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Chapter 1

RIT MKS Fault Detection Library

This C++ library was developed by the Multi-Agent BioRobotics Laboratory (MABL) at Rochester Institute of Technology (RIT) in collaboration with MKS Instruments and the MKS ENI Products division.

This library is an implementation of a fault detection library for RF Power Generators. The library provides functionality of a one-class classifier that uses Mixture of Gaussians to identify time-series system signatures as normal or faulty. The code was developed in compliance with MKS embedded requirements. No external third-party libraries were used and C++ 98 compiler standard were used. All required matrix operations and other non-fundamental mathematical operations/algorithms have been implemented.

Through the use of pre-processor definitions the library may be used within linux and windows based operating systems. Based on computational power of the target platform, matrix precision may be represented as float or double precision. Focus of the documentation is for a target platform that is linux-based.

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Date

2013-2015

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Chapter 2

Class Documentation

2.1 ftd::Array Class Reference

Container object for array of real values.

#include <Array.h>

Inheritance diagram for ftd::Array:

```
ftd::Array
   └── ftd::ComplexArray
```

Public Member Functions

- **Array (int size)**
  Constructor. Empty Array object with specified size.
- **Array (int size, data_type *data)**
  Constructor. Set values.
- **Array (const Array &c)**
  Copy Constructor.
- virtual ~Array ()
  Destructor.
- **data_type at (int index) const**
  Retrieve value in array at specified index.
- **int getSize (void) const**
  Return the number of elements in the array.

Protected Member Functions

- **Array ()**
  Default Constructor. Empty array, no size.
Protected Attributes

- data_type * data
  
  Pointer to storage of real values.

- int size
  
  Number of elements in the Array object.

Friends

- class ComplexArray
  
  Friend class ComplexArray.

2.1.1 Detailed Description

Container object for array of real values.

Container object to hold contents of an array of real numbers. Intended for use of insertion and fetch from Matrix objects.

2.1.2 Constructor & Destructor Documentation

2.1.2.1 Array::Array ( int size )

Constructor, Empty Array object with specified size.

Parameters

<table>
<thead>
<tr>
<th>size</th>
<th>Desired number of elements in array object.</th>
</tr>
</thead>
</table>

2.1.2.2 Array::Array ( int size, data_type * data )

Constructor, Set values.

Parameters

<table>
<thead>
<tr>
<th>size</th>
<th>Number of elements to place in array.</th>
</tr>
</thead>
<tbody>
<tr>
<td>data</td>
<td>Values to store in the array, must be length of size.</td>
</tr>
</tbody>
</table>

Warning

Copies values pointed to, does not free data. Memory management must be done outside scope of constructor call.

2.1.2.3 Array::Array ( const Array & c )

Copy Constructor.
2.2 ftd::Complex Struct Reference

Parameters

| c | Array to be copied. |

2.1.3 Member Function Documentation

2.1.3.1 data_type ftd::Array::at ( int index ) const [inline]
Retrieve value in array at specified index.
Parameters

| index | Index of the item to be retrieved (0 based). |

Returns

Value at specified index

2.1.3.2 int Array::getSize ( void ) const
Return the number of elements in the array.
Returns

number of elements in the array.

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

- Array.h
- Array.cpp

2.2 ftd::Complex Struct Reference

Structure for complex number representation.

#include <Array.h>

Public Member Functions

- Complex (data_type real, data_type img)
  Constructor.
- Complex operator* (Complex c)
  Multiplication operation overloaded.

Public Attributes

- data_type img
  Imaginary component of complex number.
- data_type real
  Real component of complex number.
2.2.1 Detailed Description

Structure for complex number representation.

2.2.2 Constructor & Destructor Documentation

2.2.2.1 ftd::Complex::Complex (data_type real, data_type img) [inline]

Constructor.

Parameters

<table>
<thead>
<tr>
<th>real</th>
<th>Real value of complex number.</th>
</tr>
</thead>
<tbody>
<tr>
<td>img</td>
<td>Imaginary value of complex number.</td>
</tr>
</tbody>
</table>

2.2.3 Member Function Documentation

2.2.3.1 Complex ftd::Complex::operator*(Complex c) [inline]

Multiplication operation overloaded.

Implement complex multiplication of two complex numbers.

Parameters

| c     | Structure of complex number to multiply existing complex number with. |

Returns

Copy of the result of the complex multiplication.

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

- Array.h

2.3 ftd::ComplexArray Class Reference

Container object for array of real or complex values.

#include <Array.h>

Inheritance diagram for ftd::ComplexArray:

```
ftd::Array

ftd::ComplexArray
```

Public Member Functions

- ComplexArray (int size)
Constructor, Empty container with specified size.

- **ComplexArray** (int size, data_type *real, data_type *img)
  Constructor. Set values.
- **ComplexArray** (int size, data_type *real)
  Constructor, copy real values from memory specified by pointer.
- **ComplexArray** (const ComplexArray &c)
- **ComplexArray** (const Array &arr)
  Constructor, copy real values from existing Array.
- virtual ~ComplexArray ()
  Destructor.
- data_type at (int index) const
  Retrieve value in array at specified index.
- int getSize (void) const
  Return the number of elements in the array.
- ComplexArray & operator= (const ComplexArray &c)
  Assignment operator overloaded.
- void padZeros (int n)
  Pads array with zeros at end.
- void trunc (int n)
  Truncate array to specified size.

Protected Attributes

- data_type * data
  Pointer to storage of real values.
- int size
  Number of elements in the Array object.

Friends

- class ComplexMatrix
  Friend class ComplexMatrix.
- void fft (ComplexArray &c)
  Friend function fft, performs FFT on ComplexArray.
- ComplexArray fft_pad (const ComplexArray &)
  Friend function fft_pad performs FFT on ComplexArray; padding first.

2.3.1 Detailed Description

Container object for array of real or complex values.

Container object to hold contents of an array of real or complex numbers. Intended for use of insertion and fetch from Matrix objects. Also, created for ease for implementation of FFT.

2.3.2 Constructor & Destructor Documentation

2.3.2.1 ComplexArray::ComplexArray ( int size )

Constructor, Empty container with specified size.
Parameters

| size | Number of elements to initialize. |

2.3.2.2 ComplexArray::ComplexArray ( int size, data_type * real, data_type * img )

Constructor, Set values.
Copies real and imaginary values from locations specified by input pointers.

Parameters

| size | Number of complex elements to place in array. |
| real | Pointer to memory where real values are stored. |
| img  | Pointer to memory where complex values are stored. |

Warning
Copies values pointed to, does not free data. Memory management must be done outside scope of constructor call.

2.3.2.3 ComplexArray::ComplexArray ( int size, data_type * real )

Constructor, copy real values from memory specified by pointer.
Real values are copied into new ComplexArray, and imaginary values are initialized to 0.

Parameters

| size | Number of real values in memory to copy. |
| real | Pointer to memory where real values are stored. |

Warning
Copies values pointed to, does not free data. Memory management must be done outside scope of constructor call.

2.3.2.4 ComplexArray::ComplexArray ( const ComplexArray & c )

Copy Constructor

Parameters

| c | ComplexArray to be copied. |

2.3.2.5 ComplexArray::ComplexArray ( const Array & arr )

Constructor, copy real values from existing Array.
Real values are copied into new ComplexArray, and imaginary values are initialized to 0.
Parameters

arr | Array of real values to copy into new ComplexArray.

2.3.3 Member Function Documentation

2.3.3.1 data_type ftd::Array::at ( int index ) const [inline], [inherited]

Retrieve value in array at specified index.

Parameters

index | Index of the item to be retrieved (0 based).

Returns

Value at specified index.

2.3.3.2 int Array::getSize ( void ) const [inherited]

Return the number of elements in the array.

Returns

number of elements in the array.

2.3.3.3 ComplexArray & ComplexArray::operator= ( const ComplexArray & c )

Assignment operator overloaded.

Parameters

| c | Reference to ComplexArray object assign current ComplexArray object.

Returns

Reference to newly assigned ComplexArray object.

2.3.3.4 void ComplexArray::padZeros ( int n )

Pads array with zeros at end.

Parameters

| n | Number of zeros to pad at end of array.

2.3.3.5 void ComplexArray::trunc ( int n )

Truncate array to specified size.
Parameters

| n | Final size of the array. |

Warning

\[ n \text{ must be } < \text{ size of array.} \]

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

- `Array.h`
- `Array.cpp`

2.4 ftd::ComplexDataContainer Class Reference

Container Object for data file with complex values.

```cpp
#include <DataContainer.h>
```

Inheritance diagram for ftd::ComplexDataContainer:

```
ftd::DataContainer
    ↓
ftd::ComplexDataContainer
```

Public Member Functions

- `ComplexDataContainer (int nVars, int nEntries)`
  Constructor, creates empty data container.
- `ComplexDataContainer (const ComplexDataContainer &m)`
  Copy Constructor with complex values.
- `ComplexDataContainer (const DataContainer &m)`
  Copy Constructor with real values.
- `virtual ~ComplexDataContainer ()`
  Destructor.
- `const data_type * getData (void) const`
  Copies the existing data in the `DataContainer` into a new memory location then returns the pointer to the memory location.
- `data_type getData (int row, int col) const`
  Retrieve a specific value from the `DataContainer`.
- `const data_type * getImgData (void) const`
  Returns pointer to imaginary data.
- `Matrix getMatrix (void)`
  Returns `Matrix` representation of `DataContainer`.
- `ComplexMatrix getMatrix (void) const`
  Returns a copy of the complex data container in a `ComplexMatrix` object.
- `int getNumberOfEntries (void) const`
  Returns the number of entries in the container.
2.4 ftd::ComplexDataContainer Class Reference

- **int getNumberVars (void) const**
  
  Returns the number of variable in the container.

- **const data_type * getRealData (void) const**
  
  Returns pointer to real values of the container.

- **void insertEntry (const data_type * values, int row)**
  
  Inserts an entire entry into the container.

- **void insertItem (data_type value, int row, int col)**
  
  Inserts a value into specific location in the container.

- **void insertItem (data_type real, data_type img, int row, int col)**
  
  Insert a single item into the complex data container.

- **ComplexDataContainer & operator= (const ComplexDataContainer &dc)**
  
  Overloaded Assignment operator.

- **virtual void print (FILE *fOut=stderr) const**
  
  Prints the complex data container to a file.

- **void printCLI (void) const**
  
  Function that prints the data container out to the command line.

- **void setData (const data_type *values, int nVars, int nEntries)**
  
  Sets the data of the DataContainer to new values.

**Protected Attributes**

- **data_type * data**
  
  Storage of the data for the DataContainer.

- **int nEntries**
  
  Number of entries (columns) in the DataContainer.

- **int nVars**
  
  Number variables (rows) in the DataContainer.

2.4.1 Detailed Description

Container Object for data file with complex values.

Container Object for a data file with complex values only. Access is similar to a 2D structure with entries(row) and variables (rows). However fundamental implementation uses flat structure for memory access optimization.

2.4.2 Constructor & Destructor Documentation

2.4.2.1 ComplexDataContainer::ComplexDataContainer ( int nVars, int nEntries )

Constructor, creates empty data container.

<table>
<thead>
<tr>
<th>nVars</th>
<th>Number of variables (ie columns) in complex data container.</th>
</tr>
</thead>
<tbody>
<tr>
<td>nEntries</td>
<td>Number of entries (ie rows) in complex data container.</td>
</tr>
</tbody>
</table>

2.4.2.2 ComplexDataContainer::ComplexDataContainer ( const ComplexDataContainer & m )

Copy Constructor with complex values.
Parameters

\[ m \quad \text{Existing complex data container to be copied.} \]

2.4.2.3 ComplexDataContainer::ComplexDataContainer ( const DataContainer & \( m \) )

Copy Constructor with real values.

Parameters

\[ m \quad \text{Existing non-complex data container to be copied into a complex container.} \]

2.4.3 Member Function Documentation

2.4.3.1 const data_type * DataContainer::getData ( void ) const [inherited]

Copies the existing data in the DataContainer into a new memory location then returns the pointer to the memory location.

Warning

\begin{verbatim}
DOES NOT CLEAN UP MEMORY, MUST BE DONE OUTSIDE OF THIS FUNCTION SCOPE
\end{verbatim}

Returns

Pointer to memory location of copy of data in the DataContainer.

2.4.3.2 data_type DataContainer::getData ( int row, int col ) const [inherited]

Retrieve a specific value from the DataContainer.

Parameters

\begin{tabular}{|c|c|}
\hline
\textbf{row} & Row (entry location) of the data to retrieve. \\
\textbf{col} & Column (variable location) of the data to retrieve. \\
\hline
\end{tabular}

Returns

Data value corresponding to (row,col) ie (entry,variable)

2.4.3.3 const data_type * ComplexDataContainer::getImgData ( void ) const

Returns pointer to imaginary data.

Returns

Pointer to imaginary values of the container.
2.4.3.4 Matrix DataContainer::getMatrix ( void ) [inherited]

Returns Matrix representation of DaraContainer.

Returns

DataContainer object as a Matrix object.

2.4.3.5 ComplexMatrix ComplexDataContainer::getMatrix ( void ) const

Returns a copy of the complex data container in a ComplexMatrix object.

Returns

Copy of the complex data container in a ComplexMatrix object.

2.4.3.6 int DataContainer::getNumberEntries ( void ) const [inherited]

Returns the number of entries in the container.

Returns

Number of data entries in the container.

2.4.3.7 int DataContainer::getNumberVars ( void ) const [inherited]

Returns the number of variable in the container.

Returns

Number of variable in the container.

2.4.3.8 const data_type ∗ ComplexDataContainer::getRealData ( void ) const

Returns pointer to real values of the container.

Returns

Pointer to real values of the container.

2.4.3.9 void DataContainer::insertEntry ( const data_type ∗ values, int row ) [inherited]

Inserts an entire entry into the container.

Inserts an entire entry into the container, replacing existing values. If the row location > number entries the DataContainer is resized and padded with zeros.
### 2.4.3.10 void DataContainer::insertItem(data_type value, int row, int col) [inherited]

Inserts a value into specific location in the container.

Inserts a value into specific location in the container object. If row location is outside the current number of entries, the `DataContainer` is resized, padded with zeros.

**Parameters**

<table>
<thead>
<tr>
<th>value</th>
<th>Real value to be inserted.</th>
</tr>
</thead>
<tbody>
<tr>
<td>row</td>
<td>Row (entry location) to place value.</td>
</tr>
<tr>
<td>col</td>
<td>Column (variable location) to place value.</td>
</tr>
</tbody>
</table>

**Warning**

The column location must not exceed the number of variables.

### 2.4.3.11 void ComplexDataContainer::insertItem(data_type real, data_type img, int row, int col)

Insert a single item into the complex data container.

**Parameters**

<table>
<thead>
<tr>
<th>real</th>
<th>Real component of the item to be inserted.</th>
</tr>
</thead>
<tbody>
<tr>
<td>img</td>
<td>Imaginary component of the item to be inserted.</td>
</tr>
<tr>
<td>row</td>
<td>Row (entry location) to place value.</td>
</tr>
<tr>
<td>col</td>
<td>Column (variable location) to place value.</td>
</tr>
</tbody>
</table>

### 2.4.3.12 ComplexDataContainer & ComplexDataContainer::operator=(const ComplexDataContainer & dc)

Overloaded Assignment operator.

**Parameters**

| dc      | Reference to ComplexDataContainer object to assign this ComplexDataContainer to. |

**Returns**

Reference to this ComplexDataConatiner object after assignment.

### 2.4.3.13 void ComplexDataContainer::print(FILE * fOut = stderr) const [virtual]

Prints the complex data container to a file.
Parameters

| fOut | File object pointer to print complex data container. Default is stderr if argument is not specified. |

Reimplemented from ftd::DataContainer.

2.4.3.14 void DataContainer::setData ( const data_type ∗ values, int nVars, int nEntries ) [inherited]

Sets the data of the DataContainer to new values.

Parameters

<table>
<thead>
<tr>
<th>values</th>
<th>Pointer to memory location of new data.</th>
</tr>
</thead>
<tbody>
<tr>
<td>nVars</td>
<td>Number of variable (ie columns)</td>
</tr>
<tr>
<td>nEntries</td>
<td>Number of rows (ie rows)</td>
</tr>
</tbody>
</table>

Warning

ALL OLD VALUES ARE DESTROYED, NEW MEMORY ALLOCATED AND SET.

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

- DataContainer.h
- DataContainer.cpp

2.5 ftd::ComplexMatrix Class Reference

Container for matrix of complex values.

#include <Matrix.h>

Inheritance diagram for ftd::ComplexMatrix:

```
ftd::Matrix

ftd::ComplexMatrix
```

Public Member Functions

- ComplexMatrix (int r, int c)  
  Constructor, initialize all real/imaginary values to zero.
- ComplexMatrix (int r, int c, data_type ∗real)  
  Constructor, initialize real values as specified, imaginary initialized to 0.
- ComplexMatrix (int r, int c, data_type ∗real, data_type ∗imag)  
  Constructor, initialize real and imaginary values as specified.
- ComplexMatrix (const ComplexMatrix &cm)  
  Copy Constructor.
- ComplexMatrix (const Matrix &m)  
  Copy Constructor for non-complex Matrix.
• \texttt{~ComplexMatrix()} \\
  Destructor.
• \texttt{ComplexArray getCol(int c) const} \\
  Return a column from the \texttt{ComplexMatrix}.
• \texttt{dataType getData(int r, int c) const} \\
  Get a value from a \texttt{Matrix}.
• \texttt{int getNCols() const} \\
  Return the number of columns in the \texttt{Matrix}.
• \texttt{int getNRows() const} \\
  Return the number of rows in the \texttt{Matrix}.
• \texttt{ComplexArray.getRow(int r) const} \\
  Return a row from the \texttt{ComplexMatrix}.
• \texttt{Matrix \texttt{operator*}(const Matrix &m) const} \\
  Overloaded operator \texttt{*}, performs matrix multiplication.
• \texttt{Matrix \texttt{operator*}(dataType d) const} \\
  Overloaded operator \texttt{*}, Multiplies all values of \texttt{Matrix} by a single value.
• \texttt{Matrix & \texttt{operator*=}(const Matrix &m)} \\
  Overloaded operator \texttt{*=}, performs matrix multiplication and assigns to LHS.
• \texttt{Matrix & \texttt{operator*=}(dataType d)} \\
  Overloaded operator \texttt{*=}, Multiplies all values of \texttt{Matrix} by a single value, assigns to LHS.
• \texttt{Matrix \texttt{operator+}(const Matrix &m) const} \\
  Overloaded operator \texttt{+}, Add element-wise two matrices.
• \texttt{Matrix \texttt{operator+}(dataType d) const} \\
  Overloaded operator \texttt{+}, Add each value in \texttt{Matrix} by single value.
• \texttt{Matrix & \texttt{operator+=}(const Matrix &m)} \\
  Overloaded operator \texttt{+=}, Add element-wise two matrices assign result to LHS.
• \texttt{Matrix & \texttt{operator+=}(dataType d)} \\
  Overloaded operator \texttt{+=}, Add each value in \texttt{Matrix} by single value and assign to LHS.
• \texttt{Matrix \texttt{operator-}(const Matrix &m) const} \\
  Overloaded operator \texttt{-}, Subtract element-wise two matrices.
• \texttt{Matrix \texttt{operator-}(dataType d) const} \\
  Overloaded operator \texttt{-}, Subtract each value in \texttt{Matrix} by single value.
• \texttt{Matrix & \texttt{operator-=}(const Matrix &m)} \\
  Overloaded operator \texttt{-=}, Subtract element-wise two matrices assign result to LHS.
• \texttt{Matrix & \texttt{operator-=}(dataType d)} \\
  Overloaded operator \texttt{-=}, Subtract each value in \texttt{Matrix} by single value and assign to LHS.
• \texttt{Matrix \texttt{operator/}(dataType d) const} \\
  Overloaded operator \texttt{/}, Divided all values of \texttt{Matrix} by a single value.
• \texttt{Matrix & \texttt{operator/=}(dataType d)} \\
  Overloaded operator \texttt{/=}, Divides all values of \texttt{Matrix} by a single value, assigns to LHS.
• \texttt{const ComplexMatrix & \texttt{operator=}(const ComplexMatrix &cm)} \\
  Overloaded assignment operator \texttt{=}.
• \texttt{const ComplexMatrix & \texttt{operator=}(const Matrix &m)} \\
  Overloaded assignment operator \texttt{=}.
• \texttt{virtual void print(FILE *fOut=stderr) const} \\
  Print the values into a \texttt{FILE} object.
• \texttt{void setCol(int c, const ComplexArray &ca)}
Set a column in the ComplexMatrix.
- void setData (data_type d, int r, int c)
  Set a single value within a Matrix specified by row, column.
- void setData (data_type d, int ind)
  Set a single value within a Matrix specified by raw index.
- void setData (data_type *values)
  Set all values of the Matrix.
- void setRow (int r, const ComplexArray &ca)
  Set a row in the ComplexMatrix.
- Array toArray (void) const
  Return values from the Matrix in a single Array object.
- void trunc (int r, int c)
  Truncate Matrix to specified number of rows/columns.

Protected Attributes

- int cols
  Number of columns in Matrix.
- data_type * data
  Pointer to data for real values of the Matrix.
- data_type * imgData
  Pointer to imaginary values.
- int rows
  Number of rows in Matrix.

Friends

- Matrix absm (ComplexMatrix &cm)
  Compute the absolute value of the elements in the ComplexMatrix.
- ComplexMatrix dft2 (const ComplexMatrix &m)
  Computes N-point DFT for of the ComplexMatrix.
- ComplexMatrix fft1_col (const ComplexMatrix &cm)
  Computes N-point FFT for columns of ComplexMatrix.
- ComplexMatrix fft1_row (const ComplexMatrix &cm)
  Computes N-point FFT for rows of ComplexMatrix.
- ComplexMatrix fft2 (const ComplexMatrix &cm)
  Compute the 2D N-point FFT.

2.5.1 Detailed Description

Container for matrix of complex values.

2.5.2 Constructor & Destructor Documentation

2.5.2.1 ComplexMatrix::ComplexMatrix ( int r, int c )

Constructor, initialize all real/imaginary values to zero.
**Parameters**

<table>
<thead>
<tr>
<th></th>
<th>Number of rows.</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td></td>
</tr>
</tbody>
</table>

### 2.5.2.2 ComplexMatrix::ComplexMatrix ( int r, int c, data_type * real )

Constructor, initialize real values as specified, imaginary initialized to 0.

**Parameters**

<table>
<thead>
<tr>
<th></th>
<th>Number of rows.</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td></td>
</tr>
<tr>
<td>real</td>
<td>Pointer to real values to copy into new ComplexMatrix.</td>
</tr>
</tbody>
</table>

**Warning**

The real values must match the number of elements specified by r and c. Memory management of input real values must be done outside scope of the constructor call.

### 2.5.2.3 ComplexMatrix::ComplexMatrix ( int r, int c, data_type * real, data_type * imag )

Constructor, initialize real and imaginary values as specified.

**Parameters**

<table>
<thead>
<tr>
<th></th>
<th>Number of rows.</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td></td>
</tr>
<tr>
<td>real</td>
<td>Pointer to real values to copy into new ComplexMatrix.</td>
</tr>
<tr>
<td>imag</td>
<td>Pointer to imaginary values to copy into new ComplexMatrix.</td>
</tr>
</tbody>
</table>

**Warning**

The real/imaginary values must match the number of elements specified by r and c. Memory management of input real/imaginary values must be done outside scope of the constructor call.

### 2.5.2.4 ComplexMatrix::ComplexMatrix ( const ComplexMatrix & cm )

Copy Constructor.

**Parameters**

| cm | ComplexMatrix to be copied. |

### 2.5.2.5 ComplexMatrix::ComplexMatrix ( const Matrix & m )

Copy Constructor for non-complex Matrix.

Real values are copied and imaginary are set to zero.
2.5.3 Member Function Documentation

2.5.3.1 `ComplexArray ComplexMatrix::getCol ( int c ) const`

Return a column from the `ComplexMatrix`.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>Column to return.</td>
</tr>
</tbody>
</table>

Returns

`ComplexArray` of value from specified column.

2.5.3.2 `data_type Matrix::getData ( int r, int c ) const` [inherited]

Get a value from a `Matrix`.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>Row of element.</td>
</tr>
<tr>
<td>c</td>
<td>Column of element.</td>
</tr>
</tbody>
</table>

Returns

Value of item at specified row and column.

2.5.3.3 `ComplexArray ComplexMatrix::getRow ( int r ) const`

Return a row from the `ComplexMatrix`.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>Row to return.</td>
</tr>
</tbody>
</table>

Returns

`ComplexArray` of value from specified row.

2.5.3.4 `Matrix Matrix::operator* ( const Matrix & m ) const` [inherited]

Overloaded operator (*), performs matrix multiplication.

`Matrix` multiplication resulting in matrix of size [LHS_rows x RHS_columns].
Parameters

\[
\begin{array}{|c|}
\hline
m & \text{RHS Matrix for multiplication.} \\
\hline
\end{array}
\]

Returns

Copy of \texttt{Matrix} with values from the \texttt{Matrix} multiplication.

Warning

Proper \texttt{Matrix} sizes must be provided LHS\_cols==RHS\_rows!

---

2.5.3.5 \texttt{Matrix::operator\*= ( data_type d ) const} \ [inherited]

Overloaded operator (\*=), Multiplies all values of \texttt{Matrix} by a single value.

Parameters

\[
\begin{array}{|c|}
\hline
\multirow{2}{*}{d} & \text{Value to multiply all \texttt{Matrix} values with.} \\
\cline{2-2}
\hline
\end{array}
\]

Returns

Copy of \texttt{Matrix} resulting from the scalar multiplication.

---

2.5.3.6 \texttt{Matrix & Matrix::operator\*= ( const Matrix & m )} \ [inherited]

Overloaded operator (\*=), performs matrix multiplication and assigns to LHS.

Matrix multiplication resulting in matrix of size [LHS\_rows x RHS\_columns].

Parameters

\[
\begin{array}{|c|}
\hline
\multirow{2}{*}{m} & \text{RHS Matrix for multiplication.} \\
\cline{2-2}
\hline
\end{array}
\]

Returns

Reference to \texttt{Matrix} with values from the \texttt{Matrix} multiplication.

Warning

Proper \texttt{Matrix} sizes must be provided LHS\_cols==RHS\_rows!

---

2.5.3.7 \texttt{Matrix & Matrix::operator\*= ( data_type d )} \ [inherited]

Overloaded operator (\*=), Multiplies all values of \texttt{Matrix} by a single value, assigns to LHS.

Parameters
2.5.3.8 Matrix Matrix::operator+ ( const Matrix & m ) const [inherited]

Overloaded operator (+), Add element-wise two matrices.

Parameters

\[ m \] RHS of the addition.

Returns

Copy of the result of the matrix addition.

Warning

RHS and LHS must have the same number of elements.

2.5.3.9 Matrix Matrix::operator+ ( data_type d ) const [inherited]

Overloaded operator (+), Add each value in Matrix by single value.

Parameters

\[ d \] Single value to addition from all values.

Returns

Copy of the resulting scalar addition.

2.5.3.10 Matrix & Matrix::operator+= ( const Matrix & m ) [inherited]

Overloaded operator (+=), Add element-wise two matrices assign result to LHS.

Parameters

\[ m \] RHS of the addition.

Returns

Reference to the result of the matrix addition.

Warning

RHS and LHS must have the same number of elements.

2.5.3.11 Matrix & Matrix::operator+= ( data_type d ) [inherited]

Overloaded operator (+=), Add each value in Matrix by single value and assign to LHS.
Parameters

\[
d \quad \text{Single value to addition from all values.}
\]

Returns

Reference to the resulting scalar addition.

2.5.3.12 Matrix Matrix::operator- ( const Matrix & m ) const [inherited]

Overloaded operator (-), Subtract element-wise two matrices.

Parameters

\[
m \quad \text{RHS of the subtraction.}
\]

Returns

Copy of the result of the matrix subtraction.

Warning

RHS and LHS must have the same number of elements.

2.5.3.13 Matrix Matrix::operator- ( data_type d ) const [inherited]

Overloaded operator (-), Subtract each value in Matrix by single value.

Parameters

\[
d \quad \text{Single value to subtract from all values.}
\]

Returns

Copy of the resulting scalar subtraction.

2.5.3.14 Matrix & Matrix::operator= ( const Matrix & m ) [inherited]

Overloaded operator (=), Subtract element-wise two matrices assign result to LHS.

Parameters

\[
m \quad \text{RHS of the subtraction.}
\]

Returns

Reference to the result of the matrix subtraction.

Warning

RHS and LHS must have the same number of elements.

2.5.3.15 Matrix & Matrix::operator= ( data_type d ) [inherited]

Overloaded operator (=), Subtract each value in Matrix by single value and assign to LHS.
Parameters

\[
d | \text{Single value to subtract from all values.}
\]

Returns

Reference to the resulting scalar subtraction.

2.5.3.16 \textbf{Matrix & Matrix::operator/} ( \textbf{data_type d} )\textbf{ const } [inherited]

Overloaded operator (/), Divided all values of \textbf{Matrix} by a single value.

Parameters

\[
d | \text{Value to divide all \textbf{Matrix} values with.}
\]

Returns

Copy of \textbf{Matrix} resulting from the scalar division.

2.5.3.17 \textbf{Matrix & Matrix::operator/=} ( \textbf{data_type d} ) [inherited]

Overloaded operator (/=), Divides all values of \textbf{Matrix} by a single value, assigns to LHS.

Parameters

\[
d | \text{Value to divide all \textbf{Matrix} values with.}
\]

Returns

Reference of \textbf{Matrix} resulting from the scalar division.

2.5.3.18 \textbf{const ComplexMatrix & ComplexMatrix::operator=} ( \textbf{const ComplexMatrix & cm} )

Overloaded assignment operator (=)

Parameters

\[
cm | \text{RHS of assignment with type \textbf{ComplexMatrix}}
\]

2.5.3.19 \textbf{const ComplexMatrix & ComplexMatrix::operator=} ( \textbf{const Matrix & m} )

Overloaded assignment operator (=), real values assigned, imaginary set to 0.

Parameters

\[
m | \text{RHS of assignment with type \textbf{Matrix}}
\]

2.5.3.20 \textbf{void ComplexMatrix::print} ( \textbf{FILE * fOut = stderr} )\textbf{ const } [virtual]

Print the values into a FILE object.
Parameters

| fOut | Pointer to FILE object to print values, default is stderr. |

Warning

FILE pointer fOut must be valid and opened for write then closed outside scope.

Reimplemented from ftd::Matrix.

2.5.3.21 void ComplexMatrix::setCol ( int c, const ComplexArray & ca )
Set a column in the ComplexMatrix.
Parameters

<table>
<thead>
<tr>
<th>r</th>
<th>Column to be set.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ca</td>
<td>ComplexArray of values to set in column.</td>
</tr>
</tbody>
</table>

2.5.3.22 void Matrix::setData ( data_type d, int r, int c ) [inherited]
Set a single value within a Matrix specified by row, column.
Parameters

<table>
<thead>
<tr>
<th>d</th>
<th>Value to be set.</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>Row of the value.</td>
</tr>
<tr>
<td>c</td>
<td>Column of the value.</td>
</tr>
</tbody>
</table>

2.5.3.23 void Matrix::setData ( data_type d, int ind ) [inherited]
Set a single value within a Matrix specified by raw index.
Parameters

<table>
<thead>
<tr>
<th>d</th>
<th>Value to be set.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ind</td>
<td>Raw index to store value in Matrix.</td>
</tr>
</tbody>
</table>

2.5.3.24 void Matrix::setData ( data_type * values ) [inherited]
Set all values of the Matrix.
Parameters

| values | Pointer to values to set in Matrix. |

Warning

Input values must be created and initialized outside scope and number of elements must match that of the Matrix.
2.5.3.25  void ComplexMatrix::setRow ( int r, const ComplexArray & ca )

Set a row in the ComplexMatrix.
Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>Row to be set.</td>
</tr>
<tr>
<td>ca</td>
<td>ComplexArray of values to set row.</td>
</tr>
</tbody>
</table>

2.5.3.26 Array Matrix::toArray ( void ) const [inherited]

Return values from the Matrix in a single Array object.

Returns

Array with all Matrix values, number elements are rows×cols.

2.5.3.27 void Matrix::trunc ( int r, int c ) [inherited]

Truncate Matrix to specified number of rows/columns.

The truncation process keeps the first r rows and c columns.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>Number of rows to keep.</td>
</tr>
<tr>
<td>c</td>
<td>Number of columns to keep.</td>
</tr>
</tbody>
</table>

Warning

The number of rows/columns desired must be less than current counts.

2.5.4 Friends And Related Function Documentation

2.5.4.1 Matrix absm ( ComplexMatrix & cm ) [friend]

Compute the absolute value of the elements in the ComplexMatrix.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cm</td>
<td>ComplexMatrix to compute absolute value of the elements.</td>
</tr>
</tbody>
</table>

Returns

Real-valued Matrix of the absolute values.

2.5.4.2 ComplexMatrix dft2 ( const ComplexMatrix & m ) [friend]

Computes N-point DFT for of the ComplexMatrix.

The N-point DFT is taken column-wise then row-wise for 2D implementation.
2.5 ftd::ComplexMatrix Class Reference

Parameters

| cm | ComplexMatrix to compute 2D DFT. |

Returns

Result of the 2D N-Point DFT.

2.5.4.3 ComplexMatrix fft1_col ( const ComplexMatrix & cm ) [friend]

Computes N-point FFT for columns of ComplexMatrix.
N-point FFT using the Cooley-Tukey FFT. N is set as the next power of 2 and zero padding performed.

Parameters

| cm | ComplexMatrix to compute FFT. |

Returns

Result of the column-wise N-point FFT.

2.5.4.4 ComplexMatrix fft1_row ( const ComplexMatrix & cm ) [friend]

Computes N-point FFT for rows of ComplexMatrix.
N-point FFT using the Cooley-Tukey FFT. N is set as the next power of 2 and zero padding performed.

Parameters

| cm | ComplexMatrix to compute FFT. |

Returns

Result of the row-wise N-point FFT.

2.5.4.5 ComplexMatrix fft2 ( const ComplexMatrix & cm ) [friend]

Compute the 2D N-point FFT.
The N-point FFT is taken column-wise then row-wise for 2D implementation.

Parameters

| cm | ComplexMatrix to compute 2D FFT. |

Returns

Result of the 2D N-Point FFT.

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

- Matrix.h
- Matrix.cpp
2.6 ftd::DataContainer Class Reference

Container class for real-values data files.

```
#include <DataContainer.h>
```

Inheritance diagram for ftd::DataContainer:

```
ftd::DataContainer

ftd::ComplexDataContainer
```

Public Member Functions

- **DataContainer (int nVars, int nEntries)**
  Constructor, creates empty data container.
- **DataContainer (const DataContainer &dc)**
  Copy Constructor.
- **DataContainer (data_type *data, int nVars, int nEntries)**
  Constructor given existing data array.
- **virtual ~DataContainer ()**
  Destructor.
- **const data_type * getData (void) const**
  Copies the existing data in the DataContainer into a new memory location then returns the pointer to the memory location.
- **data_type getData (int row, int col) const**
  Retrieve a specific value from the DataContainer.
- **Matrix getMatrix (void)**
  Returns Matrix representation of DataContainer.
- **int getNumberOfEntries (void) const**
  Returns the number of entries in the container.
- **int getNumberOfVars (void) const**
  Returns the number of variable in the container.
- **void insertEntry (const data_type *values, int row)**
  Inserts an entire entry into the container.
- **void insertItem (data_type value, int row, int col)**
  Inserts a value into specific location in the container.
- **DataContainer & operator= (const DataContainer &dc)**
  Overloaded Assignment operator.
- **virtual void print (FILE *fOut=stderr) const**
  Prints the data container to a file.
- **void printCLI (void) const**
  Function that prints the data container out to the command line.
- **void setData (const data_type *values, int nVars, int nEntries)**
  Sets the data of the DataContainer to new values.
2.6.1 Detailed Description

Container class for real-values data files.

Data Container Object for a data file with real values only. Access is similar to a 2D structure with entries(row) and variables (rows). However fundamental implementation uses flat structure for memory access optimization.

2.6.2 Constructor & Destructor Documentation

2.6.2.1 DataContainer::DataContainer (int nVars, int nEntries)

Constructor, creates empty data container.

Parameters

<table>
<thead>
<tr>
<th>nVars</th>
<th>Number of variables (ie columns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>nEntries</td>
<td>Number of data entries (ie rows)</td>
</tr>
</tbody>
</table>

2.6.2.2 DataContainer::DataContainer (const DataContainer & dc)

Copy Constructor.

Parameters

| dc | Reference to DataContainer object to be copied. |

2.6.2.3 DataContainer::DataContainer (data_type * data, int nVars, int nEntries)

Constructor given existing data array.
2.6.3 Member Function Documentation

2.6.3.1 const data_type * DataContainer::getData ( void ) const

Copies the existing data in the DataContainer into a new memory location then returns the pointer to the memory location.

Warning

DOES NOT CLEAN UP MEMORY, MUST BE DONE OUTSIDE OF THIS FUNCTION SCOPE

Returns

Pointer to memory location of copy of data in the DataContainer.

2.6.3.2 data_type DataContainer::getData ( int row, int col ) const

Retrieve a specific value from the DataContainer.

Parameters

<table>
<thead>
<tr>
<th>row</th>
<th>Row (entry location) of the data to retrieve.</th>
</tr>
</thead>
<tbody>
<tr>
<td>col</td>
<td>Column (variable location) of the data to retrieve.</td>
</tr>
</tbody>
</table>

Returns

Data value corresponding to (row,col) ie (entry,variable)

2.6.3.3 Matrix DataContainer::getMatrix ( void )

Returns Matrix representation of DataContainer.

Returns

DataContainer object as a Matrix object.

2.6.3.4 int DataContainer::getNumberEntries ( void ) const

Returns the number of entries in the container.

Returns

Number of data entries in the container.
2.6.3.5 int DataContainer::getNumberVars ( void ) const

Returns the number of variable in the container.

Returns

   Number of variable in the container.

2.6.3.6 void DataContainer::insertEntry ( const data_type ∗ values, int row )

Inserts an entire entry into the container.

Inserts an entire entry into the container, replacing existing values. If the row location > number entries the DataContainer is resized and padded with zeros.

Parameters

<table>
<thead>
<tr>
<th>values</th>
<th>Pointer to memory location storing values to be inserted.</th>
</tr>
</thead>
<tbody>
<tr>
<td>row</td>
<td>Row (entry location) to insert the entry values.</td>
</tr>
</tbody>
</table>

Warning

   There is no check on the number of items passed to be.

2.6.3.7 void DataContainer::insertItem ( data_type value, int row, int col )

Inserts a value into specific location in the container.

Inserts a value into specific location in the conntainer object. If row location is outside the current number of entries, the DataContainer is resized, padded with zeros.

Parameters

<table>
<thead>
<tr>
<th>value</th>
<th>Real value to be inserted.</th>
</tr>
</thead>
<tbody>
<tr>
<td>row</td>
<td>Row (entry location) to place value.</td>
</tr>
<tr>
<td>col</td>
<td>Column (variable location) to place value.</td>
</tr>
</tbody>
</table>

Warning

   The column location must not exceed the number of variables.

2.6.3.8 DataContainer & DataContainer::operator= ( const DataContainer & dc )

Overloaded Assignment operator.

Parameters

| dc   | Reference to DataContainer object to assign this DataContainer to. |

Returns

   Reference to this DataContainer object after assignment.
2.6.3.9 void DataContainer::print ( FILE * fOut = stderr ) const [virtual]

Prints the data container to a file.
Parameters

| fOut | File object pointer to print data container. Default is stderr if argument is not specified. |

Reimplemented in `ftd::ComplexDataContainer`.

### 2.6.3.10 `void DataContainer::resizeCopyOld ( int row )` [protected]

Helper function to resize the DataContainer.

Resizes `DataContainer` to a new number of rows (entries). Retains the old values and pads with zeros if needed.

<table>
<thead>
<tr>
<th>Parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>row</td>
<td>New number of rows (entries).</td>
</tr>
</tbody>
</table>

Warning

CURRENTLY ASSUMES rows > old rows!!!!

### 2.6.3.11 `void DataContainer::setData ( const data_type* values, int nVars, int nEntries )`

Sets the data of the `DataContainer` to new values.

<table>
<thead>
<tr>
<th>Parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>values</td>
<td>Pointer to memory location of new data.</td>
</tr>
<tr>
<td>nVars</td>
<td>Number of variable (ie columns)</td>
</tr>
<tr>
<td>nEntries</td>
<td>Number of rows (ie rows)</td>
</tr>
</tbody>
</table>

Warning

ALL OLD VALUES ARE DESTROYED, NEW MEMORY ALLOCATED AND SET.

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

- DataContainer.h
- DataContainer.cpp

## 2.7 `ftd::DataFileParser Class Reference`

Object for parsing a fingerprint file.

```cpp
#include <DataFileParser.h>
```

### Public Member Functions

- `DataFileParser (int nVars, const bool varUsage[], const std::string varNames[]≡NULL)`
  Constructor.
- `virtual ~DataFileParser ()`
  Destructor.
- `uchar close ()`
2.7.1 Detailed Description

Object for parsing a fingerprint file.

2.7.2 Constructor & Destructor Documentation

2.7.2.1 ftd::DataFileParser::DataFileParser ( int nVars, const bool varUsage[], const std::string varNames[] = NULL )

Constructor.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>nVars</td>
<td>Number of variables in the fingerprint file.</td>
</tr>
<tr>
<td>varUsage</td>
<td>An array of bool specifying which variable are to be parsed out.</td>
</tr>
<tr>
<td>varName</td>
<td>An array of strings with each variable's name, Default is NULL.</td>
</tr>
</tbody>
</table>

2.7.3 Member Function Documentation

2.7.3.1 uchar DataFileParser::close ( )

Closes the file.

Returns

Status of the close operation.

See also

fclose.

2.7.3.2 void ftd::DataFileParser::copyVarNamesInUse ( std::string varNames[] ) const

Copy name of the variables that were/are parsed.
Parameters

| varNames | An array to store the names of the variables were/are parsed. |

Warning

Input array must have the same size as returned by getNVarsInUse.

2.7.3.3 DataContainer DataFileParser::getDataContainer ( void ) const

Get the data from the data file.

Returns

All the parsed data in a DataContainer object.

2.7.3.4 const int DataFileParser::getNumEntries ( void ) const

Get the number of entries that were/are parsed.

Returns

Number of entries (rows) were/are parsed.

2.7.3.5 const int DataFileParser::getNVarsInUse ( void ) const

Get the number of variables were/are parsed.

Returns

Number of variables were/are parsed.

2.7.3.6 uchar DataFileParser::open ( const char ∗ fileName )

Opens the file specified by file name.
Parameters

| fileName | Name of the file to be opened. |

Returns

1 is successfully opened, 0 otherwise.

2.7.3.7 uchar DataFileParser::parseData ( int start = 0, int nEntries = -1 )

Parse out the values from the fingerprint file.
Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>start</code></td>
<td>Line to start parsing values.</td>
</tr>
<tr>
<td><code>nEntries</code></td>
<td>Number of entries(rows)</td>
</tr>
</tbody>
</table>

Returns

Status of the parse

See also

ftd::ParseResult

Warning

File must first be opened using the open function call prior to parsing.

2.7.3.8 `void ftd::DataFileParser::setVarNames ( const std::string[ ] varNames, int n )`

Sets the names of the variables.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>varNames</code></td>
<td>An array of string variable names.</td>
</tr>
<tr>
<td><code>n</code></td>
<td>Number of variable names in the array.</td>
</tr>
</tbody>
</table>

2.7.3.9 `void DataFileParser::setVarUsage ( const bool[ ] varUsage, int n )`

Sets bool value for which a variable is to be parsed.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>varUsage</code></td>
<td>An array of bool for variable usage.</td>
</tr>
<tr>
<td><code>n</code></td>
<td>Number of bool values in the array.</td>
</tr>
</tbody>
</table>

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

- DataFileParser.h
- DataFileParser.cpp

2.8 `ftd::Matrix Class Reference`

Container for real-valued matrix object.

```cpp
#include <Matrix.h>
```

Inheritance diagram for ftd::Matrix:

```
ftd::Matrix

ftd::ComplexMatrix
```
Public Member Functions

- **Matrix** (int r, int c)
  
  Constructor, create Matrix with values initialized to zero.

- **Matrix** (int r, int c, data_type *data)
  
  Constructor, create Matrix and initialize values from memory.

- **Matrix** (const Array &a)
  
  Constructor, create Matrix from existing Array object.

- **Matrix** (const Matrix &m)
  
  Copy Constructor.

- **~Matrix ()**
  
  Destructor.

- **Array getCol** (int c) const
  
  Get a column from a Matrix.

- **data_type getData** (int r, int c) const
  
  Get a value from a Matrix.

- **int getNCols () const**
  
  Return the number of columns in the Matrix.

- **int getNRows () const**
  
  Return the number of rows in the Matrix.

- **Array getRow** (int r) const
  
  Get a row from a Matrix.

- **Matrix operator* (const Matrix &m) const**
  
  Overloaded operator (*), performs matrix multiplication.

- **Matrix operator* (data_type d) const**
  
  Overloaded operator (*), Multiplies all values of Matrix by a single value.

- **Matrix & operator*= (const Matrix &m)**
  
  Overloaded operator (=), performs matrix multiplication and assigns to LHS.

- **Matrix & operator*= (data_type d)**
  
  Overloaded operator (=), Multiplies all values of Matrix by a single value, assigns to LHS.

- **Matrix operator+ (const Matrix &m) const**
  
  Overloaded operator (+), Add element-wise two matrices.

- **Matrix operator+ (data_type d) const**
  
  Overloaded operator (+), Add each value in Matrix by single value.

- **Matrix & operator+= (const Matrix &m)**
  
  Overloaded operator (+=), Add element-wise two matrices assign result to LHS.

- **Matrix & operator+= (data_type d)**
  
  Overloaded operator (+=), Add each value in Matrix by single value and assign to LHS.

- **Matrix operator- (const Matrix &m) const**
  
  Overloaded operator (-), Subtract element-wise two matrices.

- **Matrix operator- (data_type d) const**
  
  Overloaded operator (-), Subtract each value in Matrix by single value.

- **Matrix & operator-= (const Matrix &m)**
  
  Overloaded operator (-=), Subtract element-wise two matrices assign result to LHS.

- **Matrix & operator-= (data_type d)**
  
  Overloaded operator (-=), Subtract each value in Matrix by single value and assign to LHS.
Overloaded operator (/). Divided all values of Matrix by a single value.

- Matrix & operator/= (data_type d)

  Overloaded operator (/=), Divides all values of Matrix by a single value, assigns to LHS.

- const Matrix & operator= (const Matrix &m)

  Overloaded assignment operator (=), non daisy chain allowed.

- virtual void print (FILE *fOut=stderr) const

  Print the values into a FILE object.

- void setData (data_type d, int r, int c)

  Set a single value within a Matrix specified by row, column.

- void setData (data_type d, int ind)

  Set a single value within a Matrix specified by raw index.

- void setData (data_type *values)

  Set all values of the Matrix.

- Array toArray (void) const

  Return values from the Matrix in a single Array object.

- void trunc (int r, int c)

  Truncate Matrix to specified number of rows/columns.

**Protected Member Functions**

- Matrix ()

  Default Constructor, protected so empty Matrix cannot be created.

**Protected Attributes**

- int cols

  Number of columns in Matrix.

- data_type *data

  Pointer to data for real values of the Matrix.

- int rows

  Number of rows in Matrix.

**Friends**

- Matrix bandPower (const Matrix &m, int bands, int dim)

  Bands together neighbouring values in a Matrix row/column-wise based on specified dimension.

- class ComplexMatrix

  Friend class of Matrix.

- Matrix covar (const Matrix &m)

  Scales Matrix values between [0,1] in specified dimension.

- Matrix elemDiv (const Matrix &a, const Matrix &b)

  Divides two Matrix objects elementally.

- Matrix elemMult (const Matrix &a, const Matrix &b)

  Multiplies two Matrix objects elementally.

- Matrix max (const Matrix &m, int dim)

  Calculates max values of a Matrix.
• **Matrix mean** (const Matrix &m, int)
  Calculates mean of a Matrix row/columnise.

• **Matrix min** (const Matrix &m, int dim)
  Calculates max values of a Matrix.

• **Matrix normMaxMin** (const Matrix &m, int dim)
  Scales Matrix values between [0,1] in specified dimension.

• **Matrix ones** (int r, int c)
  Create a Matrix full of all ones.

• **Matrix reshape** (const Matrix &m, int r, int c)
  Reshape a Matrix to specified number of rows and columns.

• **Matrix sum** (const Matrix &m, int dim)
  Calculates sum of a Matrix row/columnise.

• **Matrix transpose** (const Matrix &m)

• **Matrix var** (const Matrix &m)
  Calculates variance of a Matrix row/columnise.

### 2.8.1 Detailed Description

Container for real-valued matrix object.

### 2.8.2 Constructor & Destructor Documentation

#### 2.8.2.1 Matrix::Matrix ( int r, int c )

Constructor, create Matrix with values initialized to zero.

**Parameters**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>r</strong></td>
<td>Number of rows.</td>
</tr>
<tr>
<td><strong>c</strong></td>
<td>Number of columns.</td>
</tr>
</tbody>
</table>

#### 2.8.2.2 Matrix::Matrix ( int r, int c, data_type *data )

Constructor, create Matrix and initialize values from memory.

**Parameters**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>r</strong></td>
<td>Number of rows.</td>
</tr>
<tr>
<td><strong>c</strong></td>
<td>Number of columns.</td>
</tr>
<tr>
<td><strong>data</strong></td>
<td>Pointer to memory where values for Matrix are stored.</td>
</tr>
</tbody>
</table>

**Warning**

data is a pointer that must be allocated and initialized, number of must be r×c and memory management must be done outside constructor scope.

#### 2.8.2.3 Matrix::Matrix ( const Array &a )

Constructor, create Matrix from existing Array object.

Size of the Matrix will be [1xM] where M is the number of elements in the input Array.
Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>a</code></td>
<td>Array to be used to create Matrix.</td>
</tr>
</tbody>
</table>

2.8.2.4 Matrix::Matrix ( const Matrix & m )

Copy Constructor.
Existing Matrix values copied to New Matrix, size is preserved.

2.8.3 Member Function Documentation

2.8.3.1 Array Matrix::getCol ( int c ) const

Get a column from a Matrix.
Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>c</code></td>
<td>Column index.</td>
</tr>
</tbody>
</table>

Returns

Array object with values from specified column.

2.8.3.2 data_type Matrix::getData ( int r, int c ) const

Get a value from a Matrix.
Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>r</code></td>
<td>Row of element.</td>
</tr>
<tr>
<td><code>c</code></td>
<td>Column of element.</td>
</tr>
</tbody>
</table>

Returns

Value of item at specified row and column.

2.8.3.3 Array Matrix::getRow ( int r ) const

Get a row from a Matrix.
Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>r</code></td>
<td>Row index.</td>
</tr>
</tbody>
</table>

Returns

Array object with values from specified row.

2.8.3.4 Matrix Matrix::operator∗ ( const Matrix & m ) const

Overloaded operator (∗), performs matrix multiplication.
Matrix multiplication resulting in matrix of size [LHS_rows x RHS_columns].
Parameters

\[ m \quad \text{RHS Matrix for multiplication.} \]

Returns

Copy of Matrix with values from the Matrix multiplication.

Warning

Proper Matrix sizes must be provided LHS_cols==RHS_rows!

2.8.3.5 Matrix Matrix::operator\(\ast\)(data_type d) const

Overloaded operator (\(\ast\)), Multiplies all values of Matrix by a single value.

Parameters

\[ d \quad \text{Value to multiply all Matrix values with.} \]

Returns

Copy of Matrix resulting from the scalar multiplication.

2.8.3.6 Matrix & Matrix::operator\(\ast=\)(const Matrix & m)

Overloaded operator (\(\ast=\)), performs matrix multiplication and assigns to LHS.

Matrix multiplication resulting in matrix of size [LHS_rows x RHS_columns].

Parameters

\[ m \quad \text{RHS Matrix for multiplication.} \]

Returns

Reference to Matrix with values from the Matrix multiplication.

Warning

Proper Matrix sizes must be provided LHS_cols==RHS_rows!

2.8.3.7 Matrix & Matrix::operator\(\ast=\)(data_type d)

Overloaded operator (\(\ast=\)), Multiplies all values of Matrix by a single value, assigns to LHS.

Parameters


| Value to multiply all Matrix values with. |

Returns
Reference of Matrix resulting from the scalar multiplication.

2.8.3.8 Matrix Matrix::operator+ ( const Matrix & m ) const
Overloaded operator (+), Add element-wise two matrices.
Parameters

| m | RHS of the addition. |

Returns
Copy of the result of the matrix addition.

Warning
RHS and LHS must have the same number of elements.

2.8.3.9 Matrix Matrix::operator+ ( data_type d ) const
Overloaded operator (+), Add each value in Matrix by single value.
Parameters

| d | Single value to addition from all values. |

Returns
Copy of the resulting scalar addition.

2.8.3.10 Matrix & Matrix::operator+= ( const Matrix & m )
Overloaded operator (+=), Add element-wise two matrices assign result to LHS.
Parameters

| m | RHS of the addition. |

Returns
Reference to the result of the matrix addition.

Warning
RHS and LHS must have the same number of elements.

2.8.3.11 Matrix & Matrix::operator+= ( data_type d )
Overloaded operator (+=), Add each value in Matrix by single value and assign to LHS.
Parameters

| d | Single value to addition from all values. |

Returns

Reference to the resulting scalar addition.

2.8.3.12 Matrix Matrix::operator- ( const Matrix & m ) const

Overloaded operator (-), Subtract element-wise two matrices.

Parameters

| m | RHS of the subtraction. |

Returns

Copy of the result of the matrix subtraction.

Warning

RHS and LHS must have the same number of elements.

2.8.3.13 Matrix Matrix::operator- ( data_type d ) const

Overloaded operator (-), Subtract each value in Matrix by single value.

Parameters

| d | Single value to subtract from all values. |

Returns

Copy of the resulting scalar subtraction.

2.8.3.14 Matrix & Matrix::operator-= ( const Matrix & m )

Overloaded operator ( -=), Subtract element-wise two matrices assign result to LHS.

Parameters

| m | RHS of the subtraction. |

Returns

Reference to the result of the matrix subtraction.

Warning

RHS and LHS must have the same number of elements.

2.8.3.15 Matrix & Matrix::operator-= ( data_type d )

Overloaded operator ( -=), Subtract each value in Matrix by single value and assign to LHS.
Parameters

| d | Single value to subtract from all values. |

Returns

Reference to the resulting scalar subtraction.

2.8.3.16 Matrix Matrix::operator/ ( data_type d ) const

Overloaded operator (/), Divided all values of Matrix by a single value.

Parameters

| d | Value to divide all Matrix values with. |

Returns

Copy of Matrix resulting from the scalar division.

2.8.3.17 Matrix & Matrix::operator/= ( data_type d )

Overloaded operator (/=), Divides all values of Matrix by a single value, assigns to LHS.

Parameters

| d | Value to divide all Matrix values with. |

Returns

Reference of Matrix resulting from the scalar division.

2.8.3.18 const Matrix & Matrix::operator= ( const Matrix & m )

Overloaded assignment operator (=), non daisy chain allowed.

Parameters

| m | Matrix to assign LHS. |

2.8.3.19 void Matrix::print ( FILE * fOut = stderr ) const [virtual]

Print the values into a FILE object.

Parameters

| fOut | Pointer to FILE object to print values, default is stderr. |

Warning

FILE pointer fOut must be valid and opened for write then closed outside scope.

Reimplemented in ftd::ComplexMatrix.
2.8.3.20 void Matrix::setData ( data_type d, int r, int c )

Set a single value within a Matrix specified by row, column.
Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( d )</td>
<td>Value to be set.</td>
</tr>
<tr>
<td>( r )</td>
<td>Row of the value.</td>
</tr>
<tr>
<td>( c )</td>
<td>Column of the value.</td>
</tr>
</tbody>
</table>

2.8.3.21  `void Matrix::setData ( data_type \( d \), int \( ind \) )`

Set a single value within a Matrix specified by raw index.

Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( d )</td>
<td>Value to be set.</td>
</tr>
<tr>
<td>( ind )</td>
<td>Raw index to store value in Matrix.</td>
</tr>
</tbody>
</table>

2.8.3.22  `void Matrix::setData ( data_type * \( \text{values} \) )`

Set all values of the Matrix.

Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{values} )</td>
<td>Pointer to values to set in Matrix.</td>
</tr>
</tbody>
</table>

Warning

Input values must be created and initialized outside scope and number of elements must match that of the Matrix.

2.8.3.23  `Array Matrix::toArray ( void ) const`

Return values from the Matrix in a single Array object.

Returns

Array with all Matrix values, number elements are rows×cols.

2.8.3.24  `void Matrix::trunc ( int \( r \), int \( c \) )`

Truncate Matrix to specified number of rows/columns.

The truncation process keeps the first \( r \) rows and \( c \) columns.

Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( r )</td>
<td>Number of rows to keep.</td>
</tr>
<tr>
<td>( c )</td>
<td>Number of columns to keep.</td>
</tr>
</tbody>
</table>

Warning

The number of rows/columns desired must be less than current counts.
2.8.4 Friends And Related Function Documentation

2.8.4.1 Matrix bandPower ( const Matrix & m, int bands, int dim ) [friend]

Bands together neighbouring values in a Matrix row/column-wise based on specified dimension. Intended for calculating the band-power of frequency components a multi-variate signal. Frequencies are banded to generate the desired number of bands. Uneven band distribution is handled by making lower indexed values have larger number of components.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>Matrix containing value to be banded together.</td>
</tr>
<tr>
<td>bands</td>
<td>Total number of bands.</td>
</tr>
<tr>
<td>dim</td>
<td>Dimension to perform bands. dim==1 banding is across columns, dim==2 banding is across rows.</td>
</tr>
</tbody>
</table>

Returns

Matrix with banded values.

Warning

The number of bands must be \(<=\) than the number of elements in specified dimension.

2.8.4.2 Matrix covar ( const Matrix & m ) [friend]

Scales Matrix values between [0,1] in specified dimension. If dim==1 normalization is done column-wise. If dim==2 normalization is done row-wise.

Returns

Resulting normalized Matrix.

2.8.4.3 Matrix elemDiv ( const Matrix & a, const Matrix & b ) [friend]

Divides two Matrix objects elementally.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Numerator Matrix for elemental division.</td>
</tr>
<tr>
<td>b</td>
<td>Denominator Matrix for elemental division.</td>
</tr>
</tbody>
</table>

Returns

Matrix result of the elemental division.

2.8.4.4 Matrix elemMult ( const Matrix & a, const Matrix & b ) [friend]

Multiplies two Matrix objects elementally.
Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$</td>
<td>Numerator Matrix for elemental multiplication.</td>
</tr>
<tr>
<td>$b$</td>
<td>Denominator Matrix for elemental multiplication.</td>
</tr>
</tbody>
</table>

Returns

Matrix result of the elemental multiplication.

### 2.8.4.5 Matrix max ( const Matrix & m, int dim ) [friend]

Calculates max values of a Matrix.

If dim==1 max is across columns result [1xM], If dim==2 max is across rows result [Nx1].

Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$m$</td>
<td>Matrix to calculate max.</td>
</tr>
<tr>
<td>$dim$</td>
<td>Direction of the max operation.</td>
</tr>
</tbody>
</table>

Returns

Matrix of the resulting max operation.

### 2.8.4.6 Matrix mean ( const Matrix & m, int dim ) [friend]

Calculates mean of a Matrix row/columnise.

If dim==1 mean is across columns result [1xM], If dim==2 mean is across rows result [Nx1].

Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$m$</td>
<td>Matrix to calculate mean.</td>
</tr>
<tr>
<td>$dim$</td>
<td>Direction of the mean operation.</td>
</tr>
</tbody>
</table>

Returns

Matrix of the resulting mean operation.

### 2.8.4.7 Matrix min ( const Matrix & m, int dim ) [friend]

Calculates min values of a Matrix.

If dim==1 min is across columns result [1xM], If dim==2 min is across rows result [Nx1].

Parameters

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$m$</td>
<td>Matrix to calculate min.</td>
</tr>
<tr>
<td>$dim$</td>
<td>Direction of the min operation.</td>
</tr>
</tbody>
</table>

Returns

Matrix of the resulting min operation.
2.8.4.8 Matrix normMaxMin ( const Matrix & m, int dim ) [friend]

Scales Matrix values between [0,1] in specified dimension.

If dim==1 normalization is done column-wise. If dim==2 normalization is done row-wise.

Parameters

<table>
<thead>
<tr>
<th>m</th>
<th>Matrix to be normalized.</th>
</tr>
</thead>
<tbody>
<tr>
<td>dim</td>
<td>Direction of the normalization operation.</td>
</tr>
</tbody>
</table>

Returns

Resulting normalized Matrix.

2.8.4.9 Matrix ones ( int r, int c ) [friend]

Create a Matrix full of all ones.

Parameters

<table>
<thead>
<tr>
<th>r</th>
<th>Number of rows in the Matrix.</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>Number of columns in the Matrix.</td>
</tr>
</tbody>
</table>

Returns

Ones Matrix of size [r x c].

2.8.4.10 Matrix reshape ( const Matrix & m, int r, int c ) [friend]

Reshape a Matrix to specified number of rows and columns.

Parameters

<table>
<thead>
<tr>
<th>m</th>
<th>Matrix to be reshaped.</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>Number of rows of resulting reshape.</td>
</tr>
<tr>
<td>c</td>
<td>Number of columns of resulting reshape.</td>
</tr>
</tbody>
</table>

Returns

Reshaped Matrix with dimensions [r x c].

Warning

The desired reshaped Matrix must contain the same number elements (r_old*c_old == r_new*c_new).

2.8.4.11 Matrix sum ( const Matrix & m, int dim ) [friend]

Calculates sum of a Matrix row/columnwise.

If dim==1 sum is across columns result [1xM], If dim==2 sum is across rows result [Nx1].
Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>Matrix to calculate sum.</td>
</tr>
<tr>
<td>dim</td>
<td>Direction of the sum operation.</td>
</tr>
</tbody>
</table>

Returns

- Matrix of the resulting sum operation.

2.8.4.12  **Matrix transpose** (const Matrix & m) [friend]

Transposes a Matrix.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>Matrix to be transposed.</td>
</tr>
</tbody>
</table>

Returns

- Transpose of Matrix m.

2.8.4.13  **Matrix var** (const Matrix & m) [friend]

Calculates variance of a Matrix row/columnise.

If dim==1 variance is across columns result [1xM]. If dim==2 variance is across rows result [Nx1].

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>Matrix to calculate variance.</td>
</tr>
<tr>
<td>dim</td>
<td>Direction of the variance operation.</td>
</tr>
</tbody>
</table>

Returns

- Matrix of the resulting variance operation.

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

- Matrix.h
- Matrix.cpp

2.9  **ftd::ModelParser Class Reference**

Object for parsing a GMM model file.

#include <ModelParser.h>

Public Member Functions

- **ModelParser ()**
  
  Default constructor.
virtual ~ModelParser ()
    Destructor.
    • void copyVarNames (std::string varNames[]) const
        Make of copy of the variable names.
    • void copyVarUsage (bool varUsage[]) const
        Make of copy of the variable names.
    • int getDataStart (void) const
        Get the line number the data for the fingerprint file starts.
    • Matrix * getDetRPtr (void) const
        Get the determinates of the GMM covariance matrices.
    • int getEntryCount (void) const
        Get the number of entries expected in fingerprint file.
    • Matrix * getMaxValuesPtr (void) const
        Get pointer to expected raw max values of variables in fingerprint.
    • Matrix * getMeanPCAPtr (void) const
        Get pointer to expected mean feature values prior to PCA.
    • Matrix * getMeanPtr (void) const
        Get pointer to GMM mean values.
    • Matrix * getMaxValuesPtr (void) const
        Get pointer to expected raw mean values of variables in fingerprint.
    • Matrix * getMinValuesPtr (void) const
        Get pointer to expected raw min values of variables in fingerprint.
    • int getNBands (void) const
        Get the number of bands used in bandpower.
    • int getNFeatures (void) const
        Get the number of features after PCA is performed.
    • int getNUsedVars (void) const
        Get number of variables used from the fingerprint during classification.
    • PCA_OPTS getPCAOpts (void) const
        Get the PCA option used.
    • Matrix * getRInvPtr (void) const
        Get pointer to inverse values of GMM covariance matrices.
    • S_OPTS getScalingOpts (void) const
        Get the scaling processing option used.
    • Matrix * getStdPCAPtr (void) const
        Get pointer to expected std of feature values prior to PCA.
    • data_type getTH (void) const
        Get the threshold log likelihood for normal.
    • int getVarCount (void) const
        Get the total number of variables in fingerprint file.
    • Matrix * getWPCAPtr (void) const
        Get pointer to PCA matrix.
    • Matrix * getWPtr (void) const
        Get the pointer to matrix containing GMM weights.
    • ZM_OPTS getZeroMeanOpts (void) const
        Get the zero-mean processing option used.
    • uchar open (const char *fileName)
        Opens the model file. fileName Absolute path to the model file to be parsed.
    • bool parse (void)
        Parses the model file.
2.9.1 Detailed Description

Object for parsing a GMM model file.
Parses and extracts information contained in a .csv model file for GMM.

2.9.2 Member Function Documentation

2.9.2.1 void ModelParser::copyVarNames( std::string varNames[ ] ) const

Make of copy of the variable names.
Parameters

| varNames | Array that variables will be copied into. |

Warning

Array must be the same size as what returns from getVarCount.

2.9.2.2 void ModelParser::copyVarUsage( bool varUsage[ ] ) const

Make of copy of the variable names.
Parameters

| varUsage | Array that variables will be copied into. |

Warning

Array must be the same size as what returns from getVarCount.

2.9.2.3 Matrix ftd::ModelParser::getDetRPtr( void ) const [inline]

Get the determinates of the GMM covariance matrices.

Warning

Pointer returned is only valid while ModelParser object is not destroyed.

2.9.2.4 Matrix ftd::ModelParser::getMaxValuesPtr( void ) const [inline]

Get pointer to expected raw max values of variables in fingerprint.

Warning

Pointer returned is only valid while ModelParser object is not destroyed.
2.9.2.5 Matrix & ftd::ModelParser::getMeanPCAPtr ( void ) const [inline]
Get pointer to expected mean feature values prior to PCA.
Warning
    Pointer returned is only valid while ModelParser object is not destroyed.

2.9.2.6 Matrix & ftd::ModelParser::getMeanPtr ( void ) const [inline]
Get pointer to GMM mean values.
Warning
    Pointer returned is only valid while ModelParser object is not destroyed.

2.9.2.7 Matrix & ftd::ModelParser::getMeanValuesPtr ( void ) const [inline]
Get pointer to expected raw mean values of variables in fingerprint.
Warning
    Pointer returned is only valid while ModelParser object is not destroyed.

2.9.2.8 Matrix & ftd::ModelParser::getMinValuesPtr ( void ) const [inline]
Get pointer to expected raw min values of variables in fingerprint.
Warning
    Pointer returned is only valid while ModelParser object is not destroyed.

2.9.2.9 Matrix & ftd::ModelParser::getRInvPtr ( void ) const [inline]
Get pointer to inverse values of GMM covariance matrices.
Warning
    Pointer returned is only valid while ModelParser object is not destroyed.

2.9.2.10 Matrix & ftd::ModelParser::getStdPCAPtr ( void ) const [inline]
Get pointer to expected std of feature values prior to PCA.
Warning
    Pointer returned is only valid while ModelParser object is not destroyed.
2.9.2.11 Matrix* ftd::ModelParser::getWPCAPtr ( void ) const [inline]

Get pointer to PCA matrix.

Warning
   Pointer returned is only valid while ModelParser object is not destroyed.

2.9.2.12 Matrix* ftd::ModelParser::getWPtr ( void ) const [inline]

Get the pointer to matrix containing GMM weights.

Warning
   Pointer returned is only valid while ModelParser object is not destroyed.

2.9.2.13 uchar ModelParser::open ( const char * fileName )

Opens the model file. fileName Absolute path to the model file to be parsed.

Returns
   1 if opens successfully, else 0.

2.9.2.14 bool ModelParser::parse ( void )

Parses the model file.

Parses the model file and reports any errors/warning or other status during the parsing process based on default logging level (ftd::MAX_LOG_LEVEL).

Returns
   True is the model file parses correctly else False.

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

- ModelParser.h
- ModelParser.cpp

2.10 variant Union Reference

Special union for storing any type in the same memory location.

```
#include <Types.h>
```
2.10 variant Union Reference

Public Attributes

- char c
- char * cptr
- float32 f
- float32 * fptr
- int32 i
- int32 * iptr
- uint32 u
- uint32 * uptr

2.10.1 Detailed Description

Special union for storing any type in the same memory location.

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

- Types.h
Chapter 3

File Documentation

3.1 Array.h File Reference

Container for Array of Real/Complex data and Complex structure.

```cpp
#include "Types.h"
#include "math_func.h"
#include <math.h>
```

Classes

- class ftd::Array
  - Container object for array of real values.
- struct ftd::Complex
  - Structure for complex number representation.
- class ftd::ComplexArray
  - Container object for array of real or complex values.

3.1.1 Detailed Description

Container for Array of Real/Complex data and Complex structure.

Container object to hold contents of an array of numbers real or complex. Intended for use of insertion and fetch from Matrix) objects. Also, created for ease for implementation of FFT.

Author

Ryan M. Bowen (rmb3518@rit.edu)
Ferat Sahin (feseee@rit.edu)

Date

02/20/2014 - 06/30/2015

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3.2 DataContainer.h File Reference

Header file for DataContainer and ComplexDataContainer.

```cpp
#include "Types.h"
#include "Matrix.h"
```

Classes

- class ftd::ComplexDataContainer
  Container Object for data file with complex values.
- class ftd::DataContainer
  Container class for real-values data files.

3.2.1 Detailed Description

Header file for DataContainer and ComplexDataContainer.

Class container object designed to hold the contents of a data file. Data file has variables and entries. Supports both real and complex values.

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02/20/2014 - 06/30/2015

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3.3 DataFileParser.h File Reference

Header file for DataFileParser class.

```cpp
#include "DataContainer.h"
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <string>
```

Classes

- class ftd::DataFileParser
  Object for parsing a fingerprint file.
3.4 fault_detection.h File Reference

3.4.1 Detailed Description

Header includes all other headers required for Fault Detection Library.

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Date

02/20/2014 - 06/30/2015

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3.5 functions.h File Reference

Header for various high-level function prototypes.

#include "fault_detection.h"
Functions

- **int ftd::getNEntries (void)**
  
  Get the number of entries expected to be in a test fingerprint file.

- **int ftd::getNVars (void)**
  
  Get the total number of variables expected to be in a test file.

- **int ftd::getNVarsUsed (void)**
  
  Get the number of variables actually used from a test fingerprint.

- **void ftd::getVarUsage (bool *varUsage)**
  
  Obtain boolean values of the usage of the variables in a test fingerprint.

- **bool ftd::loadModelParser (const char *pathToModel)**
  
  Loads GMM model information into memory.

- **void ftd::report (const char *message, uchar loglevel)**
  
  Method to handle all reporting of errors, warnings, status, etc.

- **uchar ftd::runOneClass (data_type *data)**
  
  Executes the one-class classifier from data parsed into memory.

- **uchar ftd::runOneClassGen (const char *pathToData, const char *pathToModel, uchar logLevel=LOG_NOTICE)**
  
  Executes the one-class classifier, intended to be ran within embedded environment.

- **void ftd::unloadModelParser (void)**

3.5.1 Detailed Description

Header for various high-level function prototypes.

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Date

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3.6 math_func.h File Reference

Various high-level math functions.

```c
#include <math.h>
```

Functions

- **int ftd::getFFT_padSize (int len)**
  
  Returns size of zero padding required for FFT.
3.6.1 Detailed Description

Various high-level math functions.

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02/20/2014 - 06/30/2015

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3.7 ModelParser.h File Reference

Matrix class implementation, real and complex. Several operations and other Matrix related functions.

```cpp
#include <string.h>
#include "Types.h"
#include "Matrix.h"
```

Classes

• class ftd::ModelParser

  Object for parsing a GMM model file.

Enumerations

• enum PCA_OPTS { PCA_NONE = 0, PCA_ZM, PCA_UV, PCA_ZM_UV }

  Enumeration for the different PCA options.

• enum S_OPTS {
  S_NONE = 0, S_MAX_LOCAL, S_MAX_GLOBAL, S_MAXMIN_LOCAL,
  S_MAXMIN_GLOBAL }

  Enumeration for the different scaling options.

• enum ZM_OPTS { ZM_NONE = 0, ZM_LOCAL, ZM_GLOBAL }

  Enumeration for the different zero-mean options.

Variables

• const std::string ftd::logFileName = "mog_log.log"

  Default log file name (NOT USED).

• const std::string ftd::modelFileName = "mog_model.csv"

  Default model file name.

• const std::string ftd::rel_mog_dir = "/../mog_files/"
Default relative path to model file (NOT USED).

- const std::string ftd::STR_BANDS = "bands"
  Model file tag for number of bands for FFT.
- const std::string ftd::STR_DATA_START = "data_start"
  Model file tag for line that data starts in fingerprint.
- const std::string ftd::STR_DET_R = "det_r"
  Model file tag for GMM determinate of covariances.
- const std::string ftd::STR_MAX_VALUES = "max_values"
  Model file tag for raw variable max values.
- const std::string ftd::STR_MEAN = "mean"
  Model file tag for GMM mean values.
- const std::string ftd::STR_MEAN_PCA = "mean_pca"
  Model file tag for mean of features prior to PCA.
- const std::string ftd::STR_MEAN_VALUES = "mean_values"
  Model file tag for raw variable mean values.
- const std::string ftd::STR_MIN_VALUES = "min_values"
  Model file tag for raw variable min values.
- const std::string ftd::STR_N_ENTRIES = "n_entries"
  Model file tag for number of fingerprint entries.
- const std::string ftd::STR_N_FEATURES = "n_features"
  Model file tag for number of features after PCA.
- const std::string ftd::STR_N_VARS = "n_vars"
  Model file tag for number of fingerprint variables.
- const std::string ftd::STR_OPT_TRUE = "true"
  Model file value for a true option.
- const std::string ftd::STR_OPT_YES = "yes"
  Model file value for a yes option.
- const std::string ftd::STR_PROC_SCALING = "proc_scaling"
  Model file tag for scaling options.
- const std::string ftd::STR_PROC_ZEROMEAN = "proc_zeromean"
  Model file tag for zero-mean options.
- const std::string ftd::STR_R_INV = "r_inv"
  Model file tag for GMM inverse of covariances.
- const std::string ftd::STR_RED_PCA = "red_pca"
  Model file tag for PCA options.
- const std::string ftd::STR_SCALE_MAX = "max"
  Model file value for max-scale option.
- const std::string ftd::STR_SCALE_MAXMIN = "maxmin"
  Model file value for maxmin-scale option.
- const std::string ftd::STR_SCOPE_GLOBAL = "global"
  Model file value for global option.
- const std::string ftd::STR_SCOPE_LOCAL = "local"
  Model file value for local option.
- const std::string ftd::STR_STD_PCA = "std_pca"
  Model file tag for std of features prior to PCA.
- const std::string ftd::STR_TH = "th"
  Model file tag for GMM normal threshold value.
• const std::string ftd::STR_VAR_NAMES = "var_names"
  Model file tag for name of the variables in fingerprint.
• const std::string ftd::STR_VAR_USAGE = "var_usage"
  Model file tag for boolean array of which variables are used.
• const std::string ftd::STR_W = "w"
  Model file tag for GMM weight values.
• const std::string ftd::STR_WPCA = "wpca"
  Model file tag for PCA matrix values.
• const uint16 ftd::STR_ZEROMEAN_COUNT = 2

3.7.1 Detailed Description
Matrix class implementation, real and complex. Several operations and other Matrix related functions.
Class intended to help parse csv files with model information.

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Date
02/20/2014 - 06/30/2015

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3.8 Types.h File Reference
All required typedefs, namespaces, etc.
#include <syslog.h>

Classes
• union variant
  Special union for storing any type in the same memory location.

Macros
• #define infinity() INFINITY
• #define infinityf() INFINITY
• #define LINUXx86
• #define NULL 0
• #define variant32 variant
Typedefs

- typedef float ftd::data_type
  Typedef controls the data type used in all numerical containers and operations.
- typedef float ftd::float32
- typedef double ftd::float64
- typedef long double ftd::float96
- typedef signed short ftd::int16
- typedef signed int ftd::int32
- typedef signed long long ftd::int64
- typedef signed char ftd::int8
- typedef unsigned char ftd::uchar
  Unsigned character typedef.
- typedef unsigned short ftd::uint16
- typedef unsigned int ftd::uint32
- typedef unsigned long long ftd::uint64
- typedef unsigned char ftd::uint8

Enumerations

- enum DataLabel { NORMAL, FAULTY, UNKNOWN }
  Enumeration for possible labels for a fingerprint.
- enum OneClassResult {
  RES_NORMAL, RES_FAULTY, ERROR_DATA, ERROR_MODEL, ERROR_ALG, ERROR_PATH, ERROR_LOGFILE, ERROR_OTHER }
  Enumeration for possible results from the one-class classifier, including error states.
- enum ParseResult { PARSE_OK, ERROR_VARCOUNT, ERROR_ENTRYCOUNT }
  Enumeration for parsing results.

Variables

- const data_type ftd::EPS = 1.192092896e-07F
  Definition of what is consider a the smallest value.
- int ftd::MAX_LOG_LEVEL = LOG_INFO
  Default Log Serverity.
- const data_type ftd::PI = 3.14159265358979f
  Definition of PI.

3.8.1 Detailed Description

All required typedefs, namespaces, etc.

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3.8 Types.h File Reference

Date

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