SeleDiff Manual

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1 Usages

1.1 Environment Setting

To use `SeleDiff`, you should install Java SE Runtime Enviroment 8 first.

After the installation, you can check Java version in the command line (command starts by ">" prompt).

```
> java -version
java version "1.8.0_25"
Java(TM) SE Runtime Environment (build 1.8.0_25-b17)
Java HotSpot(TM) 64-Bit Server VM (build 25.25-b02, mixed mode)
```

1.2 Installation

To install `SeleDiff`, you first clone the `SeleDiff` repository from GitHub.

```
> git clone https://github.com/xin-huang/SeleDiff
```

Then you can enter the `SeleDiff` directory and use `gradlew` to install `SeleDiff`.

```
> cd ./SeleDiff
> ./gradlew build
> ./gradlew install
```

The runnable `SeleDiff` is in `./build/install/SeleDiff/bin/`. You can add this directory into your system environment variable `PATH` by

```
> export PATH="/path/to/SeleDiff/build/install/SeleDiff/bin/":$PATH
```

You can get help information by typing

```
> SeleDiff
```

and you will get the following:

```
Usage: SeleDiff [command] [command options]
  Commands:
    var      Sub-command for computing population variances
      Usage: var [options]
        Options:
        * --geno
            The EIGENSTRAT GENO file stores allele counts: 0, zero copy of the
            reference allele; 1, one copy of the reference allele and one copy
            of the alternative allele; 2, two copies of the reference allele;
            9, missing values.
            Default: []
        * --ind
            The EIGENSTRAT IND file stores information of individuals and
            populations.
        * --output
            The output file.
        * --snp
            The EIGENSTRAT SNP file stores information of variants.

    scan      Sub-command for scanning loci under natural selection
      Usage: scan [options]
        Options:
```

```
* --geno
    The EIGENSTRAT GENO file stores allele counts: 0, zero copy of the
    reference allele; 1, one copy of the reference allele and one copy
    of the alternative allele; 2, two copies of the reference allele;
    9, missing values.
    Default: []
* --ind
    The EIGENSTRAT IND file stores information of individuals and
    populations.
* --var
    The file stores variances of drift between populations, which is
    space delimited without header the first column is the first
    population ID the second column is the second population ID the
    third column is the variance of drift of this population pair.
    This file is needed when estimating selection differences.
* --output
    The output file.
* --snp
    The EIGENSTRAT SNP file stores information of variants.
* --time
    The file stores divergence times between populations. A divergence
    time file is space delimited without header, where the first
    column is the population ID of the first population, the second
    column is the population ID of the second population, the third
    column is the divergence time of this population pair. This file
    is needed when estimating selection differences.
```

* indicates required options

There are two sub-commands in `SeleDiff`. The first sub-command `var` is used for estimating variances of population demography parameter Ω[1], which are required for the second sub-command `scan`.

1.3 Input Files

1.3.1 EIGENSTRAT

`SeleDiff` accepts EIGENSTRAT format of genetic data as inputs.

For EIGENSTRAT format, there are 3 files: **SNP** file, **IND** file and **GENO** file. Consider an example dataset containing 3 unrelated individuals (Ind1, Ind2 & Ind3) from 3 populations (Pop1, Pop2 & Pop3) that were typed on 3 SNPs (SNP1, SNP2 & SNP3):

```
        SNP1 SNP2 SNP3
Ind1    T/T  A/T  T/T
Ind2    C/G  C/G  C/G
Ind3    C/C  A/A  ?/?
```

The **SNP** file describes the information of each SNP. The SNP file corresponding to the example dataset is:

```
SNP1 1 0.1 100 A T
SNP2 1 0.2 101 C G
SNP3 1 0.3 103 C A
```

Each row corresponds to a SNP. The 6 columns are:

1. SNP ID
2. Chromosome number

3. SNP genetic position
4. SNP physical position
5. Reference allele
6. Alternative allele

The **IND** file describes the information of each individual. The IND file corresponding to the example dataset is:

```
Ind1 M pop1
Ind2 F pop2
Ind3 U pop3
```

Each row corresponds to an individual. The 3 columns are:

1. Individual ID
2. Sex: M for male, F for female and U for unknown
3. Population ID

The **GENO** file contains genetic data. The GENO file corresponding to the example dataset is:

```
010
111
209
```

Each row corresponds to a SNP, and each column corresponds to an individual. The characters, 0, 1, 2, 9, correspond to an individual's genotype:

- 0 means zero copies of reference allele.
- 1 means one copy of reference allele.
- 2 means two copies of reference allele.
- 9 means missing data.

1.3.2 Var File

The Var file is the output file from the first sub-command `var`, which stores variances of pairwise population demography parameters. When using sub-command `scan` to estimate selection differences, `SeleDiff` uses `--var` option to accept a a *TAB* delimited file without header that specifies variances of population demography parameters between two populations.

```
YRI     CEU     1.547660
YRI     CHS     1.639591
CEU     CHS     0.989241
```

The first two columns are the population IDs, and the third column is the variance of population demography parameter of the two populations.

1.3.3 Divergence Time File

When using sub-command `scan` to estimate selection differences, `SeleDiff` uses `--time` option to accept a *TAB* delimited file without header that specifies divergence time between two populations.

```
YRI    CEU    5000
YRI    CHS    5000
CEU    CHS    3000
```

The first two columns are the population IDs, and the third column is the divergence time of the two populations.

1.4 Output File

The output file from `SeleDiff` is *TAB* delimited. The first row is a header that describes the meaning of each column.

Column	Column Name	Description
1	SNP ID	The name of a SNP
2	Ref	The reference allele
3	Alt	The alternative allele
4	Population1	The first population ID
5	Population2	The second population ID
6	Selection difference	The selection difference between the first and second populations
7	Std	The standard deviation of the selection difference
8	Lower bound of 95% CI	Lower bound of 95% confidence interval of the selection coefficient difference
9	Upper bound of 95% CI	Upper bound of 95% confidence interval of the selection coefficient difference
10	Delta	The δ statistic for selection difference
11	p-value	The p-value of the δ statistic

2 An Example

Here is an example to show how `SeleDiff` estimates and tests selection differences between populations. 4 populations (YRI, CEU, CHB, CHD) from HapMap3 (release3) were extracted. CHB and CHD were merged into one population called CHS. Correlated individuals and SNPs which major allele frequencies are less than 0.05 were removed by PLINK 1.7(`--geno 0.01 --maf 0.05`). SNPs in strong linkage disequilibrium were removed, applying a window of 50 SNPs advanced by 5 SNPs and r^2 threshold of 0.01 (`--indep-pairwise 50 5 0.01`) in PLINK. All the genetic data are stored in EIGENSTRAT format.

The SNP rs12913832 in gene *HERC2* is associated with blue/non-blue eyes[2]. The SNP rs1800407 in gene *OCA2* is also associated with blue/non-blue eyes[2].

The counts of alleles in our example data were summarized in below.

SNP ID	Population	Ancestral Allele Count	Derived Allele Count
rs12913832	YRI	294	0
rs12913832	CEU	47	177
rs12913832	CHS	491	1
rs1800407	YRI	290	0
rs1800407	CEU	207	17
rs1800407	CHS	486	4

We assume the divergence time of YRI-CEU and YRI-CHS are both 5000 generations, while the divergence time of CEU-CHS is 3000 generations. This information is stored in `examples/example.time`.

First, we estimate variances of population demography parameter using sub-command `var`.

```
> SeleDiff var --geno ./examples/example.geno \
               --ind ./examples/example.ind \
               --snp ./examples/example.snp \
               --output ./examples/example.var
```

To estimate selection coefficient differences, we use the sub-command `scan`.

```
> SeleDiff scan --geno ./examples/example.candidates.geno \
                --ind ./examples/example.candidates.ind \
                --snp ./examples/example.candidates.snp \
                --var ./examples/example.var \
                --time ./examples/example.time \
                --output ./examples/example.candidates.results
```

The result is stored in `./examples/example.candidates.results`. The main result is in below.

SNP ID	Population1	Population2	Selection difference	Std	delta	p-value
rs1800407	YRI	CEU	-0.000773	0.000380	4.129	0.042154
rs1800407	YRI	CHS	-0.000336	0.000393	0.731	0.392559
rs1800407	CEU	CHS	0.000728	0.000377	3.730	0.053443
rs12913832	YRI	CEU	-0.001541	0.000378	16.583	0.000047
rs12913832	YRI	CHS	-0.000117	0.000415	0.080	0.777297
rs12913832	CEU	CHS	0.002372	0.000433	30.062	0.000000

From the result, we can see the selection coefficient of rs12913832 in CEU is significantly higher than that in YRI or CHS, which indicates rs12913832 is under positive selection in CEU. While the selection coefficient of rs1800407 in CEU is marginal significantly higher than that in YRI or CHS.

3 Dependencies

- Java 1.8
- Apache Commons Math 3.6
- JCommander 1.72
- t-digest 3.1

4 References

1 Yungang He, Minxian Wang, Xin Huang, Ran Li, Hongyang Xu, Shuhua Xu and Li Jin. A Probabilistic Method for Testing and Estimating Selection Differences Between Populations. *Genome Research*, 25:1903-1909, 2015.

2 Richard A. Sturm, David L. Duffy, Zhen Zhen Zhao, Fabio P.N. Leite, Mitchell S. Stark, Nicholas K. Hayward, Nicholas G. Martin and Gran W. Montgomery. A Single SNP in an Evolutionary Conserved Region within Intron 86 of the *HERC2* Gene Determines Human Blue-Brown Eye Color. *Am J Hum Genet*, 82:424-431.