

Data preprocessing and creation of the data objects auxiliary for the DEXSeq package

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Abstract

This vignette describes the steps that were followed for the generation of the data objects contained in the package *pasilla*.

Contents

1	Downloading the files	1
2	Read alignment and filtering	1
3	Exon count files	2
4	Creation of the <i>DEXSeqDataSet</i> dxd	3

1 Downloading the files

We used the RNA-Seq data from the publication by Brooks et al. [1]. The experiment investigated the effect of siRNA knock-down of *pasilla*, a gene that is known to bind to mRNA in the spliceosome, and which is thought to be involved in the regulation of splicing. The data set contains 3 biological replicates of the knockdown as well as 4 biological replicates for the untreated control. Data files are publicly available in the NCBI Gene Expression Omnibus under the accession GSE18508¹. The read sequences in FASTQ format were extracted from the NCBI short read archive file (.sra files), using the sra toolkit².

2 Read alignment and filtering

The reads in the FASTQ files were aligned using tophat version 1.2.0 with default parameters against the reference *Drosophila melanogaster* genome. Table 1 summarizes the read number and alignment statistics.

¹<http://www.ncbi.nlm.nih.gov/projects/geo/query/acc.cgi?acc=GSE18508>

²http://www.ncbi.nlm.nih.gov/books/NBK47540/#SRA_Download_Guid_B.5_Converting_SRA_for

	file	type	number of lanes	total number of reads	exon counts
1	treated1fb	single-read	5	35158667	15679615
2	treated2fb	paired-end	2	12242535 (x2)	15620018
3	treated3fb	paired-end	2	12443664 (x2)	12733865
4	untreated1fb	single-read	2	17812866	14924838
5	untreated2fb	single-read	6	34284521	20764558
6	untreated3fb	paired-end	2	10542625 (x2)	10283129
7	untreated4fb	paired-end	2	12214974 (x 2)	11653031

Table 1: Read numbers and alignment statistics. The column *exon counts* refers to the number of reads that could be uniquely aligned to an exon.

The reference genome fasta files were obtained from the Ensembl ftp server³. We ran `bowtie-build` to index the fasta file. For more information on this procedure see the bowtie webpage⁴. The indexed form is required by bowtie, and thus tophat.

```
wget ftp://ftp.ensembl.org/pub/release-62/fasta/drosophila_melanogaster/ \
dna/Drosophila_melanogaster.BDGP5.25.62.dna_rm.toplevel.fa.gz
```

```
gunzip Drosophila_melanogaster.BDGP5.25.62.dna_rm.toplevel.fa.gz
bowtie-build Drosophila_melanogaster.BDGP5.25.62.dna_rm.toplevel.fa \
d_melanogaster_BDGP5.25.62
```

We generated the alignment BAM file using tophat. For the single-reads data:

```
tophat bowtie_index reads1.fastq,reads2.fastq,...,readsN.fastq
```

For the paired-end data:

```
tophat -r inner-fragment-size bowtie_index \
reads1_1.fastq,reads2_1.fastq,...,readsN_1.fastq \
reads1_2.fastq,reads2_2.fastq,...,readsN_2.fastq
```

More information on tophat is provided on its webpage⁵. The SAM alignment files from which *pasilla* was generated are available at <http://www-huber.embl.de/pub/DEXSeq/analysis/brooksetal/bam/>.

3 Exon count files

To generate the per-exon read counts, we first needed to define the exonic regions. To this end, we downloaded the file `Drosophila_melanogaster.BDGP5.25.62.gtf.gz` from Ensembl⁶. The script `dexseq_prepare_annotation.py` contained in the *DEXSeq* package was used to extract the exons of the transcripts from the file, define new non-overlapping exonic regions and reformat it to create the file `Dmel.BDGP5.25.62.DEXSeq.chr.gff` contained in `pasilla/extdata`. For example, for this file we ran:

```
wget ftp://ftp.ensembl.org/pub/release-62/gtf/ \
drosophila_melanogaster/Drosophila_melanogaster.BDGP5.25.62.gtf.gz
```

³<http://www.ensembl.org/info/data/ftp/index.html>

⁴<http://bowtie-bio.sourceforge.net/tutorial.shtml>

⁵<http://tophat.cbcb.umd.edu/tutorial.html>

⁶ftp://ftp.ensembl.org/pub/release-62/gtf/drosophila_melanogaster

```
gunzip Drosophila_melanogaster.BDGP5.25.62.gtf.gz
python dexseq_prepare_annotation.py Drosophila_melanogaster.BDGP5.25.62.gtf \
    Dmel.BDGP5.25.62.DEXSeq.chr.gff
```

To count the reads that fell into each non-overlapping exonic part, the script `dexseq_count.py`, which is also contained in the *DEXSeq* package, was used. It took the alignment results in the form of a SAM file (sorted by position in the case of a paired end data) and the `gtf` file `Dmel.BDGP5.25.62.DEXSeq.chr.gff` and returned one file for each biological replicate with the exon counts. For example, for the file `treated1.bam`, which contained single-end alignments, we ran:

```
samtools index treated1.bam
samtools view treated1.bam > treated1.sam
python dexseq_count.py Dmel.BDGP5.25.62.DEXSeq.chr.gff \
    treated1.sam treated1fb.txt
```

For the file `treated2.bam`, which contained paired-end alignments:

```
samtools index treated2.bam
samtools view treated2.bam > treated2.sam
sort -k1,1 -k2,2n treated2.sam > treated2_sorted.sam
python dexseq_count.py -p yes Dmel.BDGP5.25.62.DEXSeq.chr.gff \
    treated2_sorted.sam treated2fb.txt
```

The output of the two HTSeq python scripts is provided in the *pasilla* package:

```
> library("pasilla")
> inDir = system.file("extdata", package="pasilla", mustWork=TRUE)
> dir(inDir)

[1] "Dmel.BDGP5.25.62.DEXSeq.chr.gff" "geneIDsinsubset.txt"
[3] "pasilla_gene_counts.tsv"      "treated1fb.txt"
[5] "treated2fb.txt"              "treated3fb.txt"
[7] "untreated1fb.txt"           "untreated2fb.txt"
[9] "untreated3fb.txt"           "untreated4fb.txt"
```

The Python scripts are built upon the HTSeq library⁷.

4 Creation of the *DEXSeqDataSet* `dxd`

To create an *DEXSeqDataSet* object, we started with a data frame `samples` that contained the sample annotations, as in Table 1.

```
> head(samples)

      condition      type
treated1fb    treated single-read
treated2fb    treated  paired-end
treated3fb    treated  paired-end
```

⁷<http://www-huber.embl.de/users/anders/HTSeq/doc/overview.html>

```
untreated1fb untreated single-read
untreated2fb untreated single-read
untreated3fb untreated paired-end
```

We also needed the annotation file with the per exon annotation.

```
> annotationfile = file.path(inDir, "Dmel.BDGP5.25.62.DEXSeq.chr.gff")
```

With these, we could call the function `DEXSeqDataSet` to construct the object `dxd`.

```
> library("DEXSeq")
> dxd = DEXSeqDataSetFromHTSeq(
+   countfiles = file.path(inDir, paste(rownames(samples), "txt", sep=".")),
+   sampleData=samples,
+   design= ~ sample + exon + condition:exon,
+   flattenedfile = annotationfile)
```

We only wanted to work with data from a subset of genes, which was defined in the following file.

```
> genesforsubset = readLines(file.path(inDir, "geneIDsinsubset.txt"))
> dxd = dxd[genesforsubset,]
```

We save our objects

We saved the objects in the data directory of the package:

```
> save(dxd, file=file.path("../data", "pasillaDEXSeqDataSet.RData"))
```

References

- [1] A. N. Brooks, L. Yang, M. O. Duff, K. D. Hansen, J. W. Park, S. Dudoit, S. E. Brenner, and B. R. Graveley. Conservation of an RNA regulatory map between *Drosophila* and mammals. *Genome Research*, pages 193–202, October 2010.

```
> toLatex(sessionInfo())
```

- R version 3.2.2 (2015-08-14), x86_64-pc-linux-gnu
- Locale: LC_CTYPE=en_US.UTF-8, LC_NUMERIC=C, LC_TIME=en_US.UTF-8, LC_COLLATE=C, LC_MONETARY=en_US.UTF-8, LC_MESSAGES=en_US.UTF-8, LC_PAPER=en_US.UTF-8, LC_NAME=C, LC_ADDRESS=C, LC_TELEPHONE=C, LC_MEASUREMENT=en_US.UTF-8, LC_IDENTIFICATION=C
- Base packages: base, datasets, grDevices, graphics, methods, parallel, stats, stats4, utils
- Other packages: Biobase 2.30.0, BiocGenerics 0.16.0, BiocParallel 1.4.0, DESeq2 1.10.0, DEXSeq 1.16.0, GenomeInfoDb 1.6.0, GenomicRanges 1.22.0, IRanges 2.4.0, Rcpp 0.12.1, RcppArmadillo 0.6.100.0.0, S4Vectors 0.8.0, SummarizedExperiment 1.0.0, pasilla 0.10.0, xtable 1.7-4
- Loaded via a namespace (and not attached): AnnotationDbi 1.32.0, Biostrings 2.38.0, DBI 0.3.1, Formula 1.2-1, Hmisc 3.17-0, MASS 7.3-44, RColorBrewer 1.1-2, RCurl 1.95-4.7, RSQLite 1.0.0, Rsamtools 1.22.0, XML 3.98-1.3, XVector 0.10.0, acepack 1.3-3.3, annotate 1.48.0, biomaRt 2.26.0, bitops 1.0-6, cluster 2.0.3, colorspace 1.2-6, digest 0.6.8, foreign 0.8-66, futile.logger 1.4.1, futile.options 1.0.0, genefilter 1.52.0, geneplotter 1.48.0, ggplot2 1.0.1, grid 3.2.2, gridExtra 2.0.0, gtable 0.1.2, hwriter 1.3.2, lambda.r 1.1.7, lattice 0.20-33, latticeExtra 0.6-26, locfit 1.5-9.1, magrittr 1.5, munsell 0.4.2, nnet 7.3-11, plyr 1.8.3, proto 0.3-10, reshape2 1.4.1, rpart 4.1-10, scales 0.3.0, splines 3.2.2, statmod 1.4.21, stringi 0.5-5, stringr 1.0.0, survival 2.38-3, tools 3.2.2, zlibbioc 1.16.0

Table 2: The output of `sessionInfo` on the build system after running this vignette.