Road Network Reconstruction for Organizing Paths\textsuperscript{[1]}

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Problem Statement
Road Network Model

- Road Network is modeled as Geometric Graph \( G = (V,E) \)
  - \( V \) represents the Sampling Points
  - \( E \) represents linking line between two vertices
  - Each road fragment is associated with a road width \( \varepsilon \)
Road Network Model (Cntd.)

Road Fragment ($\gamma$)

- Vertex ($V$)
- Road Width ($\varepsilon$)
- Edge ($E$)
Assumptions

• The assumptions on original road network use a parameter, b

• The value of b has been set to $2 + \sqrt{6}$ to guarantee proper behavior of the algorithm.
Assumption One: No Sharp Turn

- Length of each edge is $\geq 3b\varepsilon$
- Angle between two edges is $\geq \pi/2$
Assumption Two: Road Fragments are Long and Good

- Length(\(\beta\)) \(\geq 9b\)
- No other fragment gets too close (minimum distance \((b+2)\varepsilon\))
Assumption Three: Close Fragments Must have Intersection Point
Assumption Four

• Each input path(ℓ) is within distance ε/2 of a subcurve(γ) of a path on G.
Assumption Five

For each road fragment \( \gamma \) there exists at least one input path \( \ell \) such that \( \ell \cap \epsilon / 2 \) contains \( \gamma \)
Outline of the Algorithm

• **Step One: Find $b\varepsilon$-net**
  – Set of points ($S$) selected from the input paths
  – All points on the input paths are within $b\varepsilon$ distance of at least one point in $S$
  – Distance of any two points in $S$ is at most $b\varepsilon$
Step One: Finding $b\varepsilon$-net
Step Two: Compute Voronoi Diagram $V(S)$
Step Three: Compute Clean Graph and Primitive Chain

- Compute Delaunay Graph
- Compute Restricted Delaunay Graph
- Identify Clean Voronoi Cell (cell with degree 2)
- Compute Clean Graph and Primitive Chain
Step Three: Compute Delaunay Graph
Step Three: Compute Restricted Delaunay Graph
Step Three: Compute Restricted Delaunay Graph
Step Three: Compute Restricted Delaunay Graph
Step Three: Compute Restricted Delaunay Graph
Step Three: Identify Clean Voronoi Cells
Step Three: Compute Clean Graph
Step Three: Clean Graph

- Primitive Chains
- Cycles
Step Three: Clean Graph

Road Networks

Restricted Delaunay Graphs
Step Four: Building Structure Graph

• **Link**
  Subcurve of an input path that intersect two clean voronoi cells at two distinct edges.

• Building Structure graph
Step Four: Link
Step Four: Building Structure Graph
Step Five: Identify Clean Links and chains

• Identify Clean Links and chains

• **Clean Links**
  Whose boundary edge do not touch links of different types.
Step Five: Identify Clean Links and chains

Voronoi Diagram

Structure Graph
Step Six: Identify Clean Voronoi Cell

Clean Voronoi Cell

A voronoi cell is marked to be clean if every path cutting through $B(s, 5\varepsilon)$ must intersect $B(s, \varepsilon)$. 

![Voronoi Cell Diagram](image)
Step Seven: Reconstruction Graph
Step Seven: Reconstruction Graph
Step Seven: Reconstruction Graph
Runtime Analysis

- $O(k^2 + Mk \log k)$
- $k$ is the complexity of $b\varepsilon$-net
- $M$ is total complexity of $n$ input paths

Compute Voronoi Diagram incrementally for $k$ Points$^2$

Walk along the polygonal curve using Ray Shooting$^3$
Runtime Analysis

- $O(Mk)$ : Finding bε–net
- $O(k \log k)$ : Compute Voronoi Diagram
- $O(k)$ : Mark clean Voronoi cells and compute the clean graph
- $O(k)$ : Building Structure Graph
- $O(k)$ : Find clean links and chains
- $O(kn)$ : Mark Clean Voronoi Cell
- $O(k+n)$ : Update structure graph and compute reconstruction graph
Complexity of Reconstruction Graph

• **Theorem:**

  The number of edges in the reconstruction graph is linearly proportional to the number of edges in the underlying road network.
Correctness Proof

• Correctness of Reconstruction Graph:
  The reconstruction graph has an edge for each primitive chain, and chains are connected using links.
Experimental Results

(a) The input paths. (b) The reconstruction graph.
Experimental Results

(a) An overview of the reconstructed graph. (b) Reconstruction in two zoomed in regions.
References


Questions???