BSgenome_1.30.0 DBI_0.2-7
[7] GenomicFeatures_1.14.3 RCurl_1.95-4.1 RSQLite_0.11.4
[10] rtracklayer_1.22.4 stats4_3.0.2 tools_3.0.2
[13] XML_3.98-1.1 zlibbioc_1.8.0
```