

**NAME**

swarm — find clusters of nearly-identical nucleotide amplicons

**SYNOPSIS**

**swarm** [ *options* ] [ *filename* ]

**DESCRIPTION**

Environmental or clinical molecular studies generate large volumes of amplicons (e.g. SSU-rRNA sequences) that need to be clustered into molecular operational taxonomic units. Traditional clustering methods are based on greedy, input-order dependent algorithms, with arbitrary selection of global cluster size and cluster centroids. To address that problem, we developed **swarm**, a fast and robust method that recursively groups amplicons with *d* or less differences. **swarm** produces stable clusters (or "swarms"), free from centroid selection induced input-order dependency.

Exact clustering is impractical on large data sets when using a naïve all-vs-all approach (i.e. a 2-combination without repetitions), as it implies unrealistic numbers of pairwise comparisons. **swarm** is based on a maximum number of differences, and focuses only on close relationships. Several pre-filterings and an astute use of comparisons results obtained during the process allows to avoid up to 98% of the amplicon comparisons needed in a naïve approach. To speed up the remaining amplicon comparisons, **swarm** implements an extremely fast Needleman-Wunsch algorithm making use of the Streaming SIMD Extensions (SSE4.1) of modern x86-64 CPUs. If SSE4.1 instructions are not available, **swarm** exits with an error message.

**swarm** reads the named input *filename*, a fasta file of nucleotide amplicons. The amplicon identifier is defined as the string comprised between the ">" symbol and the first space or the end of the line, whichever comes first. As **swarm** outputs lists of amplicon identifiers, amplicon identifiers must be unique to avoid ambiguity; **swarm** exits with an error message if identifiers are not unique. If amplicon identifiers end with a "\_" followed by a number, that number is used as the amplicon copy number in the statistics output file. The amplicon sequence is defined as a string of [acgt] or [acgu] symbols (case insensitive), starting after the end of the identifier line and ending before the next identifier line or the file end; **swarm** exits with an error message if any other symbol is present. Default is to read from standard input if no file is named, or if the file name is "-".

**Options**

**swarm** recognizes the following command-line options:

**-d, --differences** *positive integer*

maximum number of differences allowed between two amplicons, meaning that two amplicons will be grouped if they have *integer* (or less) differences. This is **swarm**'s most important parameter. The number of differences is calculated as the number of mismatches (substitutions, insertions or deletions) between the two amplicons once the optimal pairwise global alignment has been found (see "advanced options" for parameters influencing the pairwise alignment). Any *integer* between 1 and 256 can be used, but aligning two very distant amplicons is difficult and results should be considered with caution. Default number of differences is 1.

**-h, --help** display this help and exit.**-o, --output-file** *filename*

output result to *filename*. Result is a list of swarms, one swarm per line. A swarm is a list of amplicon identifiers separated by spaces. Default is to write to standard output.

**-s, --statistics-file** *filename*

output statistics to the specified file. Default is not to output statistics. The file is a tab-separated table with one swarm per row and seven columns of information: number of unique amplicons in the swarm, total copy number of amplicons in the swarm, identifier of the initial seed, initial seed copy number (if applicable), number of singletons (amplicons with a copy number of 1), maximum number of generations (i.e. numbers of iterations before the swarm reached its natural limits), and the maximum radius of the swarm (i.e. number of differences between the seed and the furthestmost amplicon).

in the swarm).

- t, --threads** *positive integer*  
number of computation threads to use. The number of threads should be lesser or equal to the number of available CPU cores. Default number of threads is 1.
- u, --uclust-file** *filename*  
output results in uclust-like file format to the specified file. That option does not modify swarm default output format.
- v, --version**  
output version information and exit.

### Advanced options

**swarm** recognizes advanced command-line options modifying the pairwise global alignment scoring parameters:

- m, --match-reward** *positive integer*  
reward for a nucleotide match. Default is 5.
- p, --mismatch-penalty** *positive integer*  
penalty for a nucleotide mismatch. Default is 4.
- g, --gap-opening-penalty** *positive integer*  
gap open penalty. Default is 12.
- e, --gap-extension-penalty** *positive integer*  
gap extension penalty. Default is 4.

As **swarm** focuses on close relationships, final results are resilient to model parameters modifications. Modifying model parameters only impacts swarms with a large number of subseed levels, or analysis using a high number of differences.

### EXAMPLES

**swarm** -t 4 -o *myfile.swarms* *myfile.fasta*

Divide the data set *myfile.fasta* into swarms with the finest resolution possible (1 difference) using 4 computation threads, and write the results in the file *myfile.swarms*.

zcat file.fas.gz | **swarm** | awk "{print NF}" | sort -n | uniq -c

Use **swarm** in a pipeline to read a compressed fasta file and to get its swarm size profile (with default parameters).

### AUTHORS

Concept by Frédéric Mahé, implementation by Torbjørn Rognes.

### REPORTING BUGS

Report bugs to <mahe@rhrk.uni-kl.de> and <torognes@ifi.uio.no>.

### AVAILABILITY

The software is available from <<https://github.com/torognes/swarm>>

### COPYRIGHT

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**SEE ALSO**

**swipe**, an extremely fast Smith-Waterman database search tool by Torbjørn Rognes (available from [<https://github.com/torognes/swipe>](https://github.com/torognes/swipe)).

**VERSION HISTORY**

New features and important modifications of **swarm**:

**v1.1** released February 26, 2013

Version 1.1 introduces two new important options: the possibility to output swarming results using the uclust output format, and the possibility to output detailed statistics on each swarms. Swarm 1.1 is also faster: new filterings based on pairwise amplicon sequence lengths and composition comparisons reduce the number of pairwise alignments needed and speed up the swarming.

**v1.0** released November 10, 2012

First public release