

Median Task

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Chapter 1

Median

Example project with several implementations of median calculation:

MedianVector - uses `std::sort`

MedianNthElement - uses `std::nth_element`

MedianVectorLBound - uses `std::lower_bound`

MedianMultisetAdvance - uses `std::multiset` and `std::advance`

MedianMultisetIterator - uses `std::multiset` with median iterator

MedianRBTree - uses Red-Black tree

Compiled with VS2017 or later (with loading CMakeLists.txt from File->Open->CMake..).

This will build a console application that runs Unit Tests for several containers in Debug and several Performance tests in Release.

Chapter 2

Hierarchical Index

2.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

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Chapter 3

Class Index

3.1 Class List

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

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Chapter 4

File Index

4.1 File List

Here is a list of all documented files with brief descriptions:

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Chapter 5

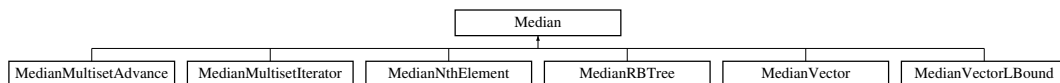
Class Documentation

5.1 Median Class Reference

[Median](#) class.

```
#include <Median.h>
```

Inheritance diagram for Median:



Public Member Functions

- virtual bool [add](#) (int a)=0
add new integer element
- virtual int [middle](#) () const =0
return value of the middle element
- virtual size_t [size](#) () const =0
return number of all elements
- virtual void [clear](#) ()=0
empty container

5.1.1 Detailed Description

[Median](#) class.

[Median](#) calculation class interface

All [Median](#) Calculations classes needs to support [Median](#) Units Tests platform and should inherit [Median](#) interface and implement its virtual methods.

Purpose of [Median](#) and the derived classes is to find the **middle** element. By **middle** it is understood the sorted in ascending order element exactly at position $N/2$, where N is the number of all added elements, if N is odd. If N is even, the **middle** element is at position $N/2-1$. This is shown below:

Odd - 1,2,3 N=3, **middle** is 2, at position 1

Even - 1,2,3,4 N=4, **middle** is 2 also at position 1

Odd - 1,2,3,4,5 N=5, **middle** is 3 at position 2

[Median](#) classes implementations were tested with units test (see [UnitTests.h](#)).

Performance tests comparing the algorithms are run in Release (see [PerformanceTest.h](#)).

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

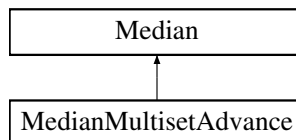
- [Median.h](#)

5.2 MedianMultisetAdvance Class Reference

[MedianMultisetAdvance](#) finds median using `std::multiset` and `std::advance`

```
#include <Median.h>
```

Inheritance diagram for MedianMultisetAdvance:



Public Member Functions

- virtual bool [add](#) (int a)
add new integer element
- virtual int [middle](#) () const
return value of the middle element
- virtual size_t [size](#) () const
return number of all elements
- virtual void [clear](#) ()
empty container

Protected Attributes

- `std::multiset< int > m_set`
multiset used for storage of the sorted elements

5.2.1 Detailed Description

[MedianMultisetAdvance](#) finds median using `std::multiset` and `std::advance`

[MedianMultisetAdvance](#) uses for storage container `std::multiset` all values are sorted by default in ascending order. Insert is done with the standard `insert()` routine of the multiset, obtaining then the middle element is done with `std::advance`.

[add\(\)](#) Average Complexity $O(\log n)$

[middle\(\)](#) Average Complexity $O(n)$

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

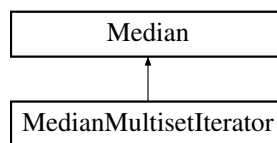
- [Median.h](#)
- [Median.cpp](#)

5.3 MedianMultisetIterator Class Reference

[MedianMultisetIterator](#) finds median using `std::multiset` and saved iterator to the middle element.

```
#include <Median.h>
```

Inheritance diagram for MedianMultisetIterator:



Public Member Functions

- virtual bool [add](#) (int a)
add new integer element
- virtual int [middle](#) () const
return value of the middle element
- virtual size_t [size](#) () const
return number of all elements
- virtual void [clear](#) ()
empty container

Protected Attributes

- `std::multiset< int > m_set`
vector used for storage of the sorted elements
- `std::multiset< int >::iterator m_it`
iterator to the middle element inside the set
- `unsigned int m_pos`
position of the middle element inside the set

5.3.1 Detailed Description

[MedianMultisetIterator](#) finds median using `std::multiset` and saved iterator to the middle element.

[MedianMultisetIterator](#) uses for storage container `std::multiset`, all values are sorted by default in ascending order. After insert `m_it` and `m_pos` variables are updated to point to the middle element.

[add\(\)](#) Average Complexity $O(\log n)$

[middle\(\)](#) Average Complexity $O(1)$

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

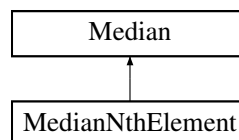
- [Median.h](#)
- [Median.cpp](#)

5.4 MedianNthElement Class Reference

[MedianVector](#) finds median using `std::vector` and `std::nth_element`

```
#include <Median.h>
```

Inheritance diagram for MedianNthElement:



Public Member Functions

- virtual bool [add](#) (int a)
add new integer element
- virtual int [middle](#) () const
return value of the middle element
- virtual size_t [size](#) () const
return number of all elements
- virtual void [clear](#) ()
empty container

Protected Attributes

- `std::vector< int > m_arr`
vector used for storage of the sorted elements

5.4.1 Detailed Description

[MedianVector](#) finds median using `std::vector` and `std::nth_element`

[MedianNthElement](#) class implements [Median](#) with using for storage `std::vector` and `std::nth_element` to keep sorted the middle element only.

[add\(\)](#) Average Complexity $O(n)$

[middle\(\)](#) Average Complexity $O(1)$

There is also additional cost for memory copies.

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

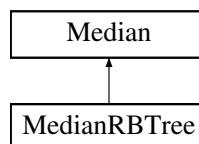
- [Median.h](#)
- [Median.cpp](#)

5.5 MedianRBTree Class Reference

[MedianRBTree](#) finds median using [RBTree](#)

```
#include <Median.h>
```

Inheritance diagram for MedianRBTree:



Public Member Functions

- virtual bool [add](#) (int a)
add new integer element
- virtual int [middle](#) () const
return value of the middle element
- virtual size_t [size](#) () const
return number of all elements
- virtual void [clear](#) ()
empty container

Protected Attributes

- [RBTREE m_bt](#)
RBTREE container used for storage of the sorted elements.

5.5.1 Detailed Description

[MedianRBTREE](#) finds median using [RBTREE](#)

[MedianRBTREE](#) uses for storage container Red-Black tree, all values are sorted in ascending order. Allows obtaining of the middle value as start iterating from the root. Since Red-Black is a self balancing tree, the middle value would be very near to the root so the search has constant average complexity

[add\(\)](#) Average Complexity $O(\log n)$

[middle\(\)](#) Average Complexity $O(1)$

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

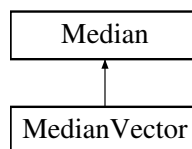
- [Median.h](#)
- [Median.cpp](#)

5.6 MedianVector Class Reference

[MedianVector](#) finds median using `std::vector` and `std::sort`

```
#include <Median.h>
```

Inheritance diagram for MedianVector:



Public Member Functions

- virtual bool [add](#) (int a)
add new integer element
- virtual int [middle](#) () const
return value of the middle element
- virtual size_t [size](#) () const
return number of all elements
- virtual void [clear](#) ()
empty container

Protected Attributes

- `std::vector< int > m_arr`
vector used for storage of the sorted elements

5.6.1 Detailed Description

`MedianVector` finds median using `std::vector` and `std::sort`

`MedianVector` class implements `Median` with using for storage `std::vector` and `std::sort` to keep elements sorted.

add() Average Complexity $O(n \log n)$

middle() Average Complexity $O(1)$

There is also additional cost for memory copies.

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

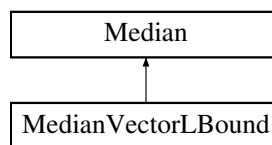
- `Median.h`
- `Median.cpp`

5.7 MedianVectorLBound Class Reference

`MedianVectorLBound` calculate median using `std::vector` and `std::lower_bound`

```
#include <Median.h>
```

Inheritance diagram for `MedianVectorLBound`:



Public Member Functions

- virtual bool `add` (int a)
add new integer element
- virtual int `middle` () const
return value of the middle element
- virtual size_t `size` () const
return number of all elements
- virtual void `clear` ()
empty container

5.7.1 Detailed Description

[MedianVectorLBound](#) calculate median using `std::vector` and `std::lower_bound`

[MedianVectorLBound](#) class implements [Median](#) with using for storage `std::vector` and `std::lower_bound` to sort only the last inserted element only. First the position of the inserted element is found with `std::lower_bound`, and then the new element is inserted there.

[add\(\)](#) Average Complexity $O(\log n)$

[middle\(\)](#) Average Complexity $O(1)$

There is also additional cost for memory copies.

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

- [Median.h](#)
- [Median.cpp](#)

5.8 RBTREE::Node Class Reference

Public Member Functions

- **Node** (const int &key, [Node](#) *parent=0)
- void **init** ()
- bool **isEmpty** () const
- int **numChildsLeft** () const
- int **numChildsRight** () const

Public Attributes

- [Node](#) * **left**
- [Node](#) * **right**
- [Node](#) * **parent**
- int **key**
- int **type**
- int **nChilds**

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

- [RBTREE.h](#)

5.9 RBTREE Class Reference

Classes

- class [Node](#)

Public Types

- enum { **BLACK** = 0, **RED** = 1 }

Public Member Functions

- bool **insert** (const int &key)
insert new element
- int **size** () const
return number of all inserted elements
- bool **clear** ()
empty tree
- int **middleValue** () const
get the value of the middle element

Protected Member Functions

- void **rotateRight** (Node *node)
- void **rotateLeft** (Node *node)
- void **insertFixup** (Node *x)
- virtual Node * **allocNode** (const int &key, Node *parent=0)
- virtual void **deleteNode** (Node *node)
- Node * **findParent** (Node *node, const int &key) const
- Node * **insertNode** (Node *node, const int &key)
- void **emptySubtree** (Node *node)

Protected Attributes

- Node * **root**
pointer to the root of the tree
- int **count**
integer to keep the number of the inserted elements

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

- [RBTREE.h](#)
- [RBTREE.cpp](#)

Chapter 6

File Documentation

6.1 Median.h File Reference

Main declaration header for [Median](#) Interface and several [Median](#) implementations.

```
#include <vector>
#include <set>
#include "RBTREE.h"
```

Classes

- class [Median](#)
Median class.
- class [MedianVector](#)
MedianVector finds median using ***std::vector*** and ***std::sort***
- class [MedianNthElement](#)
MedianVector finds median using ***std::vector*** and ***std::nth_element***
- class [MedianVectorLBound](#)
MedianVectorLBound calculate median using ***std::vector*** and ***std::lower_bound***
- class [MedianMultisetAdvance](#)
MedianMultisetAdvance finds median using ***std::multiset*** and ***std::advance***
- class [MedianMultisetIterator](#)
MedianMultisetIterator finds median using ***std::multiset*** and saved iterator to the middle element.
- class [MedianRBTree](#)
MedianRBTree finds median using ***RBTree***

6.1.1 Detailed Description

Main declaration header for [Median](#) Interface and several [Median](#) implementations.

Following [Median](#) implementations are provided: [MedianVector](#) [MedianNthElement](#) [MedianVectorLBound](#) [MedianMultisetAdvance](#) [MedianMultisetIterator](#) [MedianRBTree](#)

6.2 PerformanceTest.h File Reference

Performance tests for the [Median](#) Class.

```
#include "Median.h"
```

Functions

- bool [performanceTestAllRandom](#) (int N)
Test with randomly generated values.
- bool [performanceTestAllWorst](#) (int N)
Test with descending values.
- bool [performanceTestAllRepeating](#) (int N)
Test with repeating values.

6.2.1 Detailed Description

Performance tests for the [Median](#) Class.

Tests can be run on Windows x86/x64 platforms.

6.2.2 Function Documentation

6.2.2.1 [performanceTestAllRandom\(\)](#)

```
bool performanceTestAllRandom (  
    int N )
```

Test with randomly generated values.

Performance test with randomly generated values, also checks if the returned values are correct

Parameters

<i>N</i>	number of the test values
----------	---------------------------

Returns

True if successful

6.2.2.2 performanceTestAllRepeating()

```
bool performanceTestAllRepeating (
    int N )
```

Test with repeating values.

Performance test with repeating (0-9) values

Parameters

N	number of the test values
-----	---------------------------

Returns

True if successful

6.2.2.3 performanceTestAllWorst()

```
bool performanceTestAllWorst (
    int N )
```

Test with descending values.

Performance test with linearly descending values, also checks if the returned values are correct

Parameters

N	number of the test values
-----	---------------------------

Returns

True if successful

6.3 RBTre.h File Reference

multiset implementation of a Red-Black tree

Classes

- class [RBTre](#)
- class [RBTre::Node](#)

6.3.1 Detailed Description

multiset implementation of a Red-Black tree

Similarly to `std::multiset`, this RB tree allows inserting of duplicate values. It is specially designed to find the median element in efficient way.

6.4 UnitTests.h File Reference

Provides unit tests for [Median](#) Class.

```
#include "Median.h"
```

Functions

- void **printc** (int color, const char *output,...)
- void **printResult** (const char *fname, bool bRes)
- int **test_median_basic** ([Median](#) &m)
- int **test_median_iter** ([Median](#) &m)
- int **test_median_random** ([Median](#) &m)
- int **unitTest** ([Median](#) &m)
- int **unitTest_MedianVector** ()
- int **unitTest_MedianVectorLBound** ()
- int **unitTest_MedianNthElement** ()
- int **unitTest_MedianMultisetAdvance** ()
- int **unitTest_MedianMultisetIterator** ()
- int **unitTest_MedianRBTree** ()

6.4.1 Detailed Description

Provides unit tests for [Median](#) Class.

Tests can be run on Windows x86/x64 platforms.

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