HNCO

0.13

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top-level HNCO namespace

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  Transvection sequence affine map.

Functions

- template<class T >
  T square (T x)

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- double logistic (double x)

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Range checking

- bool is_in_range (int i, int n)

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

  Check whether an index is in a given range.

Types and functions related to bit matrices

- typedef std::vector< bit_vector_t > bit_matrix_t

  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 num_rows, int num_columns)

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

  Resize a bit matrix and make it a square matrix.

- void bm_clear (bit_matrix_t &M)

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

  Set the matrix to the identity matrix.
- void bm_identity (bit_matrix_t &M, int n)

  Set the matrix to the identity 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 i, int j)

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

  Add two columns.
- 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 (const bit_matrix_t &M, const bit_vector_t &x, bit_vector_t &y)

  Multiply a bit matrix and a bit vector.
- void bm_transpose (const bit_matrix_t &M, bit_matrix_t &N)

  Transpose.

Types and functions related to bit

- typedef char bit_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

- typedef std::vector< bit_t > bit_vector_t

  Bit vector.
- typedef std::pair< bit_vector_t, double > point_value_t

  Type to represent point value pairs.
- 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 (const bit_vector_t &src, bit_vector_t &dest)

  Add two bit vectors.
- void bv_add (const bit_vector_t &x, const bit_vector_t &y, bit_vector_t &dest)

  Add two bit vectors.
- void bv_to_vector_bool (const bit_vector_t &x, std::vector< bool > &y)

  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 bit vector to a size_t.
- void bv_from_size_type (bit_vector_t &x, std::size_t index)

  Convert a size_t to a bit vector.
- void bv_from_stream (bit_vector_t &x, std::istream &stream)

  Read a bit vector from a stream.

Types and functions related to permutations

- typedef std::vector< int > permutation_t

  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.

Types and functions related to sparse bit matrices

- typedef std::vector< sparse_bit_vector_t > sparse_bit_matrix_t

  Sparse bit matrix.
- void sbm_display (const sparse_bit_matrix_t &sbm, std::ostream &stream)

  Display sparse bit matrix.
- void bm_to_sbm (const bit_matrix_t &bm, sparse_bit_matrix_t &sbm)

  Convert a bit matrix to a sparse bit matrix.
- void sbm_multiply (const sparse_bit_matrix_t &M, const bit_vector_t &x, bit_vector_t &y)

  Multiply a sparse bit matrix and a bit vector.

Types and functions related to sparse bit vectors

- typedef std::vector< int > sparse_bit_vector_t

  Sparse bit vector.
- void bv_flip (bit_vector_t &x, const sparse_bit_vector_t &sbv)

  Flip many bits.
- void sbv_display (const sparse_bit_vector_t &v, std::ostream &stream)

  Display sparse bit vector.
- void bv_to_sbv (const bit_vector_t &bv, sparse_bit_vector_t &sbv)

  Convert a bit vector to a sparse bit vector.

Types and functions related to transvections

- typedef std::vector< Transvection > transvection_sequence_t

  Transvection sequence.
- bool transvections_commute (const Transvection &a, const Transvection &b)

  Check whether two transvections commute.
- 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 (const transvection_sequence_t &ts, bit_vector_t &x)

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

  Multiply a matrix by a transvection sequence from the left.

4.1.1 Detailed Description

top-level HNCO namespace

4.1.2 Typedef Documentation

4.1.2.1 bit_t

```
typedef char bit_t
```

Bit.

A single bit is represented by a char.

Definition at line 49 of file bit-vector.hh.

4.1.2.2 sparse_bit_matrix_t

```
typedef std::vector<sparse_bit_vector_t> sparse_bit_matrix_t
```

Sparse bit matrix.

A sparse bit matrix is represented as an array of sparse bit vectors. It knows its number of row, not its number of columns.

Definition at line 45 of file sparse-bit-matrix.hh.

4.1.2.3 sparse_bit_vector_t

```
typedef std::vector<int> sparse_bit_vector_t
```

Sparse bit vector.

A sparse bit vector is represented as an array 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 47 of file sparse-bit-vector.hh.

4.1.2.4 transvection_sequence_t

```
typedef std::vector<Transvection> transvection_sequence_t
```

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 164 of file transvection.hh.

4.1.3 Function Documentation

4.1.3.1 bm_add_columns()

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

Add two columns.

Column src is added to column dest.

Parameters

M	Bit matrix
src	Source column
dest	Destination column

Warning

M is modified by the function.

Definition at line 150 of file bit-matrix.cc.

4.1.3.2 bm_add_rows()

```
void bm_add_rows (
            bit_matrix_t & M,
            int i,
            int j )
```

Add two rows.

Row i is added to row j.

Definition at line 141 of file bit-matrix.cc.

4.1.3.3 bm_identity() [1/2]

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

Set the matrix to the identity matrix.

Precondition

bm_is_square(M)

Definition at line 56 of file bit-matrix.cc.

4.1.3.4 bm_identity() [2/2]

```
void bm_identity (
             bit_matrix_t & M,
             int n )
```

Set the matrix to the identity matrix.

Parameters

M	Bit matrix
n	Dimension

Definition at line 67 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	input matrix
N	inverse matrix

Precondition

bm_is_square(M)
bm_is_square(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 268 of file bit-matrix.cc.

4.1.3.6 bm_multiply()

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

Multiply a bit matrix and a bit vector.

The result is y = Mx.

Definition at line 312 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 196 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 165 of file bit-matrix.cc.

4.1.3.9 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 214 of file bit-matrix.cc.

4.1.3.10 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 247 of file bit-matrix.cc.

4.1.3.11 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 155 of file bit-vector.cc.

4.1.3.12 bv_to_vector_bool()

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

Convert a bit vector to a bool vector.

Warning

Vectors must be of the same size.

Definition at line 142 of file bit-vector.cc.

4.1.3.13 is_in_range() [1/2]

```
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

Returns

true if i >= 0 and i < n

Definition at line 152 of file bit-vector.hh.

4.1.3.14 is_in_range() [2/2]

```
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

Returns

true if i >= a and i < b

Definition at line 162 of file bit-vector.hh.

4.1.3.15 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 46 of file permutation.hh.

4.1.3.16 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 56 of file permutation.hh.

4.1.3.17 sbm_multiply()

```
void sbm_multiply (
             const sparse_bit_matrix_t & M,
             const bit_vector_t & x,
             bit_vector_t & y )
```

Multiply a sparse bit matrix and a bit vector.

The result is y = Mx.

Definition at line 47 of file sparse-bit-matrix.cc.

4.1.3.18 ts_is_valid() [1/2]

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

Check validity.

Parameters

ts	Transvection sequence

Definition at line 143 of file transvection.cc.

4.1.3.19 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 149 of file transvection.cc.

4.1.3.20 ts_multiply() [1/2]

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

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 348 of file transvection.cc.

4.1.3.21 ts_multiply() [2/2]

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

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 358 of file transvection.cc.

4.1.3.22 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 165 of file transvection.cc.

4.1.3.23 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

Definition at line 176 of file transvection.cc.

4.1.3.24 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 304 of file transvection.cc.

4.1.3.25 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 333 of file transvection.cc.

4.1.3.26 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 271 of file transvection.cc.

4.1.3.27 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 238 of file transvection.cc.

4.2 hnco::algorithm Namespace Reference

Algorithms.

Namespaces

- bm_pbil

  Boltzmann machine PBIL.
- hea

  Herding evolutionary algorithm.

Classes

- class Algorithm

  Abstract search algorithm.
- class BiasedCrossover

  Biased crossover.
- class CompactGa

  Compact genetic algorithm.
- class CompleteSearch

  Complete search.
- class Crossover

  Crossover.
- class FirstAscentHillClimbing

First ascent hill climbing.

- class GeneticAlgorithm

  Genetic algorithm.
- class IterativeAlgorithm

  Iterative search.
- class LogContext

  Log context.
- class Mmas

  Max-min ant system.
- class MuCommaLambdaEa

  (mu, lambda) EA.
- class MuPlusLambdaEa

  (mu+lambda) EA.
- class NpsPbil

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

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

  (1+1) EA.
- class Pbil

  Population-based incremental learning.
- class Population

  Population.
- class ProgressTrackerContext

  Log context for ProgressTracker.
- class PvAlgorithm

  Probability vector algorithm.
- class RandomLocalSearch

  Random local search.
- class RandomSearch

  Random search.
- class RandomWalk

  Random walk.
- class Restart

  Restart.
- class SimulatedAnnealing

  Simulated annealing.
- class SteepestAscentHillClimbing

  Steepest ascent hill climbing.
- class TournamentSelection

  Population with tournament selection.
- class Umda

  Univariate marginal distribution algorithm.
- class UniformCrossover

  Uniform crossover.

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 functions related to probability vectors

- typedef std::vector< double > pv_t

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

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

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

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

  Average.
- void pv_update (pv_t &pv, double rate, const bit_vector_t &x)

  Update a probability vector toward a bit vector.
- void pv_update (pv_t &pv, double rate, const std::vector< double > &x)

  Update a probability vector toward a probability vector.
- void pv_update (pv_t &pv, double rate, const std::vector< double > &x, const std::vector< double > &y)

  Update a probability vector toward a probability vector and away from another one.
- void pv_bound (pv_t &pv, double lower_bound, double upper_bound)

  Bound the components of a probability vector.

4.2.1 Detailed Description

Algorithms.

4.3 hnco::algorithm::bm_pbil Namespace Reference

Boltzmann machine PBIL.

Classes

- class BmPbil

  Boltzmann machine PBIL.
- class Model

  Model of a Boltzmann machine.
- class ModelParameters

  Parameters of a Boltzmann machine.

4.3.1 Detailed Description

Boltzmann machine PBIL.

4.4 hnco::algorithm::hea Namespace Reference

Herding evolutionary algorithm.

Classes

- class BitHerding

  Herding with bit features.
- struct BitMoment

  Moment for bit features.
- class Hea

  Herding evolutionary algorithm.
- class SpinHerding

  Herding with spin variables.
- struct SpinMoment

  Moment for spin variables.

4.4.1 Detailed Description

Herding evolutionary algorithm.

4.5 hnco::exception Namespace Reference

Exceptions.

Classes

- class Error

  Error.
- class Exception

  Basic exception.
- class LastEvaluation

  Last evaluation.
- class LocalMaximum

  Local maximum.
- class MaximumReached

  Maximum reached.
- class PointValueException

  Point-value exception.
- class TargetReached

  target reached

4.5.1 Detailed Description

Exceptions.

4.6 hnco::function Namespace Reference

Real black box functions defined on bit vectors.

Namespaces

- real

  Real multivariate functions.

Classes

- class AbstractLabs

  Abstract class for low autocorrelation binary sequences.
- class AbstractMaxSat

  Abstract class for MaxSat-like functions.
- class AdditiveGaussianNoise

  Additive Gaussian Noise.
- class Cache

  Cache.
- class CallCounter

  Call counter.
- class DeceptiveJump

  Deceptive jump.
- class EqualProducts

  Equal products.
- class Factorization

Factorization.
- class FourPeaks

  Four Peaks.
- class Function

  Function.
- class FunctionController

  Function controller.
- class FunctionDecorator

  Function decorator.
- class FunctionMapComposition

  Composition of a function and a map.
- class FunctionModifier

  Function modifier.
- class FunctionPlugin

  Function plugin.
- class Hiff

  Hierarchical if and only if.
- class Jump

  Jump.
- class Labs

  Low autocorrelation binary sequences.
- class LabsMeritFactor

  Low autocorrelation binary sequences merit factor.
- class LeadingOnes

  Leading ones.
- class LinearFunction

  Linear function.
- class LongPath

  Long path.
- class MaxNae3Sat

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

  MAX-SAT.
- class NearestNeighborIsingModel1

  Nearest neighbor Ising model in one dimension.
- class NearestNeighborIsingModel2

  Nearest neighbor Ising model in two dimensions.
- class Needle

  Needle in a haystack.
- class Negation

  Negation.
- class NkLandscape

  NK landscape.
- class OnBudgetFunction

  CallCounter with a limited number of evaluations.
- class OneMax

  OneMax.
- class ParsedModifier

  Parsed modifier.
- class Plateau

  Plateau.

- class PriorNoise

  Prior noise.
- class ProgressTracker

  ProgressTracker.
- class Qubo

  Quadratic unconstrained binary optimization.
- class Ridge

  Ridge.
- class SinusSummationCancellation

  Summation cancellation with sinus.
- class SixPeaks

  Six Peaks.
- class StopOnMaximum

  Stop on maximum.
- class StopOnTarget

  Stop on target.
- class SummationCancellation

  Summation cancellation.
- class Trap

  Trap.
- class WalshExpansion

  Walsh expansion.
- class WalshExpansion1

  Walsh expansion of degree 1.
- class WalshExpansion2

  Walsh expansion of degree 2.

Functions

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

  Insert formatted output.
- bool bv_is_locally_maximal (const bit_vector_t &bv, Function &fn, hnco::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.

4.6.1 Detailed Description

Real black box functions defined on bit vectors.

4.7 hnco::function::real Namespace Reference

Real multivariate functions.

Classes

- class DyadicRealRepresentation

  Dyadic real representation.
- class ParsedRealMultivariateFunction

  Parsed real multivariate function.
- class RealMultivariateFunction

  Real multivariate function.
- class RealMultivariateFunctionAdapter

  Real multivariate function adapter.
- class RealRepresentation

  Real representation.

4.7.1 Detailed Description

Real multivariate functions.

4.8 hnco::neighborhood Namespace Reference

Neighborhoods for local search.

Classes

- class BernoulliProcess

  Bernoulli process.
- class HammingBall

  Hamming ball.
- class HammingSphere

  Hamming sphere.
- class HammingSphereIterator

  Hamming sphere neighborhood iterator.
- class MultiBitFlip

  Multi bit flip.
- class Neighborhood

  Neighborhood.
- class NeighborhoodIterator

  Neighborhood iterator.
- class SingleBitFlip

  One bit neighborhood.
- class SingleBitFlipIterator

  Single bit flip neighborhood iterator.

4.8.1 Detailed Description

Neighborhoods for local search.

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

4.9 hnco::random Namespace Reference

Pseudo random numbers.

Classes

- struct Random

    Random numbers.

4.9.1 Detailed Description

Pseudo random numbers.

Chapter 5

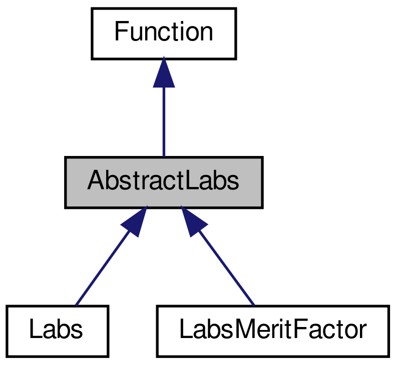
Class Documentation

5.1 AbstractLabs Class Reference

Abstract class for low autocorrelation binary sequences.

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

Inheritance diagram for AbstractLabs:



Public Member Functions

- AbstractLabs (int n)

  Constructor.
- int get_bv_size ()

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

  Compute autocorrelation.

Protected Attributes

- std::vector< int > _sequence

  Binary sequence written using 1 and -1.

5.1.1 Detailed Description

Abstract class for low autocorrelation binary sequences.

Definition at line 32 of file labs.hh.

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

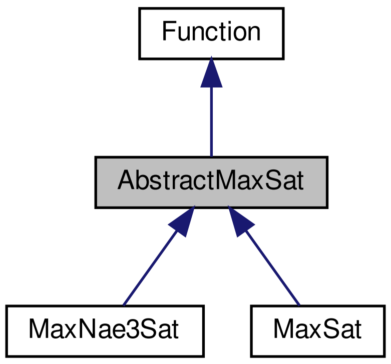
- lib/hnco/functions/labs.hh
- lib/hnco/functions/labs.cc

5.2 AbstractMaxSat Class Reference

Abstract class for MaxSat-like functions.

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

Inheritance diagram for AbstractMaxSat:



Public Member Functions

- AbstractMaxSat ()

  Default constructor.
- int get_bv_size ()

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

  Display the expression.
- virtual void load (std::istream &stream)

  Load an instance.
- virtual void save (std::ostream &stream)

  Save an instance.

Protected Attributes

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

  Expression.
- int _num_variables

  Number of variables.

5.2.1 Detailed Description

Abstract class for MaxSat-like functions.

Definition at line 35 of file max-sat.hh.

5.2.2 Member Function Documentation

5.2.2.1 load()

```
void load (
             std::istream & stream )  [virtual]
```

Load an instance.

Exceptions

Error	

Reimplemented in MaxNae3Sat.

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

5.2.3 Member Data Documentation

5.2.3.1 _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:

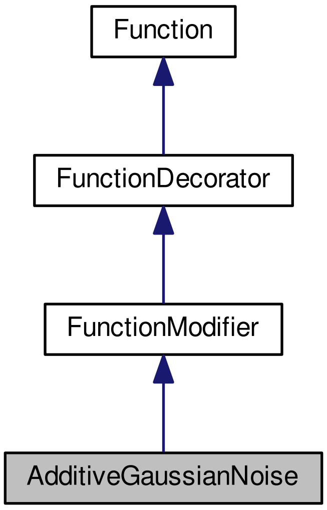
- lib/hnco/functions/max-sat.hh
- lib/hnco/functions/max-sat.cc

5.3 AdditiveGaussianNoise Class Reference

Additive Gaussian Noise.

```
#include <hnco/functions/decorators/function-modifier.hh>
```

Inheritance diagram for AdditiveGaussianNoise:



Public Member Functions

- AdditiveGaussianNoise (Function ∗function, double stddev)

    Constructor.
- double eval (const bit_vector_t &)

    Evaluate a bit vector.

Information about the function

- int get_bv_size ()

    Get bit vector size.

Private Attributes

- std::normal_distribution< double > _dist

    Normal distribution.

Additional Inherited Members

5.3.1 Detailed Description

Additive Gaussian Noise.

Definition at line 169 of file function-modifier.hh.

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

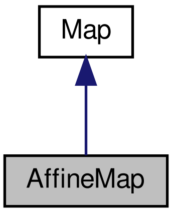
- lib/hnco/functions/decorators/function-modifier.hh
- lib/hnco/functions/decorators/function-modifier.cc

5.4 AffineMap Class Reference

Affine map.

```
#include <hnco/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)

    Map
- int get_input_size ()

    Get input size.
- int get_output_size ()

    Get output size.
- bool is_surjective ()

    Check for surjective 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**

5.4.1 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 258 of file map.hh.

5.4.2 Member Function Documentation

5.4.2.1 is_surjective()

```
bool is_surjective ( )  [virtual]
```

Check for surjective map.

Returns

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

Reimplemented from Map.

Definition at line 136 of file map.cc.

5.4.2.2 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

Error	

Definition at line 99 of file map.cc.

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

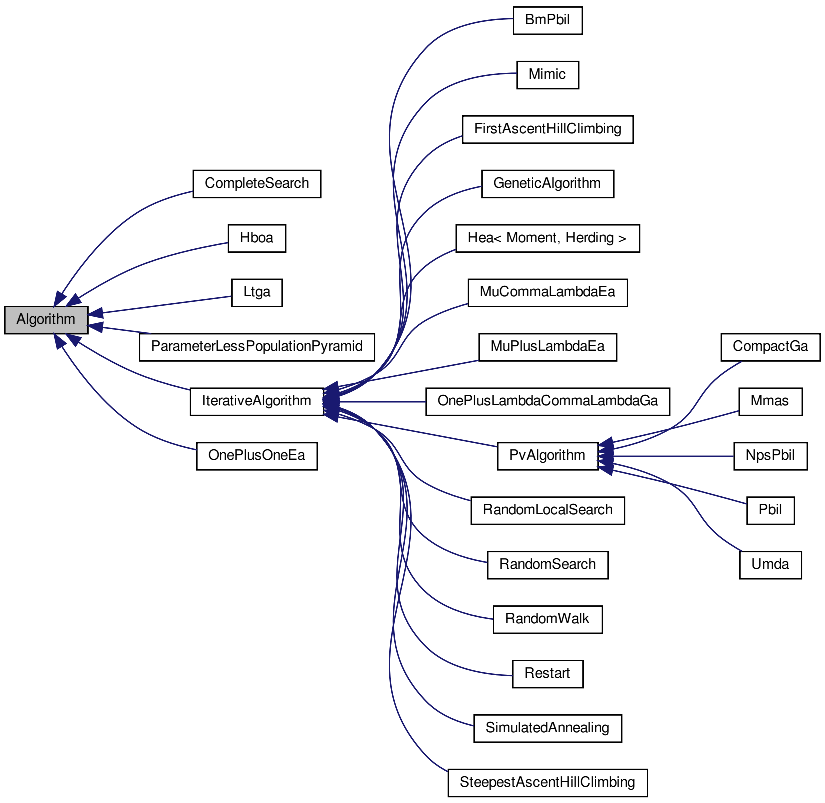
- lib/hnco/map.hh
- lib/hnco/map.cc

5.5 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.

Optimization

- virtual void init ()

  Initialization.
- virtual void maximize ()=0

  Maximize.

Getters

- virtual const point_value_t & get_solution ()

  Solution.
- virtual int get_bv_size ()

  Get bit vector size.

Setters

- virtual void set_function (function::Function ∗function)

  Set function.
- virtual void set_functions (const std::vector< function::Function ∗> functions)

  Set functions.
- void set_stream (std::ostream ∗x)

  Output stream.
- void set_log_context (LogContext ∗lc)

  Set log context.

Protected Member Functions

Managing solution

- void random_solution ()

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

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

  Set solution.
- void update_solution (const bit_vector_t &x, double value)

  Update solution (strict)
- void update_solution (const point_value_t &pv)

  Update solution (strict)
- void update_solution (const bit_vector_t &x)

  Update solution (strict).

Protected Attributes

- function::Function ∗ _function

  Function.
- std::vector< function::Function ∗ > _functions

  Functions.
- point_value_t _solution

  Solution.
- LogContext ∗ _log_context = nullptr

  Log context.

Parameters

- std::ostream ∗ _stream = &std::cout

  Output stream.

5.5.1 Detailed Description

Abstract search algorithm.

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

Definition at line 41 of file algorithm.hh.

5.5.2 Member Function Documentation

5.5.2.1 set_solution()

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

Set solution.

Warning

Evaluates the function once.

Definition at line 47 of file algorithm.cc.

5.5.2.2 update_solution()

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

Update solution (strict).

Warning

Evaluates the function once.

Definition at line 70 of file algorithm.cc.

5.5.3 Member Data Documentation

5.5.3.1 _functions

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

Functions.

Each thread has its own function.

Definition at line 52 of file algorithm.hh.

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

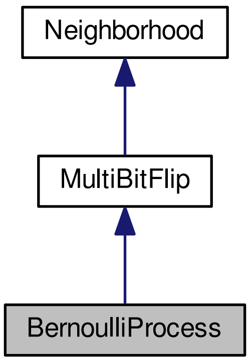
- lib/hnco/algorithms/algorithm.hh
- lib/hnco/algorithms/algorithm.cc

5.6 BernoulliProcess Class Reference

Bernoulli process.

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

Inheritance diagram for BernoulliProcess:



Public Member Functions

- BernoulliProcess (int n)

    Constructor.
- BernoulliProcess (int n, double p)

    Constructor.
- void set_probability (double p)

    Set probability.

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 _reservoir_sampling = false

    Reservoir sampling.

Parameters

- bool _allow_stay = false

    Allow stay.
- void set_allow_stay (bool x)

    Set the flag _allow_stay.

Additional Inherited Members

5.6.1 Detailed Description

Bernoulli process.

Each component of the origin bit vector is flipped with some fixed probability. 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 220 of file neighborhood.hh.

5.6.2 Constructor & Destructor Documentation

5.6.2.1 BernoulliProcess() [1/2]

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

Constructor.

Parameters

n	Size of bit vectors

The Bernoulli probability is set to 1 / n.

Definition at line 255 of file neighborhood.hh.

5.6.2.2 BernoulliProcess() [2/2]

```
BernoulliProcess (
            int n,
            double p )  [inline]
```

Constructor.

Parameters

n	Size of bit vectors
p	Bernoulli probability

Definition at line 265 of file neighborhood.hh.

5.6.3 Member Function Documentation

5.6.3.1 set_allow_stay()

```
void set_allow_stay (
            bool x )  [inline]
```

Set the flag _allow_stay.

In case no mutation occurs allow the current bit vector to stay unchanged.

Definition at line 292 of file neighborhood.hh.

5.6.3.2 set_probability()

```
void set_probability (
            double p )  [inline]
```

Set probability.

Sets _reservoir_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 276 of file neighborhood.hh.

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

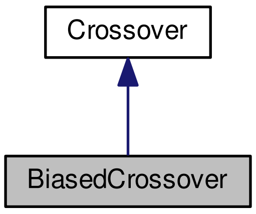
- lib/hnco/neighborhoods/neighborhood.hh
- lib/hnco/neighborhoods/neighborhood.cc

5.7 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.

5.7.1 Detailed Description

Biased crossover.

Definition at line 75 of file crossover.hh.

5.7.2 Member Function Documentation

5.7.2.1 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

5.8 BitHerding Class Reference

Herding with bit features.

```
#include <hnco/algorithms/hea/bit-herding.hh>
```

Public Types

- enum { DYNAMICS_MINIMIZE_NORM, DYNAMICS_MAXIMIZE_INNER_PRODUCT }

Public Member Functions

- BitHerding (int n)
  Constructor.
- void init ()
  Initialization.
- void sample (const BitMoment &target, bit_vector_t &x)
  Sample a bit vector.
- double error (const BitMoment &target)
  Compute the error.

Getters

- const BitMoment & get_delta ()
  Get delta.

Setters

- void set_randomize_bit_order (bool x)
  Randomize bit order.
- void set_dynamics (int x)
  Set the dynamics.
- void set_weight (double x)
  Set the weight of second order moments.

Protected Member Functions

- void compute_delta (const BitMoment &target)

  Compute delta.
- void sample_minimize_norm (const BitMoment &target, bit_vector_t &x)

  Sample a bit vector.
- void sample_maximize_inner_product (const BitMoment &target, bit_vector_t &x)

  Sample a bit vector.

Protected Attributes

- BitMoment _count

  Counter moment.
- BitMoment _delta

  Delta moment.
- permutation_t _permutation

  Permutation.
- std::uniform_int_distribution$<$ int $>$ _choose_bit

  Choose bit.
- int _time

  Time.

Parameters

- bool _randomize_bit_order = false

  Randomize bit order.
- int _dynamics = DYNAMICS_MINIMIZE_NORM

  Dynamics.
- double _weight = 1

  Weight of second order moments.

5.8.1 Detailed Description

Herding with bit features.

Definition at line 38 of file bit-herding.hh.

5.8.2 Member Enumeration Documentation

5.8.2.1 anonymous enum

```
anonymous enum
```

Enumerator

DYNAMICS_MINIMIZE_NORM	Dynamics defined as minimization of a norm.
DYNAMICS_MAXIMIZE_INNER_PRODUCT	Dynamics defined as maximization of an inner product.

Definition at line 83 of file bit-herding.hh.

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

- lib/hnco/algorithms/hea/bit-herding.hh
- lib/hnco/algorithms/hea/bit-herding.cc

5.9 BitMoment Struct Reference

Moment for bit features.

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

Public Member Functions

- BitMoment (int n)

  Constructor.
- void uniform ()

  Set the moment to that of the uniform distribution.
- void init ()

  Initialize.
- void add (const bit_vector_t &x)

  Accumulate a bit vector.
- void average (int count)

  Compute average.
- void update (const BitMoment &p, double rate)

  Update moment.
- void bound (double margin)

  Bound moment.
- double distance (const BitMoment &p) const

  Distance.
- double norm_2 () const

  Compute the norm 2.
- double diameter () const

  Compute the diameter.
- size_t size () const

  Size.
- void display (std::ostream &stream)

  Display.

Public Attributes

- std::vector< std::vector< double > > _moment

  Moment.
- double _weight = 1

  Weight of second order moments.

5.9.1 Detailed Description

Moment for bit features.

Definition at line 38 of file bit-moment.hh.

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

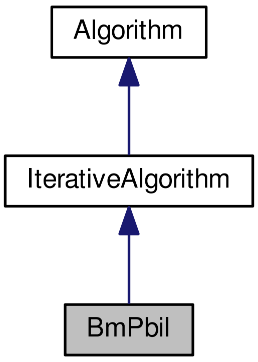
- lib/hnco/algorithms/hea/bit-moment.hh
- lib/hnco/algorithms/hea/bit-moment.cc

5.10 BmPbil Class Reference

Boltzmann machine PBIL.

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

Inheritance diagram for BmPbil:



Public Types

- enum { LOG_NORM_INFINITE, LOG_NORM_L1, **LAST_LOG** }
- enum { SAMPLING_ASYNCHRONOUS, SAMPLING_ASYNCHRONOUS_FULL_SCAN, SAMPLING_SY↩ NCHRONOUS }
- enum { RESET_NO_RESET, RESET_ITERATION, RESET_BIT_VECTOR }
- typedef std::bitset< LAST_LOG > **log_flags_t**

Public Member Functions

- BmPbil (int n, int population_size)

  Constructor.
- void init ()

  Initialization.

Private Member Functions

- void iterate ()

  Single iteration.
- void log ()

  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.

Private Attributes

- log_flags_t _log_flags

  Log flags.
- Population _population

  Population.
- Model _model

  Model.
- ModelParameters _parameters_all

  Parameters averaged over all individuals.
- ModelParameters _parameters_best

  Parameters averaged over selected individuals.
- ModelParameters _parameters_worst

  Parameters averaged over negatively selected individuals.
- std::uniform_int_distribution< size_t > _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.

- 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.
- void set_log_flags (const log_flags_t &lf)

  Set log flags.

Additional Inherited Members

5.10.1 Detailed Description

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 51 of file bm-pbil.hh.

5.10.2 Member Enumeration Documentation

5.10.2.1 anonymous enum

```
anonymous enum
```

Enumerator

LOG_NORM_INFINITE	Log infinite norm of the model parameters.
LOG_NORM_L1	Log 1-norm of the model parameters.

Definition at line 56 of file bm-pbil.hh.

5.10.2.2 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 66 of file bm-pbil.hh.

5.10.2.3 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 93 of file bm-pbil.hh.

5.10.3 Member Function Documentation

5.10.3.1 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 210 of file bm-pbil.hh.

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

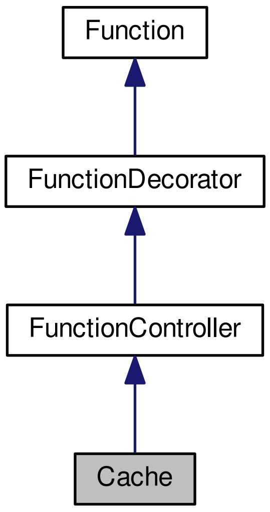
- lib/hnco/algorithms/bm-pbil/bm-pbil.hh
- lib/hnco/algorithms/bm-pbil/bm-pbil.cc

5.11 Cache Class Reference

Cache.

```
#include <hnco/functions/decorators/function-controller.hh>
```

Inheritance diagram for Cache:



Public Member Functions

- Cache (Function ∗function)

  Constructor.
- bool provides_incremental_evaluation ()

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

  Get lookup ratio.

Evaluation

- double eval (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

5.11.1 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 362 of file function-controller.hh.

5.11.2 Constructor & Destructor Documentation

5.11.2.1 Cache()

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

Constructor.

Parameters

function	Decorated function

Definition at line 381 of file function-controller.hh.

5.11.3 Member Function Documentation

5.11.3.1 provides_incremental_evaluation()

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

Check whether the function provides incremental evaluation.

Returns

false

Reimplemented from FunctionController.

Definition at line 390 of file function-controller.hh.

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

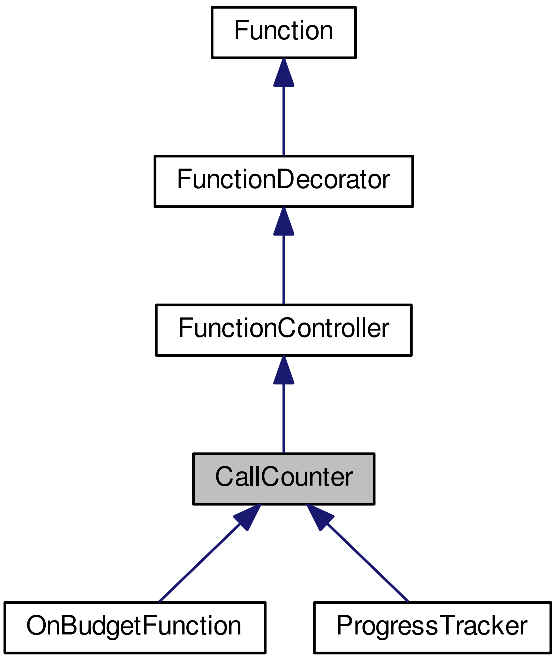
- lib/hnco/functions/decorators/function-controller.hh
- lib/hnco/functions/decorators/function-controller.cc

5.12 CallCounter Class Reference

Call counter.

```
#include <hnco/functions/decorators/function-controller.hh>
```

Inheritance diagram for CallCounter:



Public Member Functions

- CallCounter (Function ∗function)

  Constructor.
- int get_num_calls ()

  Get the number of calls.

Evaluation

- double eval (const bit_vector_t &)

  Evaluate a bit vector.
- double incremental_eval (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_t &flipped←_bits)

  Incremental evaluation.
- void update (const bit_vector_t &x, double value)

  Update after a safe evaluation.

Protected Attributes

- int _num_calls

  Number of calls.

5.12.1 Detailed Description

Call counter.

Definition at line 173 of file function-controller.hh.

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

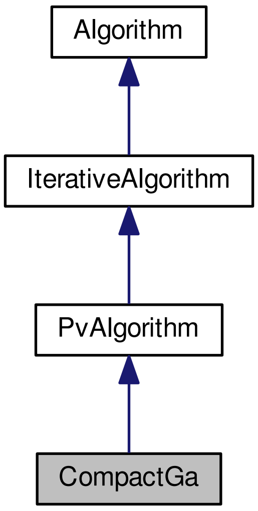
- lib/hnco/functions/decorators/function-controller.hh
- lib/hnco/functions/decorators/function-controller.cc

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.
- void init ()
  Initialization.

Setters

- void set_learning_rate (double x)
  Set the learning rate.

Protected Member Functions

- void iterate ()
  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 43 of file compact-ga.hh.

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

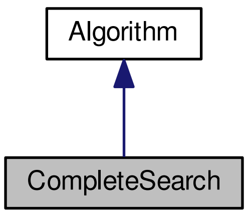
- lib/hnco/algorithms/pv/compact-ga.hh
- lib/hnco/algorithms/pv/compact-ga.cc

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 ()

  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:

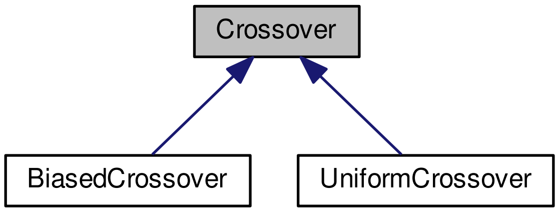
- lib/hnco/algorithms/complete-search.hh
- lib/hnco/algorithms/complete-search.cc

5.15 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.

5.15.1 Detailed Description

Crossover.

Definition at line 35 of file crossover.hh.

5.15.2 Member Function Documentation

5.15.2.1 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:

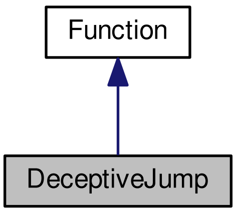
- lib/hnco/algorithms/ea/crossover.hh

5.16 DeceptiveJump Class Reference

Deceptive jump.

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

Inheritance diagram for DeceptiveJump:



Public Member Functions

- DeceptiveJump (int bv_size, int gap)

  Constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.
- bool has_known_maximum ()

  Check for a known maximum.
- double get_maximum ()

  Get the global maximum.

Private Attributes

- int _bv_size

  Bit vector size.
- int _gap

  Gap.

5.16.1 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.

5.16.2 Member Function Documentation

5.16.2.1 get_maximum()

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

Get the global maximum.

Returns

_bv_size + _gap

Reimplemented from Function.

Definition at line 111 of file jump.hh.

5.16.2.2 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 107 of file jump.hh.

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

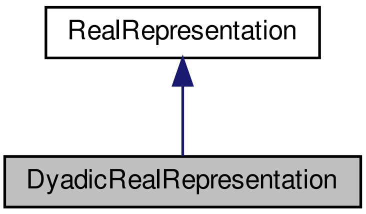
- lib/hnco/functions/jump.hh
- lib/hnco/functions/jump.cc

5.17 DyadicRealRepresentation Class Reference

Dyadic real representation.

```
#include <hnco/functions/real/real-representation.hh>
```

Inheritance diagram for DyadicRealRepresentation:



Public Member Functions

- DyadicRealRepresentation (double lower_bound, double upper_bound, int num_bits)
  Constructor.
- int size ()
  Size of the representation.
- double convert (hnco::bit_vector_t::const_iterator first, hnco::bit_vector_t::const_iterator last)
  Convert a bit vector range into a double.

Private Member Functions

- double affine_transformation (double x)

  Affine transformation.

Private Attributes

- std::vector< double > _lengths

  Lengths of dyadic intervals.
- double _lower_bound

  Lower bound of the search interval.
- double _length

  Length of the search interval.

5.17.1 Detailed Description

Dyadic real representation.

Definition at line 52 of file real-representation.hh.

5.17.2 Constructor & Destructor Documentation

5.17.2.1 DyadicRealRepresentation()

```
DyadicRealRepresentation (
            double lower_bound,
            double upper_bound,
            int num_bits )
```

Constructor.

Parameters

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

Definition at line 31 of file real-representation.cc.

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

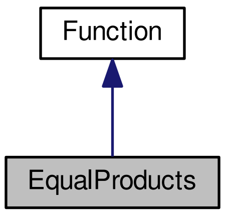
- lib/hnco/functions/real/real-representation.hh
- lib/hnco/functions/real/real-representation.cc

5.18 EqualProducts Class Reference

Equal products.

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

Inheritance diagram for EqualProducts:



Public Member Functions

- EqualProducts ()

  Constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.

Instance generators

- template<class Generator >
  void generate (int n, Generator generator)

  Instance generator.
- void random (int n)

  Random 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**

5.18.1 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 61 of file equal-products.hh.

5.18.2 Member Function Documentation

5.18.2.1 generate()

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

Instance generator.

Parameters

n	Size of bit vectors
generator	Number generator

Definition at line 94 of file equal-products.hh.

5.18.2.2 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 109 of file equal-products.hh.

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

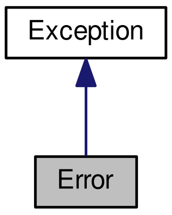
- lib/hnco/functions/equal-products.hh
- lib/hnco/functions/equal-products.cc

5.19 Error Class Reference

Error.

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

Inheritance diagram for Error:



Public Member Functions

- Error ()

    Constructor.
- Error (const std::string &s)

    Constructor.
- virtual ∼Error ()

    Destructor.
- virtual const char ∗ what () const

    Get message.

Protected Attributes

- std::string _what

    Message.

5.19.1 Detailed Description

Error.

Definition at line 84 of file exception.hh.

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

- lib/hnco/exception.hh

5.20 ProgressTracker::Event Struct Reference

Event.

```
#include <hnco/functions/decorators/function-controller.hh>
```

Public Attributes

- int num_evaluations

  Number of evaluations.
- double value

  Value.

5.20.1 Detailed Description

Event.

Definition at line 222 of file function-controller.hh.

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

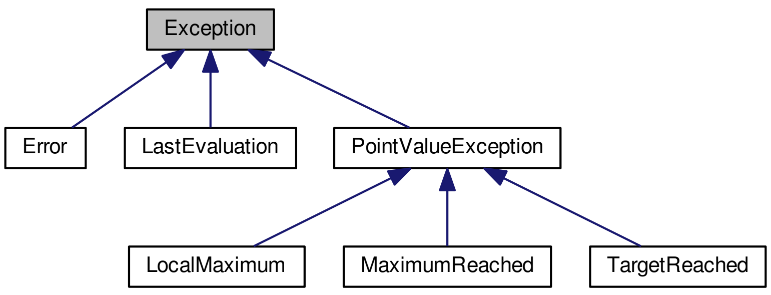
- lib/hnco/functions/decorators/function-controller.hh

5.21 Exception Class Reference

Basic exception.

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

Inheritance diagram for Exception:



5.21.1 Detailed Description

Basic exception.

Definition at line 36 of file exception.hh.

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

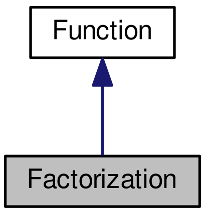
- lib/hnco/exception.hh

5.22 Factorization Class Reference

Factorization.

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

Inheritance diagram for Factorization:



Public Member Functions

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

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.

5.22.1 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 28 of file factorization.hh.

5.22.2 Constructor & Destructor Documentation

5.22.2.1 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.

5.22.3 Member Function Documentation

5.22.3.1 load()

```
void load (
             std::istream & stream )
```

Load an instance.

Warning

The file is a text file which contains exactly one natural number written in base 10 without any space.

Exceptions

Error	

Definition at line 37 of file factorization.cc.

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

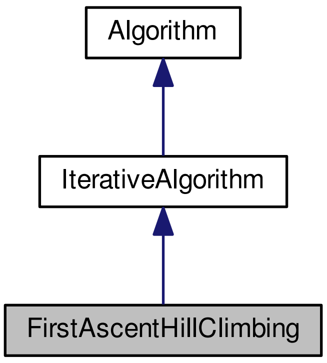
- lib/hnco/functions/factorization.hh
- lib/hnco/functions/factorization.cc

5.23 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.
- void init ()

    Random initialization.
- void init (const bit_vector_t &x)

    Explicit initialization.
- void init (const bit_vector_t &x, double value)

    Explicit initialization.

Protected Member Functions

- void iterate ()

    Single iteration.

Protected Attributes

- neighborhood::NeighborhoodIterator ∗ _neighborhood

    Neighborhood.

5.23.1 Detailed Description

First ascent hill climbing.

Definition at line 35 of file first-ascent-hill-climbing.hh.

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

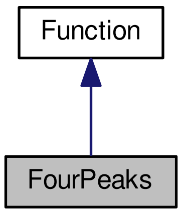
- lib/hnco/algorithms/ls/first-ascent-hill-climbing.hh
- lib/hnco/algorithms/ls/first-ascent-hill-climbing.cc

5.24 FourPeaks Class Reference

Four Peaks.

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

Inheritance diagram for FourPeaks:



Public Member Functions

- FourPeaks (int bv_size, int threshold)

    Constructor.
- int get_bv_size ()

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

    Evaluate a bit vector.
- bool has_known_maximum ()

    Check for a known maximum.
- double get_maximum ()

    Get the global maximum.

Private Attributes

- int _bv_size

    Bit vector size.
- int _threshold

    Threshold.
- int _maximum

    Maximum.

5.24.1 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.

5.24.2 Member Function Documentation

5.24.2.1 get_maximum()

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

Get the global maximum.

Returns

2 $*$ _bv_size - _threshold - 1

Reimplemented from Function.

Definition at line 91 of file four-peaks.hh.

5.24.2.2 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 87 of file four-peaks.hh.

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

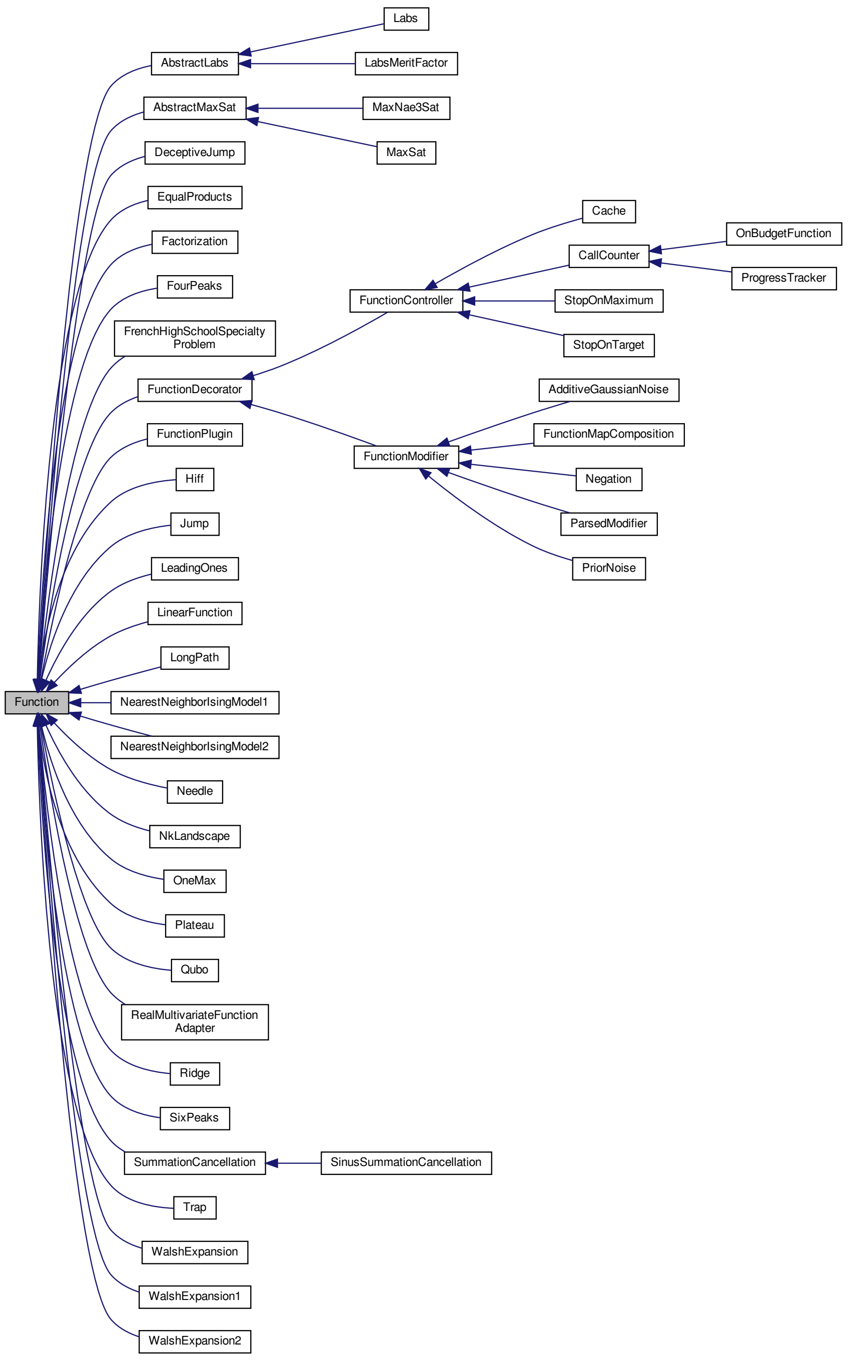
- lib/hnco/functions/four-peaks.hh
- lib/hnco/functions/four-peaks.cc

5.25 Function Class Reference

Function.

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

Inheritance diagram for Function:



Classes

- struct WalshTransformTerm

    Walsh transform term.

Public Member Functions

- virtual ∼Function ()

Destructor.

Information about the function

- virtual int get_bv_size ()=0
  Get bit vector size.
- virtual double get_maximum ()
  Get the global maximum.
- virtual bool has_known_maximum ()
  Check for a known maximum.
- virtual bool provides_incremental_evaluation ()
  Check whether the function provides incremental evaluation.
- virtual void compute_walsh_transform (std::vector< Function::WalshTransformTerm > &terms)
  Compute the Walsh transform of the function.

Evaluation

- virtual double eval (const bit_vector_t &)=0
  Evaluate a bit vector.
- virtual double incremental_eval (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_↩ t &flipped_bits)
  Incremental evaluation.
- virtual double safe_eval (const bit_vector_t &x)
  Safely evaluate a bit vector.
- virtual void update (const bit_vector_t &x, double value)
  Update after a safe evaluation.

Display

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

5.25.1 Detailed Description

Function.

Definition at line 41 of file function.hh.

5.25.2 Member Function Documentation

5.25.2.1 compute_walsh_transform()

```
void compute_walsh_transform (
             std::vector< Function::WalshTransformTerm > & terms )  [virtual]
```

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.

Parameters

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 31 of file function.cc.

5.25.2.2 get_maximum()

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

Get the global maximum.

Exceptions

Error	

Reimplemented in Plateau, Ridge, Hiff, SixPeaks, Needle, FunctionMapComposition, WalshExpansion1, Leading↩ Ones, LinearFunction, DeceptiveJump, LongPath, FourPeaks, SummationCancellation, Trap, PriorNoise, Jump, OneMax, and FunctionController.

Definition at line 80 of file function.hh.

5.25.2.3 incremental_eval()

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

Incremental evaluation.

Exceptions

Error	

Reimplemented in OnBudgetFunction, ProgressTracker, CallCounter, NearestNeighborIsingModel2, Nearest↩ NeighborIsingModel1, StopOnTarget, StopOnMaximum, WalshExpansion1, LinearFunction, Negation, and One↩ Max.

Definition at line 133 of file function.hh.

5.25.2.4 provides_incremental_evaluation()

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

Check whether the function provides incremental evaluation.

Returns

false

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

Definition at line 88 of file function.hh.

5.25.2.5 safe_eval()

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

Safely evaluate a bit vector.

Must be thread-safe, that is must avoid throwing exceptions and updating global states (e.g. maximum) in function decorators.

Reimplemented in FunctionController.

Definition at line 143 of file function.hh.

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

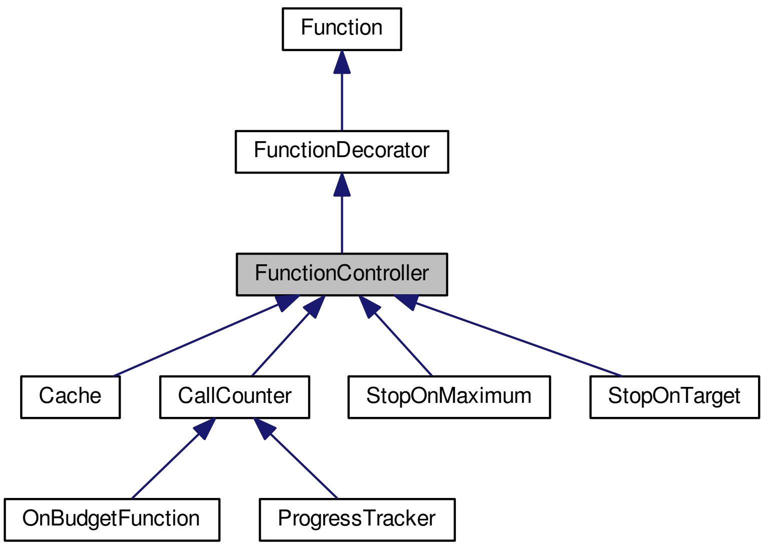
- lib/hnco/functions/function.hh
- lib/hnco/functions/function.cc

5.26 FunctionController Class Reference

Function controller.

```
#include <hnco/functions/decorators/function-controller.hh>
```

Inheritance diagram for FunctionController:



Public Member Functions

- FunctionController (Function ∗function)

  Constructor.

Information about the function

- int get_bv_size ()

  Get bit vector size.
- double get_maximum ()

  Get the global maximum.
- bool has_known_maximum ()

  Check for a known maximum.
- bool provides_incremental_evaluation ()

  Check whether the function provides incremental evaluation.

Evaluation

- double safe_eval (const bit_vector_t &x)

  Safely evaluate a bit vector.

Additional Inherited Members

5.26.1 Detailed Description

Function controller.

Definition at line 39 of file function-controller.hh.

5.26.2 Member Function Documentation

5.26.2.1 provides_incremental_evaluation()

```
bool provides_incremental_evaluation ( )  [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 64 of file function-controller.hh.

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

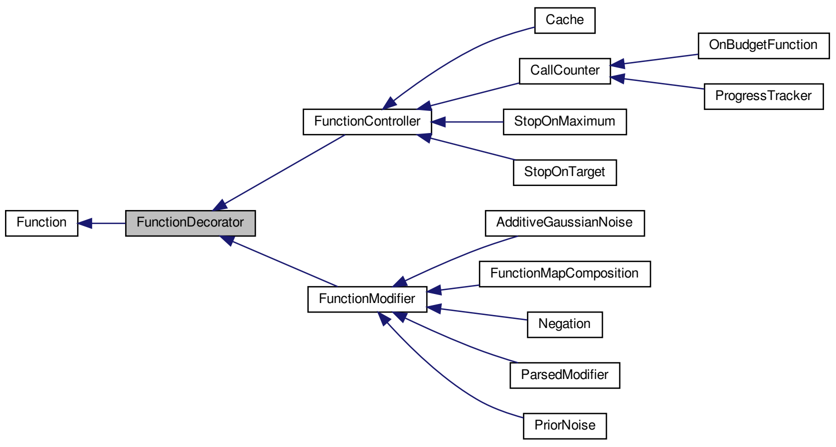
- lib/hnco/functions/decorators/function-controller.hh

5.27 FunctionDecorator Class Reference

Function decorator.

```
#include <hnco/functions/decorators/function-decorator.hh>
```

Inheritance diagram for FunctionDecorator:



Public Member Functions

- FunctionDecorator (Function ∗function)

  Constructor.

Display

- void display (std::ostream &stream)

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

  Describe a bit vector.

Protected Attributes

- Function ∗ _function

  Decorated function.

5.27.1 Detailed Description

Function decorator.

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

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

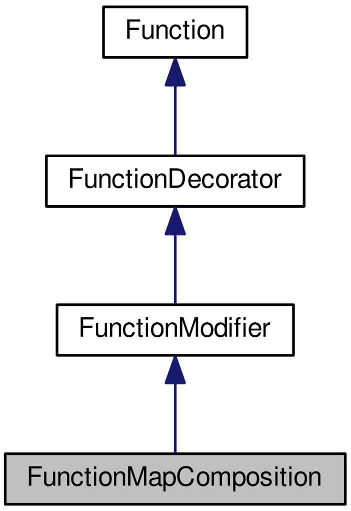
- lib/hnco/functions/decorators/function-decorator.hh

5.28 FunctionMapComposition Class Reference

Composition of a function and a map.

`#include <hnco/functions/decorators/function-modifier.hh>`

Inheritance diagram for FunctionMapComposition:



Public Member Functions

- FunctionMapComposition (Function ∗function, Map ∗map)

    Constructor.
- double eval (const bit_vector_t &)

    Evaluate a bit vector.

Information about the function

- int get_bv_size ()

    Get bit vector size.
- double get_maximum ()

    Get the global maximum.
- bool has_known_maximum ()

    Check for a known maximum.

Display

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

    Describe a bit vector.

Private Attributes

- Map ∗ _map

    Map.
- bit_vector_t _bv

    Image of bit vectors under the map.

Additional Inherited Members

5.28.1 Detailed Description

Composition of a function and a map.

Definition at line 99 of file function-modifier.hh.

5.28.2 Constructor & Destructor Documentation

5.28.2.1 FunctionMapComposition()

```
FunctionMapComposition (
            Function ∗ function,
            Map ∗ map )  [inline]
```

Constructor.

Precondition

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

Exceptions

Error	

Definition at line 114 of file function-modifier.hh.

5.28.3 Member Function Documentation

5.28.3.1 get_maximum()

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

Get the global maximum.

Exceptions

Error	

Reimplemented from Function.

Definition at line 134 of file function-modifier.hh.

5.28.3.2 has_known_maximum()

```
bool has_known_maximum ( )  [inline], [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 144 of file function-modifier.hh.

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

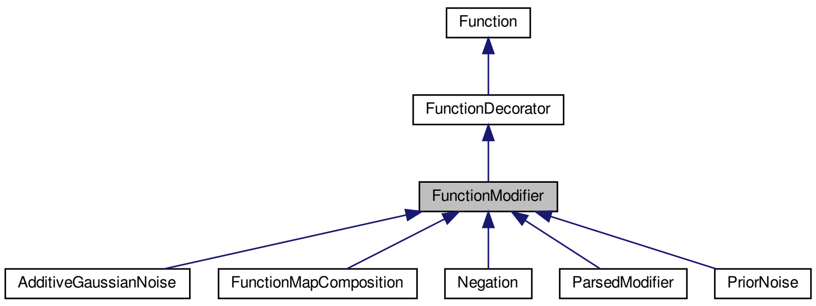
- lib/hnco/functions/decorators/function-modifier.hh
- lib/hnco/functions/decorators/function-modifier.cc

5.29 FunctionModifier Class Reference

Function modifier.

`#include <hnco/functions/decorators/function-modifier.hh>`

Inheritance diagram for FunctionModifier:



Public Member Functions

- FunctionModifier (Function ∗function)

  Constructor.

Additional Inherited Members

5.29.1 Detailed Description

Function modifier.

Definition at line 38 of file function-modifier.hh.

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

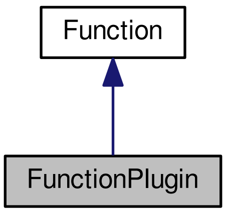
- lib/hnco/functions/decorators/function-modifier.hh

5.30 FunctionPlugin Class Reference

Function plugin.

```
#include <hnco/functions/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 ()
  Get bit vector size.
- double eval (const bit_vector_t &)
  Evaluate a bit vector.

Private Types

- typedef double(∗ extern_function_t) (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.

5.30.1 Detailed Description

Function plugin.

Definition at line 34 of file plugin.hh.

5.30.2 Constructor & Destructor Documentation

5.30.2.1 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 33 of file plugin.cc.

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

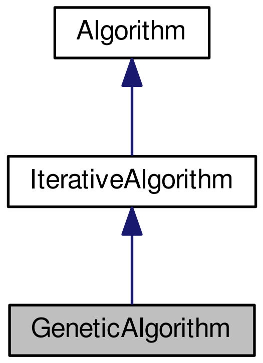
- lib/hnco/functions/plugin.hh
- lib/hnco/functions/plugin.cc

5.31 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.
- void init ()

  Initialization.

Setters

- void set_mutation_probability (double x)

  Set the mutation probability.
- void set_crossover_probability (double x)

  Set the crossover probability.
- void set_tournament_size (int x)

  Set the tournament size.
- void set_allow_stay (bool x)

  Set the flag _allow_stay.

Private Member Functions

- void iterate ()

  Single iteration.

Private Attributes

- TournamentSelection _parents

  Parents.
- TournamentSelection _offsprings

  Offsprings.
- neighborhood::BernoulliProcess _mutation

Mutation operator.
- std::bernoulli_distribution _do_crossover

  Do crossover.
- UniformCrossover _crossover

  Uniform crossover.

Parameters

- double _mutation_probability

  Mutation probability.
- double _crossover_probability = 0.5

  Crossover probability.
- int _tournament_size = 10

  Tournament size.
- bool _allow_stay = false

  Allow stay.

Additional Inherited Members

5.31.1 Detailed Description

Genetic algorithm.

- Tournament selection for reproduction
- Uniform crossover
- 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.

5.31.2 Constructor & Destructor Documentation

5.31.2.1 GeneticAlgorithm()

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

Constructor.

Parameters

n	Size of bit vectors
mu	Population size

Definition at line 97 of file genetic-algorithm.hh.

5.31.3 Member Function Documentation

5.31.3.1 set_allow_stay()

```
void set_allow_stay (
             bool x )  [inline]
```

Set the flag _allow_stay.

In case no mutation occurs allow the current bit vector to stay unchanged.

Definition at line 125 of file genetic-algorithm.hh.

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

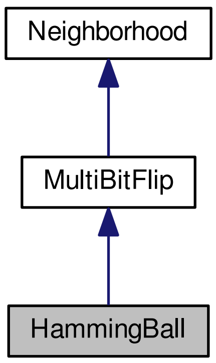
- lib/hnco/algorithms/ea/genetic-algorithm.hh
- lib/hnco/algorithms/ea/genetic-algorithm.cc

5.32 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

5.32.1 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 304 of file neighborhood.hh.

5.32.2 Constructor & Destructor Documentation

5.32.2.1 HammingBall()

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

Constructor.

Parameters

n	Size of bit vectors
r	Radius of the ball

Definition at line 320 of file neighborhood.hh.

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

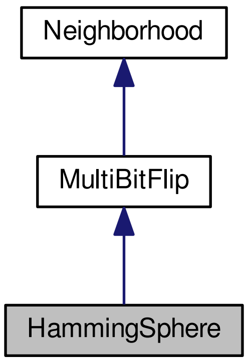
- lib/hnco/neighborhoods/neighborhood.hh
- lib/hnco/neighborhoods/neighborhood.cc

5.33 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

5.33.1 Detailed Description

Hamming sphere.

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

Definition at line 337 of file neighborhood.hh.

5.33.2 Constructor & Destructor Documentation

5.33.2.1 HammingSphere()

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

Constructor.

Parameters

n	Size of bit vectors
r	Radius of the sphere

Definition at line 353 of file neighborhood.hh.

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

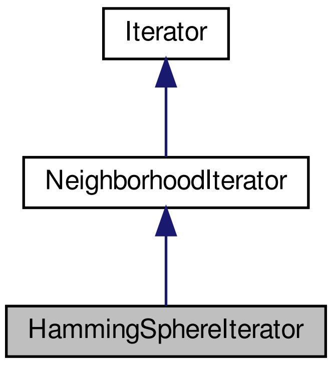
- lib/hnco/neighborhoods/neighborhood.hh
- lib/hnco/neighborhoods/neighborhood.cc

5.34 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 ()

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

    Next bit vector.

Private Attributes

- bit_vector_t _mask

    Mutation mask.
- int _radius

    Radius of the ball.
- int _index

    Index of the next bit to shift to the right.
- int _weight

    Partial Hamming weight.

Additional Inherited Members

5.34.1 Detailed Description

Hamming sphere neighborhood iterator.

This iterator enumerates mutation masks with hamming weight equal to the given radius. Suppose that _mask has a first (from left to right) sequence of ones of length _weight and ending at _index:

0 ... 0 1 ... 1 0 ...

Then the next mask is obtained by moving to the left the first _weight - 1 ones and moving to the right the last one.

1 ... 1 0 ... 0 1 ...

Definition at line 91 of file neighborhood-iterator.hh.

5.34.2 Constructor & Destructor Documentation

5.34.2.1 HammingSphereIterator()

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

Constructor.

Parameters

n	Size of bit vectors
r	Radius of Hamming Ball

Definition at line 113 of file neighborhood-iterator.hh.

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

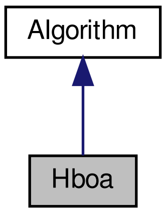
- lib/hnco/neighborhoods/neighborhood-iterator.hh
- lib/hnco/neighborhoods/neighborhood-iterator.cc

5.35 Hboa Class Reference

Hierarchical Bayesian Optimization Algorithm.

```
#include <hnco/algorithms/eda/hboa.hh>
```

Inheritance diagram for Hboa:



Public Member Functions

- Hboa (int n)

  Constructor.
- void maximize ()

  Maximize.
- void set_population_size (int n)

  Set population size.

Private Attributes

- int _population_size = 10

  Population size.

Additional Inherited Members

5.35.1 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 44 of file hboa.hh.

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

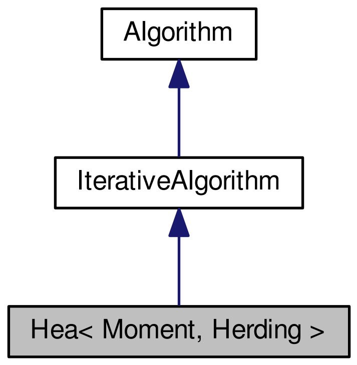
- lib/hnco/algorithms/eda/hboa.hh
- lib/hnco/algorithms/eda/hboa.cc

5.36 Hea< Moment, Herding > Class Template Reference

Herding evolutionary algorithm.

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

Inheritance diagram for Hea< Moment, Herding >:



Public Types

- enum {
  LOG_ERROR, LOG_DTU, LOG_DELTA, LOG_SELECTION,
  LOG_MOMENT_MATRIX, **LAST_LOG** }
- typedef std::bitset< LAST_LOG > log_flags_t

  Type for log flags.

Public Member Functions

- Hea (int n, int population_size)

  Constructor.
- void init ()

  Initialization.

Setters

- void set_herding (Herding ∗x)

  Set the herding algorithm.
- 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_weight (double weight)

  Set weight.
- void set_log_flags (const log_flags_t &lf)

  Set log flags.

Private Member Functions

- void iterate ()

  Single iteration.
- void log ()

  Log.

Private Attributes

- Moment _target

  Moment.
- Moment _selection

  Moment of selected individuals.
- Moment _uniform

  Uniform moment.
- algorithm::Population _population

  Population.
- Herding ∗ _herding

  Herding.

Logging

- double _error_cache

  Error cache.
- double _dtu_cache

  Distance to uniform cache.
- double _delta_cache

  Delta cache.
- double _selection_cache

  Selection distance cache.
- log_flags_t _log_flags

  Log flags.

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.

Additional Inherited Members

5.36.1 Detailed Description

template<class Moment, class Herding>
class hnco::algorithm::hea::Hea< Moment, 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 50 of file hea.hh.

5.36.2 Member Enumeration Documentation

5.36.2.1 anonymous enum

```
anonymous enum
```

Enumerator

LOG_ERROR	Log error.
LOG_DTU	Log distance to uniform.
LOG_DELTA	Log delta (moment increment)
LOG_SELECTION	Log the distance between the target and the selection moment.
LOG_MOMENT_MATRIX	Log the moment matrix.

Definition at line 55 of file hea.hh.

5.36.3 Constructor & Destructor Documentation

5.36.3.1 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 214 of file hea.hh.

5.36.4 Member Function Documentation

5.36.4.1 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 258 of file hea.hh.

5.36.4.2 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 250 of file hea.hh.

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

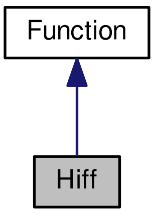
- lib/hnco/algorithms/hea/hea.hh

5.37 Hiff Class Reference

Hierarchical if and only if.

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

Inheritance diagram for Hiff:



Public Member Functions

- Hiff (int bv_size)

  Constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.
- bool has_known_maximum ()

  Check for a known maximum.
- double get_maximum ()

  Get the global maximum.

Private Attributes

- int _bv_size

  Bit vector size.
- int _depth

  Tree depth.

5.37.1 Detailed Description

Hierarchical if and only if.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 170 of file theory.hh.

5.37.2 Member Function Documentation

5.37.2.1 get_maximum()

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

Get the global maximum.

Returns

(i + 1) ∗ 2^i where 2^i = _bv_size

Reimplemented from Function.

Definition at line 196 of file theory.hh.

5.37.2.2 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 192 of file theory.hh.

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

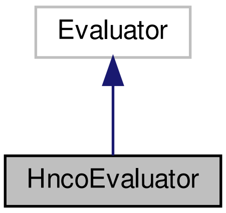
- lib/hnco/functions/theory.hh
- lib/hnco/functions/theory.cc

5.38 HncoEvaluator Class Reference

Evaluator for HNCO functions.

`#include <hnco/algorithms/eda/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.

5.38.1 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:

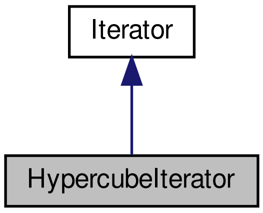
- lib/hnco/algorithms/eda/hnco-evaluator.hh

5.39 HypercubeIterator Class Reference

Hypercube iterator.

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

Inheritance diagram for HypercubeIterator:



Public Member Functions

- HypercubeIterator (int n)

  Constructor.
- bool has_next ()

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

  Next bit vector.

Additional Inherited Members

5.39.1 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:

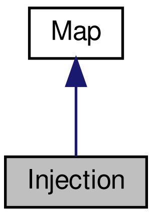
- lib/hnco/iterator.hh
- lib/hnco/iterator.cc

5.40 Injection Class Reference

Injection.

```
#include <hnco/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)

  Map
- int get_input_size ()

  Get input size.
- int get_output_size ()

  Get output size.
- bool is_surjective ()

  Check for surjective map.

Private Attributes

- std::vector< int > _bit_positions

  Bit positions.
- int _output_size

  Output size.

5.40.1 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 397 of file map.hh.

5.40.2 Constructor & Destructor Documentation

5.40.2.1 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 144 of file map.cc.

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

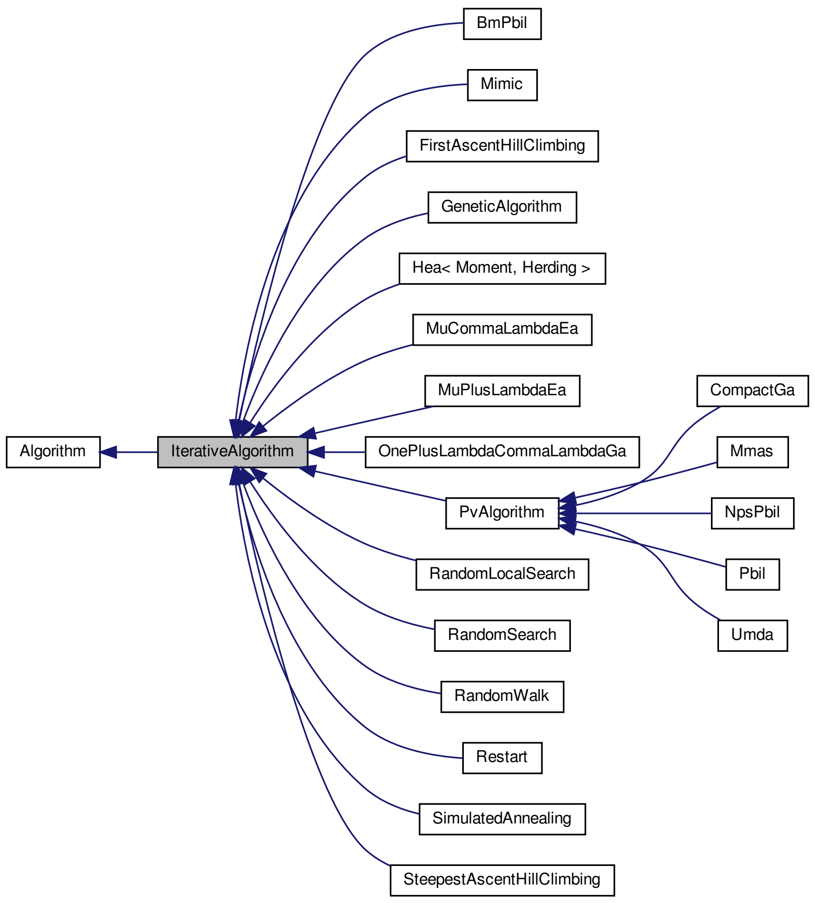
- lib/hnco/map.hh
- lib/hnco/map.cc

5.41 IterativeAlgorithm Class Reference

Iterative search.

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

Inheritance diagram for IterativeAlgorithm:



Public Member Functions

- IterativeAlgorithm (int n)

  Constructor.
- void maximize ()

  Maximize.

Setters

- void set_num_iterations (int x)

  Set the number of iterations.

Protected Member Functions

- virtual void iterate ()=0

  Single iteration.
- virtual void log ()

  Log.

Protected Attributes

- int _iteration

  Current iteration.
- bool _something_to_log

  Something to log.

Parameters

- int _num_iterations = 0

  Number of iterations.

5.41.1 Detailed Description

Iterative search.

Definition at line 169 of file algorithm.hh.

5.41.2 Constructor & Destructor Documentation

5.41.2.1 IterativeAlgorithm()

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

Constructor.

Parameters

n	Size of bit vectors

Definition at line 199 of file algorithm.hh.

5.41.3 Member Function Documentation

5.41.3.1 maximize()

```
void maximize ( )  [virtual]
```

Maximize.

Inside the loop:

- call iterate()
- call log()

Warning

If an exception such as LocalMaximum is thrown by iterate(), log() will not be called. However, hnco reports the maximum at the end of the search.

Implements Algorithm.

Definition at line 77 of file algorithm.cc.

5.41.3.2 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 223 of file algorithm.hh.

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

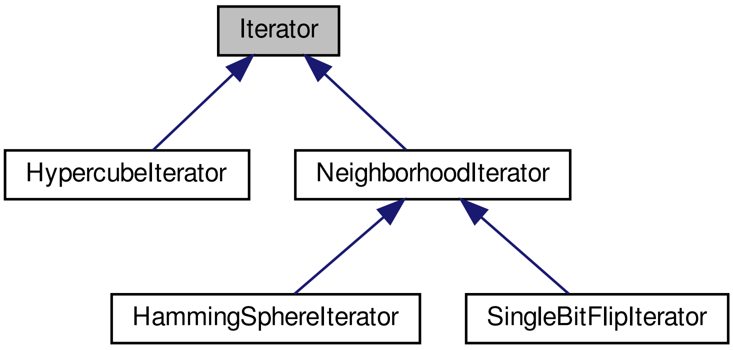
- lib/hnco/algorithms/algorithm.hh
- lib/hnco/algorithms/algorithm.cc

5.42 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.

5.42.1 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:

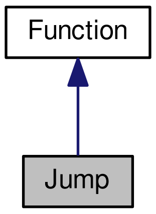
- lib/hnco/iterator.hh

5.43 Jump Class Reference

Jump.

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

Inheritance diagram for Jump:



Public Member Functions

- Jump (int bv_size, int gap)

  Constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.
- bool has_known_maximum ()

  Check for a known maximum.
- double get_maximum ()

  Get the global maximum.

Private Attributes

- int _bv_size

  Bit vector size.
- int _gap

  Gap.

5.43.1 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.

5.43.2 Member Function Documentation

5.43.2.1 get_maximum()

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

Get the global maximum.

Returns

_bv_size

Reimplemented from Function.

Definition at line 67 of file jump.hh.

5.43.2.2 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 63 of file jump.hh.

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

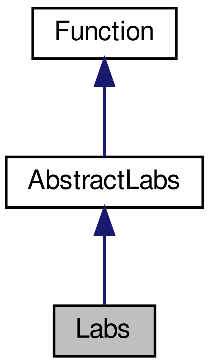
- lib/hnco/functions/jump.hh
- lib/hnco/functions/jump.cc

5.44 Labs Class Reference

Low autocorrelation binary sequences.

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

Inheritance diagram for Labs:



Public Member Functions

- Labs (int n)

    Constructor.
- double eval (const bit_vector_t &)

    Evaluate a bit vector.

Additional Inherited Members

5.44.1 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`

Definition at line 65 of file labs.hh.

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

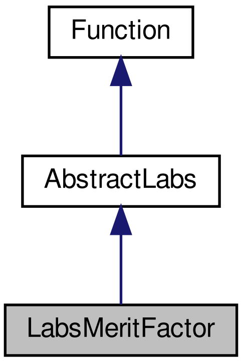
- lib/hnco/functions/labs.hh
- lib/hnco/functions/labs.cc

5.45 LabsMeritFactor Class Reference

Low autocorrelation binary sequences merit factor.

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

Inheritance diagram for LabsMeritFactor:



Public Member Functions

- LabsMeritFactor (int n)

  Constructor.
- double eval (const bit_vector_t &)

  Evaluate a bit vector.

Additional Inherited Members

5.45.1 Detailed Description

Low autocorrelation binary sequences merit factor.

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`

Definition at line 90 of file labs.hh.

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

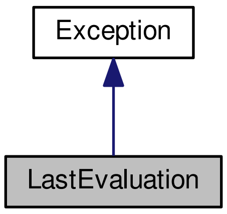
- lib/hnco/functions/labs.hh
- lib/hnco/functions/labs.cc

5.46 LastEvaluation Class Reference

Last evaluation.

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

Inheritance diagram for LastEvaluation:



5.46.1 Detailed Description

Last evaluation.

Definition at line 80 of file exception.hh.

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

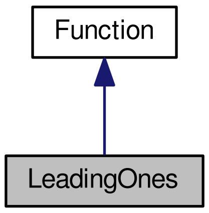
- lib/hnco/exception.hh

5.47 LeadingOnes Class Reference

Leading ones.

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

Inheritance diagram for LeadingOnes:



Public Member Functions

- LeadingOnes (int bv_size)

  Constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.
- bool has_known_maximum ()

  Check for a known maximum.
- double get_maximum ()

  Get the global maximum.

Private Attributes

- int _bv_size

  Bit vector size.

5.47.1 Detailed Description

Leading ones.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 98 of file theory.hh.

5.47.2 Member Function Documentation

5.47.2.1 get_maximum()

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

Get the global maximum.

Returns

_bv_size

Reimplemented from Function.

Definition at line 122 of file theory.hh.

5.47.2.2 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 118 of file theory.hh.

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

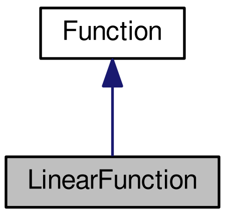
- lib/hnco/functions/theory.hh
- lib/hnco/functions/theory.cc

5.48 LinearFunction Class Reference

Linear function.

```
#include <hnco/functions/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.

Evaluation

- double eval (const bit_vector_t &)

  Evaluate a bit vector.
- double incremental_eval (const bit_vector_t &x, double v, const hnco::sparse_bit_vector_t &flipped_bits)

  Incremental evaluation.

Information about the function

- int get_bv_size ()

  Get bit vector size.
- double get_maximum ()

  Get the global maximum.
- bool has_known_maximum ()

  Check for a known maximum.
- bool provides_incremental_evaluation ()

  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 > _weights

  Weights.

Friends

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

5.48.1 Detailed Description

Linear function.

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

5.48.2 Member Function Documentation

5.48.2.1 generate()

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

Instance generator.

Parameters

n	Size of bit vectors
generator	Weight generator

Definition at line 72 of file linear-function.hh.

5.48.2.2 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 119 of file linear-function.hh.

5.48.2.3 provides_incremental_evaluation()

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

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 124 of file linear-function.hh.

5.48.2.4 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 86 of file linear-function.hh.

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

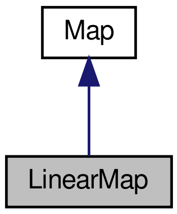
- lib/hnco/functions/linear-function.hh
- lib/hnco/functions/linear-function.cc

5.49 LinearMap Class Reference

Linear map.

```
#include <hnco/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)

  Map
- int get_input_size ()

  Get input size.
- int get_output_size ()

  Get output size.
- bool is_surjective ()

  Check for surjective 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**

5.49.1 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 194 of file map.hh.

5.49.2 Member Function Documentation

5.49.2.1 is_surjective()

```
bool is_surjective ( )  [virtual]
```

Check for surjective map.

Returns

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

Reimplemented from Map.

Definition at line 90 of file map.cc.

5.49.2.2 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

Error	

Definition at line 61 of file map.cc.

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

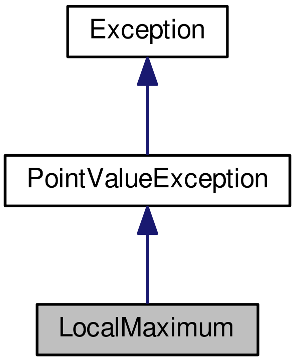
- lib/hnco/map.hh
- lib/hnco/map.cc

5.50 LocalMaximum Class Reference

Local maximum.

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

Inheritance diagram for LocalMaximum:



Public Member Functions

- LocalMaximum (const point_value_t &pv)
  Const.

Additional Inherited Members

5.50.1 Detailed Description

Local maximum.

Definition at line 71 of file exception.hh.

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

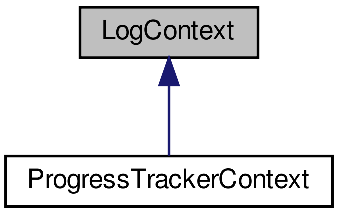
- lib/hnco/exception.hh

5.51 LogContext Class Reference

Log context.

`#include <hnco/algorithms/log-context.hh>`

Inheritance diagram for LogContext:



Public Member Functions

- virtual std::string get_context ()=0

  Get context.

5.51.1 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 39 of file log-context.hh.

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

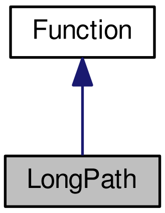
- lib/hnco/algorithms/log-context.hh

5.52 LongPath Class Reference

Long path.

```
#include <hnco/functions/long-path.hh>
```

Inheritance diagram for LongPath:



Public Member Functions

- LongPath (int bv_size, int prefix_length)

  Constructor.
- double eval (const bit_vector_t &)

  Evaluate a bit vector.

Information about the function

- int get_bv_size ()

  Get bit vector size.
- bool has_known_maximum ()

  Check for a known maximum.
- double get_maximum ()

  Get the global maximum.

Private Attributes

- int _bv_size

  Bit vector size.
- int _prefix_length

  Prefix length.

5.52.1 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.

5.52.2 Member Function Documentation

5.52.2.1 get_maximum()

```
double get_maximum ( )  [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

Error	

Reimplemented from Function.

Definition at line 62 of file long-path.cc.

5.52.2.2 has_known_maximum()

```
bool has_known_maximum ( )  [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:

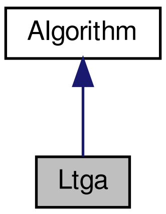
- lib/hnco/functions/long-path.hh
- lib/hnco/functions/long-path.cc

5.53 Ltga Class Reference

Linkage Tree Genetic Algorithm.

```
#include <hnco/algorithms/eda/ltga.hh>
```

Inheritance diagram for Ltga:



Public Member Functions

- Ltga (int n)

  Constructor.
- void maximize ()

  Maximize.
- void set_population_size (int n)

  Set population size.

Private Attributes

- int _population_size = 10

  Population size.

Additional Inherited Members

5.53.1 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 42 of file ltga.hh.

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

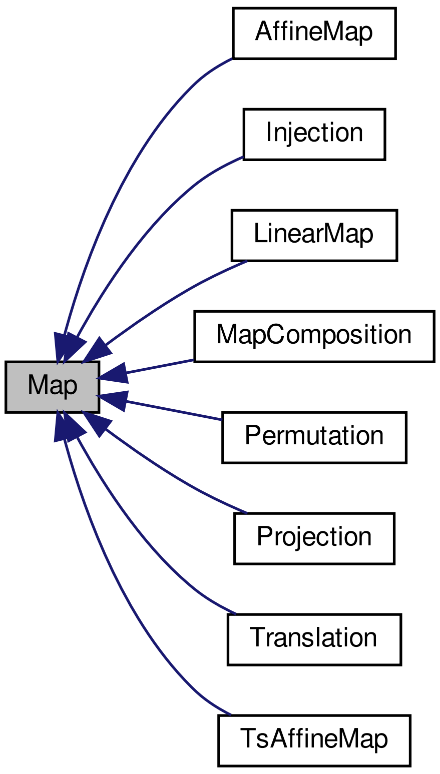
- lib/hnco/algorithms/eda/ltga.hh
- lib/hnco/algorithms/eda/ltga.cc

5.54 Map Class Reference

Map

```
#include <hnco/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 ()=0

    Get input size.
- virtual int get_output_size ()=0

    Get output size.
- virtual bool is_surjective ()

    Check for surjective map.

5.54.1 Detailed Description

Map

Definition at line 40 of file map.hh.

5.54.2 Member Function Documentation

5.54.2.1 is_surjective()

```
virtual bool is_surjective ( )  [inline], [virtual]
```

Check for surjective map.

Returns

false

Reimplemented in TsAffineMap, Projection, Injection, MapComposition, AffineMap, LinearMap, Permutation, and Translation.

Definition at line 60 of file map.hh.

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

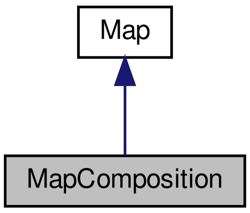
- lib/hnco/map.hh

5.55 MapComposition Class Reference

Map composition.

```
#include <hnco/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)

  Map
- int get_input_size ()

  Get input size.
- int get_output_size ()

  Get output size.
- bool is_surjective ()

  Check for surjective map.

Private Attributes

- Map ∗ _outer

  Outer map.
- Map ∗ _inner

  Inner map.
- bit_vector_t _bv

  Temporary bit vector.

5.55.1 Detailed Description

Map composition.

The resulting composition f is defined for all bit vector x by f(x) = outer(inner(x)).

Definition at line 328 of file map.hh.

5.55.2 Constructor & Destructor Documentation

5.55.2.1 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 352 of file map.hh.

5.55.3 Member Function Documentation

5.55.3.1 is_surjective()

```
bool is_surjective ( )  [inline], [virtual]
```

Check for surjective map.

Returns

true if both maps are surjective

Reimplemented from Map.

Definition at line 376 of file map.hh.

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

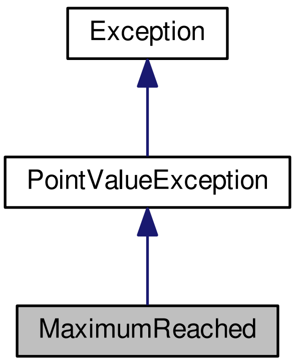
- lib/hnco/map.hh

5.56 MaximumReached Class Reference

Maximum reached.

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

Inheritance diagram for MaximumReached:



Public Member Functions

- MaximumReached (const point_value_t &pv)

  Constructor.

Additional Inherited Members

5.56.1 Detailed Description

Maximum reached.

Definition at line 53 of file exception.hh.

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

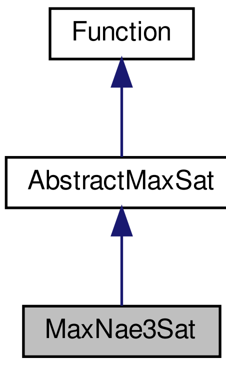
- lib/hnco/exception.hh

5.57 MaxNae3Sat Class Reference

Max not-all-equal 3SAT.

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

Inheritance diagram for MaxNae3Sat:



Public Member Functions

- MaxNae3Sat ()

  Default constructor.
- void load (std::istream &stream)

  Load an instance.
- double eval (const bit_vector_t &)

  Evaluate a bit vector.

Additional Inherited Members

5.57.1 Detailed Description

Max not-all-equal 3SAT.

Reference:

Christos M. Papadimitriou. 1994. Computational complexity. Addison-Wesley, Reading, Massachusetts.

Definition at line 125 of file max-sat.hh.

5.57.2 Member Function Documentation

5.57.2.1 load()

```
void load (
            std::istream & stream )  [virtual]
```

Load an instance.

Exceptions

Error	

Reimplemented from AbstractMaxSat.

Definition at line 282 of file max-sat.cc.

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

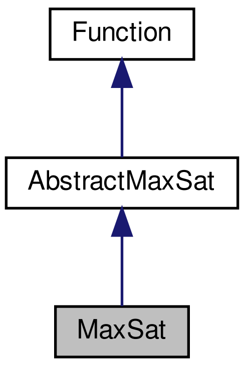
- lib/hnco/functions/max-sat.hh
- lib/hnco/functions/max-sat.cc

5.58 MaxSat Class Reference

MAX-SAT.

```
#include <hnco/functions/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 eval (const bit_vector_t &)

  Evaluate a bit vector.

Additional Inherited Members

5.58.1 Detailed Description

MAX-SAT.

Reference:

Christos M. Papadimitriou. 1994. Computational complexity. Addison-Wesley, Reading, Massachusetts.

Definition at line 81 of file max-sat.hh.

5.58.2 Member Function Documentation

5.58.2.1 random() [1/2]

```
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.

5.58.2.2 random() [2/2]

```
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.

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

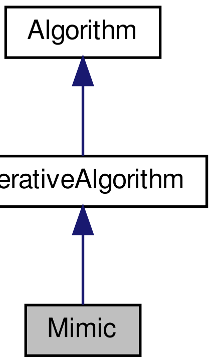
- lib/hnco/functions/max-sat.hh
- lib/hnco/functions/max-sat.cc

5.59 Mimic Class Reference

Mutual information maximizing input clustering.

```
#include <hnco/algorithms/eda/mimic.hh>
```

Inheritance diagram for Mimic:



Public Member Functions

- Mimic (int n, int population_size)

  Constructor.
- void init ()

  Initialization.

Setters

- void set_selection_size (int x)

  Set the selection size.

Protected Member Functions

- void iterate ()

  Single iteration.
- void sample (bit_vector_t &bv)

  Sample a bit vector.
- void compute_conditional_entropy (int index)

  Compute conditional entropy.
- void update_model ()

  Update model.

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.

5.59.1 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 54 of file mimic.hh.

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

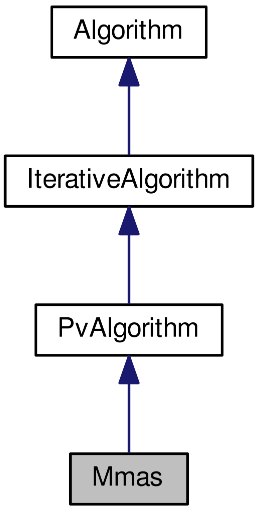
- lib/hnco/algorithms/eda/mimic.hh
- lib/hnco/algorithms/eda/mimic.cc

5.60 Mmas Class Reference

Max-min ant system.

```
#include <hnco/algorithms/pv/mmas.hh>
```

Inheritance diagram for Mmas:



Public Member Functions

- Mmas (int n)

    Constructor.
- void init ()

    Initialization.

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

- void iterate ()

    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.

5.60.1 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

5.61 Model Class Reference

Model of a Boltzmann machine.

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

Public Member Functions

- Model (int n)

  Constructor.
- void init ()

  Initialize.
- void reset_mc ()

  Reset Markov chain.
- void gibbs_sampler (size_t i)

  A Gibbs sampler cycle.
- void gibbs_sampler_synchronous ()

  A synchronous Gibbs sampler.
- const bit_vector_t & get_state ()

  Get the state of the Gibbs sampler.
- void update (const ModelParameters &p, const ModelParameters &q, double rate)

  Update parameters in the direction of p and away from q.
- double norm_infinite ()

  Infinite norm of the parameters.
- double norm_l1 ()

  l1 norm of the parameters

Private Attributes

- ModelParameters _model_parameters

  Model parameters.
- bit_vector_t _state

  State of the Gibbs sampler.
- pv_t _pv

  Probability vector for synchronous Gibbs sampling.

5.61.1 Detailed Description

Model of a Boltzmann machine.

Definition at line 75 of file model.hh.

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

- lib/hnco/algorithms/bm-pbil/model.hh
- lib/hnco/algorithms/bm-pbil/model.cc

5.62 ModelParameters Class Reference

Parameters of a Boltzmann machine.

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

Public Member Functions

- ModelParameters (int n)

  Constructor.
- void init ()

  Initialize.
- void add (const bit_vector_t &x)

  Add a bit_vector_t.
- void average (int count)

  Compute averages.
- void update (const ModelParameters &p, const ModelParameters &q, double rate)

  Update parameters in the direction of p and away from q.
- double norm_infinite ()

  Infinite norm of the parameters.
- double norm_l1 ()

  l1 norm of the parameters

Private Attributes

- std::vector< std::vector< double > > _weight

  Weights.
- std::vector< double > _bias

  Bias.

Friends

- class **Model**

5.62.1 Detailed Description

Parameters of a Boltzmann machine.

Definition at line 36 of file model.hh.

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

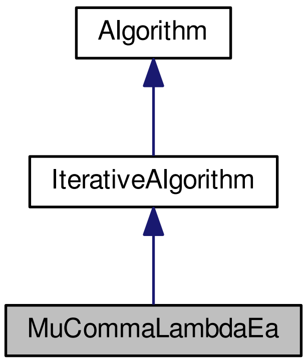
- lib/hnco/algorithms/bm-pbil/model.hh
- lib/hnco/algorithms/bm-pbil/model.cc

5.63 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.
- void init ()
  Initialization.

Setters

- void set_mutation_probability (double x)
  Set the mutation probability.
- void set_allow_stay (bool x)
  Set the flag _allow_stay.

Private Member Functions

- void iterate ()

  Single iteration.

Private Attributes

- Population _parents

  Parents.
- Population _offsprings

  Offsprings.
- neighborhood::BernoulliProcess _mutation

  Mutation operator.
- std::uniform_int_distribution< int > _select_parent

  Select parent.

Parameters

- double _mutation_probability

  Mutation probability.
- bool _allow_stay = false

  Allow stay.

Additional Inherited Members

5.63.1 Detailed Description

(mu, lambda) EA.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 41 of file mu-comma-lambda-ea.hh.

5.63.2 Constructor & Destructor Documentation

5.63.2.1 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 79 of file mu-comma-lambda-ea.hh.

5.63.3 Member Function Documentation

5.63.3.1 set_allow_stay()

```
void set_allow_stay (
             bool x )  [inline]
```

Set the flag _allow_stay.

In case no mutation occurs allow the current bit vector to stay unchanged.

Definition at line 102 of file mu-comma-lambda-ea.hh.

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

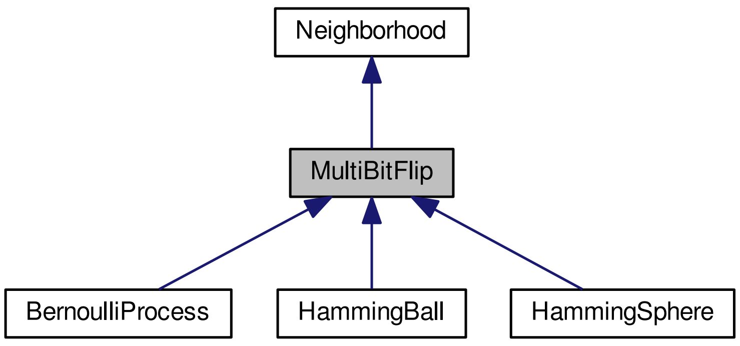
- lib/hnco/algorithms/ea/mu-comma-lambda-ea.hh
- lib/hnco/algorithms/ea/mu-comma-lambda-ea.cc

5.64 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 reservoir_sampling (int k)

  Sample a given number of bits using resevoir sampling.

Additional Inherited Members

5.64.1 Detailed Description

Multi bit flip.

Definition at line 183 of file neighborhood.hh.

5.64.2 Constructor & Destructor Documentation

5.64.2.1 MultiBitFlip()

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

Constructor.

Parameters

n	Size of bit vectors

Definition at line 206 of file neighborhood.hh.

5.64.3 Member Function Documentation

5.64.3.1 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.

5.64.3.2 reservoir_sampling()

```
void reservoir_sampling (
             int k )  [protected]
```

Sample a given number of bits using resevoir 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:

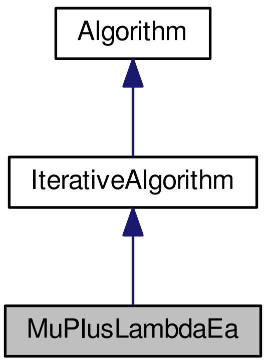
- lib/hnco/neighborhoods/neighborhood.hh
- lib/hnco/neighborhoods/neighborhood.cc

5.65 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.
- void init ()

  Initialization.

Setters

- void set_mutation_probability (double x)

  Set the mutation probability.
- void set_allow_stay (bool x)

  Set the flag _allow_stay.

Private Member Functions

- void iterate ()

  Single iteration.

Private Attributes

- Population _parents

  Parents.
- Population _offsprings

  Offsprings.
- neighborhood::BernoulliProcess _mutation

  Mutation operator.
- std::uniform_int_distribution< int > _select_parent

  Select parent.

Parameters

- double _mutation_probability

  Mutation probability.
- bool _allow_stay = false

  Allow stay.

Additional Inherited Members

5.65.1 Detailed Description

(mu+lambda) EA.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 40 of file mu-plus-lambda-ea.hh.

5.65.2 Constructor & Destructor Documentation

5.65.2.1 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 78 of file mu-plus-lambda-ea.hh.

5.65.3 Member Function Documentation

5.65.3.1 set_allow_stay()

```
void set_allow_stay (
             bool x )  [inline]
```

Set the flag _allow_stay.

In case no mutation occurs allow the current bit vector to stay unchanged.

Definition at line 101 of file mu-plus-lambda-ea.hh.

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

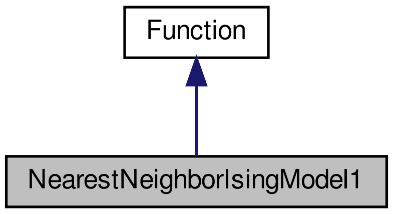
- lib/hnco/algorithms/ea/mu-plus-lambda-ea.hh
- lib/hnco/algorithms/ea/mu-plus-lambda-ea.cc

5.66 NearestNeighborIsingModel1 Class Reference

Nearest neighbor Ising model in one dimension.

```
#include <hnco/functions/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.
- void display (std::ostream &stream)

  Display.

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.

Evaluation

- double eval (const bit_vector_t &)

  Evaluate a bit vector.
- double incremental_eval (const bit_vector_t &x, double v, const sparse_bit_vector_t &flipped_bits)

  Incremental evaluation.

Information about the function

- int get_bv_size ()

  Get bit vector size.
- bool provides_incremental_evaluation ()

  Check whether the function provides incremental evaluation.

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**

5.66.1 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 Walsh↩
Expansion2.

Reference: `https://en.wikipedia.org/wiki/Ising_model`

Definition at line 65 of file nearest-neighbor-ising-model-1.hh.

5.66.2 Member Function Documentation

5.66.2.1 eval()

```
double eval (
             const bit_vector_t & s )  [virtual]
```

Evaluate a bit vector.

Complexity: O(n)

Implements Function.

Definition at line 44 of file nearest-neighbor-ising-model-1.cc.

5.66.2.2 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 126 of file nearest-neighbor-ising-model-1.hh.

5.66.2.3 provides_incremental_evaluation()

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

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 176 of file nearest-neighbor-ising-model-1.hh.

5.66.2.4 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 142 of file nearest-neighbor-ising-model-1.hh.

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

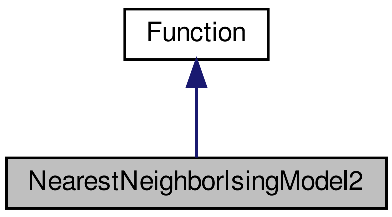
- lib/hnco/functions/ising/nearest-neighbor-ising-model-1.hh
- lib/hnco/functions/ising/nearest-neighbor-ising-model-1.cc

5.67 NearestNeighborIsingModel2 Class Reference

Nearest neighbor Ising model in two dimensions.

`#include <hnco/functions/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.
- void display (std::ostream &stream)
  Display.

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.

Evaluation

- double eval (const bit_vector_t &)
  Evaluate a bit vector.
- double incremental_eval (const bit_vector_t &x, double v, const sparse_bit_vector_t &flipped_bits)
  Incremental evaluation.

Information about the function

- int get_bv_size ()
  Get bit vector size.
- bool provides_incremental_evaluation ()
  Check whether the function provides incremental evaluation.

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**

5.67.1 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 Walsh↩ Expansion2.

Reference: `https://en.wikipedia.org/wiki/Ising_model`

Definition at line 67 of file nearest-neighbor-ising-model-2.hh.

5.67.2 Member Function Documentation

5.67.2.1 eval()

```
double eval (
            const bit_vector_t & s )  [virtual]
```

Evaluate a bit vector.

Complexity: O(n)

Implements Function.

Definition at line 47 of file nearest-neighbor-ising-model-2.cc.

5.67.2.2 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 134 of file nearest-neighbor-ising-model-2.hh.

5.67.2.3 provides_incremental_evaluation()

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

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 194 of file nearest-neighbor-ising-model-2.hh.

5.67.2.4 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 154 of file nearest-neighbor-ising-model-2.hh.

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

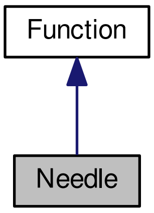
- lib/hnco/functions/ising/nearest-neighbor-ising-model-2.hh
- lib/hnco/functions/ising/nearest-neighbor-ising-model-2.cc

5.68 Needle Class Reference

Needle in a haystack.

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

Inheritance diagram for Needle:



Public Member Functions

- Needle (int bv_size)

  Constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.
- bool has_known_maximum ()

  Check for a known maximum.
- double get_maximum ()

  Get the global maximum.

Private Attributes

- int _bv_size

  Bit vector size.

5.68.1 Detailed Description

Needle in a haystack.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 134 of file theory.hh.

5.68.2 Member Function Documentation

5.68.2.1 get_maximum()

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

Get the global maximum.

Returns

1

Reimplemented from Function.

Definition at line 158 of file theory.hh.

5.68.2.2 has_known_maximum()

```
bool has_known_maximum ( )  [inline], [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:

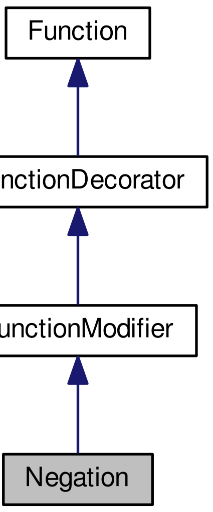
- lib/hnco/functions/theory.hh
- lib/hnco/functions/theory.cc

5.69 Negation Class Reference

Negation.

```
#include <hnco/functions/decorators/function-modifier.hh>
```

Inheritance diagram for Negation:



Public Member Functions

- Negation (Function ∗function)

  Constructor.

Information about the function

- int get_bv_size ()

  Get bit vector size.
- bool provides_incremental_evaluation ()

  Check whether the function provides incremental evaluation.

Evaluation

- double eval (const bit_vector_t &)

  Evaluate a bit vector.
- double incremental_eval (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_t &flipped←_bits)

  Incremental evaluation.

Additional Inherited Members

5.69.1 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 59 of file function-modifier.hh.

5.69.2 Member Function Documentation

5.69.2.1 provides_incremental_evaluation()

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

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 78 of file function-modifier.hh.

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

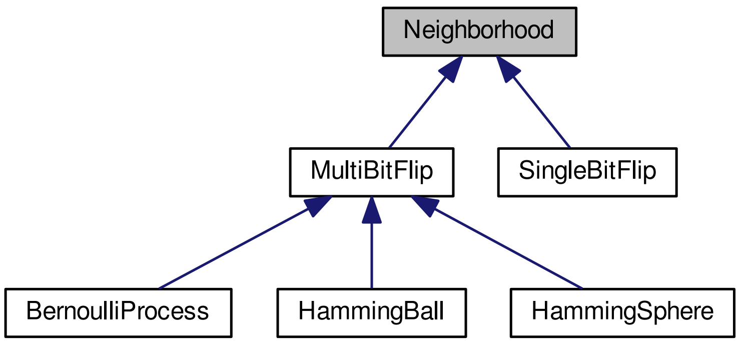
- lib/hnco/functions/decorators/function-modifier.hh
- lib/hnco/functions/decorators/function-modifier.cc

5.70 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 ()

  Get the origin.
- virtual const bit_vector_t & get_candidate ()

  Get the candidate bit vector.
- virtual const sparse_bit_vector_t & get_flipped_bits ()

  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.

5.70.1 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.

5.70.2 Constructor & Destructor Documentation

5.70.2.1 Neighborhood()

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

Constructor.

Parameters

n	Size of bit vectors

Definition at line 86 of file neighborhood.hh.

5.70.3 Member Function Documentation

5.70.3.1 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 148 of file neighborhood.hh.

5.70.3.2 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 134 of file neighborhood.hh.

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

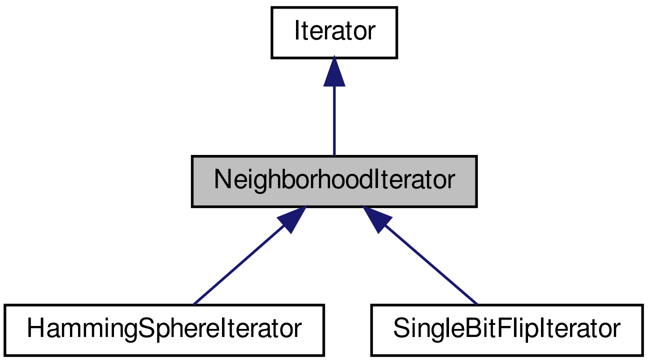
- lib/hnco/neighborhoods/neighborhood.hh

5.71 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

5.71.1 Detailed Description

Neighborhood iterator.

Definition at line 35 of file neighborhood-iterator.hh.

5.71.2 Constructor & Destructor Documentation

5.71.2.1 NeighborhoodIterator()

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

Constructor.

Parameters

n	Size of bit vectors

Definition at line 44 of file neighborhood-iterator.hh.

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

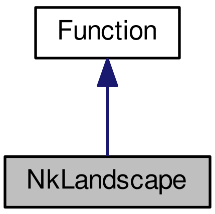
- lib/hnco/neighborhoods/neighborhood-iterator.hh
- lib/hnco/neighborhoods/neighborhood-iterator.cc

5.72 NkLandscape Class Reference

NK landscape.

```
#include <hnco/functions/nk-landscape.hh>
```

Inheritance diagram for NkLandscape:



Public Member Functions

- NkLandscape ()

  Default constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.
- void display (std::ostream &stream)

  Display.

Instance generators

- template<class Generator >
  void generate (int n, int k, Generator generator)

  Instance generator.
- void random (int n, int k)

  Random 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**

5.72.1 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 47 of file nk-landscape.hh.

5.72.2 Member Function Documentation

5.72.2.1 generate()

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

Instance generator.

Parameters

n	Size of bit vector
k	Number of neighbors of each bit
generator	Generator for partial function values

Definition at line 92 of file nk-landscape.hh.

5.72.2.2 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

Definition at line 109 of file nk-landscape.hh.

5.72.2.3 random_structure()

```
void random_structure (
             int n,
             int k )  [private]
```

Random structue.

Parameters

n	Size of bit vector
k	Number of neighbors of each bit

Definition at line 32 of file nk-landscape.cc.

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

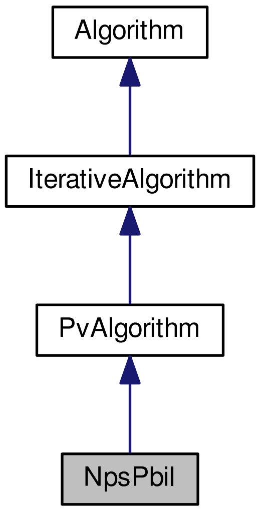
- lib/hnco/functions/nk-landscape.hh
- lib/hnco/functions/nk-landscape.cc

5.73 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.
- void init ()

  Initialization.

Setters

- void set_selection_size (int x)

  Set the selection size.
- void set_learning_rate (double x)

  Set the learning rate.

Protected Member Functions

- void iterate ()

  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.

5.73.1 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:

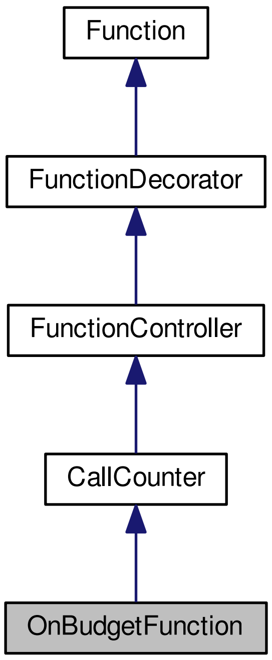
- lib/hnco/algorithms/pv/nps-pbil.hh
- lib/hnco/algorithms/pv/nps-pbil.cc

5.74 OnBudgetFunction Class Reference

CallCounter with a limited number of evaluations.

`#include <hnco/functions/decorators/function-controller.hh>`

Inheritance diagram for OnBudgetFunction:



Public Member Functions

- OnBudgetFunction (Function ∗function, int budget)

    Constructor.

Evaluation

- double eval (const bit_vector_t &)

    Evaluate a bit vector.
- double incremental_eval (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_t &flipped←_bits)

    Incremental evaluation.
- void update (const bit_vector_t &x, double value)

    Update after a safe evaluation.

Private Attributes

- int _budget

    Budget.

Additional Inherited Members

5.74.1 Detailed Description

CallCounter with a limited number of evaluations.

Definition at line 317 of file function-controller.hh.

5.74.2 Member Function Documentation

5.74.2.1 eval()

```
double eval (
            const bit_vector_t & x )   [virtual]
```

Evaluate a bit vector.

Exceptions

LastEvaluation	

Reimplemented from CallCounter.

Definition at line 121 of file function-controller.cc.

5.74.2.2 incremental_eval()

```
double incremental_eval (
            const bit_vector_t & x,
            double value,
            const hnco::sparse_bit_vector_t & flipped_bits )  [virtual]
```

Incremental evaluation.

Exceptions

LastEvaluation	

Reimplemented from CallCounter.

Definition at line 132 of file function-controller.cc.

5.74.2.3 update()

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

Update after a safe evaluation.

Exceptions

LastEvaluation	

Reimplemented from CallCounter.

Definition at line 143 of file function-controller.cc.

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

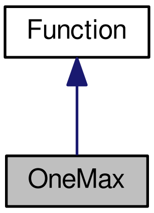
- lib/hnco/functions/decorators/function-controller.hh
- lib/hnco/functions/decorators/function-controller.cc

5.75 OneMax Class Reference

OneMax.

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

Inheritance diagram for OneMax:



Public Member Functions

- OneMax (int bv_size)

  Constructor.

Information about the function

- int get_bv_size ()

  Get bit vector size.
- double get_maximum ()

  Get the global maximum.
- bool has_known_maximum ()

  Check for a known maximum.
- bool provides_incremental_evaluation ()

  Check whether the function provides incremental evaluation.

Evaluation

- double eval (const bit_vector_t &)

  Evaluate a bit vector.
- double incremental_eval (const bit_vector_t &x, double v, const hnco::sparse_bit_vector_t &flipped_bits)

  Incremental evaluation.

Private Attributes

- int _bv_size

  Bit vector size.

5.75.1 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.

5.75.2 Member Function Documentation

5.75.2.1 get_maximum()

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

Get the global maximum.

Returns

_bv_size

Reimplemented from Function.

Definition at line 62 of file theory.hh.

5.75.2.2 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 66 of file theory.hh.

5.75.2.3 provides_incremental_evaluation()

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

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 71 of file theory.hh.

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

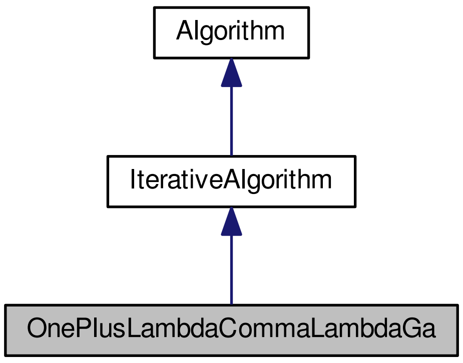
- lib/hnco/functions/theory.hh
- lib/hnco/functions/theory.cc

5.76 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.
- void init ()

    Initialization.

Setters

- void set_mutation_probability (double x)

    Set the mutation probability.
- void set_crossover_bias (double x)

    Set the crossover bias.

Private Member Functions

- void iterate ()

    Single iteration.

Private 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_probability

    Mutation probability.
- double _crossover_bias

    Crossover bias.

Additional Inherited Members

5.76.1 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.

5.76.2 Constructor & Destructor Documentation

5.76.2.1 OnePlusLambdaCommaLambdaGa()

```
OnePlusLambdaCommaLambdaGa (
            int n,
            int lambda )  [inline]
```

Constructor.

By default, _mutation_probability is set to lambda / n and _crossover_bias to 1 / lambda.

Parameters

n	Size of bit vectors
lambda	Offspring population size

Definition at line 92 of file one-plus-lambda-comma-lambda-ga.hh.

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

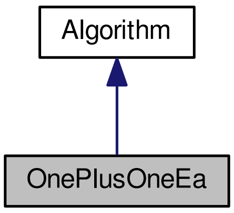
- lib/hnco/algorithms/ea/one-plus-lambda-comma-lambda-ga.hh
- lib/hnco/algorithms/ea/one-plus-lambda-comma-lambda-ga.cc

5.77 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 set_function (function::Function ∗function)

    Set function.
- void init ()

    Initialization.
- void maximize ()

    Maximize.
- const point_value_t & get_solution ()

    Solution.

Setters

- void set_num_iterations (int x)

    Set the number of iterations.
- void set_mutation_probability (double x)

    Set the mutation probability.
- void set_allow_stay (bool x)

    Set the flag _allow_stay.
- void set_incremental_evaluation (bool x)

    Set incremental evaluation.

Private Attributes

- neighborhood::BernoulliProcess _neighborhood

    Neighborhood.
- RandomLocalSearch _rls

    Random local search.

Parameters

- int _num_iterations = 0

    Number of iterations.
- double _mutation_probability

    Mutation probability.
- bool _allow_stay = false

    Allow stay.
- bool _incremental_evaluation = false

    Incremental evaluation.

Additional Inherited Members

5.77.1 Detailed Description

(1+1) EA.

(1+1) EA is implemented as a RandomLocalSearch with a BernoulliProcess neighborhood and infinite patience. Thus it does derive from IterativeAlgorithm. It should be noted that member Algorithm::_solution is not used by OnePlusOneEa.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 45 of file one-plus-one-ea.hh.

5.77.2 Constructor & Destructor Documentation

5.77.2.1 OnePlusOneEa()

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

Constructor.

Parameters

n	Size of bit vectors

_mutation_probability is initialized to 1 / n.

Definition at line 80 of file one-plus-one-ea.hh.

5.77.3 Member Function Documentation

5.77.3.1 set_allow_stay()

```
void set_allow_stay (
            bool x )  [inline]
```

Set the flag _allow_stay.

In case no mutation occurs allow the current bit vector to stay unchanged.

Definition at line 127 of file one-plus-one-ea.hh.

5.77.3.2 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 117 of file one-plus-one-ea.hh.

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

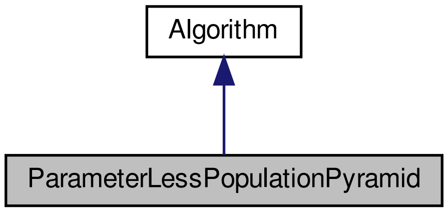
- lib/hnco/algorithms/ea/one-plus-one-ea.hh

5.78 ParameterLessPopulationPyramid Class Reference

Parameter-less Population Pyramid.

```
#include <hnco/algorithms/eda/p3.hh>
```

Inheritance diagram for ParameterLessPopulationPyramid:



Public Member Functions

- ParameterLessPopulationPyramid (int n)

  Constructor.
- void maximize ()

  Maximize.

Additional Inherited Members

5.78.1 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 46 of file p3.hh.

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

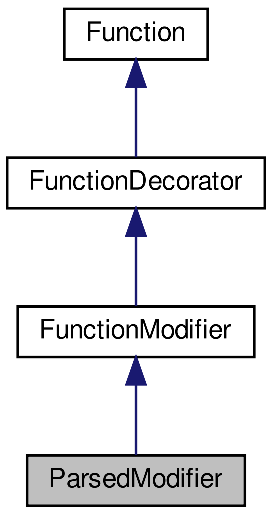
- lib/hnco/algorithms/eda/p3.hh
- lib/hnco/algorithms/eda/p3.cc

5.79 ParsedModifier Class Reference

Parsed modifier.

```
#include <hnco/functions/decorators/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 ()

  Get bit vector size.

Evaluation

- double eval (const bit_vector_t &)

  Evaluate a bit vector.

Private Attributes

- FunctionParser _fparser

  Function parser.
- double _values [1]

  Array of values.

Additional Inherited Members

5.79.1 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 39 of file parsed-modifier.hh.

5.79.2 Constructor & Destructor Documentation

5.79.2.1 ParsedModifier()

```
ParsedModifier (
            Function * function,
            std::string expression )
```

Constructor.

Parameters

function	Decorated function
expression	Expression to parse

Definition at line 30 of file parsed-modifier.cc.

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

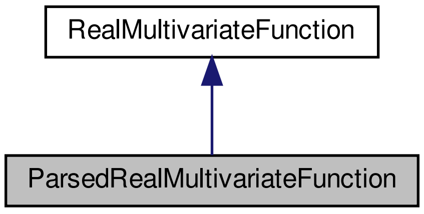
- lib/hnco/functions/decorators/parsed-modifier.hh
- lib/hnco/functions/decorators/parsed-modifier.cc

5.80 ParsedRealMultivariateFunction Class Reference

Parsed real multivariate function.

```
#include <hnco/functions/real/real-multivariate-function.hh>
```

Inheritance diagram for ParsedRealMultivariateFunction:



Public Member Functions

- ParsedRealMultivariateFunction (std::string expression)

  Constructor.
- int get_dimension ()

  Get the dimension of vectors.
- double eval (const std::vector$<$ double $>$ x)

  Evaluate a real vector.

Private Attributes

- FunctionParser _fparser

  Function parser.
- int _num_variables = 0

  Number of variables.

5.80.1 Detailed Description

Parsed real multivariate function.

Definition at line 52 of file real-multivariate-function.hh.

5.80.2 Constructor & Destructor Documentation

5.80.2.1 ParsedRealMultivariateFunction()

```
ParsedRealMultivariateFunction (
            std::string expression )
```

Constructor.

Parameters

expression	Expression to parse

Definition at line 34 of file real-multivariate-function.cc.

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

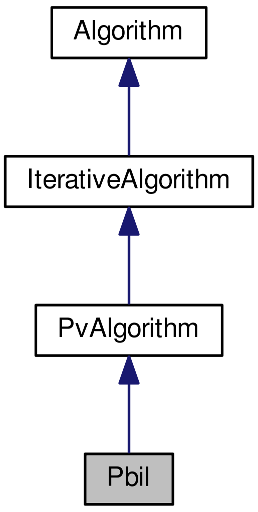
- lib/hnco/functions/real/real-multivariate-function.hh
- lib/hnco/functions/real/real-multivariate-function.cc

5.81 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.
- void init ()
  Initialization.

Setters

- void set_selection_size (int x)
  Set the selection size.
- void set_learning_rate (double x)
  Set the learning rate.

Protected Member Functions

- void iterate ()

  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.

5.81.1 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 41 of file pbil.hh.

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

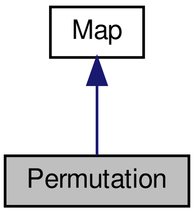
- lib/hnco/algorithms/pv/pbil.hh
- lib/hnco/algorithms/pv/pbil.cc

5.82 Permutation Class Reference

Permutation.

```
#include <hnco/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)

  Map
- int get_input_size ()

  Get input size.
- int get_output_size ()

  Get output size.
- bool is_surjective ()

  Check for surjective 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**

5.82.1 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 133 of file map.hh.

5.82.2 Member Function Documentation

5.82.2.1 is_surjective()

```
bool is_surjective ( ) [inline], [virtual]
```

Check for surjective map.

Returns

true

Reimplemented from Map.

Definition at line 184 of file map.hh.

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

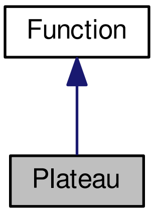
- lib/hnco/map.hh
- lib/hnco/map.cc

5.83 Plateau Class Reference

Plateau.

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

Inheritance diagram for Plateau:



Public Member Functions

- Plateau (int bv_size)

  Constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.
- bool has_known_maximum ()

  Check for a known maximum.
- double get_maximum ()

  Get the global maximum.

Private Attributes

- int _bv_size

  Bit vector size.

5.83.1 Detailed Description

Plateau.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 244 of file theory.hh.

5.83.2 Member Function Documentation

5.83.2.1 get_maximum()

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

Get the global maximum.

Returns

_bv_size + 2

Reimplemented from Function.

Definition at line 268 of file theory.hh.

5.83.2.2 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 264 of file theory.hh.

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

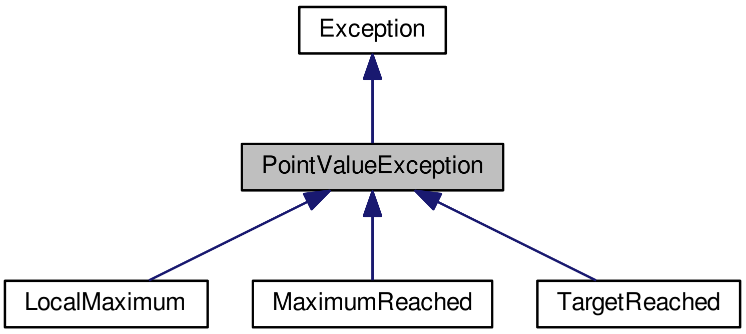
- lib/hnco/functions/theory.hh
- lib/hnco/functions/theory.cc

5.84 PointValueException Class Reference

Point-value exception.

`#include <hnco/exception.hh>`

Inheritance diagram for PointValueException:



Public Member Functions

- PointValueException (const point_value_t &pv)

  Constructor.
- const point_value_t & get_point_value () const

  Get point-value.

Protected Attributes

- point_value_t _pv

  Point-value.

5.84.1 Detailed Description

Point-value exception.

Definition at line 39 of file exception.hh.

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

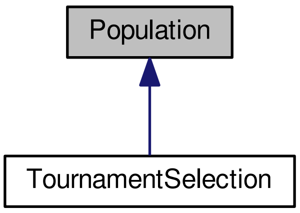
- lib/hnco/exception.hh

5.85 Population Class Reference

Population.

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

Inheritance diagram for Population:



Public Types

- typedef std::pair< int, double > index_value_t

  Index-value type.

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 eval (function::Function ∗function)
  Evaluate the population.
- void eval (const std::vector< function::Function ∗> &functions)
  Parallel evaluation of the population.
- void sort ()
  Sort the lookup table.
- void partial_sort (int selection_size)
  Partially sort the lookup table.
- void shuffle ()
  Shuffle 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
  Bit vectors.
- std::vector< index_value_t > _lookup
  Lookup table.
- std::function< bool(const index_value_t &, const index_value_t &)> _compare_index_value
  Binary operator for comparing index-value pairs.

5.85.1 Detailed Description

Population.

Definition at line 36 of file population.hh.

5.85.2 Member Function Documentation

5.85.2.1 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 112 of file population.cc.

5.85.2.2 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 126 of file population.cc.

5.85.2.3 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 85 of file population.hh.

5.85.2.4 get_best_bv() [2/4]

```
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 93 of file population.hh.

5.85.2.5 get_best_bv() [3/4]

```
const bit_vector_t& get_best_bv ( ) const [inline]
```

Get best bit vector.

Precondition

The population must be sorted.

Definition at line 117 of file population.hh.

5.85.2.6 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 125 of file population.hh.

5.85.2.7 get_best_value() [1/2]

```
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 148 of file population.hh.

5.85.2.8 get_best_value() [2/2]

```
double get_best_value ( ) const  [inline]
```

Get best value.

Precondition

The population must be sorted.

Definition at line 154 of file population.hh.

5.85.2.9 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 101 of file population.hh.

5.85.2.10 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 133 of file population.hh.

5.85.2.11 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 74 of file population.cc.

5.85.2.12 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 93 of file population.cc.

5.85.3 Member Data Documentation

5.85.3.1 _compare_index_value

```
std::function<bool(const index_value_t&, const index_value_t&)> _compare_index_value  [protected]
```

Initial value:

```
=
     [](const index_value_t& a, const index_value_t& b) { return a.second > b.
     second; }
```

Binary operator for comparing index-value pairs.

Definition at line 57 of file population.hh.

5.85.3.2 _lookup

```
std::vector<index_value_t> _lookup  [protected]
```

Lookup table.

Let p be of type std::pair<int, double>. Then p.first is the bv index in the unsorted population whereas p.second is the bv value.

Definition at line 54 of file population.hh.

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

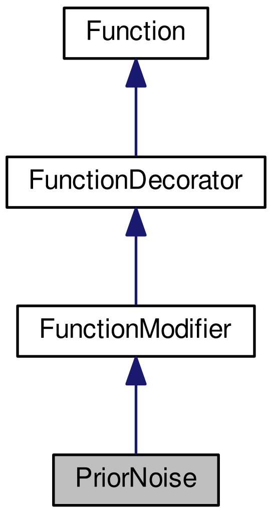
- lib/hnco/algorithms/population.hh
- lib/hnco/algorithms/population.cc

5.86 PriorNoise Class Reference

Prior noise.

```
#include <hnco/functions/decorators/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 ()

  Get bit vector size.
- double get_maximum ()

  Get the global maximum.
- bool has_known_maximum ()

  Check for a known maximum.
- bool provides_incremental_evaluation ()

  Check whether the function provides incremental evaluation.

Evaluation

- double eval (const bit_vector_t &)

  Evaluate a bit vector.

Private Attributes

- neighborhood::Neighborhood ∗ _neighborhood

  Neighborhood.
- bit_vector_t _noisy_bv

  Noisy bit vector.

Additional Inherited Members

5.86.1 Detailed Description

Prior noise.

Definition at line 36 of file prior-noise.hh.

5.86.2 Member Function Documentation

5.86.2.1 get_maximum()

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

Get the global maximum.

Delegation is questionable here.

Reimplemented from Function.

Definition at line 68 of file prior-noise.hh.

5.86.2.2 has_known_maximum()

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

Check for a known maximum.

Delegation is questionable here.

Reimplemented from Function.

Definition at line 74 of file prior-noise.hh.

5.86.2.3 provides_incremental_evaluation()

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

Check whether the function provides incremental evaluation.

Returns

false

Reimplemented from Function.

Definition at line 78 of file prior-noise.hh.

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

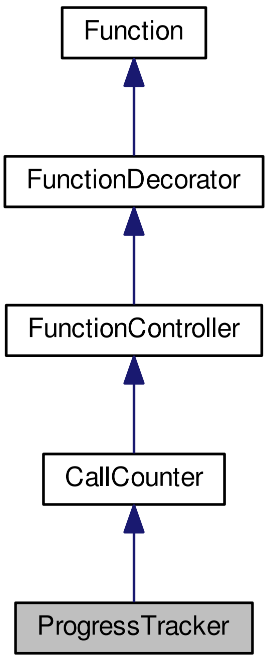
- lib/hnco/functions/decorators/prior-noise.hh
- lib/hnco/functions/decorators/prior-noise.cc

5.87 ProgressTracker Class Reference

ProgressTracker.

```
#include <hnco/functions/decorators/function-controller.hh>
```

Inheritance diagram for ProgressTracker:



Classes

- struct Event

  Event.

Public Member Functions

- ProgressTracker (Function ∗function)

  Constructor.

Evaluation

- double eval (const bit_vector_t &)

  Evaluate a bit vector.
- double incremental_eval (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_t &flipped←↩ _bits)

  Incremental evaluation.
- 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_stream (std::ostream ∗x)

  Output stream.

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.
- std::ostream ∗ _stream = &std::cout

  Output stream.

5.87.1 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 216 of file function-controller.hh.

5.87.2 Member Function Documentation

5.87.2.1 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 290 of file function-controller.hh.

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

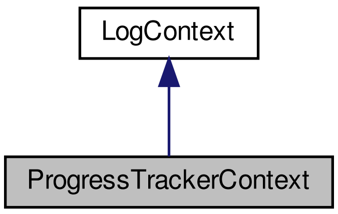
- lib/hnco/functions/decorators/function-controller.hh
- lib/hnco/functions/decorators/function-controller.cc

5.88 ProgressTrackerContext Class Reference

Log context for ProgressTracker.

```
#include <hnco/algorithms/log-context.hh>
```

Inheritance diagram for ProgressTrackerContext:



Public Member Functions

- ProgressTrackerContext (hnco::function::ProgressTracker ∗pt)

  Constructor.
- std::string get_context ()

  Get context.

Private Attributes

- hnco::function::ProgressTracker ∗ _pt

  Progress tracker.

5.88.1 Detailed Description

Log context for ProgressTracker.

Definition at line 48 of file log-context.hh.

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

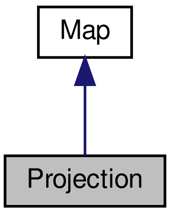
- lib/hnco/algorithms/log-context.hh

5.89 Projection Class Reference

Projection.

```
#include <hnco/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)

  Map
- int get_input_size ()

  Get input size.
- int get_output_size ()

  Get output size.
- bool is_surjective ()

  Check for surjective map.

Private Attributes

- std::vector< int > _bit_positions

  Bit positions.
- int _input_size

  Input size.

5.89.1 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 453 of file map.hh.

5.89.2 Constructor & Destructor Documentation

5.89.2.1 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 164 of file map.cc.

5.89.3 Member Function Documentation

5.89.3.1 is_surjective()

```
bool is_surjective ( )  [inline], [virtual]
```

Check for surjective map.

Returns

true

Reimplemented from Map.

Definition at line 491 of file map.hh.

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

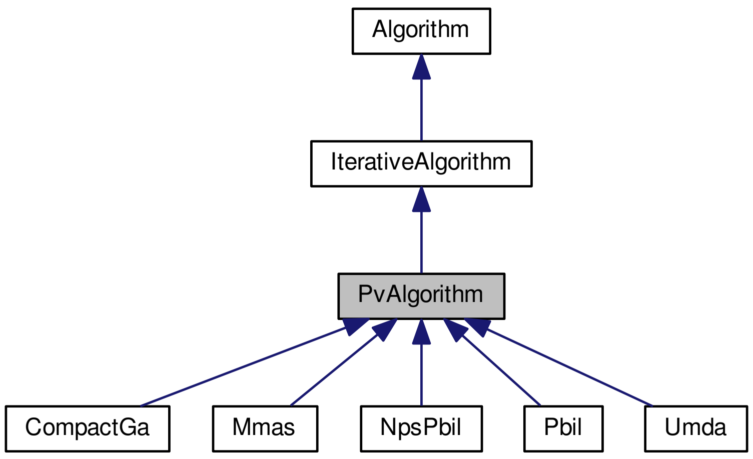
- lib/hnco/map.hh
- lib/hnco/map.cc

5.90 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.
- void set_something_to_log ()

  Set flag for something to log.

Protected Member Functions

- void log ()

  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.

5.90.1 Detailed Description

Probability vector algorithm.

Definition at line 35 of file pv-algorithm.hh.

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

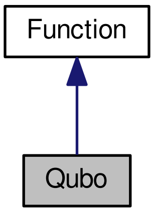
- lib/hnco/algorithms/pv/pv-algorithm.hh
- lib/hnco/algorithms/pv/pv-algorithm.cc

5.91 Qubo Class Reference

Quadratic unconstrained binary optimization.

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

Inheritance diagram for Qubo:



Public Member Functions

- Qubo ()
  Constructor.
- void load (std::istream &stream)
  Load an instance.
- int get_bv_size ()
  Get bit vector size.
- double eval (const bit_vector_t &)
  Evaluate a bit vector.

Private Attributes

- std::vector< std::vector< double > > _q

  Matrix.

5.91.1 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 (Q↩ UBO) 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.

5.91.2 Member Function Documentation

5.91.2.1 load()

```
void load (
             std::istream & stream )
```

Load an instance.

Exceptions

Error	

Definition at line 35 of file qubo.cc.

5.91.3 Member Data Documentation

5.91.3.1 _q

```
std::vector<std::vector<double> > _q  [private]
```

Matrix.

n x n upper triangular matrix.

Definition at line 83 of file qubo.hh.

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

- lib/hnco/functions/qubo.hh
- lib/hnco/functions/qubo.cc

5.92 Random Struct Reference

Random numbers.

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

Static Public Member Functions

- static double uniform ()
  Next uniformly distributed sample.
- static double normal ()
  Next normally distributed sample.
- static bool bernoulli ()
  Next random bit.

Static Public Attributes

- static std::mt19937 generator
  Mersenne Twister 19937 generator.

5.92.1 Detailed Description

Random numbers.

Definition at line 33 of file random.hh.

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

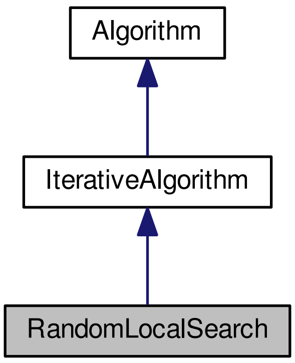
- lib/hnco/random.hh
- lib/hnco/random.cc

5.93 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 init ()
  Random initialization.
- void init (const bit_vector_t &x)
  Explicit initialization.
- void init (const bit_vector_t &x, double value)
  Explicit initialization.
- const point_value_t & get_solution ()
  Solution.

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 ()
  Single iteration.
- void iterate_full ()
  Single iteration with full evaluation.
- void iterate_incremental ()
  Single iteration with incremental evaluation.

Protected Attributes

- neighborhood::Neighborhood ∗ _neighborhood
  Neighborhood.
- 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.

5.93.1 Detailed Description

Random local search.

Definition at line 39 of file random-local-search.hh.

5.93.2 Member Function Documentation

5.93.2.1 set_patience()

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

Set patience.

Number of consecutive rejected moves before throwing a LocalMaximum exception

Parameters

x	Patience

If x <= 0 then patience is considered infinite, meaning that the algorithm will never throw any LocalMaximum exception.

Definition at line 110 of file random-local-search.hh.

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

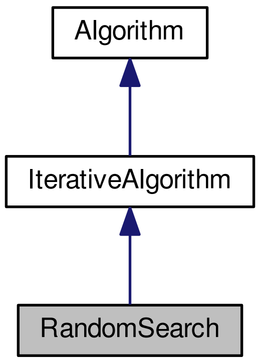
- lib/hnco/algorithms/ls/random-local-search.hh
- lib/hnco/algorithms/ls/random-local-search.cc

5.94 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

- void iterate ()
  Single iteration.

Private Attributes

- bit_vector_t _candidate
  Candidate.

Additional Inherited Members

5.94.1 Detailed Description

Random search.

Definition at line 31 of file random-search.hh.

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

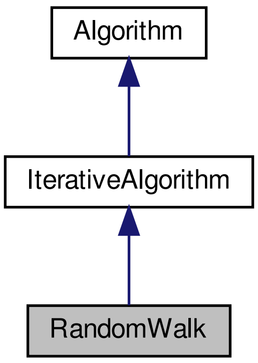
- lib/hnco/algorithms/random-search.hh
- lib/hnco/algorithms/random-search.cc

5.95 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.
- void init ()

    Random initialization.
- void init (const bit_vector_t &x)

    Explicit initialization.
- void init (const bit_vector_t &x, double value)

    Explicit initialization.
- void log ()

    Log.

Setters

- void set_incremental_evaluation (bool x)

    Set incremental evaluation.
- void set_log_value ()

    Set log.

Protected Member Functions

- void iterate ()

  Single iteration.
- void iterate_full ()

  Single iteration with full evaluation.
- void iterate_incremental ()

  Single iteration with incremental evaluation.

Protected Attributes

- neighborhood::Neighborhood ∗ _neighborhood

  Neighborhood.
- double _value

  Value of the last visited bit vector.

Parameters

- bool _incremental_evaluation = false

  Incremental evaluation.

5.95.1 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 42 of file random-walk.hh.

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

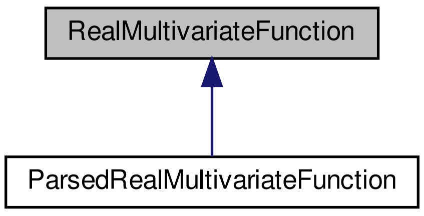
- lib/hnco/algorithms/ls/random-walk.hh
- lib/hnco/algorithms/ls/random-walk.cc

5.96 RealMultivariateFunction Class Reference

Real multivariate function.

```
#include <hnco/functions/real/real-multivariate-function.hh>
```

Inheritance diagram for RealMultivariateFunction:



Public Member Functions

- virtual ∼RealMultivariateFunction ()

  Destructor.
- virtual int get_dimension ()=0

  Get the dimension of vectors.
- virtual double eval (const std::vector< double > x)=0

  Evaluate a real vector.

5.96.1 Detailed Description

Real multivariate function.

Definition at line 35 of file real-multivariate-function.hh.

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

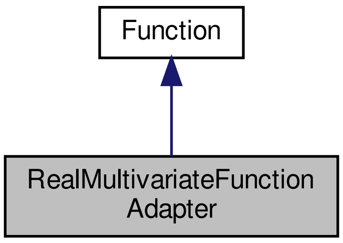
- lib/hnco/functions/real/real-multivariate-function.hh

5.97 RealMultivariateFunctionAdapter Class Reference

Real multivariate function adapter.

```
#include <hnco/functions/real/real-multivariate-function-adapter.hh>
```

Inheritance diagram for RealMultivariateFunctionAdapter:



Public Member Functions

- RealMultivariateFunctionAdapter (RealRepresentation ∗rep, RealMultivariateFunction ∗fn)

  Constructor.

Information about the function

- int get_bv_size ()

  Get bit vector size.

Evaluation

- double eval (const bit_vector_t &x)

  Evaluate a bit vector.

Display

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

  Describe a bit vector.

Private Member Functions

- void convert (const bit_vector_t &x)

  Convert a bit vector.

Private Attributes

- RealRepresentation ∗ _representation

  Real representation.
- RealMultivariateFunction ∗ _function

  Real multivariate function.
- std::vector< double > _rv

  Real vector.

5.97.1 Detailed Description

Real multivariate function adapter.

Definition at line 37 of file real-multivariate-function-adapter.hh.

5.97.2 Constructor & Destructor Documentation

5.97.2.1 RealMultivariateFunctionAdapter()

```
RealMultivariateFunctionAdapter (
            RealRepresentation ∗ rep,
            RealMultivariateFunction ∗ fn )  [inline]
```

Constructor.

Parameters

rep	Real representation
fn	Real multivariate function

Definition at line 59 of file real-multivariate-function-adapter.hh.

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

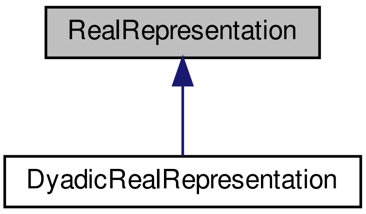
- lib/hnco/functions/real/real-multivariate-function-adapter.hh
- lib/hnco/functions/real/real-multivariate-function-adapter.cc

5.98 RealRepresentation Class Reference

Real representation.

```
#include <hnco/functions/real/real-representation.hh>
```

Inheritance diagram for RealRepresentation:



Public Member Functions

- virtual ~RealRepresentation ()
  Destructor.
- virtual int size ()=0
  Size of the representation.
- virtual double convert (hnco::bit_vector_t::const_iterator first, hnco::bit_vector_t::const_iterator last)=0
  Convert a bit vector range into a double.

5.98.1 Detailed Description

Real representation.

Definition at line 35 of file real-representation.hh.

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

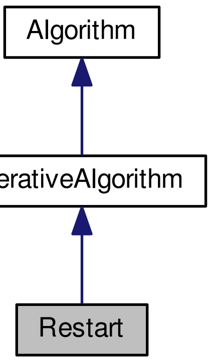
- lib/hnco/functions/real/real-representation.hh

5.99 Restart Class Reference

Restart.

```
#include <hnco/algorithms/decorators/restart.hh>
```

Inheritance diagram for Restart:



Public Member Functions

- Restart (int n, Algorithm ∗algorithm)

  Constructor.
- void init ()

  Initialization.
- void set_function (function::Function ∗function)

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

  Set functions.

Private Member Functions

- void iterate ()

  Optimize.

Private Attributes

- Algorithm ∗ _algorithm

  Algorithm.

Additional Inherited Members

5.99.1 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:

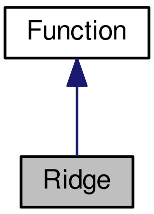
- lib/hnco/algorithms/decorators/restart.hh
- lib/hnco/algorithms/decorators/restart.cc

5.100 Ridge Class Reference

Ridge.

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

Inheritance diagram for Ridge:



Public Member Functions

- Ridge (int bv_size)

  Constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.
- bool has_known_maximum ()

  Check for a known maximum.
- double get_maximum ()

  Get the global maximum.

Private Attributes

- int _bv_size

  Bit vector size.

5.100.1 Detailed Description

Ridge.

Reference:

Thomas Jansen, Analyzing Evolutionary Algorithms. Springer, 2013.

Definition at line 208 of file theory.hh.

5.100.2 Member Function Documentation

5.100.2.1 get_maximum()

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

Get the global maximum.

Returns

$2 * \_bv\_size$

Reimplemented from Function.

Definition at line 232 of file theory.hh.

5.100.2.2 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 228 of file theory.hh.

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

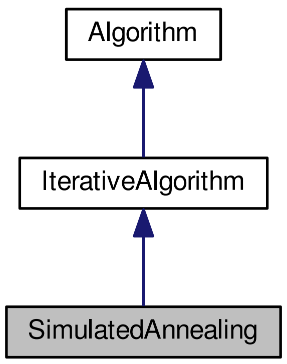
- lib/hnco/functions/theory.hh
- lib/hnco/functions/theory.cc

5.101 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.
- void init ()

  Initialization.

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.

Private Member Functions

- void init_beta ()

  Initialize beta.
- void iterate ()

  Single iteration.

Private Attributes

- neighborhood::Neighborhood ∗ _neighborhood

  Neighborhood.
- 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.

Additional Inherited Members

5.101.1 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 44 of file simulated-annealing.hh.

5.101.2 Member Function Documentation

5.101.2.1 init_beta()

```
void init_beta ( )  [private]
```

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:

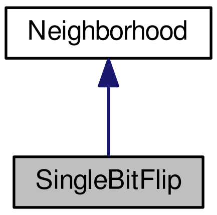
- lib/hnco/algorithms/ls/simulated-annealing.hh
- lib/hnco/algorithms/ls/simulated-annealing.cc

5.102 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

5.102.1 Detailed Description

One bit neighborhood.

Definition at line 160 of file neighborhood.hh.

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

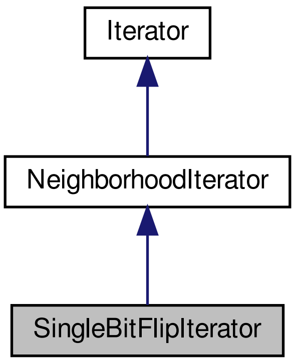
- lib/hnco/neighborhoods/neighborhood.hh

5.103 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 ()

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

  Next bit vector.

Private Attributes

- size_t _index

  Index of the last flipped bit.

Additional Inherited Members

5.103.1 Detailed Description

Single bit flip neighborhood iterator.

Definition at line 53 of file neighborhood-iterator.hh.

5.103.2 Constructor & Destructor Documentation

5.103.2.1 SingleBitFlipIterator()

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

Constructor.

Parameters

n	Size of bit vectors

Definition at line 65 of file neighborhood-iterator.hh.

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

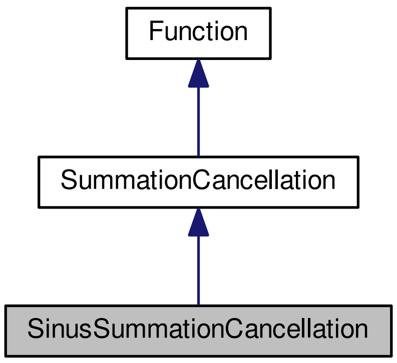
- lib/hnco/neighborhoods/neighborhood-iterator.hh
- lib/hnco/neighborhoods/neighborhood-iterator.cc

5.104 SinusSummationCancellation Class Reference

Summation cancellation with sinus.

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

Inheritance diagram for SinusSummationCancellation:



Public Member Functions

- SinusSummationCancellation (int n)

    Constructor.
- double eval (const bit_vector_t &x)

    Evaluate a bit vector.

Additional Inherited Members

5.104.1 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 104 of file cancellation.hh.

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

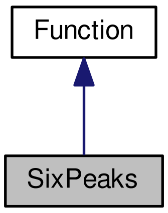
- lib/hnco/functions/cancellation.hh
- lib/hnco/functions/cancellation.cc

5.105 SixPeaks Class Reference

Six Peaks.

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

Inheritance diagram for SixPeaks:



Public Member Functions

- SixPeaks (int bv_size, int threshold)
  Constructor.
- int get_bv_size ()
  Get bit vector size.
- double eval (const bit_vector_t &)
  Evaluate a bit vector.
- bool has_known_maximum ()
  Check for a known maximum.
- double get_maximum ()
  Get the global maximum.

Private Attributes

- int _bv_size
  Bit vector size.
- int _threshold
  Threshold.
- int _maximum
  Maximum.

5.105.1 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.

5.105.2 Member Function Documentation

5.105.2.1 get_maximum()

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

Get the global maximum.

Returns

2 ∗ _bv_size - _threshold - 1

Reimplemented from Function.

Definition at line 159 of file four-peaks.hh.

5.105.2.2 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 155 of file four-peaks.hh.

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

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

5.106 SpinHerding Class Reference

Herding with spin variables.

```
#include <hnco/algorithms/hea/spin-herding.hh>
```

Public Types

- enum { SAMPLE_GREEDY, SAMPLE_RLS, SAMPLE_DLS, **LAST_SAMPLE** }

Public Member Functions

- SpinHerding (int n)

  Constructor.
- void init ()

  Initialization.
- void sample (const SpinMoment &target, bit_vector_t &x)

  Sample a bit vector.
- double error (const SpinMoment &target)

  Compute the error.

Getters

- const SpinMoment & get_delta ()

  Get delta.

Setters

- void set_randomize_bit_order (bool x)

  Randomize bit order.
- void set_sampling_method (int x)

  Set the sampling method.
- void set_num_seq_updates (int x)

  Set the number of sequential updates per sample.
- void set_weight (double x)

  Set the weight of second order moments.

Protected Member Functions

- void compute_delta (const SpinMoment &target)

  Compute delta.
- void sample_greedy (bit_vector_t &x)

  Sample by means of a greedy algorithm.
- double q_derivative (const bit_vector_t &x, int i)

  Derivative of q.
- double q_variation (const bit_vector_t &x, int i)

  Variation of q.
- void sample_rls (bit_vector_t &x)

  Sample by means of random local search.
- void sample_dls (bit_vector_t &x)

  Sample by means of deterministic local search.

Protected Attributes

- SpinMoment _delta

  Delta moment.
- SpinMoment _count

  Counter moment.
- permutation_t _permutation

  Permutation.
- std::uniform_int_distribution< int > _choose_bit

  Choose bit.
- int _time

  Time.

Parameters

- bool _randomize_bit_order = false

  Randomize bit order.
- int _sampling_method = SAMPLE_GREEDY

  Sampling method.
- int _num_seq_updates

  Number of sequential updates per sample.
- double _weight = 1

  Weight of second order moments.

5.106.1 Detailed Description

Herding with spin variables.

By spin variables, we mean variables taking values 1 or -1, instead of 0 or 1 in the case of binary variables.

Definition at line 37 of file spin-herding.hh.

5.106.2 Member Enumeration Documentation

5.106.2.1 anonymous enum

```
anonymous enum
```

Enumerator

SAMPLE_GREEDY	Greedy algorithm.
SAMPLE_RLS	Random local search.
SAMPLE_DLS	Deterministic local search.

Definition at line 97 of file spin-herding.hh.

5.106.3 Constructor & Destructor Documentation

5.106.3.1 SpinHerding()

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

Constructor.

Parameters

n	Size of bit vectors

_num_seq_updates is initialized to n.

Definition at line 116 of file spin-herding.hh.

5.106.4 Member Function Documentation

5.106.4.1 q_variation()

```
double q_variation (
            const bit_vector_t & x,
            int i )  [protected]
```

Variation of q.

Up to a positive multiplicative constant. Only the sign of the variation matters to local search.

Definition at line 162 of file spin-herding.cc.

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

- lib/hnco/algorithms/hea/spin-herding.hh
- lib/hnco/algorithms/hea/spin-herding.cc

5.107 SpinMoment Struct Reference

Moment for spin variables.

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

Public Member Functions

- SpinMoment (int n)

  Constructor.
- void uniform ()

  Set the moment to that of the uniform distribution.
- void init ()

  Initialize accumulators.
- void add (const bit_vector_t &x)

  Update accumulators.
- void average (int count)

  Compute average.
- void update (const SpinMoment &p, double rate)

  Update moment.
- void bound (double margin)

  Bound moment.
- double distance (const SpinMoment &p) const

  Distance.
- double norm_2 () const

  Compute the norm 2.
- double diameter () const

  Compute the diameter.
- size_t size () const

  Size.
- void display (std::ostream &stream)

  Display.

Public Attributes

- std::vector< double > _first

  First moment.
- std::vector< std::vector< double > > _second

  Second moment.
- double _weight = 1

  Weight of second order moments.

5.107.1 Detailed Description

Moment for spin variables.

Definition at line 38 of file spin-moment.hh.

5.107.2 Member Data Documentation

5.107.2.1 _second

```
std::vector<std::vector<double> > _second
```

Second moment.

This is a lower triangular matrix with only zeros on the diagonal. Only entries _second[i][j] with $j < i$ are considered.

Definition at line 50 of file spin-moment.hh.

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

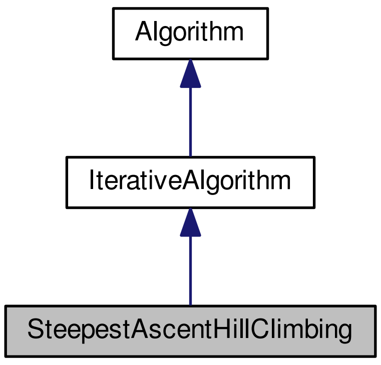
- lib/hnco/algorithms/hea/spin-moment.hh
- lib/hnco/algorithms/hea/spin-moment.cc

5.108 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.
- void init ()
  Random initialization.
- void init (const bit_vector_t &x)
  Explicit initialization.
- void init (const bit_vector_t &x, double value)
  Explicit initialization.

Protected Member Functions

- void iterate ()

  Single iteration.

Protected Attributes

- std::vector< bit_vector_t > _candidates

  Potential candidate.
- neighborhood::NeighborhoodIterator ∗ _neighborhood

  Neighborhood.

5.108.1 Detailed Description

Steepest ascent hill climbing.

Definition at line 39 of file steepest-ascent-hill-climbing.hh.

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

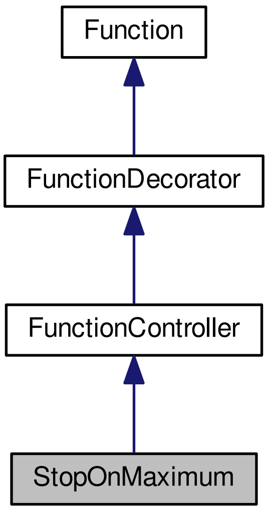
- lib/hnco/algorithms/ls/steepest-ascent-hill-climbing.hh
- lib/hnco/algorithms/ls/steepest-ascent-hill-climbing.cc

5.109 StopOnMaximum Class Reference

Stop on maximum.

`#include <hnco/functions/decorators/function-controller.hh>`

Inheritance diagram for StopOnMaximum:



Public Member Functions

- StopOnMaximum (Function ∗function)

  Constructor.

Evaluation

- double eval (const bit_vector_t &)

  Evaluate a bit vector.
- double incremental_eval (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_t &flipped↩
_bits)

  Incremental evaluation.
- void update (const bit_vector_t &x, double value)

  Update after a safe evaluation.

Additional Inherited Members

5.109.1 Detailed Description

Stop on maximum.

The member function eval throws an exception MaximumReached when its argument maximizes the decorated function.

Warning

The maximum is detected using the equality operator hence the result should be taken with care in case of non integer (floating point) function values.

Definition at line 90 of file function-controller.hh.

5.109.2 Constructor & Destructor Documentation

5.109.2.1 StopOnMaximum()

```
StopOnMaximum (
            Function ∗ function )  [inline]
```

Constructor.

Parameters

function	Decorated function

Precondition

function->has_known_maximum()

Definition at line 98 of file function-controller.hh.

5.109.3 Member Function Documentation

5.109.3.1 eval()

```
double eval (
             const bit_vector_t & x )  [virtual]
```

Evaluate a bit vector.

Exceptions

MaximumReached	

Implements Function.

Definition at line 31 of file function-controller.cc.

5.109.3.2 incremental_eval()

```
double incremental_eval (
             const bit_vector_t & x,
             double value,
             const hnco::sparse_bit_vector_t & flipped_bits )  [virtual]
```

Incremental evaluation.

Exceptions

MaximumReached	

Reimplemented from Function.

Definition at line 43 of file function-controller.cc.

5.109.3.3 update()

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

Update after a safe evaluation.

Exceptions

MaximumReached	

Reimplemented from Function.

Definition at line 55 of file function-controller.cc.

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

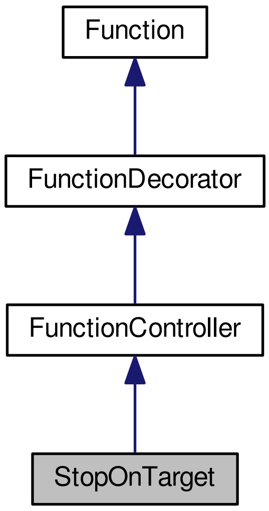
- lib/hnco/functions/decorators/function-controller.hh
- lib/hnco/functions/decorators/function-controller.cc

5.110 StopOnTarget Class Reference

Stop on target.

```
#include <hnco/functions/decorators/function-controller.hh>
```

Inheritance diagram for StopOnTarget:



Public Member Functions

- StopOnTarget (Function ∗function, double target)

  Constructor.

Evaluation

- double eval (const bit_vector_t &)

  Evaluate a bit vector.
- double incremental_eval (const bit_vector_t &x, double value, const hnco::sparse_bit_vector_t &flipped↩ _bits)

  Incremental evaluation.
- void update (const bit_vector_t &x, double value)

  Update after a safe evaluation.

Private Attributes

- double _target

  Target.

Additional Inherited Members

5.110.1 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 134 of file function-controller.hh.

5.110.2 Constructor & Destructor Documentation

5.110.2.1 StopOnTarget()

```
StopOnTarget (
            Function * function,
            double target )  [inline]
```

Constructor.

Parameters

function	Decorated function
target	Target

Definition at line 147 of file function-controller.hh.

5.110.3 Member Function Documentation

5.110.3.1 eval()

```
double eval (
             const bit_vector_t & x )  [virtual]
```

Evaluate a bit vector.

Exceptions

TargetReached	

Implements Function.

Definition at line 66 of file function-controller.cc.

5.110.3.2 incremental_eval()

```
double incremental_eval (
             const bit_vector_t & x,
             double value,
             const hnco::sparse_bit_vector_t & flipped_bits )  [virtual]
```

Incremental evaluation.

Exceptions

TargetReached	

Reimplemented from Function.

Definition at line 76 of file function-controller.cc.

5.110.3.3 update()

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

Update after a safe evaluation.

Exceptions

TargetReached	

Reimplemented from Function.

Definition at line 86 of file function-controller.cc.

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

- lib/hnco/functions/decorators/function-controller.hh
- lib/hnco/functions/decorators/function-controller.cc

5.111 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.

Private Attributes

- double _total_time = 0

  Total time.
- clock_t _start

  Start time.

5.111.1 Detailed Description

Stop watch.

Definition at line 31 of file stop-watch.hh.

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

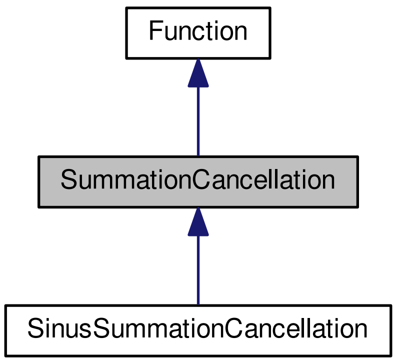
- lib/hnco/stop-watch.hh

5.112 SummationCancellation Class Reference

Summation cancellation.

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

Inheritance diagram for SummationCancellation:



Public Member Functions

- SummationCancellation (int n)

  Constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.
- bool has_known_maximum ()

  Check for a known maximum.
- double get_maximum ()

  Get the global maximum.

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.

5.112.1 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 48 of file cancellation.hh.

5.112.2 Constructor & Destructor Documentation

5.112.2.1 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 71 of file cancellation.hh.

5.112.3 Member Function Documentation

5.112.3.1 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 87 of file cancellation.hh.

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

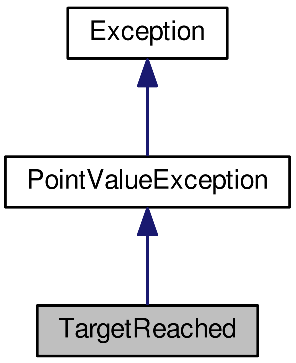
- lib/hnco/functions/cancellation.hh
- lib/hnco/functions/cancellation.cc

5.113 TargetReached Class Reference

target reached

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

Inheritance diagram for TargetReached:



Public Member Functions

- TargetReached (const point_value_t &pv)

  Constructor.

Additional Inherited Members

5.113.1 Detailed Description

target reached

Definition at line 62 of file exception.hh.

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

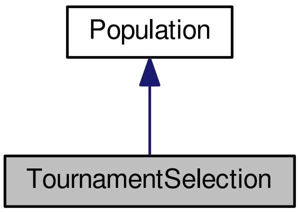
- lib/hnco/exception.hh

5.114 TournamentSelection Class Reference

Population with tournament selection.

`#include <hnco/algorithms/ea/tournament-selection.hh>`

Inheritance diagram for TournamentSelection:



Public Member Functions

- TournamentSelection (int population_size, int n)

  Constructor.
- const bit_vector_t & select ()

  Selection.

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

5.114.1 Detailed Description

Population with tournament selection.

Definition at line 34 of file tournament-selection.hh.

5.114.2 Member Function Documentation

5.114.2.1 select()

```
const bit_vector_t & select ( )
```

Selection.

The selection only requires that the population be evaluated, not necessarily sorted.

Precondition

The population must be evaluated.

Definition at line 33 of file tournament-selection.cc.

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

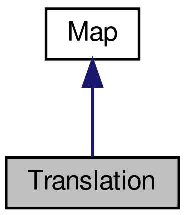
- lib/hnco/algorithms/ea/tournament-selection.hh
- lib/hnco/algorithms/ea/tournament-selection.cc

5.115 Translation Class Reference

Translation.

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

Inheritance diagram for Translation:



Public Member Functions

- void random (int n)

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

  Map
- int get_input_size ()

  Get input size.
- int get_output_size ()

  Get output size.
- bool is_surjective ()

  Check for surjective 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**

5.115.1 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 71 of file map.hh.

5.115.2 Member Function Documentation

5.115.2.1 is_surjective()

```
bool is_surjective ( )  [inline], [virtual]
```

Check for surjective map.

Returns

true

Reimplemented from Map.

Definition at line 122 of file map.hh.

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

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

5.116 Transvection Struct Reference

Transvection.

```
#include <hnco/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.
- void multiply_right (bit_matrix_t &M) const

  Multiply a bit matrix from the right.

Public Attributes

- int row_index

  Row index.
- int column_index

  Column index.

5.116.1 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 53 of file transvection.hh.

5.116.2 Member Function Documentation

5.116.2.1 is_valid()

```
bool is_valid (
             int n ) const
```

Check validity.

Parameters

n	Dimension

Definition at line 46 of file transvection.cc.

5.116.2.2 multiply() [1/2]

```
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 102 of file transvection.cc.

5.116.2.3 multiply() [2/2]

```
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 114 of file transvection.cc.

5.116.2.4 multiply_right()

```
void multiply_right (
             bit_matrix_t & M ) const
```

Multiply a bit matrix from the right.

Parameters

M	Bit matrix

Precondition

is_valid()
is_valid(bm_num_rows(M))

Warning

This function modifies the given bit vector.

Definition at line 124 of file transvection.cc.

5.116.2.5 random()

```
void random (
             int n )
```

Sample a random transvection.

Parameters

n	Dimension

Precondition

$n > 1$

Definition at line 59 of file transvection.cc.

5.116.2.6 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 75 of file transvection.cc.

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

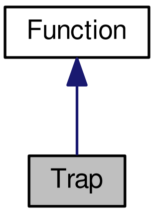
- lib/hnco/transvection.hh
- lib/hnco/transvection.cc

5.117 Trap Class Reference

Trap.

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

Inheritance diagram for Trap:



Public Member Functions

- Trap (int bv_size, int num_traps)

  Constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.
- bool has_known_maximum ()

  Check for a known maximum.
- double get_maximum ()

  Get the global maximum.

Private Attributes

- int _bv_size

  Bit vector size.
- int _num_traps

  Number of traps.
- int _trap_size

  Trap size.

5.117.1 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.

5.117.2 Constructor & Destructor Documentation

5.117.2.1 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.

5.117.3 Member Function Documentation

5.117.3.1 get_maximum()

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

Get the global maximum.

Returns

_bv_size

Reimplemented from Function.

Definition at line 88 of file trap.hh.

5.117.3.2 has_known_maximum()

```
bool has_known_maximum ( )  [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:

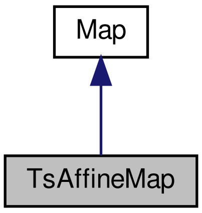
- lib/hnco/functions/trap.hh
- lib/hnco/functions/trap.cc

5.118 TsAffineMap Class Reference

Transvection sequence affine map.

```
#include <hnco/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)

  Map
- int get_input_size ()

  Get input size.
- int get_output_size ()

  Get output size.
- bool is_surjective ()

  Check for surjective 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**

5.118.1 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 505 of file map.hh.

5.118.2 Member Enumeration Documentation

5.118.2.1 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 542 of file map.hh.

5.118.3 Member Function Documentation

5.118.3.1 is_surjective()

```
bool is_surjective ( )  [inline], [virtual]
```

Check for surjective map.

Returns

true

Reimplemented from Map.

Definition at line 585 of file map.hh.

5.118.3.2 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 185 of file map.cc.

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

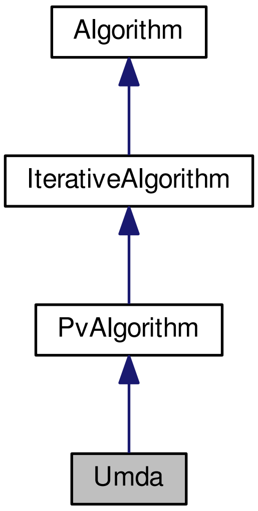
- lib/hnco/map.hh
- lib/hnco/map.cc

5.119 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.
- void init ()

  Initialization.

Setters

- void set_selection_size (int x)

  Set the selection size.

Protected Member Functions

- void iterate ()

  Single iteration.

Protected Attributes

- Population _population

  Population.

Parameters

- int _selection_size = 1

  Selection size.

5.119.1 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:

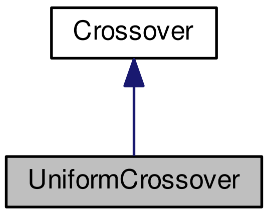
- lib/hnco/algorithms/pv/umda.hh
- lib/hnco/algorithms/pv/umda.cc

5.120 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.

5.120.1 Detailed Description

Uniform crossover.

Definition at line 56 of file crossover.hh.

5.120.2 Member Function Documentation

5.120.2.1 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:

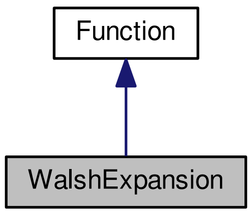
- lib/hnco/algorithms/ea/crossover.hh
- lib/hnco/algorithms/ea/crossover.cc

5.121 WalshExpansion Class Reference

Walsh expansion.

`#include <hnco/functions/walsh/walsh-expansion.hh>`

Inheritance diagram for WalshExpansion:



Public Member Functions

- WalshExpansion ()

  Constructor.
- int get_bv_size ()

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

  Evaluate a bit vector.
- void display (std::ostream &stream)

  Display.
- void set_terms (const std::vector< Function::WalshTransformTerm > 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.

Private Member Functions

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

  Save.

Private Attributes

- std::vector< Function::WalshTransformTerm > _terms

  Terms.

Friends

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

5.121.1 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 53 of file walsh-expansion.hh.

5.121.2 Member Function Documentation

5.121.2.1 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 87 of file walsh-expansion.hh.

5.121.2.2 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 113 of file walsh-expansion.hh.

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

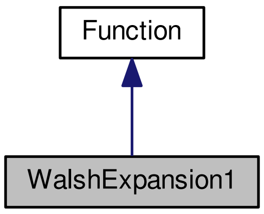
- lib/hnco/functions/walsh/walsh-expansion.hh
- lib/hnco/functions/walsh/walsh-expansion.cc

5.122 WalshExpansion1 Class Reference

Walsh expansion of degree 1.

```
#include <hnco/functions/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.

Evaluation

- double eval (const bit_vector_t &)
  Evaluate a bit vector.
- double incremental_eval (const bit_vector_t &x, double v, const hnco::sparse_bit_vector_t &flipped_bits)
  Incremental evaluation.

Information about the function

- int get_bv_size ()
  Get bit vector size.
- double get_maximum ()
  Get the global maximum.
- bool has_known_maximum ()
  Check for a known maximum.
- bool provides_incremental_evaluation ()
  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**

5.122.1 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 50 of file walsh-expansion-1.hh.

5.122.2 Member Function Documentation

5.122.2.1 generate()

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

Instance generator.

Parameters

n	Size of bit vectors
generator	Weight generator

Definition at line 83 of file walsh-expansion-1.hh.

5.122.2.2 has_known_maximum()

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

Check for a known maximum.

Returns

true

Reimplemented from Function.

Definition at line 130 of file walsh-expansion-1.hh.

5.122.2.3 provides_incremental_evaluation()

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

Check whether the function provides incremental evaluation.

Returns

true

Reimplemented from Function.

Definition at line 135 of file walsh-expansion-1.hh.

5.122.2.4 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 97 of file walsh-expansion-1.hh.

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

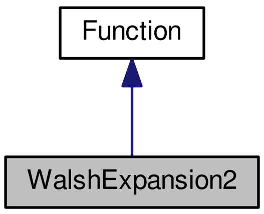
- lib/hnco/functions/walsh/walsh-expansion-1.hh
- lib/hnco/functions/walsh/walsh-expansion-1.cc

5.123 WalshExpansion2 Class Reference

Walsh expansion of degree 2.

```
#include <hnco/functions/walsh/walsh-expansion-2.hh>
```

Inheritance diagram for WalshExpansion2:



Public Member Functions

- WalshExpansion2 ()

    Constructor.
- int get_bv_size ()

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

    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.

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**

5.123.1 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 50 of file walsh-expansion-2.hh.

5.123.2 Member Function Documentation

5.123.2.1 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 95 of file walsh-expansion-2.hh.

5.123.2.2 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.

5.123.2.3 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.

5.123.2.4 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 117 of file walsh-expansion-2.hh.

5.123.3 Member Data Documentation

5.123.3.1 _quadratic

```
std::vector<std::vector<double> > _quadratic  [private]
```

Quadratic part.

Represented as a lower triangular matrix (without its diagonal).

Definition at line 73 of file walsh-expansion-2.hh.

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

- lib/hnco/functions/walsh/walsh-expansion-2.hh
- lib/hnco/functions/walsh/walsh-expansion-2.cc

5.124 Function::WalshTransformTerm Struct Reference

Walsh transform term.

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

5.124.1 Detailed Description

Walsh transform term.

Definition at line 46 of file function.hh.

5.124.2 Member Data Documentation

5.124.2.1 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 53 of file function.hh.

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

- lib/hnco/functions/function.hh

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