TD7: DSS Covering and Normal Vector Estimation

In this TP, the idea is to implement a multigrid convergent normal vector estimator. We assume that you have:

- DGtal and DGtalSkel tools updated and running (TP5)
- A function that constructs the Gauss digitalization of an Euclidean disc (TP5)
- A function that tracks the border of a DigitalSet and construct a std::vector<Point> of border points (TP6)

Exercise 1 Digital Tangent

By using the example file DSSExample.cpp and [http://libdgital.org/doc/stable/classDGtal_1_1ArithmeticalDSS.html](http://libdgital.org/doc/stable/classDGtal_1_1ArithmeticalDSS.html), we first focus on the decomposition of a contour (std::vector<Point> sequence) into maximal DSS. The functions are the following:

- Init a DSS at the "begin()" sequence iterator
- While the DSS.extendFront() returns true, we increment an iterator copy "iter" of the sequence.begin()
- When the DSS recognition fails, we init a new DSS at "iter" and repeat the above process until "iter" reaches the end of the sequence (sequence.end())

**Question:** Implement such DSS decomposition and visualize each DSS segments as shown in DSSExample.cpp

We want to implement the digital tangent estimator, which works in the following way:

- Given position iter on the contour, we init a DSS segment at this point and extend the DSS at both sides (extendFront() and extendBack())
- Returns the DSS slope (a() and b()).

**Remarks:** The DSS is defined by \( \mu \leq ax - by < \mu + \max(|a|, |b|) \). At this point, even if the sequence encodes a closed contour, we suppose that there nothing "backward" the sequence.begin() and nothing after the sequence.end().

**Questions:**

- Implement this estimator.
- If you repeat such process at each position on the sequence, what would be the computational cost to estimate all digital tangents?
Using the above algorithm, the estimations near the sequence extremities are biased and do not take into account the fact the contour is closed (i.e. tangent near the \texttt{sequence.begin()} could contain points near the \texttt{sequence.end()}). To handle extremities, we can use the concept of \texttt{Circulator} instead of \texttt{Iterator}.

Questions:
- Have a look to the \texttt{DSSCirculatorExample.cpp} in the \texttt{DGtalSkel} folder where we give you an example of Circulator construction in DGtal and its use to define DSS on circular contours.
- Update your code to be valid on closed contours.

Remarks:
- To display an arrow \((p, p + dp)\) using Board2D, you can use the following \texttt{draw} function:

  ```cpp
  Board2D board;
  RealPoint p(0.0, 0.4), dp(0.33, 0.66);
  Display2DFactory::draw( board, dp, p);
  ```

- Be careful \texttt{RealPoint} (with ”double” coordinates) differs from \texttt{Point} (Integer coordinates)
- Dereferencing an iterator (“*iter”) of std::vector returns a Point.

Exercise 2 Maximal DSS Covering (from TP6)

In this exercise, we implement the maximal DSS covering of a contour.

The algorithm is the following:
- We init a DSS (starting from \texttt{sequence.begin()} and extend it in the ”forward” direction. When the DSS recognition stops, we have out first maximal DSS.
- To get the other ones, remove one point at the left of the DSS (\texttt{dss.retractBack()}) and extend this new DSS forward.
- We repeat this process until reaching the end of the sequence.

Questions:
- If both \texttt{extend} and \texttt{retract} are in \(O(1)\), what is the complexity of the maximal covering algorithm?
- Implement this algorithm and display all the maximal DSS (cf \texttt{DSSExample.cpp}).
- When computing the maximal DSS, compute the max, min and mean length (using the \(l_\infty\) distance, between \texttt{back()} and \texttt{front()} DSS points).
- Create a small executable parametrized by a grid step \(h\) which digitizes a disk at step \(h\) and returns the max/min/mean values. Then, using a small script and gnuplot, display the behavior of these quantities when \(h \to 0\). Using logscale mode in gnuplot\(^1\) can you experimentally observed the theoretical bounds on maximal DSS we discussed during the lecture?

\(^1\)\texttt{set logscale x and set logscale y}