HNCO

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Chapter 1

Namespace Index

1.1 Namespace List

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Chapter 2

Hierarchical Index

2.1 Class Hierarchy

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Chapter 3

Class Index

3.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 4

Namespace Documentation

4.1 hnco Namespace Reference

top-level HNCO namespace

Namespaces

- algorithm

  Algorithms.
- app

  Classes for applications.
- exception

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- function

  Functions defined on bit vectors.
- logging

  Logging.
- map

  Maps.
- neighborhood

  Neighborhoods for local search.
- random

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- representation

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Classes

- class Iterator

  Iterator over bit vectors
- class HypercubeIterator

  Hypercube iterator.
- class ExtendedHypercubeIterator

  Extended Hypercube iterator.
- class StopWatch

  Stop watch.

Functions

- template<class A , class B >
  bool have_same_size (const A &a, const B &b)
  Check whether two containers have the same size.
- template<class T >
  T square (T x)
  Generic square function.
- double logistic (double x)
  Logistic function (sigmoid)
- template<typename Iter >
  std::string join (Iter begin, Iter end, std::string const &separator)
  Convert to string and join elements of a container (from SO)

Load from and save to boost archives

- template<typename T >
  void load_from_archive (T &object, std::string path, std::string name)
  Load from a boost archive.
- template<typename T >
  void save_to_archive (const T &object, std::string path, std::string name)
  Save to a boost archive.

Range checking

- bool is_in_range (int i, int a, int b)
  Check whether an index is in a given range.
- bool is_in_range (int i, int n)
  Check whether an index is in a given range.

Intervals

- bool is_in_interval (double x, double a, double b)
  Check whether a float value belongs to a given interval.
- template<typename T >
  T clip_value (T x, T low, T high)
  Clip value between two bounds.

Types and functions related to bit matrices

Output and input-output function parameters appear at the beginning of the parameter list.

Output and input-output bit_matrix_t parameters are passed by reference and must have the right size for the considered function.

Input object parameters are passed by const reference.

- using bit_matrix_t = std::vector< bit_vector_t >
  Bit matrix.
- bit_matrix_t bm_rectangular (int nrows, int ncols)
  Make a rectangular bit matrix.
- bit_matrix_t bm_square (int n)

Make a square bit matrix.
- void bm_identity (bit_matrix_t &M)

  Set a matrix to the identity matrix.
- bit_matrix_t bm_identity (int n)

  Make an identity bit matrix.
- void bm_transpose (bit_matrix_t &N, const bit_matrix_t &M)

  Transpose a bit matrix.
- bit_matrix_t bm_transpose (const bit_matrix_t &M)

  Transpose a bit matrix.
- void bm_display (const bit_matrix_t &M, std::ostream &stream)

  Display bit matrix.
- bool bm_is_valid (const bit_matrix_t &M)

  Check whether a bit matrix is valid.
- int bm_num_rows (const bit_matrix_t &M)

  Number of rows.
- int bm_num_columns (const bit_matrix_t &M)

  Number of columns.
- bool bm_is_square (const bit_matrix_t &M)

  Check whether the matrix is a square matrix.
- bool bm_is_identity (const bit_matrix_t &M)

  Check whether the matrix is the identity matrix.
- bool bm_is_upper_triangular (const bit_matrix_t &M)

  Check whether the matrix is upper triangular.
- void bm_resize (bit_matrix_t &M, int nrows, int ncols)

  Resize a bit matrix.
- void bm_resize (bit_matrix_t &M, int nrows)

  Resize a bit matrix and make it a square matrix.
- void bm_clear (bit_matrix_t &M)

  Clear bit matrix.
- void bm_random (bit_matrix_t &M)

  Sample a random bit matrix.
- void bm_swap_rows (bit_matrix_t &M, int i, int j)

  Swap two rows.
- void bm_add_rows (bit_matrix_t &M, int dest, int src)

  Add two rows.
- void bm_add_columns (bit_matrix_t &M, int dest, int src)

  Add two columns.
- void bm_set_column (bit_matrix_t &M, int j, const bit_vector_t &bv)

  Set column.
- void bm_row_echelon_form (bit_matrix_t &A)

  Compute a row echelon form of a matrix.
- int bm_rank (const bit_matrix_t &A)

  Compute the rank of a matrix.
- bool bm_solve (bit_matrix_t &A, bit_vector_t &b)

  Solve a linear system.
- bool bm_solve_upper_triangular (bit_matrix_t &A, bit_vector_t &b)

  Solve a linear system in upper triangular form.
- bool bm_invert (bit_matrix_t &M, bit_matrix_t &N)

  Invert a bit matrix.
- void bm_multiply (bit_vector_t &y, const bit_matrix_t &M, const bit_vector_t &x)

  Multiply a bit matrix and a bit vector.

Types and functions related to bit

- using bit_t = std::uint8_t

  Bit.
- bit_t bit_flip (bit_t b)

  Flip bit.
- bit_t bit_random (double p)

  Sample a random bit.

Types and functions related to bit vectors

Output and input-output function parameters appear at the beginning of the parameter list.

Output and input-output bit_vector_t parameters are passed by reference and must have the right size for the considered function.

Input bit_vector_t parameters are passed by const reference.

- using bit_vector_t = std::vector< bit_t >

  Bit vector.
- std::string bv_domain (const bit_vector_t &x)

  Display bit vector.
- void bv_display (const bit_vector_t &v, std::ostream &stream)

  Display bit vector.
- bool bv_is_valid (const bit_vector_t &x)

  Check whether the bit vector is valid.
- bool bv_is_zero (const bit_vector_t &x)

  Check whether the bit vector is zero.
- int bv_hamming_weight (const bit_vector_t &x)

  Hamming weight.
- int bv_hamming_weight (const std::vector< bool > &x)

  Hamming weight.
- int bv_hamming_distance (const bit_vector_t &x, const bit_vector_t &y)

  Hamming distance between two bit vectors.
- bit_t bv_dot_product (const bit_vector_t &x, const bit_vector_t &y)

  Dot product.
- bit_t bv_dot_product (const bit_vector_t &x, const std::vector< bool > &y)

  Dot product.
- void bv_clear (bit_vector_t &x)

  Clear bit vector.
- void bv_flip (bit_vector_t &x, int i)

  Flip a single bit.
- void bv_flip (bit_vector_t &x, const bit_vector_t &mask)

  Flip many bits.
- void bv_random (bit_vector_t &x)

  Sample a random bit vector.
- void bv_random (bit_vector_t &x, int k)

  Sample a random bit vector with given Hamming weight.
- void bv_add (bit_vector_t &dest, const bit_vector_t &src)

  Add two bit vectors.

- void bv_add (bit_vector_t &dest, const bit_vector_t &x, const bit_vector_t &y)
  Add two bit vectors.
- void bv_to_vector_bool (std::vector< bool > &y, const bit_vector_t &x)
  Convert a bit vector to a bool vector.
- void bv_from_vector_bool (bit_vector_t &x, const std::vector< bool > &y)
  Convert a bool vector to a bit vector.
- std::size_t bv_to_size_type (const bit_vector_t &x)
  Convert a small bit vector to a size_t.
- std::size_t bv_to_size_type (const bit_vector_t &x, int start, int stop)
  Convert a slice of a small bit vector to a size_t.
- void bv_from_size_type (bit_vector_t &x, std::size_t u)
  Convert a size_t to a small bit vector.
- bit_vector_t bv_from_string (const std::string &str)
  Read a bit vector from a string.
- bit_vector_t bv_from_stream (std::istream &stream)
  Read a bit vector from a stream.

Types and functions related to permutations

- using permutation_t = std::vector< int >
  Permutation type
- bool perm_is_valid (const permutation_t &permutation)
  Check that a vector represents a permutation.
- void perm_identity (permutation_t &s)
  Identity permutation.
- void perm_random (permutation_t &s)
  Sample a random permutation.
- void perm_display (const permutation_t &permutation, std::ostream &stream)
  Display a permutation.

Types and functions related to sparse bit vectors

Output and input-output function parameters appear at the beginning of the parameter list.

Input object parameters are passed by const reference.

- using sparse_bit_vector_t = std::vector< int >
  Sparse bit vector.
- bool sbv_is_valid (const sparse_bit_vector_t &sbv)
  Check that a sparse bit vector is valid.
- bool sbv_is_valid (const sparse_bit_vector_t &sbv, int n)
  Check that a sparse bit vector is valid.
- void sbv_flip (bit_vector_t &x, const sparse_bit_vector_t &sbv)
  Flip many bits of a bit vector.
- void sbv_display (const sparse_bit_vector_t &v, std::ostream &stream)
  Display sparse bit vector.
- sparse_bit_vector_t sbv_from_bv (const bit_vector_t &bv)
  Convert a bit vector to a sparse bit vector.

4.1.1 Detailed Description

top-level HNCO namespace

4.1.2 Typedef Documentation

4.1.2.1 sparse_bit_vector_t

```
using sparse_bit_vector_t = std::vector<int>
```

Sparse bit vector.

A sparse bit vector is represented as an vector containing the indices of its non-zero components. The indices must be sorted in ascending order.

A sparse bit vector does not know the dimension of the space it belongs to.

Definition at line 50 of file sparse-bit-vector.hh.

4.1.3 Function Documentation

4.1.3.1 bm_add_columns()

```
void bm_add_columns (
            bit_matrix_t & M,
            int dest,
            int src )
```

Add two columns.

Equivalent to dest = dest + src.

Parameters

M	Bit matrix
dest	Destination column
src	Source column

Warning

M is modified by the function.

Definition at line 187 of file bit-matrix.cc.

4.1.3.2 bm_add_rows()

```
void bm_add_rows (
            bit_matrix_t & M,
            int dest,
            int src )
```

Add two rows.

Equivalent to dest = dest + src.

Parameters

M	Bit matrix
dest	Destination row
src	Source row

Definition at line 178 of file bit-matrix.cc.

4.1.3.3 bm_identity() [1/2]

```
void bm_identity (
            bit_matrix_t & M )
```

Set a matrix to the identity matrix.

Precondition

bm_is_square(M)

Definition at line 39 of file bit-matrix.cc.

4.1.3.4 bm_identity() [2/2]

```
bit_matrix_t bm_identity (
            int n )
```

Make an identity bit matrix.

Parameters

n	Dimension

Returns

An order n identity matrix

Definition at line 50 of file bit-matrix.cc.

4.1.3.5 bm_invert()

```
bool bm_invert (
            bit_matrix_t & M,
            bit_matrix_t & N )
```

Invert a bit matrix.

Parameters

M	Bit matrix
N	Inverse bit matrix

Precondition

bm_is_square(M)

bm_is_square(N)

bm_num_rows(M) == bm_num_rows(N)

Returns

true if M is invertible

Warning

M is modified by the function. Provided that M is invertible, after returning from the function, M is the identity matrix and N is the computed inverse matrix.

Definition at line 316 of file bit-matrix.cc.

4.1.3.6 bm_multiply()

```
void bm_multiply (
            bit_vector_t & y,
            const bit_matrix_t & M,
            const bit_vector_t & x )
```

Multiply a bit matrix and a bit vector.

Computes y = Mx.

Parameters

y	Output bit vector
M	Bit matrix
x	Bit vector

Definition at line 360 of file bit-matrix.cc.

4.1.3.7 bm_rank()

```
int bm_rank (
            const bit_matrix_t & A )
```

Compute the rank of a matrix.

Precondition

A must be in row echelon form.

Definition at line 244 of file bit-matrix.cc.

4.1.3.8 bm_row_echelon_form()

```
void bm_row_echelon_form (
            bit_matrix_t & A )
```

Compute a row echelon form of a matrix.

Warning

A is modified by the function.

Definition at line 213 of file bit-matrix.cc.

4.1.3.9 bm_set_column()

```
void bm_set_column (
            bit_matrix_t & M,
            int j,
            const bit_vector_t & bv )
```

Set column.

Set a column to a given bit vector.

Parameters

M	Bit matrix
j	Column index
bv	Bit vector

Precondition

bm_num_rows(M) == bv.size()

Definition at line 202 of file bit-matrix.cc.

4.1.3.10 bm_solve()

```
bool bm_solve (
            bit_matrix_t & A,
            bit_vector_t & b )
```

Solve a linear system.

Solve the linear equation Ax = b.

Parameters

A	Matrix
b	Right hand side

Precondition

bm_is_square(A)

bm_num_rows(A) == b.size()

Returns

true if the system has a unique solution

Warning

Both A and b are modified by the function. Provided that A is invertible, after returning from the function, A is the identity matrix and b is the unique solution to the linear equation.

Definition at line 262 of file bit-matrix.cc.

4.1.3.11 bm_solve_upper_triangular()

```
bool bm_solve_upper_triangular (
            bit_matrix_t & A,
            bit_vector_t & b )
```

Solve a linear system in upper triangular form.

Solve the linear equation Ax = b.

Parameters

A	Upper triangular matrix
b	Right hand side

Precondition

bm_is_square(A)

bm_num_rows(A) == b.size()

bm_is_upper_triangular(A)

Returns

true if the system has a unique solution

Warning

Both A and b are modified by the function. Provided that A is invertible, after returning from the function, A is the identity matrix and b is the unique solution to the linear equation.

Definition at line 295 of file bit-matrix.cc.

4.1.3.12 bm_transpose() [1/2]

```
void bm_transpose (
            bit_matrix_t & N,
            const bit_matrix_t & M )
```

Transpose a bit matrix.

Precondition

bm_num_columns(N) == bm_num_rows(M)

bm_num_rows(N) == bm_num_columns(M)

Definition at line 59 of file bit-matrix.cc.

4.1.3.13 bm_transpose() [2/2]

```
bit_matrix_t bm_transpose (
            const bit_matrix_t & M )
```

Transpose a bit matrix.

Parameters

M	Bit matrix

Returns

Transposed bit matrix

Definition at line 73 of file bit-matrix.cc.

4.1.3.14 bv_add() [1/2]

```
void bv_add (
            bit_vector_t & dest,
            const bit_vector_t & src )
```

Add two bit vectors.

Equivalent to dest = dest + src.

Parameters

dest	Destination bit vector
src	Source bit vector

Warning

Vectors must be of the same size.

Definition at line 124 of file bit-vector.cc.

4.1.3.15 bv_add() [2/2]

```
void bv_add (
            bit_vector_t & dest,
            const bit_vector_t & x,
            const bit_vector_t & y )
```

Add two bit vectors.

Equivalent to dest = x + y.

Parameters

dest	Destination bit vector
x	First operand
y	Second operand

Warning

Vectors must be of the same size.

Definition at line 133 of file bit-vector.cc.

4.1.3.16 bv_from_size_type()

```
void bv_from_size_type (
            bit_vector_t & x,
            std::size_t u )
```

Convert a size_t to a small bit vector.

Parameters

x	Output bit vector
u	Unsigned integer representing a bit vector

Precondition

x.size() <= 8 ∗ sizeof(std::size_t)

Warning

Depending on the size of the output bit vector, some bits might be lost. The original bit vector can be reconstructed only if it is small and the unsigned integer u is the result of bv_to_size_type.

Definition at line 201 of file bit-vector.cc.

4.1.3.17 bv_from_stream()

```
bit_vector_t bv_from_stream (
            std::istream & stream )
```

Read a bit vector from a stream.

Parameters

stream	Input stream

Returns

A bit_vector_t

Definition at line 232 of file bit-vector.cc.

4.1.3.18 bv_from_string()

```
bit_vector_t bv_from_string (
            const std::string & str )
```

Read a bit vector from a string.

Parameters

str	Input string

Returns

A bit_vector_t

Definition at line 216 of file bit-vector.cc.

4.1.3.19 bv_from_vector_bool()

```
void bv_from_vector_bool (
            bit_vector_t & x,
            const std::vector< bool > & y )
```

Convert a bool vector to a bit vector.

Warning

Vectors must be of the same size.

Definition at line 156 of file bit-vector.cc.

4.1.3.20 bv_to_size_type() [1/2]

```
std::size_t bv_to_size_type (
            const bit_vector_t & x )
```

Convert a small bit vector to a size_t.

x[0] is the least significant bit.

Parameters

x	Input bit vector

Returns

An unsigned integer representing x

Precondition

x.size() <= 8 ∗ sizeof(std::size_t)

Definition at line 169 of file bit-vector.cc.

4.1.3.21 bv_to_size_type() [2/2]

```
std::size_t bv_to_size_type (
            const bit_vector_t & x,
            int start,
            int stop )
```

Convert a slice of a small bit vector to a size_t.

x[start] is the least significant bit.

x[stop-1] is the most significant bit.

Parameters

x	Input bit vector
start	Start bit
stop	Stop bit

Returns

An unsigned integer representing x[start], ..., x[stop-1]

Precondition

start in [0, x.size())

stop in [start+1, x.size()]

(stop - start) <= 8 ∗ sizeof(std::size_t)

Definition at line 184 of file bit-vector.cc.

4.1.3.22 bv_to_vector_bool()

```
void bv_to_vector_bool (
            std::vector< bool > & y,
            const bit_vector_t & x )
```

Convert a bit vector to a bool vector.

Warning

Vectors must be of the same size.

Definition at line 143 of file bit-vector.cc.

4.1.3.23 is_in_range() [1/2]

```
bool hnco::is_in_range (
            int i,
            int a,
            int b )  [inline]
```

Check whether an index is in a given range.

Parameters

i	Index
a	Lower bound
b	Upper bound (excluded)

Returns

true if i >= a and i < b

Definition at line 45 of file util.hh.

4.1.3.24 is_in_range() [2/2]

```
bool hnco::is_in_range (
            int i,
            int n )  [inline]
```

Check whether an index is in a given range.

The lower bound is implicit and is equal to 0.

Parameters

i	Index
n	Upper bound (excluded)

Returns

true if i >= 0 and i < n

Definition at line 56 of file util.hh.

4.1.3.25 load_from_archive()

```
void hnco::load_from_archive (
            T & object,
            std::string path,
            std::string name )
```

Load from a boost archive.

Parameters

object	Object to load
path	Path of the file
name	Class name

Definition at line 44 of file serialization.hh.

4.1.3.26 perm_identity()

```
void hnco::perm_identity (
            permutation_t & s )  [inline]
```

Identity permutation.

Warning

This function does not set the size of the permutation.

Definition at line 47 of file permutation.hh.

4.1.3.27 perm_random()

```
void hnco::perm_random (
            permutation_t & s )  [inline]
```

Sample a random permutation.

Warning

This function does not set the size of the permutation.

Definition at line 57 of file permutation.hh.

4.1.3.28 save_to_archive()

```
void hnco::save_to_archive (
            const T & object,
            std::string path,
            std::string name )
```

Save to a boost archive.

Parameters

object	Object to save
path	Path of the file
name	Class name

Definition at line 64 of file serialization.hh.

4.1.3.29 sbv_flip()

```
void sbv_flip (
            bit_vector_t & x,
            const sparse_bit_vector_t & sbv )
```

Flip many bits of a bit vector.

Parameters

x	Input-output bit vector
sbv	Bits to flip

Definition at line 54 of file sparse-bit-vector.cc.

4.1.3.30 sbv_is_valid() [1/2]

```
bool sbv_is_valid (
            const sparse_bit_vector_t & sbv )
```

Check that a sparse bit vector is valid.

A sparse bit vector is valid if:

- Its elements are non negative.
- Its elements are sorted in non-descending order.

Definition at line 32 of file sparse-bit-vector.cc.

4.1.3.31 sbv_is_valid() [2/2]

```
bool sbv_is_valid (
            const sparse_bit_vector_t & sbv,
            int n )
```

Check that a sparse bit vector is valid.

A sparse bit vector is valid if:

- Its elements are non negative.
- Its elements are sorted in non-descending order.
- Its elements are valid indices w.r.t. the given dimension.

Parameters

sbv	Input sparse bit vector
n	Dimension

Definition at line 43 of file sparse-bit-vector.cc.

4.2 hnco::algorithm Namespace Reference

Algorithms.

Namespaces

- fast_efficient_p3
  Algorithms from the FastEfficientP3 library.
- walsh_moment
  Algorithms using Walsh moments.

Classes

- class Algorithm
  Abstract search algorithm.
- class CompleteSearch
  Complete search.
- class Restart
  Restart.
- class Crossover
  Crossover
- class UniformCrossover
  Uniform crossover.
- class BiasedCrossover
  Biased crossover.

- class GeneticAlgorithm

  Genetic algorithm.
- class MuCommaLambdaEa

  (mu, lambda) EA.
- class MuPlusLambdaEa

  (mu+lambda) EA.
- class OnePlusLambdaCommaLambdaGa

  (1+(lambda, lambda)) genetic algorithm.
- class OnePlusOneEa

  (1+1) EA.
- class Human

  Human.
- class IterativeAlgorithm

  Iterative search.
- class FirstAscentHillClimbing

  First ascent hill climbing.
- class LocalSearchAlgorithm

  Local search algorithm.
- class RandomLocalSearch

  Random local search.
- class RandomWalk

  Random walk.
- class SimulatedAnnealing

  Simulated annealing.
- class SteepestAscentHillClimbing

  Steepest ascent hill climbing.
- class Mimic

  Mutual information maximizing input clustering.
- class Population

  Population.
- class CompactGa

  Compact genetic algorithm.
- class Mmas

  Max-min ant system.
- class NpsPbil

  Population-based incremental learning with negative and positive selection.
- class Pbil

  Population-based incremental learning.
- class PvAlgorithm

  Probability vector algorithm.
- class Umda

  Univariate marginal distribution algorithm.
- class RandomSearch

  Random search.
- class RandomSelection

  Random selection.
- class UniformSelection

  Uniform selection.
- class TournamentSelection

  Tournament selection.

Typedefs

- using solution_t = std::pair< bit_vector_t, double >

    Type of a solution.

Functions

- template<class T >
  bool matrix_is_symmetric (const std::vector< std::vector< T > > &A)

    Check for symmetric matrix.
- template<class T >
  bool matrix_is_strictly_lower_triangular (const std::vector< std::vector< T > > &A)

    Check for strictly lower triangular matrix.
- template<class T >
  bool matrix_has_diagonal (const std::vector< std::vector< T > > &A, T x)

    Check for diagonal elements.
- template<class T >
  bool matrix_has_range (const std::vector< std::vector< T > > &A, T inf, T sup)

    Check for element range.
- template<class T >
  bool matrix_has_dominant_diagonal (const std::vector< std::vector< T > > &A)

    Check for element range.

Type and function related to index-value pairs

- using index_value_t = std::pair< int, double >

    Index-value type.
- bool compare_index_value (const index_value_t &a, const index_value_t &b)

    Binary operator for comparing index-value pairs.

Type and functions related to probability vectors

Output and input-output function parameters appear at the beginning of the parameter list.

Output and input-output pv_t parameters are passed by reference and must have the right size for the considered function.

Input object parameters are passed by const reference.

- using pv_t = std::vector< double >

    Probability vector type.
- double pv_entropy (const pv_t &pv)

    Entropy of a probability vector.
- void pv_sample (bit_vector_t &x, const pv_t &pv)

    Sample a bit vector.
- void pv_uniform (pv_t &pv)

    Probability vector of the uniform distribution.
- void pv_init (pv_t &pv)

    Initialize.

- void pv_add (pv_t &pv, const bit_vector_t &x)

  Accumulate a bit vector into a probability vector.
- void pv_average (pv_t &pv, int count)

  Average.
- template<class T >
  void pv_update (pv_t &pv, double rate, const T &x)

  Update a probability vector.
- void pv_update (pv_t &pv, double rate, const pv_t &x, const pv_t &y)

  Update a probability vector.
- void pv_bound (pv_t &pv, double lower_bound, double upper_bound)

  Bound the elements of a probability vector.

4.2.1 Detailed Description

Algorithms.

4.2.2 Function Documentation

4.2.2.1 pv_add()

```
void pv_add (
            pv_t & pv,
            const bit_vector_t & x )
```

Accumulate a bit vector into a probability vector.

Equivalent to pv += x

Parameters

pv	Probability vector
x	Bit vector

Definition at line 58 of file probability-vector.cc.

4.2.2.2 pv_average()

```
void pv_average (
            pv_t & pv,
            int count )
```

Average.

Equivalent to pv = pv / count.

Parameters

pv	Probability vector
count	Number of accumulated bit vectors

Definition at line 67 of file probability-vector.cc.

4.2.2.3 pv_bound()

```
void pv_bound (
            pv_t & pv,
            double lower_bound,
            double upper_bound )
```

Bound the elements of a probability vector.

Parameters

pv	Probability vector
lower_bound	Lower bound
upper_bound	Upper bound

Definition at line 82 of file probability-vector.cc.

4.2.2.4 pv_init()

```
void hnco::algorithm::pv_init (
            pv_t & pv )  [inline]
```

Initialize.

All the elements of the probability vector are set to 0.

Parameters

pv	Probability vector

Definition at line 74 of file probability-vector.hh.

4.2.2.5 pv_sample()

```
void pv_sample (
            bit_vector_t & x,
            const pv_t & pv )
```

Sample a bit vector.

Parameters

x	Sampled bit vector
pv	Probability vector

Definition at line 46 of file probability-vector.cc.

4.2.2.6 pv_uniform()

```
void hnco::algorithm::pv_uniform (
            pv_t & pv )  [inline]
```

Probability vector of the uniform distribution.

All the elements of the probability vector are set to 1/2.

Parameters

pv	Probability vector

Definition at line 66 of file probability-vector.hh.

4.2.2.7 pv_update() [1/2]

```
void pv_update (
            pv_t & pv,
            double rate,
            const pv_t & x,
            const pv_t & y )
```

Update a probability vector.

Equivalent to pv += rate(x - y)

Parameters

pv	Probability vector
rate	Rate
x	Attractor probability vector
y	Repulsor probability vector

Definition at line 73 of file probability-vector.cc.

4.2.2.8 pv_update() [2/2]

```
void hnco::algorithm::pv_update (
            pv_t & pv,
            double rate,
            const T & x )
```

Update a probability vector.

Equivalent to pv += rate ∗ (x - pv)

Parameters

pv	Probability vector
rate	Rate
x	Attractor bit vector

Definition at line 103 of file probability-vector.hh.

4.3 hnco::algorithm::fast_efficient_p3 Namespace Reference

Algorithms from the FastEfficientP3 library.

Classes

- class Hboa

  Hierarchical Bayesian Optimization Algorithm.
- class HncoEvaluator

  Evaluator for HNCO functions.
- struct Implementation

  Implementation
- class Ltga

  Linkage Tree Genetic Algorithm.
- class ParameterLessPopulationPyramid

  Parameter-less Population Pyramid.

4.3.1 Detailed Description

Algorithms from the FastEfficientP3 library.

4.4 hnco::algorithm::walsh_moment Namespace Reference

Algorithms using Walsh moments.

Classes

- class BmPbil

  Boltzmann machine PBIL.
- class LowerTriangularWalshMoment2GibbsSampler

  Gibbs sampler with lower triangular Walsh moments.
- class SymmetricWalshMoment2GibbsSampler

  Gibbs sampler with symmetric Walsh moments.
- class Hea

  Herding evolutionary algorithm.
- class LowerTriangularWalshMoment2Herding

  Herding with lower triangular Walsh moment.
- class SymmetricWalshMoment2Herding

  Herding with symmetric Walsh moment.
- struct LowerTriangularWalshMoment2

  Lower triangular Walsh moment.
- struct SymmetricWalshMoment2

  Symmetric Walsh moment.

4.4.1 Detailed Description

Algorithms using Walsh moments.

4.5 hnco::app Namespace Reference

Classes for applications.

Classes

- class AlgorithmFactory

  Algorithm factory.
- class CommandLineAlgorithmFactory

  Command line algorithm factory.
- class CommandLineApplication

  Command line application.
- class DecoratedFunctionFactory

  Decorated function factory.
- class FunctionFactory

  Function factory.
- class CommandLineFunctionFactory

  Command line function factory.
- class HncoOptions

  Command line options for hnco.
- class FfgenOptions

  Command line options for ffgen.
- class MapgenOptions

  Command line options for mapgen.

Functions

- std::ostream & operator<< (std::ostream &stream, const HncoOptions &options)

  Print a header containing the parameter values.
- std::ostream & operator<< (std::ostream &stream, const FfgenOptions &options)

  Print a header containing the parameter values.
- std::ostream & operator<< (std::ostream &stream, const MapgenOptions &options)

  Print a header containing the parameter values.

4.5.1 Detailed Description

Classes for applications.

4.6 hnco::exception Namespace Reference

Exceptions.

Classes

- class LastEvaluation

  Last evaluation.
- class TargetReached

  Target reached.

4.6.1 Detailed Description

Exceptions.

4.7 hnco::function Namespace Reference

Functions defined on bit vectors.

Namespaces

- controller

  Controllers.
- modifier

  Modifiers.

Classes

- class SummationCancellation

  Summation cancellation.
- class SinusSummationCancellation

  Summation cancellation with sinus.
- class EqualProducts

  Equal products.
- class Factorization

  Factorization.
- class FourPeaks

  Four Peaks.
- class SixPeaks

  Six Peaks.
- class NearestNeighborIsingModel1

  Nearest neighbor Ising model in one dimension.
- class NearestNeighborIsingModel2

  Nearest neighbor Ising model in two dimensions.
- class Jump

  Jump.
- class DeceptiveJump

  Deceptive jump.
- class Labs

  Low autocorrelation binary sequences.
- class LinearFunction

  Linear function.
- class LongPath

  Long path.
- class AbstractMaxSat

  Abstract class for MaxSat-like functions.
- class MaxSat

  MAX-SAT.
- class MaxNae3Sat

  Max not-all-equal 3SAT.
- class NkLandscape

  NK landscape.
- class ParsedMultivariateFunction

  Parsed multivariate function.
- class Partition

  Partition.
- class FunctionPlugin

  Function plugin
- class PythonFunction

  Python function.
- class Qubo

  Quadratic unconstrained binary optimization.
- class Sudoku

  Sudoku
- class OneMax

  OneMax.
- class LeadingOnes

Leading ones.
- class Needle

  Needle in a haystack.
- class Hiff

  Hierarchical if and only if.
- class Ridge

  Ridge.
- class Plateau

  Plateau.
- class Trap

  Trap.
- class Tsp

  Traveling salesman problem.
- class WalshExpansion1

  Walsh expansion of degree 1.
- class WalshExpansion2

  Walsh expansion of degree 2.
- class WalshExpansion

  Walsh expansion.
- struct ScalarToDouble

  Convert a scalar to a double.
- struct ComplexToDouble

  Convert a complex to a double.
- class Decorator

  Function decorator
- class Function

  Function
- class MultivariateFunctionAdapter

  Multivariate function adapter.
- class PermutationFunctionAdapter

  Permutation function adapter.
- class UniversalFunctionAdapter

  Universal function adapter.
- class UniversalFunction

  Universal function.
- struct WalshTerm

  Walsh transform term.

Functions

- void compute_walsh_transform (function::Function ∗function, std::vector< function::WalshTerm > &terms)

  Compute the Walsh transform of the function.
- void compute_fast_walsh_transform (function::Function ∗function, std::vector< function::WalshTerm > &terms)

  Compute the Walsh transform of the function using a fast Walsh transform.
- bool bv_is_locally_maximal (const bit_vector_t &bv, Function &fn, neighborhood::NeighborhoodIterator &it)

  Check whether a bit vector is locally maximal.
- bool bv_is_globally_maximal (const bit_vector_t &bv, Function &fn)

  Check whether a bit vector is globally maximal.

4.7.1 Detailed Description

Functions defined on bit vectors.

4.7.2 Function Documentation

4.7.2.1 compute_fast_walsh_transform()

```
void compute_fast_walsh_transform (
            function::Function * function,
            std::vector< function::WalshTerm > & terms )
```

Compute the Walsh transform of the function using a fast Walsh transform.

Let f be a fitness function defined on the hypercube $\{0,1\}^n$. Then it can be expressed as $\sum_u c_u \chi_u$ where $c_u = \langle f, \chi_u \rangle$, $\langle f, g \rangle = \frac{1}{2^n} \sum_x f(x) g(x)$, $\chi_u(x) = (-1)^{x \cdot u}$, and $x \cdot u = \sum_i x_i u_i$ (mod 2). In the respective sums, we have x and u in the hypercube and i in $\{1, \ldots, n\}$.

We have dropped the normalizing constant 2^n since we are mostly interested in ratios $|c_u / c_{\max}|$, where $c_{\max}$ is the coefficient with the largest amplitude. It is also helpful to achieve exact computations in the case of functions taking only integer values.

Parameters

function	Function the Walsh transform of which to compute
terms	Vector of non zero terms of the Walsh transform

Warning

The time complexity is exponential in the dimension n. It requires 2^n function evaluations and $n2^n$ additions, which is faster than compute_walsh_transform.

The size of the Walsh transform is potentially exponential in the dimension n. For example, if n = 10 then the number of terms is at most 1024.

Definition at line 77 of file function.cc.

4.7.2.2 compute_walsh_transform()

```
void compute_walsh_transform (
            function::Function * function,
            std::vector< function::WalshTerm > & terms )
```

Compute the Walsh transform of the function.

Let f be a fitness function defined on the hypercube $\{0,1\}^n$. Then it can be expressed as $\sum_u c_u \chi_u$ where $c_u = \langle f, \chi_u \rangle$, $\langle f, g \rangle = \frac{1}{2^n} \sum_x f(x) g(x)$, $\chi_u(x) = (-1)^{x \cdot u}$, and $x \cdot u = \sum_i x_i u_i$ (mod 2). In the respective sums, we have x and u in the hypercube and i in $\{1, \ldots, n\}$.

We have dropped the normalizing constant 2^n since we are mostly interested in ratios $|c_u / c_{\max}|$, where $c_{\max}$ is the coefficient with the largest amplitude. It is also helpful to achieve exact computations in the case of functions taking only integer values.

Parameters

function	Function the Walsh transform of which to compute
terms	Vector of non zero terms of the Walsh transform

Warning

The time complexity is exponential in the dimension n. The computation is done with two nested loops over the hypercube. It requires 2^n function evaluations and 2^{2n} dot products and additions.

The size of the Walsh transform is potentially exponential in the dimension n. For example, if n = 10 then the number of terms is at most 1024.

Definition at line 33 of file function.cc.

4.8 hnco::function::controller Namespace Reference

Controllers.

Classes

- class Controller

  Function controller.
- class StopOnTarget

  Stop on target.
- class StopOnMaximum

  Stop on maximum.
- class CallCounter

  Call counter.
- class OnBudgetFunction

  Function with a limited number of evaluations.
- class ProgressTracker

  ProgressTracker.
- class Cache

  Cache.

Functions

- std::ostream & operator<< (std::ostream &stream, const ProgressTracker::Event &event)

  Insert formatted output.

4.8.1 Detailed Description

Controllers.

4.9 hnco::function::modifier Namespace Reference

Modifiers.

Classes

- class Modifier
  Function modifier.
- class Negation
  Negation.
- class FunctionMapComposition
  Composition of a function and a map.
- class AdditiveGaussianNoise
  Additive Gaussian Noise.
- class ParsedModifier
  Parsed modifier.
- class PriorNoise
  Prior noise.

4.9.1 Detailed Description

Modifiers.

4.10 hnco::logging Namespace Reference

Logging.

Classes

- class LogContext
  Log context.
- class ProgressTrackerContext
  Log context for ProgressTracker.
- class Logger
  Logger.

4.10.1 Detailed Description

Logging.

4.11 hnco::map Namespace Reference

Maps.

Classes

- class Map
  Map
- class Translation
  Translation.
- class Permutation
  Permutation.
- class LinearMap
  Linear map.
- class AffineMap
  Affine map.
- class MapComposition
  Map composition.
- class Injection
  Injection.
- class Projection
  Projection.
- class TsAffineMap
  Transvection sequence affine map.
- struct Transvection
  Transvection.

Types and functions related to transvections

Output and input-output function parameters appear at the beginning of the parameter list.

Output and input-output transvection_sequence_t parameters are passed by reference.

Input object parameters are passed by const reference.

- using transvection_sequence_t = std::vector< Transvection >
  Transvection sequence.
- bool transvections_commute (const Transvection &a, const Transvection &b)
  Check whether two transvections commute.
- bool transvections_are_disjoint (const Transvection &a, const Transvection &b)
  Check whether two transvections are disjoint.
- bool ts_is_valid (const transvection_sequence_t &ts)
  Check validity.
- bool ts_is_valid (const transvection_sequence_t &ts, int n)
  Check validity.
- void ts_display (const transvection_sequence_t &ts, std::ostream &stream)
  Display a transvection sequence.
- void ts_random (transvection_sequence_t &ts, int n, int t)
  Sample a random transvection sequence.
- void ts_random_commuting (transvection_sequence_t &ts, int n, int t)
  Sample a random sequence of commuting transvections.
- void ts_random_unique_source (transvection_sequence_t &ts, int n, int t)
  Sample a random sequence of transvections with unique source.
- void ts_random_unique_destination (transvection_sequence_t &ts, int n, int t)

Sample a random sequence of transvections with unique destination.
- void ts_random_disjoint (transvection_sequence_t &ts, int n, int t)

  Sample a random sequence of disjoint transvections.
- void ts_random_non_commuting (transvection_sequence_t &ts, int n, int t)

  Sample a random sequence of non commuting transvections.
- void ts_multiply (bit_vector_t &x, const transvection_sequence_t &ts)

  Multiply a vector by a transvection sequence from the left.
- void ts_multiply (bit_matrix_t &M, const transvection_sequence_t &ts)

  Multiply a matrix by a transvection sequence from the left.

4.11.1 Detailed Description

Maps.

4.11.2 Typedef Documentation

4.11.2.1 transvection_sequence_t

```
using transvection_sequence_t = std::vector<Transvection>
```

Transvection sequence.

The general linear group of a linear space of dimension n over the finite field F_2 is the group of invertible n by n bit matrices.

Any invertible bit matrix can be expressed as a finite product of transvections.

Finite transvection sequences can then represent all invertible bit matrices.

Definition at line 166 of file transvection.hh.

4.11.3 Function Documentation

4.11.3.1 ts_is_valid() [1/2]

```
bool ts_is_valid (
            const transvection_sequence_t & ts )
```

Check validity.

Parameters

ts	Transvection sequence

Definition at line 150 of file transvection.cc.

4.11.3.2 ts_is_valid() [2/2]

```
bool ts_is_valid (
            const transvection_sequence_t & ts,
            int n )
```

Check validity.

Parameters

ts	Transvection sequence
n	Dimension

Definition at line 156 of file transvection.cc.

4.11.3.3 ts_multiply() [1/2]

```
void ts_multiply (
            bit_matrix_t & M,
            const transvection_sequence_t & ts )
```

Multiply a matrix by a transvection sequence from the left.

Parameters

ts	Transvection sequence
M	Bit matrix

Precondition

ts_is_valid(ts)

ts_is_valid(ts, bm_num_rows(M))

Warning

This function modifies the given bit vector.

Definition at line 366 of file transvection.cc.

4.11.3.4 ts_multiply() [2/2]

```
void ts_multiply (
            bit_vector_t & x,
            const transvection_sequence_t & ts )
```

Multiply a vector by a transvection sequence from the left.

Parameters

ts	Transvection sequence
x	Bit vector

Precondition

ts_is_valid(ts)

ts_is_valid(ts, x.size())

Warning

This function modifies the given bit vector.

Definition at line 356 of file transvection.cc.

4.11.3.5 ts_random()

```
void ts_random (
            transvection_sequence_t & ts,
            int n,
            int t )
```

Sample a random transvection sequence.

Parameters

ts	Transvection sequence
n	Dimension
t	Length of the sequence

Precondition

n > 1

t >= 0

Definition at line 172 of file transvection.cc.

4.11.3.6 ts_random_commuting()

```
void ts_random_commuting (
            transvection_sequence_t & ts,
            int n,
            int t )
```

Sample a random sequence of commuting transvections.

This function ensures that all transvections in the sequence commute.

Parameters

ts	Transvection sequence
n	Dimension
t	Length of the sequence

Precondition

n $>$ 1

t $>$= 0

Warning

If t $>$ floor(n / 2) then t is set to floor(n / 2).

If t = floor(n / 2) then the space and time complexity of ts_random_commuting is quadratic in the dimension n.

Definition at line 183 of file transvection.cc.

4.11.3.7 ts_random_disjoint()

```
void ts_random_disjoint (
            transvection_sequence_t & ts,
            int n,
            int t )
```

Sample a random sequence of disjoint transvections.

Two transvections τ_{ij} and τ_{kl} are said to be disjoint if the pairs {i,j} and {k,l} are disjoint.

If 2t$>$n then the sequence length is set to the largest t such that 2t$<$=n.

Parameters

ts	Transvection sequence
n	Dimension
t	Length of the sequence

Precondition

n > 1

t >= 0

Definition at line 311 of file transvection.cc.

4.11.3.8 ts_random_non_commuting()

```
void ts_random_non_commuting (
            transvection_sequence_t & ts,
            int n,
            int t )
```

Sample a random sequence of non commuting transvections.

This function ensures that two consecutive transvections do not commute.

Parameters

ts	Transvection sequence
n	Dimension
t	Length of the sequence

Precondition

n > 1

t >= 0

Definition at line 341 of file transvection.cc.

4.11.3.9 ts_random_unique_destination()

```
void ts_random_unique_destination (
            transvection_sequence_t & ts,
            int n,
            int t )
```

Sample a random sequence of transvections with unique destination.

A transvection sequence with unique destination is such that, for each source, there is a unique destination.

Parameters

ts	Transvection sequence
n	Dimension
t	Length of the sequence

Precondition

n > 1

t >= 0

Definition at line 278 of file transvection.cc.

4.11.3.10 ts_random_unique_source()

```
void ts_random_unique_source (
            transvection_sequence_t & ts,
            int n,
            int t )
```

Sample a random sequence of transvections with unique source.

A transvection sequence with unique source is such that, for each destination, there is a unique source.

Parameters

ts	Transvection sequence
n	Dimension
t	Length of the sequence

Precondition

n > 1

t >= 0

Definition at line 245 of file transvection.cc.

4.12 hnco::neighborhood Namespace Reference

Neighborhoods for local search.

Classes

- class NeighborhoodIterator

  Neighborhood iterator.
- class SingleBitFlipIterator

  Single bit flip neighborhood iterator.
- class HammingSphereIterator

  Hamming sphere neighborhood iterator.
- class Neighborhood

  Neighborhood.
- class SingleBitFlip

One bit neighborhood.

- class MultiBitFlip

  Multi bit flip.
- class StandardBitMutation

  Standard bit mutation.
- class HammingBall

  Hamming ball.
- class HammingSphere

  Hamming sphere.

4.12.1 Detailed Description

Neighborhoods for local search.

There are two unrelated kinds of neighborhoods, those for random local search and those for exhaustive local search.

4.13 hnco::random Namespace Reference

Random numbers.

Classes

- struct Generator

  Random number generator.

4.13.1 Detailed Description

Random numbers.

4.14 hnco::representation Namespace Reference

Representations.

Classes

- class LinearCategoricalRepresentation

  Linear categorical representation.
- class IntegerCategoricalRepresentation

  Integer categorical representation.
- class DyadicComplexRepresentation

  Dyadic complex representation.
- class DyadicFloatRepresentation

  Dyadic float representation.
- class DyadicIntegerRepresentation

  Dyadic integer representation.
- class PermutationRepresentation

  Permutation representation.

Functions

- template<class T >
  bool difference_is_safe (T a, T b)

  Check whether the difference is safe.

4.14.1 Detailed Description

Representations.

4.14.2 Function Documentation

4.14.2.1 difference_is_safe()

```
bool hnco::representation::difference_is_safe (
            T a,
            T b )
```

Check whether the difference is safe.

The template parameter T must be an integral type such as int or long.

The difference b - a is safe if it can be represented by the type of a and b, i.e. there is no overflow.

Parameters

a	Smallest value
b	Greatest value

Precondition

$a < b$

Definition at line 56 of file integer.hh.

Chapter 5

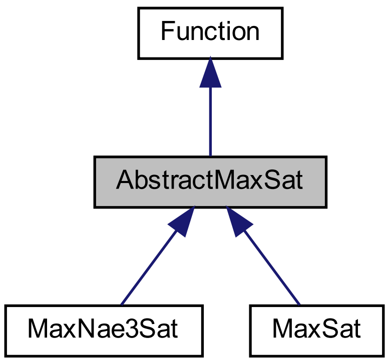
Class Documentation

5.1 AbstractMaxSat Class Reference

Abstract class for MaxSat-like functions.

`#include <hnco/functions/collection/max-sat.hh>`

Inheritance diagram for AbstractMaxSat:



Public Member Functions

- AbstractMaxSat ()

  Default constructor.
- int get_bv_size () const override

  Get bit vector size.
- void display (std::ostream &stream) const override

  Display the expression.

Load and save instance

- void load (std::string path)

  Load instance.
- void save (std::string path) const

  Save instance.

Protected Member Functions

- void load_ (std::istream &stream)

  Load an instance.
- void save_ (std::ostream &stream) const

  Save an instance.

Protected Attributes

- std::vector< std::vector< int > > _expression

  Expression.
- int _num_variables

  Number of variables.

5.1.1 Detailed Description

Abstract class for MaxSat-like functions.

Definition at line 36 of file max-sat.hh.

5.1.2 Member Function Documentation

5.1.2.1 load()

```
void load (
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 87 of file max-sat.hh.

5.1.2.2 load_()

```
void load_ (
            std::istream & stream )  [protected]
```

Load an instance.

Parameters

stream	Input stream

Exceptions

std::runtime_error	

Definition at line 61 of file max-sat.cc.

5.1.2.3 save()

```
void save (
            std::string path ) const  [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 99 of file max-sat.hh.

5.1.2.4 save_()

```
void save_ (
            std::ostream & stream ) const  [protected]
```

Save an instance.

Parameters

stream	Outputstream

Definition at line 153 of file max-sat.cc.

5.1.3 Member Data Documentation

5.1.3.1 _expression

`std::vector<std::vector<int> > _expression [protected]`

Expression.

An expression is represented by a vector of clauses. A clause is represented by a vector of literals. A literal is represented by a non null integer; if the integer is positive then the literal is a variable; if it is negative then it is the logical negation of a variable.

Definition at line 47 of file max-sat.hh.

The documentation for this class was generated from the following files:

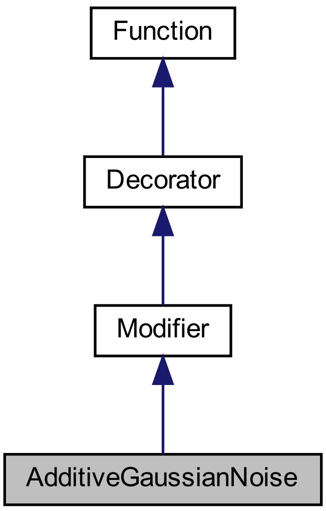
- lib/hnco/functions/collection/max-sat.hh
- lib/hnco/functions/collection/max-sat.cc

5.2 AdditiveGaussianNoise Class Reference

Additive Gaussian Noise.

`#include <hnco/functions/modifiers/modifier.hh>`

Inheritance diagram for AdditiveGaussianNoise:



Public Member Functions

- AdditiveGaussianNoise (Function ∗function, double stddev)

  Constructor.
- double evaluate (const bit_vector_t &) override

  Evaluate a bit vector.

Information about the function

- int get_bv_size () const override

  Get bit vector size.

Private Attributes

- std::normal_distribution< double > _dist

  Normal distribution.

Additional Inherited Members

5.2.1 Detailed Description

Additive Gaussian Noise.

Definition at line 170 of file modifier.hh.

The documentation for this class was generated from the following files:

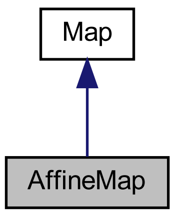
- lib/hnco/functions/modifiers/modifier.hh
- lib/hnco/functions/modifiers/modifier.cc

5.3 AffineMap Class Reference

Affine map.

```
#include <hnco/maps/map.hh>
```

Inheritance diagram for AffineMap:



Public Member Functions

- void random (int rows, int cols, bool surjective)

  Random instance.
- void map (const bit_vector_t &input, bit_vector_t &output) override

  Map
- int get_input_size () const override

  Get input size.
- int get_output_size () const override

  Get output size.
- bool is_surjective () const override

  Check for surjective map.
- void display (std::ostream &stream) const override

  Display.

Load and save map

- void load (std::string path)

  Load map.
- void save (std::string path) const

  Save map.

Private Member Functions

- template<class Archive >
  void save (Archive &ar, const unsigned int version) const

  Save.
- template<class Archive >
  void load (Archive &ar, const unsigned int version)

  Load.

Private Attributes

- bit_matrix_t _bm

  Bit matrix.
- bit_vector_t _bv

  Translation vector

Friends

- class **boost::serialization::access**

5.3.1 Detailed Description

Affine map.

An affine map f from F_2^m to F_2^n is defined by $f(x) = Ax+b$, where A is an n x m bit matrix and b is an n-dimensional bit vector.

Definition at line 331 of file map.hh.

5.3.2 Member Function Documentation

5.3.2.1 is_surjective()

```
bool is_surjective ( ) const  [override], [virtual]
```

Check for surjective map.

Returns

true if rank(_bm) == bm_num_rows(_bm)

Reimplemented from Map.

Definition at line 156 of file map.cc.

5.3.2.2 load()

```
void load (
            std::string path )  [inline]
```

Load map.

Parameters

path	Path of the file

Exceptions

std::runtime_error	

Definition at line 405 of file map.hh.

5.3.2.3 random()

```
void random (
            int rows,
            int cols,
            bool surjective )
```

Random instance.

Parameters

rows	Number of rows
cols	Number of columns
surjective	Flag to ensure a surjective map

Exceptions

std::runtime_error	

Definition at line 119 of file map.cc.

5.3.2.4 save()

```
void save (
            std::string path ) const  [inline]
```

Save map.

Parameters

path	Path of the file

Exceptions

std::runtime_error	

Definition at line 412 of file map.hh.

The documentation for this class was generated from the following files:

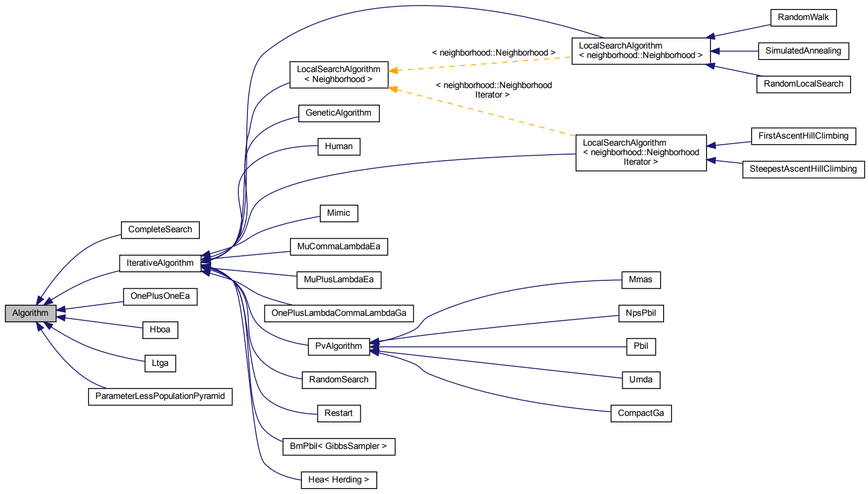
- lib/hnco/maps/map.hh
- lib/hnco/maps/map.cc

5.4 Algorithm Class Reference

Abstract search algorithm.

`#include <hnco/algorithms/algorithm.hh>`

Inheritance diagram for Algorithm:



Public Member Functions

- Algorithm (int n)

    Constructor.
- virtual ∼Algorithm ()

    Destructor.
- void set_log_context (logging::LogContext ∗log_context)

    Set the log context.

Optimization

- virtual void maximize (const std::vector< function::Function ∗ > &functions)=0

    Maximize.
- virtual void finalize ()

    Finalize.
- const solution_t & get_solution ()

    Get the solution.

Protected Member Functions

- void set_functions (const std::vector< function::Function ∗ > &functions)

    Set functions.
- int get_bv_size ()

    Get bit vector size.

Managing solution

- void random_solution ()

    Random solution.
- void set_solution (const bit_vector_t &bv, double value)

    Set solution.
- void set_solution (const bit_vector_t &bv)

Set solution.
- void update_solution (const bit_vector_t &bv, double value)
  Update solution (strict)
- void update_solution (const solution_t &s)
  Update solution (strict)
- void update_solution (const bit_vector_t &bv)
  Update solution (strict).

Protected Attributes

- std::vector< function::Function ∗ > _functions
  Functions.
- function::Function ∗ _function
  Function.
- solution_t _solution
  Solution.

Parameters

- logging::LogContext ∗ _log_context = nullptr
  Log context.

5.4.1 Detailed Description

Abstract search algorithm.

All algorithms maximize some given function, sometimes called a fitness function or an objective function.

Definition at line 46 of file algorithm.hh.

5.4.2 Member Function Documentation

5.4.2.1 finalize()

```
virtual void finalize ( ) [inline], [virtual]
```

Finalize.

Does nothing.

It is usually overridden by algorithms which do not keep _solution up-to-date. In case _function throws a Last↩ Evaluation exception, the algorithm might leave _solution in an undefined state. This can be fixed in this member function.

Reimplemented in RandomLocalSearch, OnePlusOneEa, ParameterLessPopulationPyramid, Ltga, and Hboa.

Definition at line 143 of file algorithm.hh.

5.4.2.2 set_solution()

```
void set_solution (
            const bit_vector_t & bv )  [protected]
```

Set solution.

Warning

Evaluates the function once.

Definition at line 45 of file algorithm.cc.

5.4.2.3 update_solution()

```
void update_solution (
            const bit_vector_t & bv )  [protected]
```

Update solution (strict).

Warning

Evaluates the function once.

Definition at line 69 of file algorithm.cc.

5.4.3 Member Data Documentation

5.4.3.1 _functions

```
std::vector<function::Function *> _functions  [protected]
```

Functions.

Each thread has its own function.

Definition at line 54 of file algorithm.hh.

The documentation for this class was generated from the following files:

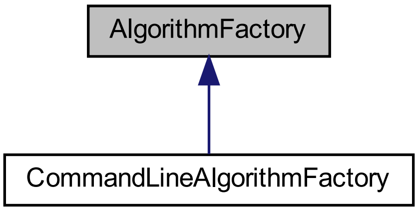
- lib/hnco/algorithms/algorithm.hh
- lib/hnco/algorithms/algorithm.cc

5.5 AlgorithmFactory Class Reference

Algorithm factory.

```
#include <hnco/app/algorithm-factory.hh>
```

Inheritance diagram for AlgorithmFactory:



Public Member Functions

- virtual hnco::algorithm::Algorithm * make (int bv_size)=0

  Make an algorithm.

5.5.1 Detailed Description

Algorithm factory.

Definition at line 32 of file algorithm-factory.hh.

5.5.2 Member Function Documentation

5.5.2.1 make()

```
virtual hnco::algorithm::Algorithm* make (
            int bv_size )  [pure virtual]
```

Make an algorithm.

Parameters

bv_size	Bit vector size

Implemented in CommandLineAlgorithmFactory.

The documentation for this class was generated from the following file:

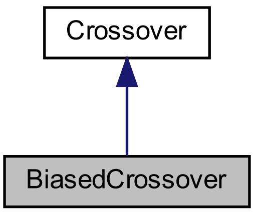
- lib/hnco/app/algorithm-factory.hh

5.6 BiasedCrossover Class Reference

Biased crossover.

`#include <hnco/algorithms/ea/crossover.hh>`

Inheritance diagram for BiasedCrossover:



Public Member Functions

- BiasedCrossover ()
  Constructor.
- void breed (const bit_vector_t &parent1, const bit_vector_t &parent2, bit_vector_t &offspring)
  Breed.
- void set_bias (double b)
  Set bias.

Private Attributes

- std::bernoulli_distribution _bernoulli_dist
  Bernoulli distribution.

5.6.1 Detailed Description

Biased crossover.

Definition at line 75 of file crossover.hh.

5.6.2 Member Function Documentation

5.6.2.1 breed()

```
void breed (
            const bit_vector_t & parent1,
            const bit_vector_t & parent2,
            bit_vector_t & offspring ) [virtual]
```

Breed.

Each offspring's bit is copied from second parent with a fixed probability (the crossover bias), from first parent otherwise.

Parameters

parent1	First parent
parent2	Second parent
offspring	Offspring

Implements Crossover.

Definition at line 45 of file crossover.cc.

The documentation for this class was generated from the following files:

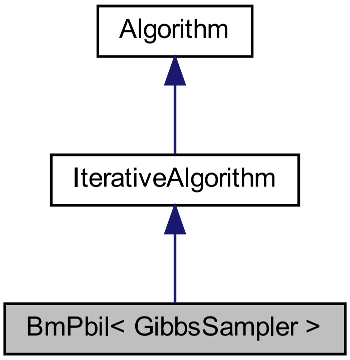
- lib/hnco/algorithms/ea/crossover.hh
- lib/hnco/algorithms/ea/crossover.cc

5.7 BmPbil< GibbsSampler > Class Template Reference

Boltzmann machine PBIL.

```
#include <hnco/algorithms/walsh-moment/bm-pbil.hh>
```

Inheritance diagram for BmPbil< GibbsSampler >:



Public Types

- enum { SAMPLING_ASYNCHRONOUS , SAMPLING_ASYNCHRONOUS_FULL_SCAN , SAMPLING_SYNCHRONOUS }
- enum { RESET_NO_RESET , RESET_ITERATION , RESET_BIT_VECTOR }

Public Member Functions

- BmPbil (int n, int population_size)
  Constructor.

Setters for parameters

- void set_selection_size (int x)
  Set the selection size.
- void set_learning_rate (double x)
  Set the learning rate.
- void set_num_gs_steps (int x)
  Set the number of gibbs sampler steps.
- void set_num_gs_cycles (int x)
  Set the number of gibbs sampler cycles.
- void set_negative_positive_selection (bool x)
  Set negative and positive selection.
- void set_sampling (int x)
  Set the sampling mode.
- void set_mc_reset_strategy (int x)
  Set the MC reset strategy.

Setters for logging

- void set_log_norm_infinite (bool x)
  Log infinite norm of the model parameters.
- void set_log_norm_1 (bool x)
  Log 1-norm of the model parameters.

Protected Member Functions

- void set_something_to_log ()

  Set flag for something to log.
- void sample (bit_vector_t &x)

  Sample a bit vector.
- void sample_asynchronous ()

  Asynchronous sampling.
- void sample_asynchronous_full_scan ()

  Asynchronous sampling with full scan.
- void sample_synchronous ()

  Synchronous sampling.

Loop

- void init () override

  Initialize.
- void iterate () override

  Single iteration.
- void log () override

  Log.

Protected Attributes

- Population _population

  Population.
- GibbsSampler::Moment _model_parameters

  Model parameters.
- GibbsSampler _gibbs_sampler

  Model.
- GibbsSampler::Moment _walsh_moment_all

  Parameters averaged over all individuals.
- GibbsSampler::Moment _walsh_moment_best

  Parameters averaged over selected individuals.
- GibbsSampler::Moment _walsh_moment_worst

  Parameters averaged over negatively selected individuals.
- std::uniform_int_distribution< int > _choose_bit

  Uniform distribution on bit_vector_t components.
- permutation_t _permutation

  Permutation.

Parameters

- int _selection_size = 1

  Selection size (number of selected individuals in the population)
- double _learning_rate = 1e-3

  Learning rate.
- int _num_gs_steps = 100

  Number of gibbs sampler steps.
- int _num_gs_cycles = 1

  Number of gibbs sampler cycles.
- bool _negative_positive_selection = false

Negative and positive selection.
- int _sampling = SAMPLING_ASYNCHRONOUS

  Sampling mode.
- int _mc_reset_strategy = RESET_NO_RESET

  MC reset strategy.

Logging

- bool _log_norm_infinite = false

  Log infinite norm of the model parameters.
- bool _log_norm_1 = false

  Log 1-norm of the model parameters.

5.7.1 Detailed Description

template<class GibbsSampler>
class hnco::algorithm::walsh_moment::BmPbil< GibbsSampler >

Boltzmann machine PBIL.

The BM model is slightly different from the one given in the reference below. More precisely, 0/1 variables are mapped to -1/+1 variables as in Walsh analysis.

Reference:

Arnaud Berny. 2002. Boltzmann machine for population-based incremental learning. In ECAI 2002. IOS Press, Lyon.

Definition at line 50 of file bm-pbil.hh.

5.7.2 Member Enumeration Documentation

5.7.2.1 anonymous enum

`anonymous enum`

Enumerator

SAMPLING_ASYNCHRONOUS	Asynchronous sampling. `A single component of the internal state is randomly selected then updated by Gibbs sampling. This step is repeated _num_gs_steps times.`
SAMPLING_ASYNCHRONOUS_FULL_SCAN	Asynchronous sampling with full scan. `To sample a new bit vector, a random permutation is sampled and all components of the internal state are updated by Gibbs sampling in the order defined by the permutation.`
SAMPLING_SYNCHRONOUS	Synchronous sampling. `The full internal state is updated in one step from the probability vector made of the very marginal probabilities used in Gibbs sampling.`

Definition at line 54 of file bm-pbil.hh.

5.7.2.2 anonymous enum

```
anonymous enum
```

Enumerator

RESET_NO_RESET	No reset.
RESET_ITERATION	Reset MC at the beginning of each iteration.
RESET_BIT_VECTOR	Reset MC before sampling each bit vector.

Definition at line 82 of file bm-pbil.hh.

5.7.3 Member Function Documentation

5.7.3.1 set_selection_size()

```
void set_selection_size (
            int x )  [inline]
```

Set the selection size.

The selection size is the number of selected individuals in the population.

Definition at line 309 of file bm-pbil.hh.

The documentation for this class was generated from the following file:

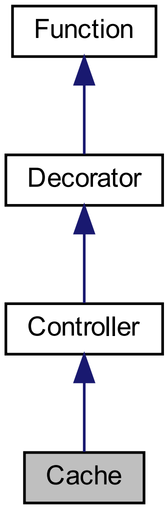
- lib/hnco/algorithms/walsh-moment/bm-pbil.hh

5.8 Cache Class Reference

Cache.

```
#include <hnco/functions/controllers/controller.hh>
```

Inheritance diagram for Cache:



Public Member Functions

- Cache (Function *function)

  Constructor.
- bool provides_incremental_evaluation () const

  Check whether the function provides incremental evaluation.
- double get_lookup_ratio ()

  Get lookup ratio.

Evaluation

- double evaluate (const bit_vector_t &)

  Evaluate a bit vector.

Private Attributes

- std::unordered_map< std::vector< bool >, double > _cache

  Cache.
- std::vector< bool > _key

  Key.
- int _num_evaluations

  Evaluation counter.
- int _num_lookups

  Lookup counter.

Additional Inherited Members

5.8.1 Detailed Description

Cache.

This is a naive approach, in particular with respect to time complexity. Moreover, there is no control on the size of the database.

There is no default hash function for std::vector<char> hence the need to first copy a bit_vector_t into a std::vector<bool>, for which such a function exists, before inserting it or checking its existence in the map.

Definition at line 339 of file controller.hh.

5.8.2 Constructor & Destructor Documentation

5.8.2.1 Cache()

```
Cache (
            Function * function )  [inline]
```

Constructor.

Parameters

function	Decorated function

Definition at line 358 of file controller.hh.

5.8.3 Member Function Documentation

5.8.3.1 provides_incremental_evaluation()

```
bool provides_incremental_evaluation ( ) const  [inline], [virtual]
```

Check whether the function provides incremental evaluation.

Returns

false

Reimplemented from Controller.

Definition at line 367 of file controller.hh.

The documentation for this class was generated from the following files:

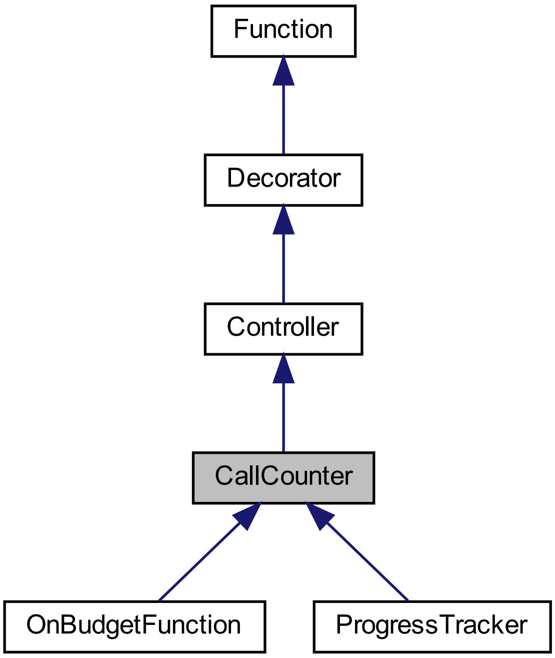
- lib/hnco/functions/controllers/controller.hh
- lib/hnco/functions/controllers/controller.cc

5.9 CallCounter Class Reference

Call counter.

```
#include <hnco/functions/controllers/controller.hh>
```

Inheritance diagram for CallCounter:



Public Member Functions

- CallCounter (Function *function)
  Constructor.
- int get_num_calls ()
  Get the number of calls.

Evaluation

- double evaluate (const bit_vector_t &)
  Evaluate a bit vector.
- double evaluate_incrementally (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_t &flipped_bits)
  Incrementally evaluate a bit vector.
- void update (const bit_vector_t &x, double value)
  Update after a safe evaluation.

Protected Attributes

- int _num_calls

  Number of calls.

5.9.1 Detailed Description

Call counter.

Definition at line 149 of file controller.hh.

The documentation for this class was generated from the following files:

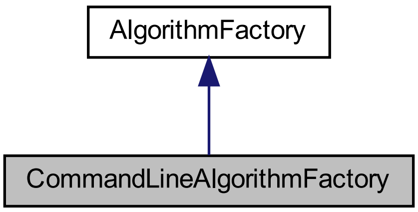
- lib/hnco/functions/controllers/controller.hh
- lib/hnco/functions/controllers/controller.cc

5.10 CommandLineAlgorithmFactory Class Reference

Command line algorithm factory.

```
#include <hnco/app/algorithm-factory.hh>
```

Inheritance diagram for CommandLineAlgorithmFactory:



Public Member Functions

- CommandLineAlgorithmFactory (const HncoOptions &options)

  Constructor.
- hnco::algorithm::Algorithm * make (int bv_size)

  Make an algorithm.

Private Attributes

- const HncoOptions & _options

  HNCO options.

5.10.1 Detailed Description

Command line algorithm factory.

Definition at line 42 of file algorithm-factory.hh.

5.10.2 Member Function Documentation

5.10.2.1 make()

```
Algorithm * make (
            int bv_size )  [virtual]
```

Make an algorithm.

Parameters

bv_size	Bit vector size

Implements AlgorithmFactory.

Definition at line 81 of file algorithm-factory.cc.

The documentation for this class was generated from the following files:

- lib/hnco/app/algorithm-factory.hh
- lib/hnco/app/algorithm-factory.cc

5.11 CommandLineApplication Class Reference

Command line application.

```
#include <hnco/app/application.hh>
```

Public Member Functions

- CommandLineApplication (const HncoOptions &options, FunctionFactory &function_factory, AlgorithmFactory &algorithm_factory)

    Constructor.
- void run ()

    Run the application.

Private Member Functions

- void init ()

  Initialization.
- void make_functions ()

  Make all functions.
- void load_solution ()

  Load a solution.
- void print_information ()

  Print information about the function.
- void make_algorithm ()

  Make algorithm.
- void maximize ()

  Maximize the function.
- void print_results (double total_time, bool target_reached)

  Print results.
- void manage_solution (const bit_vector_t &bv)

  Manage solution.

Private Attributes

- const HncoOptions & _options

  HNCO options.
- DecoratedFunctionFactory _decorated_function_factory

  Decorated functin factory.
- AlgorithmFactory & _algorithm_factory

  Algorithm factory.
- std::vector< function::Function * > _fns

  All functions.
- function::Function * _fn = nullptr

  Main function.
- hnco::algorithm::Algorithm * _algorithm = nullptr

  Algorithm.
- logging::ProgressTrackerContext * _log_context = nullptr

  Log context.

5.11.1 Detailed Description

Command line application.

Definition at line 34 of file application.hh.

5.11.2 Constructor & Destructor Documentation

5.11.2.1 CommandLineApplication()

```
CommandLineApplication (
            const HncoOptions & options,
            FunctionFactory & function_factory,
            AlgorithmFactory & algorithm_factory )  [inline]
```

Constructor.

Parameters

options	HNCO options
function_factory	Function factory
algorithm_factory	Algorithm factory

Definition at line 89 of file application.hh.

The documentation for this class was generated from the following files:

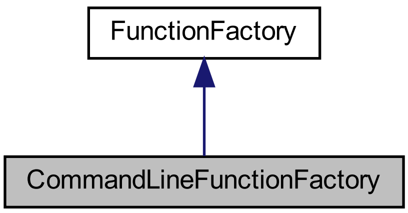
- lib/hnco/app/application.hh
- lib/hnco/app/application.cc

5.12 CommandLineFunctionFactory Class Reference

Command line function factory.

`#include <hnco/app/function-factory.hh>`

Inheritance diagram for CommandLineFunctionFactory:



Public Member Functions

- CommandLineFunctionFactory (const HncoOptions &options)

  Constructor.
- hnco::function::Function ∗ make ()

  Make a function.

Private Attributes

- const HncoOptions & _options

  HNCO options.

5.12.1 Detailed Description

Command line function factory.

Definition at line 40 of file function-factory.hh.

The documentation for this class was generated from the following files:

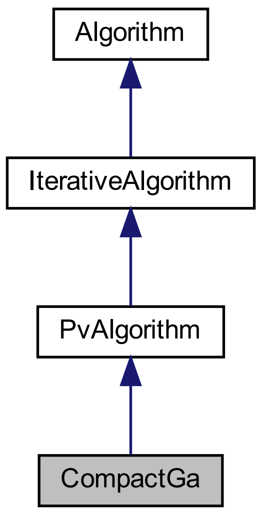
- lib/hnco/app/function-factory.hh
- lib/hnco/app/function-factory.cc

5.13 CompactGa Class Reference

Compact genetic algorithm.

```
#include <hnco/algorithms/pv/compact-ga.hh>
```

Inheritance diagram for CompactGa:



Public Member Functions

- CompactGa (int n)

  Constructor.

Setters

- void set_learning_rate (double x)

  Set the learning rate.

Protected Member Functions

Loop

- void init () override
  Initialize.
- void iterate () override
  Single iteration.

Protected Attributes

- std::vector< bit_vector_t > _candidates
  Candidates.

Parameters

- double _learning_rate = 1e-3
  Learning rate.

5.13.1 Detailed Description

Compact genetic algorithm.

Reference:

Georges R. Harik, Fernando G. Lobo, and David E. Goldberg. 1999. The Compact Genetic Algorithm. IEEE Trans. on Evolutionary Computation 3, 4 (November 1999), 287–297.

Definition at line 41 of file compact-ga.hh.

The documentation for this class was generated from the following files:

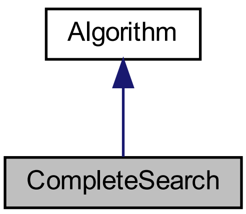
- lib/hnco/algorithms/pv/compact-ga.hh
- lib/hnco/algorithms/pv/compact-ga.cc

5.14 CompleteSearch Class Reference

Complete search.

```
#include <hnco/algorithms/complete-search.hh>
```

Inheritance diagram for CompleteSearch:



Public Member Functions

- CompleteSearch (int n)

  Constructor.
- void maximize (const std::vector$<$ function::Function $*$ $>$ &functions)

  Maximize.

Additional Inherited Members

5.14.1 Detailed Description

Complete search.

Definition at line 34 of file complete-search.hh.

The documentation for this class was generated from the following files:

- lib/hnco/algorithms/complete-search.hh
- lib/hnco/algorithms/complete-search.cc

5.15 ComplexToDouble$<$ T $>$ Struct Template Reference

Convert a complex to a double.

`#include <hnco/functions/converter.hh>`

Public Types

- using codomain_type = std::complex$<$ T $>$

  Codomain type.

Public Member Functions

- double operator() (std::complex$<$ T $>$ z)

  Convert to double.

5.15.1 Detailed Description

template$<$class T$>$
struct hnco::function::ComplexToDouble$<$ T $>$

Convert a complex to a double.

Definition at line 44 of file converter.hh.

The documentation for this struct was generated from the following file:

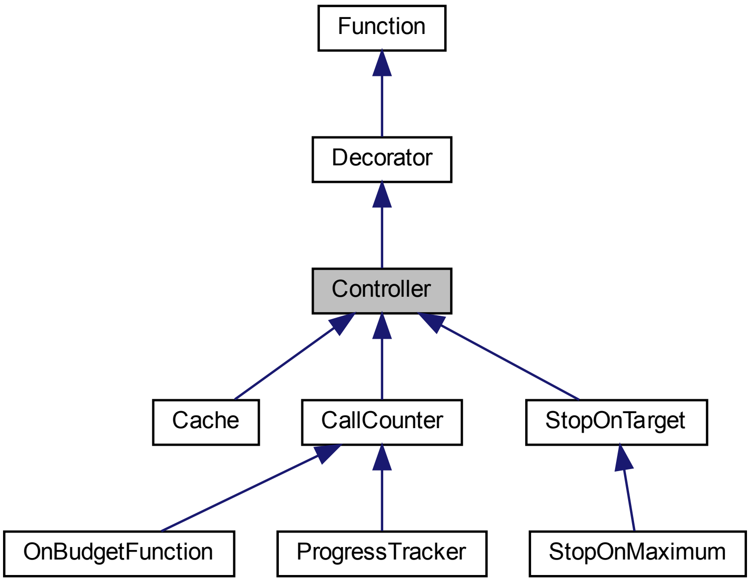
- lib/hnco/functions/converter.hh

5.16 Controller Class Reference

Function controller.

`#include <hnco/functions/controllers/controller.hh>`

Inheritance diagram for Controller:



Public Member Functions

- Controller (Function ∗function)

  Constructor.

Information about the function

- int get_bv_size () const

  Get bit vector size.
- double get_maximum () const

  Get the global maximum.
- bool has_known_maximum () const

  Check for a known maximum.
- bool provides_incremental_evaluation () const

  Check whether the function provides incremental evaluation.

Evaluation

- double evaluate_safely (const bit_vector_t &x)

  Safely evaluate a bit vector.

Additional Inherited Members

5.16.1 Detailed Description

Function controller.

Definition at line 42 of file controller.hh.

5.16.2 Member Function Documentation

5.16.2.1 provides_incremental_evaluation()

```
bool provides_incremental_evaluation ( ) const  [inline], [virtual]
```

Check whether the function provides incremental evaluation.

Returns

true if the decorated function does

Reimplemented from Function.

Reimplemented in Cache.

Definition at line 66 of file controller.hh.

The documentation for this class was generated from the following file:

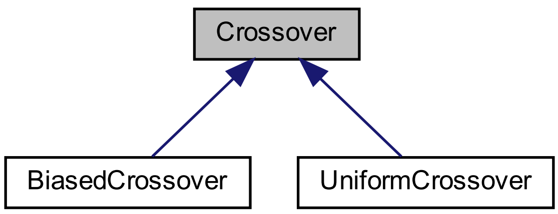
- lib/hnco/functions/controllers/controller.hh

5.17 Crossover Class Reference

Crossover

```
#include <hnco/algorithms/ea/crossover.hh>
```

Inheritance diagram for Crossover:



Public Member Functions

- virtual ~Crossover ()
  Destructor.
- virtual void breed (const bit_vector_t &parent1, const bit_vector_t &parent2, bit_vector_t &offspring)=0
  Breed.

5.17.1 Detailed Description

Crossover

Definition at line 35 of file crossover.hh.

5.17.2 Member Function Documentation

5.17.2.1 breed()

```
virtual void breed (
            const bit_vector_t & parent1,
            const bit_vector_t & parent2,
            bit_vector_t & offspring )  [pure virtual]
```

Breed.

The offspring is the crossover of two parents.

Parameters

parent1	First parent
parent2	Second parent
offspring	Offspring

Implemented in BiasedCrossover, and UniformCrossover.

The documentation for this class was generated from the following file:

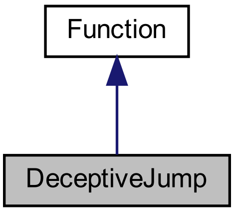
- lib/hnco/algorithms/ea/crossover.hh

5.18 DeceptiveJump Class Reference

Deceptive jump.

```
#include <hnco/functions/collection/jump.hh>
```

Inheritance diagram for DeceptiveJump:



Public Member Functions

- DeceptiveJump (int bv_size, int gap)

    Constructor.
- int get_bv_size () const override

    Get bit vector size.
- bool has_known_maximum () const override

    Check for a known maximum.
- double get_maximum () const override

    Get the global maximum.
- double evaluate (const bit_vector_t &) override

    Evaluate a bit vector.

Private Attributes

- int _bv_size

    Bit vector size.
- int _gap

    Gap.

5.18.1 Detailed Description

Deceptive jump.

This is a jump function with a deceptive gap as defined in "Analyzing evolutionary algorithms" by Thomas Jansen, where it is called Jump_k. Algorithms in the neighborhood of the maximizer (which is the all one bit vector) are taken away from it.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 85 of file jump.hh.

5.18.2 Member Function Documentation

5.18.2.1 get_maximum()

```
double get_maximum ( ) const  [inline], [override], [virtual]
```

Get the global maximum.

Returns

_bv_size + _gap

Reimplemented from Function.

Definition at line 108 of file jump.hh.

5.18.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const  [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 104 of file jump.hh.

The documentation for this class was generated from the following files:

- lib/hnco/functions/collection/jump.hh
- lib/hnco/functions/collection/jump.cc

5.19 DecoratedFunctionFactory Class Reference

Decorated function factory.

```
#include <hnco/app/decorated-function-factory.hh>
```

Public Member Functions

- DecoratedFunctionFactory (const HncoOptions &options, FunctionFactory &function_factory)
  Constructor.
- hnco::function::Function ∗ make_function_modifier ()
  Make a function modifier.
- hnco::function::Function ∗ make_function_controller (hnco::function::Function ∗function)
  Make a function controller.
- hnco::map::Map ∗ get_map ()
  Get map.
- hnco::function::controller::ProgressTracker ∗ get_tracker ()
  Get tracker controller.
- hnco::function::controller::Cache ∗ get_cache ()
  Get Cache controller.
- hnco::function::controller::StopOnTarget ∗ get_stop_on_target ()
  Get StopOnTarget controller.

Private Member Functions

- hnco::function::Function ∗ make_function ()
  Make a function.

Private Attributes

- const HncoOptions & _options
  HNCO options.
- FunctionFactory & _function_factory
  Factory function.
- hnco::map::Map ∗ _map = nullptr
  Map.
- hnco::function::controller::ProgressTracker ∗ _tracker = nullptr
  Tracker controller.
- hnco::function::controller::Cache ∗ _cache = nullptr
  Cache controller.
- hnco::function::controller::StopOnTarget ∗ _stop_on_target = nullptr
  StopOnTarget controller.

5.19.1 Detailed Description

Decorated function factory.

Definition at line 35 of file decorated-function-factory.hh.

5.19.2 Member Function Documentation

5.19.2.1 make_function_controller()

```
Function * make_function_controller (
            hnco::function::Function * function )
```

Make a function controller.

Parameters

function	Decorated function

Definition at line 254 of file decorated-function-factory.cc.

The documentation for this class was generated from the following files:

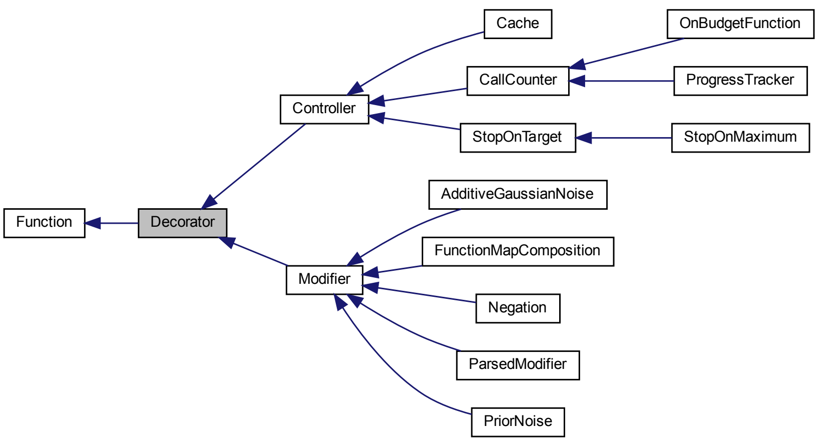
- lib/hnco/app/decorated-function-factory.hh
- lib/hnco/app/decorated-function-factory.cc

5.20 Decorator Class Reference

Function decorator

`#include <hnco/functions/decorator.hh>`

Inheritance diagram for Decorator:



Public Member Functions

- Decorator (Function ∗function)

  Constructor.

Display

- void display (std::ostream &stream) const override

  Display.
- void describe (const bit_vector_t &x, std::ostream &stream) override

  Describe a bit vector.

Protected Attributes

- Function ∗ _function

    Decorated function.

5.20.1 Detailed Description

Function decorator

Definition at line 34 of file decorator.hh.

The documentation for this class was generated from the following file:

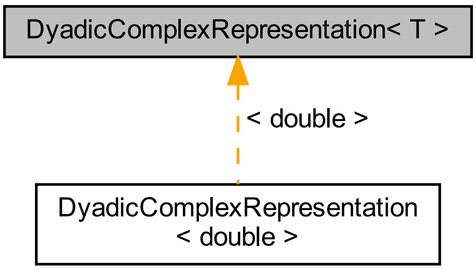
- lib/hnco/functions/decorator.hh

5.21 DyadicComplexRepresentation< T > Class Template Reference

Dyadic complex representation.

```
#include <hnco/representations/complex.hh>
```

Inheritance diagram for DyadicComplexRepresentation< T >:



Public Types

- using domain_type = std::complex< T >

    Domain type.

Public Member Functions

- DyadicComplexRepresentation (DyadicFloatRepresentation< T > real_part, DyadicFloatRepresentation< T > imaginary_part)

  Constructor.
- DyadicComplexRepresentation (DyadicFloatRepresentation< T > rep)

  Constructor.
- int size () const

  Size of the representation.
- domain_type unpack (const bit_vector_t &bv, int start)

  Unpack bit vector into a value.
- void display (std::ostream &stream) const

  Display.

Private Attributes

- DyadicFloatRepresentation< T > _real_part

  Representation of the real part.
- DyadicFloatRepresentation< T > _imaginary_part

  Representation of the imaginary part.

5.21.1 Detailed Description

template<class T>
class hnco::representation::DyadicComplexRepresentation< T >

Dyadic complex representation.

Definition at line 46 of file complex.hh.

5.21.2 Constructor & Destructor Documentation

5.21.2.1 DyadicComplexRepresentation() [1/2]

```
DyadicComplexRepresentation (
            DyadicFloatRepresentation< T > real_part,
            DyadicFloatRepresentation< T > imaginary_part )  [inline]
```

Constructor.

Parameters

real_part	Representation of real part
imaginary_part	Representation of imaginary part

Definition at line 64 of file complex.hh.

5.21.2.2 DyadicComplexRepresentation() [2/2]

```
DyadicComplexRepresentation (
            DyadicFloatRepresentation< T > rep )  [inline]
```

Constructor.

Parameters

rep	Representation of both real and imaginary parts

Definition at line 73 of file complex.hh.

The documentation for this class was generated from the following file:

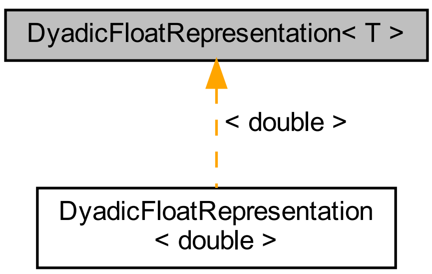
- lib/hnco/representations/complex.hh

5.22 DyadicFloatRepresentation< T > Class Template Reference

Dyadic float representation.

```
#include <hnco/representations/float.hh>
```

Inheritance diagram for DyadicFloatRepresentation< T >:



Public Types

- using domain_type = T

  Domain type.

Public Member Functions

- DyadicFloatRepresentation (T lower_bound, T upper_bound, int num_bits)
  Constructor.
- DyadicFloatRepresentation (T lower_bound, T upper_bound, T precision)
  Constructor.
- int size () const
  Size of the representation.
- domain_type unpack (const bit_vector_t &bv, int start)
  Unpack bit vector into a value.
- void display (std::ostream &stream) const
  Display.

Private Member Functions

- T affine_transformation (T x)
  Affine transformation.
- void compute_lengths (int num_bits)
  Compute lengths.

Private Attributes

- std::vector< T > _lengths
  Lengths of dyadic intervals.
- T _lower_bound
  Lower bound of the interval.
- T _length
  Length of the interval.

5.22.1 Detailed Description

template<class T>
class hnco::representation::DyadicFloatRepresentation< T >

Dyadic float representation.

Definition at line 44 of file float.hh.

5.22.2 Constructor & Destructor Documentation

5.22.2.1 DyadicFloatRepresentation() [1/2]

```
DyadicFloatRepresentation (
            T lower_bound,
            T upper_bound,
            int num_bits )  [inline]
```

Constructor.

The represented interval is [lower_bound, upper_bound).

Parameters

lower_bound	Lower bound of the interval
upper_bound	Upper bound of the interval
num_bits	Number of bits per float number

Definition at line 87 of file float.hh.

5.22.2.2 DyadicFloatRepresentation() [2/2]

```
DyadicFloatRepresentation (
            T lower_bound,
            T upper_bound,
            T precision )  [inline]
```

Constructor.

The represented interval is [lower_bound, upper_bound).

Parameters

lower_bound	Lower bound of the interval
upper_bound	Upper bound of the interval
precision	Precision

Definition at line 105 of file float.hh.

5.22.3 Member Function Documentation

5.22.3.1 compute_lengths()

```
void compute_lengths (
            int num_bits )  [inline], [private]
```

Compute lengths.

Parameters

num_bits	Number of bits per float number

Definition at line 62 of file float.hh.

The documentation for this class was generated from the following file:

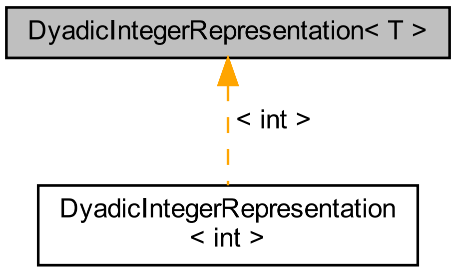
- lib/hnco/representations/float.hh

5.23 DyadicIntegerRepresentation< T > Class Template Reference

Dyadic integer representation.

```
#include <hnco/representations/integer.hh>
```

Inheritance diagram for DyadicIntegerRepresentation< T >:



Public Types

- using domain_type = T
  Domain type.

Public Member Functions

- DyadicIntegerRepresentation (T lower_bound, T upper_bound, int num_bits)
  Constructor.
- DyadicIntegerRepresentation (T lower_bound, T upper_bound)
  Constructor.
- int size () const
  Size of the representation.
- domain_type unpack (const bit_vector_t &bv, int start)
  Unpack bit vector into a value.
- void display (std::ostream &stream) const
  Display.

Private Member Functions

- void set_num_bits_complete (T lower_bound, T upper_bound)
  The the number of bits of a complete representation.

Private Attributes

- int _num_bits
  Number of bits.
- int _num_bits_complete
  Number of bits for a complete representation.
- T _lower_bound
  Lower bound of the interval.
- T _upper_bound
  Upper bound of the interval.

5.23.1 Detailed Description

template<class T>
class hnco::representation::DyadicIntegerRepresentation< T >

Dyadic integer representation.

Definition at line 78 of file integer.hh.

5.23.2 Constructor & Destructor Documentation

5.23.2.1 DyadicIntegerRepresentation() [1/2]

```
DyadicIntegerRepresentation (
            T lower_bound,
            T upper_bound,
            int num_bits )  [inline]
```

Constructor.

The represented interval is [lower_bound..upper_bound].

Parameters

num_bits	Number of bits per integer
lower_bound	Lower bound of the interval
upper_bound	Upper bound of the interval

Definition at line 115 of file integer.hh.

5.23.2.2 DyadicIntegerRepresentation() [2/2]

```
DyadicIntegerRepresentation (
```

```
T lower_bound,
T upper_bound )  [inline]
```

Constructor.

The represented interval is [lower_bound..upper_bound].

Parameters

lower_bound	Lower bound of the interval
upper_bound	Upper bound of the interval

Definition at line 135 of file integer.hh.

The documentation for this class was generated from the following file:

- lib/hnco/representations/integer.hh

5.24 PermutationRepresentation::Element Struct Reference

Element.

```
#include <hnco/representations/permutation.hh>
```

Public Attributes

- int index
  Index.
- int value
  Value.

5.24.1 Detailed Description

Element.

Definition at line 44 of file permutation.hh.

The documentation for this struct was generated from the following file:

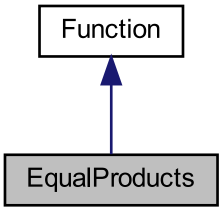
- lib/hnco/representations/permutation.hh

5.25 EqualProducts Class Reference

Equal products.

`#include <hnco/functions/collection/equal-products.hh>`

Inheritance diagram for EqualProducts:



Public Member Functions

- EqualProducts ()
  Constructor.
- int get_bv_size () const override
  Get bit vector size.
- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.

Instance generators

- template<class Generator >
  void generate (int n, Generator generator)
  Instance generator.
- void random (int n)
  Random instance.

Load and save instance

- void load (std::string path)
  Load instance.
- void save (std::string path) const
  Save instance.

Private Member Functions

- template<class Archive >
  void serialize (Archive &ar, const unsigned int version)
  Serialize.

Private Attributes

- std::vector< double > _numbers

    Numbers.

Friends

- class **boost::serialization::access**

5.25.1 Detailed Description

Equal products.

Partition a finite set of positive numbers into two subsets such that the product of numbers in the first subset is the closest to the product of numbers in the second subset. This is equivalent to the partition problem applied to the logarithms of the given numbers.

The function computes the negation of the distance between the product of numbers corresponding to ones in the bit vector and the product of those corresponding to zeros. The negation is a consequence of the fact that algorithms in HNCO maximize rather than minimize a function.

Reference:

S. Baluja and S. Davies. 1997. Using optimal dependency-trees for combinatorial optimization: learning the structure of the search space. Technical Report CMU- CS-97-107. Carnegie-Mellon University.

Definition at line 59 of file equal-products.hh.

5.25.2 Member Function Documentation

5.25.2.1 generate()

```
void generate (
            int n,
            Generator generator )  [inline]
```

Instance generator.

Parameters

n	Size of bit vectors
generator	Number generator

Definition at line 91 of file equal-products.hh.

5.25.2.2 load()

```
void load (
            std::string path ) [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 124 of file equal-products.hh.

5.25.2.3 random()

```
void random (
            int n ) [inline]
```

Random instance.

The weights are sampled from the uniform distribution on [0,1).

Parameters

n	Size of bit vector

Definition at line 106 of file equal-products.hh.

5.25.2.4 save()

```
void save (
            std::string path ) const [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 131 of file equal-products.hh.

The documentation for this class was generated from the following files:

- lib/hnco/functions/collection/equal-products.hh
- lib/hnco/functions/collection/equal-products.cc

5.26 ProgressTracker::Event Struct Reference

Event

`#include <hnco/functions/controllers/controller.hh>`

Public Attributes

- int num_evaluations

  Number of evaluations.
- double value

  Value.

5.26.1 Detailed Description

Event

Definition at line 231 of file controller.hh.

The documentation for this struct was generated from the following file:

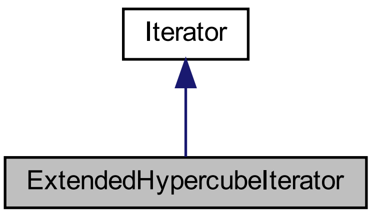
- lib/hnco/functions/controllers/controller.hh

5.27 ExtendedHypercubeIterator Class Reference

Extended Hypercube iterator.

`#include <hnco/iterator.hh>`

Inheritance diagram for ExtendedHypercubeIterator:



Public Member Functions

- ExtendedHypercubeIterator (int n)

  Constructor.
- bool has_next () override

  Has next bit vector.
- const bit_vector_t & next () override

  Next bit vector.

Additional Inherited Members

5.27.1 Detailed Description

Extended Hypercube iterator.

Similar to Hypercube. In dimension 0, an HypercubeIterator does not contain any element. However, in dimension 0, an ExtendedHypercubeIterator contains a unique element which is the vector of size 0. An ExtendedHypercubeIterator is helpful when the enumerated vectors are seen as prefixes or suffixes hence can be empty. This is used, in particular, in compute_fast_walsh_transform.

Definition at line 97 of file iterator.hh.

The documentation for this class was generated from the following files:

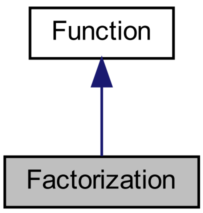
- lib/hnco/iterator.hh
- lib/hnco/iterator.cc

5.28 Factorization Class Reference

Factorization.

`#include <hnco/functions/collection/factorization.hh>`

Inheritance diagram for Factorization:



Public Member Functions

- Factorization ()
  Constructor.
- Factorization (const std::string number)
  Constructor.
- ∼Factorization ()
  Destructor.
- int get_bv_size () const override
  Get bit vector size.
- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.
- void display (std::ostream &stream) const override
  Display.
- void describe (const bit_vector_t &x, std::ostream &stream) override
  Describe a bit vector.

Load and save instance

- void load (std::string path)
  Load instance.

Private Member Functions

- void init ()
  Init GMP data structures.
- void clear ()
  Clear GMP data structures.
- void set_number (const std::string number)
  Set number.
- void convert (const bit_vector_t &x)
  Convert a bit vector into two numbers.

Private Attributes

- mpz_t _number
  Number to factorize.
- mpz_t _first_factor
  First factor.
- mpz_t _second_factor
  Second factor.
- mpz_t _product
  Product.
- std::string _first_factor_string
  First factor in binary form.
- std::string _second_factor_string
  Secon factor in binary form.
- size_t _number_size
  Number size in bits.
- size_t _first_factor_size
  First factor size in bits.
- size_t _second_factor_size
  Second factor size in bits.
- int _bv_size
  Bit vector size.

5.28.1 Detailed Description

Factorization.

Reference:

Torbjörn Granlund and the GMP development team. 2012. GNU MP: The GNU Multiple Precision Arithmetic Library (5.0.5 ed.).

http://gmplib.org/.

Definition at line 29 of file factorization.hh.

5.28.2 Constructor & Destructor Documentation

5.28.2.1 Factorization()

```
Factorization (
            const std::string number )  [inline]
```

Constructor.

Parameters

number	Number to factorize written in decimal form

Definition at line 82 of file factorization.hh.

5.28.3 Member Function Documentation

5.28.3.1 load()

```
void load (
            std::string path )  [inline]
```

Load instance.

The file referenced by the path is a text file which contains exactly one natural number written in base 10 without any space

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 102 of file factorization.hh.

The documentation for this class was generated from the following files:

- lib/hnco/functions/collection/factorization.hh
- lib/hnco/functions/collection/factorization.cc

5.29 FfgenOptions Class Reference

Command line options for ffgen.

```
#include <ffgen-options.hh>
```

Public Member Functions

- FfgenOptions (int argc, char *argv[ ])
  Constructor.
- int get_bv_size () const
  Get bv_size.
- void set_bv_size (int x)
  Set bv_size.
- bool set_bv_size () const
  Get set-flag for bv_size.
- double get_coupling_constant () const
  Get coupling_constant.
- void set_coupling_constant (double x)
  Set coupling_constant.
- bool set_coupling_constant () const
  Get set-flag for coupling_constant.
- double get_ep_upper_bound () const
  Get ep_upper_bound.
- void set_ep_upper_bound (double x)
  Set ep_upper_bound.
- bool set_ep_upper_bound () const
  Get set-flag for ep_upper_bound.
- double get_field_constant () const
  Get field_constant.
- void set_field_constant (double x)
  Set field_constant.
- bool set_field_constant () const
  Get set-flag for field_constant.
- int get_function () const
  Get function.
- void set_function (int x)

Set function.
- bool set_function () const

  Get set-flag for function.
- double get_lin_distance () const

  Get lin_distance.
- void set_lin_distance (double x)

  Set lin_distance.
- bool set_lin_distance () const

  Get set-flag for lin_distance.
- int get_lin_generator () const

  Get lin_generator.
- void set_lin_generator (int x)

  Set lin_generator.
- bool set_lin_generator () const

  Get set-flag for lin_generator.
- double get_lin_initial_weight () const

  Get lin_initial_weight.
- void set_lin_initial_weight (double x)

  Set lin_initial_weight.
- bool set_lin_initial_weight () const

  Get set-flag for lin_initial_weight.
- double get_lin_ratio () const

  Get lin_ratio.
- void set_lin_ratio (double x)

  Set lin_ratio.
- bool set_lin_ratio () const

  Get set-flag for lin_ratio.
- int get_ms_num_clauses () const

  Get ms_num_clauses.
- void set_ms_num_clauses (int x)

  Set ms_num_clauses.
- bool set_ms_num_clauses () const

  Get set-flag for ms_num_clauses.
- int get_ms_num_literals_per_clause () const

  Get ms_num_literals_per_clause.
- void set_ms_num_literals_per_clause (int x)

  Set ms_num_literals_per_clause.
- bool set_ms_num_literals_per_clause () const

  Get set-flag for ms_num_literals_per_clause.
- int get_nk_k () const

  Get nk_k.
- void set_nk_k (int x)

  Set nk_k.
- bool set_nk_k () const

  Get set-flag for nk_k.
- int get_nn1_generator () const

  Get nn1_generator.
- void set_nn1_generator (int x)

  Set nn1_generator.
- bool set_nn1_generator () const

  Get set-flag for nn1_generator.

- int get_nn2_generator () const
  Get nn2_generator.
- void set_nn2_generator (int x)
  Set nn2_generator.
- bool set_nn2_generator () const
  Get set-flag for nn2_generator.
- int get_nn2_num_columns () const
  Get nn2_num_columns.
- void set_nn2_num_columns (int x)
  Set nn2_num_columns.
- bool set_nn2_num_columns () const
  Get set-flag for nn2_num_columns.
- int get_nn2_num_rows () const
  Get nn2_num_rows.
- void set_nn2_num_rows (int x)
  Set nn2_num_rows.
- bool set_nn2_num_rows () const
  Get set-flag for nn2_num_rows.
- int get_part_upper_bound () const
  Get part_upper_bound.
- void set_part_upper_bound (int x)
  Set part_upper_bound.
- bool set_part_upper_bound () const
  Get set-flag for part_upper_bound.
- std::string get_path () const
  Get path.
- void set_path (std::string x)
  Set path.
- bool set_path () const
  Get set-flag for path.
- int get_seed () const
  Get seed.
- void set_seed (int x)
  Set seed.
- bool set_seed () const
  Get set-flag for seed.
- double get_stddev () const
  Get stddev.
- void set_stddev (double x)
  Set stddev.
- bool set_stddev () const
  Get set-flag for stddev.
- int get_sudoku_num_empty_cells () const
  Get sudoku_num_empty_cells.
- void set_sudoku_num_empty_cells (int x)
  Set sudoku_num_empty_cells.
- bool set_sudoku_num_empty_cells () const
  Get set-flag for sudoku_num_empty_cells.
- int get_walsh2_generator () const
  Get walsh2_generator.
- void set_walsh2_generator (int x)

Set walsh2_generator.
- bool set_walsh2_generator () const
  Get set-flag for walsh2_generator.
- double get_walsh2_ising_alpha () const
  Get walsh2_ising_alpha.
- void set_walsh2_ising_alpha (double x)
  Set walsh2_ising_alpha.
- bool set_walsh2_ising_alpha () const
  Get set-flag for walsh2_ising_alpha.
- int get_walsh_num_features () const
  Get walsh_num_features.
- void set_walsh_num_features (int x)
  Set walsh_num_features.
- bool set_walsh_num_features () const
  Get set-flag for walsh_num_features.
- bool with_ms_planted_solution () const
  Get ms_planted_solution.
- void set_ms_planted_solution ()
  Set ms_planted_solution.
- bool with_periodic_boundary_conditions () const
  Get periodic_boundary_conditions.
- void set_periodic_boundary_conditions ()
  Set periodic_boundary_conditions.

Private Member Functions

- void print_help (std::ostream &stream) const
  Print help message.
- void print_version (std::ostream &stream) const
  Print version.

Private Attributes

- std::string _exec_name
  Name of the executable.
- std::string _version
  Name Version.
- int _bv_size
  Size of bit vectors.
- bool **_opt_bv_size**
- double _coupling_constant
  Coupling constant.
- bool **_opt_coupling_constant**
- double _ep_upper_bound
  Upper bound of numbers.
- bool **_opt_ep_upper_bound**
- double _field_constant
  Field constant.
- bool **_opt_field_constant**
- int _function

Type of function.

- bool **_opt_function**
- double _lin_distance

  Common distance of arithmetic progression.

- bool **_opt_lin_distance**
- int _lin_generator

  Type of LinearFunction generator.

- bool **_opt_lin_generator**
- double _lin_initial_weight

  Initial weight.

- bool **_opt_lin_initial_weight**
- double _lin_ratio

  Common ratio of geometric progression.

- bool **_opt_lin_ratio**
- int _ms_num_clauses

  Number of clauses.

- bool **_opt_ms_num_clauses**
- int _ms_num_literals_per_clause

  Number of literals per clause.

- bool **_opt_ms_num_literals_per_clause**
- int _nk_k

  Each bit is connected to k other bits.

- bool **_opt_nk_k**
- int _nn1_generator

  Type of NearestNeighborIsingModel1 generator.

- bool **_opt_nn1_generator**
- int _nn2_generator

  Type of NearestNeighborIsingModel2 generator.

- bool **_opt_nn2_generator**
- int _nn2_num_columns

  Number of columns.

- bool **_opt_nn2_num_columns**
- int _nn2_num_rows

  Number of rows.

- bool **_opt_nn2_num_rows**
- int _part_upper_bound

  Upper bound of numbers.

- bool **_opt_part_upper_bound**
- std::string _path

  Path (relative or absolute) of a function file.

- bool **_opt_path**
- int _seed

  Seed for the random number generator.

- bool **_opt_seed**
- double _stddev

  Standard deviation.

- bool **_opt_stddev**
- int _sudoku_num_empty_cells

  Number of empty cells.

- bool **_opt_sudoku_num_empty_cells**
- int _walsh2_generator

  Type of WalshExpansion2 generator.

- bool **_opt_walsh2_generator**
- double _walsh2_ising_alpha

  Dyson-Ising: exponential decay parameter for long range interactions.
- bool **_opt_walsh2_ising_alpha**
- int _walsh_num_features

  Number of features.
- bool **_opt_walsh_num_features**
- bool _ms_planted_solution

  Generate an instance with a planted solution.
- bool _periodic_boundary_conditions

  Periodic boundary conditions.

Friends

- std::ostream & operator<< (std::ostream &, const FfgenOptions &)

  Print a header containing the parameter values.

5.29.1 Detailed Description

Command line options for ffgen.

Definition at line 11 of file ffgen-options.hh.

The documentation for this class was generated from the following files:

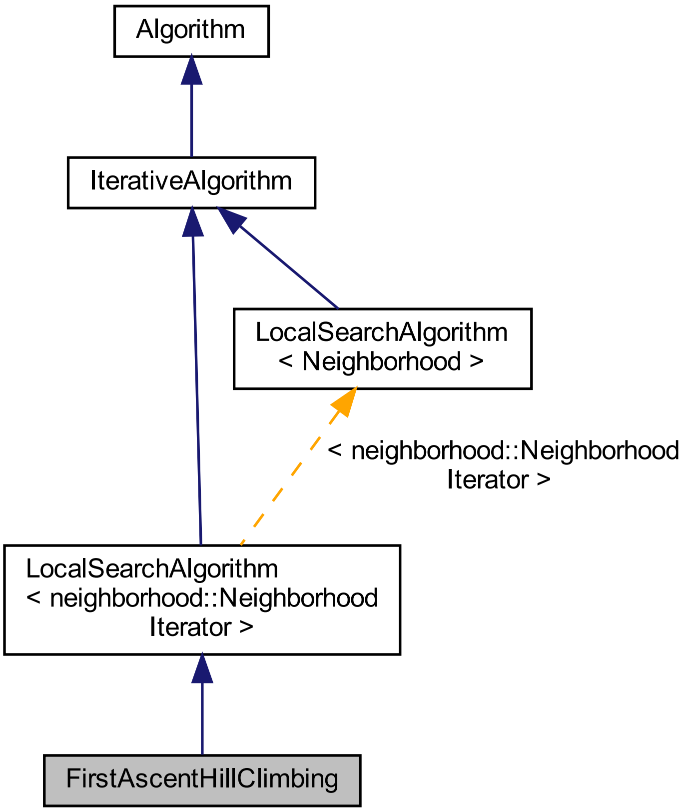
- app/ffgen-options.hh
- app/ffgen-options.cc

5.30 FirstAscentHillClimbing Class Reference

First ascent hill climbing.

```
#include <hnco/algorithms/ls/first-ascent-hill-climbing.hh>
```

Inheritance diagram for FirstAscentHillClimbing:



Public Member Functions

- FirstAscentHillClimbing (int n, neighborhood::NeighborhoodIterator ∗neighborhood)

  Constructor.

Protected Member Functions

- void iterate () override

  Single iteration.

Additional Inherited Members

5.30.1 Detailed Description

First ascent hill climbing.

Definition at line 34 of file first-ascent-hill-climbing.hh.

The documentation for this class was generated from the following files:

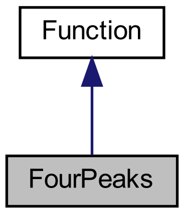
- lib/hnco/algorithms/ls/first-ascent-hill-climbing.hh
- lib/hnco/algorithms/ls/first-ascent-hill-climbing.cc

5.31 FourPeaks Class Reference

Four Peaks.

`#include <hnco/functions/collection/four-peaks.hh>`

Inheritance diagram for FourPeaks:



Public Member Functions

- FourPeaks (int bv_size, int threshold)

  Constructor.
- int get_bv_size () const override

  Get bit vector size.
- bool has_known_maximum () const override

  Check for a known maximum.
- double get_maximum () const override

  Get the global maximum.
- double evaluate (const bit_vector_t &) override

  Evaluate a bit vector.

Private Attributes

- int _bv_size

  Bit vector size.
- int _threshold

  Threshold.
- int _maximum

  Maximum.

5.31.1 Detailed Description

Four Peaks.

It is defined by

f(x) = max{head(x, 1) + tail(x, 0)} + R(x)

where:

- head(x, 1) is the length of the longest prefix of x made of ones;
- tail(x, 0) is the length of the longest suffix of x made of zeros;
- R(x) is the reward;
- R(x) = n if (head(x, 1) $>$ t and tail(x, 0) $>$ t);
- R(x) = 0 otherwise;
- the threshold t is a parameter of the function.

This function has four maxima, of which exactly two are global ones.

For example, if n = 6 and t = 1:

- f(111111) = 6 (local maximum)
- f(111110) = 5
- f(111100) = 10 (global maximum)

Reference:

S. Baluja and R. Caruana. 1995. Removing the genetics from the standard genetic algorithm. In Proceedings of the 12th Annual Conference on Machine Learning. 38–46.

Definition at line 60 of file four-peaks.hh.

5.31.2 Member Function Documentation

5.31.2.1 get_maximum()

```
double get_maximum ( ) const  [inline], [override], [virtual]
```

Get the global maximum.

Returns

2 $*$ _bv_size - _threshold - 1

Reimplemented from Function.

Definition at line 88 of file four-peaks.hh.

5.31.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const  [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 84 of file four-peaks.hh.

The documentation for this class was generated from the following files:

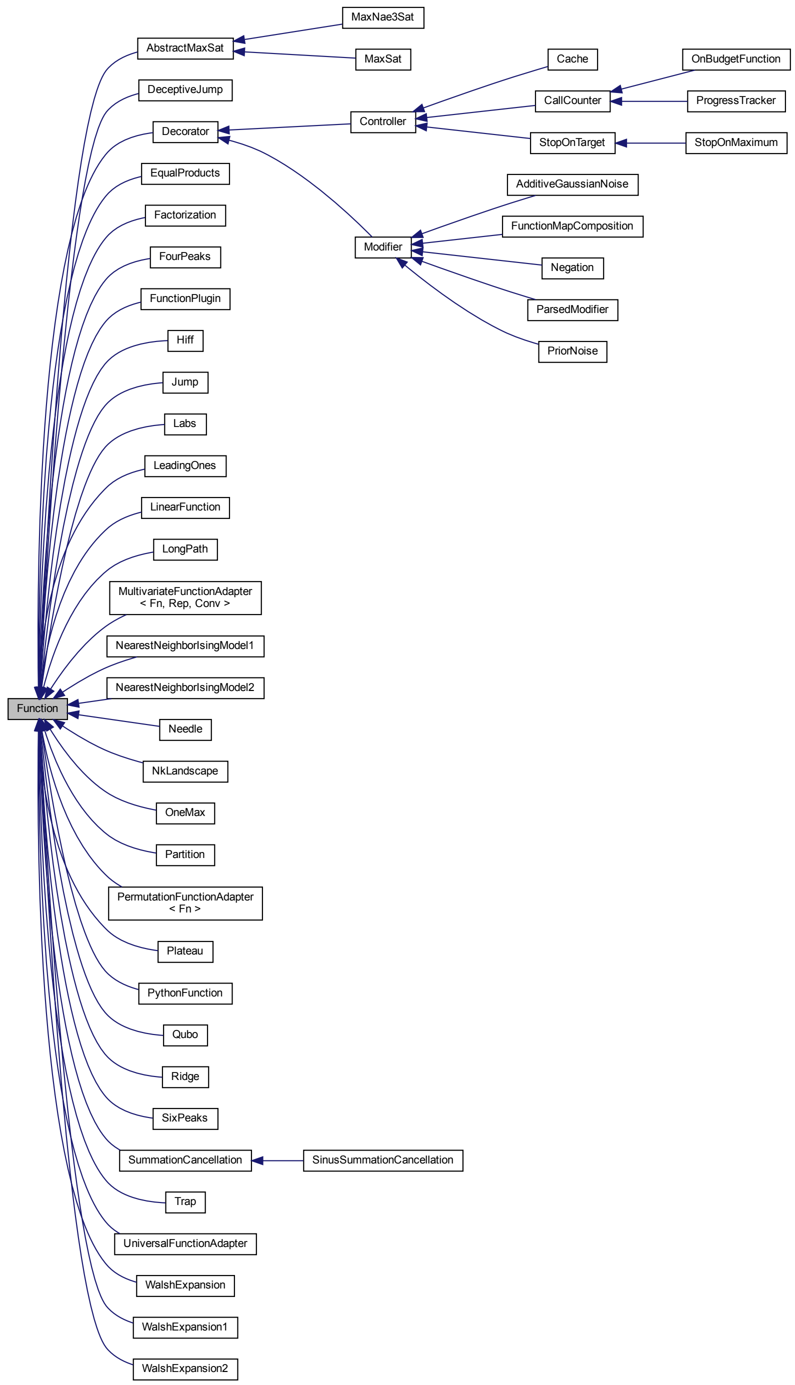
- lib/hnco/functions/collection/four-peaks.hh
- lib/hnco/functions/collection/four-peaks.cc

5.32 Function Class Reference

Function

```
#include <hnco/functions/function.hh>
```

Inheritance diagram for Function:



Public Member Functions

- virtual ~Function ()

  Destructor.

Information about the function

- virtual int get_bv_size () const =0
  Get bit vector size.
- virtual double get_maximum () const
  Get the global maximum.
- virtual bool has_known_maximum () const
  Check for a known maximum.
- virtual bool provides_incremental_evaluation () const
  Check whether the function provides incremental evaluation.

Evaluation

- virtual double evaluate (const bit_vector_t &)=0
  Evaluate a bit vector.
- virtual double evaluate_incrementally (const bit_vector_t &x, double value, const sparse_bit_vector_t &flipped_bits)
  Incrementally evaluate a bit vector.
- virtual double evaluate_safely (const bit_vector_t &x)
  Safely evaluate a bit vector.
- virtual void update (const bit_vector_t &x, double value)
  Update states after a safe evaluation.

Display

- virtual void display (std::ostream &stream) const
  Display.
- virtual void describe (const bit_vector_t &x, std::ostream &stream)
  Describe a bit vector.

5.32.1 Detailed Description

Function

Definition at line 45 of file function.hh.

5.32.2 Member Function Documentation

5.32.2.1 describe()

```
virtual void describe (
            const bit_vector_t & x,
            std::ostream & stream )  [inline], [virtual]
```

Describe a bit vector.

The member function Function::describe is not declared const for the same reason Function::evaluate is not: it might need to decode the given bit vector hence use some pre-allocated memory buffer.

Reimplemented in FunctionMapComposition, Decorator, Partition, Factorization, UniversalFunctionAdapter, PermutationFunctionAdapter< Fn >, and MultivariateFunctionAdapter< Fn, Rep, Conv >.

Definition at line 134 of file function.hh.

5.32.2.2 evaluate()

```
virtual double evaluate (
            const bit_vector_t & )  [pure virtual]
```

Evaluate a bit vector.

This member function is not declared const and is not supposed to be thread-safe. In particular, in order to evaluate a bit vector, it might require some data member to store temporary results. In case of parallel evaluation, there should be a copy of the function per thread, as is done in Population::evaluate_in_parallel.

Implemented in SinusSummationCancellation, SummationCancellation, UniversalFunctionAdapter, PermutationFunctionAdapter< Fn MultivariateFunctionAdapter< Fn, Rep, Conv >, PriorNoise, ParsedModifier, AdditiveGaussianNoise, FunctionMapComposition, Negation, WalshExpansion, WalshExpansion2, WalshExpansion1, Plateau, Ridge, Hiff, Needle, LeadingOnes, OneMax, Qubo, Partition, NkLandscape, MaxNae3Sat, MaxSat, LinearFunction, Labs, DeceptiveJump, Jump, NearestNeighborIsingModel2, NearestNeighborIsingModel1, SixPeaks, FourPeaks, Factorization, EqualProducts, Cache, ProgressTracker, OnBudgetFunction, CallCounter, StopOnTarget, Trap, PythonFunction, FunctionPlugin, and LongPath.

5.32.2.3 evaluate_incrementally()

```
virtual double evaluate_incrementally (
            const bit_vector_t & x,
            double value,
            const sparse_bit_vector_t & flipped_bits )  [inline], [virtual]
```

Incrementally evaluate a bit vector.

Exceptions

std::runtime_error	

Reimplemented in Negation, ProgressTracker, OnBudgetFunction, CallCounter, StopOnTarget, NearestNeighborIsingModel2, NearestNeighborIsingModel1, WalshExpansion1, OneMax, and LinearFunction.

Definition at line 95 of file function.hh.

5.32.2.4 evaluate_safely()

```
virtual double evaluate_safely (
            const bit_vector_t & x )  [inline], [virtual]
```

Safely evaluate a bit vector.

Must neither throw any exception nor update global states (e.g. maximum) in function controllers. It is used in Population::evaluate_in_parallel inside a OMP parallel for loop.

By default, calls evaluate.

Reimplemented in Controller.

Definition at line 109 of file function.hh.

5.32.2.5 get_maximum()

```
virtual double get_maximum ( ) const  [inline], [virtual]
```

Get the global maximum.

Exceptions

std::runtime_error	

Reimplemented in PriorNoise, FunctionMapComposition, WalshExpansion1, Plateau, Ridge, Hiff, Needle, LeadingOnes, OneMax, LinearFunction, DeceptiveJump, Jump, SixPeaks, FourPeaks, SummationCancellation, Controller, Trap, and LongPath.

Definition at line 61 of file function.hh.

5.32.2.6 provides_incremental_evaluation()

```
virtual bool provides_incremental_evaluation ( ) const  [inline], [virtual]
```

Check whether the function provides incremental evaluation.

Returns

false

Reimplemented in PriorNoise, Negation, WalshExpansion1, OneMax, LinearFunction, NearestNeighborIsingModel2, NearestNeighborIsingModel1, Cache, and Controller.

Definition at line 71 of file function.hh.

5.32.2.7 update()

```
virtual void update (
            const bit_vector_t & x,
            double value )  [inline], [virtual]
```

Update states after a safe evaluation.

By default, does nothing.

Reimplemented in ProgressTracker, OnBudgetFunction, CallCounter, and StopOnTarget.

Definition at line 115 of file function.hh.

The documentation for this class was generated from the following file:

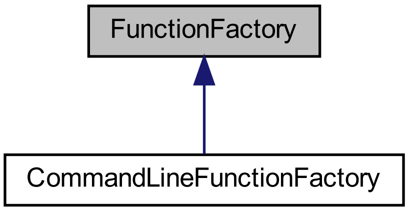
- lib/hnco/functions/function.hh

5.33 FunctionFactory Class Reference

Function factory.

`#include <hnco/app/function-factory.hh>`

Inheritance diagram for FunctionFactory:



Public Member Functions

- virtual hnco::function::Function ∗ make ()=0

    Make a function.

5.33.1 Detailed Description

Function factory.

Definition at line 33 of file function-factory.hh.

The documentation for this class was generated from the following file:

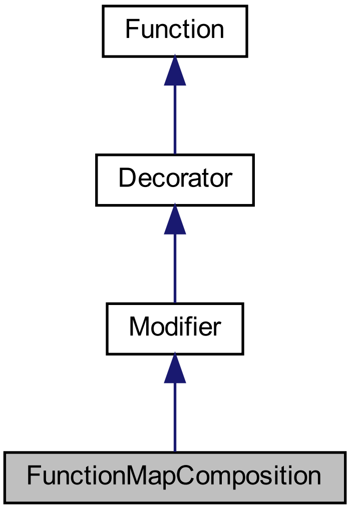
- lib/hnco/app/function-factory.hh

5.34 FunctionMapComposition Class Reference

Composition of a function and a map.

`#include <hnco/functions/modifiers/modifier.hh>`

Inheritance diagram for FunctionMapComposition:



Public Member Functions

- FunctionMapComposition (Function ∗function, hnco::map::Map ∗map)

    Constructor.
- double evaluate (const bit_vector_t &) override

    Evaluate a bit vector.

Information about the function

- int get_bv_size () const override

    Get bit vector size.
- double get_maximum () const override

    Get the global maximum.
- bool has_known_maximum () const override

    Check for a known maximum.

Display

- void describe (const bit_vector_t &x, std::ostream &stream) override

    Describe a bit vector.

Private Attributes

- hnco::map::Map ∗ _map

    Map.
- bit_vector_t _bv

    Image of bit vectors under the map.

Additional Inherited Members

5.34.1 Detailed Description

Composition of a function and a map.

Definition at line 100 of file modifier.hh.

5.34.2 Constructor & Destructor Documentation

5.34.2.1 FunctionMapComposition()

```
FunctionMapComposition (
            Function * function,
            hnco::map::Map * map )  [inline]
```

Constructor.

Precondition

map->get_output_size() == function->get_bv_size()

Exceptions

std::runtime_error	

Definition at line 115 of file modifier.hh.

5.34.3 Member Function Documentation

5.34.3.1 get_maximum()

```
double get_maximum ( ) const  [inline], [override], [virtual]
```

Get the global maximum.

Exceptions

std::runtime_error	

Reimplemented from Function.

Definition at line 135 of file modifier.hh.

5.34.3.2 has_known_maximum()

`bool has_known_maximum ( ) const [inline], [override], [virtual]`

Check for a known maximum.

Returns

true if the function has a known maximum and the map is bijective.

Reimplemented from Function.

Definition at line 145 of file modifier.hh.

The documentation for this class was generated from the following files:

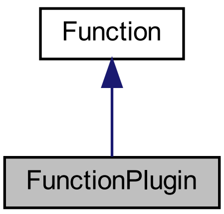
- lib/hnco/functions/modifiers/modifier.hh
- lib/hnco/functions/modifiers/modifier.cc

5.35 FunctionPlugin Class Reference

Function plugin

`#include <hnco/functions/collection/plugin.hh>`

Inheritance diagram for FunctionPlugin:



Public Member Functions

- FunctionPlugin (int bv_size, std::string path, std::string name)

  Constructor.
- ∼FunctionPlugin ()

  Destructor.
- int get_bv_size () const

  Get bit vector size.
- double evaluate (const bit_vector_t &)

  Evaluate a bit vector.

Private Types

- using extern_function_t = double(∗)(const bit_t ∗, size_t)

  Type of an extern function.

Private Attributes

- int _bv_size

  Bit vector size.
- void ∗ _handle

  Handle returned by dlopen.
- extern_function_t _extern_function

  Extern function.

5.35.1 Detailed Description

Function plugin

Definition at line 34 of file plugin.hh.

5.35.2 Constructor & Destructor Documentation

5.35.2.1 FunctionPlugin()

```
FunctionPlugin (
        int bv_size,
        std::string path,
        std::string name )
```

Constructor.

Parameters

bv_size	Size of bit vectors
path	Path to a shared library
name	Name of a function of the shared library

Definition at line 35 of file plugin.cc.

The documentation for this class was generated from the following files:

- lib/hnco/functions/collection/plugin.hh
- lib/hnco/functions/collection/plugin.cc

5.36 Generator Struct Reference

Random number generator.

```
#include <hnco/random.hh>
```

Static Public Member Functions

- static void set_seed (unsigned n)
  Set seed.
- static void set_seed ()
  Set seed.
- static void reset ()
  Reset engine.
- static double uniform ()
  Sample random number with uniform distribution.
- static double normal ()
  Sample random number with normal distribution.
- static bool bernoulli ()
  Sample random number with Bernoulli distribution.

Static Public Attributes

- static std::mt19937 engine
  Mersenne Twister engine.
- static unsigned seed = std::mt19937::default_seed
  Seed.

5.36.1 Detailed Description

Random number generator.

Definition at line 34 of file random.hh.

5.36.2 Member Function Documentation

5.36.2.1 reset()

```
void reset ( )  [static]
```

Reset engine.

Using static member seed.

Definition at line 45 of file random.cc.

5.36.2.2 set_seed()

```
void set_seed ( ) [static]
```

Set seed.

Uses std::chrono::system_clock.

Definition at line 39 of file random.cc.

The documentation for this struct was generated from the following files:

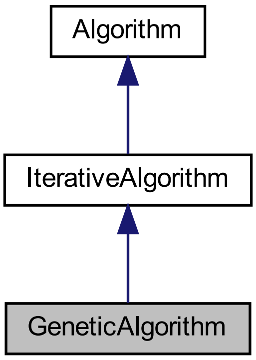
- lib/hnco/random.hh
- lib/hnco/random.cc

5.37 GeneticAlgorithm Class Reference

Genetic algorithm.

```
#include <hnco/algorithms/ea/genetic-algorithm.hh>
```

Inheritance diagram for GeneticAlgorithm:



Public Member Functions

- GeneticAlgorithm (int n, int mu)
  Constructor.

Setters

- void set_mutation_rate (double p)
  Set the mutation rate.
- void set_crossover_probability (double x)
  Set the crossover probability.
- void set_tournament_size (int x)
  Set the tournament size.
- void set_allow_no_mutation (bool b)
  Set the flag _allow_no_mutation.

Protected Member Functions

Loop

- void init () override
  Initialize.
- void iterate () override
  Single iteration.

Protected Attributes

- TournamentSelection _parents
  Parents.
- TournamentSelection _offsprings
  Offsprings.
- neighborhood::StandardBitMutation _mutation
  Mutation operator.
- std::bernoulli_distribution _do_crossover
  Do crossover.
- UniformCrossover _crossover
  Uniform crossover.

Parameters

- double _mutation_rate
  Mutation rate.
- double _crossover_probability = 0.5
  Crossover probability.
- int _tournament_size = 10
  Tournament size.
- bool _allow_no_mutation = false
  Allow no mutation.

5.37.1 Detailed Description

Genetic algorithm.

- Tournament selection for reproduction
- Uniform crossover
- Standard bit mutation
- (mu, mu) selection (offspring population replaces parent population)

Reference:

J. H. Holland. 1975. Adaptation in natural and artificial systems. University of Michigan Press, Ann Arbor.

Definition at line 51 of file genetic-algorithm.hh.

5.37.2 Constructor & Destructor Documentation

5.37.2.1 GeneticAlgorithm()

```
GeneticAlgorithm (
            int n,
            int mu )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors
mu	Population size

Definition at line 108 of file genetic-algorithm.hh.

The documentation for this class was generated from the following files:

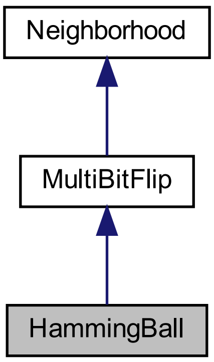
- lib/hnco/algorithms/ea/genetic-algorithm.hh
- lib/hnco/algorithms/ea/genetic-algorithm.cc

5.38 HammingBall Class Reference

Hamming ball.

`#include <hnco/neighborhoods/neighborhood.hh>`

Inheritance diagram for HammingBall:



Public Member Functions

- HammingBall (int n, int r)
  Constructor.

Private Member Functions

- void sample_bits ()
  Sample bits.

Private Attributes

- std::uniform_int_distribution< int > _choose_k

  Choose the distance to the center.

Additional Inherited Members

5.38.1 Detailed Description

Hamming ball.

Choose k uniformly on [1..r], where r is the radius of the ball, choose k bits uniformly among n and flip them.

Definition at line 302 of file neighborhood.hh.

5.38.2 Constructor & Destructor Documentation

5.38.2.1 HammingBall()

```
HammingBall (
            int n,
            int r )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors
r	Radius of the ball

Definition at line 318 of file neighborhood.hh.

The documentation for this class was generated from the following files:

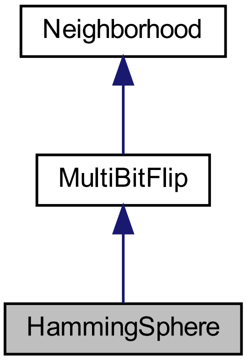
- lib/hnco/neighborhoods/neighborhood.hh
- lib/hnco/neighborhoods/neighborhood.cc

5.39 HammingSphere Class Reference

Hamming sphere.

```
#include <hnco/neighborhoods/neighborhood.hh>
```

Inheritance diagram for HammingSphere:



Public Member Functions

- HammingSphere (int n, int r)

    Constructor.
- void set_radius (int r)

    Set radius.

Private Member Functions

- void sample_bits ()

    Sample bits.

Private Attributes

- int _radius

    Radius of the sphere.

Additional Inherited Members

5.39.1 Detailed Description

Hamming sphere.

Uniformly choose r bits among n and flip them, where r is the radius of the sphere.

Definition at line 334 of file neighborhood.hh.

5.39.2 Constructor & Destructor Documentation

5.39.2.1 HammingSphere()

```
HammingSphere (
            int n,
            int r )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors
r	Radius of the sphere

Definition at line 350 of file neighborhood.hh.

The documentation for this class was generated from the following files:

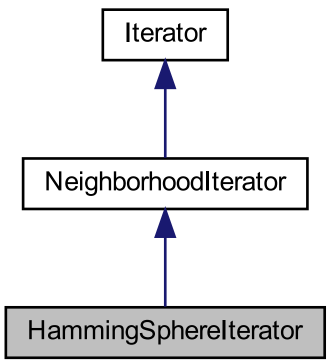
- lib/hnco/neighborhoods/neighborhood.hh
- lib/hnco/neighborhoods/neighborhood.cc

5.40 HammingSphereIterator Class Reference

Hamming sphere neighborhood iterator.

`#include <hnco/neighborhoods/neighborhood-iterator.hh>`

Inheritance diagram for HammingSphereIterator:



Public Member Functions

- HammingSphereIterator (int n, int r)

    Constructor.
- bool has_next () override

    Has next bit vector.
- const bit_vector_t & next () override

    Next bit vector.

Private Attributes

- int _radius

    Radius of the ball.
- sparse_bit_vector_t _bit_indexes

    Bit indexes.

Additional Inherited Members

5.40.1 Detailed Description

Hamming sphere neighborhood iterator.

The Hamming sphere iterator is implemented using an array of indexes which indicate the bits to flip in the given origin.

For example, in dimension n = 4 and with radius = 2, the sequence of indexes is as follows (assuming indexes start at 1):

- 12 (first state, bits 1 and 2 are flipped)
- 13
- 14
- 23 (last index cannot be increased, first index is increased and second index is reset)
- 24
- 34

Reference: `https://en.wikipedia.org/wiki/Combination#Enumerating_k-combinations`

Definition at line 96 of file neighborhood-iterator.hh.

5.40.2 Constructor & Destructor Documentation

5.40.2.1 HammingSphereIterator()

```
HammingSphereIterator (
            int n,
            int r )
```

Constructor.

Parameters

n	Size of bit vectors
r	Radius of Hamming Ball

Definition at line 72 of file neighborhood-iterator.cc.

The documentation for this class was generated from the following files:

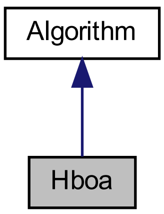
- lib/hnco/neighborhoods/neighborhood-iterator.hh
- lib/hnco/neighborhoods/neighborhood-iterator.cc

5.41 Hboa Class Reference

Hierarchical Bayesian Optimization Algorithm.

`#include <hnco/algorithms/fast-efficient-p3/hboa.hh>`

Inheritance diagram for Hboa:



Public Member Functions

- Hboa (int n)

    Constructor.
- ∼Hboa ()

    Destructor.
- void maximize (const std::vector< function::Function * > &functions)

    Maximize.
- void finalize ()

    Finalize.
- void set_population_size (int n)

    Set population size.

Private Attributes

- Implementation ∗ _pimpl

    Pointer to implementation.
- int _population_size = 10

    Population size.

Additional Inherited Members

5.41.1 Detailed Description

Hierarchical Bayesian Optimization Algorithm.

Implementation of the Hierarchical Bayesian Optimization Algorithm and helper classes based on the publication: Pelikan, M. and Goldberg, D. (2006). Hierarchical bayesian optimization algorithm. In Scalable Optimization via Probabilistic Modeling, volume 33 of Studies in Computational Intelligence, pages 63–90. Springer Berlin Heidelberg.

Author: Brian W. Goldman

Integrated into HNCO by Arnaud Berny

Definition at line 48 of file hboa.hh.

5.41.2 Member Data Documentation

5.41.2.1 _pimpl

`Implementation* _pimpl [private]`

Pointer to implementation.

The main motivation for this pattern is to avoid including declarations from fast_efficient_p3 into the global namespace.

A raw pointer is used instead of a unique_ptr because the latter will not compile with pybind11.

Definition at line 59 of file hboa.hh.

The documentation for this class was generated from the following files:

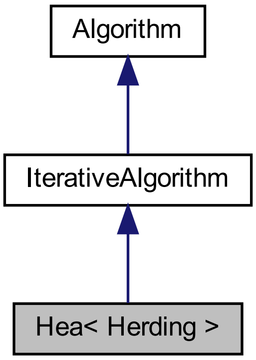
- lib/hnco/algorithms/fast-efficient-p3/hboa.hh
- lib/hnco/algorithms/fast-efficient-p3/hboa.cc

5.42 Hea< Herding > Class Template Reference

Herding evolutionary algorithm.

`#include <hnco/algorithms/walsh-moment/hea.hh>`

Inheritance diagram for Hea< Herding >:



Public Member Functions

- Hea (int n, int population_size)

  Constructor.

Setters

- void set_margin (double x)

  Set the moment margin.
- void set_selection_size (int x)

  Set the selection size.
- void set_reset_period (int x)

  Set the reset period.
- void set_learning_rate (double x)

  Set the learning rate.
- void set_bound_moment (bool x)

  Set the bound moment after update.
- void set_randomize_bit_order (bool b)

  Randomize bit order.

Setters for logging

- void set_log_herding_error (bool b)

  Log herding error (moment discrepancy)
- void set_log_target_norm (bool b)

  Log target 2-norm (distance to uniform moment)
- void set_log_delta_norm (bool b)

  Log delta (moment increment) 2-norm.
- void set_log_target (bool b)

  Log target moment as a symmetric matrix.

Private Member Functions

Loop

- void init () override
  Initialization.
- void iterate () override
  Single iteration.
- void set_something_to_log ()
  Set flag for something to log.
- void log () override
  Log.

Private Attributes

- Herding::Moment _target
  Target moment.
- Herding::Moment _selection
  Moment of selected individuals.
- algorithm::Population _population
  Population
- Herding _herding
  Herding.
- double _herding_error
  Herding error (moment discrepancy)
- double _target_norm
  Target 2-norm (distance to uniform moment)
- double _delta_norm
  Delta (moment increment) 2-norm.

Parameters

- double _margin
  Moment margin.
- int _selection_size = 1
  Selection size.
- int _reset_period = 0
  Reset period.
- double _learning_rate = 1e-4
  Learning rate.
- bool _bound_moment = false
  Bound moment after update.

Logging

- bool _log_herding_error = false
  Log herding error (moment discrepancy)
- bool _log_target_norm = false
  Log target 2-norm (distance to uniform moment)
- bool _log_delta_norm = false
  Log delta 2-norm (moment increment)
- bool _log_target = false
  Log target moment as a symmetric matrix.

Additional Inherited Members

5.42.1 Detailed Description

template<class Herding>
class hnco::algorithm::walsh_moment::Hea< Herding >

Herding evolutionary algorithm.

Reference:

Arnaud Berny. 2015. Herding Evolutionary Algorithm. In Proceedings of the Companion Publication of the 2015 Annual Conference on Genetic and Evolutionary Computation (GECCO Companion '15). ACM, New York, NY, USA, 1355–1356.

Definition at line 47 of file hea.hh.

5.42.2 Constructor & Destructor Documentation

5.42.2.1 Hea()

```
Hea (
            int n,
            int population_size ) [inline]
```

Constructor.

Parameters

n	Size of bit vectors
population_size	Population size

_margin is initialized to 1 / n.

Definition at line 200 of file hea.hh.

5.42.3 Member Function Documentation

5.42.3.1 set_reset_period()

```
void set_reset_period (
            int x ) [inline]
```

Set the reset period.

Parameters

x	Reset period

x <= 0 means no reset.

Definition at line 229 of file hea.hh.

5.42.3.2 set_selection_size()

```
void set_selection_size (
            int x ) [inline]
```

Set the selection size.

The selection size is the number of selected individuals in the population.

Definition at line 221 of file hea.hh.

The documentation for this class was generated from the following file:

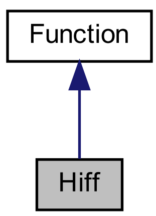
- lib/hnco/algorithms/walsh-moment/hea.hh

5.43 Hiff Class Reference

Hierarchical if and only if.

```
#include <hnco/functions/collection/theory.hh>
```

Inheritance diagram for Hiff:



Public Member Functions

- Hiff (int bv_size)

  Constructor.
- int get_bv_size () const override

  Get bit vector size.
- double evaluate (const bit_vector_t &) override

  Evaluate a bit vector.
- bool has_known_maximum () const override

  Check for a known maximum.
- double get_maximum () const override

  Get the global maximum.

Private Attributes

- int _bv_size

  Bit vector size.
- int _depth

  Tree depth.

5.43.1 Detailed Description

Hierarchical if and only if.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 170 of file theory.hh.

5.43.2 Member Function Documentation

5.43.2.1 get_maximum()

```
double get_maximum ( ) const  [inline], [override], [virtual]
```

Get the global maximum.

Returns

(i + 1) ∗ 2^i where 2^i = _bv_size

Reimplemented from Function.

Definition at line 195 of file theory.hh.

5.43.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const  [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 191 of file theory.hh.

The documentation for this class was generated from the following files:

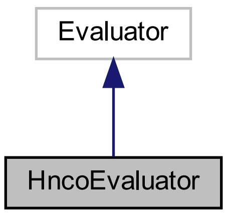
- lib/hnco/functions/collection/theory.hh
- lib/hnco/functions/collection/theory.cc

5.44 HncoEvaluator Class Reference

Evaluator for HNCO functions.

```
#include <hnco/algorithms/fast-efficient-p3/hnco-evaluator.hh>
```

Inheritance diagram for HncoEvaluator:



Public Member Functions

- HncoEvaluator (hnco::function::Function *function)

  Constructor.
- float evaluate (const std::vector< bool > &x)

  Evaluate a bit vector.

Private Attributes

- hnco::function::Function ∗ _function

    HNCO function.
- hnco::bit_vector_t _bv

    Argument of HNCO function.

5.44.1 Detailed Description

Evaluator for HNCO functions.

Definition at line 36 of file hnco-evaluator.hh.

The documentation for this class was generated from the following file:

- lib/hnco/algorithms/fast-efficient-p3/hnco-evaluator.hh

5.45 HncoOptions Class Reference

Command line options for hnco.

`#include <hnco/app/hnco-options.hh>`

Public Member Functions

- HncoOptions (int argc, char ∗argv[ ])

    Constructor.
- int get_algorithm () const

    Get algorithm.
- void set_algorithm (int x)

    Set algorithm.
- bool set_algorithm () const

    Get set-flag for algorithm.
- int get_bm_mc_reset_strategy () const

    Get bm_mc_reset_strategy.
- void set_bm_mc_reset_strategy (int x)

    Set bm_mc_reset_strategy.
- bool set_bm_mc_reset_strategy () const

    Get set-flag for bm_mc_reset_strategy.
- int get_bm_num_gs_cycles () const

    Get bm_num_gs_cycles.
- void set_bm_num_gs_cycles (int x)

    Set bm_num_gs_cycles.
- bool set_bm_num_gs_cycles () const

    Get set-flag for bm_num_gs_cycles.
- int get_bm_num_gs_steps () const

    Get bm_num_gs_steps.
- void set_bm_num_gs_steps (int x)

Set bm_num_gs_steps.
- bool set_bm_num_gs_steps () const

  Get set-flag for bm_num_gs_steps.
- int get_bm_sampling () const

  Get bm_sampling.
- void set_bm_sampling (int x)

  Set bm_sampling.
- bool set_bm_sampling () const

  Get set-flag for bm_sampling.
- int get_budget () const

  Get budget.
- void set_budget (int x)

  Set budget.
- bool set_budget () const

  Get set-flag for budget.
- int get_bv_size () const

  Get bv_size.
- void set_bv_size (int x)

  Set bv_size.
- bool set_bv_size () const

  Get set-flag for bv_size.
- std::string get_description_path () const

  Get description_path.
- void set_description_path (std::string x)

  Set description_path.
- bool set_description_path () const

  Get set-flag for description_path.
- int get_ea_lambda () const

  Get ea_lambda.
- void set_ea_lambda (int x)

  Set ea_lambda.
- bool set_ea_lambda () const

  Get set-flag for ea_lambda.
- int get_ea_mu () const

  Get ea_mu.
- void set_ea_mu (int x)

  Set ea_mu.
- bool set_ea_mu () const

  Get set-flag for ea_mu.
- std::string get_expression () const

  Get expression.
- void set_expression (std::string x)

  Set expression.
- bool set_expression () const

  Get set-flag for expression.
- std::string get_fn_name () const

  Get fn_name.
- void set_fn_name (std::string x)

  Set fn_name.
- bool set_fn_name () const

  Get set-flag for fn_name.

- int get_fn_num_traps () const
  Get fn_num_traps.
- void set_fn_num_traps (int x)
  Set fn_num_traps.
- bool set_fn_num_traps () const
  Get set-flag for fn_num_traps.
- int get_fn_prefix_length () const
  Get fn_prefix_length.
- void set_fn_prefix_length (int x)
  Set fn_prefix_length.
- bool set_fn_prefix_length () const
  Get set-flag for fn_prefix_length.
- int get_fn_threshold () const
  Get fn_threshold.
- void set_fn_threshold (int x)
  Set fn_threshold.
- bool set_fn_threshold () const
  Get set-flag for fn_threshold.
- std::string get_fp_expression () const
  Get fp_expression.
- void set_fp_expression (std::string x)
  Set fp_expression.
- bool set_fp_expression () const
  Get set-flag for fp_expression.
- double get_fp_lower_bound () const
  Get fp_lower_bound.
- void set_fp_lower_bound (double x)
  Set fp_lower_bound.
- bool set_fp_lower_bound () const
  Get set-flag for fp_lower_bound.
- int get_fp_num_bits () const
  Get fp_num_bits.
- void set_fp_num_bits (int x)
  Set fp_num_bits.
- bool set_fp_num_bits () const
  Get set-flag for fp_num_bits.
- double get_fp_precision () const
  Get fp_precision.
- void set_fp_precision (double x)
  Set fp_precision.
- bool set_fp_precision () const
  Get set-flag for fp_precision.
- double get_fp_upper_bound () const
  Get fp_upper_bound.
- void set_fp_upper_bound (double x)
  Set fp_upper_bound.
- bool set_fp_upper_bound () const
  Get set-flag for fp_upper_bound.
- int get_function () const
  Get function.
- void set_function (int x)

Set function.
- bool set_function () const

  Get set-flag for function.
- double get_ga_crossover_bias () const

  Get ga_crossover_bias.
- void set_ga_crossover_bias (double x)

  Set ga_crossover_bias.
- bool set_ga_crossover_bias () const

  Get set-flag for ga_crossover_bias.
- double get_ga_crossover_probability () const

  Get ga_crossover_probability.
- void set_ga_crossover_probability (double x)

  Set ga_crossover_probability.
- bool set_ga_crossover_probability () const

  Get set-flag for ga_crossover_probability.
- int get_ga_tournament_size () const

  Get ga_tournament_size.
- void set_ga_tournament_size (int x)

  Set ga_tournament_size.
- bool set_ga_tournament_size () const

  Get set-flag for ga_tournament_size.
- int get_hea_reset_period () const

  Get hea_reset_period.
- void set_hea_reset_period (int x)

  Set hea_reset_period.
- bool set_hea_reset_period () const

  Get set-flag for hea_reset_period.
- double get_learning_rate () const

  Get learning_rate.
- void set_learning_rate (double x)

  Set learning_rate.
- bool set_learning_rate () const

  Get set-flag for learning_rate.
- int get_map () const

  Get map.
- void set_map (int x)

  Set map.
- bool set_map () const

  Get set-flag for map.
- int get_map_input_size () const

  Get map_input_size.
- void set_map_input_size (int x)

  Set map_input_size.
- bool set_map_input_size () const

  Get set-flag for map_input_size.
- std::string get_map_path () const

  Get map_path.
- void set_map_path (std::string x)

  Set map_path.
- bool set_map_path () const

  Get set-flag for map_path.

- int get_map_ts_length () const
  Get map_ts_length.
- void set_map_ts_length (int x)
  Set map_ts_length.
- bool set_map_ts_length () const
  Get set-flag for map_ts_length.
- int get_map_ts_sampling_mode () const
  Get map_ts_sampling_mode.
- void set_map_ts_sampling_mode (int x)
  Set map_ts_sampling_mode.
- bool set_map_ts_sampling_mode () const
  Get set-flag for map_ts_sampling_mode.
- double get_mutation_rate () const
  Get mutation_rate.
- void set_mutation_rate (double x)
  Set mutation_rate.
- bool set_mutation_rate () const
  Get set-flag for mutation_rate.
- int get_neighborhood () const
  Get neighborhood.
- void set_neighborhood (int x)
  Set neighborhood.
- bool set_neighborhood () const
  Get set-flag for neighborhood.
- int get_neighborhood_iterator () const
  Get neighborhood_iterator.
- void set_neighborhood_iterator (int x)
  Set neighborhood_iterator.
- bool set_neighborhood_iterator () const
  Get set-flag for neighborhood_iterator.
- double get_noise_stddev () const
  Get noise_stddev.
- void set_noise_stddev (double x)
  Set noise_stddev.
- bool set_noise_stddev () const
  Get set-flag for noise_stddev.
- int get_num_iterations () const
  Get num_iterations.
- void set_num_iterations (int x)
  Set num_iterations.
- bool set_num_iterations () const
  Get set-flag for num_iterations.
- int get_num_threads () const
  Get num_threads.
- void set_num_threads (int x)
  Set num_threads.
- bool set_num_threads () const
  Get set-flag for num_threads.
- std::string get_path () const
  Get path.
- void set_path (std::string x)

Set path.
- bool set_path () const

  Get set-flag for path.
- double get_pn_mutation_rate () const

  Get pn_mutation_rate.
- void set_pn_mutation_rate (double x)

  Set pn_mutation_rate.
- bool set_pn_mutation_rate () const

  Get set-flag for pn_mutation_rate.
- int get_pn_neighborhood () const

  Get pn_neighborhood.
- void set_pn_neighborhood (int x)

  Set pn_neighborhood.
- bool set_pn_neighborhood () const

  Get set-flag for pn_neighborhood.
- int get_pn_radius () const

  Get pn_radius.
- void set_pn_radius (int x)

  Set pn_radius.
- bool set_pn_radius () const

  Get set-flag for pn_radius.
- int get_population_size () const

  Get population_size.
- void set_population_size (int x)

  Set population_size.
- bool set_population_size () const

  Get set-flag for population_size.
- int get_pv_log_num_components () const

  Get pv_log_num_components.
- void set_pv_log_num_components (int x)

  Set pv_log_num_components.
- bool set_pv_log_num_components () const

  Get set-flag for pv_log_num_components.
- int get_radius () const

  Get radius.
- void set_radius (int x)

  Set radius.
- bool set_radius () const

  Get set-flag for radius.
- int get_rep_categorical_representation () const

  Get rep_categorical_representation.
- void set_rep_categorical_representation (int x)

  Set rep_categorical_representation.
- bool set_rep_categorical_representation () const

  Get set-flag for rep_categorical_representation.
- int get_rep_num_additional_bits () const

  Get rep_num_additional_bits.
- void set_rep_num_additional_bits (int x)

  Set rep_num_additional_bits.
- bool set_rep_num_additional_bits () const

  Get set-flag for rep_num_additional_bits.

- std::string get_results_path () const
  Get results_path.
- void set_results_path (std::string x)
  Set results_path.
- bool set_results_path () const
  Get set-flag for results_path.
- int get_rls_patience () const
  Get rls_patience.
- void set_rls_patience (int x)
  Set rls_patience.
- bool set_rls_patience () const
  Get set-flag for rls_patience.
- double get_sa_beta_ratio () const
  Get sa_beta_ratio.
- void set_sa_beta_ratio (double x)
  Set sa_beta_ratio.
- bool set_sa_beta_ratio () const
  Get set-flag for sa_beta_ratio.
- double get_sa_initial_acceptance_probability () const
  Get sa_initial_acceptance_probability.
- void set_sa_initial_acceptance_probability (double x)
  Set sa_initial_acceptance_probability.
- bool set_sa_initial_acceptance_probability () const
  Get set-flag for sa_initial_acceptance_probability.
- int get_sa_num_transitions () const
  Get sa_num_transitions.
- void set_sa_num_transitions (int x)
  Set sa_num_transitions.
- bool set_sa_num_transitions () const
  Get set-flag for sa_num_transitions.
- int get_sa_num_trials () const
  Get sa_num_trials.
- void set_sa_num_trials (int x)
  Set sa_num_trials.
- bool set_sa_num_trials () const
  Get set-flag for sa_num_trials.
- unsigned get_seed () const
  Get seed.
- void set_seed (unsigned x)
  Set seed.
- bool set_seed () const
  Get set-flag for seed.
- int get_selection_size () const
  Get selection_size.
- void set_selection_size (int x)
  Set selection_size.
- bool set_selection_size () const
  Get set-flag for selection_size.
- std::string get_solution_path () const
  Get solution_path.
- void set_solution_path (std::string x)

Set solution_path.
- bool set_solution_path () const

  Get set-flag for solution_path.
- double get_target () const

  Get target.
- void set_target (double x)

  Set target.
- bool set_target () const

  Get set-flag for target.
- bool with_additive_gaussian_noise () const

  Get additive_gaussian_noise.
- void set_additive_gaussian_noise ()

  Set additive_gaussian_noise.
- bool with_allow_no_mutation () const

  Get allow_no_mutation.
- void set_allow_no_mutation ()

  Set allow_no_mutation.
- bool with_bm_log_norm_1 () const

  Get bm_log_norm_1.
- void set_bm_log_norm_1 ()

  Set bm_log_norm_1.
- bool with_bm_log_norm_infinite () const

  Get bm_log_norm_infinite.
- void set_bm_log_norm_infinite ()

  Set bm_log_norm_infinite.
- bool with_bm_negative_positive_selection () const

  Get bm_negative_positive_selection.
- void set_bm_negative_positive_selection ()

  Set bm_negative_positive_selection.
- bool with_cache () const

  Get cache.
- void set_cache ()

  Set cache.
- bool with_cache_budget () const

  Get cache_budget.
- void set_cache_budget ()

  Set cache_budget.
- bool with_concrete_solution () const

  Get concrete_solution.
- void set_concrete_solution ()

  Set concrete_solution.
- bool with_fn_display () const

  Get fn_display.
- void set_fn_display ()

  Set fn_display.
- bool with_fn_get_bv_size () const

  Get fn_get_bv_size.
- void set_fn_get_bv_size ()

  Set fn_get_bv_size.
- bool with_fn_get_maximum () const

  Get fn_get_maximum.

- void set_fn_get_maximum ()
  Set fn_get_maximum.
- bool with_fn_has_known_maximum () const
  Get fn_has_known_maximum.
- void set_fn_has_known_maximum ()
  Set fn_has_known_maximum.
- bool with_fn_provides_incremental_evaluation () const
  Get fn_provides_incremental_evaluation.
- void set_fn_provides_incremental_evaluation ()
  Set fn_provides_incremental_evaluation.
- bool with_fn_walsh_transform () const
  Get fn_walsh_transform.
- void set_fn_walsh_transform ()
  Set fn_walsh_transform.
- bool with_hea_bound_moment () const
  Get hea_bound_moment.
- void set_hea_bound_moment ()
  Set hea_bound_moment.
- bool with_hea_log_delta_norm () const
  Get hea_log_delta_norm.
- void set_hea_log_delta_norm ()
  Set hea_log_delta_norm.
- bool with_hea_log_herding_error () const
  Get hea_log_herding_error.
- void set_hea_log_herding_error ()
  Set hea_log_herding_error.
- bool with_hea_log_target () const
  Get hea_log_target.
- void set_hea_log_target ()
  Set hea_log_target.
- bool with_hea_log_target_norm () const
  Get hea_log_target_norm.
- void set_hea_log_target_norm ()
  Set hea_log_target_norm.
- bool with_hea_randomize_bit_order () const
  Get hea_randomize_bit_order.
- void set_hea_randomize_bit_order ()
  Set hea_randomize_bit_order.
- bool with_incremental_evaluation () const
  Get incremental_evaluation.
- void set_incremental_evaluation ()
  Set incremental_evaluation.
- bool with_load_solution () const
  Get load_solution.
- void set_load_solution ()
  Set load_solution.
- bool with_log_improvement () const
  Get log_improvement.
- void set_log_improvement ()
  Set log_improvement.
- bool with_map_display () const

Get map_display.
- void set_map_display ()

  Set map_display.
- bool with_map_random () const

  Get map_random.
- void set_map_random ()

  Set map_random.
- bool with_map_surjective () const

  Get map_surjective.
- void set_map_surjective ()

  Set map_surjective.
- bool with_mmas_strict () const

  Get mmas_strict.
- void set_mmas_strict ()

  Set mmas_strict.
- bool with_negation () const

  Get negation.
- void set_negation ()

  Set negation.
- bool with_parsed_modifier () const

  Get parsed_modifier.
- void set_parsed_modifier ()

  Set parsed_modifier.
- bool with_pn_allow_no_mutation () const

  Get pn_allow_no_mutation.
- void set_pn_allow_no_mutation ()

  Set pn_allow_no_mutation.
- bool with_print_defaults () const

  Get print_defaults.
- void set_print_defaults ()

  Set print_defaults.
- bool with_print_description () const

  Get print_description.
- void set_print_description ()

  Set print_description.
- bool with_print_header () const

  Get print_header.
- void set_print_header ()

  Set print_header.
- bool with_print_results () const

  Get print_results.
- void set_print_results ()

  Set print_results.
- bool with_print_solution () const

  Get print_solution.
- void set_print_solution ()

  Set print_solution.
- bool with_prior_noise () const

  Get prior_noise.
- void set_prior_noise ()

  Set prior_noise.

- bool with_pv_log_entropy () const

  Get pv_log_entropy.
- void set_pv_log_entropy ()

  Set pv_log_entropy.
- bool with_pv_log_pv () const

  Get pv_log_pv.
- void set_pv_log_pv ()

  Set pv_log_pv.
- bool with_record_evaluation_time () const

  Get record_evaluation_time.
- void set_record_evaluation_time ()

  Set record_evaluation_time.
- bool with_restart () const

  Get restart.
- void set_restart ()

  Set restart.
- bool with_rls_strict () const

  Get rls_strict.
- void set_rls_strict ()

  Set rls_strict.
- bool with_rw_log_value () const

  Get rw_log_value.
- void set_rw_log_value ()

  Set rw_log_value.
- bool with_save_description () const

  Get save_description.
- void set_save_description ()

  Set save_description.
- bool with_save_results () const

  Get save_results.
- void set_save_results ()

  Set save_results.
- bool with_save_solution () const

  Get save_solution.
- void set_save_solution ()

  Set save_solution.
- bool with_stop_on_maximum () const

  Get stop_on_maximum.
- void set_stop_on_maximum ()

  Set stop_on_maximum.
- bool with_stop_on_target () const

  Get stop_on_target.
- void set_stop_on_target ()

  Set stop_on_target.

Private Member Functions

- void print_help (std::ostream &stream) const
  Print help message.
- void print_help_fp (std::ostream &stream) const
  Print help message for section fp.
- void print_help_rep (std::ostream &stream) const
  Print help message for section rep.
- void print_help_pn (std::ostream &stream) const
  Print help message for section pn.
- void print_help_map (std::ostream &stream) const
  Print help message for section map.
- void print_help_ls (std::ostream &stream) const
  Print help message for section ls.
- void print_help_sa (std::ostream &stream) const
  Print help message for section sa.
- void print_help_ea (std::ostream &stream) const
  Print help message for section ea.
- void print_help_eda (std::ostream &stream) const
  Print help message for section eda.
- void print_help_hea (std::ostream &stream) const
  Print help message for section hea.
- void print_help_bm (std::ostream &stream) const
  Print help message for section bm.
- void print_version (std::ostream &stream) const
  Print version.

Private Attributes

- std::string _exec_name
  Name of the executable.
- std::string _version
  Name Version.
- int _algorithm
  Type of algorithm.
- bool **_opt_algorithm**
- int _bm_mc_reset_strategy
  Markov chain reset strategy.
- bool **_opt_bm_mc_reset_strategy**
- int _bm_num_gs_cycles
  Number of Gibbs sampler cycles per bit vector.
- bool **_opt_bm_num_gs_cycles**
- int _bm_num_gs_steps
  Number of Gibbs sampler steps per bit vector.
- bool **_opt_bm_num_gs_steps**
- int _bm_sampling
  Sampling mode for the Boltzmann machine.
- bool **_opt_bm_sampling**
- int _budget
  Number of allowed function evaluations (<= 0 means indefinite)
- bool **_opt_budget**

- int _bv_size

  Size of bit vectors.
- bool **_opt_bv_size**
- std::string _description_path

  Path of the description file.
- bool **_opt_description_path**
- int _ea_lambda

  Offspring population size.
- bool **_opt_ea_lambda**
- int _ea_mu

  Parent population size.
- bool **_opt_ea_mu**
- std::string _expression

  Expression of the variable x.
- bool **_opt_expression**
- std::string _fn_name

  Name of the function in the dynamic library.
- bool **_opt_fn_name**
- int _fn_num_traps

  Number of traps.
- bool **_opt_fn_num_traps**
- int _fn_prefix_length

  Prefix length for long path.
- bool **_opt_fn_prefix_length**
- int _fn_threshold

  Threshold (in bits) for Jump, Four Peaks, and Six Peaks.
- bool **_opt_fn_threshold**
- std::string _fp_expression

  Expression to parse.
- bool **_opt_fp_expression**
- double _fp_lower_bound

  Lower bound.
- bool **_opt_fp_lower_bound**
- int _fp_num_bits

  Number of bits in the dyadic representation of a number.
- bool **_opt_fp_num_bits**
- double _fp_precision

  Precision of the dyadic representation of a number.
- bool **_opt_fp_precision**
- double _fp_upper_bound

  Upper bound.
- bool **_opt_fp_upper_bound**
- int _function

  Type of function.
- bool **_opt_function**
- double _ga_crossover_bias

  Crossover bias.
- bool **_opt_ga_crossover_bias**
- double _ga_crossover_probability

  Crossover probability.
- bool **_opt_ga_crossover_probability**
- int _ga_tournament_size

Tournament size.
- bool **_opt_ga_tournament_size**
- int _hea_reset_period

  Reset period (<= 0 means no reset)
- bool **_opt_hea_reset_period**
- double _learning_rate

  Learning rate.
- bool **_opt_learning_rate**
- int _map

  Type of map.
- bool **_opt_map**
- int _map_input_size

  Input size of linear and affine maps.
- bool **_opt_map_input_size**
- std::string _map_path

  Path of a map file.
- bool **_opt_map_path**
- int _map_ts_length

  Transvection sequence length.
- bool **_opt_map_ts_length**
- int _map_ts_sampling_mode

  Transvection sequence sampling mode.
- bool **_opt_map_ts_sampling_mode**
- double _mutation_rate

  Mutation rate relative to bv_size.
- bool **_opt_mutation_rate**
- int _neighborhood

  Type of neighborhood.
- bool **_opt_neighborhood**
- int _neighborhood_iterator

  Type of neighborhood iterator.
- bool **_opt_neighborhood_iterator**
- double _noise_stddev

  Noise standard deviation.
- bool **_opt_noise_stddev**
- int _num_iterations

  Number of iterations (<= 0 means indefinite)
- bool **_opt_num_iterations**
- int _num_threads

  Number of threads.
- bool **_opt_num_threads**
- std::string _path

  Path of a function file.
- bool **_opt_path**
- double _pn_mutation_rate

  Mutation rate relative to bv_size.
- bool **_opt_pn_mutation_rate**
- int _pn_neighborhood

  Type of neighborhood.
- bool **_opt_pn_neighborhood**
- int _pn_radius

  Radius of Hamming ball or sphere.

- bool **_opt_pn_radius**
- int _population_size

    Population size.
- bool **_opt_population_size**
- int _pv_log_num_components

    Number of probability vector components to log.
- bool **_opt_pv_log_num_components**
- int _radius

    Radius of Hamming ball or sphere.
- bool **_opt_radius**
- int _rep_categorical_representation

    Categorical representation.
- bool **_opt_rep_categorical_representation**
- int _rep_num_additional_bits

    Number of additional bits per element for permutation representation.
- bool **_opt_rep_num_additional_bits**
- std::string _results_path

    Path of the results file.
- bool **_opt_results_path**
- int _rls_patience

    Number of consecutive rejected moves before ending the search (<= 0 means infinite)
- bool **_opt_rls_patience**
- double _sa_beta_ratio

    Ratio for beta or inverse temperature.
- bool **_opt_sa_beta_ratio**
- double _sa_initial_acceptance_probability

    Initial acceptance probability.
- bool **_opt_sa_initial_acceptance_probability**
- int _sa_num_transitions

    Number of accepted transitions before annealing.
- bool **_opt_sa_num_transitions**
- int _sa_num_trials

    Number of trials to estimate initial inverse temperature.
- bool **_opt_sa_num_trials**
- unsigned _seed

    Seed for the random number generator.
- bool **_opt_seed**
- int _selection_size

    Selection size (number of selected individuals)
- bool **_opt_selection_size**
- std::string _solution_path

    Path of the solution file.
- bool **_opt_solution_path**
- double _target

    Target.
- bool **_opt_target**
- bool _additive_gaussian_noise

    Additive Gaussian noise.
- bool _allow_no_mutation

    Allow no mutation with standard bit mutation.
- bool _bm_log_norm_1

    Log 1-norm of the parameters.

- bool _bm_log_norm_infinite

  Log infinite norm of the parameters.
- bool _bm_negative_positive_selection

  Negative and positive selection.
- bool _cache

  Cache function evaluations.
- bool _cache_budget

  Set cache on budget.
- bool _concrete_solution

  At the end, print or save the solution in the domain of the concrete function.
- bool _fn_display

  Display the function and exit.
- bool _fn_get_bv_size

  Print the size of bit vectors.
- bool _fn_get_maximum

  If the maximum is known then print it and exit with status 0 else exit with status 1.
- bool _fn_has_known_maximum

  Does the function have a known maximum?
- bool _fn_provides_incremental_evaluation

  Does the function provide incremental evaluation?
- bool _fn_walsh_transform

  Compute the Walsh transform of the function.
- bool _hea_bound_moment

  Bound moment after update.
- bool _hea_log_delta_norm

  Log delta (moment increment) 2-norm.
- bool _hea_log_herding_error

  Log herding error (moment discrepancy)
- bool _hea_log_target

  Log target moment as a symmetric matrix.
- bool _hea_log_target_norm

  Log target 2-norm (distance to uniform moment)
- bool _hea_randomize_bit_order

  Randomize bit order.
- bool _incremental_evaluation

  Incremental evaluation.
- bool _load_solution

  Load a solution from a file.
- bool _log_improvement

  Log improvement.
- bool _map_display

  Display the map and exit.
- bool _map_random

  Sample a random map.
- bool _map_surjective

  Ensure that the sampled linear or affine map is surjective.
- bool _mmas_strict

  Strict (>) max-min ant system.
- bool _negation

  Negation (hence minimization) of the function.
- bool _parsed_modifier

Parsed modifier.
- bool _pn_allow_no_mutation

  Allow no mutation with standard bit mutation.
- bool _print_defaults

  Print the default parameters and exit.
- bool _print_description

  Print a description of the solution.
- bool _print_header

  At the beginning, print the header.
- bool _print_results

  Print results.
- bool _print_solution

  Print the solution.
- bool _prior_noise

  Prior noise.
- bool _pv_log_entropy

  Log entropy of probability vector.
- bool _pv_log_pv

  Log probability vector.
- bool _record_evaluation_time

  Record evaluation time.
- bool _restart

  Restart any algorithm an indefinite number of times.
- bool _rls_strict

  Strict (>) random local search.
- bool _rw_log_value

  Log bit vector value during random walk.
- bool _save_description

  At the end, save a description of the solution in a file.
- bool _save_results

  At the end, save results in a file.
- bool _save_solution

  At the end, save the solution in a file.
- bool _stop_on_maximum

  Stop on maximum.
- bool _stop_on_target

  Stop on target.

Friends

- std::ostream & operator<< (std::ostream &, const HncoOptions &)

  Print a header containing the parameter values.

5.45.1 Detailed Description

Command line options for hnco.

Definition at line 11 of file hnco-options.hh.

The documentation for this class was generated from the following files:

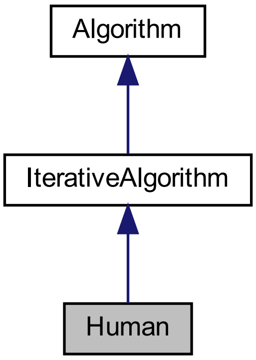
- lib/hnco/app/hnco-options.hh
- lib/hnco/app/hnco-options.cc

5.46 Human Class Reference

Human

`#include <hnco/algorithms/human.hh>`

Inheritance diagram for Human:



Public Member Functions

- Human (int n)
  Constructor.

Protected Member Functions

- void parse_bit_vector ()
  Parse bit vector.

Loop

- void init () override
  Initialize.
- void iterate () override
  Single iteration.

Protected Attributes

- bit_vector_t _candidate
  Candidate.

5.46.1 Detailed Description

Human

Definition at line 32 of file human.hh.

The documentation for this class was generated from the following files:

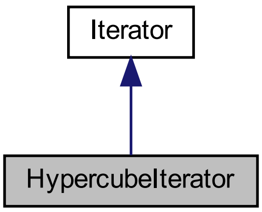
- lib/hnco/algorithms/human.hh
- lib/hnco/algorithms/human.cc

5.47 HypercubeIterator Class Reference

Hypercube iterator.

`#include <hnco/iterator.hh>`

Inheritance diagram for HypercubeIterator:



Public Member Functions

- HypercubeIterator (int n)
  Constructor.
- bool has_next () override
  Has next bit vector.
- const bit_vector_t & next () override
  Next bit vector.

Additional Inherited Members

5.47.1 Detailed Description

Hypercube iterator.

Implemented as a simple binary adder.

Definition at line 69 of file iterator.hh.

The documentation for this class was generated from the following files:

- lib/hnco/iterator.hh
- lib/hnco/iterator.cc

5.48 Implementation Struct Reference

Implementation

`#include <hnco/algorithms/fast-efficient-p3/implementation.hh>`

Public Attributes

- Configuration configuration

  Configuration.
- std::shared_ptr< HncoEvaluator > evaluator

  Evaluator.
- std::shared_ptr< Middle_Layer > middle_layer

  Middle layer.

5.48.1 Detailed Description

Implementation

Definition at line 37 of file implementation.hh.

The documentation for this struct was generated from the following file:

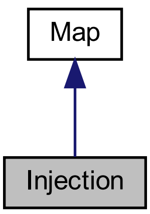
- lib/hnco/algorithms/fast-efficient-p3/implementation.hh

5.49 Injection Class Reference

Injection.

`#include <hnco/maps/map.hh>`

Inheritance diagram for Injection:



Public Member Functions

- Injection (const std::vector< int > &bit_positions, int output_size)
  Constructor.
- void map (const bit_vector_t &input, bit_vector_t &output) override
  Map
- int get_input_size () const override
  Get input size.
- int get_output_size () const override
  Get output size.
- bool is_surjective () const override
  Check for surjective map.

Private Attributes

- std::vector< int > _bit_positions
  Bit positions.
- int _output_size
  Output size.

5.49.1 Detailed Description

Injection.

An injection copies the bits of input x to given positions of output y.

Let $I = \{i_1, i_2, \ldots, i_m\}$ be a subset of $\{1, 2, \ldots, n\}$.

An injection f from F_2^m to F_2^n, where $n \geq m$, is defined by $f(x) = y$, where, for all $j \in \{1, 2, \ldots, m\}$, $y_{i_j} = x_j$.

If f is a projection and g is an injection with the same bit positions then their composition $f \circ g$ is the identity.

Definition at line 493 of file map.hh.

5.49.2 Constructor & Destructor Documentation

5.49.2.1 Injection()

```
Injection (
            const std::vector< int > & bit_positions,
            int output_size )
```

Constructor.

The input size of the map is given by the size of bit_positions.

Parameters

bit_positions	Bit positions in the output to where input bits are copied
output_size	Output size

Precondition

output_size >= bit_positions.size()

Definition at line 176 of file map.cc.

The documentation for this class was generated from the following files:

- lib/hnco/maps/map.hh
- lib/hnco/maps/map.cc

5.50 IntegerCategoricalRepresentation Class Reference

Integer categorical representation.

`#include <hnco/representations/categorical.hh>`

Public Types

- using domain_type = std::size_t

  Domain type.

Public Member Functions

- IntegerCategoricalRepresentation (int num_categories)

  Constructor.
- int size () const

  Size of the representation.
- domain_type unpack (const bit_vector_t &bv, int start)

  Unpack bit vector into a category.
- void display (std::ostream &stream) const

  Display.

Private Attributes

- int _num_categories

  Number of categories.
- int _num_bits

  Number of bits.

5.50.1 Detailed Description

Integer categorical representation.

Definition at line 142 of file categorical.hh.

5.50.2 Constructor & Destructor Documentation

5.50.2.1 IntegerCategoricalRepresentation()

```
IntegerCategoricalRepresentation (
            int num_categories )  [inline]
```

Constructor.

Parameters

num_categories	Number of categories

Definition at line 159 of file categorical.hh.

The documentation for this class was generated from the following file:

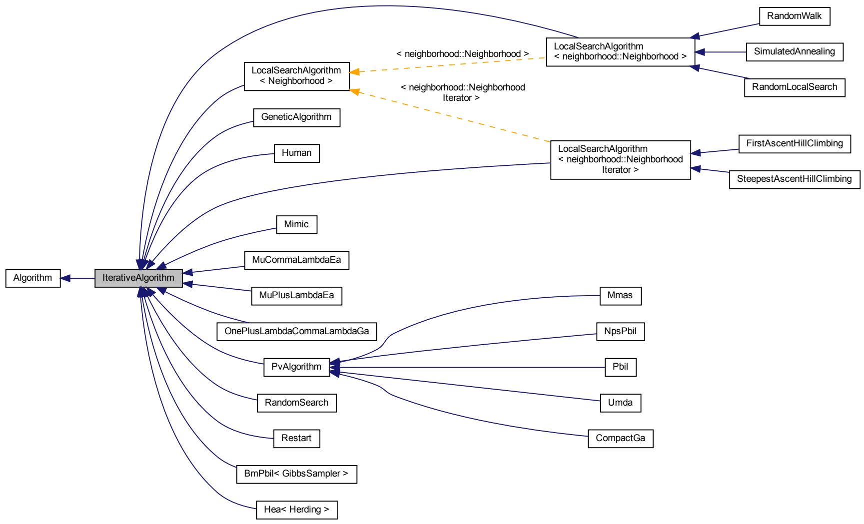
- lib/hnco/representations/categorical.hh

5.51 IterativeAlgorithm Class Reference

Iterative search.

```
#include <hnco/algorithms/iterative-algorithm.hh>
```

Inheritance diagram for IterativeAlgorithm:



Public Member Functions

- IterativeAlgorithm (int n)

  Constructor.

Optimization

- void maximize (const std::vector< function::Function ∗ > &functions) override

  Maximize.

Setters

- void set_num_iterations (int x)

  Set the number of iterations.

Protected Member Functions

Loop

- virtual void init ()

  Initialize.
- virtual void iterate ()=0

  Single iteration.
- virtual void log ()

  Log.
- virtual void loop () final

  Loop.

Protected Attributes

- int _iteration
  Current iteration.
- bool _last_iteration = false
  Last iteration.
- bool _something_to_log = false
  Something to log.

Parameters

- int _num_iterations = 0
  Number of iterations.

5.51.1 Detailed Description

Iterative search.

Definition at line 32 of file iterative-algorithm.hh.

5.51.2 Constructor & Destructor Documentation

5.51.2.1 IterativeAlgorithm()

```
IterativeAlgorithm (
              int n )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors

Definition at line 83 of file iterative-algorithm.hh.

5.51.3 Member Function Documentation

5.51.3.1 loop()

```
void loop ( )  [final], [protected], [virtual]
```

Loop.

Calls init() then enter the main loop which, at each iteration, calls iterate() then log() only if _something_to_log is true.

Definition at line 28 of file iterative-algorithm.cc.

5.51.3.2 maximize()

```
void maximize (
            const std::vector< function::Function * > & functions ) [override], [virtual]
```

Maximize.

Calls set_functions() then loop.

Implements Algorithm.

Definition at line 53 of file iterative-algorithm.cc.

5.51.3.3 set_num_iterations()

```
void set_num_iterations (
            int x ) [inline]
```

Set the number of iterations.

Parameters

x	Number of iterations

Warning

x <= 0 means indefinite

Definition at line 109 of file iterative-algorithm.hh.

The documentation for this class was generated from the following files:

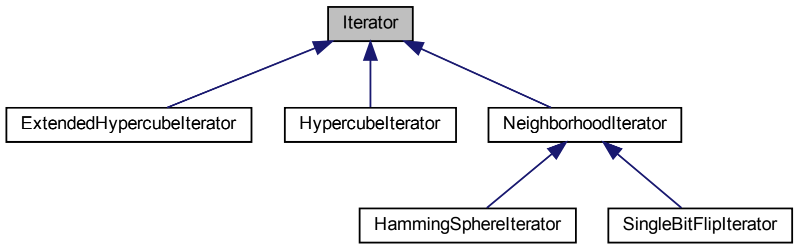
- lib/hnco/algorithms/iterative-algorithm.hh
- lib/hnco/algorithms/iterative-algorithm.cc

5.52 Iterator Class Reference

Iterator over bit vectors

`#include <hnco/iterator.hh>`

Inheritance diagram for Iterator:



Public Member Functions

- Iterator (int n)

  Constructor.
- virtual ∼Iterator ()

  Destructor.
- virtual void init ()

  Initialization.
- virtual bool has_next ()=0

  Has next bit vector.
- virtual const bit_vector_t & next ()=0

  Next bit vector.

Protected Attributes

- bit_vector_t _current

  Current bit vector.
- bool _initial_state = true

  Flag for initial state.

5.52.1 Detailed Description

Iterator over bit vectors

Definition at line 34 of file iterator.hh.

The documentation for this class was generated from the following file:

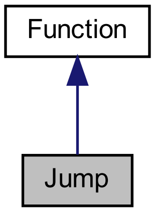
- lib/hnco/iterator.hh

5.53 Jump Class Reference

Jump.

`#include <hnco/functions/collection/jump.hh>`

Inheritance diagram for Jump:



Public Member Functions

- Jump (int bv_size, int gap)

    Constructor.
- int get_bv_size () const override

    Get bit vector size.
- bool has_known_maximum () const override

    Check for a known maximum.
- double get_maximum () const override

    Get the global maximum.
- double evaluate (const bit_vector_t &) override

    Evaluate a bit vector.

Private Attributes

- int _bv_size

    Bit vector size.
- int _gap

    Gap.

5.53.1 Detailed Description

Jump.

Reference:

H. Mühlenbein and T. Mahnig. 2001. Evolutionary Algorithms: From Recombination to Search Distributions. In Theoretical Aspects of Evolutionary Computing, Leila Kallel, Bart Naudts, and Alex Rogers (Eds.). Springer Berlin Heidelberg, 135–174.

Definition at line 41 of file jump.hh.

5.53.2 Member Function Documentation

5.53.2.1 get_maximum()

```
double get_maximum ( ) const  [inline], [override], [virtual]
```

Get the global maximum.

Returns

_bv_size

Reimplemented from Function.

Definition at line 64 of file jump.hh.

5.53.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const  [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 60 of file jump.hh.

The documentation for this class was generated from the following files:

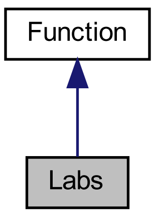
- lib/hnco/functions/collection/jump.hh
- lib/hnco/functions/collection/jump.cc

5.54 Labs Class Reference

Low autocorrelation binary sequences.

```
#include <hnco/functions/collection/labs.hh>
```

Inheritance diagram for Labs:



Public Member Functions

- Labs (int n)

  Constructor.
- void set_merit_factor_flag (bool b)

  Set merit factor flag.
- int get_bv_size () const override

  Get bit vector size.
- double evaluate (const bit_vector_t &) override

  Evaluate a bit vector.

Protected Member Functions

- double compute_autocorrelation (const bit_vector_t &)

  Compute autocorrelation.

Protected Attributes

- std::vector$<$ int $>$ _sequence

  Binary sequence written using 1 and -1.
- bool _merit_factor_flag = false

  Merit factor flag.

5.54.1 Detailed Description

Low autocorrelation binary sequences.

Reference:

S Mertens. 1996. Exhaustive search for low-autocorrelation binary sequences. Journal of Physics A: Mathematical and General 29, 18 (1996), L473.

http://stacks.iop.org/0305-4470/29/i=18/a=005

If _merit_factor_flag is true then the function returns n / (2 $*$ autocorrelation) else it returns -autocorrelation.

Definition at line 44 of file labs.hh.

The documentation for this class was generated from the following files:

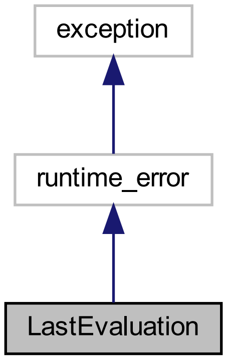
- lib/hnco/functions/collection/labs.hh
- lib/hnco/functions/collection/labs.cc

5.55 LastEvaluation Class Reference

Last evaluation.

`#include <hnco/exception.hh>`

Inheritance diagram for LastEvaluation:



5.55.1 Detailed Description

Last evaluation.

Definition at line 33 of file exception.hh.

The documentation for this class was generated from the following file:

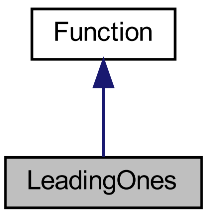
- lib/hnco/exception.hh

5.56 LeadingOnes Class Reference

Leading ones.

`#include <hnco/functions/collection/theory.hh>`

Inheritance diagram for LeadingOnes:



Public Member Functions

- LeadingOnes (int bv_size)
  Constructor.
- int get_bv_size () const override
  Get bit vector size.
- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.
- bool has_known_maximum () const override
  Check for a known maximum.
- double get_maximum () const override
  Get the global maximum.

Private Attributes

- int _bv_size
  Bit vector size.

5.56.1 Detailed Description

Leading ones.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 100 of file theory.hh.

5.56.2 Member Function Documentation

5.56.2.1 get_maximum()

```
double get_maximum ( ) const  [inline], [override], [virtual]
```

Get the global maximum.

Returns

_bv_size

Reimplemented from Function.

Definition at line 123 of file theory.hh.

5.56.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 119 of file theory.hh.

The documentation for this class was generated from the following files:

- lib/hnco/functions/collection/theory.hh
- lib/hnco/functions/collection/theory.cc

5.57 LinearCategoricalRepresentation Class Reference

Linear categorical representation.

```
#include <hnco/representations/categorical.hh>
```

Public Types

- using domain_type = std::size_t

  Domain type.

Public Member Functions

- LinearCategoricalRepresentation (int num_categories)

  Constructor.
- int size () const

  Size of the representation.
- domain_type unpack (const bit_vector_t &bv, int start)

  Unpack bit vector into a category.
- void display (std::ostream &stream) const

  Display.

Private Attributes

- int _num_categories

    Number of categories.
- int _nrows

    Number of rows.
- int _ncols

    Number of columns.
- bit_matrix_t _A

    Linear code as a bit matrix.
- bit_vector_t _y

    Output category.
- bit_vector_t _x

    Input bit vector.

5.57.1 Detailed Description

Linear categorical representation.

Definition at line 43 of file categorical.hh.

5.57.2 Constructor & Destructor Documentation

5.57.2.1 LinearCategoricalRepresentation()

```
LinearCategoricalRepresentation (
            int num_categories )  [inline]
```

Constructor.

Parameters

num_categories	Number of categories

Definition at line 72 of file categorical.hh.

The documentation for this class was generated from the following file:

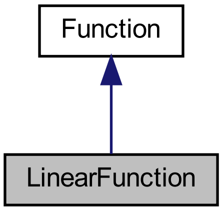
- lib/hnco/representations/categorical.hh

5.58 LinearFunction Class Reference

Linear function.

```
#include <hnco/functions/collection/linear-function.hh>
```

Inheritance diagram for LinearFunction:



Public Member Functions

- LinearFunction ()

  Constructor.

Instance generators

- template<class Generator >
  void generate (int n, Generator generator)

  Instance generator.
- void random (int n)

  Random instance.

Load and save instance

- void load (std::string path)

  Load instance.
- void save (std::string path) const

  Save instance.

Evaluation

- double evaluate (const bit_vector_t &) override

  Evaluate a bit vector.
- double evaluate_incrementally (const bit_vector_t &x, double v, const hnco::sparse_bit_vector_t &flipped_bits) override

  Incrementally evaluate a bit vector.

Information about the function

- int get_bv_size () const override

  Get bit vector size.
- double get_maximum () const override

  Get the global maximum.
- bool has_known_maximum () const override

  Check for a known maximum.
- bool provides_incremental_evaluation () const override

  Check whether the function provides incremental evaluation.
- void display (std::ostream &stream) const override

  Display.

Private Member Functions

- template<class Archive >
  void serialize (Archive &ar, const unsigned int version)
  Serialize.

Private Attributes

- std::vector< double > _weights
  Weights.

Friends

- class **boost::serialization::access**

5.58.1 Detailed Description

Linear function.

Definition at line 39 of file linear-function.hh.

5.58.2 Member Function Documentation

5.58.2.1 generate()

```
void generate (
            int n,
            Generator generator )  [inline]
```

Instance generator.

Parameters

n	Size of bit vectors
generator	Weight generator

Definition at line 70 of file linear-function.hh.

5.58.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const  [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 135 of file linear-function.hh.

5.58.2.3 load()

```
void load (
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 99 of file linear-function.hh.

5.58.2.4 provides_incremental_evaluation()

```
bool provides_incremental_evaluation ( ) const  [inline], [override], [virtual]
```

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 140 of file linear-function.hh.

5.58.2.5 random()

```
void random (
            int n )  [inline]
```

Random instance.

The weights are sampled from the normal distribution.

Parameters

n	Size of bit vectors

Definition at line 82 of file linear-function.hh.

5.58.2.6 save()

```
void save (
            std::string path ) const  [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 106 of file linear-function.hh.

The documentation for this class was generated from the following files:

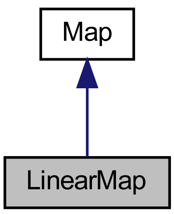
- lib/hnco/functions/collection/linear-function.hh
- lib/hnco/functions/collection/linear-function.cc

5.59 LinearMap Class Reference

Linear map.

`#include <hnco/maps/map.hh>`

Inheritance diagram for LinearMap:



Public Member Functions

- void random (int rows, int cols, bool surjective)

  Random instance.
- void map (const bit_vector_t &input, bit_vector_t &output) override

  Map
- int get_input_size () const override

  Get input size.
- int get_output_size () const override

  Get output size.
- bool is_surjective () const override

  Check for surjective map.

Load and save map

- void load (std::string path)

  Load map.
- void save (std::string path) const

  Save map.

Private Member Functions

- template<class Archive >
  void save (Archive &ar, const unsigned int version) const

  Save.
- template<class Archive >
  void load (Archive &ar, const unsigned int version)

  Load.

Private Attributes

- bit_matrix_t _bm

  Bit matrix.

Friends

- class **boost::serialization::access**

5.59.1 Detailed Description

Linear map.

A linear map f from F_2^m to F_2^n is defined by $f(x) = Ax$, where A is an n x m bit matrix.

Definition at line 248 of file map.hh.

5.59.2 Member Function Documentation

5.59.2.1 is_surjective()

```
bool is_surjective ( ) const  [override], [virtual]
```

Check for surjective map.

Returns

true if rank(_bm) == bm_num_rows(_bm)

Reimplemented from Map.

Definition at line 110 of file map.cc.

5.59.2.2 load()

```
void load (
            std::string path )  [inline]
```

Load map.

Parameters

path	Path of the file

Exceptions

std::runtime_error	

Definition at line 311 of file map.hh.

5.59.2.3 random()

```
void random (
            int rows,
            int cols,
            bool surjective )
```

Random instance.

Parameters

rows	Number of rows
cols	Number of columns
surjective	Flag to ensure a surjective map

Exceptions

std::runtime_error	

Definition at line 81 of file map.cc.

5.59.2.4 save()

```
void save (
            std::string path ) const  [inline]
```

Save map.

Parameters

path	Path of the file

Exceptions

std::runtime_error	

Definition at line 318 of file map.hh.

The documentation for this class was generated from the following files:

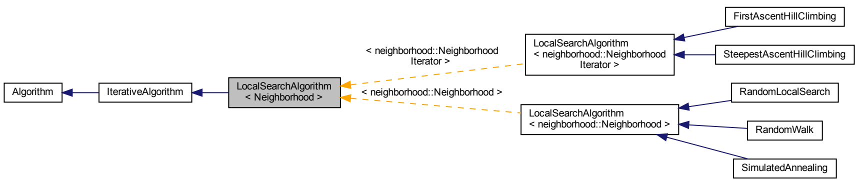
- lib/hnco/maps/map.hh
- lib/hnco/maps/map.cc

5.60 LocalSearchAlgorithm< Neighborhood > Class Template Reference

Local search algorithm.

```
#include <hnco/algorithms/ls/local-search-algorithm.hh>
```

Inheritance diagram for LocalSearchAlgorithm< Neighborhood >:



Public Member Functions

- LocalSearchAlgorithm (int n, Neighborhood ∗neighborhood)

  Constructor.

Setters

- void set_random_initialization (bool b)

  Set random initialization.
- void set_starting_point (const bit_vector_t &x)

  Set the starting point.

Protected Member Functions

Loop

- void init () override

  Initialize.

Protected Attributes

- bit_vector_t _starting_point

  Starting point.
- Neighborhood ∗ _neighborhood

  Neighborhood.

Parameters

- bool _random_initialization = true

  Random initialization.

5.60.1 Detailed Description

template< class Neighborhood >
class hnco::algorithm::LocalSearchAlgorithm< Neighborhood >

Local search algorithm.

Definition at line 33 of file local-search-algorithm.hh.

The documentation for this class was generated from the following file:

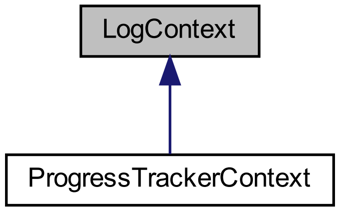
- lib/hnco/algorithms/ls/local-search-algorithm.hh

5.61 LogContext Class Reference

Log context.

```
#include <hnco/logging/log-context.hh>
```

Inheritance diagram for LogContext:



Public Member Functions

- virtual std::string to_string ()=0

    Get context.

5.61.1 Detailed Description

Log context.

A log context gives an algorithm more information about what is going on during optimization than what can be gained through its function. In particular, its function may not be a function controller. Information is provided through a log context in the form of a string.

Definition at line 41 of file log-context.hh.

The documentation for this class was generated from the following file:

- lib/hnco/logging/log-context.hh

5.62 Logger Class Reference

Logger.

```
#include <hnco/logging/logger.hh>
```

Public Member Functions

- Logger ()
  Default constructor.
- Logger (LogContext ∗context)
  Constructor.
- std::ostringstream & line ()
  Get the line.
- virtual ∼Logger ()
  Destructor.

Static Public Member Functions

- static std::ostream & stream ()
  Get the stream.
- static void set_stream (std::ostream ∗stream)
  Set the stream.

Private Attributes

- std::ostringstream _line
  Line.

Static Private Attributes

- static std::ostream ∗ _stream = &std::cout
  Output stream.

5.62.1 Detailed Description

Logger.

Simple logger inspired by the Log class published in Dr. Dobb's:

https://www.drdobbs.com/cpp/logging-in-c/201804215

Definition at line 43 of file logger.hh.

5.62.2 Constructor & Destructor Documentation

5.62.2.1 Logger()

```
Logger (
            LogContext ∗ context )  [inline]
```

Constructor.

The constructor converts the context to a string which it writes at the beginning of the line.

Parameters

context	Log context

Definition at line 69 of file logger.hh.

5.62.2.2 ∼Logger()

```
virtual ∼Logger ( ) [inline], [virtual]
```

Destructor.

Send the line to the output stream and add an end of line.

Definition at line 81 of file logger.hh.

The documentation for this class was generated from the following files:

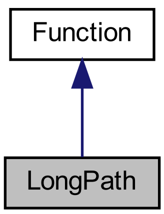
- lib/hnco/logging/logger.hh
- lib/hnco/logging/logger.cc

5.63 LongPath Class Reference

Long path.

```
#include <hnco/functions/collection/long-path.hh>
```

Inheritance diagram for LongPath:



Public Member Functions

- LongPath (int bv_size, int prefix_length)
  Constructor.
- double evaluate (const bit_vector_t &)
  Evaluate a bit vector.

Information about the function

- int get_bv_size () const
  Get bit vector size.
- bool has_known_maximum () const
  Check for a known maximum.
- double get_maximum () const
  Get the global maximum.

Private Attributes

- int _bv_size
  Bit vector size.
- int _prefix_length
  Prefix length.

5.63.1 Detailed Description

Long path.

Long paths have been introduced by Jeffrey Horn, David E. Goldberg, and Kalyanmoy Deb. Here we mostly follow the definition given by Thomas Jansen (see references below).

As an example, here is the 2-long path of dimension 4:

- 0000
- 0001
- 0011
- 0111
- 1111
- 1101
- 1100

The fitness is increasing along the path. The fitness on the complementary of the path is defined as a linear function pointing to the beginning of the path.

To help with the detection of maximum, we have dropped the constant n^2 whose sole purpose was to make the function non negative.

References:

Jeffrey Horn, David E. Goldberg, and Kalyanmoy Deb, "Long Path Problems", PPSN III, 1994.

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 62 of file long-path.hh.

5.63.2 Member Function Documentation

5.63.2.1 get_maximum()

```
double get_maximum ( ) const  [virtual]
```

Get the global maximum.

Let n be the bit vector size and k the prefix length which must divide n. Then the maximum is $k2^{n/k} - k + 1$.

Exceptions

std::runtime_error	

Reimplemented from Function.

Definition at line 62 of file long-path.cc.

5.63.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const  [virtual]
```

Check for a known maximum.

Let n be the bit vector size and k the prefix length which must divide n.

We have to check that the maximum can be represented exactly as a double, that is, it must be lower or equal to 2^{53}. We are a little bit more conservative with the following test.

If $\log_2(k) + n/k \leq 53$ then returns true else returns false.

Reimplemented from Function.

Definition at line 52 of file long-path.cc.

The documentation for this class was generated from the following files:

- lib/hnco/functions/collection/long-path.hh
- lib/hnco/functions/collection/long-path.cc

5.64 LowerTriangularWalshMoment2 Struct Reference

Lower triangular Walsh moment.

```
#include <hnco/algorithms/walsh-moment/walsh-moment.hh>
```

Public Member Functions

- LowerTriangularWalshMoment2 (int n)
  Constructor.
- void display (std::ostream &stream)
  Display Walsh moment.
- void init ()
  Initialize Walsh moment.
- void add (const bit_vector_t &bv)
  Add a bit vector to a Walsh moment.
- void average (int count)
  Average each Walsh moment.
- void update (const LowerTriangularWalshMoment2 &wm, double rate)
  Update a Walsh moment.
- void update (const LowerTriangularWalshMoment2 &wm1, const LowerTriangularWalshMoment2 &wm2, double rate)
  Update a Walsh moment.
- void scaled_difference (double lambda, const LowerTriangularWalshMoment2 &wm1, const LowerTriangularWalshMoment2 &wm2)
  Compute a scaled difference between two moments.
- void bound (double margin)
  Bound Walsh moment.
- double norm_1 () const
  1-norm of the Walsh moment
- double norm_2 () const
  2-norm of the Walsh moment
- double norm_infinite () const
  infinite-norm of the Walsh moment
- double distance (const LowerTriangularWalshMoment2 &wm) const
  distance between the Walsh moment and another Walsh moment

Public Attributes

- std::vector< double > first_moment
  First moment.
- std::vector< std::vector< double > > second_moment
  Second moment.

5.64.1 Detailed Description

Lower triangular Walsh moment.

Definition at line 37 of file walsh-moment.hh.

5.64.2 Constructor & Destructor Documentation

5.64.2.1 LowerTriangularWalshMoment2()

```
LowerTriangularWalshMoment2 (
            int n )
```

Constructor.

Parameters

n	Size of bit vector

Definition at line 32 of file walsh-moment.cc.

5.64.3 Member Function Documentation

5.64.3.1 bound()

```
void bound (
            double margin )
```

Bound Walsh moment.

Ensure that the distance from each Walsh moment to the -1/1 bounds is greater or equal to the given margin.

Parameters

margin	Distance from the -1/1 bounds

Definition at line 161 of file walsh-moment.cc.

5.64.3.2 display()

```
void display (
            std::ostream & stream )
```

Display Walsh moment.

A LowerTriangularWalshMoment2 is displayed as a full symmetric matrix with diagonal entries equal to first moments and off-diagonal entries equal to second moments.

Definition at line 43 of file walsh-moment.cc.

5.64.3.3 scaled_difference()

```
void scaled_difference (
            double lambda,
            const LowerTriangularWalshMoment2 & wm1,
            const LowerTriangularWalshMoment2 & wm2 )
```

Compute a scaled difference between two moments.

This member function implements:

self = lambda $*$ wm1 - wm2

It is mostly useful in herding (Hea).

Parameters

lambda	Scale
wm1	First Walsh moment
wm2	Second Walsh moment

Definition at line 142 of file walsh-moment.cc.

5.64.3.4 update() [1/2]

```
void update (
            const LowerTriangularWalshMoment2 & wm,
            double rate )
```

Update a Walsh moment.

This member function implements:

self += rate ∗ (wm1 - self)

Parameters

wm	Target Walsh moment
rate	Learning rate

Postcondition

For all i, is_in_interval(first_moment[i], -1, 1)

For all j $<$ i, is_in_interval(second_moment[i][j], -1, 1)

Definition at line 104 of file walsh-moment.cc.

5.64.3.5 update() [2/2]

```
void update (
            const LowerTriangularWalshMoment2 & wm1,
            const LowerTriangularWalshMoment2 & wm2,
            double rate )
```

Update a Walsh moment.

This member function implements:

self += rate ∗ (wm1 - wm2)

The resulting entries are not necessarily those of a Walsh moment, that is

is_in_interval(first_moment[i], -1, 1) or

is_in_interval(second_moment[i][j], -1, 1)

might fail for some i, j.

Parameters

wm1	Target Walsh moment
wm2	Walsh moment to move away from
rate	Learning rate

Definition at line 122 of file walsh-moment.cc.

The documentation for this struct was generated from the following files:

- lib/hnco/algorithms/walsh-moment/walsh-moment.hh
- lib/hnco/algorithms/walsh-moment/walsh-moment.cc

5.65 LowerTriangularWalshMoment2GibbsSampler Class Reference

Gibbs sampler with lower triangular Walsh moments.

```
#include <hnco/algorithms/walsh-moment/gibbs-sampler.hh>
```

Public Types

- using Moment = LowerTriangularWalshMoment2

  Walsh moment type.

Public Member Functions

- LowerTriangularWalshMoment2GibbsSampler (int n, const LowerTriangularWalshMoment2 &mp)

  Constructor.
- void init ()

  Initialize.
- void update (int i)

  Update state.
- void update_sync ()

  Update state synchronously.
- const bit_vector_t & get_state ()

  Get the state of the Gibbs sampler.

Private Attributes

- const LowerTriangularWalshMoment2 & _model_parameters

  Model parameters.
- bit_vector_t _state

  State of the Gibbs sampler.
- pv_t _pv

  Probability vector for synchronous Gibbs sampling.

5.65.1 Detailed Description

Gibbs sampler with lower triangular Walsh moments.

Definition at line 38 of file gibbs-sampler.hh.

The documentation for this class was generated from the following files:

- lib/hnco/algorithms/walsh-moment/gibbs-sampler.hh
- lib/hnco/algorithms/walsh-moment/gibbs-sampler.cc

5.66 LowerTriangularWalshMoment2Herding Class Reference

Herding with lower triangular Walsh moment.

```
#include <hnco/algorithms/walsh-moment/herding.hh>
```

Public Types

- using Moment = LowerTriangularWalshMoment2

  Walsh moment type.

Public Member Functions

- LowerTriangularWalshMoment2Herding (int n)

  Constructor.
- void init ()

  Initialization.
- void sample (const LowerTriangularWalshMoment2 &target, bit_vector_t &x)

  Sample a bit vector.
- double error (const LowerTriangularWalshMoment2 &target)

  Compute the error.

Getters

- const LowerTriangularWalshMoment2 & get_delta () const

  Get delta.

Setters

- void set_randomize_bit_order (bool x)

  Randomize bit order.

Protected Attributes

- LowerTriangularWalshMoment2 _delta

  Delta moment.
- LowerTriangularWalshMoment2 _count

  Counter moment.
- LowerTriangularWalshMoment2 _error

  Error moment.
- permutation_t _permutation

  Permutation.
- int _time

  Time.

Parameters

- bool _randomize_bit_order = false

  Randomize bit order.

5.66.1 Detailed Description

Herding with lower triangular Walsh moment.

Definition at line 37 of file herding.hh.

5.66.2 Constructor & Destructor Documentation

5.66.2.1 LowerTriangularWalshMoment2Herding()

```
LowerTriangularWalshMoment2Herding (
            int n )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors

Definition at line 74 of file herding.hh.

The documentation for this class was generated from the following files:

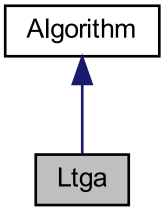
- lib/hnco/algorithms/walsh-moment/herding.hh
- lib/hnco/algorithms/walsh-moment/herding.cc

5.67 Ltga Class Reference

Linkage Tree Genetic Algorithm.

`#include <hnco/algorithms/fast-efficient-p3/ltga.hh>`

Inheritance diagram for Ltga:



Public Member Functions

- Ltga (int n)
  Constructor.
- ∼Ltga ()
  Destructor.
- void maximize (const std::vector< function::Function ∗ > &functions)
  Maximize.
- void finalize ()
  Finalize.
- void set_population_size (int n)
  Set population size.

Private Attributes

- Implementation ∗ _pimpl
  Pointer to implementation.
- int _population_size = 10
  Population size.

Additional Inherited Members

5.67.1 Detailed Description

Linkage Tree Genetic Algorithm.

Implementation of the Linkage Tree Genetic Algorithm Designed to match the variant in the paper: "Hierarchical problem solving with the linkage tree genetic algorithm" by D. Thierens and P. A. N. Bosman

Author: Brian W. Goldman

Integrated into HNCO by Arnaud Berny

Definition at line 47 of file ltga.hh.

5.67.2 Member Data Documentation

5.67.2.1 _pimpl

`Implementation* _pimpl [private]`

Pointer to implementation.

The main motivation for this pattern is to avoid including declarations from fast_efficient_p3 into the global namespace.

A raw pointer is used instead of a unique_ptr because the latter will not compile with pybind11.

Definition at line 57 of file ltga.hh.

The documentation for this class was generated from the following files:

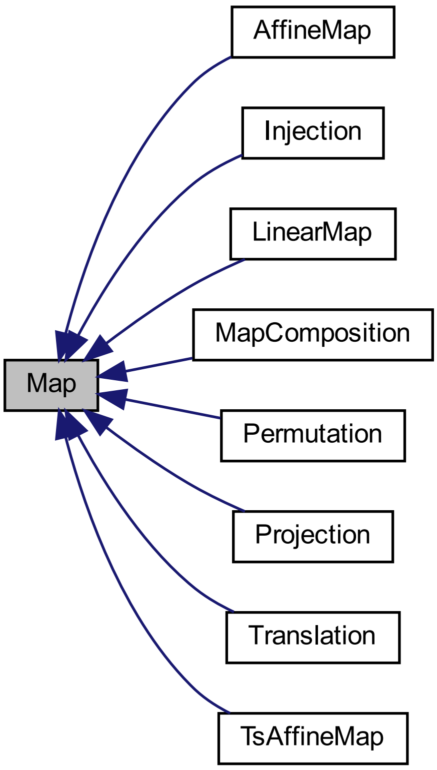
- lib/hnco/algorithms/fast-efficient-p3/ltga.hh
- lib/hnco/algorithms/fast-efficient-p3/ltga.cc

5.68 Map Class Reference

Map

`#include <hnco/maps/map.hh>`

Inheritance diagram for Map:



Public Member Functions

- virtual ~Map ()
  Destructor.
- virtual void map (const bit_vector_t &input, bit_vector_t &output)=0
  Map
- virtual int get_input_size () const =0
  Get input size.
- virtual int get_output_size () const =0
  Get output size.
- virtual bool is_surjective () const
  Check for surjective map.
- virtual void display (std::ostream &stream) const
  Display.

5.68.1 Detailed Description

Map

Definition at line 46 of file map.hh.

5.68.2 Member Function Documentation

5.68.2.1 is_surjective()

```
virtual bool is_surjective ( ) const  [inline], [virtual]
```

Check for surjective map.

Returns

false

Reimplemented in TsAffineMap, Projection, Injection, MapComposition, AffineMap, LinearMap, Permutation, and Translation.

Definition at line 66 of file map.hh.

The documentation for this class was generated from the following file:

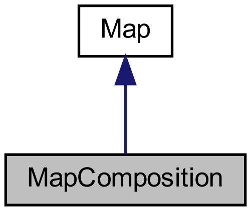
- lib/hnco/maps/map.hh

5.69 MapComposition Class Reference

Map composition.

`#include <hnco/maps/map.hh>`

Inheritance diagram for MapComposition:



Public Member Functions

- MapComposition ()
  Default constructor.
- MapComposition (Map ∗outer, Map ∗inner)
  Constructor.
- void map (const bit_vector_t &input, bit_vector_t &output) override
  Map
- int get_input_size () const override
  Get input size.
- int get_output_size () const override
  Get output size.
- bool is_surjective () const override
  Check for surjective map.

Private Attributes

- Map ∗ _outer
  Outer map.
- Map ∗ _inner
  Inner map.
- bit_vector_t _bv
  Temporary bit vector.

5.69.1 Detailed Description

Map composition.

The resulting composition f is defined for all bit vector x by f(x) = outer(inner(x)).

Definition at line 424 of file map.hh.

5.69.2 Constructor & Destructor Documentation

5.69.2.1 MapComposition()

```
MapComposition (
            Map * outer,
            Map * inner )  [inline]
```

Constructor.

Parameters

outer	outer map
inner	inner map

Precondition

outer->get_input_size() == inner->get_output_size()

Definition at line 448 of file map.hh.

5.69.3 Member Function Documentation

5.69.3.1 is_surjective()

```
bool is_surjective ( ) const  [inline], [override], [virtual]
```

Check for surjective map.

Returns

true if both maps are surjective

Reimplemented from Map.

Definition at line 472 of file map.hh.

The documentation for this class was generated from the following file:

- lib/hnco/maps/map.hh

5.70 MapgenOptions Class Reference

Command line options for mapgen.

`#include <mapgen-options.hh>`

Public Member Functions

- MapgenOptions (int argc, char *argv[ ])
  Constructor.
- int get_input_size () const
  Get input_size.
- void set_input_size (int x)
  Set input_size.
- bool set_input_size () const
  Get set-flag for input_size.
- int get_map () const
  Get map.
- void set_map (int x)
  Set map.
- bool set_map () const
  Get set-flag for map.
- int get_output_size () const
  Get output_size.
- void set_output_size (int x)
  Set output_size.
- bool set_output_size () const
  Get set-flag for output_size.
- std::string get_path () const
  Get path.
- void set_path (std::string x)
  Set path.
- bool set_path () const
  Get set-flag for path.
- int get_seed () const
  Get seed.
- void set_seed (int x)
  Set seed.
- bool set_seed () const
  Get set-flag for seed.
- int get_ts_length () const
  Get ts_length.
- void set_ts_length (int x)
  Set ts_length.
- bool set_ts_length () const
  Get set-flag for ts_length.
- int get_ts_sampling_mode () const
  Get ts_sampling_mode.
- void set_ts_sampling_mode (int x)
  Set ts_sampling_mode.

- bool set_ts_sampling_mode () const

  Get set-flag for ts_sampling_mode.
- bool with_surjective () const

  Get surjective.
- void set_surjective ()

  Set surjective.

Private Member Functions

- void print_help (std::ostream &stream) const

  Print help message.
- void print_version (std::ostream &stream) const

  Print version.

Private Attributes

- std::string _exec_name

  Name of the executable.
- std::string _version

  Name Version.
- int _input_size

  Input bit vector size.
- bool **_opt_input_size**
- int _map

  Type of map.
- bool **_opt_map**
- int _output_size

  Output bit vector size.
- bool **_opt_output_size**
- std::string _path

  Path (relative or absolute) of a map file.
- bool **_opt_path**
- int _seed

  Seed for the random number generator.
- bool **_opt_seed**
- int _ts_length

  Transvection sequence length.
- bool **_opt_ts_length**
- int _ts_sampling_mode

  Transvection sequence sampling mode.
- bool **_opt_ts_sampling_mode**
- bool _surjective

  Ensure that the sampled linear or affine map is surjective.

Friends

- std::ostream & operator<< (std::ostream &, const MapgenOptions &)

  Print a header containing the parameter values.

5.70.1 Detailed Description

Command line options for mapgen.

Definition at line 11 of file mapgen-options.hh.

The documentation for this class was generated from the following files:

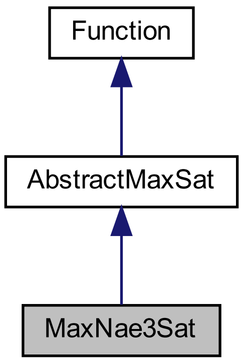
- app/mapgen-options.hh
- app/mapgen-options.cc

5.71 MaxNae3Sat Class Reference

Max not-all-equal 3SAT.

`#include <hnco/functions/collection/max-sat.hh>`

Inheritance diagram for MaxNae3Sat:



Public Member Functions

- MaxNae3Sat ()
  Default constructor.
- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.
- void load (std::string path)
  Load instance.

Additional Inherited Members

5.71.1 Detailed Description

Max not-all-equal 3SAT.

Reference:

Christos M. Papadimitriou. 1994. Computational complexity. Addison-Wesley, Reading, Massachusetts.

Definition at line 162 of file max-sat.hh.

5.71.2 Member Function Documentation

5.71.2.1 load()

```
void load (
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 177 of file max-sat.hh.

The documentation for this class was generated from the following files:

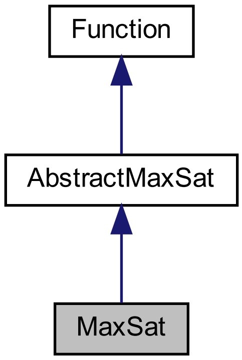
- lib/hnco/functions/collection/max-sat.hh
- lib/hnco/functions/collection/max-sat.cc

5.72 MaxSat Class Reference

MAX-SAT.

```
#include <hnco/functions/collection/max-sat.hh>
```

Inheritance diagram for MaxSat:



Public Member Functions

- MaxSat ()

    Default constructor.
- void random (int n, int k, int c)

    Random instance.
- void random (const bit_vector_t &solution, int k, int c)

    Random instance with satisfiable expression.
- double evaluate (const bit_vector_t &) override

    Evaluate a bit vector.

Additional Inherited Members

5.72.1 Detailed Description

MAX-SAT.

Reference:

Christos M. Papadimitriou. 1994. Computational complexity. Addison-Wesley, Reading, Massachusetts.

Definition at line 119 of file max-sat.hh.

5.72.2 Member Function Documentation

5.72.2.1 random() [1/2]

```
void random (
            const bit_vector_t & solution,
            int k,
            int c )
```

Random instance with satisfiable expression.

Warning

Since the expression is satisfiable, the maximum of the function is equal to the number of clauses in the expression. However, this information is lost in the save and load cycle as the archive format only manages the expression itself.

Parameters

solution	Solution
k	Number of literals per clause
c	Number of clauses

Definition at line 218 of file max-sat.cc.

5.72.2.2 random() [2/2]

```
void random (
            int n,
            int k,
            int c )
```

Random instance.

Parameters

n	Size of bit vectors
k	Number of literals per clause
c	Number of clauses

Definition at line 190 of file max-sat.cc.

The documentation for this class was generated from the following files:

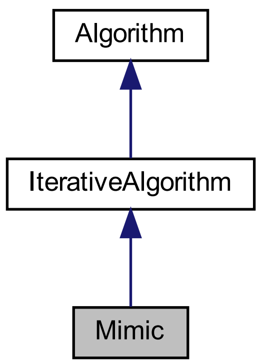
- lib/hnco/functions/collection/max-sat.hh
- lib/hnco/functions/collection/max-sat.cc

5.73 Mimic Class Reference

Mutual information maximizing input clustering.

```
#include <hnco/algorithms/mimic.hh>
```

Inheritance diagram for Mimic:



Public Member Functions

- Mimic (int n, int population_size)

  Constructor.

Setters

- void set_selection_size (int selection_size)

  Set the selection size.

Protected Member Functions

- void sample (bit_vector_t &bv)

  Sample a bit vector.
- void compute_conditional_entropy (int index)

  Compute conditional entropy.
- void update_model ()

  Update model.

Loop

- void init () override

  Initialize.
- void iterate () override

  Single iteration.

Protected Attributes

- Population _population
  Population.
- permutation_t _permutation
  Permutation.
- std::array< pv_t, 2 > _parameters
  Model parameters.
- pv_t _mean
  Mean of selected bit vectors.
- std::vector< double > _entropies
  Conditional entropies.
- std::array< std::array< int, 2 >, 2 > _table
  Contingency table.
- double _lower_bound
  Lower bound of probability.
- double _upper_bound
  Upper bound of probability.

Parameters

- int _selection_size
  Selection size.

5.73.1 Detailed Description

Mutual information maximizing input clustering.

This implementation differs from the algorithm described in the reference below in that it constrains all probabilities (marginal and conditional) to stay away from the values 0 and 1 by a fixed margin equal to 1 / n, as usually done in algorithms such as Pbil or Umda.

Reference:

Jeremy S. De Bonet and Charles L. Isbell and Jr. and Paul Viola, MIMIC: Finding Optima by Estimating Probability Densities, in Advances in Neural Information Processing Systems, 1996, MIT Press.

Definition at line 52 of file mimic.hh.

The documentation for this class was generated from the following files:

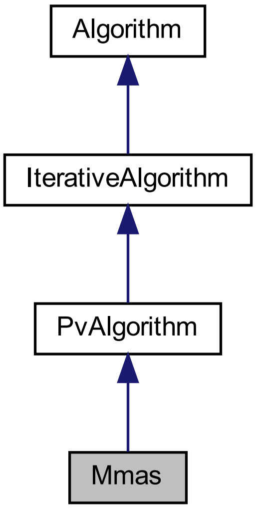
- lib/hnco/algorithms/mimic.hh
- lib/hnco/algorithms/mimic.cc

5.74 Mmas Class Reference

Max-min ant system.

```
#include <hnco/algorithms/pv/mmas.hh>
```

Inheritance diagram for Mmas:



Public Member Functions

- Mmas (int n)

  Constructor.

Setters

- void set_compare (std::function< bool(double, double)> x)

  Set the binary operator for comparing evaluations.
- void set_learning_rate (double x)

  Set the learning rate.

Protected Member Functions

Loop

- void init () override

  Initialize.
- void iterate () override

  Single iteration.

Protected Attributes

- bit_vector_t _x
  Candidate solution.

Parameters

- std::function< bool(double, double)> _compare = std::greater_equal<double>()
  Binary operator for comparing evaluations.
- double _learning_rate = 1e-3
  Learning rate.

5.74.1 Detailed Description

Max-min ant system.

Reference:

Thomas Stützle and Holger H. Hoos. 2000. MAX–MIN Ant System. Future Generation Computer Systems 16, 8 (2000), 889–914.

Definition at line 42 of file mmas.hh.

The documentation for this class was generated from the following files:

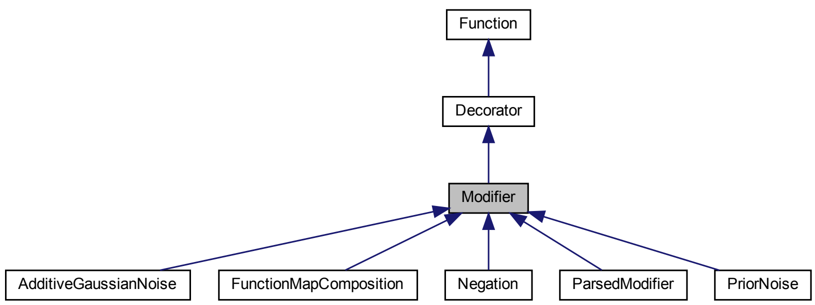
- lib/hnco/algorithms/pv/mmas.hh
- lib/hnco/algorithms/pv/mmas.cc

5.75 Modifier Class Reference

Function modifier.

`#include <hnco/functions/modifiers/modifier.hh>`

Inheritance diagram for Modifier:



Public Member Functions

- Modifier (Function *function)

  Constructor.

Additional Inherited Members

5.75.1 Detailed Description

Function modifier.

Definition at line 39 of file modifier.hh.

The documentation for this class was generated from the following file:

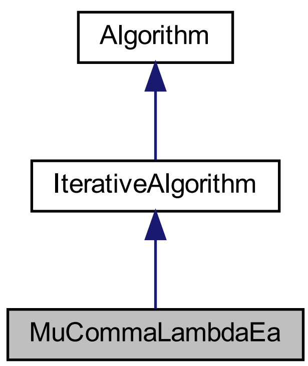
- lib/hnco/functions/modifiers/modifier.hh

5.76 MuCommaLambdaEa Class Reference

(mu, lambda) EA.

`#include <hnco/algorithms/ea/mu-comma-lambda-ea.hh>`

Inheritance diagram for MuCommaLambdaEa:



Public Member Functions

- MuCommaLambdaEa (int n, int mu, int lambda)

  Constructor.

Setters

- void set_mutation_rate (double p)

  Set the mutation rate.
- void set_allow_no_mutation (bool b)

  Set the flag _allow_no_mutation.

Protected Member Functions

Loop

- void init () override
  Initialize.
- void iterate () override
  Single iteration.

Protected Attributes

- Population _parents
  Parents.
- Population _offsprings
  Offsprings.
- neighborhood::StandardBitMutation _mutation
  Mutation operator.
- std::uniform_int_distribution< int > _select_parent
  Select parent.

Parameters

- double _mutation_rate
  Mutation rate.
- bool _allow_no_mutation = false
  Allow no mutation.

5.76.1 Detailed Description

(mu, lambda) EA.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 41 of file mu-comma-lambda-ea.hh.

5.76.2 Constructor & Destructor Documentation

5.76.2.1 MuCommaLambdaEa()

```
MuCommaLambdaEa (
            int n,
            int mu,
            int lambda )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors
mu	Parent population size
lambda	Offspring population size

Definition at line 89 of file mu-comma-lambda-ea.hh.

The documentation for this class was generated from the following files:

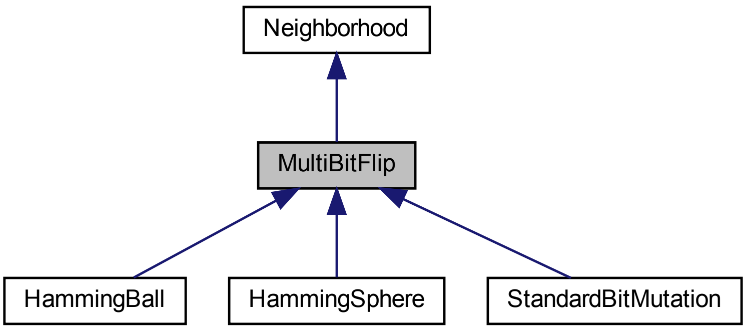
- lib/hnco/algorithms/ea/mu-comma-lambda-ea.hh
- lib/hnco/algorithms/ea/mu-comma-lambda-ea.cc

5.77 MultiBitFlip Class Reference

Multi bit flip.

```
#include <hnco/neighborhoods/neighborhood.hh>
```

Inheritance diagram for MultiBitFlip:



Public Member Functions

- MultiBitFlip (int n)

    Constructor.

Protected Member Functions

- void bernoulli_trials (int k)

    Sample a given number of bits using Bernoulli trials.
- void rejection_sampling (int k)

    Sample a given number of bits using rejection sampling.

Additional Inherited Members

5.77.1 Detailed Description

Multi bit flip.

Definition at line 185 of file neighborhood.hh.

5.77.2 Constructor & Destructor Documentation

5.77.2.1 MultiBitFlip()

```
MultiBitFlip (
             int n )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors

Definition at line 208 of file neighborhood.hh.

5.77.3 Member Function Documentation

5.77.3.1 bernoulli_trials()

```
void bernoulli_trials (
             int k )  [protected]
```

Sample a given number of bits using Bernoulli trials.

Parameters

k	Number of bits to sample

Definition at line 34 of file neighborhood.cc.

5.77.3.2 rejection_sampling()

```
void rejection_sampling (
            int k )  [protected]
```

Sample a given number of bits using rejection sampling.

Parameters

k	Number of bits to sample

Definition at line 52 of file neighborhood.cc.

The documentation for this class was generated from the following files:

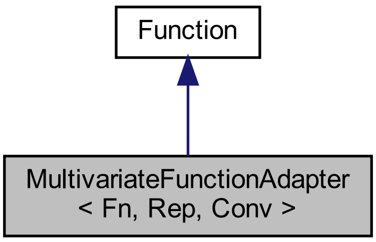
- lib/hnco/neighborhoods/neighborhood.hh
- lib/hnco/neighborhoods/neighborhood.cc

5.78 MultivariateFunctionAdapter< Fn, Rep, Conv > Class Template Reference

Multivariate function adapter.

```
#include <hnco/functions/multivariate-function-adapter.hh>
```

Inheritance diagram for MultivariateFunctionAdapter< Fn, Rep, Conv >:



Public Member Functions

- MultivariateFunctionAdapter (Fn *fn, std::vector< Rep > reps)

  Constructor.

Information about the function

- int get_bv_size () const override

Get bit vector size.

Evaluation

- double evaluate (const bit_vector_t &bv) override
  Evaluate.

Display

- void display (std::ostream &stream) const override
  Display.
- void describe (const bit_vector_t &bv, std::ostream &stream) override
  Describe a bit vector.

Private Member Functions

- void unpack (const bit_vector_t &bv)
  Unpack a bit vector into values.

Private Attributes

- Fn ∗ _function
  Multivariate function.
- std::vector< Rep > _representations
  Representations.
- std::vector< typename Rep::domain_type > _variables
  Variables.
- Conv _converter
  Converter from codomain to double.

5.78.1 Detailed Description

template<class Fn, class Rep, class Conv>
class hnco::function::MultivariateFunctionAdapter< Fn, Rep, Conv >

Multivariate function adapter.

The purpose of this class is to build a regular hnco function from an arbitrary multivariate function. This is achieved using a composition:

- Representations (Rep): hypercube -> domain
- Multivariate function (Fn): product of domains -> codomain
- Converter (Conv): codomain -> double

Definition at line 46 of file multivariate-function-adapter.hh.

5.78.2 Constructor & Destructor Documentation

5.78.2.1 MultivariateFunctionAdapter()

```
MultivariateFunctionAdapter (
            Fn * fn,
            std::vector< Rep > reps )  [inline]
```

Constructor.

Parameters

fn	Multivariate function
reps	Representations

Definition at line 86 of file multivariate-function-adapter.hh.

The documentation for this class was generated from the following file:

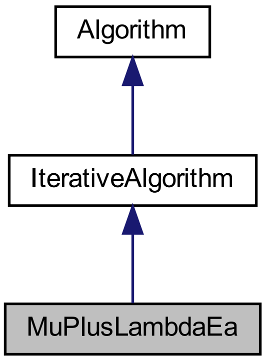
- lib/hnco/functions/multivariate-function-adapter.hh

5.79 MuPlusLambdaEa Class Reference

(mu+lambda) EA.

`#include <hnco/algorithms/ea/mu-plus-lambda-ea.hh>`

Inheritance diagram for MuPlusLambdaEa:



Public Member Functions

- MuPlusLambdaEa (int n, int mu, int lambda)
  Constructor.

Setters

- void set_mutation_rate (double p)
  Set the mutation rate.
- void set_allow_no_mutation (bool b)
  Set the flag _allow_no_mutation.

Protected Member Functions

Loop

- void init () override
  Initialize.
- void iterate () override
  Single iteration.

Protected Attributes

- Population _parents
  Parents.
- Population _offsprings
  Offsprings.
- neighborhood::StandardBitMutation _mutation
  Mutation operator.
- std::uniform_int_distribution< int > _select_parent
  Select parent.

Parameters

- double _mutation_rate
  Mutation rate.
- bool _allow_no_mutation = false
  Allow no mutation.

5.79.1 Detailed Description

(mu+lambda) EA.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 40 of file mu-plus-lambda-ea.hh.

5.79.2 Constructor & Destructor Documentation

5.79.2.1 MuPlusLambdaEa()

```
MuPlusLambdaEa (
            int n,
            int mu,
            int lambda )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors
mu	Parent population size
lambda	Offspring population size

Definition at line 89 of file mu-plus-lambda-ea.hh.

The documentation for this class was generated from the following files:

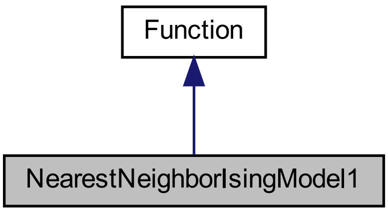
- lib/hnco/algorithms/ea/mu-plus-lambda-ea.hh
- lib/hnco/algorithms/ea/mu-plus-lambda-ea.cc

5.80 NearestNeighborIsingModel1 Class Reference

Nearest neighbor Ising model in one dimension.

```
#include <hnco/functions/collection/ising/nearest-neighbor-ising-model-1.↩
hh>
```

Inheritance diagram for NearestNeighborIsingModel1:



Public Member Functions

- NearestNeighborIsingModel1 ()
  Constructor.
- void set_periodic_boundary_conditions (bool x)
  Set periodic boundary conditions.

Instance generators

- template<class CouplingGen , class FieldGen >
  void generate (int n, CouplingGen coupling_gen, FieldGen field_gen)
  Instance generator.
- void random (int n)
  Random instance.

Load and save instance

- void load (std::string path)
  Load instance.
- void save (std::string path) const
  Save instance.

Evaluation

- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.
- double evaluate_incrementally (const bit_vector_t &x, double v, const sparse_bit_vector_t &flipped_bits) override
  Incrementally evaluate a bit vector.

Information about the function

- int get_bv_size () const override
  Get bit vector size.
- bool provides_incremental_evaluation () const override
  Check whether the function provides incremental evaluation.
- void display (std::ostream &stream) const override
  Display.

Private Member Functions

- template<class Archive >
  void save (Archive &ar, const unsigned int version) const
  Save.
- template<class Archive >
  void load (Archive &ar, const unsigned int version)
  Load.
- void resize (int n)
  Resize data structures.

Private Attributes

- std::vector< double > _coupling
  Coupling with nearest neighbor to the right.
- std::vector< double > _field
  External field.
- bit_vector_t _flipped_bits
  Flipped bits.
- bool _periodic_boundary_conditions = false
  Periodic boundary conditions.

Friends

- class **boost::serialization::access**

5.80.1 Detailed Description

Nearest neighbor Ising model in one dimension.

Its expression is of the form

$f(x) = \sum_i J_{i,i+1}(1-2x_i)(1-2x_{i+1}) + \sum_i h_i(1-2x_i)$

or equivalently

$f(x) = \sum_i J_{i,i+1}(-1)^{x_i+x_{i+1}} + \sum_i h_i(-1)^{x_i}$

where $J_{i,i+1}$ is the interaction between adjacent sites i and i+1 and h_i is the external magnetic field interacting with site i.

In the case of periodic boundary conditions, the sum $i+1$ is mod n.

Since we are maximizing f or minimizing -f, the expression of f is compatible with what can be found in physics textbooks.

It should be noted that such an Ising model can be represented by a Walsh expansion of degree 2, that is WalshExpansion2.

Reference: https://en.wikipedia.org/wiki/Ising_model

Definition at line 63 of file nearest-neighbor-ising-model-1.hh.

5.80.2 Member Function Documentation

5.80.2.1 evaluate()

```
double evaluate (
            const bit_vector_t & s )  [override], [virtual]
```

Evaluate a bit vector.

Complexity: O(n)

Implements Function.

Definition at line 44 of file nearest-neighbor-ising-model-1.cc.

5.80.2.2 generate()

```
void generate (
            int n,
            CouplingGen coupling_gen,
            FieldGen field_gen )  [inline]
```

Instance generator.

Parameters

n	Size of bit vectors
coupling_gen	Coupling generator
field_gen	External field generator

Definition at line 124 of file nearest-neighbor-ising-model-1.hh.

5.80.2.3 load()

```
void load (
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 158 of file nearest-neighbor-ising-model-1.hh.

5.80.2.4 provides_incremental_evaluation()

```
bool provides_incremental_evaluation ( ) const  [inline], [override], [virtual]
```

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 199 of file nearest-neighbor-ising-model-1.hh.

5.80.2.5 random()

```
void random (
            int n )  [inline]
```

Random instance.

The weights are sampled from the normal distribution.

Parameters

n	Size of bit vector

Definition at line 140 of file nearest-neighbor-ising-model-1.hh.

5.80.2.6 save()

```
void save (
            std::string path ) const  [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 165 of file nearest-neighbor-ising-model-1.hh.

The documentation for this class was generated from the following files:

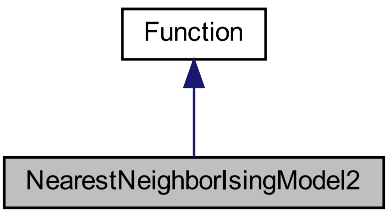
- lib/hnco/functions/collection/ising/nearest-neighbor-ising-model-1.hh
- lib/hnco/functions/collection/ising/nearest-neighbor-ising-model-1.cc

5.81 NearestNeighborIsingModel2 Class Reference

Nearest neighbor Ising model in two dimensions.

`#include <hnco/functions/collection/ising/nearest-neighbor-ising-model-2.hh>`

Inheritance diagram for NearestNeighborIsingModel2:



Public Member Functions

- NearestNeighborIsingModel2 ()
  Constructor.
- void set_periodic_boundary_conditions (bool x)
  Set periodic boundary conditions.

Instance generators

- template<class CouplingGen , class FieldGen >
  void generate (int num_rows, int num_columns, CouplingGen coupling_gen, FieldGen field_gen)
  Instance generator.
- void random (int num_rows, int num_columns)
  Random instance.

Load and save instance

- void load (std::string path)
  Load instance.
- void save (std::string path) const
  Save instance.

Evaluation

- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.
- double evaluate_incrementally (const bit_vector_t &x, double v, const sparse_bit_vector_t &flipped_bits) override
  Incrementally evaluate a bit vector.

Information about the function

- int get_bv_size () const override
  Get bit vector size.
- bool provides_incremental_evaluation () const override
  Check whether the function provides incremental evaluation.
- void display (std::ostream &stream) const override
  Display.

Private Member Functions

- template<class Archive >
  void save (Archive &ar, const unsigned int version) const
  Save.
- template<class Archive >
  void load (Archive &ar, const unsigned int version)
  Load.
- void resize (int num_rows, int num_columns)
  Resize data structures.

Private Attributes

- std::vector< std::vector< double > > _coupling_right

  Coupling with nearest neighbor to the right.
- std::vector< std::vector< double > > _coupling_below

  Coupling with nearest neighbor below.
- std::vector< std::vector< double > > _field

  External field.
- bit_vector_t _flipped_bits

  Flipped bits.
- bool _periodic_boundary_conditions = false

  Periodic boundary conditions.

Friends

- class **boost::serialization::access**

5.81.1 Detailed Description

Nearest neighbor Ising model in two dimensions.

We are considering a rectangular lattice in which each site has (at most) four neighbors (left, right, above, below).

The expression of the function is of the form

$f(x) = \sum_{(i,j)} J_{ij}(1 - 2x_i)(1 - 2x_j) + \sum_i h_i(1 - 2x_i)$

or equivalently

$f(x) = \sum_{(i,j)} J_{ij}(-1)^{x_i + x_j} + \sum_i h_i(-1)^{x_i}$

where the first sum is over adjacent sites (i, j), J_{ij} is the interaction between adjacent sites i and j, and h_i is the external magnetic field interacting with site i.

Since we are maximizing f or minimizing -f, the expression of f is compatible with what can be found in physics textbooks.

It should be noted that such an Ising model can be represented by a Walsh expansion of degree 2, that is WalshExpansion2.

Reference: `https://en.wikipedia.org/wiki/Ising_model`

Definition at line 65 of file nearest-neighbor-ising-model-2.hh.

5.81.2 Member Function Documentation

5.81.2.1 evaluate()

```
double evaluate (
            const bit_vector_t & s )  [override], [virtual]
```

Evaluate a bit vector.

Complexity: O(n)

Implements Function.

Definition at line 47 of file nearest-neighbor-ising-model-2.cc.

5.81.2.2 generate()

```
void generate (
            int num_rows,
            int num_columns,
            CouplingGen coupling_gen,
            FieldGen field_gen )  [inline]
```

Instance generator.

Parameters

num_rows	Number of rows
num_columns	Number of columns
coupling_gen	Coupling generator
field_gen	External field generator

Definition at line 132 of file nearest-neighbor-ising-model-2.hh.

5.81.2.3 load()

```
void load (
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 170 of file nearest-neighbor-ising-model-2.hh.

5.81.2.4 provides_incremental_evaluation()

```
bool provides_incremental_evaluation ( ) const  [inline], [override], [virtual]
```

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 216 of file nearest-neighbor-ising-model-2.hh.

5.81.2.5 random()

```
void random (
             int num_rows,
             int num_columns )  [inline]
```

Random instance.

The weights are sampled from the normal distribution.

Parameters

num_rows	Number of rows
num_columns	Number of columns

Definition at line 152 of file nearest-neighbor-ising-model-2.hh.

5.81.2.6 save()

```
void save (
             std::string path ) const  [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 177 of file nearest-neighbor-ising-model-2.hh.

The documentation for this class was generated from the following files:

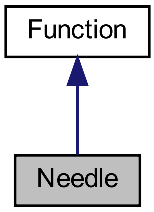
- lib/hnco/functions/collection/ising/nearest-neighbor-ising-model-2.hh
- lib/hnco/functions/collection/ising/nearest-neighbor-ising-model-2.cc

5.82 Needle Class Reference

Needle in a haystack.

`#include <hnco/functions/collection/theory.hh>`

Inheritance diagram for Needle:



Public Member Functions

- Needle (int bv_size)

    Constructor.
- int get_bv_size () const override

    Get bit vector size.
- double evaluate (const bit_vector_t &) override

    Evaluate a bit vector.
- bool has_known_maximum () const override

    Check for a known maximum.
- double get_maximum () const override

    Get the global maximum.

Private Attributes

- int _bv_size

    Bit vector size.

5.82.1 Detailed Description

Needle in a haystack.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 135 of file theory.hh.

5.82.2 Member Function Documentation

5.82.2.1 get_maximum()

```
double get_maximum ( ) const  [inline], [override], [virtual]
```

Get the global maximum.

Returns

1

Reimplemented from Function.

Definition at line 158 of file theory.hh.

5.82.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const  [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 154 of file theory.hh.

The documentation for this class was generated from the following files:

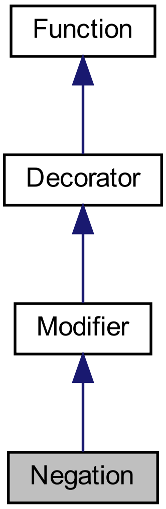
- lib/hnco/functions/collection/theory.hh
- lib/hnco/functions/collection/theory.cc

5.83 Negation Class Reference

Negation.

```
#include <hnco/functions/modifiers/modifier.hh>
```

Inheritance diagram for Negation:



Public Member Functions

- Negation (Function *function)

  Constructor.

Information about the function

- int get_bv_size () const override

  Get bit vector size.
- bool provides_incremental_evaluation () const override

  Check whether the function provides incremental evaluation.

Evaluation

- double evaluate (const bit_vector_t &) override

  Evaluate a bit vector.
- double evaluate_incrementally (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_t &flipped_bits) override

  Incrementally evaluate a bit vector.

Additional Inherited Members

5.83.1 Detailed Description

Negation.

Use cases:

- for algorithms which minimize rather than maximize a function
- for functions one wishes to minimize
- when minimization is needed inside an algorithm

Definition at line 60 of file modifier.hh.

5.83.2 Member Function Documentation

5.83.2.1 provides_incremental_evaluation()

```
bool provides_incremental_evaluation ( ) const  [inline], [override], [virtual]
```

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 79 of file modifier.hh.

The documentation for this class was generated from the following files:

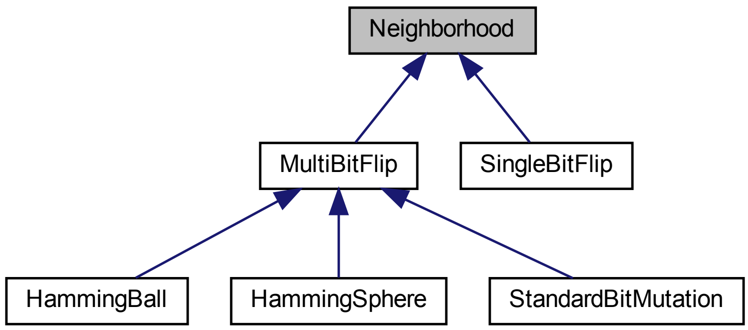
- lib/hnco/functions/modifiers/modifier.hh
- lib/hnco/functions/modifiers/modifier.cc

5.84 Neighborhood Class Reference

Neighborhood.

```
#include <hnco/neighborhoods/neighborhood.hh>
```

Inheritance diagram for Neighborhood:



Public Member Functions

- Neighborhood (int n)

    Constructor.
- virtual ∼Neighborhood ()

    Destructor.
- virtual void set_origin (const bit_vector_t &x)

    Set the origin.
- virtual const bit_vector_t & get_origin () const

    Get the origin.
- virtual const bit_vector_t & get_candidate () const

    Get the candidate bit vector.
- virtual const sparse_bit_vector_t & get_flipped_bits () const

    Get flipped bits.
- virtual void propose ()

    Propose a candidate bit vector.
- virtual void keep ()

    Keep the candidate bit vector.
- virtual void forget ()

    Forget the candidate bit vector.
- virtual void mutate (bit_vector_t &bv)

    Mutate.
- virtual void map (const bit_vector_t &input, bit_vector_t &output)

    Map.

Protected Member Functions

- virtual void sample_bits ()=0

    Sample bits.

Protected Attributes

- bit_vector_t _origin

    Origin of the neighborhood.
- bit_vector_t _candidate

    candidate bit vector
- std::uniform_int_distribution< int > _index_dist

    Index distribution.
- sparse_bit_vector_t _flipped_bits

    Flipped bits.

5.84.1 Detailed Description

Neighborhood.

A neighborhood maintains two points, _origin and _candidate. They are initialized in the same state by set_origin. A Neighborhood class must implement the member function sample_bits which samples the bits to flip in _origin to get a _candidate. The following member functions take care of the modifications:

- propose: flip _candidate
- keep: flip _origin
- forget flip _candidate

After keep or forget, _origin and _candidate are in the same state again.

A Neighborhood class can also behave as a mutation operator through the member functions mutate and map.

Definition at line 61 of file neighborhood.hh.

5.84.2 Constructor & Destructor Documentation

5.84.2.1 Neighborhood()

```
Neighborhood (
            int n ) [inline]
```

Constructor.

Parameters

n	Size of bit vectors

Definition at line 86 of file neighborhood.hh.

5.84.3 Member Function Documentation

5.84.3.1 map()

```
virtual void map (
            const bit_vector_t & input,
            bit_vector_t & output )  [inline], [virtual]
```

Map.

The output bit vector is a mutated version of the input bit vector.

Parameters

input	Input bit vector
output	Output bit vector

Definition at line 151 of file neighborhood.hh.

5.84.3.2 mutate()

```
virtual void mutate (
            bit_vector_t & bv )  [inline], [virtual]
```

Mutate.

In-place mutation of the bit vector.

Parameters

bv	Bit vector to mutate

Definition at line 137 of file neighborhood.hh.

The documentation for this class was generated from the following file:

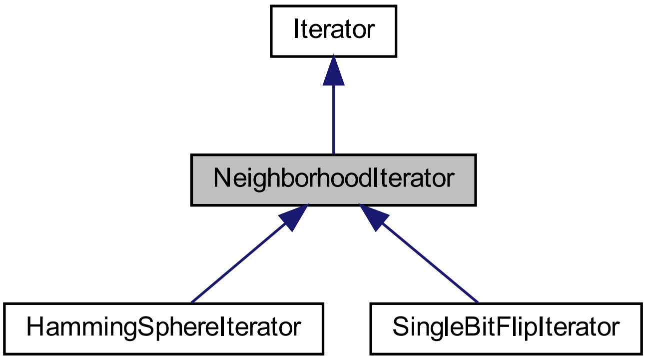
- lib/hnco/neighborhoods/neighborhood.hh

5.85 NeighborhoodIterator Class Reference

Neighborhood iterator.

`#include <hnco/neighborhoods/neighborhood-iterator.hh>`

Inheritance diagram for NeighborhoodIterator:



Public Member Functions

- NeighborhoodIterator (int n)

    Constructor.
- virtual void set_origin (const bit_vector_t &x)

    Set origin.

Additional Inherited Members

5.85.1 Detailed Description

Neighborhood iterator.

A neighborhood iterator allows to iterate over bit vectors in the neighborhood of a given origin. The origin itself should not belong to the neighborhood.

Definition at line 38 of file neighborhood-iterator.hh.

5.85.2 Constructor & Destructor Documentation

5.85.2.1 NeighborhoodIterator()

```
NeighborhoodIterator (
            int n ) [inline]
```

Constructor.

Parameters

n	Size of bit vectors

Definition at line 47 of file neighborhood-iterator.hh.

The documentation for this class was generated from the following files:

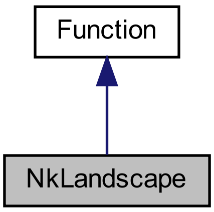
- lib/hnco/neighborhoods/neighborhood-iterator.hh
- lib/hnco/neighborhoods/neighborhood-iterator.cc

5.86 NkLandscape Class Reference

NK landscape.

`#include <hnco/functions/collection/nk-landscape.hh>`

Inheritance diagram for NkLandscape:



Public Member Functions

- NkLandscape ()
  Default constructor.
- int get_bv_size () const override
  Get bit vector size.
- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.
- void display (std::ostream &stream) const override
  Display.

Instance generators

- template<class Generator >
  void generate (int n, int k, Generator generator)
  Instance generator.
- void random (int n, int k)
  Random instance.

Load and save instance

- void load (std::string path)
  Load instance.
- void save (std::string path) const
  Save instance.

Private Member Functions

- template<class Archive >
  void serialize (Archive &ar, const unsigned int version)

  Serialize.
- void random_structure (int n, int k)

  Random structue.

Private Attributes

- std::vector< std::vector< int > > _neighbors

  Bit neighbors.
- std::vector< std::vector< double > > _partial_functions

  Partial functions.

Friends

- class **boost::serialization::access**

5.86.1 Detailed Description

NK landscape.

Reference:

S. A. Kauffman. 1993. The origins of order: self-organisation and selection in evolution. Oxford University Press.

Definition at line 45 of file nk-landscape.hh.

5.86.2 Member Function Documentation

5.86.2.1 generate()

```
void generate (
            int n,
            int k,
            Generator generator )  [inline]
```

Instance generator.

Parameters

n	Size of bit vector
k	Number of neighbors per bit
generator	Generator for partial function values

Definition at line 89 of file nk-landscape.hh.

5.86.2.2 load()

```
void load (
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 126 of file nk-landscape.hh.

5.86.2.3 random()

```
void random (
            int n,
            int k )  [inline]
```

Random instance.

Partial function values are sampled from the normal distribution.

Parameters

n	Size of bit vector
k	Number of neighbors per bit

Definition at line 107 of file nk-landscape.hh.

5.86.2.4 random_structure()

```
void random_structure (
            int n,
            int k )  [private]
```

Random structue.

Parameters

n	Size of bit vector
k	Number of neighbors per bit

Definition at line 32 of file nk-landscape.cc.

5.86.2.5 save()

```
void save (
            std::string path ) const  [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 133 of file nk-landscape.hh.

The documentation for this class was generated from the following files:

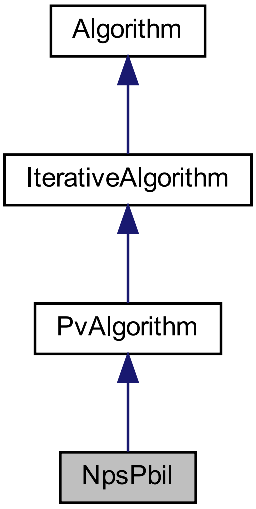
- lib/hnco/functions/collection/nk-landscape.hh
- lib/hnco/functions/collection/nk-landscape.cc

5.87 NpsPbil Class Reference

Population-based incremental learning with negative and positive selection.

```
#include <hnco/algorithms/pv/nps-pbil.hh>
```

Inheritance diagram for NpsPbil:



Public Member Functions

- NpsPbil (int n, int population_size)

  Constructor.

Setters

- void set_selection_size (int x)

  Set the selection size.
- void set_learning_rate (double x)

  Set the learning rate.

Protected Member Functions

Loop

- void init () override

  Initialize.
- void iterate () override

  Single iteration.

Protected Attributes

- Population _population
  Population.
- pv_t _mean_best
  Mean of best individuals.
- pv_t _mean_worst
  Mean of worst individuals.

Parameters

- int _selection_size = 1
  Selection size.
- double _learning_rate = 1e-3
  Learning rate.

5.87.1 Detailed Description

Population-based incremental learning with negative and positive selection.

Reference:

Arnaud Berny. 2001. Extending selection learning toward fixed-length d-ary strings. In Artificial Evolution (Lecture Notes in Computer Science), P. Collet and others (Eds.). Springer, Le Creusot.

Definition at line 42 of file nps-pbil.hh.

The documentation for this class was generated from the following files:

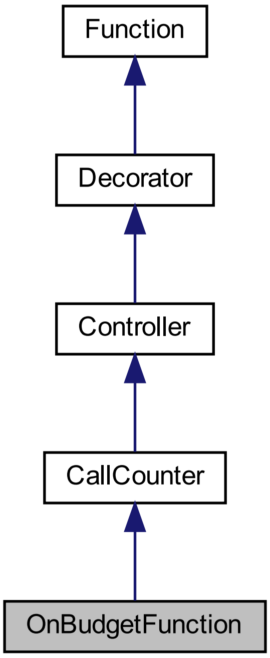
- lib/hnco/algorithms/pv/nps-pbil.hh
- lib/hnco/algorithms/pv/nps-pbil.cc

5.88 OnBudgetFunction Class Reference

Function with a limited number of evaluations.

```
#include <hnco/functions/controllers/controller.hh>
```

Inheritance diagram for OnBudgetFunction:



Public Member Functions

- OnBudgetFunction (Function ∗function, int budget)

  Constructor.

Evaluation

- double evaluate (const bit_vector_t &)

  Evaluate a bit vector.
- double evaluate_incrementally (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_t &flipped_bits)

  Incrementally evaluate a bit vector.
- void update (const bit_vector_t &x, double value)

  Update after a safe evaluation.

Private Attributes

- int _budget

  Budget.

Additional Inherited Members

5.88.1 Detailed Description

Function with a limited number of evaluations.

Definition at line 186 of file controller.hh.

5.88.2 Member Function Documentation

5.88.2.1 evaluate()

```
double evaluate (
            const bit_vector_t & x )  [virtual]
```

Evaluate a bit vector.

Exceptions

LastEvaluation	

Reimplemented from CallCounter.

Definition at line 97 of file controller.cc.

5.88.2.2 evaluate_incrementally()

```
double evaluate_incrementally (
            const bit_vector_t & x,
            double value,
            const hnco::sparse_bit_vector_t & flipped_bits )  [virtual]
```

Incrementally evaluate a bit vector.

Exceptions

LastEvaluation	

Reimplemented from CallCounter.

Definition at line 106 of file controller.cc.

5.88.2.3 update()

```
void update (
            const bit_vector_t & x,
            double value )  [virtual]
```

Update after a safe evaluation.

Exceptions

LastEvaluation	

Reimplemented from CallCounter.

Definition at line 115 of file controller.cc.

The documentation for this class was generated from the following files:

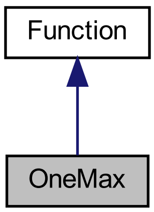
- lib/hnco/functions/controllers/controller.hh
- lib/hnco/functions/controllers/controller.cc

5.89 OneMax Class Reference

OneMax.

```
#include <hnco/functions/collection/theory.hh>
```

Inheritance diagram for OneMax:



Public Member Functions

- OneMax (int bv_size)

  Constructor.

Information about the function

- int get_bv_size () const override

  Get bit vector size.
- double get_maximum () const override

  Get the global maximum.
- bool has_known_maximum () const override

  Check for a known maximum.
- bool provides_incremental_evaluation () const override

  Check whether the function provides incremental evaluation.
- void display (std::ostream &stream) const override

  Display.

Evaluation

- double evaluate (const bit_vector_t &) override

  Evaluate a bit vector.
- double evaluate_incrementally (const bit_vector_t &x, double v, const hnco::sparse_bit_vector_t &flipped_bits) override

  Incrementally evaluate a bit vector.

Private Attributes

- int _bv_size

  Bit vector size.

5.89.1 Detailed Description

OneMax.

References:

Heinz Mühlenbein, "How genetic algorithms really work: I. mutation and hillclimbing", in Proc. 2nd Int. Conf. on Parallel Problem Solving from Nature, 1992

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 41 of file theory.hh.

5.89.2 Member Function Documentation

5.89.2.1 get_maximum()

```
double get_maximum ( ) const  [inline], [override], [virtual]
```

Get the global maximum.

Returns

_bv_size

Reimplemented from Function.

Definition at line 61 of file theory.hh.

5.89.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const  [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 65 of file theory.hh.

5.89.2.3 provides_incremental_evaluation()

```
bool provides_incremental_evaluation ( ) const  [inline], [override], [virtual]
```

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 70 of file theory.hh.

The documentation for this class was generated from the following files:

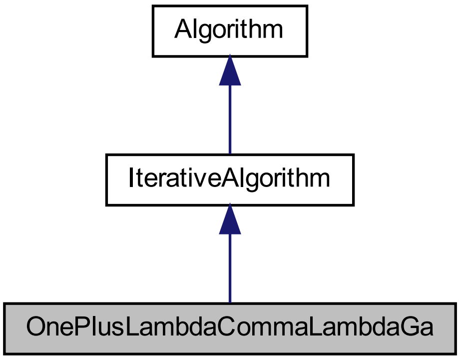
- lib/hnco/functions/collection/theory.hh
- lib/hnco/functions/collection/theory.cc

5.90 OnePlusLambdaCommaLambdaGa Class Reference

(1+(lambda, lambda)) genetic algorithm.

`#include <hnco/algorithms/ea/one-plus-lambda-comma-lambda-ga.hh>`

Inheritance diagram for OnePlusLambdaCommaLambdaGa:



Public Member Functions

- OnePlusLambdaCommaLambdaGa (int n, int lambda)

  Constructor.

Setters

- void set_mutation_rate (double p)

  Set the mutation rate.
- void set_crossover_bias (double x)

  Set the crossover bias.

Protected Member Functions

Loop

- void init () override

  Initialize.
- void iterate () override

  Single iteration.

Protected Attributes

- Population _offsprings
  Offsprings.
- std::binomial_distribution< int > _radius_dist
  Radius distribution.
- neighborhood::HammingSphere _mutation
  Mutation operator.
- bit_vector_t _parent
  Parent.
- BiasedCrossover _crossover
  Biased crossover.

Parameters

- double _mutation_rate
  Mutation rate.
- double _crossover_bias
  Crossover bias.

5.90.1 Detailed Description

(1+(lambda, lambda)) genetic algorithm.

Reference:

Benjamin Doerr, Carola Doerr, and Franziska Ebel. 2015. From black-box complexity to designing new genetic algorithms. Theoretical Computer Science 567 (2015), 87–104.

Definition at line 49 of file one-plus-lambda-comma-lambda-ga.hh.

5.90.2 Constructor & Destructor Documentation

5.90.2.1 OnePlusLambdaCommaLambdaGa()

```
OnePlusLambdaCommaLambdaGa (
              int n,
              int lambda )  [inline]
```

Constructor.

By default, _mutation_rate is set to lambda / n and _crossover_bias to 1 / lambda.

Parameters

n	Size of bit vectors
lambda	Offspring population size

Definition at line 103 of file one-plus-lambda-comma-lambda-ga.hh.

The documentation for this class was generated from the following files:

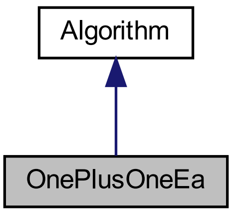
- lib/hnco/algorithms/ea/one-plus-lambda-comma-lambda-ga.hh
- lib/hnco/algorithms/ea/one-plus-lambda-comma-lambda-ga.cc

5.91 OnePlusOneEa Class Reference

(1+1) EA.

```
#include <hnco/algorithms/ea/one-plus-one-ea.hh>
```

Inheritance diagram for OnePlusOneEa:



Public Member Functions

- OnePlusOneEa (int n)

  Constructor.
- void maximize (const std::vector< function::Function ∗ > &functions) override

  Maximize.
- void finalize () override

  Finalize.

Setters

- void set_num_iterations (int x)

  Set the number of iterations.
- void set_mutation_rate (double p)

  Set the mutation rate.
- void set_allow_no_mutation (bool b)

  Set the flag _allow_no_mutation.
- void set_incremental_evaluation (bool x)

  Set incremental evaluation.

Private Attributes

- neighborhood::StandardBitMutation _neighborhood

  Neighborhood.
- RandomLocalSearch _rls

  Random local search.

Parameters

- int _num_iterations = 0

  Number of iterations.
- double _mutation_rate

  Mutation rate.
- bool _allow_no_mutation = false

  Allow no mutation.
- bool _incremental_evaluation = false

  Incremental evaluation.

Additional Inherited Members

5.91.1 Detailed Description

(1+1) EA.

(1+1) EA is implemented as a RandomLocalSearch with a StandardBitMutation neighborhood and infinite patience. Thus the class OnePlusOneEa is derived from Algorithm instead of IterativeAlgorithm.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 45 of file one-plus-one-ea.hh.

5.91.2 Constructor & Destructor Documentation

5.91.2.1 OnePlusOneEa()

```
OnePlusOneEa (
        int n )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors

_mutation_rate is initialized to 1 / n.

Definition at line 80 of file one-plus-one-ea.hh.

5.91.3 Member Function Documentation

5.91.3.1 set_num_iterations()

```
void set_num_iterations (
             int x )  [inline]
```

Set the number of iterations.

Parameters

x	Number of iterations

x <= 0 means indefinite

Definition at line 111 of file one-plus-one-ea.hh.

The documentation for this class was generated from the following file:

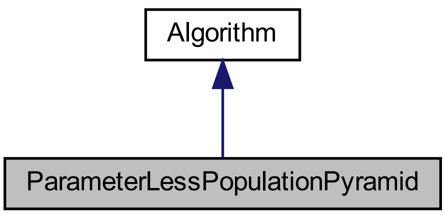
- lib/hnco/algorithms/ea/one-plus-one-ea.hh

5.92 ParameterLessPopulationPyramid Class Reference

Parameter-less Population Pyramid.

```
#include <hnco/algorithms/fast-efficient-p3/p3.hh>
```

Inheritance diagram for ParameterLessPopulationPyramid:



Public Member Functions

- ParameterLessPopulationPyramid (int n)
  Constructor.
- ∼ParameterLessPopulationPyramid ()
  Destructor.
- void maximize (const std::vector< function::Function ∗ > &functions)
  Maximize.
- void finalize ()
  Finalize.

Private Attributes

- Implementation ∗ _pimpl
  Pointer to implementation.

Additional Inherited Members

5.92.1 Detailed Description

Parameter-less Population Pyramid.

Implemention of the Parameter-less Population Pyramid (P3 for short).

Author: Brian W. Goldman

Reference:

"Fast and Efficient Black Box Optimization using the Parameter-less Population Pyramid" by B. W. Goldman and W. F. Punch

Integrated into HNCO by Arnaud Berny

Definition at line 53 of file p3.hh.

5.92.2 Member Data Documentation

5.92.2.1 _pimpl

```
Implementation* _pimpl [private]
```

Pointer to implementation.

The main motivation for this pattern is to avoid including declarations from fast_efficient_p3 into the global namespace.

A raw pointer is used instead of a unique_ptr because the latter will not compile with pybind11.

Definition at line 64 of file p3.hh.

The documentation for this class was generated from the following files:

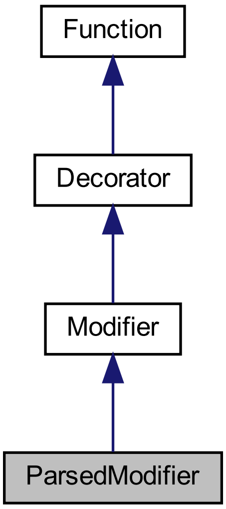
- lib/hnco/algorithms/fast-efficient-p3/p3.hh
- lib/hnco/algorithms/fast-efficient-p3/p3.cc

5.93 ParsedModifier Class Reference

Parsed modifier.

`#include <hnco/functions/modifiers/parsed-modifier.hh>`

Inheritance diagram for ParsedModifier:



Public Member Functions

- ParsedModifier (Function *function, std::string expression)
  Constructor.

Information about the function

- int get_bv_size () const override
  Get bit vector size.

Evaluation

- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.

Private Attributes

- FunctionParser _fparser
  Function parser.
- double _values [1]
  Array of values.

Additional Inherited Members

5.93.1 Detailed Description

Parsed modifier.

Let f be the original function. Then the modified function is equivalent to $g \circ f$, where g is a real function defined by an expression $g(x)$ provided as a string.

Definition at line 40 of file parsed-modifier.hh.

5.93.2 Constructor & Destructor Documentation

5.93.2.1 ParsedModifier()

```
ParsedModifier (
            Function * function,
            std::string expression )
```

Constructor.

Parameters

function	Decorated function
expression	Expression to parse

Definition at line 31 of file parsed-modifier.cc.

The documentation for this class was generated from the following files:

- lib/hnco/functions/modifiers/parsed-modifier.hh
- lib/hnco/functions/modifiers/parsed-modifier.cc

5.94 ParsedMultivariateFunction< Parser > Class Template Reference

Parsed multivariate function.

```
#include <hnco/functions/collection/parsed-multivariate-function.hh>
```

Public Types

- using domain_type = typename Parser::value_type
  Domain type.
- using codomain_type = typename Parser::value_type
  Codomain type.

Public Member Functions

- ParsedMultivariateFunction (std::string expression)
  Constructor.
- void display (std::ostream &stream) const
  Display the problem.
- codomain_type evaluate (const std::vector< domain_type > &x)
  Evaluate.
- void describe (const std::vector< domain_type > &x, std::ostream &stream)
  Describe a solution.
- int get_num_variables ()
  Get the number of variables.

Private Attributes

- Parser _fparser
  Function parser.
- std::vector< std::string > _variable_names
  Variable names.
- std::string _expression
  Expression.

5.94.1 Detailed Description

template<class Parser>
class hnco::function::ParsedMultivariateFunction< Parser >

Parsed multivariate function.

Uses the C++ library "Function Parser" (fparser):

`http://warp.povusers.org/FunctionParser/fparser.html`

Warning

The function string syntax depends on the chosen parser.

Definition at line 48 of file parsed-multivariate-function.hh.

5.94.2 Constructor & Destructor Documentation

5.94.2.1 ParsedMultivariateFunction()

```
ParsedMultivariateFunction (
            std::string expression ) [inline]
```

Constructor.

Parameters

expression	Expression to parse

Definition at line 71 of file parsed-multivariate-function.hh.

The documentation for this class was generated from the following file:

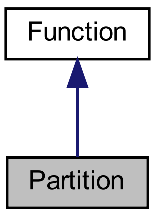
- lib/hnco/functions/collection/parsed-multivariate-function.hh

5.95 Partition Class Reference

Partition.

`#include <hnco/functions/collection/partition.hh>`

Inheritance diagram for Partition:



Public Member Functions

- Partition ()
  Constructor.
- int get_bv_size () const override
  Get bit vector size.
- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.

Instance generators

- template<class Generator >
  void generate (int n, Generator generator)
  Instance generator.
- void random (int n, int upper_bound)
  Random instance.

Load and save instance

- void load (std::string path)
  Load instance.
- void save (std::string path) const
  Save instance.

Display

- void display (std::ostream &stream) const override
  Display.
- void describe (const bit_vector_t &x, std::ostream &stream) override
  Describe a bit vector.

Private Member Functions

- template<class Archive >
  void serialize (Archive &ar, const unsigned int version)
  Serialize.

Private Attributes

- std::vector< int > _numbers
  Multiset of positive integers.

Friends

- class **boost::serialization::access**

5.95.1 Detailed Description

Partition.

Partition a finite multiset of positive integers into two subsets such that the sum of numbers in the first subset is the closest to the sum of numbers in the second subset.

The function computes the negation of the distance between the sum of numbers corresponding to ones in the bit vector and the sum of those corresponding to zeros. The negation is a consequence of the fact that algorithms in HNCO maximize rather than minimize a function.

Definition at line 52 of file partition.hh.

5.95.2 Member Function Documentation

5.95.2.1 generate()

```
void generate (
            int n,
            Generator generator )  [inline]
```

Instance generator.

Parameters

n	Size of bit vectors
generator	Number generator

Definition at line 84 of file partition.hh.

5.95.2.2 load()

```
void load (
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 120 of file partition.hh.

5.95.2.3 random()

```
void random (
            int n,
            int upper_bound )  [inline]
```

Random instance.

The numbers are sampled from the uniform distribution on [1..upper_bound].

Parameters

n	Size of bit vector
upper_bound	Upper bound of positive integers

Definition at line 100 of file partition.hh.

5.95.2.4 save()

```
void save (
            std::string path ) const  [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 127 of file partition.hh.

The documentation for this class was generated from the following files:

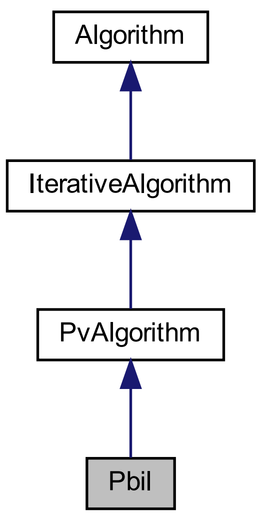
- lib/hnco/functions/collection/partition.hh
- lib/hnco/functions/collection/partition.cc

5.96 Pbil Class Reference

Population-based incremental learning.

`#include <hnco/algorithms/pv/pbil.hh>`

Inheritance diagram for Pbil:



Public Member Functions

- Pbil (int n, int population_size)

    Constructor.

Setters

- void set_selection_size (int x)

    Set the selection size.
- void set_learning_rate (double x)

    Set the learning rate.

Protected Member Functions

Loop

- void init () override

    Initialize.
- void iterate () override

    Single iteration.

Protected Attributes

- Population _population

    Population.
- pv_t _mean

    Mean of selected bit vectors.

Parameters

- int _selection_size = 1

    Selection size.
- double _learning_rate = 1e-3

    Learning rate.

5.96.1 Detailed Description

Population-based incremental learning.

Reference:

S. Baluja and R. Caruana. 1995. Removing the genetics from the standard genetic algorithm. In Proceedings of the 12th Annual Conference on Machine Learning. 38–46.

Definition at line 42 of file pbil.hh.

The documentation for this class was generated from the following files:

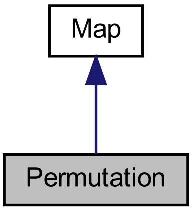
- lib/hnco/algorithms/pv/pbil.hh
- lib/hnco/algorithms/pv/pbil.cc

5.97 Permutation Class Reference

Permutation.

```
#include <hnco/maps/map.hh>
```

Inheritance diagram for Permutation:



Public Member Functions

- void random (int n)

  Random instance.
- void map (const bit_vector_t &input, bit_vector_t &output) override

  Map
- int get_input_size () const override

  Get input size.
- int get_output_size () const override

  Get output size.
- bool is_surjective () const override

  Check for surjective map.

Load and save map

- void load (std::string path)

  Load map.
- void save (std::string path) const

  Save map.

Private Member Functions

- template<class Archive >
  void save (Archive &ar, const unsigned int version) const

  Save.
- template<class Archive >
  void load (Archive &ar, const unsigned int version)

  Load.

Private Attributes

- permutation_t _permutation

  Permutation.

Friends

- class **boost::serialization::access**

5.97.1 Detailed Description

Permutation.

A permutation is a linear map f from F_2^n to itself defined by $f(x) = y$, where $y_i = x_{\sigma_i}$ and σ is a permutation of 0, 1, ..., n - 1.

Definition at line 167 of file map.hh.

5.97.2 Member Function Documentation

5.97.2.1 is_surjective()

```
bool is_surjective ( ) const  [inline], [override], [virtual]
```

Check for surjective map.

Returns

true

Reimplemented from Map.

Definition at line 218 of file map.hh.

5.97.2.2 load()

```
void load (
            std::string path )  [inline]
```

Load map.

Parameters

path	Path of the file

Exceptions

std::runtime_error	

Definition at line 229 of file map.hh.

5.97.2.3 save()

```
void save (
            std::string path ) const  [inline]
```

Save map.

Parameters

path	Path of the file

Exceptions

std::runtime_error	

Definition at line 236 of file map.hh.

The documentation for this class was generated from the following files:

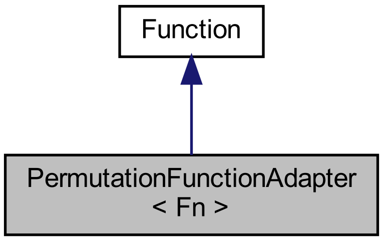
- lib/hnco/maps/map.hh
- lib/hnco/maps/map.cc

5.98 PermutationFunctionAdapter< Fn > Class Template Reference

Permutation function adapter.

```
#include <hnco/functions/permutation-function-adapter.hh>
```

Inheritance diagram for PermutationFunctionAdapter< Fn >:



Public Member Functions

- PermutationFunctionAdapter (Fn ∗fn, representation::PermutationRepresentation rep)

  Constructor.
- int get_bv_size () const override

  Get bit vector size.
- double evaluate (const bit_vector_t &bv) override

  Evaluate.
- void display (std::ostream &stream) const override

  Display.
- void describe (const bit_vector_t &bv, std::ostream &stream) override

  Describe a bit vector.

Private Member Functions

- void unpack (const bit_vector_t &bv)

  Unpack a bit vector into a permutation.

Private Attributes

- Fn ∗ _function

  Permutation function.
- representation::PermutationRepresentation _representation

  Permutation representation.
- permutation_t _permutation

  Permutation.

5.98.1 Detailed Description

template<class Fn>
class hnco::function::PermutationFunctionAdapter< Fn >

Permutation function adapter.

The purpose of this class is to build a regular hnco function from an arbitrary function over permutations. This is achieved using a permutation representation.

Definition at line 42 of file permutation-function-adapter.hh.

5.98.2 Constructor & Destructor Documentation

5.98.2.1 PermutationFunctionAdapter()

```
PermutationFunctionAdapter (
            Fn * fn,
            representation::PermutationRepresentation rep )  [inline]
```

Constructor.

Parameters

fn	Multivariate function
rep	Permutation representation

Definition at line 66 of file permutation-function-adapter.hh.

The documentation for this class was generated from the following file:

- lib/hnco/functions/permutation-function-adapter.hh

5.99 PermutationRepresentation Class Reference

Permutation representation.

```
#include <hnco/representations/permutation.hh>
```

Classes

- struct Element

    Element.

Public Member Functions

- PermutationRepresentation (int num_elements, int num_additional_bits)

    Constructor.
- int get_num_elements () const

    Get number of elements.
- int size () const

    Size of the representation.
- void unpack (const bit_vector_t &bv, int start, hnco::permutation_t &permutation)

    Unpack bit vector into a permutation.
- void display (std::ostream &stream) const

    Display.

Private Attributes

- std::vector< Element > _elements

    Elements.
- int _num_bits

    Number of bits per element.
- int _representation_size

    Representation size.

5.99.1 Detailed Description

Permutation representation.

Definition at line 39 of file permutation.hh.

5.99.2 Constructor & Destructor Documentation

5.99.2.1 PermutationRepresentation()

```
PermutationRepresentation (
            int num_elements,
            int num_additional_bits )  [inline]
```

Constructor.

Each element is represented by an integer encoded using std::ceil(std::log(num_elements) / std::log(2)) + num_additional_bits.

Parameters

num_elements	Number of elements
num_additional_bits	Number of additional bits per element

Definition at line 73 of file permutation.hh.

The documentation for this class was generated from the following file:

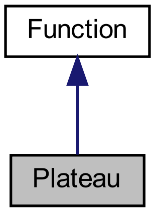
- lib/hnco/representations/permutation.hh

5.100 Plateau Class Reference

Plateau.

```
#include <hnco/functions/collection/theory.hh>
```

Inheritance diagram for Plateau:



Public Member Functions

- Plateau (int bv_size)

    Constructor.
- int get_bv_size () const override

    Get bit vector size.
- double evaluate (const bit_vector_t &) override

    Evaluate a bit vector.
- bool has_known_maximum () const override

    Check for a known maximum.
- double get_maximum () const override

    Get the global maximum.

Private Attributes

- int _bv_size

    Bit vector size.

5.100.1 Detailed Description

Plateau.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 242 of file theory.hh.

5.100.2 Member Function Documentation

5.100.2.1 get_maximum()

```
double get_maximum ( ) const [inline], [override], [virtual]
```

Get the global maximum.

Returns

_bv_size + 2

Reimplemented from Function.

Definition at line 265 of file theory.hh.

5.100.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 261 of file theory.hh.

The documentation for this class was generated from the following files:

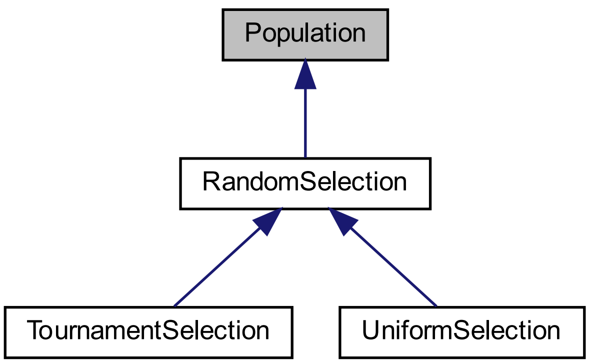
- lib/hnco/functions/collection/theory.hh
- lib/hnco/functions/collection/theory.cc

5.101 Population Class Reference

Population

```
#include <hnco/algorithms/population.hh>
```

Inheritance diagram for Population:



Public Member Functions

- Population (int population_size, int n)

  Constructor.
- int size () const

  Size.
- void random ()

  Initialize the population with random bit vectors.

Get bit vectors for non const populations

- bit_vector_t & get_bv (int i)

  Get a bit vector.
- bit_vector_t & get_best_bv ()

  Get best bit vector.
- bit_vector_t & get_best_bv (int i)

  Get best bit vector.
- bit_vector_t & get_worst_bv (int i)

  Get worst bit vector.

Get bit vectors for const populations

- const bit_vector_t & get_bv (int i) const

  Get a bit vector.
- const bit_vector_t & get_best_bv () const

  Get best bit vector.
- const bit_vector_t & get_best_bv (int i) const

  Get best bit vector.
- const bit_vector_t & get_worst_bv (int i) const

  Get worst bit vector.

Get sorted values

- double get_best_value (int i) const

  Get best value.
- double get_best_value () const

  Get best value.

Evaluation and sorting

- void evaluate (function::Function ∗function)

  Evaluate the population.
- void evaluate_in_parallel (const std::vector< function::Function ∗ > &functions)

  Evaluate the population in parallel.
- void shuffle ()

  Shuffle the lookup table.
- void sort ()

  Sort the lookup table.
- void partial_sort (int selection_size)

  Partially sort the lookup table.

Selection

- void plus_selection (const Population &offsprings)

  Plus selection.
- void plus_selection (Population &offsprings)

  Plus selection.
- void comma_selection (const Population &offsprings)

  Comma selection.
- void comma_selection (Population &offsprings)

  Comma selection.

Protected Attributes

- std::vector< bit_vector_t > _bvs

    Unsorted population of bit vectors.
- std::vector< index_value_t > _lookup

    Lookup table.

5.101.1 Detailed Description

Population

Definition at line 50 of file population.hh.

5.101.2 Constructor & Destructor Documentation

5.101.2.1 Population()

```
Population (
            int population_size,
            int n )  [inline]
```

Constructor.

Parameters

population_size	Population size
n	Bit vector size

Definition at line 72 of file population.hh.

5.101.3 Member Function Documentation

5.101.3.1 comma_selection() [1/2]

```
void comma_selection (
            const Population & offsprings )
```

Comma selection.

Implemented with a copy.

Precondition

Offspring population must be partially sorted.

Warning

The function does not break ties randomly (workaround: shuffle offsprings).

Definition at line 116 of file population.cc.

5.101.3.2 comma_selection() [2/2]

```
void comma_selection (
            Population & offsprings )
```

Comma selection.

Implemented with a swap. Should be faster than comma_selection with a copy.

Precondition

Offspring population must be partially sorted.

Warning

The function does not break ties randomly (workaround: shuffle offsprings).

Modifies its argument.

Definition at line 130 of file population.cc.

5.101.3.3 get_best_bv() [1/4]

```
bit_vector_t& get_best_bv ( )  [inline]
```

Get best bit vector.

Precondition

The population must be sorted.

Definition at line 95 of file population.hh.

5.101.3.4 get_best_bv() [2/4]

```
const bit_vector_t& get_best_bv ( ) const [inline]
```

Get best bit vector.

Precondition

The population must be sorted.

Definition at line 127 of file population.hh.

5.101.3.5 get_best_bv() [3/4]

```
bit_vector_t& get_best_bv (
            int i ) [inline]
```

Get best bit vector.

Parameters

i	Index in the sorted population

Precondition

The population must be sorted.

Definition at line 103 of file population.hh.

5.101.3.6 get_best_bv() [4/4]

```
const bit_vector_t& get_best_bv (
            int i ) const [inline]
```

Get best bit vector.

Parameters

i	Index in the sorted population

Precondition

The population must be sorted.

Definition at line 135 of file population.hh.

5.101.3.7 get_best_value() [1/2]

```
double get_best_value ( ) const [inline]
```

Get best value.

Precondition

The population must be sorted.

Definition at line 164 of file population.hh.

5.101.3.8 get_best_value() [2/2]

```
double get_best_value (
            int i ) const [inline]
```

Get best value.

Parameters

i	Index in the sorted population

Precondition

The population must be sorted.

Definition at line 158 of file population.hh.

5.101.3.9 get_worst_bv() [1/2]

```
bit_vector_t& get_worst_bv (
            int i ) [inline]
```

Get worst bit vector.

Parameters

i	Index in the sorted population

Precondition

The population must be sorted.

Definition at line 111 of file population.hh.

5.101.3.10 get_worst_bv() [2/2]

```
const bit_vector_t& get_worst_bv (
            int i ) const  [inline]
```

Get worst bit vector.

Parameters

i	Index in the sorted population

Precondition

The population must be sorted.

Definition at line 143 of file population.hh.

5.101.3.11 plus_selection() [1/2]

```
void plus_selection (
            const Population & offsprings )
```

Plus selection.

Implemented with a copy.

Precondition

Both populations must be completely sorted.

Warning

The function does not break ties randomly (workaround: shuffle parents and offsprings).

Definition at line 78 of file population.cc.

5.101.3.12 plus_selection() [2/2]

```
void plus_selection (
            Population & offsprings )
```

Plus selection.

Implemented with a swap. Should be faster than plus_selection with a copy.

Precondition

Both populations must be completely sorted.

Warning

The function does not break ties randomly (workaround: shuffle parents and offsprings).
Modifies its argument.

Definition at line 97 of file population.cc.

5.101.4 Member Data Documentation

5.101.4.1 _lookup

```
std::vector<index_value_t> _lookup [protected]
```

Lookup table.

If p is an element of _lookup, then p.first is the index of the corresponding bit vector in the unsorted population whereas p.second is its value.

Definition at line 63 of file population.hh.

The documentation for this class was generated from the following files:

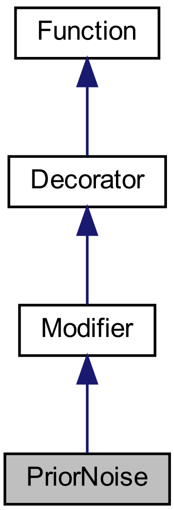
- lib/hnco/algorithms/population.hh
- lib/hnco/algorithms/population.cc

5.102 PriorNoise Class Reference

Prior noise.

```
#include <hnco/functions/modifiers/prior-noise.hh>
```

Inheritance diagram for PriorNoise:



Public Member Functions

- PriorNoise (Function ∗fn, neighborhood::Neighborhood ∗nh)
    Constructor.

Information about the function

- int get_bv_size () const override
    Get bit vector size.
- double get_maximum () const override
    Get the global maximum.
- bool has_known_maximum () const override
    Check for a known maximum.
- bool provides_incremental_evaluation () const override
    Check whether the function provides incremental evaluation.

Evaluation

- double evaluate (const bit_vector_t &) override
    Evaluate a bit vector.

Private Attributes

- neighborhood::Neighborhood ∗ _neighborhood
    Neighborhood.
- bit_vector_t _noisy_bv
    Noisy bit vector.

Additional Inherited Members

5.102.1 Detailed Description

Prior noise.

Definition at line 37 of file prior-noise.hh.

5.102.2 Member Function Documentation

5.102.2.1 get_maximum()

```
double get_maximum ( ) const  [inline], [override], [virtual]
```

Get the global maximum.

Delegation is questionable here.

Reimplemented from Function.

Definition at line 69 of file prior-noise.hh.

5.102.2.2 has_known_maximum()

`bool has_known_maximum ( ) const [inline], [override], [virtual]`

Check for a known maximum.

Delegation is questionable here.

Reimplemented from Function.

Definition at line 75 of file prior-noise.hh.

5.102.2.3 provides_incremental_evaluation()

`bool provides_incremental_evaluation ( ) const [inline], [override], [virtual]`

Check whether the function provides incremental evaluation.

Returns

false

Reimplemented from Function.

Definition at line 79 of file prior-noise.hh.

The documentation for this class was generated from the following files:

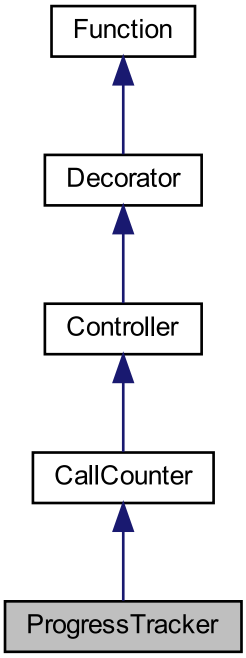
- lib/hnco/functions/modifiers/prior-noise.hh
- lib/hnco/functions/modifiers/prior-noise.cc

5.103 ProgressTracker Class Reference

ProgressTracker.

`#include <hnco/functions/controllers/controller.hh>`

Inheritance diagram for ProgressTracker:



Classes

- struct Event

    Event

Public Member Functions

- ProgressTracker (Function ∗function)

    Constructor.

Evaluation

- double evaluate (const bit_vector_t &)

    Evaluate a bit vector.
- double evaluate_incrementally (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_t &flipped_bits)

    Incrementally evaluate a bit vector.
- void update (const bit_vector_t &x, double value)

    Update after a safe evaluation.

Get information

- const Event & get_last_improvement ()

Get the last improvement.
- double get_evaluation_time ()

  Get evaluation time.

Setters

- void set_log_improvement (bool x)

  Log improvement.
- void set_record_evaluation_time (bool b)

  Record evaluation time.

Protected Member Functions

- void update_last_improvement (double value)

  Update last improvement.

Protected Attributes

- Event _last_improvement

  Last improvement.
- StopWatch _stop_watch

  Stop watch.

Parameters

- bool _log_improvement = false

  Log improvement.
- bool _record_evaluation_time = false

  Record evaluation time.

5.103.1 Detailed Description

ProgressTracker.

A ProgressTracker is a CallCounter which keeps track the last improvement, that is its value and the number of evaluations needed to reach it.

Definition at line 226 of file controller.hh.

5.103.2 Member Function Documentation

5.103.2.1 get_last_improvement()

```
const Event& get_last_improvement ( ) [inline]
```

Get the last improvement.

Warning

If _last_improvement.num_evaluations is zero then _function has never been called. The Event returned by get_last_improvement has therefore no meaning.

Definition at line 302 of file controller.hh.

5.103.3 Member Data Documentation

5.103.3.1 _record_evaluation_time

```
bool _record_evaluation_time = false [protected]
```

Record evaluation time.

Only relevant for ProgressTracker::evaluate.

Definition at line 260 of file controller.hh.

The documentation for this class was generated from the following files:

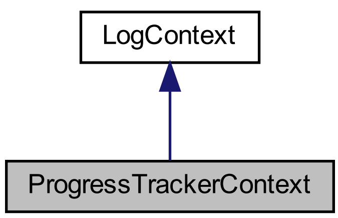
- lib/hnco/functions/controllers/controller.hh
- lib/hnco/functions/controllers/controller.cc

5.104 ProgressTrackerContext Class Reference

Log context for ProgressTracker.

```
#include <hnco/logging/log-context.hh>
```

Inheritance diagram for ProgressTrackerContext:



Public Member Functions

- ProgressTrackerContext (hnco::function::controller::ProgressTracker *pt)

  Constructor.
- std::string to_string ()

  Get context.

Private Attributes

- hnco::function::controller::ProgressTracker * _pt

  Progress tracker.

5.104.1 Detailed Description

Log context for ProgressTracker.

Definition at line 50 of file log-context.hh.

The documentation for this class was generated from the following file:

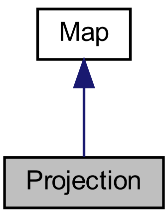
- lib/hnco/logging/log-context.hh

5.105 Projection Class Reference

Projection.

`#include <hnco/maps/map.hh>`

Inheritance diagram for Projection:



Public Member Functions

- Projection (const std::vector< int > &bit_positions, int input_size)
  Constructor.
- void map (const bit_vector_t &input, bit_vector_t &output) override
  Map
- int get_input_size () const override
  Get input size.
- int get_output_size () const override
  Get output size.
- bool is_surjective () const override
  Check for surjective map.

Private Attributes

- std::vector< int > _bit_positions
  Bit positions.
- int _input_size
  Input size.

5.105.1 Detailed Description

Projection.

The projection y of a bit vector x is x where we have dropped a given set of components.

Let $I = \{i_1, i_2, \ldots, i_m\}$ be a subset of $\{1, 2, \ldots, n\}$.

A projection f from F_2^n to F_2^m, where $n \geq m$, is defined by $f(x) = y$, where, for all $j \in \{1, 2, \ldots, m\}$, $y_j = x_{i_j}$.

If f is a projection and g is an injection with the same bit positions then their composition $f \circ g$ is the identity.

Definition at line 549 of file map.hh.

5.105.2 Constructor & Destructor Documentation

5.105.2.1 Projection()

```
Projection (
            const std::vector< int > & bit_positions,
            int input_size )
```

Constructor.

The output size of the map is given by the size of bit_positions.

Parameters

bit_positions	Bit positions in the input from where output bits are copied
input_size	Input size

Precondition

input_size >= bit_positions.size()

Definition at line 196 of file map.cc.

5.105.3 Member Function Documentation

5.105.3.1 is_surjective()

```
bool is_surjective ( ) const  [inline], [override], [virtual]
```

Check for surjective map.

Returns

true

Reimplemented from Map.

Definition at line 587 of file map.hh.

The documentation for this class was generated from the following files:

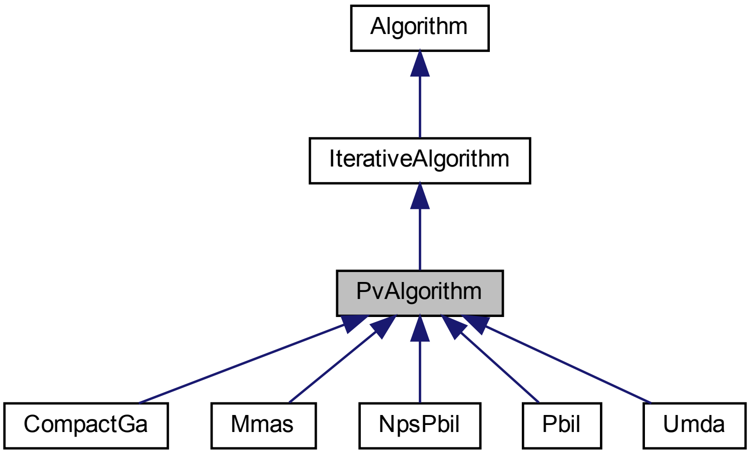
- lib/hnco/maps/map.hh
- lib/hnco/maps/map.cc

5.106 PvAlgorithm Class Reference

Probability vector algorithm.

```
#include <hnco/algorithms/pv/pv-algorithm.hh>
```

Inheritance diagram for PvAlgorithm:



Public Member Functions

- PvAlgorithm (int n)

  Constructor.

Setters for logging

- void set_log_entropy (bool x)

  Log entropy.
- void set_log_num_components (int x)

  Set the number of probability vector components to log.
- void set_log_pv (bool x)

  Log probability vector.

Protected Member Functions

- void set_something_to_log ()

  Set flag for something to log.

Loop

- void log () override

  Log.

Protected Attributes

- pv_t _pv

    Probability vector.
- double _lower_bound

    Lower bound of probability.
- double _upper_bound

    Upper bound of probability.

Logging

- bool _log_entropy = false

    Log entropy.
- bool _log_pv = false

    Log probability vector.
- int _log_num_components = 5

    Number of probability vector components to log.

5.106.1 Detailed Description

Probability vector algorithm.

Definition at line 33 of file pv-algorithm.hh.

The documentation for this class was generated from the following files:

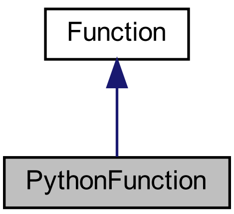
- lib/hnco/algorithms/pv/pv-algorithm.hh
- lib/hnco/algorithms/pv/pv-algorithm.cc

5.107 PythonFunction Class Reference

Python function.

```
#include <hnco/functions/collection/python-function.hh>
```

Inheritance diagram for PythonFunction:



Public Member Functions

- PythonFunction (std::string path, std::string name)

    Constructor.
- ∼PythonFunction ()

    Destructor.
- int get_bv_size () const

    Get bit vector size.
- double evaluate (const bit_vector_t &)

    Evaluate a bit vector.

Private Attributes

- pybind11::object _scope

    Module.
- Function ∗ _function

    Function.

5.107.1 Detailed Description

Python function.

Uses pybind11.

The constructor initializes the python interpreter and the destructor finalizes it.

The python code must import the hnco module (built separately) to allow for communication between C++ and python. It must also define a derived class that inherits Function and an instance of it.

Definition at line 47 of file python-function.hh.

5.107.2 Constructor & Destructor Documentation

5.107.2.1 PythonFunction()

```
PythonFunction (
            std::string path,
            std::string name )
```

Constructor.

Parameters

path	Path of the python file
name	Name of the Function instance defined in the python file

Definition at line 32 of file python-function.cc.

The documentation for this class was generated from the following files:

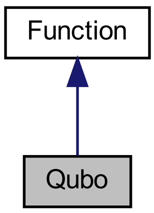
- lib/hnco/functions/collection/python-function.hh
- lib/hnco/functions/collection/python-function.cc

5.108 Qubo Class Reference

Quadratic unconstrained binary optimization.

`#include <hnco/functions/collection/qubo.hh>`

Inheritance diagram for Qubo:



Public Member Functions

- Qubo ()
  Constructor.
- int get_bv_size () const override
  Get bit vector size.
- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.

Load and save instance

- void load (std::string path)
  Load instance.

Private Member Functions

- void load (std::istream &stream)
  Load an instance.

Private Attributes

- std::vector< std::vector< double > > _q

  Matrix.

5.108.1 Detailed Description

Quadratic unconstrained binary optimization.

Its expression is of the form $f(x) = \sum_i Q_{ii} x_i + \sum_{i<j} Q_{ij} x_i x_j = x^T Q x$, where Q is an n x n upper-triangular matrix.

Qubo is the problem addressed by qbsolv. Here is its description as given on github:

Qbsolv, a decomposing solver, finds a minimum value of a large quadratic unconstrained binary optimization (QUBO) problem by splitting it into pieces solved either via a D-Wave system or a classical tabu solver.

There are some differences between WalshExpansion2 and Qubo:

- WalshExpansion2 maps 0/1 variables into -1/1 variables whereas Qubo directly deals with binary variables.
- Hence, there is a separate linear part in WalshExpansion2 whereas the linear part in Qubo stems from the diagonal elements of the given matrix.

qbsolv aims at minimizing quadratic functions whereas hnco algorithms aim at maximizing them. Hence Qubo::load negates all elements so that maximizing the resulting function is equivalent to minimizing the original Qubo.

References:

Michael Booth, Steven P. Reinhardt, and Aidan Roy. 2017. Partitioning Optimization Problems for Hybrid Classical/Quantum Execution. Technical Report. D-Wave.

https://github.com/dwavesystems/qbsolv

http://people.brunel.ac.uk/~mastjjb/jeb/orlib/bqpinfo.html

Definition at line 74 of file qubo.hh.

5.108.2 Member Function Documentation

5.108.2.1 load() [1/2]

```
void load (
            std::istream & stream )  [private]
```

Load an instance.

Exceptions

std::runtime_error	

Definition at line 37 of file qubo.cc.

5.108.2.2 load() [2/2]

```
void load (
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 105 of file qubo.hh.

5.108.3 Member Data Documentation

5.108.3.1 _q

```
std::vector<std::vector<double> > _q  [private]
```

Matrix.

n x n upper triangular matrix.

Definition at line 82 of file qubo.hh.

The documentation for this class was generated from the following files:

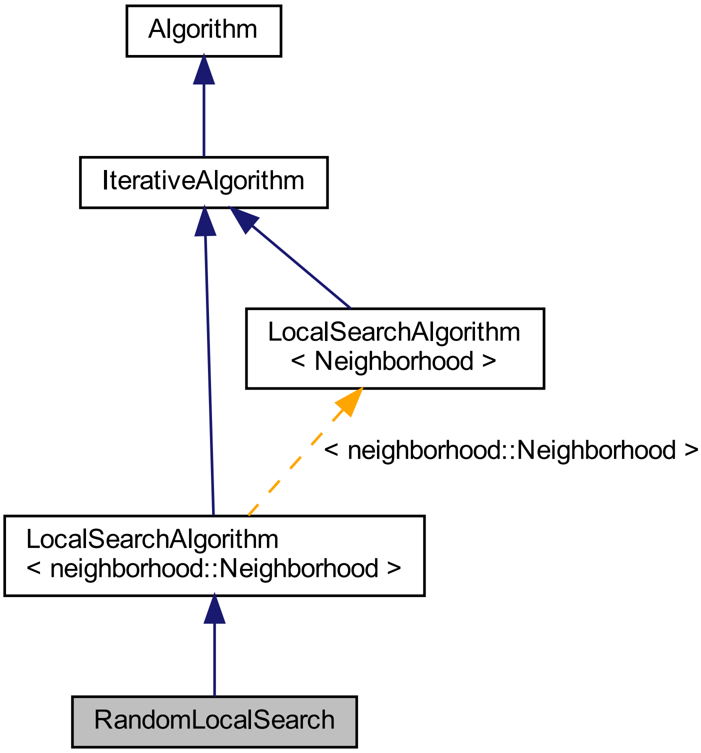
- lib/hnco/functions/collection/qubo.hh
- lib/hnco/functions/collection/qubo.cc

5.109 RandomLocalSearch Class Reference

Random local search.

`#include <hnco/algorithms/ls/random-local-search.hh>`

Inheritance diagram for RandomLocalSearch:



Public Member Functions

- RandomLocalSearch (int n, neighborhood::Neighborhood ∗neighborhood)
  Constructor.
- void finalize () override
  Finalize.

Setters

- void set_compare (std::function< bool(double, double)> x)
  Set the binary operator for comparing evaluations.
- void set_patience (int x)
  Set patience.
- void set_incremental_evaluation (bool x)
  Set incremental evaluation.

Protected Member Functions

- void iterate_full ()

  Single iteration with full evaluation.
- void iterate_incremental ()

  Single iteration with incremental evaluation.

Loop

- void init () override

  Initialize.
- void iterate () override

  Single iteration.

Protected Attributes

- int _num_failures

  Number of failure.

Parameters

- std::function< bool(double, double)> _compare = std::greater_equal<double>()

  Binary operator for comparing evaluations.
- int _patience = 50

  Patience.
- bool _incremental_evaluation = false

  Incremental evaluation.

5.109.1 Detailed Description

Random local search.

Definition at line 36 of file random-local-search.hh.

5.109.2 Member Function Documentation

5.109.2.1 set_patience()

```
void set_patience (
            int x )  [inline]
```

Set patience.

Number of consecutive rejected moves before ending the search.

Parameters

x	Patience

If x <= 0 then patience is considered infinite.

Definition at line 104 of file random-local-search.hh.

5.109.3 Member Data Documentation

5.109.3.1 _patience

```
int _patience = 50  [protected]
```

Patience.

Number of consecutive rejected moves before ending the search.

Definition at line 55 of file random-local-search.hh.

The documentation for this class was generated from the following files:

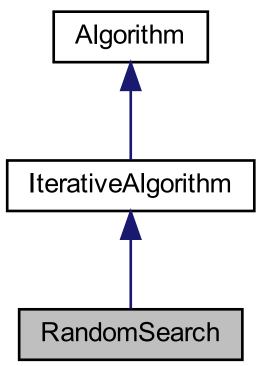
- lib/hnco/algorithms/ls/random-local-search.hh
- lib/hnco/algorithms/ls/random-local-search.cc

5.110 RandomSearch Class Reference

Random search.

```
#include <hnco/algorithms/random-search.hh>
```

Inheritance diagram for RandomSearch:



Public Member Functions

- RandomSearch (int n)
  Constructor.

Protected Member Functions

Loop

- void init () override
  Initialize.
- void iterate () override
  Single iteration.

Protected Attributes

- bit_vector_t _candidate
  Candidate.

5.110.1 Detailed Description

Random search.

Definition at line 31 of file random-search.hh.

The documentation for this class was generated from the following files:

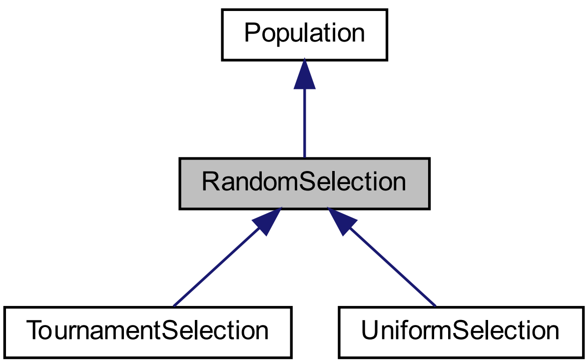
- lib/hnco/algorithms/random-search.hh
- lib/hnco/algorithms/random-search.cc

5.111 RandomSelection Class Reference

Random selection.

```
#include <hnco/algorithms/random-selection.hh>
```

Inheritance diagram for RandomSelection:



Public Member Functions

- RandomSelection (int population_size, int n)

  Constructor.
- virtual void init ()

  Initialize.
- virtual const bit_vector_t & select ()=0

  Select an individual in the population.

Additional Inherited Members

5.111.1 Detailed Description

Random selection.

Definition at line 34 of file random-selection.hh.

5.111.2 Constructor & Destructor Documentation

5.111.2.1 RandomSelection()

```
RandomSelection (
            int population_size,
            int n )  [inline]
```

Constructor.

Parameters

population_size	Population size
n	Bit vector size

Definition at line 44 of file random-selection.hh.

The documentation for this class was generated from the following file:

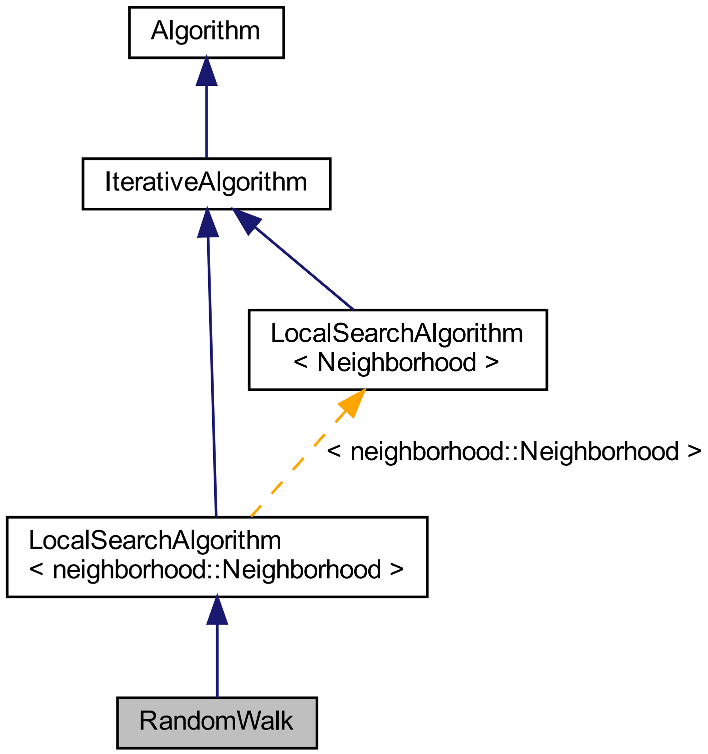
- lib/hnco/algorithms/random-selection.hh

5.112 RandomWalk Class Reference

Random walk.

```
#include <hnco/algorithms/ls/random-walk.hh>
```

Inheritance diagram for RandomWalk:



Public Member Functions

- RandomWalk (int n, neighborhood::Neighborhood ∗neighborhood)

  Constructor.

Setters

- void set_incremental_evaluation (bool x)

  Set incremental evaluation.
- void set_log_value ()

  Set log.

Protected Member Functions

- void iterate_full ()

  Single iteration with full evaluation.
- void iterate_incremental ()

  Single iteration with incremental evaluation.

Loop

- void iterate () override

  Single iteration.
- void log () override

  Log.

Protected Attributes

- double _value

  Value of the last visited bit vector.

Parameters

- bool _incremental_evaluation = false

  Incremental evaluation.

5.112.1 Detailed Description

Random walk.

The algorithm simply performs a random walk on the graph implicitly given by the neighborhood. At each iteration, the chosen neighbor does not depend on its evaluation. However optimization takes place as in random search, that is the best visited bit vector is remembered.

Definition at line 41 of file random-walk.hh.

The documentation for this class was generated from the following files:

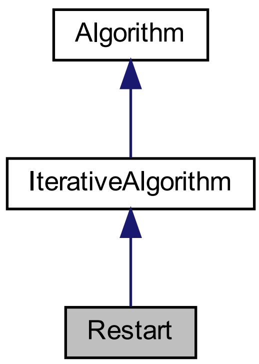
- lib/hnco/algorithms/ls/random-walk.hh
- lib/hnco/algorithms/ls/random-walk.cc

5.113 Restart Class Reference

Restart.

`#include <hnco/algorithms/decorators/restart.hh>`

Inheritance diagram for Restart:



Public Member Functions

- Restart (int n, Algorithm ∗algorithm)

  Constructor.

Protected Member Functions

Loop

- void iterate () override

  Single iteration.

Protected Attributes

- Algorithm ∗ _algorithm

  Algorithm.

5.113.1 Detailed Description

Restart.

Restart an Algorithm an indefinite number of times. Should be used in conjonction with OnBudgetFunction or StopOnMaximum.

Definition at line 38 of file restart.hh.

The documentation for this class was generated from the following files:

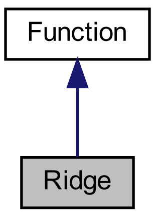
- lib/hnco/algorithms/decorators/restart.hh
- lib/hnco/algorithms/decorators/restart.cc

5.114 Ridge Class Reference

Ridge.

`#include <hnco/functions/collection/theory.hh>`

Inheritance diagram for Ridge:



Public Member Functions

- Ridge (int bv_size)
  Constructor.
- int get_bv_size () const override
  Get bit vector size.
- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.
- bool has_known_maximum () const override
  Check for a known maximum.
- double get_maximum () const override
  Get the global maximum.

Private Attributes

- int _bv_size
  Bit vector size.

5.114.1 Detailed Description

Ridge.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 207 of file theory.hh.

5.114.2 Member Function Documentation

5.114.2.1 get_maximum()

```
double get_maximum ( ) const  [inline], [override], [virtual]
```

Get the global maximum.

Returns

2 * _bv_size

Reimplemented from Function.

Definition at line 230 of file theory.hh.

5.114.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const  [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 226 of file theory.hh.

The documentation for this class was generated from the following files:

- lib/hnco/functions/collection/theory.hh
- lib/hnco/functions/collection/theory.cc

5.115 ScalarToDouble< T > Struct Template Reference

Convert a scalar to a double.

```
#include <hnco/functions/converter.hh>
```

Public Types

- using codomain_type = T

  Codomain type.

Public Member Functions

- double operator() (T x)

  Convert to double.

5.115.1 Detailed Description

template<class T>
struct hnco::function::ScalarToDouble< T >

Convert a scalar to a double.

Definition at line 32 of file converter.hh.

The documentation for this struct was generated from the following file:

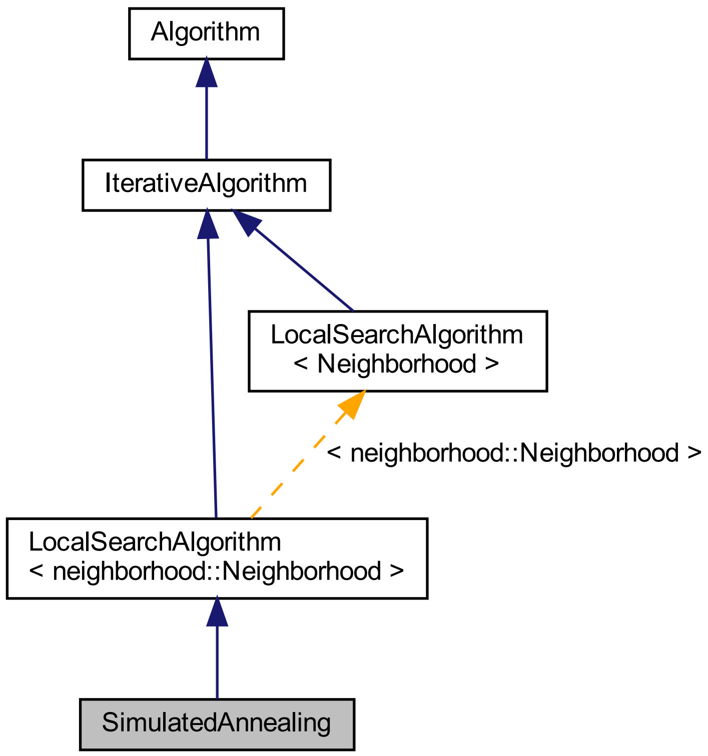
- lib/hnco/functions/converter.hh

5.116 SimulatedAnnealing Class Reference

Simulated annealing.

`#include <hnco/algorithms/ls/simulated-annealing.hh>`

Inheritance diagram for SimulatedAnnealing:



Public Member Functions

- SimulatedAnnealing (int n, neighborhood::Neighborhood ∗neighborhood)

  Constructor.

Setters

- void set_num_transitions (int x)

  Set the number of accepted transitions before annealing.
- void set_num_trials (int x)

  Set the Number of trials.
- void set_initial_acceptance_probability (double x)

  Set the initial acceptance probability.
- void set_beta_ratio (double x)

  Set ratio for beta.

Protected Member Functions

- void init_beta ()

    Initialize beta.

Loop

- void init () override

    Initialize.
- void iterate () override

    Single iteration.

Protected Attributes

- double _beta

    Inverse temperature.
- double _current_value

    Current value.
- int _transitions

    Number of accepted transitions.

Parameters

- int _num_transitions = 50

    Number of accepted transitions before annealing.
- int _num_trials = 100

    Number of trials.
- double _initial_acceptance_probability = 0.6

    Initial acceptance probability.
- double _beta_ratio = 1.2

    Ratio for beta.

5.116.1 Detailed Description

Simulated annealing.

Reference:

S. Kirkpatrick, C. D. Gelatt, and M. P. Vecchi. 1983. Optimization by simulated annealing. Science 220, 4598 (May 1983), 671–680.

Definition at line 42 of file simulated-annealing.hh.

5.116.2 Member Function Documentation

5.116.2.1 init_beta()

```
void init_beta ( ) [protected]
```

Initialize beta.

Requires (2 $*$ _num_trials) evaluations. This should be taken into account when using OnBudgetFunction.

Definition at line 34 of file simulated-annealing.cc.

The documentation for this class was generated from the following files:

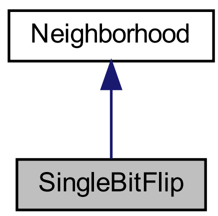
- lib/hnco/algorithms/ls/simulated-annealing.hh
- lib/hnco/algorithms/ls/simulated-annealing.cc

5.117 SingleBitFlip Class Reference

One bit neighborhood.

```
#include <hnco/neighborhoods/neighborhood.hh>
```

Inheritance diagram for SingleBitFlip:



Public Member Functions

- SingleBitFlip (int n)
  Constructor.

Private Member Functions

- void sample_bits ()
  Sample bits.

Additional Inherited Members

5.117.1 Detailed Description

One bit neighborhood.

Definition at line 163 of file neighborhood.hh.

The documentation for this class was generated from the following file:

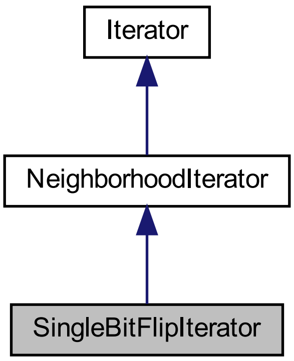
- lib/hnco/neighborhoods/neighborhood.hh

5.118 SingleBitFlipIterator Class Reference

Single bit flip neighborhood iterator.

```
#include <hnco/neighborhoods/neighborhood-iterator.hh>
```

Inheritance diagram for SingleBitFlipIterator:



Public Member Functions

- SingleBitFlipIterator (int n)

    Constructor.
- bool has_next () override

    Has next bit vector.
- const bit_vector_t & next () override

    Next bit vector.

Private Attributes

- size_t _index

    Index of the last flipped bit.

Additional Inherited Members

5.118.1 Detailed Description

Single bit flip neighborhood iterator.

Definition at line 56 of file neighborhood-iterator.hh.

5.118.2 Constructor & Destructor Documentation

5.118.2.1 SingleBitFlipIterator()

```
SingleBitFlipIterator (
            int n )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors

Definition at line 68 of file neighborhood-iterator.hh.

The documentation for this class was generated from the following files:

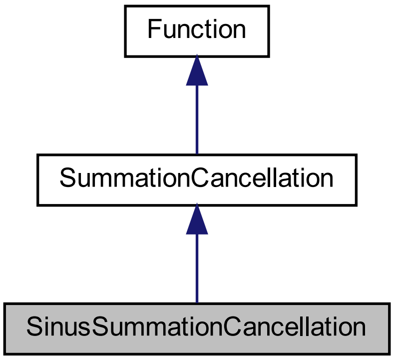
- lib/hnco/neighborhoods/neighborhood-iterator.hh
- lib/hnco/neighborhoods/neighborhood-iterator.cc

5.119 SinusSummationCancellation Class Reference

Summation cancellation with sinus.

```
#include <hnco/functions/collection/cancellation.hh>
```

Inheritance diagram for SinusSummationCancellation:



Public Member Functions

- SinusSummationCancellation (int n)

  Constructor.
- double evaluate (const bit_vector_t &x) override

  Evaluate a bit vector.

Additional Inherited Members

5.119.1 Detailed Description

Summation cancellation with sinus.

Reference:

M. Sebag and M. Schoenauer. 1997. A society of hill-climbers. In Proc. IEEE Int. Conf. on Evolutionary Computation. Indianapolis, 319–324.

Definition at line 101 of file cancellation.hh.

The documentation for this class was generated from the following files:

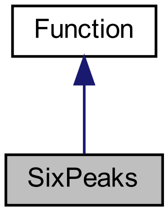
- lib/hnco/functions/collection/cancellation.hh
- lib/hnco/functions/collection/cancellation.cc

5.120 SixPeaks Class Reference

Six Peaks.

`#include <hnco/functions/collection/four-peaks.hh>`

Inheritance diagram for SixPeaks:



Public Member Functions

- SixPeaks (int bv_size, int threshold)

  Constructor.
- int get_bv_size () const override

  Get bit vector size.
- bool has_known_maximum () const override

  Check for a known maximum.
- double get_maximum () const override

  Get the global maximum.
- double evaluate (const bit_vector_t &) override

  Evaluate a bit vector.

Private Attributes

- int _bv_size

  Bit vector size.
- int _threshold

  Threshold.
- int _maximum

  Maximum.

5.120.1 Detailed Description

Six Peaks.

It is defined by

f(x) = max{head(x, 0) + tail(x, 1) + head(x, 1) + tail(x, 0)} + R(x)

where:

- head(x, 0) is the length of the longest prefix of x made of zeros;
- head(x, 1) is the length of the longest prefix of x made of ones;
- tail(x, 0) is the length of the longest suffix of x made of zeros;
- tail(x, 1) is the length of the longest suffix of x made of ones;
- R(x) is the reward;
- R(x) = n if (head(x, 0) $>$ t and tail(x, 1) $>$ t) or (head(x, 1) $>$ t and tail(x, 0) $>$ t);
- R(x) = 0 otherwise;
- the threshold t is a parameter of the function.

This function has six maxima, of which exactly four are global ones.

For example, if n = 6 and t = 1:

- f(111111) = 6 (local maximum)
- f(111110) = 5
- f(111100) = 10 (global maximum)

Reference:

J. S. De Bonet, C. L. Isbell, and P. Viola. 1996. MIMIC: finding optima by estimating probability densities. In Advances in Neural Information Processing Systems. Vol. 9. MIT Press, Denver.

Definition at line 128 of file four-peaks.hh.

5.120.2 Member Function Documentation

5.120.2.1 get_maximum()

`double get_maximum ( ) const [inline], [override], [virtual]`

Get the global maximum.

Returns

2 $*$ _bv_size - _threshold - 1

Reimplemented from Function.

Definition at line 156 of file four-peaks.hh.

5.120.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 152 of file four-peaks.hh.

The documentation for this class was generated from the following files:

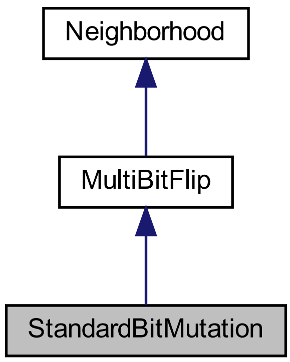
- lib/hnco/functions/collection/four-peaks.hh
- lib/hnco/functions/collection/four-peaks.cc

5.121 StandardBitMutation Class Reference

Standard bit mutation.

```
#include <hnco/neighborhoods/neighborhood.hh>
```

Inheritance diagram for StandardBitMutation:



Public Member Functions

- StandardBitMutation (int n)
  Constructor.
- StandardBitMutation (int n, double p)
  Constructor.
- void set_mutation_rate (double p)
  Set mutation rate.

Setters

- void set_allow_no_mutation (bool b)
  Set the flag _allow_no_mutation.

Private Member Functions

- void sample_bits ()
  Sample bits.
- void bernoulli_process ()
  Bernoulli process.

Private Attributes

- std::bernoulli_distribution _bernoulli_dist
  Bernoulli distribution (biased coin)
- std::binomial_distribution< int > _binomial_dist
  Binomial distribution.
- bool _rejection_sampling = false
  Rejection sampling.

Parameters

- bool _allow_no_mutation = false
  Allow no mutation.

Additional Inherited Members

5.121.1 Detailed Description

Standard bit mutation.

Each component of the origin bit vector is flipped with some fixed probability. Unless stated otherwise, if no component has been flipped at the end, the process is started all over again. Thus the number of flipped bits follows a pseudo binomial law.

Definition at line 222 of file neighborhood.hh.

5.121.2 Constructor & Destructor Documentation

5.121.2.1 StandardBitMutation() [1/2]

```
StandardBitMutation (
              int n )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors

The Bernoulli probability is set to 1 / n.

Definition at line 257 of file neighborhood.hh.

5.121.2.2 StandardBitMutation() [2/2]

```
StandardBitMutation (
            int n,
            double p ) [inline]
```

Constructor.

Parameters

n	Size of bit vectors
p	Bernoulli probability

Definition at line 267 of file neighborhood.hh.

5.121.3 Member Function Documentation

5.121.3.1 set_mutation_rate()

```
void set_mutation_rate (
            double p ) [inline]
```

Set mutation rate.

Sets _rejection_sampling to true if E(X) $<$ sqrt(n), where X is a random variable with a binomial distribution B(n, p), that is if np $<$ sqrt(n) or p $<$ 1 / sqrt(n).

Definition at line 278 of file neighborhood.hh.

The documentation for this class was generated from the following files:

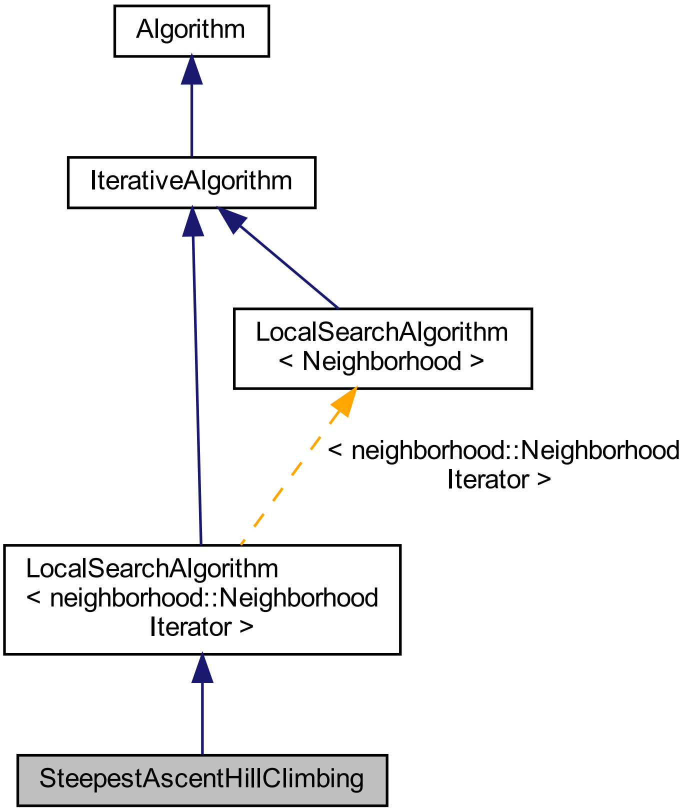
- lib/hnco/neighborhoods/neighborhood.hh
- lib/hnco/neighborhoods/neighborhood.cc

5.122 SteepestAscentHillClimbing Class Reference

Steepest ascent hill climbing.

`#include <hnco/algorithms/ls/steepest-ascent-hill-climbing.hh>`

Inheritance diagram for SteepestAscentHillClimbing:



Public Member Functions

- SteepestAscentHillClimbing (int n, neighborhood::NeighborhoodIterator ∗neighborhood)

    Constructor.

Protected Member Functions

- void iterate () override

    Single iteration.

Protected Attributes

- std::vector< bit_vector_t > _candidates

    Potential candidate.

5.122.1 Detailed Description

Steepest ascent hill climbing.

Definition at line 34 of file steepest-ascent-hill-climbing.hh.

The documentation for this class was generated from the following files:

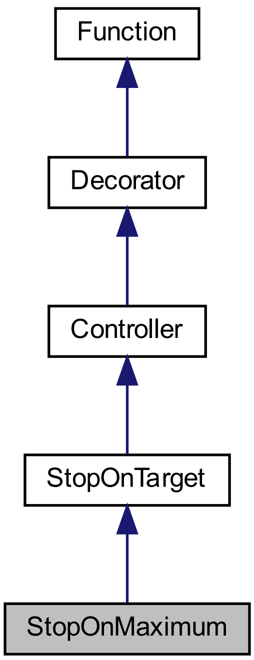
- lib/hnco/algorithms/ls/steepest-ascent-hill-climbing.hh
- lib/hnco/algorithms/ls/steepest-ascent-hill-climbing.cc

5.123 StopOnMaximum Class Reference

Stop on maximum.

```
#include <hnco/functions/controllers/controller.hh>
```

Inheritance diagram for StopOnMaximum:



Public Member Functions

- StopOnMaximum (Function ∗function)

  Constructor.

Additional Inherited Members

5.123.1 Detailed Description

Stop on maximum.

Definition at line 136 of file controller.hh.

5.123.2 Constructor & Destructor Documentation

5.123.2.1 StopOnMaximum()

```
StopOnMaximum (
            Function * function )  [inline]
```

Constructor.

Precondition

function->has_known_maximum()

Definition at line 143 of file controller.hh.

The documentation for this class was generated from the following file:

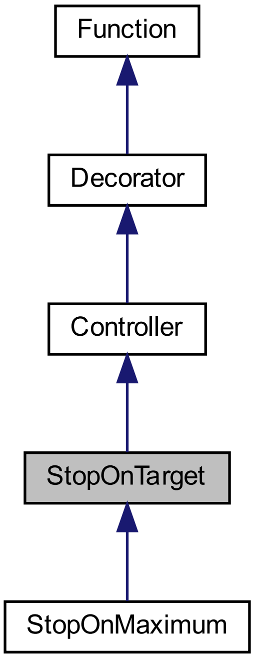
- lib/hnco/functions/controllers/controller.hh

5.124 StopOnTarget Class Reference

Stop on target.

`#include <hnco/functions/controllers/controller.hh>`

Inheritance diagram for StopOnTarget:



Public Member Functions

- StopOnTarget (Function ∗function, double target)

    Constructor.
- const algorithm::solution_t & get_trigger ()

    Get trigger.

Evaluation

- double evaluate (const bit_vector_t &)

    Evaluate a bit vector.
- double evaluate_incrementally (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_t &flipped_bits)

    Incrementally evaluate a bit vector.
- void update (const bit_vector_t &x, double value)

    Update after a safe evaluation.

Private Attributes

- double _target
  Target.
- algorithm::solution_t _trigger
  Trigger.

Additional Inherited Members

5.124.1 Detailed Description

Stop on target.

The member function eval throws an exception TargetReached when the value of its decorated function reaches a given target.

Warning

The target is detected using the greater or equal operator hence the result should be taken with care in case of non integer (floating point) function values.

Definition at line 92 of file controller.hh.

5.124.2 Constructor & Destructor Documentation

5.124.2.1 StopOnTarget()

```
StopOnTarget (
            Function * function,
            double target )  [inline]
```

Constructor.

Parameters

function	Decorated function
target	Target

Definition at line 107 of file controller.hh.

5.124.3 Member Function Documentation

5.124.3.1 evaluate()

```
double evaluate (
            const bit_vector_t & x )  [virtual]
```

Evaluate a bit vector.

Exceptions

TargetReached	

Implements Function.

Definition at line 33 of file controller.cc.

5.124.3.2 evaluate_incrementally()

```
double evaluate_incrementally (
            const bit_vector_t & x,
            double value,
            const hnco::sparse_bit_vector_t & flipped_bits )  [virtual]
```

Incrementally evaluate a bit vector.

Exceptions

TargetReached	

Reimplemented from Function.

Definition at line 46 of file controller.cc.

5.124.3.3 update()

```
void update (
            const bit_vector_t & x,
            double value )  [virtual]
```

Update after a safe evaluation.

Exceptions

TargetReached	

Reimplemented from Function.

Definition at line 59 of file controller.cc.

The documentation for this class was generated from the following files:

- lib/hnco/functions/controllers/controller.hh
- lib/hnco/functions/controllers/controller.cc

5.125 StopWatch Class Reference

Stop watch.

```
#include <hnco/stop-watch.hh>
```

Public Member Functions

- void start ()
  Start.
- void stop ()
  Stop.
- double get_total_time ()
  Get total time.
- void reset ()
  Reset.

Private Attributes

- double _total_time = 0
  Total time.
- clock_t _start
  Start time.

5.125.1 Detailed Description

Stop watch.

Definition at line 31 of file stop-watch.hh.

The documentation for this class was generated from the following file:

- lib/hnco/stop-watch.hh

5.126 Sudoku Class Reference

Sudoku

```
#include <hnco/functions/collection/sudoku.hh>
```

Public Types

- using domain_type = std::size_t

    Domain type.
- using codomain_type = double

    Codomain type.

Public Member Functions

- Sudoku ()

    Default constructor.
- void random (int c)

    Random instance.
- int get_num_variables ()

    Get the number of variables.
- void display (std::ostream &stream) const

    Display the problem.
- void describe (const std::vector< domain_type > &x, std::ostream &stream)

    Describe a solution.
- double evaluate (const std::vector< domain_type > &x)

    Evaluate a solution.

Private Member Functions

- void write_variables (const std::vector< domain_type > &x)

    Write variables.

Private Attributes

- std::vector< std::vector< char > > _problem_instance

    Problem instance.
- std::vector< std::vector< domain_type > > _candidate

    Candidate.
- std::vector< int > _counts

    Counts.
- int _num_variables

    Number of variables.

Load and save instance

- void load_ (std::istream &stream)

    Load an instance.
- void save_ (std::ostream &stream) const

    Save an instance.
- void load (std::string path)

    Load instance.
- void save (std::string path) const

    Save instance.

5.126.1 Detailed Description

Sudoku

Definition at line 34 of file sudoku.hh.

5.126.2 Member Function Documentation

5.126.2.1 load()

```
void load (
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 100 of file sudoku.hh.

5.126.2.2 load_()

```
void load_ (
            std::istream & stream )  [private]
```

Load an instance.

Exceptions

std::runtime_error	

Definition at line 57 of file sudoku.cc.

5.126.2.3 random()

```
void random (
            int c )
```

Random instance.

Parameters

c	Number of empty cells

Definition at line 96 of file sudoku.cc.

5.126.2.4 save()

```
void save (
            std::string path ) const  [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 112 of file sudoku.hh.

The documentation for this class was generated from the following files:

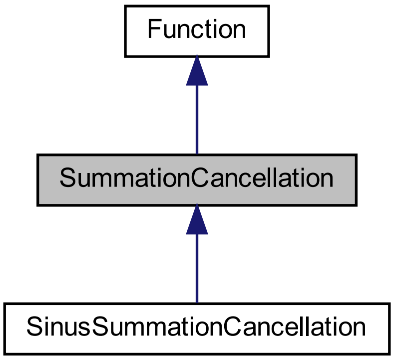
- lib/hnco/functions/collection/sudoku.hh
- lib/hnco/functions/collection/sudoku.cc

5.127 SummationCancellation Class Reference

Summation cancellation.

```
#include <hnco/functions/collection/cancellation.hh>
```

Inheritance diagram for SummationCancellation:



Public Member Functions

- SummationCancellation (int n)

  Constructor.
- int get_bv_size () const override

  Get bit vector size.
- bool has_known_maximum () const override

  Check for a known maximum.
- double get_maximum () const override

  Get the global maximum.
- double evaluate (const bit_vector_t &x) override

  Evaluate a bit vector.

Protected Member Functions

- void convert (const bit_vector_t &x)

  Convert a bit vector into a real vector.

Protected Attributes

- int _bv_size

  Bit vector size.
- std::vector< double > _buffer

  Buffer.

5.127.1 Detailed Description

Summation cancellation.

Encoding of a signed integer:

- bit 0: sign
- bits 1 to 8: two's complement representation

Reference:

S. Baluja and S. Davies. 1997. Using optimal dependency-trees for combinatorial optimization: learning the structure of the search space. Technical Report CMU- CS-97-107. Carnegie-Mellon University.

Definition at line 46 of file cancellation.hh.

5.127.2 Constructor & Destructor Documentation

5.127.2.1 SummationCancellation()

```
SummationCancellation (
            int n )  [inline]
```

Constructor.

The bit vector size n must be a multiple of 9. The size of _buffer is then n / 9.

Parameters

n	Size of the bit vector

Definition at line 68 of file cancellation.hh.

5.127.3 Member Function Documentation

5.127.3.1 has_known_maximum()

```
bool has_known_maximum ( ) const  [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 81 of file cancellation.hh.

The documentation for this class was generated from the following files:

- lib/hnco/functions/collection/cancellation.hh
- lib/hnco/functions/collection/cancellation.cc

5.128 SymmetricWalshMoment2 Struct Reference

Symmetric Walsh moment.

`#include <hnco/algorithms/walsh-moment/walsh-moment.hh>`

Public Member Functions

- SymmetricWalshMoment2 (int n)

  Constructor.
- void display (std::ostream &stream)

  Display Walsh moment.
- void init ()

  Initialize Walsh moment.
- void add (const bit_vector_t &bv)

  Add a bit vector to a Walsh moment.
- void average (int count)

  Average each Walsh moment.
- void update (const SymmetricWalshMoment2 &wm, double rate)

  Update a Walsh moment.
- void update (const SymmetricWalshMoment2 &wm1, const SymmetricWalshMoment2 &wm2, double rate)

  Update a Walsh moment.
- void scaled_difference (double lambda, const SymmetricWalshMoment2 &wm1, const SymmetricWalshMoment2 &wm2)

  Compute a scaled difference between two moments.
- void bound (double margin)

  Bound Walsh moment.
- double norm_1 () const

  1-norm of the Walsh moment
- double norm_2 () const

  2-norm of the Walsh moment
- double norm_infinite () const

  infinite-norm of the Walsh moment
- double distance (const SymmetricWalshMoment2 &wm) const

  distance between the Walsh moment and another Walsh moment

Public Attributes

- std::vector< double > first_moment
  First moment.
- std::vector< std::vector< double > > second_moment
  Second moment.

5.128.1 Detailed Description

Symmetric Walsh moment.

Definition at line 144 of file walsh-moment.hh.

5.128.2 Constructor & Destructor Documentation

5.128.2.1 SymmetricWalshMoment2()

```
SymmetricWalshMoment2 (
            int n )
```

Constructor.

Parameters

n	Size of bit vector

Definition at line 236 of file walsh-moment.cc.

5.128.3 Member Function Documentation

5.128.3.1 average()

```
void average (
            int count )
```

Average each Walsh moment.

Postcondition

matrix_is_symmetric(second_moment)

Definition at line 296 of file walsh-moment.cc.

5.128.3.2 bound()

```
void bound (
            double margin )
```

Bound Walsh moment.

Ensure that the distance from each Walsh moment to the -1/1 bounds is greater or equal to the given margin.

Parameters

margin	Distance from the -1/1 bounds

Definition at line 378 of file walsh-moment.cc.

5.128.3.3 display()

```
void display (
            std::ostream & stream )
```

Display Walsh moment.

A SymmetricWalshMoment2 is displayed as a full symmetric matrix with diagonal entries equal to first moments and off-diagonal entries equal to second moments.

Definition at line 247 of file walsh-moment.cc.

5.128.3.4 scaled_difference()

```
void scaled_difference (
            double lambda,
            const SymmetricWalshMoment2 & wm1,
            const SymmetricWalshMoment2 & wm2 )
```

Compute a scaled difference between two moments.

This member function implements:

self = lambda $*$ wm1 - wm2

It is mostly useful in herding (Hea).

Parameters

lambda	Scale
wm1	First Walsh moment
wm2	Second Walsh moment

Definition at line 357 of file walsh-moment.cc.

5.128.3.5 update() [1/2]

```
void update (
            const SymmetricWalshMoment2 & wm,
            double rate )
```

Update a Walsh moment.

This member function implements:

self += rate ∗ (wm1 - self)

Parameters

wm	Target Walsh moment
rate	Learning rate

Postcondition

For all i, is_in_interval(first_moment[i], -1, 1)
For all i != j, is_in_interval(second_moment[i][j], -1, 1)
matrix_is_symmetric(second_moment)

Definition at line 314 of file walsh-moment.cc.

5.128.3.6 update() [2/2]

```
void update (
            const SymmetricWalshMoment2 & wm1,
            const SymmetricWalshMoment2 & wm2,
            double rate )
```

Update a Walsh moment.

This member function implements:

self += rate ∗ (wm1 - wm2)

The resulting entries are not necessarily those of a Walsh moment, that is

is_in_interval(first_moment[i], -1, 1) or

is_in_interval(second_moment[i][j], -1, 1)

might fail for some i != j.

Parameters

wm1	Target Walsh moment
wm2	Walsh moment to move away from
rate	Learning rate

Definition at line 335 of file walsh-moment.cc.

The documentation for this struct was generated from the following files:

- lib/hnco/algorithms/walsh-moment/walsh-moment.hh
- lib/hnco/algorithms/walsh-moment/walsh-moment.cc

5.129 SymmetricWalshMoment2GibbsSampler Class Reference

Gibbs sampler with symmetric Walsh moments.

```
#include <hnco/algorithms/walsh-moment/gibbs-sampler.hh>
```

Public Types

- using Moment = SymmetricWalshMoment2

  Walsh moment type.

Public Member Functions

- SymmetricWalshMoment2GibbsSampler (int n, const SymmetricWalshMoment2 &mp)

  Constructor.
- void init ()

  Initialize.
- void update (int i)

  Update state.
- void update_sync ()

  Update state synchronously.
- const bit_vector_t & get_state ()

  Get the state of the Gibbs sampler.

Private Attributes

- const SymmetricWalshMoment2 & _model_parameters

  Model parameters.
- bit_vector_t _state

  State of the Gibbs sampler.
- pv_t _pv

  Probability vector for synchronous Gibbs sampling.

5.129.1 Detailed Description

Gibbs sampler with symmetric Walsh moments.

Definition at line 75 of file gibbs-sampler.hh.

The documentation for this class was generated from the following files:

- lib/hnco/algorithms/walsh-moment/gibbs-sampler.hh
- lib/hnco/algorithms/walsh-moment/gibbs-sampler.cc

5.130 SymmetricWalshMoment2Herding Class Reference

Herding with symmetric Walsh moment.

```
#include <hnco/algorithms/walsh-moment/herding.hh>
```

Public Types

- using Moment = SymmetricWalshMoment2

  Walsh moment type.

Public Member Functions

- SymmetricWalshMoment2Herding (int n)

  Constructor.
- void init ()

  Initialization.
- void sample (const SymmetricWalshMoment2 &target, bit_vector_t &x)

  Sample a bit vector.
- double error (const SymmetricWalshMoment2 &target)

  Compute the error.

Getters

- const SymmetricWalshMoment2 & get_delta () const

  Get delta.

Setters

- void set_randomize_bit_order (bool x)

  Randomize bit order.

Protected Attributes

- SymmetricWalshMoment2 _delta

  Delta moment.
- SymmetricWalshMoment2 _count

  Counter moment.
- SymmetricWalshMoment2 _error

  Error moment.
- permutation_t _permutation

  Permutation.
- int _time

  Time.

Parameters

- bool _randomize_bit_order = false

  Randomize bit order.

5.130.1 Detailed Description

Herding with symmetric Walsh moment.

Definition at line 112 of file herding.hh.

5.130.2 Constructor & Destructor Documentation

5.130.2.1 SymmetricWalshMoment2Herding()

```
SymmetricWalshMoment2Herding (
            int n )   [inline]
```

Constructor.

Parameters

n	Size of bit vectors

Definition at line 149 of file herding.hh.

The documentation for this class was generated from the following files:

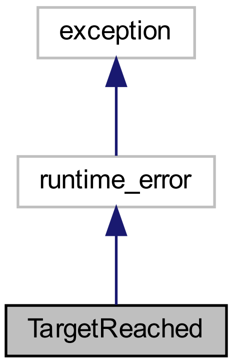
- lib/hnco/algorithms/walsh-moment/herding.hh
- lib/hnco/algorithms/walsh-moment/herding.cc

5.131 TargetReached Class Reference

Target reached.

```
#include <hnco/exception.hh>
```

Inheritance diagram for TargetReached:



5.131.1 Detailed Description

Target reached.

Definition at line 40 of file exception.hh.

The documentation for this class was generated from the following file:

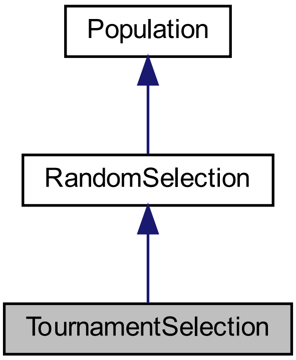
- lib/hnco/exception.hh

5.132 TournamentSelection Class Reference

Tournament selection.

```
#include <hnco/algorithms/random-selection.hh>
```

Inheritance diagram for TournamentSelection:



Public Member Functions

- TournamentSelection (int population_size, int n)

    Constructor.
- const bit_vector_t & select () override

    Select an individual in the population.

Setters

- void set_tournament_size (int x)

    Set the tournament size.

Private Attributes

- std::uniform_int_distribution< int > _choose_individual

    Random index.

Parameters

- int _tournament_size = 10

    Tournament size.

Additional Inherited Members

5.132.1 Detailed Description

Tournament selection.

Definition at line 82 of file random-selection.hh.

5.132.2 Constructor & Destructor Documentation

5.132.2.1 TournamentSelection()

```
TournamentSelection (
            int population_size,
            int n ) [inline]
```

Constructor.

Parameters

population_size	Population size
n	Bit vector size

Definition at line 104 of file random-selection.hh.

5.132.3 Member Function Documentation

5.132.3.1 select()

```
const bit_vector_t & select ( ) [override], [virtual]
```

Select an individual in the population.

The selection only requires that the population be evaluated, not necessarily sorted.

Precondition

The population must be evaluated.

Implements RandomSelection.

Definition at line 38 of file random-selection.cc.

The documentation for this class was generated from the following files:

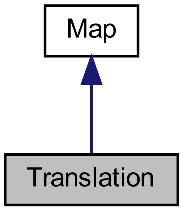
- lib/hnco/algorithms/random-selection.hh
- lib/hnco/algorithms/random-selection.cc

5.133 Translation Class Reference

Translation.

`#include <hnco/maps/map.hh>`

Inheritance diagram for Translation:



Public Member Functions

- void map (const bit_vector_t &input, bit_vector_t &output) override
  Map
- int get_input_size () const override
  Get input size.
- int get_output_size () const override
  Get output size.
- bool is_surjective () const override
  Check for surjective map.
- void display (std::ostream &stream) const override
  Display.
- void random (int n)
  Random instance.
- void set_bv (const bit_vector_t &bv)
  Set the translation vector.

Load and save map

- void load (std::string path)
  Load map.
- void save (std::string path) const
  Save map.

Private Member Functions

- template<class Archive >
  void save (Archive &ar, const unsigned int version) const
  Save.
- template<class Archive >
  void load (Archive &ar, const unsigned int version)
  Load.

Private Attributes

- bit_vector_t _bv

    Translation vector

Friends

- class **boost::serialization::access**

5.133.1 Detailed Description

Translation.

A translation is an affine map f from F_2y^n to itself defined by $f(x) = x + b$, where b is an n-dimensional bit vector.

Definition at line 80 of file map.hh.

5.133.2 Member Function Documentation

5.133.2.1 is_surjective()

```
bool is_surjective ( ) const  [inline], [override], [virtual]
```

Check for surjective map.

Returns

true

Reimplemented from Map.

Definition at line 122 of file map.hh.

5.133.2.2 load()

```
void load (
            std::string path )  [inline]
```

Load map.

Parameters

path	Path of the file

Exceptions

std::runtime_error	

Definition at line 147 of file map.hh.

5.133.2.3 save()

```
void save (
            std::string path ) const  [inline]
```

Save map.

Parameters

path	Path of the file

Exceptions

std::runtime_error	

Definition at line 154 of file map.hh.

The documentation for this class was generated from the following files:

- lib/hnco/maps/map.hh
- lib/hnco/maps/map.cc

5.134 Transvection Struct Reference

Transvection.

`#include <hnco/maps/transvection.hh>`

Public Member Functions

- template<class Archive >
  void save (Archive &ar, const unsigned int version) const
  Save.
- template<class Archive >
  void load (Archive &ar, const unsigned int version)
  Load.
- bool is_valid () const
  Check validity.
- bool is_valid (int n) const

Check validity.

- void display (std::ostream &stream) const

  Display transvection.

- void random (int n)

  Sample a random transvection.

- void random_non_commuting (int n, const Transvection &a)

  Sample a random transvection.

- void multiply (bit_vector_t &x) const

  Multiply a bit vector from the left.

- void multiply (bit_matrix_t &M) const

  Multiply a bit matrix from the left.

Public Attributes

- int row_index

  Row index.

- int column_index

  Column index.

5.134.1 Detailed Description

Transvection.

We only consider transvections defined by matrices $\tau_{ij} = I_n + B_{ij}$, where I_n is the $n \times n$ identity matrix and B_{ij} is the matrix whose (i, j) entry is 1 and other entries are zero. Such a matrix is also sometimes called a shear matrix.

Transvections generate invertible matrices over the finite field F_2.

Definition at line 63 of file transvection.hh.

5.134.2 Member Function Documentation

5.134.2.1 is_valid()

```
bool is_valid (
            int n ) const
```

Check validity.

Parameters

n	Dimension

Definition at line 48 of file transvection.cc.

5.134.2.2 multiply() [1/2]

```
void multiply (
            bit_matrix_t & M ) const
```

Multiply a bit matrix from the left.

Parameters

M	Bit matrix

Precondition

is_valid()

is_valid(bm_num_rows(M))

Warning

This function modifies the given bit vector.

Definition at line 117 of file transvection.cc.

5.134.2.3 multiply() [2/2]

```
void multiply (
            bit_vector_t & x ) const
```

Multiply a bit vector from the left.

Parameters

x	Bit vector

Precondition

is_valid()

is_valid(x.size())

Warning

This function modifies the given bit vector.

Definition at line 105 of file transvection.cc.

5.134.2.4 random()

```
void random (
            int n )
```

Sample a random transvection.

Parameters

n	Dimension

Precondition

$n > 1$

Definition at line 61 of file transvection.cc.

5.134.2.5 random_non_commuting()

```
void random_non_commuting (
            int n,
            const Transvection & a )
```

Sample a random transvection.

This member function ensures that the sampled transvection does not commute with some given one.

Parameters

n	Dimension
a	Given transvection

Precondition

$n > 1$

Definition at line 77 of file transvection.cc.

The documentation for this struct was generated from the following files:

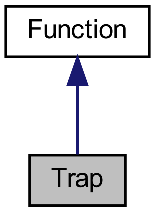
- lib/hnco/maps/transvection.hh
- lib/hnco/maps/transvection.cc

5.135 Trap Class Reference

Trap.

```
#include <hnco/functions/collection/trap.hh>
```

Inheritance diagram for Trap:



Public Member Functions

- Trap (int bv_size, int num_traps)
  Constructor.
- int get_bv_size () const
  Get bit vector size.
- double evaluate (const bit_vector_t &)
  Evaluate a bit vector.
- bool has_known_maximum () const
  Check for a known maximum.
- double get_maximum () const
  Get the global maximum.

Private Attributes

- int _bv_size
  Bit vector size.
- int _num_traps
  Number of traps.
- int _trap_size
  Trap size.

5.135.1 Detailed Description

Trap.

Reference:

Kalyanmoy Deb and David E. Goldberg. 1993. Analyzing Deception in Trap Functions. In Foundations of Genetic Algorithms 2, L. Darrell Whitley (Ed.). Morgan Kaufmann, San Mateo, CA, 93–108.

Definition at line 43 of file trap.hh.

5.135.2 Constructor & Destructor Documentation

5.135.2.1 Trap()

```
Trap (
            int bv_size,
            int num_traps )  [inline]
```

Constructor.

Parameters

bv_size	Bit vector size
num_traps	Number of traps

Warning

bv_size must be a multiple of num_traps

Definition at line 64 of file trap.hh.

5.135.3 Member Function Documentation

5.135.3.1 get_maximum()

```
double get_maximum ( ) const  [inline], [virtual]
```

Get the global maximum.

Returns

_bv_size

Reimplemented from Function.

Definition at line 88 of file trap.hh.

5.135.3.2 has_known_maximum()

```
bool has_known_maximum ( ) const  [inline], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 84 of file trap.hh.

The documentation for this class was generated from the following files:

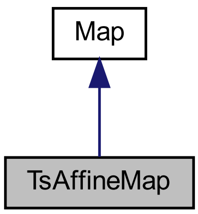
- lib/hnco/functions/collection/trap.hh
- lib/hnco/functions/collection/trap.cc

5.136 TsAffineMap Class Reference

Transvection sequence affine map.

`#include <hnco/maps/map.hh>`

Inheritance diagram for TsAffineMap:



Public Types

- enum SamplingMode {
  Unconstrained , CommutingTransvections , UniqueSource , UniqueDestination ,
  DisjointTransvections , NonCommutingTransvections }

  Sampling mode.

Public Member Functions

- void random (int n, int t, SamplingMode mode)
  Random instance.
- void map (const bit_vector_t &input, bit_vector_t &output) override
  Map
- int get_input_size () const override
  Get input size.
- int get_output_size () const override
  Get output size.
- bool is_surjective () const override
  Check for surjective map.
- void display (std::ostream &stream) const override
  Display.
- void inverse ()
  Inverse.

Load and save map

- void load (std::string path)
  Load map.
- void save (std::string path) const
  Save map.

Private Member Functions

- template<class Archive >
  void save (Archive &ar, const unsigned int version) const
  Save.
- template<class Archive >
  void load (Archive &ar, const unsigned int version)
  Load.

Private Attributes

- transvection_sequence_t _ts
  Transvection sequence
- bit_vector_t _bv
  Translation vector

Friends

- class **boost::serialization::access**

5.136.1 Detailed Description

Transvection sequence affine map.

An affine map f from F_2^m to F_2^n is defined by $f(x) = Ax+b$, where A is an n x m bit matrix and b is an n-dimensional bit vector.

In TsAffineMap, A is a finite product of transvections represented by a transvection_sequence_t.

Definition at line 601 of file map.hh.

5.136.2 Member Enumeration Documentation

5.136.2.1 SamplingMode

```
enum SamplingMode
```

Sampling mode.

Enumerator

Unconstrained	Unconstrained.
CommutingTransvections	Commuting transvections.
UniqueSource	Transvection sequence with unique source
UniqueDestination	Transvection sequence with unique destination
DisjointTransvections	Disjoint transvections.
NonCommutingTransvections	Non commuting transvections.

Definition at line 637 of file map.hh.

5.136.3 Member Function Documentation

5.136.3.1 is_surjective()

```
bool is_surjective ( ) const  [inline], [override], [virtual]
```

Check for surjective map.

Returns

true

Reimplemented from Map.

Definition at line 680 of file map.hh.

5.136.3.2 load()

```
void load (
            std::string path )  [inline]
```

Load map.

Parameters

path	Path of the file

Exceptions

std::runtime_error	

Definition at line 697 of file map.hh.

5.136.3.3 random()

```
void random (
            int n,
            int t,
            SamplingMode mode )
```

Random instance.

Parameters

n	Dimension
t	Length of sequence of transvections
mode	Sampling mode

Definition at line 217 of file map.cc.

5.136.3.4 save()

```
void save (
            std::string path ) const  [inline]
```

Save map.

Parameters

path	Path of the file

Exceptions

std::runtime_error	

Definition at line 704 of file map.hh.

The documentation for this class was generated from the following files:

- lib/hnco/maps/map.hh
- lib/hnco/maps/map.cc

5.137 Tsp Class Reference

Traveling salesman problem.

```
#include <hnco/functions/collection/tsp.hh>
```

Public Member Functions

- Tsp ()
  Default constructor.
- int get_num_elements () const
  Get the number of elements.
- void display (std::ostream &stream) const
  Display the problem.
- void describe (const hnco::permutation_t &permutation, std::ostream &stream)
  Describe a solution.
- double evaluate (const hnco::permutation_t &permutation)
  Evaluate a solution.

Instance generators

- template<class Generator >
  void generate (int n, Generator generator)
  Instance generator.
- void random (int n)
  Random instance.

Private Types

- enum { **ATT** , **EUC_2D** }

Private Member Functions

- void **compute_distances** ()
- void **compute_distances_att** ()
- void **compute_distances_euc_2d** ()

Private Attributes

- std::string **_name**
- std::string **_comment**
- int **_num_cities**
- std::vector< float > **_x**
- std::vector< float > **_y**
- int **_edge_weight_type** = ATT
- std::vector< std::vector< float > > _distances

    Distances.

Load and save instance

- void load_ (std::istream &stream)

    Load an instance.
- void **load_coordinates** (std::istream &stream)
- void save_ (std::ostream &stream) const

    Save an instance.
- void load (std::string path)

    Load instance.
- void save (std::string path) const

    Save instance.

5.137.1 Detailed Description

Traveling salesman problem.

Source: TSPLIB 95, Gerhard Reinelt

Definition at line 40 of file tsp.hh.

5.137.2 Member Function Documentation

5.137.2.1 generate()

```
void generate (
            int n,
            Generator generator )  [inline]
```

Instance generator.

Parameters

n	Number of vertices
generator	Generator for distances

Definition at line 94 of file tsp.hh.

5.137.2.2 load()

```
void load (
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 129 of file tsp.hh.

5.137.2.3 load_()

```
void load_ (
            std::istream & stream )  [private]
```

Load an instance.

Exceptions

std::runtime_error	

Definition at line 32 of file tsp.cc.

5.137.2.4 random()

```
void random (
            int n )  [inline]
```

Random instance.

Distances are sampled from the normal distribution.

Parameters

n	Number of vertices

Definition at line 113 of file tsp.hh.

5.137.2.5 save()

```
void save (
            std::string path ) const  [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 141 of file tsp.hh.

The documentation for this class was generated from the following files:

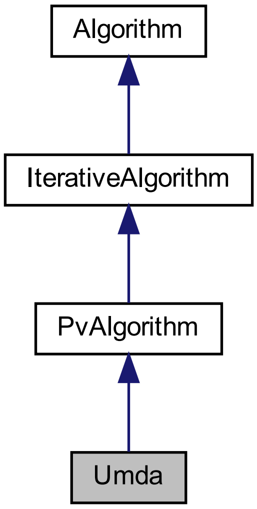
- lib/hnco/functions/collection/tsp.hh
- lib/hnco/functions/collection/tsp.cc

5.138 Umda Class Reference

Univariate marginal distribution algorithm.

`#include <hnco/algorithms/pv/umda.hh>`

Inheritance diagram for Umda:



Public Member Functions

- Umda (int n, int population_size)
  Constructor.

Setters

- void set_selection_size (int x)
  Set the selection size.

Protected Member Functions

Loop

- void init () override
  Initialize.
- void iterate () override
  Single iteration.

Protected Attributes

- Population _population
  Population.

Parameters

- int _selection_size = 1
  Selection size.

5.138.1 Detailed Description

Univariate marginal distribution algorithm.

Reference:

H. Mühlenbein. 1997. The equation for response to selection and its use for prediction. Evolutionary Computation 5, 3 (1997), 303–346.

Definition at line 41 of file umda.hh.

The documentation for this class was generated from the following files:

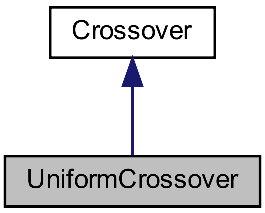
- lib/hnco/algorithms/pv/umda.hh
- lib/hnco/algorithms/pv/umda.cc

5.139 UniformCrossover Class Reference

Uniform crossover.

`#include <hnco/algorithms/ea/crossover.hh>`

Inheritance diagram for UniformCrossover:



Public Member Functions

- void breed (const bit_vector_t &parent1, const bit_vector_t &parent2, bit_vector_t &offspring)
  Breed.

5.139.1 Detailed Description

Uniform crossover.

Definition at line 56 of file crossover.hh.

5.139.2 Member Function Documentation

5.139.2.1 breed()

```
void breed (
            const bit_vector_t & parent1,
            const bit_vector_t & parent2,
            bit_vector_t & offspring )  [virtual]
```

Breed.

The offspring is the uniform crossover of two parents.

Parameters

parent1	First parent
parent2	Second parent
offspring	Offspring

Implements Crossover.

Definition at line 30 of file crossover.cc.

The documentation for this class was generated from the following files:

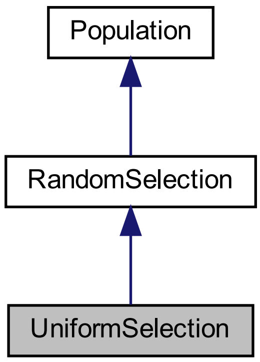
- lib/hnco/algorithms/ea/crossover.hh
- lib/hnco/algorithms/ea/crossover.cc

5.140 UniformSelection Class Reference

Uniform selection.

```
#include <hnco/algorithms/random-selection.hh>
```

Inheritance diagram for UniformSelection:



Public Member Functions

- UniformSelection (int population_size, int n)

    Constructor.
- const bit_vector_t & select () override

    Select an individual in the population.

Private Attributes

- std::uniform_int_distribution< int > _choose_individual

    Random index.

Additional Inherited Members

5.140.1 Detailed Description

Uniform selection.

Definition at line 58 of file random-selection.hh.

5.140.2 Constructor & Destructor Documentation

5.140.2.1 UniformSelection()

```
UniformSelection (
            int population_size,
            int n )  [inline]
```

Constructor.

Parameters

population_size	Population size
n	Bit vector size

Definition at line 71 of file random-selection.hh.

The documentation for this class was generated from the following files:

- lib/hnco/algorithms/random-selection.hh
- lib/hnco/algorithms/random-selection.cc

5.141 UniversalFunction Class Reference

Universal function.

`#include <hnco/functions/universal-function.hh>`

Public Member Functions

- virtual ~UniversalFunction ()

  Destructor.
- virtual double evaluate (const bit_vector_t &boolean_vars, const std::vector< int > &integer_vars, const std::vector< double > &float_vars, const std::vector< std::complex< double >> &complex_vars, const std::vector< int > &categorical_vars, const std::vector< permutation_t > permutation_vars)=0

  Evaluate the function.
- virtual void display (std::ostream &stream) const

  Display the function.
- virtual void describe (const bit_vector_t &boolean_vars, const std::vector< int > &integer_vars, const std::vector< double > &float_vars, const std::vector< std::complex< double >> &complex_vars, const std::vector< int > &categorical_vars, const std::vector< permutation_t > permutation_vars, std::ostream &stream)

  Describe variables in the context of the function.

5.141.1 Detailed Description

Universal function.

A universal function is a function taking parameters of all types (boolean, integer, float, complex, categorical, permutation) and returning a double.

Definition at line 40 of file universal-function.hh.

The documentation for this class was generated from the following file:

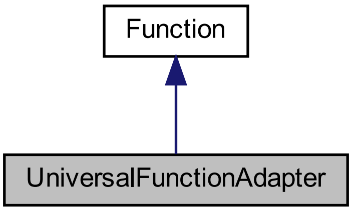
- lib/hnco/functions/universal-function.hh

5.142 UniversalFunctionAdapter Class Reference

Universal function adapter.

```
#include <hnco/functions/universal-function-adapter.hh>
```

Inheritance diagram for UniversalFunctionAdapter:



Public Member Functions

- UniversalFunctionAdapter (UniversalFunction ∗fn, int num_boolean_vars, std::vector< representation::DyadicIntegerRepresent int >> integer_reps, std::vector< representation::DyadicFloatRepresentation< double >> float_reps, std::vector< representation::DyadicComplexRepresentation< double >> complex_reps, std::vector< representation::LinearCategoricalRepresentation > categorical_reps, std::vector< representation::PermutationRepresentation > permutation_reps)

    Constructor.
- int get_bv_size () const override

    Get bit vector size.
- double evaluate (const bit_vector_t &bv) override

    Evaluate a bit vector.
- void display (std::ostream &stream) const override

    Display.
- void describe (const bit_vector_t &bv, std::ostream &stream) override

    Describe a bit vector.

Private Member Functions

- void unpack (const bit_vector_t &bv)

    Unpack bit vector into variables.

Private Attributes

- UniversalFunction * _function
  Universal function.
- std::vector< representation::DyadicIntegerRepresentation< int > > _integer_reps
  Integer representations.
- std::vector< representation::DyadicFloatRepresentation< double > > _float_reps
  Float representations.
- std::vector< representation::DyadicComplexRepresentation< double > > _complex_reps
  Complex representations.
- std::vector< representation::LinearCategoricalRepresentation > _categorical_reps
  Categorical representations.
- std::vector< representation::PermutationRepresentation > _permutation_reps
  Permuation representations.
- bit_vector_t _boolean_vars
  Boolean variables.
- std::vector< int > _integer_vars
  Integer variables.
- std::vector< double > _float_vars
  Float variables.
- std::vector< std::complex< double > > _complex_vars
  Complex variables.
- std::vector< int > _categorical_vars
  Categorical variables.
- std::vector< permutation_t > _permutation_vars
  Permutation variables.
- int _bv_size
  Bit vector size.

5.142.1 Detailed Description

Universal function adapter.

A universal function adapter turns a universal function into a regular hnco function defined on bit vectors.

Definition at line 45 of file universal-function-adapter.hh.

5.142.2 Constructor & Destructor Documentation

5.142.2.1 UniversalFunctionAdapter()

```
UniversalFunctionAdapter (
            UniversalFunction * fn,
            int num_boolean_vars,
            std::vector< representation::DyadicIntegerRepresentation< int >> integer_reps,
            std::vector< representation::DyadicFloatRepresentation< double >> float_reps,
            std::vector< representation::DyadicComplexRepresentation< double >> complex_↩
reps,
            std::vector< representation::LinearCategoricalRepresentation > categorical_reps,
            std::vector< representation::PermutationRepresentation > permutation_reps )  [inline]
```

Constructor.

Parameters

fn	Universal function
num_boolean_vars	Number of boolean variables
integer_reps	Integer representations
float_reps	Float representations
complex_reps	Complex representations
categorical_reps	Categorical representations
permutation_reps	Permutation representations

Replace reps with {} if there is no corresponding variable. For example, if there is no categorical variable,

UniversalFunctionAdapter(fn, num_boolean_vars, integer_reps, float_reps, complex_reps, {}, permutation_reps)

Definition at line 132 of file universal-function-adapter.hh.

The documentation for this class was generated from the following file:

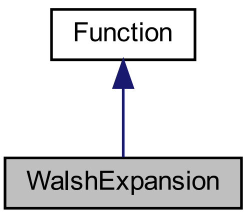
- lib/hnco/functions/universal-function-adapter.hh

5.143 WalshExpansion Class Reference

Walsh expansion.

`#include <hnco/functions/collection/walsh/walsh-expansion.hh>`

Inheritance diagram for WalshExpansion:



Public Member Functions

- WalshExpansion ()
  Constructor.
- int get_bv_size () const override
  Get bit vector size.
- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.
- void display (std::ostream &stream) const override
  Display.
- void set_terms (const std::vector$<$ function::WalshTerm $>$ terms)
  Set terms.

Instance generators

- template$<$class Generator $>$
  void generate (int n, int num_features, Generator generator)
  Instance generator.
- void random (int n, int num_features)
  Random instance.

Load and save instance

- void load (std::string path)
  Load instance.
- void save (std::string path) const
  Save instance.

Private Member Functions

- template$<$class Archive $>$
  void serialize (Archive &ar, const unsigned int version)
  Save.

Private Attributes

- std::vector$<$ function::WalshTerm $>$ _terms
  Terms.

Friends

- class **boost::serialization::access**

5.143.1 Detailed Description

Walsh expansion.

Its expression is of the form

$f(x) = \sum_u a_u (-1)^{x \cdot u}$

where the sum is over a subset of $\{0, 1\}^n$ and $x \cdot u = \sum_i x_i u_i$ is mod 2. The real numbers a_u are the coefficients of the expansion and the bit vectors u are its feature vectors.

Definition at line 52 of file walsh-expansion.hh.

5.143.2 Member Function Documentation

5.143.2.1 generate()

```
void generate (
            int n,
            int num_features,
            Generator generator )  [inline]
```

Instance generator.

Parameters

n	Size of bit vectors
num_features	Number of feature vectors
generator	Coefficient generator

Definition at line 85 of file walsh-expansion.hh.

5.143.2.2 load()

```
void load (
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 130 of file walsh-expansion.hh.

5.143.2.3 random()

```
void random (
            int n,
            int num_features )  [inline]
```

Random instance.

The coefficients are sampled from the normal distribution.

Parameters

n	Size of bit vector
num_features	Number of feature vectors

Definition at line 111 of file walsh-expansion.hh.

5.143.2.4 save()

```
void save (
            std::string path ) const  [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 137 of file walsh-expansion.hh.

The documentation for this class was generated from the following files:

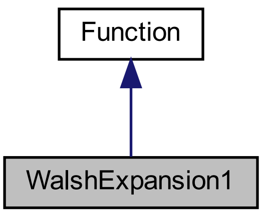
- lib/hnco/functions/collection/walsh/walsh-expansion.hh
- lib/hnco/functions/collection/walsh/walsh-expansion.cc

5.144 WalshExpansion1 Class Reference

Walsh expansion of degree 1.

`#include <hnco/functions/collection/walsh/walsh-expansion-1.hh>`

Inheritance diagram for WalshExpansion1:



Public Member Functions

- WalshExpansion1 ()
  Constructor.

Instance generators

- template<class Generator >
  void generate (int n, Generator generator)
  Instance generator.
- void random (int n)
  Random instance.

Load and save instance

- void load (std::string path)
  Load instance.
- void save (std::string path) const
  Save instance.

Evaluation

- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.
- double evaluate_incrementally (const bit_vector_t &x, double v, const hnco::sparse_bit_vector_t &flipped_bits) override
  Incrementally evaluate a bit vector.

Information about the function

- int get_bv_size () const override
  Get bit vector size.
- double get_maximum () const override
  Get the global maximum.
- bool has_known_maximum () const override
  Check for a known maximum.
- bool provides_incremental_evaluation () const override
  Check whether the function provides incremental evaluation.

Private Member Functions

- template<class Archive >
  void serialize (Archive &ar, const unsigned int version)
  Serialize.

Private Attributes

- std::vector< double > _linear
  Linear part.

Friends

- class **boost::serialization::access**

5.144.1 Detailed Description

Walsh expansion of degree 1.

Its expression is of the form

$f(x) = \sum_i a_i (1 - 2x_i)$

or equivalently

$f(x) = \sum_i a_i (-1)^{x_i}$

Definition at line 49 of file walsh-expansion-1.hh.

5.144.2 Member Function Documentation

5.144.2.1 generate()

```
void generate (
             int n,
             Generator generator )  [inline]
```

Instance generator.

Parameters

n	Size of bit vectors
generator	Weight generator

Definition at line 81 of file walsh-expansion-1.hh.

5.144.2.2 has_known_maximum()

```
bool has_known_maximum ( ) const  [inline], [override], [virtual]
```

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 149 of file walsh-expansion-1.hh.

5.144.2.3 load()

```
void load (
            std::string path ) [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 113 of file walsh-expansion-1.hh.

5.144.2.4 provides_incremental_evaluation()

```
bool provides_incremental_evaluation ( ) const [inline], [override], [virtual]
```

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 154 of file walsh-expansion-1.hh.

5.144.2.5 random()

```
void random (
            int n ) [inline]
```

Random instance.

The weights are sampled from the normal distribution.

Parameters

n	Size of bit vectors

Definition at line 95 of file walsh-expansion-1.hh.

5.144.2.6 save()

```
void save (
            std::string path ) const  [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 120 of file walsh-expansion-1.hh.

The documentation for this class was generated from the following files:

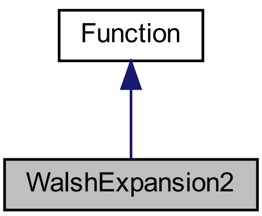
- lib/hnco/functions/collection/walsh/walsh-expansion-1.hh
- lib/hnco/functions/collection/walsh/walsh-expansion-1.cc

5.145 WalshExpansion2 Class Reference

Walsh expansion of degree 2.

`#include <hnco/functions/collection/walsh/walsh-expansion-2.hh>`

Inheritance diagram for WalshExpansion2:



Public Member Functions

- WalshExpansion2 ()
  Constructor.
- int get_bv_size () const override
  Get bit vector size.
- double evaluate (const bit_vector_t &) override
  Evaluate a bit vector.

Instance generators

- template<class LinearGen , class QuadraticGen >
  void generate (int n, LinearGen linear_gen, QuadraticGen quadratic_gen)
  Instance generators.
- void random (int n)
  Instance generator.
- void generate_ising1_long_range (int n, double alpha)
  Generate one dimensional Ising model with long range interactions.
- void generate_ising1_long_range_periodic (int n, double alpha)
  Generate one dimensional Ising model with long range interactions and periodic boundary conditions.

Load and save instance

- void load (std::string path)
  Load instance.
- void save (std::string path) const
  Save instance.

Private Member Functions

- template<class Archive >
  void serialize (Archive &ar, const unsigned int version)
  Serialize.
- void resize (int n)
  Resize data structures.

Private Attributes

- std::vector< double > _linear
  Linear part.
- std::vector< std::vector< double > > _quadratic
  Quadratic part.

Friends

- class **boost::serialization::access**

5.145.1 Detailed Description

Walsh expansion of degree 2.

Its expression is of the form

$f(x) = \sum_i a_i (1 - 2x_i) + \sum_{i<j} a_{ij} (1 - 2x_i)(1 - 2x_j)$

or equivalently

$f(x) = \sum_i a_i (-1)^{x_i} + \sum_{i<j} a_{ij} (-1)^{x_i + x_j}$

Definition at line 49 of file walsh-expansion-2.hh.

5.145.2 Member Function Documentation

5.145.2.1 generate()

```
void generate (
            int n,
            LinearGen linear_gen,
            QuadraticGen quadratic_gen )  [inline]
```

Instance generators.

Parameters

n	Size of bit vectors
linear_gen	Generator for the linear part
quadratic_gen	Generator for the quadratic part

Definition at line 93 of file walsh-expansion-2.hh.

5.145.2.2 generate_ising1_long_range()

```
void generate_ising1_long_range (
            int n,
            double alpha )
```

Generate one dimensional Ising model with long range interactions.

Similar to a Dyson-Ising model except for the finite, instead of infinite, linear chain of spins.

Its expression is of the form

$f(x) = \sum_{ij} J(d_{ij})(1 - 2x_i)(1 - 2x_j)$

or equivalently

$f(x) = \sum_{ij} J(d_{ij})(-1)^{x_i + x_j}$

where $J(d_{ij})$ is the interaction between sites i and j, $d_{ij} = |i - j|$, and $J(n) = n^{-\alpha}$.

Since we are maximizing f or minimizing -f, the expression of f is compatible with what can be found in physics textbooks.

Parameters

n	Size of bit vectors
alpha	Exponential decay parameter

Definition at line 82 of file walsh-expansion-2.cc.

5.145.2.3 generate_ising1_long_range_periodic()

```
void generate_ising1_long_range_periodic (
            int n,
            double alpha )
```

Generate one dimensional Ising model with long range interactions and periodic boundary conditions.

Similar to a Dyson-Ising model except for the finite, instead of infinite, linear chain of spins.

Its expression is of the form

$f(x) = \sum_{ij} J(d_{ij})(1 - 2x_i)(1 - 2x_j)$

or equivalently

$f(x) = \sum_{ij} J(d_{ij})(-1)^{x_i + x_j}$

where $J(d_{ij})$ is the interaction between sites i and j, $d_{ij} = \min\{|i - j|, n - |i - j|\}$, and $J(n) = n^{-\alpha}$.

Since we are maximizing f or minimizing -f, the expression of f is compatible with what can be found in physics textbooks.

Parameters

n	Size of bit vectors
alpha	Exponential decay parameter

Definition at line 103 of file walsh-expansion-2.cc.

5.145.2.4 load()

```
void load (
```

```
            std::string path )  [inline]
```

Load instance.

Parameters

path	Path of the instance to load

Exceptions

std::runtime_error	

Definition at line 184 of file walsh-expansion-2.hh.

5.145.2.5 random()

```
void random (
            int n )  [inline]
```

Instance generator.

The weights are sampled from the normal distribution.

Parameters

n	Size of bit vector

Definition at line 115 of file walsh-expansion-2.hh.

5.145.2.6 save()

```
void save (
            std::string path ) const  [inline]
```

Save instance.

Parameters

path	Path of the instance to save

Exceptions

std::runtime_error	

Definition at line 191 of file walsh-expansion-2.hh.

5.145.3 Member Data Documentation

5.145.3.1 _quadratic

```
std::vector<std::vector<double> > _quadratic [private]
```

Quadratic part.

Represented as a lower triangular matrix (without its diagonal).

Definition at line 71 of file walsh-expansion-2.hh.

The documentation for this class was generated from the following files:

- lib/hnco/functions/collection/walsh/walsh-expansion-2.hh
- lib/hnco/functions/collection/walsh/walsh-expansion-2.cc

5.146 WalshTerm Struct Reference

Walsh transform term.

```
#include <hnco/functions/walsh-term.hh>
```

Public Member Functions

- template<class Archive >
  void serialize (Archive &ar, const unsigned int version)
  Serialize.

Public Attributes

- std::vector< bool > feature
  Feature.
- double coefficient
  Coefficient.

5.146.1 Detailed Description

Walsh transform term.

Definition at line 35 of file walsh-term.hh.

5.146.2 Member Data Documentation

5.146.2.1 feature

```
std::vector<bool> feature
```

Feature.

Implemented with a vector bool instead of a bit_vector_t to reduce the memory consumption.

Definition at line 42 of file walsh-term.hh.

The documentation for this struct was generated from the following file:

- lib/hnco/functions/walsh-term.hh

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