CS471 Project 1

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Namespace Documentation

4.1 cs471 Namespace Reference

Classes

- class mfuncExperiment

  Contains classes for running the CS471 project experiment.
- struct RandomBounds

  Simple struct for storing the minimum and maximum input vector bounds for a function.

4.2 mdata Namespace Reference

Classes

- class DataTable

  The DataTable class is a simple table of values with labeled columns.
- class Population

  Data class for storing a multi-dimensional population of data. Includes fitness analysis functions.

Functions

- template<class T = double>
  T average (T *v, size_t vSize)

  Calculates the average for an array of values.
- template<class T = double>
  T standardDeviation (T *v, size_t vSize)

  Calculates the standard deviation for an array of values.
- template<class T = double>
  T range (T *v, size_t vSize)

  Calculates the range for an array of values.
- template<class T = double>
  T median (T *v, size_t vSize)

  Calculates the median for an array of values.

4.2.1 Function Documentation

4.2.1.1 average()

```
template<class T = double>
T mdata::average (
            T * v,
            size_t vSize )
```

Calculates the average for an array of values.

Parameters

v	Array of values

Returns

The average value of the array

Definition at line 29 of file datastats.h.

```
00030     {
00031         T sum = 0;
00032 
00033         for (size_t i = 0; i < vSize; i++)
00034             sum += v[i];
00035 
00036         return sum / vSize;
00037     }
```

4.2.1.2 median()

```
template<class T = double>
T mdata::median (
            T * v,
            size_t vSize )
```

Calculates the median for an array of values.

Parameters

v	Array of values

Returns

The median value of the array

Definition at line 91 of file datastats.h.

```
00092     {
00093         T* vSorted = new T[vSize];
00094         T retVal = 0;
00095 
00096         for (size_t i = 0; i < vSize; i++)
00097             vSorted[i] = v[i];
00098 
00099         std::sort(vSorted, vSorted + vSize);
00100 
00101         if (vSize % 2 != 0)
00102         {
00103             // Odd number of values
00104             retVal = vSorted[vSize / 2];
00105         }
00106         else
00107         {
00108             // Even number of values
00109             T low = vSorted[(vSize / 2) - 1];
00110             T high = vSorted[vSize / 2];
00111             retVal = (high + low) / 2;
00112         }
00113 
00114         delete[] vSorted;
00115         return retVal;
00116     }
```

4.2.1.3 range()

```
template<class T = double>
T mdata::range (
            T * v,
            size_t vSize )
```

Calculates the range for an array of values.

Parameters

v	Array of values

Returns

The range of the array

Definition at line 67 of file datastats.h.

```
00068     {
00069         T min = v[0];
00070         T max = v[0];
00071 
00072         for (size_t i = 1; i < vSize; i++)
00073         {
00074             T cur = v[i];
00075 
00076             if (cur < min) min = cur;
00077 
00078             if (cur > max) max = cur;
00079         }
00080 
00081         return max - min;
00082     }
```

4.2.1.4 standardDeviation()

```
template<class T = double>
T mdata::standardDeviation (
            T * v,
            size_t vSize )
```

Calculates the standard deviation for an array of values.

Parameters

v	Array of values

Returns

The standard deviation value of the array

Definition at line 46 of file datastats.h.

```
00047     {
00048         T mean = average<T>(v, vSize);
00049         T sum = 0;
00050
00051         for (size_t i = 0; i < vSize; i++)
00052         {
00053             T subMean = v[i] - mean;
00054             sum += subMean * subMean;
00055         }
00056
00057         return (T)sqrt((double)(sum / vSize));
00058     }
```

4.3 mfunc Namespace Reference

Functions

- const char * schwefelDesc ()
- double schwefel (double *v, size_t n)

  Function 1. Implementation of Schwefel's mathematical function.
- const char * dejongDesc ()
- double dejong (double *v, size_t n)

  Function 2. Implementation of 1st De Jong's mathematical function.
- const char * rosenbrokDesc ()
- double rosenbrok (double *v, size_t n)

  Function 3. Implementation of the Rosenbrock mathematical function.
- const char * rastriginDesc ()
- double rastrigin (double *v, size_t n)

  Function 4. Implementation of the Rastrigin mathematical function.
- const char * griewangkDesc ()
- double griewangk (double *v, size_t n)

  Function 5. Implementation of the Griewangk mathematical function.
- const char * sineEnvelopeSineWaveDesc ()
- double sineEnvelopeSineWave (double *v, size_t n)

  Function 6. Implementation of the Sine Envelope Sine Wave mathematical function.

- const char * stretchedVSineWaveDesc ()
- double stretchedVSineWave (double *v, size_t n)

  Function 7. Implementation of the Stretched V Sine Wave mathematical function.
- const char * ackleysOneDesc ()
- double ackleysOne (double *v, size_t n)

  Function 8. Implementation of Ackley's One mathematical function.
- const char * ackleysTwoDesc ()
- double ackleysTwo (double *v, size_t n)

  Function 9. Implementation of Ackley's Two mathematical function.
- const char * eggHolderDesc ()
- double eggHolder (double *v, size_t n)

  Function 10. Implementation of the Egg Holder mathematical function.
- const char * ranaDesc ()
- double rana (double *v, size_t n)

  Function 11. Implementation of the Rana mathematical function.
- const char * pathologicalDesc ()
- double pathological (double *v, size_t n)

  Function 12. Implementation of the Pathological mathematical function.
- const char * michalewiczDesc ()
- double michalewicz (double *v, size_t n)

  Function 13. Implementation of the Michalewicz mathematical function.
- const char * mastersCosineWaveDesc ()
- double mastersCosineWave (double *v, size_t n)

  Function 14. Implementation of the Masters Cosine Wave mathematical function.
- const char * quarticDesc ()
- double quartic (double *v, size_t n)

  Function 15. Implementation of the Quartic mathematical function.
- const char * levyDesc ()
- double levy (double *v, size_t n)

  Function 16. Implementation of the Levy mathematical function.
- const char * stepDesc ()
- double step (double *v, size_t n)

  Function 17. Implementation of the Step mathematical function.
- const char * alpineDesc ()
- double alpine (double *v, size_t n)

  Function 18. Implementation of the Alpine mathematical function.
- bool fExec (unsigned int f, double *v, size_t n, double &outResult)

  Executes a specific function Executes the function with the given id and returns true on success. Otherwise returns false if id is invalid.
- const char * fDesc (unsigned int f)

  Returns a function's description Returns a C-string description for the given function id if the id is valid. Otherwise returns null.

Variables

- const unsigned int NUM_FUNCTIONS = 18

4.3.1 Detailed Description

Scope for all math functions

4.3.2 Function Documentation

4.3.2.1 ackleysOne()

```
double mfunc::ackleysOne (
            double * v,
            size_t n )
```

Function 8. Implementation of Ackley's One mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 295 of file mfunc.cpp.

Referenced by fExec().

```
00296 {
00297     double f = 0.0;
00298
00299     for (size_t i = 0; i < n - 1; i++)
00300     {
00301         double a = (1.0 / pow(M_E, 0.2)) * sqrt(v[i]*v[i] + v[i+1]*v[i+1]);
00302         double b = 3.0 * (cos(2.0*v[i]) + sin(2.0*v[i+1]));
00303         f += a + b;
00304     }
00305
00306     return f;
00307 }
```

4.3.2.2 ackleysOneDesc()

```
const char * mfunc::ackleysOneDesc ( )
```

Returns a string description of the ackleysOne() function

Returns

C-string description

Definition at line 283 of file mfunc.cpp.

References _ackleysOneDesc.

Referenced by fDesc().

```
00284 {
00285     return _ackleysOneDesc;
00286 }
```

4.3.2.3 ackleysTwo()

```
double mfunc::ackleysTwo (
            double * v,
            size_t n )
```

Function 9. Implementation of Ackley's Two mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 327 of file mfunc.cpp.

Referenced by fExec().

```
00328 {
00329     double f = 0.0;
00330
00331     for (size_t i = 0; i < n - 1; i++)
00332     {
00333         double a = 20.0 / pow(M_E, 0.2 * sqrt((v[i]*v[i] + v[i+1]*v[i+1]) / 2.0));
00334         double b = pow(M_E, 0.5 * (cos(2.0 * M_PI * v[i]) + cos(2.0 * M_PI * v[i+1])));
00335         f += 20.0 + M_E - a - b;
00336     }
00337
00338     return f;
00339 }
```

4.3.2.4 ackleysTwoDesc()

```
const char * mfunc::ackleysTwoDesc ( )
```

Returns a string description of the ackleysTwo() function

Returns

C-string description

Definition at line 315 of file mfunc.cpp.

References _ackleysTwoDesc.

Referenced by fDesc().

```
00316 {
00317     return _ackleysTwoDesc;
00318 }
```

4.3.2.5 alpine()

```
double mfunc::alpine (
            double * v,
            size_t n )
```

Function 18. Implementation of the Alpine mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 627 of file mfunc.cpp.

Referenced by fExec().

```
00628 {
00629     double f = 0.0;
00630
00631     for (size_t i = 0; i < n; i++)
00632     {
00633         f += fabs(v[i] * sin(v[i]) + 0.1*v[i]);
00634     }
00635
00636     return f;
00637 }
```

4.3.2.6 alpineDesc()

```
const char * mfunc::alpineDesc ( )
```

Returns a string description of the alpine() function

Returns

C-string description

Definition at line 615 of file mfunc.cpp.

References _alpineDesc.

Referenced by fDesc().

```
00616 {
00617     return _alpineDesc;
00618 }
```

4.3.2.7 dejong()

```
double mfunc::dejong (
            double * v,
            size_t n )
```

Function 2. Implementation of 1st De Jong's mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 99 of file mfunc.cpp.

Referenced by fExec().

```
00100 {
00101     double f = 0.0;
00102
00103     for (size_t i = 0; i < n; i++)
00104     {
00105         f += v[i] * v[i];
00106     }
00107
00108     return f;
00109 }
```

4.3.2.8 dejongDesc()

```
const char * mfunc::dejongDesc ( )
```

Returns a string description of the dejong() function

Returns

C-string description

Definition at line 87 of file mfunc.cpp.

References _dejongDesc.

Referenced by fDesc().

```
00088 {
00089     return _dejongDesc;
00090 }
```

4.3.2.9 eggHolder()

```
double mfunc::eggHolder (
            double * v,
            size_t n )
```

Function 10. Implementation of the Egg Holder mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 359 of file mfunc.cpp.

Referenced by fExec().

```
00360 {
00361     double f = 0.0;
00362
00363     for (size_t i = 0; i < n - 1; i++)
00364     {
00365         double a = -1.0 * v[i] * sin(sqrt(fabs(v[i] - v[i+1] - 47.0)));
00366         double b = (v[i+1] + 47) * sin(sqrt(fabs(v[i+1] + 47.0 + (v[i]/2.0))));
00367         f += a - b;
00368     }
00369
00370     return f;
00371 }
```

4.3.2.10 eggHolderDesc()

```
const char * mfunc::eggHolderDesc ( )
```

Returns a string description of the eggHolder() function

Returns

C-string description

Definition at line 347 of file mfunc.cpp.

References _eggHolderDesc.

Referenced by fDesc().

```
00348 {
00349     return _eggHolderDesc;
00350 }
```

4.3.2.11 fDesc()

```
const char * mfunc::fDesc (
            unsigned int f )
```

Returns a function's description Returns a C-string description for the given function id if the id is valid. Otherwise returns null.

Parameters

f	Function id to retrieve the description for

Returns

A C-string containing the function description if id is valid, otherwise null.

Definition at line 723 of file mfunc.cpp.

References ackleysOneDesc(), ackleysTwoDesc(), alpineDesc(), dejongDesc(), eggHolderDesc(), griewangk↩Desc(), levyDesc(), mastersCosineWaveDesc(), michalewiczDesc(), pathologicalDesc(), quarticDesc(), ranaDesc(), rastriginDesc(), rosenbrokDesc(), schwefelDesc(), sineEnvelopeSineWaveDesc(), stepDesc(), and stretchedV↩SineWaveDesc().

Referenced by cs471::mfuncExperiment::runAllFunc().

```
00724 {
00725     switch (f)
00726     {
00727         case 1:
00728             return schwefelDesc();
00729         case 2:
00730             return dejongDesc();
00731         case 3:
00732             return rosenbrokDesc();
00733         case 4:
00734             return rastriginDesc();
00735         case 5:
00736             return griewangkDesc();
00737         case 6:
00738             return sineEnvelopeSineWaveDesc();
00739         case 7:
00740             return stretchedVSineWaveDesc();
00741         case 8:
00742             return ackleysOneDesc();
00743         case 9:
00744             return ackleysTwoDesc();
00745         case 10:
00746             return eggHolderDesc();
00747         case 11:
00748             return ranaDesc();
00749         case 12:
00750             return pathologicalDesc();
00751         case 13:
00752             return michalewiczDesc();
00753         case 14:
00754             return mastersCosineWaveDesc();
00755         case 15:
00756             return quarticDesc();
00757         case 16:
00758             return levyDesc();
00759         case 17:
00760             return stepDesc();
00761         case 18:
00762             return alpineDesc();
00763         default:
00764             return NULL;
00765     }
00766 }
```

4.3.2.12 fExec()

```
bool mfunc::fExec (
            unsigned int f,
            double * v,
            size_t n,
            double & outResult )
```

Executes a specific function Executes the function with the given id and returns true on success. Otherwise returns false if id is invalid.

Parameters

f	Function id to execute
v	Vector as a double array
n	Size of the vector 'v'
outResult	Output reference variable for the result of the mathematical function

Returns

true if 'f' is a valid id and the function was ran. Otherwise false.

Definition at line 651 of file mfunc.cpp.

References ackleysOne(), ackleysTwo(), alpine(), dejong(), eggHolder(), griewangk(), levy(), mastersCosineWave(), michalewicz(), pathological(), quartic(), rana(), rastrigin(), rosenbrok(), schwefel(), sineEnvelopeSineWave(), step(), and stretchedVSineWave().

Referenced by cs471::mfuncExperiment::runFunc().

```
00652 {
00653     switch (f)
00654     {
00655         case 1:
00656             outResult = schwefel(v, n);
00657             return true;
00658         case 2:
00659             outResult = dejong(v, n);
00660             return true;
00661         case 3:
00662             outResult = rosenbrok(v, n);
00663             return true;
00664         case 4:
00665             outResult = rastrigin(v, n);
00666             return true;
00667         case 5:
00668             outResult = griewangk(v, n);
00669             return true;
00670         case 6:
00671             outResult = sineEnvelopeSineWave(v, n);
00672             return true;
00673         case 7:
00674             outResult = stretchedVSineWave(v, n);
00675             return true;
00676         case 8:
00677             outResult = ackleysOne(v, n);
00678             return true;
00679         case 9:
00680             outResult = ackleysTwo(v, n);
00681             return true;
00682         case 10:
00683             outResult = eggHolder(v, n);
00684             return true;
00685         case 11:
00686             outResult = rana(v, n);
00687             return true;
00688         case 12:
00689             outResult = pathological(v, n);
00690             return true;
00691         case 13:
00692             outResult = michalewicz(v, n);
00693             return true;
00694         case 14:
00695             outResult = mastersCosineWave(v, n);
00696             return true;
00697         case 15:
00698             outResult = quartic(v, n);
00699             return true;
00700         case 16:
00701             outResult = levy(v, n);
00702             return true;
00703         case 17:
00704             outResult = step(v, n);
00705             return true;
00706         case 18:
```

```
00707             outResult = alpine(v, n);
00708             return true;
00709         default:
00710             return false;
00711     }
00712 }
```

4.3.2.13 griewangk()

```
double mfunc::griewangk (
            double * v,
            size_t n )
```

Function 5. Implementation of the Griewangk mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 192 of file mfunc.cpp.

Referenced by fExec().

```
00193 {
00194     double sum = 0.0;
00195     double product = 0.0;
00196 
00197     for (size_t i = 0; i < n; i++)
00198     {
00199         sum += (v[i] * v[i]) / 4000.0;
00200     }
00201 
00202     for (size_t i = 0; i < n; i++)
00203     {
00204         product *= cos(v[i] / sqrt(i + 1.0));
00205     }
00206 
00207     return 1.0 + sum - product;
00208 }
```

4.3.2.14 griewangkDesc()

```
const char * mfunc::griewangkDesc ( )
```

Returns a string description of the griewangk() function

Returns

C-string description

Definition at line 180 of file mfunc.cpp.

References _griewangkDesc.

Referenced by fDesc().

```
00181 {
00182     return _griewangkDesc;
00183 }
```

4.3.2.15 levy()

```
double mfunc::levy (
            double * v,
            size_t n )
```

Function 16. Implementation of the Levy mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 557 of file mfunc.cpp.

References w().

Referenced by fExec().

```
00558 {
00559     double f = 0.0;
00560
00561     for (size_t i = 0; i < n - 1; i++)
00562     {
00563         double a = w(v[i]) - 1.0;
00564         a *= a;
00565         double b = sin(M_PI * w(v[i]) + 1.0);
00566         b *= b;
00567         double c = w(v[n - 1]) - 1.0;
00568         c *= c;
00569         double d = sin(2.0 * M_PI * w(v[n - 1]));
00570         d *= d;
00571         f += a * (1.0 + 10.0 * b) + c * (1.0 + d);
00572     }
00573
00574     double e = sin(M_PI * w(v[0]));
00575     return e*e + f;
00576 }
```

4.3.2.16 levyDesc()

```
const char * mfunc::levyDesc ( )
```

Returns a string description of the levy() function

Returns

C-string description

Definition at line 545 of file mfunc.cpp.

References _levyDesc.

Referenced by fDesc().

```
00546 {
00547     return _levyDesc;
00548 }
```

4.3.2.17 mastersCosineWave()

```
double mfunc::mastersCosineWave (
            double * v,
            size_t n )
```

Function 14. Implementation of the Masters Cosine Wave mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 487 of file mfunc.cpp.

Referenced by fExec().

```
00488 {
00489     double f = 0.0;
00490
00491     for (size_t i = 0; i < n - 1; i++)
00492     {
00493         double a = pow(M_E, (-1.0/8.0)*(v[i]*v[i] + v[i+1]*v[i+1] + 0.5*v[i+1]*v[i]));
00494         double b = cos(4 * sqrt(v[i]*v[i] + v[i+1]*v[i+1] + 0.5*v[i]*v[i+1]));
00495         f += a * b;
00496     }
00497
00498     return -1.0 * f;
00499 }
```

4.3.2.18 mastersCosineWaveDesc()

```
const char * mfunc::mastersCosineWaveDesc ( )
```

Returns a string description of the mastersCosineWave() function

Returns

C-string description

Definition at line 475 of file mfunc.cpp.

References _mastersCosineWaveDesc.

Referenced by fDesc().

```
00476 {
00477     return _mastersCosineWaveDesc;
00478 }
```

4.3.2.19 michalewicz()

```
double mfunc::michalewicz (
            double * v,
            size_t n )
```

Function 13. Implementation of the Michalewicz mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 457 of file mfunc.cpp.

Referenced by fExec().

```
00458 {
00459     double f = 0.0;
00460
00461     for (size_t i = 0; i < n; i++)
00462     {
00463         f += sin(v[i]) * pow(sin(((i+1) * v[i] * v[i]) / M_PI), 20);
00464     }
00465
00466     return -1.0 * f;
00467 }
```

4.3.2.20 michalewiczDesc()

```
const char * mfunc::michalewiczDesc ( )
```

Returns a string description of the michalewicz() function

Returns

C-string description

Definition at line 445 of file mfunc.cpp.

References _michalewiczDesc.

Referenced by fDesc().

```
00446 {
00447     return _michalewiczDesc;
00448 }
```

4.3.2.21 pathological()

```
double mfunc::pathological (
            double * v,
            size_t n )
```

Function 12. Implementation of the Pathological mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 423 of file mfunc.cpp.

Referenced by fExec().

```
00424 {
00425     double f = 0.0;
00426
00427     for (size_t i = 0; i < n - 1; i++)
00428     {
00429         double a = sin(sqrt(100.0*v[i]*v[i] + v[i+1]*v[i+1]));
00430         a = (a*a) - 0.5;
00431         double b = (v[i]*v[i] - 2*v[i]*v[i+1] + v[i+1]*v[i+1]);
00432         b = 1.0 + 0.001 * b*b;
00433         f += 0.5 + (a/b);
00434     }
00435
00436     return f;
00437 }
```

4.3.2.22 pathologicalDesc()

```
const char * mfunc::pathologicalDesc ( )
```

Returns a string description of the pathological() function

Returns

C-string description

Definition at line 411 of file mfunc.cpp.

References _pathologicalDesc.

Referenced by fDesc().

```
00412 {
00413     return _pathologicalDesc;
00414 }
```

4.3.2.23 quartic()

```
double mfunc::quartic (
            double * v,
            size_t n )
```

Function 15. Implementation of the Quartic mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 519 of file mfunc.cpp.

Referenced by fExec().

```
00520 {
00521     double f = 0.0;
00522
00523     for (size_t i = 0; i < n; i++)
00524     {
00525         f += (i+1) * v[i] * v[i] * v[i] * v[i];
00526     }
00527
00528     return f;
00529 }
```

4.3.2.24 quarticDesc()

```
const char * mfunc::quarticDesc ( )
```

Returns a string description of the quartic() function

Returns

C-string description

Definition at line 507 of file mfunc.cpp.

References _quarticDesc.

Referenced by fDesc().

```
00508 {
00509     return _quarticDesc;
00510 }
```

4.3.2.25 rana()

```
double mfunc::rana (
            double * v,
            size_t n )
```

Function 11. Implementation of the Rana mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 391 of file mfunc.cpp.

Referenced by fExec().

```
00392 {
00393     double f = 0.0;
00394
00395     for (size_t i = 0; i < n - 1; i++)
00396     {
00397         double a = v[i] * sin(sqrt(fabs(v[i+1] - v[i] + 1.0))) * cos(sqrt(fabs(v[i+1] + v[i] + 1.0)));
00398         double b = (v[i+1] + 1.0) * cos(sqrt(fabs(v[i+1] - v[i] + 1.0))) * sin(sqrt(fabs(v[i+1] + v[i] + 1.
      0)));
00399         f += a + b;
00400     }
00401
00402     return f;
00403 }
```

4.3.2.26 ranaDesc()

```
const char * mfunc::ranaDesc ( )
```

Returns a string description of the rana() function

Returns

C-string description

Definition at line 379 of file mfunc.cpp.

References _ranaDesc.

Referenced by fDesc().

```
00380 {
00381     return _ranaDesc;
00382 }
```

4.3.2.27 rastrigin()

```
double mfunc::rastrigin (
            double * v,
            size_t n )
```

Function 4. Implementation of the Rastrigin mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 162 of file mfunc.cpp.

Referenced by fExec().

```
00163 {
00164     double f = 0.0;
00165
00166     for (size_t i = 0; i < n; i++)
00167     {
00168         f += (v[i] * v[i]) - (10.0 * cos(2.0 * M_PI * v[i]));
00169     }
00170
00171     return 10.0 * n * f;
00172 }
```

4.3.2.28 rastriginDesc()

```
const char * mfunc::rastriginDesc ( )
```

Returns a string description of the rastrigin() function

Returns

C-string description

Definition at line 150 of file mfunc.cpp.

References _rastriginDesc.

Referenced by fDesc().

```
00151 {
00152     return _rastriginDesc;
00153 }
```

4.3.2.29 rosenbrok()

```
double mfunc::rosenbrok (
            double * v,
            size_t n )
```

Function 3. Implementation of the Rosenbrock mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 129 of file mfunc.cpp.

Referenced by fExec().

```
00130 {
00131     double f = 0.0;
00132
00133     for (size_t i = 0; i < n - 1; i++)
00134     {
00135         double a = ((v[i] * v[i]) - v[i+1]);
00136         double b = (1.0 - v[i]);
00137         f += 100.0 * a * a;
00138         f += b * b;
00139     }
00140
00141     return f;
00142 }
```

4.3.2.30 rosenbrokDesc()

```
const char * mfunc::rosenbrokDesc ( )
```

Returns a string description of the rosenbrok() function

Returns

C-string description

Definition at line 117 of file mfunc.cpp.

References _rosenbrokDesc.

Referenced by fDesc().

```
00118 {
00119     return _rosenbrokDesc;
00120 }
```

4.3.2.31 schwefel()

```
double mfunc::schwefel (
            double * v,
            size_t n )
```

Function 1. Implementation of Schwefel's mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 69 of file mfunc.cpp.

Referenced by fExec().

```
00070 {
00071     double f = 0.0;
00072
00073     for (size_t i = 0; i < n; i++)
00074     {
00075         f += (-1.0 * v[i]) * sin(sqrt(fabs(v[i])));
00076     }
00077
00078     return (418.9829 * n) - f;
00079 }
```

4.3.2.32 schwefelDesc()

```
const char * mfunc::schwefelDesc ( )
```

Returns a string description of the schwefel() function

Returns

C-string description

Definition at line 57 of file mfunc.cpp.

References _schwefelDesc.

Referenced by fDesc().

```
00058 {
00059     return _schwefelDesc;
00060 }
```

4.3.2.33 sineEnvelopeSineWave()

```
double mfunc::sineEnvelopeSineWave (
            double * v,
            size_t n )
```

Function 6. Implementation of the Sine Envelope Sine Wave mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 228 of file mfunc.cpp.

Referenced by fExec().

```
00229 {
00230     double f = 0.0;
00231
00232     for (size_t i = 0; i < n - 1; i++)
00233     {
00234         double a = sin(v[i]*v[i] + v[i+1]*v[i+1] - 0.5);
00235         a *= a;
00236         double b = (1 + 0.001*(v[i]*v[i] + v[i+1]*v[i+1]));
00237         b *= b;
00238         f += 0.5 + (a / b);
00239     }
00240
00241     return -1.0 * f;
00242 }
```

4.3.2.34 sineEnvelopeSineWaveDesc()

```
const char * mfunc::sineEnvelopeSineWaveDesc ( )
```

Returns a string description of the sineEnvelopeSineWave() function

Returns

C-string description

Definition at line 216 of file mfunc.cpp.

References _sineEnvelopeSineWaveDesc.

Referenced by fDesc().

```
00217 {
00218     return _sineEnvelopeSineWaveDesc;
00219 }
```

4.3.2.35 step()

```
double mfunc::step (
            double * v,
            size_t n )
```

Function 17. Implementation of the Step mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 596 of file mfunc.cpp.

Referenced by fExec().

```
00597 {
00598     double f = 0.0;
00599
00600     for (size_t i = 0; i < n; i++)
00601     {
00602         double a = fabs(v[i]) + 0.5;
00603         f += a * a;
00604     }
00605
00606     return f;
00607 }
```

4.3.2.36 stepDesc()

```
const char * mfunc::stepDesc ( )
```

Returns a string description of the step() function

Returns

C-string description

Definition at line 584 of file mfunc.cpp.

References _stepDesc.

Referenced by fDesc().

```
00585 {
00586     return _stepDesc;
00587 }
```

4.3.2.37 stretchedVSineWave()

```
double mfunc::stretchedVSineWave (
            double * v,
            size_t n )
```

Function 7. Implementation of the Stretched V Sine Wave mathematical function.

Parameters

v	Vector as a double array
n	Size of the vector 'v'

Returns

The result of the mathematical function

Definition at line 262 of file mfunc.cpp.

References nthroot().

Referenced by fExec().

```
00263 {
00264     double f = 0.0;
00265
00266     for (size_t i = 0; i < n - 1; i++)
00267     {
00268         double a = nthroot(v[i]*v[i] + v[i+1]*v[i+1], 4.0);
00269         double b = sin(50.0 * nthroot(v[i]*v[i] + v[i+1]*v[i+1], 10.0));
00270         b *= b;
00271         f += a * b + 1.0;
00272     }
00273
00274     return f;
00275 }
```

4.3.2.38 stretchedVSineWaveDesc()

```
const char * mfunc::stretchedVSineWaveDesc ( )
```

Returns a string description of the stretchedVSineWave() function

Returns

C-string description

Definition at line 250 of file mfunc.cpp.

References _stretchedVSineWaveDesc.

Referenced by fDesc().

```
00251 {
00252     return _stretchedVSineWaveDesc;
00253 }
```

4.3.3 Variable Documentation

4.3.3.1 NUM_FUNCTIONS

```
const unsigned int mfunc::NUM_FUNCTIONS = 18
```

Constant value for the total number of math functions contained in this namespace

Definition at line 49 of file mfunc.cpp.

Referenced by cs471::mfuncExperiment::runAllFunc(), and cs471::mfuncExperiment::runFunc().

4.4 util Namespace Reference

Classes

- class IniReader

  *The IniReader class is a simple *.ini file reader and parser.*

Functions

- template<class T = double>
  void initArray (T *a, size_t size, T val)

  Initializes an array with some set value.
- template<class T = double>
  void initMatrix (T **m, size_t rows, size_t cols, T val)

  Initializes a matrix with a set value for each entry.
- template<class T = double>
  void releaseArray (T *&a)

  Releases an allocated array's memory and sets the pointer to nullptr.
- template<class T = double>
  void releaseMatrix (T **&m, size_t rows)

  Releases an allocated matrix's memory and sets the pointer to nullptr.
- template<class T = double>
  T * allocArray (size_t size)

  Allocates a new array of the given data type.
- template<class T = double>
  T ** allocMatrix (size_t rows, size_t cols)

  Allocates a new matrix of the given data type.

4.4.1 Function Documentation

4.4.1.1 allocArray()

```
template<class T = double>
T* util::allocArray (
            size_t size )  [inline]
```

Allocates a new array of the given data type.

Template Parameters

Data	type of the array

Parameters

size	Number of elements in the array

Returns

Returns a pointer to the new array, or nullptr allocation fails

Definition at line 105 of file mem.h.

```
00106     {
00107         return new(std::nothrow) T[size];
00108     }
```

4.4.1.2 allocMatrix()

```
template<class T = double>
T** util::allocMatrix (
            size_t rows,
            size_t cols )  [inline]
```

Allocates a new matrix of the given data type.

Template Parameters

Data	type of the matrix entries

Parameters

rows	The number of rows
cols	The number of columns

Returns

Returns a pointer to the new matrix, or nullptr if allocation fails

Definition at line 119 of file mem.h.

```
00120     {
00121         T** m = (T**)allocArray<T*>(rows);
00122         if (m == nullptr) return nullptr;
00123 
00124         for (size_t i = 0; i < rows; i++)
00125         {
00126             m[i] = allocArray<T>(cols);
00127             if (m[i] == nullptr)
00128             {
00129                 releaseMatrix<T>(m, rows);
00130                 return nullptr;
00131             }
00132         }
00133 
00134         return m;
00135     }
```

4.4.1.3 initArray()

```
template<class T = double>
void util::initArray (
            T * a,
            size_t size,
            T val )  [inline]
```

Initializes an array with some set value.

Template Parameters

Data	type of array

Parameters

a	Pointer to array
size	Size of the array
val	Value to initialize the array to

Definition at line 26 of file mem.h.

Referenced by initMatrix().

```
00027     {
00028         if (a == nullptr) return;
00029
00030         for (size_t i = 0; i < size; i++)
00031         {
00032             a[i] = val;
00033         }
00034     }
```

4.4.1.4 initMatrix()

```
template<class T = double>
void util::initMatrix (
            T ** m,
            size_t rows,
            size_t cols,
            T val )  [inline]
```

Initializes a matrix with a set value for each entry.

Template Parameters

Data	type of matrix entries

Parameters

m	Pointer to a matrix
rows	Number of rows in matrix
cols	Number of columns in matrix
val	Value to initialize the matrix to

Definition at line 46 of file mem.h.

References initArray().

```
00047     {
00048         if (m == nullptr) return;
00049
00050         for (size_t i = 0; i < rows; i++)
00051         {
00052             initArray(m[i], cols, val);
00053         }
00054     }
```

4.4.1.5 releaseArray()

```
template<class T = double>
void util::releaseArray (
              T *& a )
```

Releases an allocated array's memory and sets the pointer to nullptr.

Template Parameters

Data	type of array

Parameters

a	Pointer to array

Definition at line 63 of file mem.h.

```
00064     {
00065         if (a == nullptr) return;
00066
00067         delete[] a;
00068         a = nullptr;
00069     }
```

4.4.1.6 releaseMatrix()

```
template<class T = double>
void util::releaseMatrix (
              T **& m,
              size_t rows )
```

Releases an allocated matrix's memory and sets the pointer to nullptr.

Template Parameters

Data	type of the matrix

Parameters

m	Pointer th the matrix
rows	The number of rows in the matrix

Definition at line 79 of file mem.h.

```
00080     {
00081         if (m == nullptr) return;
00082
00083         for (size_t i = 0; i < rows; i++)
```

```
00084         {
00085             if (m[i] != nullptr)
00086             {
00087                 // Release each row
00088                 releaseArray<T>(m[i]);
00089             }
00090         }
00091 
00092         // Release columns
00093         delete[] m;
00094         m = nullptr;
00095     }
```

Chapter 5

Class Documentation

5.1 mdata::DataTable Class Reference

The DataTable class is a simple table of values with labeled columns.

`#include <datatable.h>`

Public Member Functions

- DataTable (unsigned int cols)

  Constructs a new DataTable object with a specified number of columns.
- ~DataTable ()

  Destroys the DataTable object.
- std::string getColLabel (unsigned int colIndex)

  Returns the label for the column at the specified index. The first column = index 0.
- bool setColLabel (unsigned int colIndex, std::string newLabel)

  Sets the label for the column at the specified index. The first column = index 0.
- unsigned int addRow ()

  Adds a new row to the end of the table.
- unsigned int addRow (const std::vector< std::string > &rowData)

  Adds a new row to the end of the table and fills the row with the data given in the vector of strings rowData.
- std::vector< std::string > & getRow (unsigned int row)

  Returns a reference to the string vector that contains the entries for the given row index.
- void setRow (unsigned int row, const std::vector< std::string > &rowData)

  Sets the data entries for the row at the given index.
- std::string getEntry (unsigned int row, unsigned int col)

  Returns the string value of the entry at the given row and column indices.
- void setEntry (unsigned int row, unsigned int col, std::string val)

  Sets the value of the entry at the given row and column indices.
- void setEntry (unsigned int row, unsigned int col, int val)

  Sets the value of the entry at the given row and column indices.
- void setEntry (unsigned int row, unsigned int col, long val)

  Sets the value of the entry at the given row and column indices.
- void setEntry (unsigned int row, unsigned int col, float val)

  Sets the value of the entry at the given row and column indices.
- void setEntry (unsigned int row, unsigned int col, double val)

  Sets the value of the entry at the given row and column indices.
- bool exportCSV (const char *filePath)

  *Exports the current data table to the given file path in the *.csv format. If the file already exists, it is replaced.*

Protected Attributes

- unsigned int cols
- unsigned int rows
- std::vector< std::string > colLabels
- std::map< unsigned int, std::vector< std::string > > tableData

5.1.1 Detailed Description

The DataTable class is a simple table of values with labeled columns.

– Initialize a DataTable object with a specified number of columns: DataTable table(n);

Set a column's label:

table.setColLabel(0, "Column 1");

Add a row to the table: int rowIndex = table.addRow();

or

int rowIndex = table.addRow((std::vector<std::string>)dataVector);

Set an entry in the table:

table.setEntry(n, m, value);

Where 'n' is the row, 'm' is the column, and 'value' is the value of the entry

Export the table to a *.csv file:

bool success = table.exportCSV("my_file.csv");

Definition at line 55 of file datatable.h.

5.1.2 Constructor & Destructor Documentation

5.1.2.1 DataTable()

```
DataTable::DataTable (
            unsigned int columns )
```

Constructs a new DataTable object with a specified number of columns.

Parameters

columns	The number of columns to be created for the table

Definition at line 24 of file datatable.cpp.

References colLabels, and cols.

```
00024                                          : rows(0), cols(columns),
      colLabels(columns)
00025 {
00026     for (int i = 0; i < cols; i++)
00027     {
00028         colLabels.push_back("(No label)");
00029     }
00030 }
```

5.1.2.2 ~DataTable()

```
DataTable::~DataTable ( )
```

Destroys the DataTable object.

Definition at line 35 of file datatable.cpp.

References colLabels, and tableData.

```
00036 {
00037     colLabels.clear();
00038     tableData.clear();
00039 }
```

5.1.3 Member Function Documentation

5.1.3.1 addRow() [1/2]

```
unsigned int DataTable::addRow ( )
```

Adds a new row to the end of the table.

Returns

The index of the newly added row

Definition at line 77 of file datatable.cpp.

References cols, rows, and tableData.

Referenced by cs471::mfuncExperiment::runAllFunc().

```
00078 {
00079     unsigned int newRowIndex = rows;
00080     rows++;
00081
00082     auto& tableRow = tableData[newRowIndex];
00083     tableRow.clear();
00084
00085     for (int i = 0; i < cols; i++)
00086     {
00087         tableRow.push_back("");
00088     }
00089
00090     return newRowIndex;
00091 }
```

5.1.3.2 addRow() [2/2]

```
unsigned int DataTable::addRow (
            const std::vector< std::string > & rowData )
```

Adds a new row to the end of the table and fills the row with the data given in the vector of strings rowData.

Parameters

rowData	Vector of strings to be entered into the table. rowData[n] = Column[n]

Returns

The index of the newly added row

Definition at line 100 of file datatable.cpp.

References rows, and setRow().

```
00101 {
00102     unsigned int newRowIndex = rows;
00103     rows++;
00104     setRow(newRowIndex, rowData);
00105
00106     return newRowIndex;
00107 }
```

5.1.3.3 exportCSV()

```
bool DataTable::exportCSV (
            const char * filePath )
```

Exports the current data table to the given file path in the ∗.csv format. If the file already exists, it is replaced.

Parameters

filePath	File path to be exported to

Returns

Returns true if the file was succesfully exported. Otherwise false.

Definition at line 230 of file datatable.cpp.

References colLabels, cols, rows, and tableData.

Referenced by cs471::mfuncExperiment::runAllFunc().

```
00231 {
00232     using namespace std;
00233
00234     ofstream outFile;
00235     outFile.open(filePath, ofstream::out | ofstream::trunc);
00236     if (!outFile.good()) return false;
00237
00238     // Print column labels
00239     for (unsigned int c = 0; c < cols; c++)
00240     {
00241         outFile << colLabels[c];
00242         if (c < cols - 1) outFile << ",";
00243     }
00244
00245     outFile << endl;
00246
00247     // Print data rows
00248     for (unsigned int r = 0; r < rows; r++)
00249     {
00250         for (unsigned int c = 0; c < cols; c++)
00251         {
00252             outFile << tableData[r][c];
00253             if (c < cols - 1) outFile << ",";
00254         }
00255         outFile << endl;
00256     }
00257
00258     outFile.close();
00259     return true;
00260 }
```

5.1.3.4 getColLabel()

```
std::string DataTable::getColLabel (
              unsigned int colIndex )
```

Returns the label for the column at the specified index. The first column = index 0.

Parameters

colIndex	Column index

Returns

A std::string containing the column label

Definition at line 48 of file datatable.cpp.

References colLabels, and cols.

```
00049 {
00050     if (colIndex >= cols) throw "Invalid Column Index";
00051
00052     return colLabels[colIndex];
00053 }
```

5.1.3.5 getEntry()

```
std::string DataTable::getEntry (
              unsigned int row,
              unsigned int col )
```

Returns the string value of the entry at the given row and column indices.

Parameters

row	Index of the row you wish to access
col	Index of the column you wish to access

Returns

The value of the given row and column. Throws a string exception of the row or column is out of bounds.

Definition at line 154 of file datatable.cpp.

References cols, rows, and tableData.

```
00155 {
00156     if (row >= rows || col >= cols) throw "Invalid row/column";
00157
00158     return tableData[row][col];
00159 }
```

5.1.3.6 getRow()

```
std::vector< std::string > & DataTable::getRow (
            unsigned int row )
```

Returns a reference to the string vector that contains the entries for the given row index.

Parameters

row	Index of the row that you wish to access.

Returns

std::vector<std::string>&

Definition at line 116 of file datatable.cpp.

References rows, and tableData.

```
00117 {
00118     if (row >= rows) throw "Invalid row index";
00119
00120     return tableData[row];
00121 }
```

5.1.3.7 setColLabel()

```
bool DataTable::setColLabel (
            unsigned int colIndex,
            std::string newLabel )
```

Sets the label for the column at the specified index. The first column = index 0.

Parameters

colIndex	Column index
newLabel	std::string containing the new column label

Returns

true If the column label was succesfully changed.
false If the column index was invalid.

Definition at line 64 of file datatable.cpp.

References colLabels, and cols.

Referenced by cs471::mfuncExperiment::runAllFunc().

```
00065 {
00066     if (colIndex >= cols) return false;
00067
00068     colLabels[colIndex] = newLabel;
00069     return true;
00070 }
```

5.1.3.8 setEntry() [1/5]

```
void DataTable::setEntry (
            unsigned int row,
            unsigned int col,
            std::string val )
```

Sets the value of the entry at the given row and column indices.

Parameters

row	Index of the row you wish to access
col	Index of the column you wish to access
val	The new value for the entry

Definition at line 168 of file datatable.cpp.

References cols, rows, and tableData.

Referenced by cs471::mfuncExperiment::runAllFunc(), and setEntry().

```
00169 {
00170     if (row >= rows || col >= cols) throw "Invalid row/column";
00171
00172     tableData[row][col] = val;
00173 }
```

5.1.3.9 setEntry() [2/5]

```
void DataTable::setEntry (
            unsigned int row,
            unsigned int col,
            int val )
```

Sets the value of the entry at the given row and column indices.

Parameters

row	Index of the row you wish to access
col	Index of the column you wish to access
val	The new value for the entry

Definition at line 182 of file datatable.cpp.

References setEntry().

```
00183 {
00184     setEntry(row, col, std::to_string(val));
00185 }
```

5.1.3.10 setEntry() [3/5]

```
void DataTable::setEntry (
            unsigned int row,
            unsigned int col,
            long val )
```

Sets the value of the entry at the given row and column indices.

Parameters

row	Index of the row you wish to access
col	Index of the column you wish to access
val	The new value for the entry

Definition at line 194 of file datatable.cpp.

References setEntry().

```
00195 {
00196     setEntry(row, col, std::to_string(val));
00197 }
```

5.1.3.11 setEntry() [4/5]

```
void DataTable::setEntry (
            unsigned int row,
            unsigned int col,
            float val )
```

Sets the value of the entry at the given row and column indices.

Parameters

row	Index of the row you wish to access
col	Index of the column you wish to access
val	The new value for the entry

Definition at line 206 of file datatable.cpp.

References setEntry().

```
00207 {
00208     setEntry(row, col, std::to_string(val));
00209 }
```

5.1.3.12 setEntry() [5/5]

```
void DataTable::setEntry (
            unsigned int row,
            unsigned int col,
            double val )
```

Sets the value of the entry at the given row and column indices.

Parameters

row	Index of the row you wish to access
col	Index of the column you wish to access
val	The new value for the entry

Definition at line 218 of file datatable.cpp.

References setEntry().

```
00219 {
00220     setEntry(row, col, std::to_string(val));
00221 }
```

5.1.3.13 setRow()

```
void DataTable::setRow (
            unsigned int row,
            const std::vector< std::string > & rowData )
```

Sets the data entries for the row at the given index.

Parameters

row	Index of the row that you wish to update.
rowData	Vector of strings that contain the new row data entries.

Definition at line 129 of file datatable.cpp.

References cols, rows, and tableData.

Referenced by addRow().

```
00130 {
00131     if (row >= rows) throw "Invalid row index";
00132
00133     auto& tableRow = tableData[row];
00134     tableRow.clear();
00135
00136     for (unsigned int i = 0; i < cols; i++)
00137     {
00138         if (i < rowData.size())
00139             tableRow.push_back(rowData[i]);
00140         else
00141             tableRow.push_back("(No data)");
00142     }
00143 }
```

5.1.4 Member Data Documentation

5.1.4.1 colLabels

```
std::vector<std::string> mdata::DataTable::colLabels  [protected]
```

Number of rows in the table.

Definition at line 80 of file datatable.h.

Referenced by DataTable(), exportCSV(), getColLabel(), setColLabel(), and ~DataTable().

5.1.4.2 cols

```
unsigned int mdata::DataTable::cols  [protected]
```

Definition at line 78 of file datatable.h.

Referenced by addRow(), DataTable(), exportCSV(), getColLabel(), getEntry(), setColLabel(), setEntry(), and setRow().

5.1.4.3 rows

```
unsigned int mdata::DataTable::rows  [protected]
```

Number of columns in the table.

Definition at line 79 of file datatable.h.

Referenced by addRow(), exportCSV(), getEntry(), getRow(), setEntry(), and setRow().

5.1.4.4 tableData

```
std::map<unsigned int, std::vector<std::string> > mdata::DataTable::tableData  [protected]
```

Vector of column labels. Index n = Col n.

Definition at line 81 of file datatable.h.

Referenced by addRow(), exportCSV(), getEntry(), getRow(), setEntry(), setRow(), and ~DataTable().

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

- include/datatable.h
- src/datatable.cpp

5.2 util::IniReader Class Reference

The IniReader class is a simple *.ini file reader and parser.

```
#include <inireader.h>
```

Public Member Functions

- IniReader ()
  Construct a new IniReader object.
- ~IniReader ()
  Destroys the IniReader object.
- bool openFile (std::string filePath)
  Opens the given ini file and parses all sections/entries. The all file data is stored in memory and the file is closed.
- bool sectionExists (std::string section)
  Returns true if the given section exists in the current ini file.
- bool entryExists (std::string section, std::string entry)
  Returns true if the given section and entry key exists in the current ini file.
- std::string getEntry (std::string section, std::string entry)
  Returns the value for the entry that has the given entry key within the given section.

Protected Member Functions

- bool parseFile ()

  Protected helper function that is called by IniReader::openFile(). Parses the complete ini file and stores all sections and entries in memory.
- void parseEntry (const std::string &sectionName, const std::string &entry)

  Protected helper function that is called by IniReader::parseFile(). Parses a single entry by extracting the key and value.

Protected Attributes

- std::string file
- std::map< std::string, std::map< std::string, std::string > > iniMap

5.2.1 Detailed Description

The IniReader class is a simple *.ini file reader and parser.

– Initialize an IniReader object:

IniReader ini;

Open and parse an *.ini file:

ini.openFile("my_ini_file.ini");

Note that the file is immediately closed after parsing, and the file data is retained in memory.

Retrieve an entry from the ini file:

std::string value = ini.getEntry("My Section", "entryKey");

Definition at line 45 of file inireader.h.

5.2.2 Constructor & Destructor Documentation

5.2.2.1 IniReader()

```
IniReader::IniReader ( )
```

Construct a new IniReader object.

Definition at line 21 of file inireader.cpp.

```
00021                     : file(""), iniMap()
00022 {
00023 }
```

5.2.2.2 ~IniReader()

```
IniReader::~IniReader ( )
```

Destroys the IniReader object.

Definition at line 28 of file inireader.cpp.

References iniMap.

```
00029 {
00030     iniMap.clear();
00031 }
```

5.2.3 Member Function Documentation

5.2.3.1 entryExists()

```
bool IniReader::entryExists (
            std::string section,
            std::string entry )
```

Returns true if the given section and entry key exists in the current ini file.

Parameters

section	std::string containing the section name
entry	std::string containing the entry key name

Returns

Returns true if the section and entry key exist in the ini file, otherwise false.

Definition at line 67 of file inireader.cpp.

References iniMap.

Referenced by getEntry().

```
00068 {
00069     auto it = iniMap.find(section);
00070     if (it == iniMap.end()) return false;
00071
00072     return it->second.find(entry) != it->second.end();
00073 }
```

5.2.3.2 getEntry()

```
std::string IniReader::getEntry (
            std::string section,
            std::string entry )
```

Returns the value for the entry that has the given entry key within the given section.

Parameters

section	std::string containing the section name
entry	std::string containing the entry key name

Returns

The value of the entry with the given entry key and section. Returns an empty string if the entry does not exist.

Definition at line 84 of file inireader.cpp.

References entryExists(), and iniMap.

Referenced by cs471::mfuncExperiment::init(), and cs471::mfuncExperiment::runFunc().

```
00085 {
00086     if (!entryExists(section, entry)) return std::string();
00087
00088     return iniMap[section][entry];
00089 }
```

5.2.3.3 openFile()

```
bool IniReader::openFile (
            std::string filePath )
```

Opens the given ini file and parses all sections/entries. The all file data is stored in memory and the file is closed.

Parameters

filePath	Path to the ini file you wish to open

Returns

Returns true if the file was succesfully opened and parsed. Otherwise false.

Definition at line 40 of file inireader.cpp.

References file, and parseFile().

Referenced by cs471::mfuncExperiment::init().

```
00041 {
00042     file = filePath;
00043     if (!parseFile())
00044         return false;
00045
00046     return true;
00047 }
```

5.2.3.4 parseEntry()

```
void IniReader::parseEntry (
            const std::string & sectionName,
            const std::string & entry )  [protected]
```

Protected helper function that is called by IniReader::parseFile(). Parses a single entry by extracting the key and value.

Definition at line 144 of file inireader.cpp.

References iniMap.

Referenced by parseFile().

```
00145 {
00146     using namespace std;
00147
00148     // Split string around equals sign character
00149     const string delim = "=";
00150     string entryName;
00151     string entryValue;
00152
00153     // Find index of '='
00154     auto delimPos = entry.find(delim);
00155
00156     if (delimPos == string::npos || delimPos >= entry.length() - 1)
00157         return; // '=' is missing, or is last char in string
00158
00159     // Extract entry name/key and value
00160     entryName = entry.substr((size_t)0, delimPos);
00161     entryValue = entry.substr(delimPos + 1, entry.length());
00162
00163     // Remove leading and trailing whitespace
00164     s_trim(entryName);
00165     s_trim(entryValue);
00166
00167     // We cannot have entries with empty keys
00168     if (entryName.empty()) return;
00169
00170     // Add entry to cache
00171     iniMap[sectionName][entryName] = entryValue;
00172 }
```

5.2.3.5 parseFile()

```
bool IniReader::parseFile ( )  [protected]
```

Protected helper function that is called by IniReader::openFile(). Parses the complete ini file and stores all sections and entries in memory.

The parsed ini file data.

Returns

Returns true if the file was succesfully opened and parsed.

Definition at line 97 of file inireader.cpp.

References file, iniMap, and parseEntry().

Referenced by openFile().

```
00098 {
00099     iniMap.clear();
00100
00101     using namespace std;
00102
00103     ifstream inputF(file, ifstream::in);
00104     if (!inputF.good()) return false;
00105
00106     string curSection;
00107     string line;
00108
00109     while (getline(inputF, line))
00110     {
00111         // Trim whitespace on both ends of the line
00112         s_trim(line);
00113
00114         // Ignore empty lines and comments
00115         if (line.empty() || line.front() == '#')
00116         {
00117             continue;
00118         }
00119         else if (line.front() == '[' && line.back() == ']')
00120         {
00121             // Line is a section definition
00122             // Erase brackets and trim to get section name
00123             line.erase(0, 1);
00124             line.erase(line.length() - 1, 1);
00125             s_trim(line);
00126             curSection = line;
00127         }
00128         else if (!curSection.empty())
00129         {
00130             // Line is an entry, parse the key and value
00131             parseEntry(curSection, line);
00132         }
00133     }
00134
00135     // Close input file
00136     inputF.close();
00137     return true;
00138 }
```

5.2.3.6 sectionExists()

```
bool IniReader::sectionExists (
            std::string section )
```

Returns true if the given section exists in the current ini file.

Parameters

section	std::string containing the section name

Returns

Returns true if the section exists in the ini file, otherwise false.

Definition at line 55 of file inireader.cpp.

References iniMap.

```
00056 {
00057     return iniMap.find(section) != iniMap.end();
00058 }
```

5.2.4 Member Data Documentation

5.2.4.1 file

```
std::string util::IniReader::file  [protected]
```

Definition at line 55 of file inireader.h.

Referenced by openFile(), and parseFile().

5.2.4.2 iniMap

```
std::map<std::string, std::map<std::string, std::string> > util::IniReader::iniMap  [protected]
```

The file path for the current ini file data.

Definition at line 56 of file inireader.h.

Referenced by entryExists(), getEntry(), parseEntry(), parseFile(), sectionExists(), and ~IniReader().

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

- include/inireader.h
- src/inireader.cpp

5.3 cs471::mfuncExperiment Class Reference

Contains classes for running the CS471 project experiment.

```
#include <cs471.h>
```

Public Member Functions

- mfuncExperiment ()

  Construct a new mfuncExperiment object.
- ~mfuncExperiment ()

  Destroys the mfuncExperiment object.
- bool init (const char *paramFile)

  Initializes the CS471 project 1 experiment. Opens the given parameter file and extracts test parameters. Allocates memory for function vectors and function bounds. Extracts all function bounds.
- int runAllFunc ()

  *Executes all functions as specified in the CS471 project 1 document, records results, computes statistics, and outputs the data as a *.csv file.*
- int runFunc (unsigned int funcId, double &timeOut)

  Runs the specifed function given by it's function id a certain number of times, records the execution time, and appends all results to the resultArrOut reference vector.

5.3.1 Detailed Description

Contains classes for running the CS471 project experiment.

The mfuncExperiment class opens a given parameter .ini file and executes the CS471 project 1 experiment with the specified parameters. runAllFunc() runs all 18 functions defined in mfunc.cpp a given number of times with vectors of random values that have a given number of dimensions and collects all results/data. This data is then entered into a DataTable and exported as a *.csv file.

Definition at line 47 of file cs471.h.

5.3.2 Constructor & Destructor Documentation

5.3.2.1 mfuncExperiment()

```
mfuncExperiment::mfuncExperiment ( )
```

Construct a new mfuncExperiment object.

Definition at line 28 of file cs471.cpp.

```
00028                                  : population(nullptr), vBounds(nullptr), outputPop(false), outputFitness(
    false)
00029 {
00030 }
```

5.3.2.2 ~mfuncExperiment()

```
mfuncExperiment::~mfuncExperiment ( )
```

Destroys the mfuncExperiment object.

Definition at line 36 of file cs471.cpp.

```
00037 {
00038     releasePopulation();
00039     releaseVBounds();
00040 }
```

5.3.3 Member Function Documentation

5.3.3.1 init()

```
bool mfuncExperiment::init (
            const char * paramFile )
```

Initializes the CS471 project 1 experiment. Opens the given parameter file and extracts test parameters. Allocates memory for function vectors and function bounds. Extracts all function bounds.

Parameters

paramFile	File path to the parameter ini file

Returns

Returns true if initialization was successful. Otherwise false.

Definition at line 50 of file cs471.cpp.

References util::IniReader::getEntry(), and util::IniReader::openFile().

Referenced by main().

```
00051 {
00052     // Open and parse parameters file
00053     if (!iniParams.openFile(paramFile))
00054     {
00055         cerr << "Experiment init failed: Unable to open param file: " << paramFile << endl;
00056         return false;
00057     }
00058
00059     long numberSol;
00060     long numberDim;
00061
00062     // Attempt to parse number of solutions and vector dimensions size
00063     // from iniParams
00064     try
00065     {
00066         std::string entry;
00067
00068         entry = iniParams.getEntry("test", "population");
```

```
00069         if (entry.empty())
00070         {
00071             cerr << "Experiment init failed: Param file missing [test]->population entry: " << paramFile <<
      endl;
00072             return false;
00073         }
00074
00075         numberSol = std::atol(entry.c_str());
00076
00077         entry = iniParams.getEntry("test", "dimensions");
00078         if (entry.empty())
00079         {
00080             cerr << "Experiment init failed: Param file missing [test]->dimensions entry: " << paramFile <<
      endl;
00081             return false;
00082         }
00083
00084         numberDim = std::atol(entry.c_str());
00085
00086         if (numberSol <= 0)
00087         {
00088             cerr << "Experiment init failed: Param file [test]->population entry out of bounds: " <<
     paramFile << endl;
00089             return false;
00090         }
00091
00092         if (numberDim <= 0)
00093         {
00094             cerr << "Experiment init failed: Param file [test]->dimensions entry out of bounds: " <<
     paramFile << endl;
00095             return false;
00096         }
00097     }
00098     catch (const std::exception& ex)
00099     {
00100         cerr << "Experiment init failed: Exception while parsing param file: " << paramFile << endl;
00101         return false;
00102     }
00103
00104     // Get csv output file path
00105     resultsFile = iniParams.getEntry("test", "results_file");
00106     outputPop = iniParams.getEntry("test", "output_population") == "true";
00107     outputFitness = iniParams.getEntry("test", "output_fitness") == "true";
00108
00109     // Allocate memory for vector * solutions matrix
00110     if (!allocatePopulation((size_t)numberSol, (size_t)numberDim))
00111     {
00112         cerr << "Experiment init failed: Unable to allocate population matrix." << endl;
00113         return false;
00114     }
00115
00116     // Allocate memory for function bounds
00117     if (!allocateVBounds())
00118     {
00119         cerr << "Experiment init failed: Unable to allocate vector bounds array." << endl;
00120         return false;
00121     }
00122
00123     // Fill function bounds array with data parsed from iniParams
00124     if (!parseFuncBounds())
00125     {
00126         cerr << "Experiment init failed: Unable to parse vector bounds array." << endl;
00127         return false;
00128     }
00129
00130     return true;
00131 }
```

5.3.3.2 runAllFunc()

```
int mfuncExperiment::runAllFunc ( )
```

Executes all functions as specified in the CS471 project 1 document, records results, computes statistics, and outputs the data as a ∗.csv file.

Returns

Returns 0 on success. Returns a non-zero error code on failure.

Definition at line 140 of file cs471.cpp.

References mdata::DataTable::addRow(), mdata::DataTable::exportCSV(), mfunc::fDesc(), mdata::Population< T >::getDimensionsSize(), mdata::Population< T >::getFitnessAverage(), mdata::Population< T >::getFitnessMedian(), mdata::Population< T >::getFitnessRange(), mdata::Population< T >::getFitnessStandardDev(), mdata::Population< T >::isReady(), mfunc::NUM_FUNCTIONS, mdata::Population< T >::outputFitness(), runFunc(), mdata::DataTable::setColLabel(), and mdata::DataTable::setEntry().

Referenced by main().

```
00141 {
00142     if (population == nullptr || !population->isReady()) return 1;
00143 
00144     // function desc. | average | standard dev. | range | median | time
00145     mdata::DataTable resultsTable(8);
00146     resultsTable.setColLabel(0, "Function");
00147     resultsTable.setColLabel(1, "Vector Min");
00148     resultsTable.setColLabel(2, "Vector Max");
00149     resultsTable.setColLabel(3, "Average");
00150     resultsTable.setColLabel(4, "Standard Deviation");
00151     resultsTable.setColLabel(5, "Range");
00152     resultsTable.setColLabel(6, "Median");
00153     resultsTable.setColLabel(7, "Total Time (ms)");
00154 
00155     double fTime = 0.0;
00156     ofstream fitnessFile;
00157     if (outputFitness)
00158     {
00159         std::string fitFile = "fitness-dim_";
00160         fitFile += to_string(population->getDimensionsSize());
00161         fitFile += ".csv";
00162         fitnessFile.open(fitFile, ios::out | ios::trunc);
00163         if (!fitnessFile.good()) outputFitness = false;
00164     }
00165 
00166     // Execute all functions
00167     for (unsigned int f = 1; f <= mfunc::NUM_FUNCTIONS; f++)
00168     {
00169         int err = runFunc(f, fTime);
00170         if (err)
00171         {
00172             if (outputFitness) fitnessFile.close();
00173             return err;
00174         }
00175         else
00176         {
00177             // Export all population data if flag is set
00178             if (outputPop)
00179                 exportPop(f);
00180 
00181             // Export all fitness data if flag is set
00182             if (outputFitness)
00183             {
00184                 fitnessFile << mfunc::fDesc(f) << ",";
00185                 population->outputFitness(fitnessFile, ",", "\n");
00186             }
00187 
00188             // Insert function results and statistics into the results table as a new row
00189             unsigned int rowIndex = resultsTable.addRow();
00190             resultsTable.setEntry(rowIndex, 0, mfunc::fDesc(f));
00191             resultsTable.setEntry(rowIndex, 1, to_string(vBounds[f-1].min));
00192             resultsTable.setEntry(rowIndex, 2, to_string(vBounds[f-1].max));
00193             resultsTable.setEntry(rowIndex, 3, population->getFitnessAverage());
00194             resultsTable.setEntry(rowIndex, 4, population->getFitnessStandardDev());
00195             resultsTable.setEntry(rowIndex, 5, population->getFitnessRange());
00196             resultsTable.setEntry(rowIndex, 6, population->getFitnessMedian());
00197             resultsTable.setEntry(rowIndex, 7, fTime);
00198         }
00199     }
00200 
00201     if (!resultsFile.empty())
00202     {
00203         // Export results table to a *.csv file
00204         cout << "Exporting results to: " << resultsFile << endl;
00205         resultsTable.exportCSV(resultsFile.c_str());
00206     }
```

```
00207
00208     if (outputFitness) fitnessFile.close();
00209     return 0;
00210 }
```

5.3.3.3 runFunc()

```
int mfuncExperiment::runFunc (
            unsigned int funcId,
            double & timeOut )
```

Runs the specifed function given by it's function id a certain number of times, records the execution time, and appends all results to the resultArrOut reference vector.

Parameters

funcId	The id of the function to run
resultArrOut	Out reference variable that function results are appended to
timeOut	Out reference variable that the execution time in ms is set to.

Returns

Returns 0 on success. Returns a non-zero error code on failure.

Definition at line 221 of file cs471.cpp.

References mfunc::fExec(), mdata::Population< T >::generate(), mdata::Population< T >::getDimensionsSize(), util::IniReader::getEntry(), mdata::Population< T >::getPopulation(), mdata::Population< T >::getPopulationSize(), cs471::RandomBounds< T >::max, cs471::RandomBounds< T >::min, mfunc::NUM_FUNCTIONS, mdata::Population< T >::outputPopulation(), and mdata::Population< T >::setFitness().

Referenced by runAllFunc().

```
00222 {
00223     if (!genFuncVectors(funcId)) return 1;
00224
00225     double fResult = 0;
00226     size_t nbrSol = population->getPopulationSize();
00227     size_t nbrDim = population->getDimensionsSize();
00228     double* curPop = nullptr;
00229
00230     high_resolution_clock::time_point t_start = high_resolution_clock::now();
00231
00232     for (int i = 0; i < nbrSol; i++)
00233     {
00234         curPop = population->getPopulation(i);
00235         if (curPop == nullptr || !mfunc::fExec(funcId, curPop, nbrDim, fResult))
00236             return 2;
00237
00238         if (!population->setFitness(i, fResult))
00239             return 3;
00240     }
00241
00242     high_resolution_clock::time_point t_end = high_resolution_clock::now();
00243     timeOut = (double)duration_cast<nanoseconds>(t_end - t_start).count() / 1000000.0;
00244
00245     return 0;
00246 }
```

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

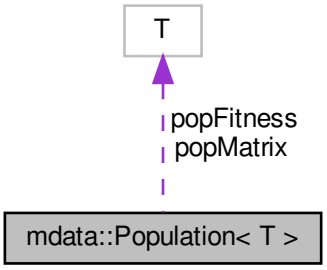
- include/cs471.h
- src/cs471.cpp

5.4 mdata::Population< T > Class Template Reference

Data class for storing a multi-dimensional population of data. Includes fitness analysis functions.

`#include <population.h>`

Collaboration diagram for mdata::Population< T >:



Public Member Functions

- Population (size_t popSize, size_t dimensions)
  Construct a new Population object.
- ~Population ()
  Destroy Population object.
- bool isReady ()
  Returns true if the population instance is allocated and ready to be used.
- size_t getPopulationSize ()
  Returns the size of the population.
- size_t getDimensionsSize ()
  Returns the dimensions of the population.
- T * getPopulation (size_t popIndex)
  Returns an array for the population with the given index.
- bool generate (T minBound, T maxBound)
  Generates new random values for this population that are within the given bounds. Resets all fitness values to zero.
- bool setFitness (size_t popIndex, T value)
  Sets the fitness value for a specific population vector index.
- T getFitnessValue (size_t popIndex)
  Returns the fitness value for a specific population vector index.
- T getFitnessAverage ()
  Calculates the average of all current fitness values.
- T getFitnessStandardDev ()
  Calculates the standard deviation of all current fitness values.
- T getFitnessRange ()
  Calculates the range of all current fitness values.
- T getFitnessMedian ()
  Calculates the median of all current fitness values.
- void outputPopulation (std::ostream &outStream, const char *delim, const char *lineBreak)
  Outputs all population data to the given output stream.
- void outputFitness (std::ostream &outStream, const char *delim, const char *lineBreak)
  Outputs all fitness data to the given output stream.

Protected Member Functions

- bool allocPopMatrix ()

  Helper function that allocates the population matrix.
- void releasePopMatrix ()

  Helper function that releases the population matrix memory.
- bool allocPopFitness ()

  Helper function that allocates the population fitness array.
- void releasePopFitness ()

  Helper function that releases the population fitness array memory.

Protected Attributes

- const size_t popSize
- const size_t popDim
- T ** popMatrix
- T * popFitness
- std::random_device rdev
- std::mt19937 rgen

5.4.1 Detailed Description

template<class T>
class mdata::Population< T >

Data class for storing a multi-dimensional population of data. Includes fitness analysis functions.

Template Parameters

T	Data type of the population.

Definition at line 29 of file population.h.

5.4.2 Constructor & Destructor Documentation

5.4.2.1 Population()

```
template<class T >
Population::Population (
            size_t pSize,
            size_t dimensions )
```

Construct a new Population object.

Template Parameters

T	Data type of the population.

Parameters

pSize	Size of the population.
dimensions	Dimensions of the population.

Definition at line 29 of file population.cpp.

```
00029                                                       : popMatrix(nullptr),
      popSize(pSize), popDim(dimensions)
00030 {
00031     if (!allocPopMatrix() || !allocPopFitness())
00032         throw std::bad_alloc();
00033 }
```

5.4.2.2 ~Population()

```
template<class T >
Population::~Population ( )
```

Destroy Population object.

Template Parameters

T	Data type of the population.

Definition at line 41 of file population.cpp.

```
00042 {
00043     releasePopMatrix();
00044     releasePopFitness();
00045 }
```

5.4.3 Member Function Documentation

5.4.3.1 allocPopFitness()

```
template<class T >
bool Population::allocPopFitness ( )  [protected]
```

Helper function that allocates the population fitness array.

Template Parameters

T	Data type of the population.

Returns

Returns true if the fitness array was succesfully allocated, otherwise false.

Definition at line 310 of file population.cpp.

```
00311 {
00312     if (popSize == 0 || popDim == 0) return false;
00313
00314     popFitness = allocArray<T>(popSize);
00315     initArray<T>(popFitness, popSize, 0);
00316
00317     return popFitness != nullptr;
00318 }
```

5.4.3.2 allocPopMatrix()

```
template<class T >
bool Population::allocPopMatrix ( )  [protected]
```

Helper function that allocates the population matrix.

Mersenne twister random number generator engine

Template Parameters

T	Data type of the population.

Returns

Returns true if the population matrix was succesfully allocated, otherwise false.

Definition at line 282 of file population.cpp.

```
00283 {
00284     if (popSize == 0 || popDim == 0) return false;
00285
00286     popMatrix = allocMatrix<T>(popSize, popDim);
00287     initMatrix<T>(popMatrix, popSize, popDim, 0);
00288
00289     return popMatrix != nullptr;
00290 }
```

5.4.3.3 generate()

```
template<class T>
bool Population::generate (
             T minBound,
             T maxBound )
```

Generates new random values for this population that are within the given bounds. Resets all fitness values to zero.

Template Parameters

T	Data type of the population.

Parameters

minBound	The minimum bound for a population value.
maxBound	The maximum bound for a population value.

Returns

Returns true of the population was succesfully generated, otherwise false.

Definition at line 110 of file population.cpp.

Referenced by cs471::mfuncExperiment::runFunc().

```
00111 {
00112     if (popMatrix == nullptr) return false;
00113 
00114     // Generate a new seed for the mersenne twister engine
00115     rgen = std::mt19937(rdev());
00116 
00117     // Set up a normal (bell-shaped) distribution for the random number generator with the correct function
      bounds
00118     std::uniform_real_distribution<double> dist((double)minBound, (double)maxBound);
00119 
00120     // Generate values for all vectors in popMatrix
00121     for (size_t s = 0; s < popSize; s++)
00122     {
00123         for (size_t d = 0; d < popDim; d++)
00124         {
00125             T rand = (T)dist(rgen);
00126             popMatrix[s][d] = rand;
00127         }
00128     }
00129 
00130     // Reset popFitness values to 0
00131     initArray<T>(popFitness, popSize, (T)0.0);
00132 
00133     return true;
00134 }
```

5.4.3.4 getDimensionsSize()

```
template<class T >
size_t Population::getDimensionsSize ( )
```

Returns the dimensions of the population.

Template Parameters

T	Data type of the population.

Returns

The number of dimensions in the population.

Definition at line 79 of file population.cpp.

Referenced by cs471::mfuncExperiment::runAllFunc(), and cs471::mfuncExperiment::runFunc().

```
00080 {
00081     return popDim;
00082 }
```

5.4.3.5 getFitnessAverage()

```
template<class T >
T Population::getFitnessAverage ( )
```

Calculates the average of all current fitness values.

Template Parameters

T	Data type of the population.

Returns

Returns the average of all current fitness values.

Definition at line 176 of file population.cpp.

Referenced by cs471::mfuncExperiment::runAllFunc().

```
00177 {
00178     if (popFitness == nullptr) return 0;
00179
00180     return average<T>(popFitness, popSize);
00181 }
```

5.4.3.6 getFitnessMedian()

```
template<class T >
T Population::getFitnessMedian ( )
```

Calculates the median of all current fitness values.

Template Parameters

T	Data type of the population.

Returns

T Returns the median of all current fitness values.

Definition at line 218 of file population.cpp.

Referenced by cs471::mfuncExperiment::runAllFunc().

```
00219 {
00220     if (popFitness == nullptr) return 0;
00221
00222     return median<T>(popFitness, popSize);
00223 }
```

5.4.3.7 getFitnessRange()

```
template<class T >
T Population::getFitnessRange ( )
```

Calculates the range of all current fitness values.

Template Parameters

T	Data type of the population.

Returns

T Returns the range of all current fitness values.

Definition at line 204 of file population.cpp.

Referenced by cs471::mfuncExperiment::runAllFunc().

```
00205 {
00206     if (popFitness == nullptr) return 0;
00207
00208     return range<T>(popFitness, popSize);
00209 }
```

5.4.3.8 getFitnessStandardDev()

```
template<class T >
T Population::getFitnessStandardDev ( )
```

Calculates the standard deviation of all current fitness values.

Template Parameters

T	Data type of the population.

Returns

T Returns the standard deviation of all current fitness values.

Definition at line 190 of file population.cpp.

Referenced by cs471::mfuncExperiment::runAllFunc().

```
00191 {
00192     if (popFitness == nullptr) return 0;
00193
00194     return standardDeviation<T>(popFitness, popSize);
00195 }
```

5.4.3.9 getFitnessValue()

```
template<class T >
T Population::getFitnessValue (
            size_t popIndex )
```

Returns the fitness value for a specific population vector index.

Template Parameters

T	Data type of the population.

Parameters

popIndex	Index of the population vector you wish to retrieve the fitness from.

Returns

Returns the fitness value if popIndex is valid. Otherwise zero.

Definition at line 162 of file population.cpp.

```
00163 {
00164     if (popFitness == nullptr || popIndex >= popSize) return 0;
00165
00166     return popFitness[popIndex];
00167 }
```

5.4.3.10 getPopulation()

```
template<class T >
T * Population::getPopulation (
            size_t popIndex )
```

Returns an array for the population with the given index.

Template Parameters

T	Data type of the population.

Parameters

popIndex	Index of the population vector you wish to retrieve.

Returns

Pointer to population vector array at the given index.

Definition at line 92 of file population.cpp.

Referenced by cs471::mfuncExperiment::runFunc().

```
00093 {
00094     if (popFitness == nullptr || popIndex >= popSize) return nullptr;
00095
00096     return popMatrix[popIndex];
00097 }
```

5.4.3.11 getPopulationSize()

```
template<class T >
size_t Population::getPopulationSize ( )
```

Returns the size of the population.

Template Parameters

T	Data type of the population.

Returns

The size of the population.

Definition at line 67 of file population.cpp.

Referenced by cs471::mfuncExperiment::runFunc().

```
00068 {
00069     return popSize;
00070 }
```

5.4.3.12 isReady()

```
template<class T >
bool Population::isReady ( )
```

Returns true if the population instance is allocated and ready to be used.

Template Parameters

T	Data type of the population.

Returns

Returns true if the population instance is in a valid state.

Definition at line 55 of file population.cpp.

Referenced by cs471::mfuncExperiment::runAllFunc().

```
00056 {
00057     return popMatrix != nullptr && popFitness != nullptr;
00058 }
```

5.4.3.13 outputFitness()

```
template<class T >
void Population::outputFitness (
            std::ostream & outStream,
            const char * delim,
            const char * lineBreak )
```

Outputs all fitness data to the given output stream.

Template Parameters

T	Data type of the population.

Parameters

outStream	Output stream to write the data to.
delim	Delimiter characters to separate columns.
lineBreak	Delimiter characters to separate rows.

Definition at line 260 of file population.cpp.

Referenced by cs471::mfuncExperiment::runAllFunc().

```
00261 {
00262     if (popFitness == nullptr) return;
00263
00264     for (size_t j = 0; j < popSize; j++)
00265     {
00266         outStream << popFitness[j];
00267             if (j < popSize - 1)
00268                 outStream << delim;
00269     }
00270
00271     if (lineBreak != nullptr)
00272         outStream << lineBreak;
00273 }
```

5.4.3.14 outputPopulation()

```
template<class T >
void Population::outputPopulation (
             std::ostream & outStream,
             const char * delim,
             const char * lineBreak )
```

Outputs all population data to the given output stream.

Template Parameters

T	Data type of the population.

Parameters

outStream	Output stream to write the data to.
delim	Delimiter characters to separate columns.
lineBreak	Delimiter characters to separate rows.

Definition at line 234 of file population.cpp.

Referenced by cs471::mfuncExperiment::runFunc().

```
00235 {
00236     if (popMatrix == nullptr) return;
00237
00238     for (size_t j = 0; j < popSize; j++)
00239     {
00240         for (size_t k = 0; k < popDim; k++)
00241         {
00242             outStream << popMatrix[j][k];
00243             if (k < popDim - 1)
00244                 outStream << delim;
00245         }
00246
00247         outStream << lineBreak;
00248     }
00249 }
```

5.4.3.15 releasePopFitness()

```
template<class T >
void Population::releasePopFitness ( )  [protected]
```

Helper function that releases the population fitness array memory.

Template Parameters

T	Data type of the population.

Definition at line 326 of file population.cpp.

```
00327 {
00328     releaseArray<T>(popFitness);
00329 }
```

5.4.3.16 releasePopMatrix()

```
template<class T >
void Population::releasePopMatrix ( )  [protected]
```

Helper function that releases the population matrix memory.

Template Parameters

T	Data type of the population.

Definition at line 298 of file population.cpp.

```
00299 {
00300     releaseMatrix<T>(popMatrix, popSize);
00301 }
```

5.4.3.17 setFitness()

```
template<class T>
bool Population::setFitness (
            size_t popIndex,
            T value )
```

Sets the fitness value for a specific population vector index.

Template Parameters

T	Data type of the population.

Parameters

popIndex	Index of the population vector you wish to set the fitness for.
value	The value of the fitness.

Returns

Returns true if the fitness was succesfully set, otherwise false.

Definition at line 145 of file population.cpp.

Referenced by cs471::mfuncExperiment::runFunc().

```
00146 {
00147     if (popFitness == nullptr || popIndex >= popSize) return false;
00148
00149     popFitness[popIndex] = value;
00150
00151     return true;
00152 }
```

5.4.4 Member Data Documentation

5.4.4.1 popDim

```
template<class T>
const size_t mdata::Population< T >::popDim  [protected]
```

Size of the population, and the number of rows in the popMatrix

Definition at line 52 of file population.h.

5.4.4.2 popFitness

```
template<class T>
T* mdata::Population< T >::popFitness  [protected]
```

Matrix of population values

Definition at line 54 of file population.h.

5.4.4.3 popMatrix

```
template<class T>
T** mdata::Population< T >::popMatrix  [protected]
```

Dimensions of the population, and the number of columns in the popMatrix

Definition at line 53 of file population.h.

5.4.4.4 popSize

```
template<class T>
const size_t mdata::Population< T >::popSize  [protected]
```

Definition at line 51 of file population.h.

5.4.4.5 rdev

```
template<class T>
std::random_device mdata::Population< T >::rdev  [protected]
```

Array of fitness values

Definition at line 56 of file population.h.

5.4.4.6 rgen

```
template<class T>
std::mt19937 mdata::Population< T >::rgen  [protected]
```

Random seed for random number generator

Definition at line 57 of file population.h.

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

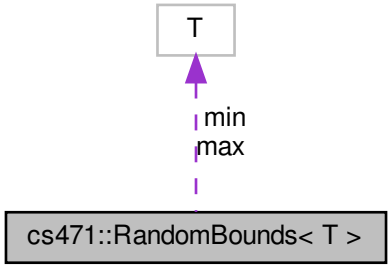
- include/population.h
- src/population.cpp

5.5 cs471::RandomBounds< T > Struct Template Reference

Simple struct for storing the minimum and maximum input vector bounds for a function.

`#include <cs471.h>`

Collaboration diagram for cs471::RandomBounds< T >:



Public Attributes

- T min = 0.0
- T max = 0.0

5.5.1 Detailed Description

template<class T>
struct cs471::RandomBounds< T >

Simple struct for storing the minimum and maximum input vector bounds for a function.

Definition at line 31 of file cs471.h.

5.5.2 Member Data Documentation

5.5.2.1 max

```
template<class T>
T cs471::RandomBounds< T >::max = 0.0
```

Definition at line 34 of file cs471.h.

Referenced by cs471::mfuncExperiment::runFunc().

5.5.2.2 min

```
template<class T>
T cs471::RandomBounds< T >::min = 0.0
```

Definition at line 33 of file cs471.h.

Referenced by cs471::mfuncExperiment::runFunc().

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

- include/cs471.h

Chapter 6

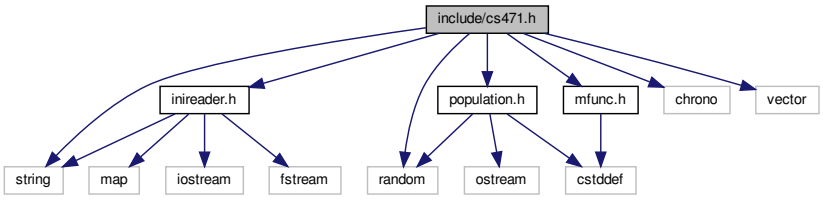
File Documentation

6.1 include/cs471.h File Reference

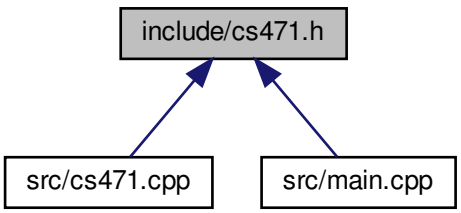
Header file for the mfuncExperiment class. Contains the basic logic and functions to run the cs471 project experiment.

```
#include <string>
#include <random>
#include <chrono>
#include <vector>
#include "mfunc.h"
#include "inireader.h"
#include "population.h"
```

Include dependency graph for cs471.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct cs471::RandomBounds< T >

  Simple struct for storing the minimum and maximum input vector bounds for a function.
- class cs471::mfuncExperiment

  Contains classes for running the CS471 project experiment.

Namespaces

- cs471

6.1.1 Detailed Description

Header file for the mfuncExperiment class. Contains the basic logic and functions to run the cs471 project experiment.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-04-01

Copyright

Copyright (c) 2019

Definition in file cs471.h.

6.2 cs471.h

```
00001
00013 #ifndef __CS471_H
00014 #define __CS471_H
00015
00016 #include <string>
00017 #include <random>
00018 #include <chrono>
00019 #include <vector>
00020 #include "mfunc.h"
00021 #include "inireader.h"
00022 #include "population.h"
00023
00024 namespace cs471
00025 {
00030     template<class T>
00031     struct RandomBounds
00032     {
00033         T min = 0.0;
00034         T max = 0.0;
00035     };
```

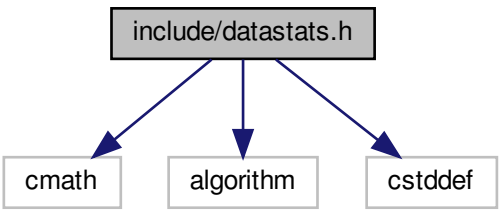
```
00036
00047     class mfuncExperiment
00048     {
00049     public:
00050         mfuncExperiment();
00051         ~mfuncExperiment();
00052         bool init(const char* paramFile);
00053         int runAllFunc();
00054         int runFunc(unsigned int funcId, double& timeOut);
00055     private:
00056         util::IniReader iniParams;
00057         std::string resultsFile;
00058         mdata::Population<double>* population;
00059         RandomBounds<double>* vBounds;
00060         bool outputPop;
00061         bool outputFitness;
00063         bool genFuncVectors(unsigned int funcId);
00064
00065         bool parseFuncBounds();
00066
00067         void exportPop(unsigned int func);
00068
00069         bool allocatePopulation(size_t popSize, size_t dimensions);
00070         void releasePopulation();
00071
00072         bool allocateVBounds();
00073         void releaseVBounds();
00074     };
00075 } // proj1
00076
00077 #endif
00078
00079 // ========================
00080 // End of proj1.h
00081 // ========================
```

6.3 include/datastats.h File Reference

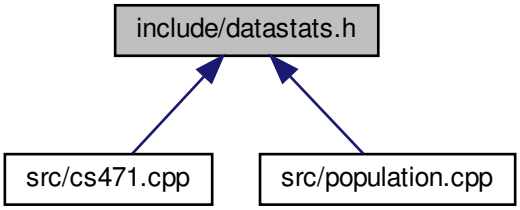
Header file for various data statistic functions.

```
#include <cmath>
#include <algorithm>
#include <cstddef>
```

Include dependency graph for datastats.h:



This graph shows which files directly or indirectly include this file:



Namespaces

- mdata

Functions

- template<class T = double>
  T mdata::average (T *v, size_t vSize)
  Calculates the average for an array of values.
- template<class T = double>
  T mdata::standardDeviation (T *v, size_t vSize)
  Calculates the standard deviation for an array of values.
- template<class T = double>
  T mdata::range (T *v, size_t vSize)
  Calculates the range for an array of values.
- template<class T = double>
  T mdata::median (T *v, size_t vSize)
  Calculates the median for an array of values.

6.3.1 Detailed Description

Header file for various data statistic functions.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-04-01

Copyright

Copyright (c) 2019

Definition in file datastats.h.

6.4 datastats.h

```
00001
00012 #ifndef __DATASTATS_H
00013 #define __DATASTATS_H
00014
00015 #include <cmath>     // sqrt()
00016 #include <algorithm> // std::sort()
00017 #include <cstddef>   // size_t definition
00018
00019
00020 namespace mdata
00021 {
00028     template<class T = double>
00029     T average(T* v, size_t vSize)
00030     {
00031         T sum = 0;
00032
00033         for (size_t i = 0; i < vSize; i++)
00034             sum += v[i];
00035
00036         return sum / vSize;
00037     }
00038
00045     template<class T = double>
00046     T standardDeviation(T* v, size_t vSize)
00047     {
00048         T mean = average<T>(v, vSize);
00049         T sum = 0;
00050
00051         for (size_t i = 0; i < vSize; i++)
00052         {
00053             T subMean = v[i] - mean;
00054             sum += subMean * subMean;
00055         }
00056
00057         return (T)sqrt((double)(sum / vSize));
00058     }
00059
00066     template<class T = double>
00067     T range(T* v, size_t vSize)
00068     {
00069         T min = v[0];
00070         T max = v[0];
00071
00072         for (size_t i = 1; i < vSize; i++)
00073         {
00074             T cur = v[i];
00075
00076             if (cur < min) min = cur;
00077
00078             if (cur > max) max = cur;
00079         }
00080
00081         return max - min;
00082     }
00083
00090     template<class T = double>
00091     T median(T* v, size_t vSize)
00092     {
00093         T* vSorted = new T[vSize];
00094         T retVal = 0;
00095
00096         for (size_t i = 0; i < vSize; i++)
00097             vSorted[i] = v[i];
00098
00099         std::sort(vSorted, vSorted + vSize);
00100
00101         if (vSize % 2 != 0)
00102         {
00103             // Odd number of values
00104             retVal = vSorted[vSize / 2];
00105         }
00106         else
00107         {
00108             // Even number of values
00109             T low = vSorted[(vSize / 2) - 1];
00110             T high = vSorted[vSize / 2];
00111             retVal = (high + low) / 2;
00112         }
00113
00114         delete[] vSorted;
00115         return retVal;
00116     }
00117 }
00118
```

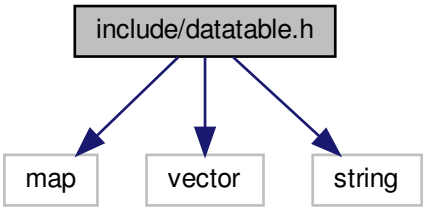
```
00119 #endif
00120
00121 // ========================
00122 // End of datastats.h
00123 // ========================
```

6.5 include/datatable.h File Reference

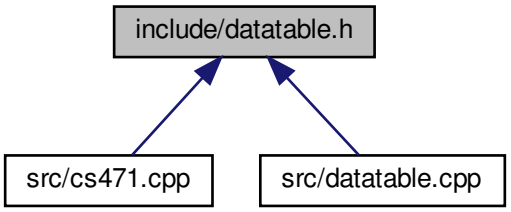
Header file for the DataTable class, which represents a spreadsheet/table of values that can be exported to a ∗.csv file.

```
#include <map>
#include <vector>
#include <string>
```

Include dependency graph for datatable.h:



This graph shows which files directly or indirectly include this file:



Classes

- class mdata::DataTable

  The DataTable class is a simple table of values with labeled columns.

Namespaces

- mdata

6.5.1 Detailed Description

Header file for the DataTable class, which represents a spreadsheet/table of values that can be exported to a ∗.csv file.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-04-01

Copyright

Copyright (c) 2019

Definition in file datatable.h.

6.6 datatable.h

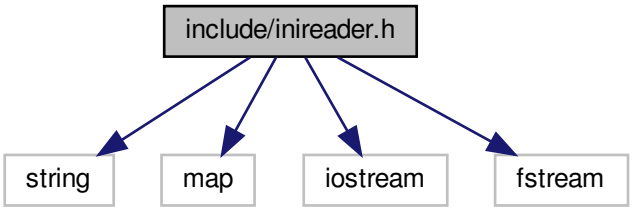
```
00001
00013 #ifndef __DATATABLE_H
00014 #define __DATATABLE_H
00015
00016 #include <map>
00017 #include <vector>
00018 #include <string>
00019
00020 namespace mdata
00021 {
00055     class DataTable
00056     {
00057     public:
00058         DataTable(unsigned int cols);
00059         ~DataTable();
00060
00061         std::string getColLabel(unsigned int colIndex);
00062         bool setColLabel(unsigned int colIndex, std::string newLabel);
00063
00064         unsigned int addRow();
00065         unsigned int addRow(const std::vector<std::string>& rowData);
00066         std::vector<std::string>& getRow(unsigned int row);
00067         void setRow(unsigned int row, const std::vector<std::string>& rowData);
00068
00069         std::string getEntry(unsigned int row, unsigned int col);
00070         void setEntry(unsigned int row, unsigned int col, std::string val);
00071         void setEntry(unsigned int row, unsigned int col, int val);
00072         void setEntry(unsigned int row, unsigned int col, long val);
00073         void setEntry(unsigned int row, unsigned int col, float val);
00074         void setEntry(unsigned int row, unsigned int col, double val);
00075
00076         bool exportCSV(const char* filePath);
00077     protected:
00078         unsigned int cols;
00079         unsigned int rows;
00080         std::vector<std::string> colLabels;
00081         std::map<unsigned int, std::vector<std::string>> tableData;
00082     };
00083 } // mdata
00084
00085 #endif
00086
00087 // =========================
00088 // End of datatable.h
00089 // =========================
```

6.7 include/inireader.h File Reference

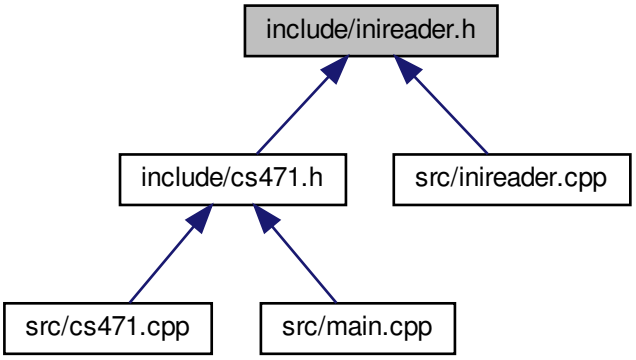
Header file for the IniReader class, which can open and parse simple ∗.ini files.

```
#include <string>
#include <map>
#include <iostream>
#include <fstream>
```

Include dependency graph for inireader.h:



This graph shows which files directly or indirectly include this file:



Classes

- class util::IniReader

  The IniReader class is a simple ∗.ini file reader and parser.

Namespaces

- util

6.7.1 Detailed Description

Header file for the IniReader class, which can open and parse simple ∗.ini files.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-04-01

Copyright

Definition in file inireader.h.

6.8 inireader.h

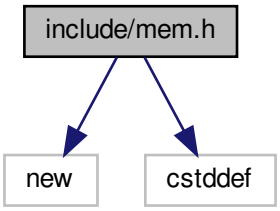
```
00001
00013 #ifndef __INIREADER_H
00014 #define __INIREADER_H
00015
00016 #include <string>
00017 #include <map>
00018 #include <iostream>
00019 #include <fstream>
00020
00021 namespace util
00022 {
00045     class IniReader
00046     {
00047     public:
00048         IniReader();
00049         ~IniReader();
00050         bool openFile(std::string filePath);
00051         bool sectionExists(std::string section);
00052         bool entryExists(std::string section, std::string entry);
00053         std::string getEntry(std::string section, std::string entry);
00054     protected:
00055         std::string file;
00056         std::map<std::string, std::map<std::string, std::string>> iniMap;
00058         bool parseFile();
00059         void parseEntry(const std::string& sectionName, const std::string& entry);
00060     };
00061 }
00062
00063 #endif
00064
00065 // ========================
00066 // End of inireader.h
00067 // ========================
```

6.9 include/mem.h File Reference

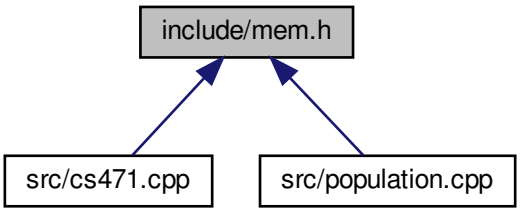
Header file for various memory utility functions.

```
#include <new>
#include <cstddef>
```

Include dependency graph for mem.h:



This graph shows which files directly or indirectly include this file:



Namespaces

- util

Functions

- template<class T = double>
  void util::initArray (T *a, size_t size, T val)

  Initializes an array with some set value.
- template<class T = double>
  void util::initMatrix (T **m, size_t rows, size_t cols, T val)

  Initializes a matrix with a set value for each entry.

- template<class T = double>
  void util::releaseArray (T *&a)

  Releases an allocated array's memory and sets the pointer to nullptr.
- template<class T = double>
  void util::releaseMatrix (T **&m, size_t rows)

  Releases an allocated matrix's memory and sets the pointer to nullptr.
- template<class T = double>
  T * util::allocArray (size_t size)

  Allocates a new array of the given data type.
- template<class T = double>
  T ** util::allocMatrix (size_t rows, size_t cols)

  Allocates a new matrix of the given data type.

6.9.1 Detailed Description

Header file for various memory utility functions.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-04-02

Copyright

Copyright (c) 2019

Definition in file mem.h.

6.10 mem.h

```
00001
00012 #include <new> // std::nothrow
00013 #include <cstddef> // size_t definition
00014
00015 namespace util
00016 {
00025     template <class T = double>
00026     inline void initArray(T* a, size_t size, T val)
00027     {
00028         if (a == nullptr) return;
00029
00030         for (size_t i = 0; i < size; i++)
00031         {
00032             a[i] = val;
00033         }
00034     }
00035
00045     template <class T = double>
00046     inline void initMatrix(T** m, size_t rows, size_t cols, T val)
```

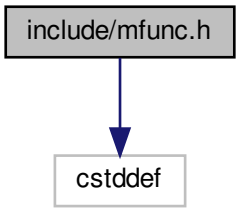
```
00047     {
00048         if (m == nullptr) return;
00049 
00050         for (size_t i = 0; i < rows; i++)
00051         {
00052             initArray(m[i], cols, val);
00053         }
00054     }
00055 
00062     template <class T = double>
00063     void releaseArray(T*& a)
00064     {
00065         if (a == nullptr) return;
00066 
00067         delete[] a;
00068         a = nullptr;
00069     }
00070 
00078     template <class T = double>
00079     void releaseMatrix(T**& m, size_t rows)
00080     {
00081         if (m == nullptr) return;
00082 
00083         for (size_t i = 0; i < rows; i++)
00084         {
00085             if (m[i] != nullptr)
00086             {
00087                 // Release each row
00088                 releaseArray<T>(m[i]);
00089             }
00090         }
00091 
00092         // Release columns
00093         delete[] m;
00094         m = nullptr;
00095     }
00096 
00104     template <class T = double>
00105     inline T* allocArray(size_t size)
00106     {
00107         return new(std::nothrow) T[size];
00108     }
00109 
00118     template <class T = double>
00119     inline T** allocMatrix(size_t rows, size_t cols)
00120     {
00121         T** m = (T**)allocArray<T*>(rows);
00122         if (m == nullptr) return nullptr;
00123 
00124         for (size_t i = 0; i < rows; i++)
00125         {
00126             m[i] = allocArray<T>(cols);
00127             if (m[i] == nullptr)
00128             {
00129                 releaseMatrix<T>(m, rows);
00130                 return nullptr;
00131             }
00132         }
00133 
00134         return m;
00135     }
00136 }
00137 
00138 // ========================
00139 // End of mem.h
00140 // ========================
```

6.11 include/mfunc.h File Reference

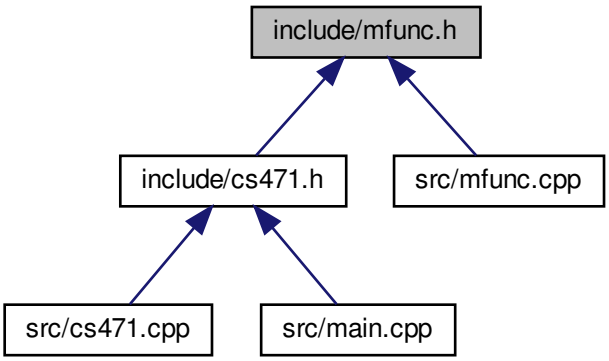
Contains various math function definitions.

```
#include <cstddef>
```

Include dependency graph for mfunc.h:



This graph shows which files directly or indirectly include this file:



Namespaces

- mfunc

Functions

- const char * mfunc::schwefelDesc ()
- double mfunc::schwefel (double *v, size_t n)

  Function 1. Implementation of Schwefel's mathematical function.
- const char * mfunc::dejongDesc ()
- double mfunc::dejong (double *v, size_t n)

  Function 2. Implementation of 1st De Jong's mathematical function.
- const char * mfunc::rosenbrokDesc ()
- double mfunc::rosenbrok (double *v, size_t n)

Function 3. Implementation of the Rosenbrock mathematical function.

- const char * mfunc::rastriginDesc ()
- double mfunc::rastrigin (double *v, size_t n)

Function 4. Implementation of the Rastrigin mathematical function.

- const char * mfunc::griewangkDesc ()
- double mfunc::griewangk (double *v, size_t n)

Function 5. Implementation of the Griewangk mathematical function.

- const char * mfunc::sineEnvelopeSineWaveDesc ()
- double mfunc::sineEnvelopeSineWave (double *v, size_t n)

Function 6. Implementation of the Sine Envelope Sine Wave mathematical function.

- const char * mfunc::stretchedVSineWaveDesc ()
- double mfunc::stretchedVSineWave (double *v, size_t n)

Function 7. Implementation of the Stretched V Sine Wave mathematical function.

- const char * mfunc::ackleysOneDesc ()
- double mfunc::ackleysOne (double *v, size_t n)

Function 8. Implementation of Ackley's One mathematical function.

- const char * mfunc::ackleysTwoDesc ()
- double mfunc::ackleysTwo (double *v, size_t n)

Function 9. Implementation of Ackley's Two mathematical function.

- const char * mfunc::eggHolderDesc ()
- double mfunc::eggHolder (double *v, size_t n)

Function 10. Implementation of the Egg Holder mathematical function.

- const char * mfunc::ranaDesc ()
- double mfunc::rana (double *v, size_t n)

Function 11. Implementation of the Rana mathematical function.

- const char * mfunc::pathologicalDesc ()
- double mfunc::pathological (double *v, size_t n)

Function 12. Implementation of the Pathological mathematical function.

- const char * mfunc::michalewiczDesc ()
- double mfunc::michalewicz (double *v, size_t n)

Function 13. Implementation of the Michalewicz mathematical function.

- const char * mfunc::mastersCosineWaveDesc ()
- double mfunc::mastersCosineWave (double *v, size_t n)

Function 14. Implementation of the Masters Cosine Wave mathematical function.

- const char * mfunc::quarticDesc ()
- double mfunc::quartic (double *v, size_t n)

Function 15. Implementation of the Quartic mathematical function.

- const char * mfunc::levyDesc ()
- double mfunc::levy (double *v, size_t n)

Function 16. Implementation of the Levy mathematical function.

- const char * mfunc::stepDesc ()
- double mfunc::step (double *v, size_t n)

Function 17. Implementation of the Step mathematical function.

- const char * mfunc::alpineDesc ()
- double mfunc::alpine (double *v, size_t n)

Function 18. Implementation of the Alpine mathematical function.

- bool mfunc::fExec (unsigned int f, double *v, size_t n, double &outResult)

  Executes a specific function Executes the function with the given id and returns true on success. Otherwise returns false if id is invalid.

- const char * mfunc::fDesc (unsigned int f)

  Returns a function's description Returns a C-string description for the given function id if the id is valid. Otherwise returns null.

Variables

- const unsigned int mfunc::NUM_FUNCTIONS = 18

6.11.1 Detailed Description

Contains various math function definitions.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-03-29

Copyright

Copyright (c) 2019

Definition in file mfunc.h.

6.12 mfunc.h

```
00001
00012 #ifndef __MFUNC_H
00013 #define __MFUNC_H
00014
00015 #include <cstddef> // size_t definition
00016
00020 namespace mfunc
00021 {
00022     extern const unsigned int NUM_FUNCTIONS;
00023
00024     const char* schwefelDesc();
00025     double schwefel(double* v, size_t n);
00026
00027     const char* dejongDesc();
00028     double dejong(double* v, size_t n);
00029
00030     const char* rosenbrokDesc();
00031     double rosenbrok(double* v, size_t n);
00032
00033     const char* rastriginDesc();
00034     double rastrigin(double* v, size_t n);
00035
00036     const char* griewangkDesc();
00037     double griewangk(double* v, size_t n);
00038
00039     const char* sineEnvelopeSineWaveDesc();
00040     double sineEnvelopeSineWave(double* v, size_t n);
00041
00042     const char* stretchedVSineWaveDesc();
00043     double stretchedVSineWave(double* v, size_t n);
00044
00045     const char* ackleysOneDesc();
00046     double ackleysOne(double* v, size_t n);
00047
00048     const char* ackleysTwoDesc();
```

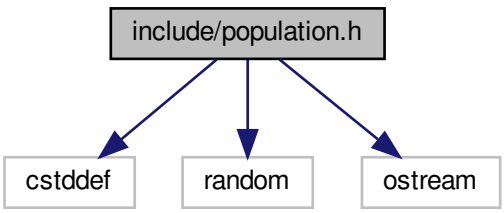
```
00049     double ackleysTwo(double* v, size_t n);
00050
00051     const char* eggHolderDesc();
00052     double eggHolder(double* v, size_t n);
00053
00054     const char* ranaDesc();
00055     double rana(double* v, size_t n);
00056
00057     const char* pathologicalDesc();
00058     double pathological(double* v, size_t n);
00059
00060     const char* michalewiczDesc();
00061     double michalewicz(double* v, size_t n);
00062
00063     const char* mastersCosineWaveDesc();
00064     double mastersCosineWave(double* v, size_t n);
00065
00066     const char* quarticDesc();
00067     double quartic(double* v, size_t n);
00068
00069     const char* levyDesc();
00070     double levy(double* v, size_t n);
00071
00072     const char* stepDesc();
00073     double step(double* v, size_t n);
00074
00075     const char* alpineDesc();
00076     double alpine(double* v, size_t n);
00077
00078     bool fExec(unsigned int f, double* v, size_t n, double& outResult);
00079     const char* fDesc(unsigned int f);
00080 }
00081
00082 #endif
00083
00084 // ========================
00085 // End of mfunc.h
00086 // ========================
```

6.13 include/population.h File Reference

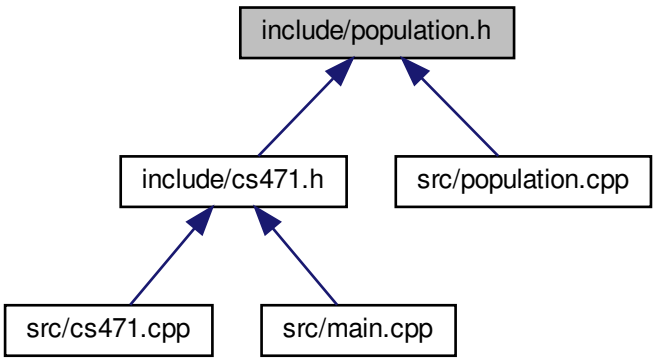
Header file for the Population class. Stores a population and fitness values. Includes functions to analyze the fitness data.

```
#include <cstddef>
#include <random>
#include <ostream>
```

Include dependency graph for population.h:



This graph shows which files directly or indirectly include this file:



Classes

- class mdata::Population< T >

  Data class for storing a multi-dimensional population of data. Includes fitness analysis functions.

Namespaces

- mdata

6.13.1 Detailed Description

Header file for the Population class. Stores a population and fitness values. Includes functions to analyze the fitness data.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-04-04

Copyright

Copyright (c) 2019

Definition in file population.h.

6.14 population.h

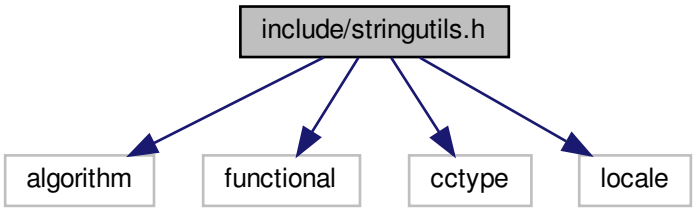
```
00001
00013 #ifndef __POPULATION_H
00014 #define __POPULATION_H
00015
00016 #include <cstddef> // size_t definition
00017 #include <random>
00018 #include <ostream>
00019
00020 namespace mdata
00021 {
00028     template<class T>
00029     class Population
00030     {
00031     public:
00032         Population(size_t popSize, size_t dimensions);
00033         ~Population();
00034
00035         bool isReady();
00036         size_t getPopulationSize();
00037         size_t getDimensionsSize();
00038         T* getPopulation(size_t popIndex);
00039
00040         bool generate(T minBound, T maxBound);
00041         bool setFitness(size_t popIndex, T value);
00042         T getFitnessValue(size_t popIndex);
00043         T getFitnessAverage();
00044         T getFitnessStandardDev();
00045         T getFitnessRange();
00046         T getFitnessMedian();
00047
00048         void outputPopulation(std::ostream& outStream, const char* delim, const char*
      lineBreak);
00049         void outputFitness(std::ostream& outStream, const char* delim, const char* lineBreak);
00050     protected:
00051         const size_t popSize;
00052         const size_t popDim;
00053         T** popMatrix;
00054         T* popFitness;
00056         std::random_device rdev;
00057         std::mt19937 rgen;
00059         bool allocPopMatrix();
00060         void releasePopMatrix();
00061
00062         bool allocPopFitness();
00063         void releasePopFitness();
00064     };
00065 }
00066
00067 #endif
00068
00069 // ========================
00070 // End of population.h
00071 // ========================
```

6.15 include/stringutils.h File Reference

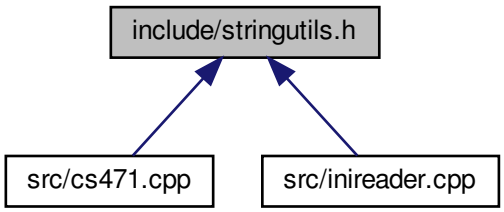
Contains various string manipulation helper functions.

```
#include <algorithm>
#include <functional>
#include <cctype>
#include <locale>
```

Include dependency graph for stringutils.h:



This graph shows which files directly or indirectly include this file:



Namespaces

- util

6.15.1 Detailed Description

Contains various string manipulation helper functions.

Author

Evan Teran (https://github.com/eteran)

Date

2019-04-01

Definition in file stringutils.h.

6.16 stringutils.h

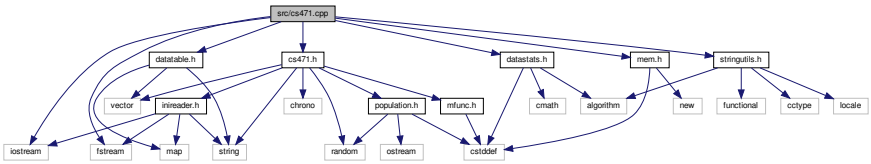
```
00001
00008 #ifndef __STRINGUTILS_H
00009 #define __STRINGUTILS_H
00010
00011 #include <algorithm>
00012 #include <functional>
00013 #include <cctype>
00014 #include <locale>
00015
00016 namespace util
00017 {
00018     // =========================================================
00019     // The string functions below were written by Evan Teran
00020     // from Stack Overflow:
00021     // https://stackoverflow.com/questions/216823/whats-the-best-way-to-trim-stdstring
00022     // =========================================================
00023
00024     // trim from start (in place)
00025     static inline void s_ltrim(std::string &s) {
00026         s.erase(s.begin(), std::find_if(s.begin(), s.end(),
00027                 std::not1(std::ptr_fun<int, int>(std::isspace))));
00028     }
00029
00030     // trim from end (in place)
00031     static inline void s_rtrim(std::string &s) {
00032         s.erase(std::find_if(s.rbegin(), s.rend(),
00033                 std::not1(std::ptr_fun<int, int>(std::isspace))).base(), s.end());
00034     }
00035
00036     // trim from both ends (in place)
00037     static inline void s_trim(std::string &s) {
00038         s_ltrim(s);
00039         s_rtrim(s);
00040     }
00041
00042     // trim from start (copying)
00043     static inline std::string s_ltrim_copy(std::string s) {
00044         s_ltrim(s);
00045         return s;
00046     }
00047
00048     // trim from end (copying)
00049     static inline std::string s_rtrim_copy(std::string s) {
00050         s_rtrim(s);
00051         return s;
00052     }
00053
00054     // trim from both ends (copying)
00055     static inline std::string s_trim_copy(std::string s) {
00056         s_trim(s);
00057         return s;
00058     }
00059 }
00060 #endif
00061
00062 // =========================
00063 // End of stringutils.h
00064 // =========================
```

6.17 src/cs471.cpp File Reference

Implementation file for the mfuncExperiment class. Contains the basic logic and functions to run the cs471 project experiment.

```
#include "cs471.h"
#include "datatable.h"
#include "datastats.h"
#include "stringutils.h"
#include "mem.h"
#include <iostream>
```

`#include <fstream>`
Include dependency graph for cs471.cpp:



6.17.1 Detailed Description

Implementation file for the mfuncExperiment class. Contains the basic logic and functions to run the cs471 project experiment.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-04-01

Copyright

Copyright (c) 2019

Definition in file cs471.cpp.

6.18 cs471.cpp

```
00001
00013 #include "cs471.h"
00014 #include "datatable.h"
00015 #include "datastats.h"
00016 #include "stringutils.h"
00017 #include "mem.h"
00018 #include <iostream>
00019 #include <fstream>
00020
00021 using namespace std;
00022 using namespace std::chrono;
00023 using namespace cs471;
00024
00028 mfuncExperiment::mfuncExperiment() : population(nullptr), vBounds(nullptr), outputPop(false), outputFitness
      (false)
00029 {
00030 }
00031
00036 mfuncExperiment::~mfuncExperiment()
00037 {
00038     releasePopulation();
```

```
00039     releaseVBounds();
00040 }
00041
00050 bool mfuncExperiment::init(const char* paramFile)
00051 {
00052     // Open and parse parameters file
00053     if (!iniParams.openFile(paramFile))
00054     {
00055         cerr << "Experiment init failed: Unable to open param file: " << paramFile << endl;
00056         return false;
00057     }
00058
00059     long numberSol;
00060     long numberDim;
00061
00062     // Attempt to parse number of solutions and vector dimensions size
00063     // from iniParams
00064     try
00065     {
00066         std::string entry;
00067
00068         entry = iniParams.getEntry("test", "population");
00069         if (entry.empty())
00070         {
00071             cerr << "Experiment init failed: Param file missing [test]->population entry: " << paramFile <<
     endl;
00072             return false;
00073         }
00074
00075         numberSol = std::atol(entry.c_str());
00076
00077         entry = iniParams.getEntry("test", "dimensions");
00078         if (entry.empty())
00079         {
00080             cerr << "Experiment init failed: Param file missing [test]->dimensions entry: " << paramFile <<
     endl;
00081             return false;
00082         }
00083
00084         numberDim = std::atol(entry.c_str());
00085
00086         if (numberSol <= 0)
00087         {
00088             cerr << "Experiment init failed: Param file [test]->population entry out of bounds: " <<
    paramFile << endl;
00089             return false;
00090         }
00091
00092         if (numberDim <= 0)
00093         {
00094             cerr << "Experiment init failed: Param file [test]->dimensions entry out of bounds: " <<
    paramFile << endl;
00095             return false;
00096         }
00097     }
00098     catch (const std::exception& ex)
00099     {
00100         cerr << "Experiment init failed: Exception while parsing param file: " << paramFile << endl;
00101         return false;
00102     }
00103
00104     // Get csv output file path
00105     resultsFile = iniParams.getEntry("test", "results_file");
00106     outputPop = iniParams.getEntry("test", "output_population") == "true";
00107     outputFitness = iniParams.getEntry("test", "output_fitness") == "true";
00108
00109     // Allocate memory for vector * solutions matrix
00110     if (!allocatePopulation((size_t)numberSol, (size_t)numberDim))
00111     {
00112         cerr << "Experiment init failed: Unable to allocate population matrix." << endl;
00113         return false;
00114     }
00115
00116     // Allocate memory for function bounds
00117     if (!allocateVBounds())
00118     {
00119         cerr << "Experiment init failed: Unable to allocate vector bounds array." << endl;
00120         return false;
00121     }
00122
00123     // Fill function bounds array with data parsed from iniParams
00124     if (!parseFuncBounds())
00125     {
00126         cerr << "Experiment init failed: Unable to parse vector bounds array." << endl;
00127         return false;
00128     }
00129
```

```
00130     return true;
00131 }
00132
00140 int mfuncExperiment::runAllFunc()
00141 {
00142     if (population == nullptr || !population->isReady()) return 1;
00143
00144     // function desc. | average | standard dev. | range | median | time
00145     mdata::DataTable resultsTable(8);
00146     resultsTable.setColLabel(0, "Function");
00147     resultsTable.setColLabel(1, "Vector Min");
00148     resultsTable.setColLabel(2, "Vector Max");
00149     resultsTable.setColLabel(3, "Average");
00150     resultsTable.setColLabel(4, "Standard Deviation");
00151     resultsTable.setColLabel(5, "Range");
00152     resultsTable.setColLabel(6, "Median");
00153     resultsTable.setColLabel(7, "Total Time (ms)");
00154
00155     double fTime = 0.0;
00156     ofstream fitnessFile;
00157     if (outputFitness)
00158     {
00159         std::string fitFile = "fitness-dim_";
00160         fitFile += to_string(population->getDimensionsSize());
00161         fitFile += ".csv";
00162         fitnessFile.open(fitFile, ios::out | ios::trunc);
00163         if (!fitnessFile.good()) outputFitness = false;
00164     }
00165
00166     // Execute all functions
00167     for (unsigned int f = 1; f <= mfunc::NUM_FUNCTIONS; f++)
00168     {
00169         int err = runFunc(f, fTime);
00170         if (err)
00171         {
00172             if (outputFitness) fitnessFile.close();
00173             return err;
00174         }
00175         else
00176         {
00177             // Export all population data if flag is set
00178             if (outputPop)
00179                 exportPop(f);
00180
00181             // Export all fitness data if flag is set
00182             if (outputFitness)
00183             {
00184                 fitnessFile << mfunc::fDesc(f) << ",";
00185                 population->outputFitness(fitnessFile, ",", "\n");
00186             }
00187
00188             // Insert function results and statistics into the results table as a new row
00189             unsigned int rowIndex = resultsTable.addRow();
00190             resultsTable.setEntry(rowIndex, 0, mfunc::fDesc(f));
00191             resultsTable.setEntry(rowIndex, 1, to_string(vBounds[f-1].min));
00192             resultsTable.setEntry(rowIndex, 2, to_string(vBounds[f-1].max));
00193             resultsTable.setEntry(rowIndex, 3, population->
      getFitnessAverage());
00194             resultsTable.setEntry(rowIndex, 4, population->
      getFitnessStandardDev());
00195             resultsTable.setEntry(rowIndex, 5, population->
      getFitnessRange());
00196             resultsTable.setEntry(rowIndex, 6, population->
      getFitnessMedian());
00197             resultsTable.setEntry(rowIndex, 7, fTime);
00198         }
00199     }
00200
00201     if (!resultsFile.empty())
00202     {
00203         // Export results table to a *.csv file
00204         cout << "Exporting results to: " << resultsFile << endl;
00205         resultsTable.exportCSV(resultsFile.c_str());
00206     }
00207
00208     if (outputFitness) fitnessFile.close();
00209     return 0;
00210 }
00211
00221 int mfuncExperiment::runFunc(unsigned int funcId, double& timeOut)
00222 {
00223     if (!genFuncVectors(funcId)) return 1;
00224
00225     double fResult = 0;
00226     size_t nbrSol = population->getPopulationSize();
00227     size_t nbrDim = population->getDimensionsSize();
00228     double* curPop = nullptr;
```

```
00229
00230     high_resolution_clock::time_point t_start = high_resolution_clock::now();
00231
00232     for (int i = 0; i < nbrSol; i++)
00233     {
00234         curPop = population->getPopulation(i);
00235         if (curPop == nullptr || !mfunc::fExec(funcId, curPop, nbrDim, fResult))
00236             return 2;
00237
00238         if (!population->setFitness(i, fResult))
00239             return 3;
00240     }
00241
00242     high_resolution_clock::time_point t_end = high_resolution_clock::now();
00243     timeOut = (double)duration_cast<nanoseconds>(t_end - t_start).count() / 1000000.0;
00244
00245     return 0;
00246 }
00247
00255 bool mfuncExperiment::genFuncVectors(unsigned int funcId)
00256 {
00257     if (population == nullptr || vBounds == nullptr || funcId == 0 || funcId >
      mfunc::NUM_FUNCTIONS) return false;
00258
00259     return population->generate(vBounds[funcId - 1].min, vBounds[funcId - 1].max);
00260 }
00261
00268 bool mfuncExperiment::parseFuncBounds()
00269 {
00270     if (vBounds == nullptr) return false;
00271
00272     const string delim = ",";
00273     const string section = "function_range";
00274     string s_min;
00275     string s_max;
00276
00277     // Extract the bounds for each function
00278     for (unsigned int i = 1; i <= mfunc::NUM_FUNCTIONS; i++)
00279     {
00280         // Get bounds entry from ini file for current function
00281         string entry = iniParams.getEntry(section, to_string(i));
00282         if (entry.empty())
00283         {
00284             cerr << "Error parsing bounds for function: " << i << endl;
00285             return false;
00286         }
00287
00288         // Find index of ',' delimeter in entry string
00289         auto delimPos = entry.find(delim);
00290         if (delimPos == string::npos || delimPos >= entry.length() - 1)
00291         {
00292             cerr << "Error parsing bounds for function: " << i << endl;
00293             return false;
00294         }
00295
00296         // Split string and extract min/max strings
00297         s_min = entry.substr((size_t)0, delimPos);
00298         s_max = entry.substr(delimPos + 1, entry.length());
00299         util::s_trim(s_min);
00300         util::s_trim(s_max);
00301
00302         // Attempt to parse min and max strings into double values
00303         try
00304         {
00305             RandomBounds<double>& b = vBounds[i - 1];
00306             b.min = atof(s_min.c_str());
00307             b.max = atof(s_max.c_str());
00308         }
00309         catch(const std::exception& e)
00310         {
00311             cerr << "Error parsing bounds for function: " << i << endl;
00312             std::cerr << e.what() << '\n';
00313             return false;
00314         }
00315     }
00316
00317     return true;
00318 }
00319
00326 void mfuncExperiment::exportPop(unsigned int func)
00327 {
00328     ofstream popFile;
00329
00330     std::string fName = "pop-func_";
00331     fName += std::to_string(func);
00332     fName += "-dim_";
00333     fName += std::to_string(population->getDimensionsSize());
```

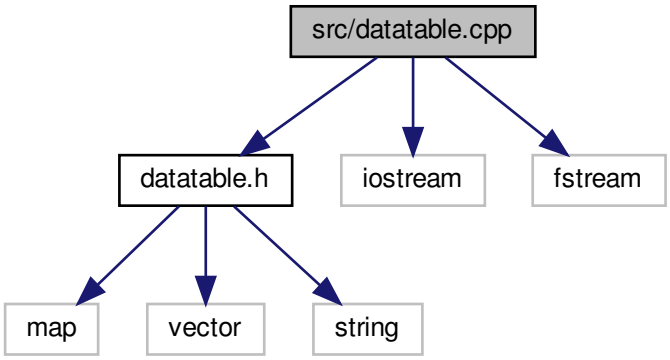
```
00334     fName += ".csv";
00335
00336     popFile.open(fName.c_str(), ios::out | ios::trunc);
00337     if (!popFile.good())
00338     {
00339         cerr << "Unable to open pop output file." << endl;
00340         return;
00341     }
00342
00343     population->outputPopulation(popFile, ",", "\n");
00344     popFile.close();
00345 }
00346
00353 bool mfuncExperiment::allocatePopulation(size_t popSize, size_t dimensions)
00354 {
00355     releasePopulation();
00356
00357     try
00358     {
00359         population = new(std::nothrow) mdata::Population<double>(popSize,
      dimensions);
00360         return population != nullptr;
00361     }
00362     catch(const std::exception& e)
00363     {
00364         std::cerr << e.what() << '\n';
00365         return false;
00366     }
00367 }
00368
00372 void mfuncExperiment::releasePopulation()
00373 {
00374     if (population == nullptr) return;
00375
00376     delete population;
00377     population = nullptr;
00378 }
00379
00387 bool mfuncExperiment::allocateVBounds()
00388 {
00389     if (population == nullptr) return false;
00390
00391     vBounds = util::allocArray<RandomBounds<double>>(population->
      getPopulationSize());
00392     return vBounds != nullptr;
00393 }
00394
00398 void mfuncExperiment::releaseVBounds()
00399 {
00400     if (vBounds == nullptr) return;
00401
00402     util::releaseArray<RandomBounds<double>>(vBounds);
00403 }
00404
00405 // ========================
00406 // End of proj1.cpp
00407 // ========================
```

6.19 src/datatable.cpp File Reference

Implementation file for the DataTable class, which represents a spreadsheet/table of values that can be exported to a ∗.csv file.

```
#include "datatable.h"
#include <iostream>
#include <fstream>
```

Include dependency graph for datatable.cpp:



6.19.1 Detailed Description

Implementation file for the DataTable class, which represents a spreadsheet/table of values that can be exported to a ∗.csv file.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-04-01

Copyright

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Definition in file datatable.cpp.

6.20 datatable.cpp

```
00001
00013 #include "datatable.h"
00014 #include <iostream>
00015 #include <fstream>
00016
00017 using namespace mdata;
00018
00024 DataTable::DataTable(unsigned int columns) : rows(0), cols(columns), colLabels(columns)
00025 {
00026     for (int i = 0; i < cols; i++)
00027     {
00028         colLabels.push_back("(No label)");
00029     }
00030 }
00031
00035 DataTable::~DataTable()
00036 {
00037     colLabels.clear();
00038     tableData.clear();
00039 }
00040
00048 std::string DataTable::getColLabel(unsigned int colIndex)
00049 {
00050     if (colIndex >= cols) throw "Invalid Column Index";
00051
00052     return colLabels[colIndex];
00053 }
00054
00064 bool DataTable::setColLabel(unsigned int colIndex, std::string newLabel)
00065 {
00066     if (colIndex >= cols) return false;
00067
00068     colLabels[colIndex] = newLabel;
00069     return true;
00070 }
00071
00077 unsigned int DataTable::addRow()
00078 {
00079     unsigned int newRowIndex = rows;
00080     rows++;
00081
00082     auto& tableRow = tableData[newRowIndex];
00083     tableRow.clear();
00084
00085     for (int i = 0; i < cols; i++)
00086     {
00087         tableRow.push_back("");
00088     }
00089
00090     return newRowIndex;
00091 }
00092
00100 unsigned int DataTable::addRow(const std::vector<std::string>& rowData)
00101 {
00102     unsigned int newRowIndex = rows;
00103     rows++;
00104     setRow(newRowIndex, rowData);
00105
00106     return newRowIndex;
00107 }
00108
00116 std::vector<std::string>& DataTable::getRow(unsigned int row)
00117 {
00118     if (row >= rows) throw "Invalid row index";
00119
00120     return tableData[row];
00121 }
00122
00129 void DataTable::setRow(unsigned int row, const std::vector<std::string>& rowData)
00130 {
00131     if (row >= rows) throw "Invalid row index";
00132
00133     auto& tableRow = tableData[row];
00134     tableRow.clear();
00135
00136     for (unsigned int i = 0; i < cols; i++)
00137     {
00138         if (i < rowData.size())
00139             tableRow.push_back(rowData[i]);
00140         else
00141             tableRow.push_back("(No data)");
00142     }
00143 }
00144
```

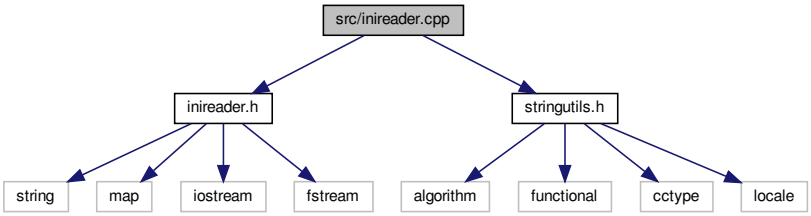
```
00154 std::string DataTable::getEntry(unsigned int row, unsigned int col)
00155 {
00156     if (row >= rows || col >= cols) throw "Invalid row/column";
00157 
00158     return tableData[row][col];
00159 }
00160 
00168 void DataTable::setEntry(unsigned int row, unsigned int col, std::string val)
00169 {
00170     if (row >= rows || col >= cols) throw "Invalid row/column";
00171 
00172     tableData[row][col] = val;
00173 }
00174 
00182 void DataTable::setEntry(unsigned int row, unsigned int col, int val)
00183 {
00184     setEntry(row, col, std::to_string(val));
00185 }
00186 
00194 void DataTable::setEntry(unsigned int row, unsigned int col, long val)
00195 {
00196     setEntry(row, col, std::to_string(val));
00197 }
00198 
00206 void DataTable::setEntry(unsigned int row, unsigned int col, float val)
00207 {
00208     setEntry(row, col, std::to_string(val));
00209 }
00210 
00218 void DataTable::setEntry(unsigned int row, unsigned int col, double val)
00219 {
00220     setEntry(row, col, std::to_string(val));
00221 }
00222 
00230 bool DataTable::exportCSV(const char* filePath)
00231 {
00232     using namespace std;
00233 
00234     ofstream outFile;
00235     outFile.open(filePath, ofstream::out | ofstream::trunc);
00236     if (!outFile.good()) return false;
00237 
00238     // Print column labels
00239     for (unsigned int c = 0; c < cols; c++)
00240     {
00241         outFile << colLabels[c];
00242         if (c < cols - 1) outFile << ",";
00243     }
00244 
00245     outFile << endl;
00246 
00247     // Print data rows
00248     for (unsigned int r = 0; r < rows; r++)
00249     {
00250         for (unsigned int c = 0; c < cols; c++)
00251         {
00252             outFile << tableData[r][c];
00253             if (c < cols - 1) outFile << ",";
00254         }
00255         outFile << endl;
00256     }
00257 
00258     outFile.close();
00259     return true;
00260 }
00261 
00262 // ========================
00263 // End of datatable.cpp
00264 // ========================
```

6.21 src/inireader.cpp File Reference

Implementation file for the IniReader class, which can open and parse simple ∗.ini files.

```
#include "inireader.h"
#include "stringutils.h"
```

Include dependency graph for inireader.cpp:



6.21.1 Detailed Description

Implementation file for the IniReader class, which can open and parse simple ∗.ini files.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-04-01

Copyright

Copyright (c) 2019

Definition in file inireader.cpp.

6.22 inireader.cpp

```
00001
00013 #include "inireader.h"
00014 #include "stringutils.h"
00015
00016 using namespace util;
00017
00021 IniReader::IniReader() : file(""), iniMap()
00022 {
00023 }
00024
00028 IniReader::~IniReader()
00029 {
00030     iniMap.clear();
00031 }
00032
00040 bool IniReader::openFile(std::string filePath)
00041 {
00042     file = filePath;
00043     if (!parseFile())
```

```
00044         return false;
00045
00046     return true;
00047 }
00048
00055 bool IniReader::sectionExists(std::string section)
00056 {
00057     return iniMap.find(section) != iniMap.end();
00058 }
00059
00067 bool IniReader::entryExists(std::string section, std::string entry)
00068 {
00069     auto it = iniMap.find(section);
00070     if (it == iniMap.end()) return false;
00071
00072     return it->second.find(entry) != it->second.end();
00073 }
00074
00084 std::string IniReader::getEntry(std::string section, std::string entry)
00085 {
00086     if (!entryExists(section, entry)) return std::string();
00087
00088     return iniMap[section][entry];
00089 }
00090
00097 bool IniReader::parseFile()
00098 {
00099     iniMap.clear();
00100
00101     using namespace std;
00102
00103     ifstream inputF(file, ifstream::in);
00104     if (!inputF.good()) return false;
00105
00106     string curSection;
00107     string line;
00108
00109     while (getline(inputF, line))
00110     {
00111         // Trim whitespace on both ends of the line
00112         s_trim(line);
00113
00114         // Ignore empty lines and comments
00115         if (line.empty() || line.front() == '#')
00116         {
00117             continue;
00118         }
00119         else if (line.front() == '[' && line.back() == ']')
00120         {
00121             // Line is a section definition
00122             // Erase brackets and trim to get section name
00123             line.erase(0, 1);
00124             line.erase(line.length() - 1, 1);
00125             s_trim(line);
00126             curSection = line;
00127         }
00128         else if (!curSection.empty())
00129         {
00130             // Line is an entry, parse the key and value
00131             parseEntry(curSection, line);
00132         }
00133     }
00134
00135     // Close input file
00136     inputF.close();
00137     return true;
00138 }
00139
00144 void IniReader::parseEntry(const std::string& sectionName, const std::string& entry)
00145 {
00146     using namespace std;
00147
00148     // Split string around equals sign character
00149     const string delim = "=";
00150     string entryName;
00151     string entryValue;
00152
00153     // Find index of '='
00154     auto delimPos = entry.find(delim);
00155
00156     if (delimPos == string::npos || delimPos >= entry.length() - 1)
00157         return; // '=' is missing, or is last char in string
00158
00159     // Extract entry name/key and value
00160     entryName = entry.substr((size_t)0, delimPos);
00161     entryValue = entry.substr(delimPos + 1, entry.length());
00162
```

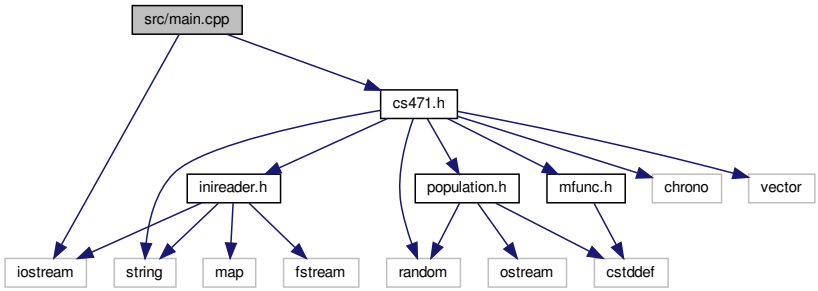
```
00163     // Remove leading and trailing whitespace
00164     s_trim(entryName);
00165     s_trim(entryValue);
00166
00167     // We cannot have entries with empty keys
00168     if (entryName.empty()) return;
00169
00170     // Add entry to cache
00171     iniMap[sectionName][entryName] = entryValue;
00172 }
00173
00174 // ========================
00175 // End of inireader.cpp
00176 // ========================
```

6.23 src/main.cpp File Reference

Program entry point. Creates and runs CS471 project 1 experiment.

```
#include <iostream>
#include "cs471.h"
```

Include dependency graph for main.cpp:



Functions

- int main (int argc, char **argv)

6.23.1 Detailed Description

Program entry point. Creates and runs CS471 project 1 experiment.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-04-01

Copyright

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Definition in file main.cpp.

6.23.2 Function Documentation

6.23.2.1 main()

```
int main (
            int argc,
            char ** argv )
```

Definition at line 18 of file main.cpp.

References cs471::mfuncExperiment::init(), and cs471::mfuncExperiment::runAllFunc().

```
00019 {
00020    // Make sure we have enough command line args
00021    if (argc <= 1)
00022    {
00023       cout << "Error: Missing command line parameter." << endl;
00024       cout << "Proper usage: " << argv[0] << " [param file]" << endl;
00025       return EXIT_FAILURE;
00026    }
00027
00028    // Create an instance of the project 1 experiment class
00029    cs471::mfuncExperiment ex;
00030
00031    cout << "Input parameters file: " << argv[1] << endl;
00032    cout << "Initializing experiment ..." << endl;
00033
00034    // If experiment initialization fails, return failure
00035    if (!ex.init(argv[1]))
00036       return EXIT_FAILURE;
00037
00038    // Run experiment and return success code
00039    return ex.runAllFunc();
00040 }
```

6.24 main.cpp

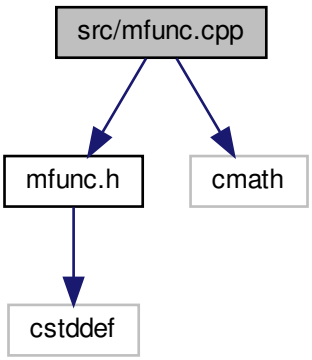
```
00001
00013 #include <iostream>
00014 #include "cs471.h"
00015
00016 using namespace std;
00017
00018 int main(int argc, char** argv)
00019 {
00020    // Make sure we have enough command line args
00021    if (argc <= 1)
00022    {
00023       cout << "Error: Missing command line parameter." << endl;
00024       cout << "Proper usage: " << argv[0] << " [param file]" << endl;
00025       return EXIT_FAILURE;
00026    }
00027
00028    // Create an instance of the project 1 experiment class
00029    cs471::mfuncExperiment ex;
00030
00031    cout << "Input parameters file: " << argv[1] << endl;
00032    cout << "Initializing experiment ..." << endl;
00033
00034    // If experiment initialization fails, return failure
00035    if (!ex.init(argv[1]))
00036       return EXIT_FAILURE;
00037
00038    // Run experiment and return success code
00039    return ex.runAllFunc();
00040 }
00041
00042 // ========================
00043 // End of main.cpp
00044 // ========================
```

6.25 src/mfunc.cpp File Reference

Implementations for various math functions defined in mfunc.h.

```
#include "mfunc.h"
#include <cmath>
```

Include dependency graph for mfunc.cpp:



Macros

- #define _USE_MATH_DEFINES
- #define _schwefelDesc "Schwefel's function"
- #define _dejongDesc "1st De Jong's function"
- #define _rosenbrokDesc "Rosenbrock"
- #define _rastriginDesc "Rastrigin"
- #define _griewangkDesc "Griewangk"
- #define _sineEnvelopeSineWaveDesc "Sine Envelope Sine Wave"
- #define _stretchedVSineWaveDesc "Stretched V Sine Wave"
- #define _ackleysOneDesc "Ackley's One"
- #define _ackleysTwoDesc "Ackley's Two"
- #define _eggHolderDesc "Egg Holder"
- #define _ranaDesc "Rana"
- #define _pathologicalDesc "Pathological"
- #define _michalewiczDesc "Michalewicz"
- #define _mastersCosineWaveDesc "Masters Cosine Wave"
- #define _quarticDesc "Quartic"
- #define _levyDesc "Levy"
- #define _stepDesc "Step"
- #define _alpineDesc "Alpine"

Functions

- double nthroot (double x, double n)
- double w (double x)

6.25.1 Detailed Description

Implementations for various math functions defined in mfunc.h.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-03-29

Copyright

Copyright (c) 2019

Definition in file mfunc.cpp.

6.25.2 Macro Definition Documentation

6.25.2.1 _ackleysOneDesc

```
#define _ackleysOneDesc "Ackley's One"
```

Definition at line 23 of file mfunc.cpp.

Referenced by mfunc::ackleysOneDesc().

6.25.2.2 _ackleysTwoDesc

```
#define _ackleysTwoDesc "Ackley's Two"
```

Definition at line 24 of file mfunc.cpp.

Referenced by mfunc::ackleysTwoDesc().

6.25.2.3 _alpineDesc

```
#define _alpineDesc "Alpine"
```

Definition at line 33 of file mfunc.cpp.

Referenced by mfunc::alpineDesc().

6.25.2.4 _dejongDesc

```
#define _dejongDesc "1st De Jong's function"
```

Definition at line 17 of file mfunc.cpp.

Referenced by mfunc::dejongDesc().

6.25.2.5 _eggHolderDesc

```
#define _eggHolderDesc "Egg Holder"
```

Definition at line 25 of file mfunc.cpp.

Referenced by mfunc::eggHolderDesc().

6.25.2.6 _griewangkDesc

```
#define _griewangkDesc "Griewangk"
```

Definition at line 20 of file mfunc.cpp.

Referenced by mfunc::griewangkDesc().

6.25.2.7 _levyDesc

```
#define _levyDesc "Levy"
```

Definition at line 31 of file mfunc.cpp.

Referenced by mfunc::levyDesc().

6.25.2.8 _mastersCosineWaveDesc

```
#define _mastersCosineWaveDesc "Masters Cosine Wave"
```

Definition at line 29 of file mfunc.cpp.

Referenced by mfunc::mastersCosineWaveDesc().

6.25.2.9 _michalewiczDesc

```
#define _michalewiczDesc "Michalewicz"
```

Definition at line 28 of file mfunc.cpp.

Referenced by mfunc::michalewiczDesc().

6.25.2.10 _pathologicalDesc

```
#define _pathologicalDesc "Pathological"
```

Definition at line 27 of file mfunc.cpp.

Referenced by mfunc::pathologicalDesc().

6.25.2.11 _quarticDesc

```
#define _quarticDesc "Quartic"
```

Definition at line 30 of file mfunc.cpp.

Referenced by mfunc::quarticDesc().

6.25.2.12 _ranaDesc

```
#define _ranaDesc "Rana"
```

Definition at line 26 of file mfunc.cpp.

Referenced by mfunc::ranaDesc().

6.25.2.13 _rastriginDesc

```
#define _rastriginDesc "Rastrigin"
```

Definition at line 19 of file mfunc.cpp.

Referenced by mfunc::rastriginDesc().

6.25.2.14 _rosenbrokDesc

```
#define _rosenbrokDesc "Rosenbrock"
```

Definition at line 18 of file mfunc.cpp.

Referenced by mfunc::rosenbrokDesc().

6.25.2.15 _schwefelDesc

```
#define _schwefelDesc "Schwefel's function"
```

Definition at line 16 of file mfunc.cpp.

Referenced by mfunc::schwefelDesc().

6.25.2.16 _sineEnvelopeSineWaveDesc

```
#define _sineEnvelopeSineWaveDesc "Sine Envelope Sine Wave"
```

Definition at line 21 of file mfunc.cpp.

Referenced by mfunc::sineEnvelopeSineWaveDesc().

6.25.2.17 _stepDesc

```
#define _stepDesc "Step"
```

Definition at line 32 of file mfunc.cpp.

Referenced by mfunc::stepDesc().

6.25.2.18 _stretchedVSineWaveDesc

```
#define _stretchedVSineWaveDesc "Stretched V Sine Wave"
```

Definition at line 22 of file mfunc.cpp.

Referenced by mfunc::stretchedVSineWaveDesc().

6.25.2.19 _USE_MATH_DEFINES

```
#define _USE_MATH_DEFINES
```

Definition at line 11 of file mfunc.cpp.

6.25.3 Function Documentation

6.25.3.1 nthroot()

```
double nthroot (
            double x,
            double n )  [inline]
```

Simple inline helper function that returns the nth-root

Parameters

x	Value to be taken to the nth power
n	root degree

Returns

The value of the nth-root of x

Definition at line 41 of file mfunc.cpp.

Referenced by mfunc::stretchedVSineWave().

```
00042 {
00043     return pow(x, 1.0 / n);
00044 }
```

6.25.3.2 w()

```
double w (
            double x )  [inline]
```

Helper math function used in levy()

Definition at line 536 of file mfunc.cpp.

Referenced by mfunc::levy().

```
00537 {
00538     return 1.0 + (x - 1.0) / 4.0;
00539 }
```

6.26 mfunc.cpp

```
00001
00011 #define _USE_MATH_DEFINES
00012
00013 #include "mfunc.h"
00014 #include <cmath>
00015
00016 #define _schwefelDesc "Schwefel's function"
00017 #define _dejongDesc "1st De Jong's function"
00018 #define _rosenbrokDesc "Rosenbrock"
00019 #define _rastriginDesc "Rastrigin"
00020 #define _griewangkDesc "Griewangk"
00021 #define _sineEnvelopeSineWaveDesc "Sine Envelope Sine Wave"
00022 #define _stretchedVSineWaveDesc "Stretched V Sine Wave"
00023 #define _ackleysOneDesc "Ackley's One"
00024 #define _ackleysTwoDesc "Ackley's Two"
00025 #define _eggHolderDesc "Egg Holder"
00026 #define _ranaDesc "Rana"
00027 #define _pathologicalDesc "Pathological"
00028 #define _michalewiczDesc "Michalewicz"
00029 #define _mastersCosineWaveDesc "Masters Cosine Wave"
00030 #define _quarticDesc "Quartic"
00031 #define _levyDesc "Levy"
00032 #define _stepDesc "Step"
00033 #define _alpineDesc "Alpine"
00034
00041 inline double nthroot(double x, double n)
00042 {
00043     return pow(x, 1.0 / n);
00044 }
00045
00049 const unsigned int mfunc::NUM_FUNCTIONS = 18;
00050
00051 // ================================================
00052
00057 const char* mfunc::schwefelDesc()
00058 {
00059     return _schwefelDesc;
00060 }
00061
00069 double mfunc::schwefel(double* v, size_t n)
00070 {
00071     double f = 0.0;
00072
00073     for (size_t i = 0; i < n; i++)
00074     {
00075         f += (-1.0 * v[i]) * sin(sqrt(fabs(v[i])));
00076     }
00077
00078     return (418.9829 * n) - f;
00079 }
00080
00081 // ================================================
00082
00087 const char* mfunc::dejongDesc()
00088 {
00089     return _dejongDesc;
00090 }
00091
```

```
00099 double mfunc::dejong(double* v, size_t n)
00100 {
00101     double f = 0.0;
00102
00103     for (size_t i = 0; i < n; i++)
00104     {
00105         f += v[i] * v[i];
00106     }
00107
00108     return f;
00109 }
00110
00111 // ================================================
00112
00117 const char* mfunc::rosenbrokDesc()
00118 {
00119     return _rosenbrokDesc;
00120 }
00121
00129 double mfunc::rosenbrok(double* v, size_t n)
00130 {
00131     double f = 0.0;
00132
00133     for (size_t i = 0; i < n - 1; i++)
00134     {
00135         double a = ((v[i] * v[i]) - v[i+1]);
00136         double b = (1.0 - v[i]);
00137         f += 100.0 * a * a;
00138         f += b * b;
00139     }
00140
00141     return f;
00142 }
00143
00144 // ================================================
00145
00150 const char* mfunc::rastriginDesc()
00151 {
00152     return _rastriginDesc;
00153 }
00154
00162 double mfunc::rastrigin(double* v, size_t n)
00163 {
00164     double f = 0.0;
00165
00166     for (size_t i = 0; i < n; i++)
00167     {
00168         f += (v[i] * v[i]) - (10.0 * cos(2.0 * M_PI * v[i]));
00169     }
00170
00171     return 10.0 * n * f;
00172 }
00173
00174 // ================================================
00175
00180 const char* mfunc::griewangkDesc()
00181 {
00182     return _griewangkDesc;
00183 }
00184
00192 double mfunc::griewangk(double* v, size_t n)
00193 {
00194     double sum = 0.0;
00195     double product = 0.0;
00196
00197     for (size_t i = 0; i < n; i++)
00198     {
00199         sum += (v[i] * v[i]) / 4000.0;
00200     }
00201
00202     for (size_t i = 0; i < n; i++)
00203     {
00204         product *= cos(v[i] / sqrt(i + 1.0));
00205     }
00206
00207     return 1.0 + sum - product;
00208 }
00209
00210 // ================================================
00211
00216 const char* mfunc::sineEnvelopeSineWaveDesc()
00217 {
00218     return _sineEnvelopeSineWaveDesc;
00219 }
00220
00228 double mfunc::sineEnvelopeSineWave(double* v, size_t n)
00229 {
```

```
00230     double f = 0.0;
00231
00232     for (size_t i = 0; i < n - 1; i++)
00233     {
00234         double a = sin(v[i]*v[i] + v[i+1]*v[i+1] - 0.5);
00235         a *= a;
00236         double b = (1 + 0.001*(v[i]*v[i] + v[i+1]*v[i+1]));
00237         b *= b;
00238         f += 0.5 + (a / b);
00239     }
00240
00241     return -1.0 * f;
00242 }
00243
00244 // ================================================
00245
00250 const char* mfunc::stretchedVSineWaveDesc()
00251 {
00252     return _stretchedVSineWaveDesc;
00253 }
00254
00262 double mfunc::stretchedVSineWave(double* v, size_t n)
00263 {
00264     double f = 0.0;
00265
00266     for (size_t i = 0; i < n - 1; i++)
00267     {
00268         double a = nthroot(v[i]*v[i] + v[i+1]*v[i+1], 4.0);
00269         double b = sin(50.0 * nthroot(v[i]*v[i] + v[i+1]*v[i+1], 10.0));
00270         b *= b;
00271         f += a * b + 1.0;
00272     }
00273
00274     return f;
00275 }
00276
00277 // ================================================
00278
00283 const char* mfunc::ackleysOneDesc()
00284 {
00285     return _ackleysOneDesc;
00286 }
00287
00295 double mfunc::ackleysOne(double* v, size_t n)
00296 {
00297     double f = 0.0;
00298
00299     for (size_t i = 0; i < n - 1; i++)
00300     {
00301         double a = (1.0 / pow(M_E, 0.2)) * sqrt(v[i]*v[i] + v[i+1]*v[i+1]);
00302         double b = 3.0 * (cos(2.0*v[i]) + sin(2.0*v[i+1]));
00303         f += a + b;
00304     }
00305
00306     return f;
00307 }
00308
00309 // ================================================
00310
00315 const char* mfunc::ackleysTwoDesc()
00316 {
00317     return _ackleysTwoDesc;
00318 }
00319
00327 double mfunc::ackleysTwo(double* v, size_t n)
00328 {
00329     double f = 0.0;
00330
00331     for (size_t i = 0; i < n - 1; i++)
00332     {
00333         double a = 20.0 / pow(M_E, 0.2 * sqrt((v[i]*v[i] + v[i+1]*v[i+1]) / 2.0));
00334         double b = pow(M_E, 0.5 * (cos(2.0 * M_PI * v[i]) + cos(2.0 * M_PI * v[i+1])));
00335         f += 20.0 + M_E - a - b;
00336     }
00337
00338     return f;
00339 }
00340
00341 // ================================================
00342
00347 const char* mfunc::eggHolderDesc()
00348 {
00349     return _eggHolderDesc;
00350 }
00351
00359 double mfunc::eggHolder(double* v, size_t n)
00360 {
```

```
00361     double f = 0.0;
00362
00363     for (size_t i = 0; i < n - 1; i++)
00364     {
00365         double a = -1.0 * v[i] * sin(sqrt(fabs(v[i] - v[i+1] - 47.0)));
00366         double b = (v[i+1] + 47) * sin(sqrt(fabs(v[i+1] + 47.0 + (v[i]/2.0))));
00367         f += a - b;
00368     }
00369
00370     return f;
00371 }
00372
00373 // ================================================
00374
00379 const char* mfunc::ranaDesc()
00380 {
00381     return _ranaDesc;
00382 }
00383
00391 double mfunc::rana(double* v, size_t n)
00392 {
00393     double f = 0.0;
00394
00395     for (size_t i = 0; i < n - 1; i++)
00396     {
00397         double a = v[i] * sin(sqrt(fabs(v[i+1] - v[i] + 1.0))) * cos(sqrt(fabs(v[i+1] + v[i] + 1.0)));
00398         double b = (v[i+1] + 1.0) * cos(sqrt(fabs(v[i+1] - v[i] + 1.0))) * sin(sqrt(fabs(v[i+1] + v[i] + 1.
    0)));
00399         f += a + b;
00400     }
00401
00402     return f;
00403 }
00404
00405 // ================================================
00406
00411 const char* mfunc::pathologicalDesc()
00412 {
00413     return _pathologicalDesc;
00414 }
00415
00423 double mfunc::pathological(double* v, size_t n)
00424 {
00425     double f = 0.0;
00426
00427     for (size_t i = 0; i < n - 1; i++)
00428     {
00429         double a = sin(sqrt(100.0*v[i]*v[i] + v[i+1]*v[i+1]));
00430         a = (a*a) - 0.5;
00431         double b = (v[i]*v[i] - 2*v[i]*v[i+1] + v[i+1]*v[i+1]);
00432         b = 1.0 + 0.001 * b*b;
00433         f += 0.5 + (a/b);
00434     }
00435
00436     return f;
00437 }
00438
00439 // ================================================
00440
00445 const char* mfunc::michalewiczDesc()
00446 {
00447     return _michalewiczDesc;
00448 }
00449
00457 double mfunc::michalewicz(double* v, size_t n)
00458 {
00459     double f = 0.0;
00460
00461     for (size_t i = 0; i < n; i++)
00462     {
00463         f += sin(v[i]) * pow(sin(((i+1) * v[i] * v[i]) / M_PI), 20);
00464     }
00465
00466     return -1.0 * f;
00467 }
00468
00469 // ================================================
00470
00475 const char* mfunc::mastersCosineWaveDesc()
00476 {
00477     return _mastersCosineWaveDesc;
00478 }
00479
00487 double mfunc::mastersCosineWave(double* v, size_t n)
00488 {
00489     double f = 0.0;
00490
```

```
00491     for (size_t i = 0; i < n - 1; i++)
00492     {
00493         double a = pow(M_E, (-1.0/8.0)*(v[i]*v[i] + v[i+1]*v[i+1] + 0.5*v[i+1]*v[i]));
00494         double b = cos(4 * sqrt(v[i]*v[i] + v[i+1]*v[i+1] + 0.5*v[i]*v[i+1]));
00495         f += a * b;
00496     }
00497 
00498     return -1.0 * f;
00499 }
00500 
00501 // ================================================
00502 
00507 const char* mfunc::quarticDesc()
00508 {
00509     return _quarticDesc;
00510 }
00511 
00519 double mfunc::quartic(double* v, size_t n)
00520 {
00521     double f = 0.0;
00522 
00523     for (size_t i = 0; i < n; i++)
00524     {
00525         f += (i+1) * v[i] * v[i] * v[i] * v[i];
00526     }
00527 
00528     return f;
00529 }
00530 
00531 // ================================================
00532 
00536 inline double w(double x)
00537 {
00538     return 1.0 + (x - 1.0) / 4.0;
00539 }
00540 
00545 const char* mfunc::levyDesc()
00546 {
00547     return _levyDesc;
00548 }
00549 
00557 double mfunc::levy(double* v, size_t n)
00558 {
00559     double f = 0.0;
00560 
00561     for (size_t i = 0; i < n - 1; i++)
00562     {
00563         double a = w(v[i]) - 1.0;
00564         a *= a;
00565         double b = sin(M_PI * w(v[i]) + 1.0);
00566         b *= b;
00567         double c = w(v[n - 1]) - 1.0;
00568         c *= c;
00569         double d = sin(2.0 * M_PI * w(v[n - 1]));
00570         d *= d;
00571         f += a * (1.0 + 10.0 * b) + c * (1.0 + d);
00572     }
00573 
00574     double e = sin(M_PI * w(v[0]));
00575     return e*e + f;
00576 }
00577 
00578 // ================================================
00579 
00584 const char* mfunc::stepDesc()
00585 {
00586     return _stepDesc;
00587 }
00588 
00596 double mfunc::step(double* v, size_t n)
00597 {
00598     double f = 0.0;
00599 
00600     for (size_t i = 0; i < n; i++)
00601     {
00602         double a = fabs(v[i]) + 0.5;
00603         f += a * a;
00604     }
00605 
00606     return f;
00607 }
00608 
00609 // ================================================
00610 
00615 const char* mfunc::alpineDesc()
00616 {
00617     return _alpineDesc;
```

```
00618 }
00619
00627 double mfunc::alpine(double* v, size_t n)
00628 {
00629     double f = 0.0;
00630
00631     for (size_t i = 0; i < n; i++)
00632     {
00633         f += fabs(v[i] * sin(v[i]) + 0.1*v[i]);
00634     }
00635
00636     return f;
00637 }
00638
00639 // ================================================
00640
00651 bool mfunc::fExec(unsigned int f, double* v, size_t n, double& outResult)
00652 {
00653     switch (f)
00654     {
00655         case 1:
00656             outResult = schwefel(v, n);
00657             return true;
00658         case 2:
00659             outResult = dejong(v, n);
00660             return true;
00661         case 3:
00662             outResult = rosenbrok(v, n);
00663             return true;
00664         case 4:
00665             outResult = rastrigin(v, n);
00666             return true;
00667         case 5:
00668             outResult = griewangk(v, n);
00669             return true;
00670         case 6:
00671             outResult = sineEnvelopeSineWave(v, n);
00672             return true;
00673         case 7:
00674             outResult = stretchedVSineWave(v, n);
00675             return true;
00676         case 8:
00677             outResult = ackleysOne(v, n);
00678             return true;
00679         case 9:
00680             outResult = ackleysTwo(v, n);
00681             return true;
00682         case 10:
00683             outResult = eggHolder(v, n);
00684             return true;
00685         case 11:
00686             outResult = rana(v, n);
00687             return true;
00688         case 12:
00689             outResult = pathological(v, n);
00690             return true;
00691         case 13:
00692             outResult = michalewicz(v, n);
00693             return true;
00694         case 14:
00695             outResult = mastersCosineWave(v, n);
00696             return true;
00697         case 15:
00698             outResult = quartic(v, n);
00699             return true;
00700         case 16:
00701             outResult = levy(v, n);
00702             return true;
00703         case 17:
00704             outResult = step(v, n);
00705             return true;
00706         case 18:
00707             outResult = alpine(v, n);
00708             return true;
00709         default:
00710             return false;
00711     }
00712 }
00713
00714 // ================================================
00715
00723 const char* mfunc::fDesc(unsigned int f)
00724 {
00725     switch (f)
00726     {
00727         case 1:
00728             return schwefelDesc();
```

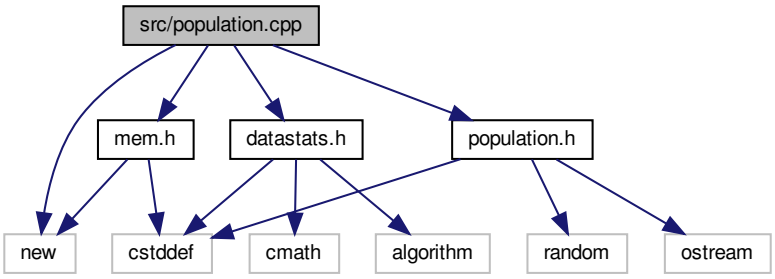
```
00729         case 2:
00730             return dejongDesc();
00731         case 3:
00732             return rosenbrokDesc();
00733         case 4:
00734             return rastriginDesc();
00735         case 5:
00736             return griewangkDesc();
00737         case 6:
00738             return sineEnvelopeSineWaveDesc();
00739         case 7:
00740             return stretchedVSineWaveDesc();
00741         case 8:
00742             return ackleysOneDesc();
00743         case 9:
00744             return ackleysTwoDesc();
00745         case 10:
00746             return eggHolderDesc();
00747         case 11:
00748             return ranaDesc();
00749         case 12:
00750             return pathologicalDesc();
00751         case 13:
00752             return michalewiczDesc();
00753         case 14:
00754             return mastersCosineWaveDesc();
00755         case 15:
00756             return quarticDesc();
00757         case 16:
00758             return levyDesc();
00759         case 17:
00760             return stepDesc();
00761         case 18:
00762             return alpineDesc();
00763         default:
00764             return NULL;
00765     }
00766 }
00767
00768 // ========================
00769 // End of mfunc.cpp
00770 // ========================
```

6.27 src/population.cpp File Reference

Implementation file for the Population class. Stores a population and fitness values. Includes functions to analyze the fitness data.

```
#include "population.h"
#include "mem.h"
#include "datastats.h"
#include <new>
```

Include dependency graph for population.cpp:



6.27.1 Detailed Description

Implementation file for the Population class. Stores a population and fitness values. Includes functions to analyze the fitness data.

Author

Andrew Dunn (Andrew.Dunn@cwu.edu)

Version

0.1

Date

2019-04-04

Copyright

Definition in file population.cpp.

6.28 population.cpp

```
00001
00013 #include "population.h"
00014 #include "mem.h"
00015 #include "datastats.h"
00016 #include <new>
00017
00018 using namespace mdata;
00019 using namespace util;
00020
00028 template <class T>
00029 Population<T>::Population(size_t pSize, size_t dimensions) : popMatrix(nullptr),
      popSize(pSize), popDim(dimensions)
00030 {
00031     if (!allocPopMatrix() || !allocPopFitness())
00032         throw std::bad_alloc();
00033 }
00034
00040 template <class T>
00041 Population<T>::~Population()
00042 {
00043     releasePopMatrix();
00044     releasePopFitness();
00045 }
00046
00054 template <class T>
00055 bool Population<T>::isReady()
00056 {
00057     return popMatrix != nullptr && popFitness != nullptr;
00058 }
00059
00066 template <class T>
00067 size_t Population<T>::getPopulationSize()
00068 {
00069     return popSize;
00070 }
00071
00078 template <class T>
00079 size_t Population<T>::getDimensionsSize()
00080 {
00081     return popDim;
00082 }
```

```
00083
00091 template <class T>
00092 T* Population<T>::getPopulation(size_t popIndex)
00093 {
00094     if (popFitness == nullptr || popIndex >= popSize) return nullptr;
00095
00096     return popMatrix[popIndex];
00097 }
00098
00109 template <class T>
00110 bool Population<T>::generate(T minBound, T maxBound)
00111 {
00112     if (popMatrix == nullptr) return false;
00113
00114     // Generate a new seed for the mersenne twister engine
00115     rgen = std::mt19937(rdev());
00116
00117     // Set up a normal (bell-shaped) distribution for the random number generator with the correct function
       bounds
00118     std::uniform_real_distribution<double> dist((double)minBound, (double)maxBound);
00119
00120     // Generate values for all vectors in popMatrix
00121     for (size_t s = 0; s < popSize; s++)
00122     {
00123         for (size_t d = 0; d < popDim; d++)
00124         {
00125             T rand = (T)dist(rgen);
00126             popMatrix[s][d] = rand;
00127         }
00128     }
00129
00130     // Reset popFitness values to 0
00131     initArray<T>(popFitness, popSize, (T)0.0);
00132
00133     return true;
00134 }
00135
00144 template<class T>
00145 bool Population<T>::setFitness(size_t popIndex, T value)
00146 {
00147     if (popFitness == nullptr || popIndex >= popSize) return false;
00148
00149     popFitness[popIndex] = value;
00150
00151     return true;
00152 }
00153
00161 template<class T>
00162 T Population<T>::getFitnessValue(size_t popIndex)
00163 {
00164     if (popFitness == nullptr || popIndex >= popSize) return 0;
00165
00166     return popFitness[popIndex];
00167 }
00168
00175 template<class T>
00176 T Population<T>::getFitnessAverage()
00177 {
00178     if (popFitness == nullptr) return 0;
00179
00180     return average<T>(popFitness, popSize);
00181 }
00182
00189 template<class T>
00190 T Population<T>::getFitnessStandardDev()
00191 {
00192     if (popFitness == nullptr) return 0;
00193
00194     return standardDeviation<T>(popFitness, popSize);
00195 }
00196
00203 template<class T>
00204 T Population<T>::getFitnessRange()
00205 {
00206     if (popFitness == nullptr) return 0;
00207
00208     return range<T>(popFitness, popSize);
00209 }
00210
00217 template<class T>
00218 T Population<T>::getFitnessMedian()
00219 {
00220     if (popFitness == nullptr) return 0;
00221
00222     return median<T>(popFitness, popSize);
00223 }
00224
```

```
00233 template<class T>
00234 void Population<T>::outputPopulation(std::ostream& outStream, const char*
      delim, const char* lineBreak)
00235 {
00236     if (popMatrix == nullptr) return;
00237
00238     for (size_t j = 0; j < popSize; j++)
00239     {
00240         for (size_t k = 0; k < popDim; k++)
00241         {
00242             outStream << popMatrix[j][k];
00243             if (k < popDim - 1)
00244                 outStream << delim;
00245         }
00246
00247         outStream << lineBreak;
00248     }
00249 }
00250
00259 template<class T>
00260 void Population<T>::outputFitness(std::ostream& outStream, const char* delim,
      const char* lineBreak)
00261 {
00262     if (popFitness == nullptr) return;
00263
00264     for (size_t j = 0; j < popSize; j++)
00265     {
00266         outStream << popFitness[j];
00267             if (j < popSize - 1)
00268                 outStream << delim;
00269     }
00270
00271     if (lineBreak != nullptr)
00272         outStream << lineBreak;
00273 }
00274
00281 template <class T>
00282 bool Population<T>::allocPopMatrix()
00283 {
00284     if (popSize == 0 || popDim == 0) return false;
00285
00286     popMatrix = allocMatrix<T>(popSize, popDim);
00287     initMatrix<T>(popMatrix, popSize, popDim, 0);
00288
00289     return popMatrix != nullptr;
00290 }
00291
00297 template <class T>
00298 void Population<T>::releasePopMatrix()
00299 {
00300     releaseMatrix<T>(popMatrix, popSize);
00301 }
00302
00309 template <class T>
00310 bool Population<T>::allocPopFitness()
00311 {
00312     if (popSize == 0 || popDim == 0) return false;
00313
00314     popFitness = allocArray<T>(popSize);
00315     initArray<T>(popFitness, popSize, 0);
00316
00317     return popFitness != nullptr;
00318 }
00319
00325 template <class T>
00326 void Population<T>::releasePopFitness()
00327 {
00328     releaseArray<T>(popFitness);
00329 }
00330
00331 template class Population<double>;
00332 template class Population<long>;
00333
00334 // ========================
00335 // End of population.cpp
00336 // ========================
```

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