A pipeline to analyse PAT-seq data

Reference

This repository contains the pipeline and raw results described in the manuscript:

- Botond Sipos, Adrian M. Stütz, Greg Slodkowicz, Tim Massingham, Jan Korbel, Nick Goldman: *PAT-seq - a whole-transcriptome poly(A) tail length determination assay for the Illumina platform*.

Click here for more details on the wetlab experiment.

Using the pipeline

The pipeline can be used by invoking the following `make` targets:

- Fetch raw data from ENA: `make fetch`
- Generate transcriptome from SGD annotation: `make transcriptome`
- Align and parse reads: `make parse`
- Test for differential polyadenylation: `make test` or `make lsf_test`
- Parse spike-in reads (`make parse_spikeins`) and build "error model" (`make error_model`)
- Filter test results by G-tail coverage: `make gtail_cov_filter`
- Plot correlation between technical replicates: `make gtail_tech_corr`
- Plot and cluster tail length distributions: `make classify_tail_dists`
- Correlate thresholded tail lengths with PASTA and PAL-seq: `make corr_with_studies`

Index of selected raw results

Illumina reads

Sequencing data are available in the ArrayExpress database under accession number E-MTAB-2456.

Alignment

Sample	Alignment log	Alignment report
WT1A	http://bit.ly/PAT-seq-WT1A_aln_log	http://bit.ly/PAT-seq-WT1A_align_pdf
WT1B	http://bit.ly/PAT-seq-WT1B_aln_log	http://bit.ly/PAT-seq-WT1B_align_pdf
WT1C	http://bit.ly/PAT-seq-WT1C_aln_log	http://bit.ly/PAT-seq-WT1C_align_pdf`
WT1D	http://bit.ly/PAT-seq-WT1D_aln_log	http://bit.ly/PAT-seq-WT1D_align_pdf

Sample	Alignment log	Alignment report
WT2A	http://bit.ly/PAT-seq-WT2A_aln_log	http://bit.ly/PAT-seq-WT2A_align_pdf
WT2B	http://bit.ly/PAT-seq-WT2B_aln_log	http://bit.ly/PAT-seq-WT2B_align_pdf
WT2C	http://bit.ly/PAT-seq-WT2C_aln_log	http://bit.ly/PAT-seq-WT2C_align_pdf
WT2D	http://bit.ly/PAT-seq-WT2D_aln_log	http://bit.ly/PAT-seq-WT2D_align_pdf
MUT1A	http://bit.ly/PAT-seq-MUT1A_aln_log	http://bit.ly/PAT-seq-MUT1A_aln_pdf
MUT1B	http://bit.ly/PAT-seq-MUT1B_aln_log	http://bit.ly/PAT-seq-MUT1B_aln_pdf
MUT1C	http://bit.ly/PAT-seq-MUT1C_aln_log	http://bit.ly/PAT-seq-MUT1C_aln_pdf`
MUT1D	http://bit.ly/PAT-seq-MUT1D_aln_log	http://bit.ly/PAT-seq-MUT1D_aln_pdf
MUT2A	http://bit.ly/PAT-seq-MUT2A_aln_log	http://bit.ly/PAT-seq-MUT2A_aln_pdf
MUT2B	http://bit.ly/PAT-seq-MUT2B_aln_log	http://bit.ly/PAT-seq-MUT2B_aln_pdf
MUT2C	http://bit.ly/PAT-seq-MUT2C_aln_log	http://bit.ly/PAT-seq-MUT2C_aln_pdf
MUT2D	http://bit.ly/PAT-seq-MUT2D_aln_log	http://bit.ly/PAT-seq-MUT2D_aln_pdf

Parsing alignments

Sample	Parse log	Parse report
WT1A	http://bit.ly/PAT-seq-WT1A_parse_log	http://bit.ly/PAT-seq-WT1A_parse_pdf
WT1B	http://bit.ly/PAT-seq-WT1B_parse_log	http://bit.ly/PAT-seq-WT1B_parse_pdf
WT1C	http://bit.ly/PAT-seq-WT1C_parse_log	http://bit.ly/PAT-seq-WT1C_parse_pdf
WT1D	http://bit.ly/PAT-seq-WT1D_parse_log	http://bit.ly/PAT-seq-WT1D_parse_pdf
WT2A	http://bit.ly/PAT-seq-WT2A_parse_log	http://bit.ly/PAT-seq-WT2A_parse_pdf
WT2B	http://bit.ly/PAT-seq-WT2B_parse_log	http://bit.ly/PAT-seq-WT2B_parse_pdf
WT2C	http://bit.ly/PAT-seq-WT2C_parse_log	http://bit.ly/PAT-seq-WT2C_parse_pdf

Sample	Parse log	Parse report
WT2D	http://bit.ly/PAT-seq-WT2D_parse_log	http://bit.ly/PAT-seq-WT2D_parse_pdf
MUT1A	http://bit.ly/PAT-seq-MUT1A_parse_log	http://bit.ly/PAT-seq-MUT1A_parse_pdf
MUT1B	http://bit.ly/PAT-seq-MUT1B_parse_log	http://bit.ly/PAT-seq-MUT1B_parse_pdf
MUT1C	http://bit.ly/PAT-seq-MUT1C_parse_log	http://bit.ly/PAT-seq-MUT1C_parse_pdf
MUT1D	http://bit.ly/PAT-seq-MUT1D_parse_log	http://bit.ly/PAT-seq-MUT1D_parse_pdf
MUT2A	http://bit.ly/PAT-seq-MUT2A_parse_log	http://bit.ly/PAT-seq-MUT2A_parse_pdf
MUT2B	http://bit.ly/PAT-seq-MUT2B_parse_log	http://bit.ly/PAT-seq-MUT2B_parse_pdf
MUT2C	http://bit.ly/PAT-seq-MUT2C_parse_log	http://bit.ly/PAT-seq-MUT2C_parse_pdf
MUT2D	http://bit.ly/PAT-seq-MUT2D_parse_log	http://bit.ly/PAT-seq-MUT2D_parse_pdf

Quantifying tail length slippage using spike-in standards

- Tail run lengths until the first 1-5 non-A bases in reads mapped to spike-in poly(A) tracts PDF

Testing differences between wild type and mutant tail runs

Comparison	Test log	Test report	Results
WT1 vs. MUT1	http://bit.ly/PAT-seq-TEST_WT1_vs_MUT1_log	http://bit.ly/PAT-seq-TEST_WT1_vs_MUT1_pdf	http://bit.ly/PAT-seq-TEST_WT1_vs_MUT1_trs_tab
WT2 vs. MUT2	http://bit.ly/PAT-seq-TEST_WT2_vs_MUT2_log	http://bit.ly/PAT-seq-TEST_WT2_vs_MUT2_pdf	http://bit.ly/PAT-seq-TEST_WT2_vs_MUT2_trs_tab

Tail run distributions from all transcripts with G-tail coverage > 1000

- WT1: http://bit.ly/PAT-seq-CLS_WT1_pdf
- WT2: http://bit.ly/PAT-seq_CLS_WT2_pdf
- MUT1: http://bit.ly/PAT-seq-CLS_MUT1_pdf
- MUT2: http://bit.ly/PAT-seq-CLS_MUT2_pdf

Cross-study correlation

- PAL_total vs. WT1: http://bit.ly/PAT_seq_PAL_total_vs_WT1_pdf
- PAL_total vs. WT2: http://bit.ly/PAT-seq_PAL_total_vs_WT2_pdf
- PAL_total vs. PASTA: http://bit.ly/PAT-seq-PAL_total_vs_PASTA_pdf

Dependencies

- Platform LSF
- Python 2.x
- numpy >= 1.6.2
- matplotlib >= 1.1.0
- scipy >= 0.10.1
- biopython >= 1.60
- Bowtie2 >= 2.1.0
- samtools >= 0.1.19+
- wget

Using the analysis tools

The analysis tool can be found under `patsy/`:

patsy-align - classify read pairs and align them using Bowtie2

```
usage: patsy-align [-h] -1 fq1 -2 fq2 -f ref [-o outdir] [-s stats_pickle]
                   [-l gtail_sig] [-G gtag_min] [-N max_N] [-I min_fsize]
                   [-X max_fsize] [-p nr_threads] [-r report]

Align PAT-seq reads using Bowtie2 (1.1).

optional arguments:
  -h, --help        show this help message and exit
  -1 fq1            First FASTQ file.
  -2 fq2            Second FASTQ file.
  -f ref            Reference fasta.
  -o outdir         Output directory.
  -s stats_pickle   Stats pickle file.
  -l gtail_sig      Portion of read start/end used for G-tail classification
                    (14).
  -G gtag_min       Minimum G-tag length(3).
  -N max_N          Maximum number of Ns in the first -l bases (6).
  -I min_fsize      Minimum fragment size (0).
  -X max_fsize      Maximum fragment size (500).
  -p nr_threads     Number of threads to use (1).
  -r report         Report PDF.
```

patsy-parse - parse classified and aligned PAT-seq read pairs

```
usage: patsy-parse [-h] -g gtail_sam -n nvtr_sam -d dataset_id -f ref
                   [-l gtail_sig] [-G gtag_min] [-N max_N] [-e err_tol]
                   [-o out_pickle] [-i tr_list] [-q min_q] [-r report] [-t]

Parse classified and aligned PAT-seq read pairs (1.1).

optional arguments:
  -h, --help      show this help message and exit
  -g gtail_sam    SAM file containing G-tail alignments.
  -n nvtr_sam     SAM file containing NVTR alignments.
  -d dataset_id   Dataset identifier.
  -f ref          Reference fasta.
  -l gtail_sig   Portion of read start/end used for G-tail classification.
  -G gtag_min    Minimum G-tag length(3).
  -N max_N       Maximum number of Ns in the first -l bases (6).
  -e err_tol     Number of errors tolerated in the tail.
  -o out_pickle  Output pickle file.
  -i tr_list     List of transcripts considered.
  -q min_q       Mapping quality treshold (30).
  -r report      Report PDF.
  -t             Plot per-transcript coverage reports.
```

patsy-test - test for differential polyadenylation in PAT-seq data

```
usage: patsy-test [-h] -a [a_pickles [a_pickles ...]] -na a_name -b
                  [b_pickles [b_pickles ...]] -nb b_name [-i lrt_list]
                  [-P lik_penalty] [-M min_size_U] [-s sig_level]
                  [-op out_pickle] [-ot out_trs] [-og out_glob]
                  [-otr out_runs_prefix] [-orr out_rep_prefix] [-r report]
                  [-t]

Test for differential polyadenylation in PAT-seq data (1.1).

optional arguments:
  -h, --help            show this help message and exit
  -a [a_pickles [a_pickles ...]]
                        Parsed read pickles - group A.
  -na a_name            Name of data group A.
  -b [b_pickles [b_pickles ...]]
                        Parsed read pickles - group B.
  -nb b_name            Name of data group B.
  -i lrt_list           Transcripts to be tested with anchors LRT.
  -P lik_penalty        Log-likelihood penalty for data points outside valid
                        range.
  -M min_size_U         Minimum sample size when performing Mann-Whitney U
                        test (30).
  -s sig_level          Significance level.
  -op out_pickle        Output pickle file.
  -ot out_trs           Output tabular file: transcript properties.
  -og out_glob          Output tabular file: global results.
  -otr out_runs_prefix  Output tabular file: tail runs prefix.
  -orr out_rep_prefix   Output tabular file: tail means per replicate.
  -r report             Report PDF.
  -t                    Plot reports for all transcripts.
```

patsy-spike - estimate the number of sequencing errors in runs of bases.

```
usage: patsy-spike [-h] -n spike_sam -f ref [-w window] [-m max_errors_plot]
                   [-o out_pickle] [-q min_q] [-r report] [-l read_len]
                   [-pk pickle]

Estimate the number of sequencing errors in runs of bases (1.0).

optional arguments:
  -h, --help          show this help message and exit
  -n spike_sam        SAM file containing NVTR alignments.
  -f ref              Reference fasta with the spike-in sequences.
  -w window           Size of the flanking sequence around the run of As.
  -m max_errors_plot  Maximum number of errors for which to plot the length
                      distribution.
  -o out_pickle       Output pickle file.
  -q min_q            Mapping quality treshold (30).
  -r report           Report PDF.
  -l read_len         Read length.
  -pk pickle          Result pickle file.
```