

Overview of **ensemblVEP** Pre Ensembl 90

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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 Robjects 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.

NOTE: As of Ensembl version 88 the VEP script has been renamed from `variant_effect_predictor.pl` to `vep`. The **ensemblVEP** package code and documentation have been updated to reflect this change.

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

Complete documentation for runtime options: http://uswest.ensembl.org/info/docs/tools/vep/script/vep_options.html

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

```
vep
```

2 Results as R objects

```
> library(ensemblVEP)
```

The **ensemblVEP** function can return variant consequences from Ensembl VEP as Robjects (**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(version=88)
```

```
> param
```

```
class: VEPParam88
```

```
identifier(0):
```

```
colocatedVariants(0):
```

```
dataformat(0):
```

```
basic(0):
```

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

```

cache(3): dir, dir_cache, dir_plugins
output(1): terms
filterqc(0):
database(1): database
advanced(1): buffer_size
version: 88
scriptPath:

```

```
> 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 object with 3 ranges and 23 metadata columns:

	seqnames	ranges	strand	Allele	
	<Rle>	<IRanges>	<Rle>	<factor>	
rs6054257	20	[14370, 14370]	*	A	
20:17330_T/A	20	[17330, 17330]	*	A	
rs6040355	20	[1110696, 1110696]	*	G	
	Consequence	IMPACT	SYMBOL	Gene	
	<factor>	<factor>	<factor>	<factor>	
rs6054257	intergenic_variant	MODIFIER	<NA>	<NA>	
20:17330_T/A	intergenic_variant	MODIFIER	<NA>	<NA>	
rs6040355	upstream_gene_variant	MODIFIER	PSMF1	ENSG00000125818	
	Feature_type	Feature	BIOTYPE	EXON	
	<factor>	<factor>	<factor>	<factor>	
rs6054257	<NA>	<NA>	<NA>	<NA>	
20:17330_T/A	<NA>	<NA>	<NA>	<NA>	
rs6040355	Transcript	ENST00000479715	processed_transcript	<NA>	
	INTRON	HGVSc	HGVSp	cDNA_position	CDS_position
	<factor>	<factor>	<factor>	<factor>	<factor>
rs6054257	<NA>	<NA>	<NA>	<NA>	<NA>
20:17330_T/A	<NA>	<NA>	<NA>	<NA>	<NA>
rs6040355	<NA>	<NA>	<NA>	<NA>	<NA>
	Protein_position	Amino_acids	Codons	Existing_variation	
	<factor>	<factor>	<factor>	<factor>	

rs6054257	<NA>	<NA>	<NA>	<NA>
20:17330_T/A	<NA>	<NA>	<NA>	<NA>
rs6040355	<NA>	<NA>	<NA>	<NA>

	DISTANCE	STRAND	FLAGS	SYMBOL_SOURCE	HGNC_ID
	<factor>	<factor>	<factor>	<factor>	<factor>
rs6054257	<NA>	<NA>	<NA>	<NA>	<NA>
20:17330_T/A	<NA>	<NA>	<NA>	<NA>	<NA>
rs6040355	2610	1	<NA>	HGNC	HGNC:9571

seqinfo: 1 sequence from genome

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), version=88)
```

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 0

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 object with 0 ranges and 23 metadata columns:

seqnames	ranges	strand	Allele	Consequence	IMPACT	SYMBOL
<Rle>	<IRanges>	<Rle>	<character>	<character>	<character>	<character>
Gene	Feature_type	Feature	BIOTYPE	EXON	INTRON	
<character>	<character>	<character>	<character>	<character>	<character>	
HGVSc	HGVSp	cDNA_position	CDS_position	Protein_position		
<character>	<character>	<character>	<character>	<character>		
Amino_acids	Codons	Existing_variation	DISTANCE	STRAND		
<character>	<character>	<character>	<character>	<character>		
FLAGS	SYMBOL_SOURCE	HGNC_ID				
<character>	<character>	<character>				

seqinfo: no sequences

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: 0 1
rowRanges(vcf):
  GRanges with 5 metadata columns: paramRangeID, REF, ALT, QUAL, FILTER
info(vcf):
  DFrame 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 asse...
CIEND     2      Integer Confidence interval around END for imprecise var...
CIPOS     2      Integer Confidence interval around POS for imprecise var...
END       1      Integer End position of the variant described in this re...
HOMLEN    .      Integer Length of base pair identical micro-homology at ...
HOMSEQ    .      String Sequence of base pair identical micro-homology a...
IMPRECISE 0      Flag    Imprecise structural variation
MEINFO    4      String Mobile element info of the form NAME,START,END,P...
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"), version=88)
> ## Write a gvf file to myfile.gvf:
> myparam <- VEPParam(dataformat=c(gvf=TRUE),
+                       input=c(output_file="/path/myfile.gvf"), version=88)
> ## Write a tab delimited file to myfile.txt:
> myparam <- VEPParam(input=c(output_file="/path/myfile.txt"), version=88)
```

4 Configuring runtime options

The Ensembl VEP web page has complete descriptions of all runtime options. http://uswest.ensembl.org/info/docs/tools/vep/script/vep_options.html 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 <- VEPPParam(output=c(regulatory=TRUE), version=88)
> gr <- ensemblVEP(fl, param)
```

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

```
> param <- VEPPParam(input=c(format="vcf"),
+                      output=c(terms="so"),
+                      identifiers=c(symbol=TRUE), version=88)
> gr <- ensemblVEP(fl, param)
```

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

```
> param <- VEPPParam(filterqc=c(coding_only=TRUE),
+                      colocatedVariants=c(check_existing=TRUE),
+                      identifiers=c(symbol=TRUE), version=88)
> 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 <- VEPPParam(output=c(sift="b", polyphen="p"),
                    dataformat=c(vcf=TRUE), version=88)
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 3.6.1 (2019-07-05)
```

```
Platform: x86_64-apple-darwin15.6.0 (64-bit)
```

```
Running under: OS X El Capitan 10.11.6
```

```
Matrix products: default
```

```
BLAS: /Library/Frameworks/R.framework/Versions/3.6/Resources/lib/libRblas.0.dylib
```

```
LAPACK: /Library/Frameworks/R.framework/Versions/3.6/Resources/lib/libRlapack.dylib
```

```
locale:
```

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

```
attached base packages:
```

```
[1] stats4    parallel  stats      graphics  grDevices  utils      datasets
[8] methods   base
```

```
other attached packages:
```

```
[1] ensemblVEP_1.28.0      VariantAnnotation_1.32.0
[3] Rsamtools_2.2.0        Biostrings_2.54.0
[5] XVector_0.26.0         SummarizedExperiment_1.16.0
```

[7] DelayedArray_0.12.0	BiocParallel_1.20.0
[9] matrixStats_0.55.0	Biobase_2.46.0
[11] GenomicRanges_1.38.0	GenomeInfoDb_1.22.0
[13] IRanges_2.20.0	S4Vectors_0.24.0
[15] BiocGenerics_0.32.0	

loaded via a namespace (and not attached):

[1] progress_1.2.2	tidyselect_0.2.5	purrr_0.3.3
[4] lattice_0.20-38	vctrs_0.2.0	BiocFileCache_1.10.0
[7] rtracklayer_1.46.0	GenomicFeatures_1.38.0	blob_1.2.0
[10] XML_3.98-1.20	rlang_0.4.1	pillar_1.4.2
[13] glue_1.3.1	DBI_1.0.0	rappdirs_0.3.1
[16] bit64_0.9-7	dbplyr_1.4.2	GenomeInfoDbData_1.2.2
[19] stringr_1.4.0	zlibbioc_1.32.0	memoise_1.1.0
[22] biomaRt_2.42.0	curl_4.2	AnnotationDbi_1.48.0
[25] Rcpp_1.0.2	BSgenome_1.54.0	openssl_1.4.1
[28] backports_1.1.5	bit_1.1-14	hms_0.5.1
[31] askpass_1.1	digest_0.6.22	stringi_1.4.3
[34] dplyr_0.8.3	grid_3.6.1	tools_3.6.1
[37] bitops_1.0-6	magrittr_1.5	RCurl_1.95-4.12
[40] tibble_2.1.3	RSQLite_2.1.2	crayon_1.3.4
[43] pkgconfig_2.0.3	zeallot_0.1.0	Matrix_1.2-17
[46] prettyunits_1.0.2	assertthat_0.2.1	httr_1.4.1
[49] R6_2.4.0	GenomicAlignments_1.22.0	compiler_3.6.1