DGtal: Digital Geometry Tools and Algorithms Library

1D Geometry

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Objectives

Tools that help in analysing any one-dimensional discrete structures in a generic framework.

Examples in digital geometry

- digital curves
  - 2d, 3d, nd
  - 4-connected, 8-connected, disconnected
  - pixels, interpixels, points
  - open or closed
- chain codes

Constant structures, not mutable

Structures

2 characteristics

- discrete
- one-dimensional

2 notions

- element
- local order (next and previous element)

Iterators

Iterator

- operator* (to get the element)
- operator++, operator- - (to point to the next and previous element)

Reachability

An iterator j is reachable from an iterator i if and only if i can be made equal to j with finitely many applications of the operator++.

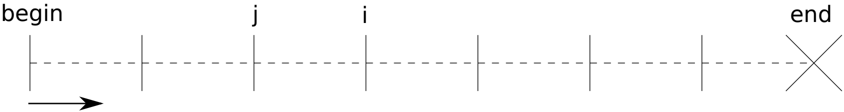
Range

If j is reachable from i, one can iterate over the range of elements bounded by i and j, from the one pointed to by i and up to but not including the one pointed to by j. Such a range is valid and is denoted by [i,j).

Open/Linear structures

Classic iterator

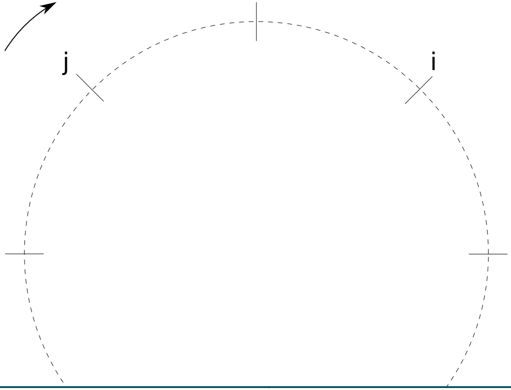
- past-the-end value
- $[begin, end)$ is the whole range
- $[i, j)$ is not always valid
- $[i, i)$ is the empty range



Closed/Circular structures

CGAL circular iterator (circulator)

- no past-the-end value
- $[i, j)$ is always valid
- $[i, i)$ is the whole range
- As long as $i \neq j$, the range $[i, j)$ behaves like a classic iterator range.



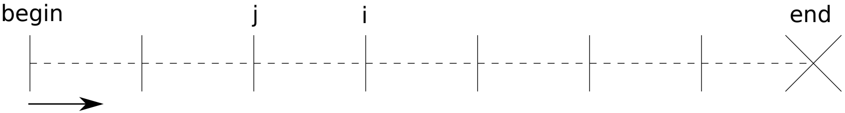
Scanning backward

Reverse iterator

A reverse iterator is an adaptor for scanning backward. The operator++ of the adaptor calls the operator– of the underlying (circular)iterator and conversely. You can use the STL reverse iterator.

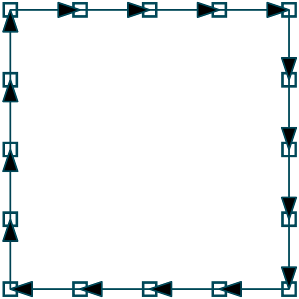
Tricky part

Operator* of the adaptor calls operator- - of the underlying (circular)iterator before calling its operator*.



GridCurve

GridCurve is an (open or closed) n-dimensional oriented grid curve. It stores a list of alternated (signed) 0-cells and 1-cells.

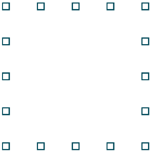


GridCurve

Ranges

GridCurve provides many ranges as nested types to iterate over different kinds of elements:

- nd
  - SCellsRange
  - PointsRange
  - MidPointsRange
  - ArrowsRange
- 2d TODO
  - InnerPointsRange
  - OuterPointsRange
  - IncidentPointsRange
  - CodesRange



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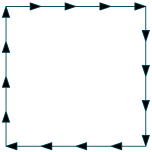

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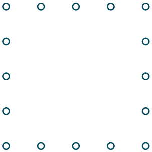

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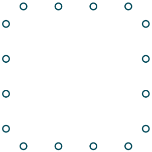

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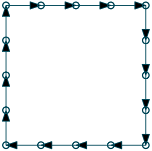

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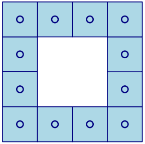

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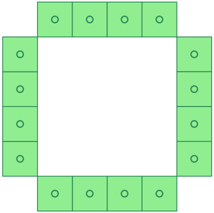

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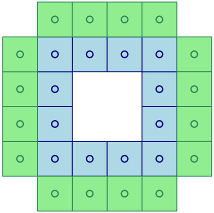


Code

FreemanChain

FreemanChain is 2-dimensional and 4-connected digital curve stored as a string of codes 0,1,2,3. As GridCurve, it provides a CodesRange.

Conversion between FreemanChain and GridCurve

TODO

Segments

A segment is a valid and not empty range. The concept CSegment is such that:

Types

- Self
- ConstIterator

Methods

- begin()
- end()

Class of segments

A class of segments can be defined from a valid property P. P is valid iff P is true for any range of only one element and for any not empty range of any segment.

Examples

- - to be a DSS
- - to be a balanced word
- x to contain at least k elements (k > 1)

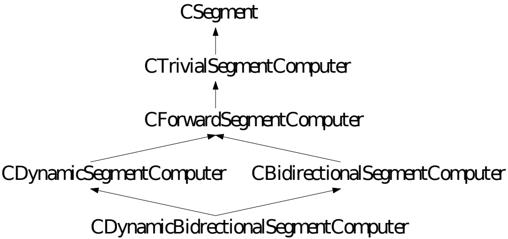
Segment computer

Detection problem

Deciding whether a given segment belongs to a class of segments defined from a valid property P or not. If P is valid, the detection of a segment can be performed in an incremental way: a segment is initialized at a starting element and then can be extended to the neighbors elements if the property P still holds.

Segment computer

Segment that can control its own extension (so that the property P remains true)



CSegment

CTrivialSegmentComputer

CForwardSegmentComputer

CDynamicSegmentComputer

CBidirectionalSegmentComputer

CDynamicBidirectionalSegmentComputer

CTrivialSegmentComputer

Refinement of CSegment that provides in addition the following methods:

- void init (const ConstIterator& it) : set the segment to the element pointed to by it.
- bool isExtendable () : return ’true’ if the segment can be extended to the element pointed to by end() and ’false’ otherwise (no extension is performed).
- bool extend () : return ’true’ and extend the segment to the element pointed to by end() if it is possible, return ’false’ and does not extend the segment otherwise.

Detection of a segment

```
//s is a segment computer
//[begin,end) is a range
s.init( begin );
while ( (s.end() != end) && (s.extend()) ) {}
```

Avoiding infinite loops with circulators

```
//s is a segment computer
//c is a circulator
s.init( c );
while ( (s.end() != s.begin()) && (s.extend()) ) {}
```

List of segment computers

- ArithmeticalDSS
- ArithmeticalDSS3d
- CombinatorialDSS
- GeometricalDSS
- GeometricalDCA
- ThickSegment
- ConvexPart
- ...
- other based on linear programming

Useful functions

The code can be different if an iterator or a circulator is used as the nested ConstIterator type. Moreover, some tasks can be made faster for a given kind of segment computer than for another kind of segment computer. That's why many generic functions are provided in SegmentComputerUtils.h:

- maximalExtension, oppositeEndMaximalExtension, maximalSymmetricExtension,
- maximalRetraction, oppositeEndMaximalRetraction,
- longestSegment (init the segment computer),
- firstMaximalSegment, lastMaximalSegment, mostCenteredMaximalSegment,
- previousMaximalSegment, nextMaximalSegment,

Segmentation

Definition

A given range contains a finite set of segments verifying a valid property P. A segmentation is a subset of the whole set of segments, such that:

1. each element of the range belongs to a segment of the subset
2. no segment contains another segment of the subset

Due to (2), the segments of a segmentation can be ordered without ambiguity (according to the relative position of their first element for instance).

Types

SegmentComputerIterator

- dereference operator: return an instance of a segment computer.
- intersectPrevious(), intersectNext(): return 'true' if the current segment intersects, respectively, the previous and the next one (when they exist), 'false' otherwise.

Methods

init method taking as input parameters:

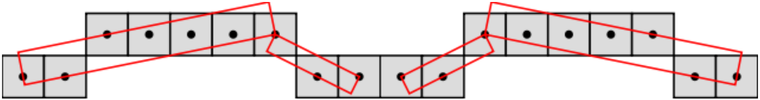
- begin/end (circular)iterators of the range to be segmented
- an instance of segment computer

Greedy segmentation

```
//types definition
typedef PointVector<2,int> Point;
typedef std::vector<Point> Range;
typedef Range::const_iterator ConstIterator;
typedef ArithmeticalDSS<ConstIterator,int,8> SegmentComputer;
typedef GreedySegmentation<SegmentComputer> Segmentation;


Range curve;
... //create curve


//Segmentation
SegmentComputer recognitionAlgorithm;
Segmentation theSegmentation(curve.begin(), curve.end(), recognitionAlgorithm);


Segmentation::SegmentComputerIterator i = theSegmentation.begin();
Segmentation::SegmentComputerIterator end = theSegmentation.end();
for ( ; i != end; ++i) {
  SegmentComputer current(*i);
  trace.info() << current << std::endl;   //standard output
}
```

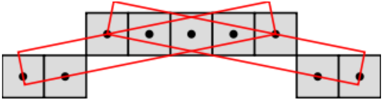
Greedy segmentation

```
...
  typedef Range::const_reverse_iterator ConstIterator;
...
  Segmentation theSegmentation(curve.rbegin(), curve.rend(), recognitionAlgorithm)
...
```



Saturated segmentation

```
...
   typedef SaturatedSegmentation<SegmentComputer> Segmentation;
...
```



Segmentation of subranges

```
theSegmentation.setSubRange(beginIt, endIt);
theSegmentation.setMode("myMode");
```

- greedy
    - "Truncate" (default)
    - "Truncate+1"
    - "DoNotTruncate"
- saturated
    - "First",
    - "MostCentered" (default)
    - "Last"