Algorithms for Generation of Irregular Space Frame Structures

Franz Gruber Günter Wallner

University of Applied Arts Vienna
Institute for Art and Technology

14th International Conference on Geometry and Graphics, Kyoto, Japan, 2010

Introduction

Motivation

Space Frames

A space frame is a lightweight rigid structure which is constructed from interlocking struts which are arranged in a geometric pattern

Space Frame were independently developed by

- Alexander Graham Bell
- Buckminster Fuller

Introduction

Famous Buildings

Introduction

Famous Buildings

Introduction

Famous Buildings

Introduction

Famous Buildings

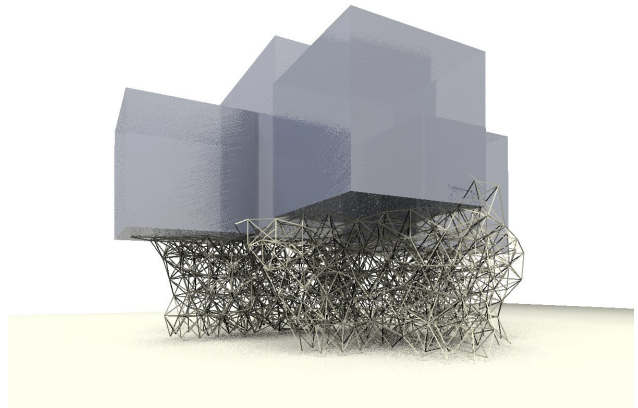
Introduction

Related Work

Contemporary landmark architecture has a tendency toward unique building elements

$\Rightarrow$ research on irregular structures has increased over the last years, e.g.

Przemyslaw L. Jaworski, *Using simulations and artificial life algorithms to grow elements of construction*, Master's Thesis, University College London, 2006



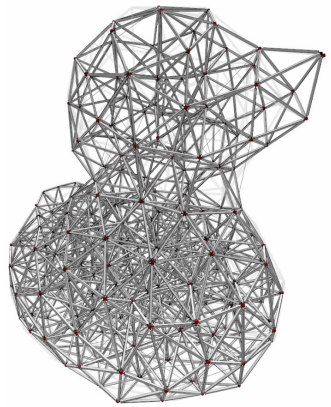
Introduction

Related Work

Contemporary landmark architecture has a tendency toward unique building elements

$\Rightarrow$ research on irregular structures has increased over the last years, e.g.

Anastasios Kanellos, *Topological self-organisaton: Using a particle-spring system simulation to generate structural space*, Master's Thesis, University College London, 2007



Introduction

Problem

Project: Algorithmic Generation of Complex Space Frames

Goal: to analyze new and innovative approaches to develop irregular and at the same time effective structures

Klaus Bollinger, Arne Hofmann and Clemens Preisinger, *Algorithmic Generation of Complex Space Frames*, Austrian Science Fund Project, 2009

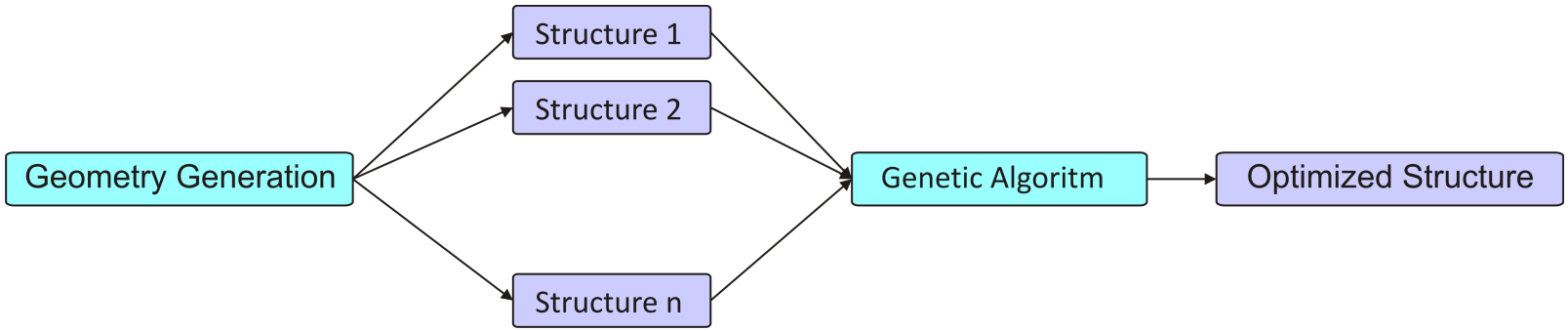
Introduction

Problem

Project: Algorithmic Generation of Complex Space Frames

Goal: to analyze new and innovative approaches to develop irregular and at the same time effective structures

Klaus Bollinger, Arne Hofmann and Clemens Preisinger, *Algorithmic Generation of Complex Space Frames*, Austrian Science Fund Project, 2009



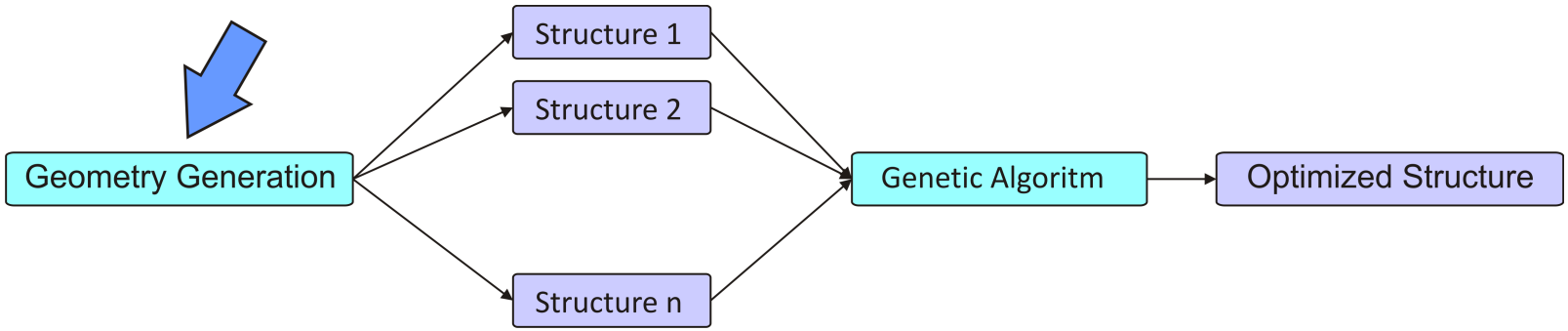
Introduction

Problem

Project: Algorithmic Generation of Complex Space Frames

Goal: to analyze new and innovative approaches to develop irregular and at the same time effective structures

Klaus Bollinger, Arne Hofmann and Clemens Preisinger, *Algorithmic Generation of Complex Space Frames*, Austrian Science Fund Project, 2009



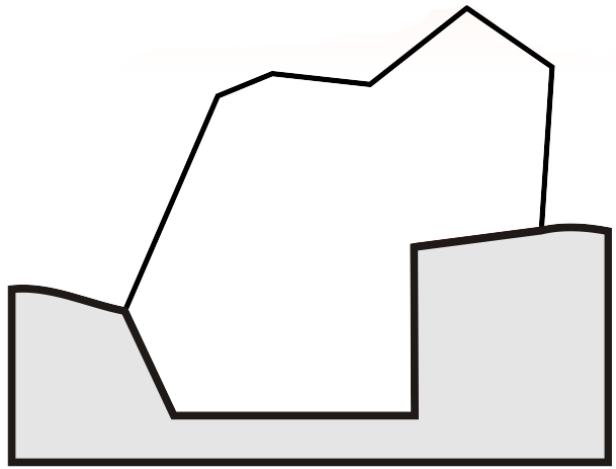
Introduction

Problem

Problem

Given: a polygonal bounding volume (not necessarily convex) with support areas

$\Rightarrow$ a certain number of irregular structures inside this bounding volume which are then optimized by a genetic algorithm in respect to static stability



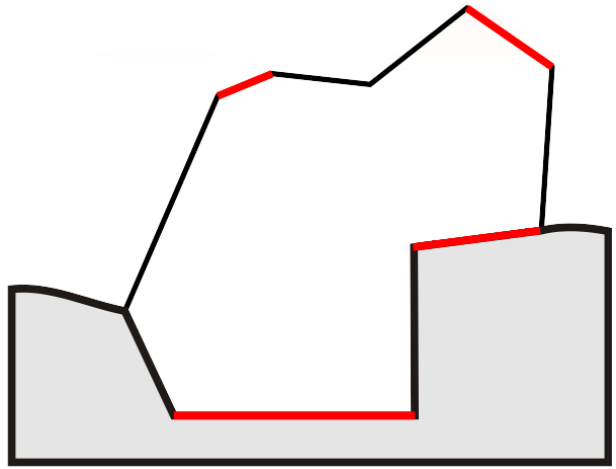
Introduction

Problem

Problem

Given: a polygonal bounding volume (not necessarily convex) with support areas

$\Rightarrow$ a certain number of irregular structures inside this bounding volume which are then optimized by a genetic algorithm in respect to static stability



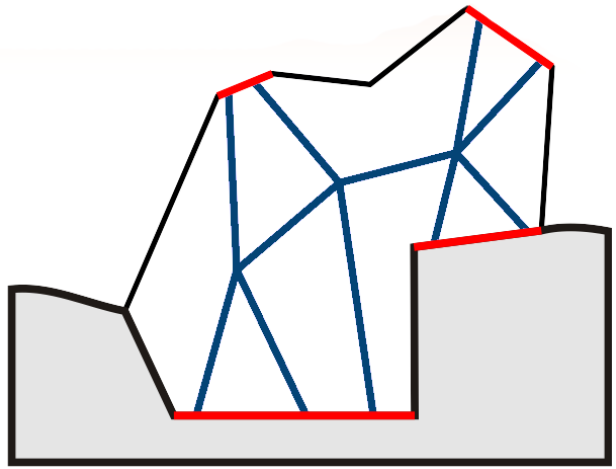
Introduction

Problem

Problem

Given: a polygonal bounding volume (not necessarily convex) with support areas

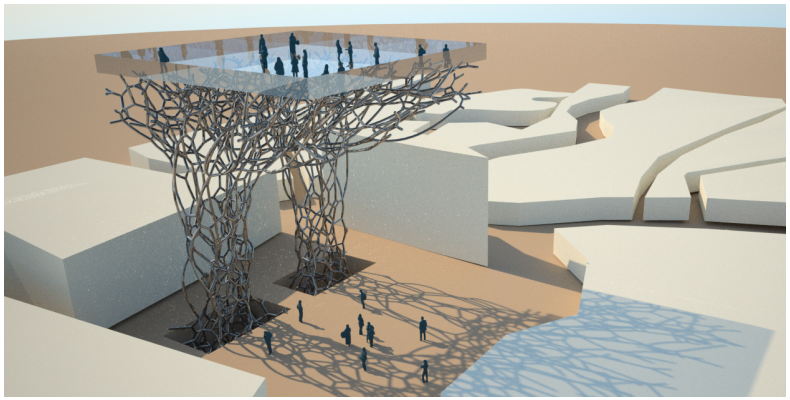
$\Rightarrow$ a certain number of irregular structures inside this bounding volume which are then optimized by a genetic algorithm in respect to static stability



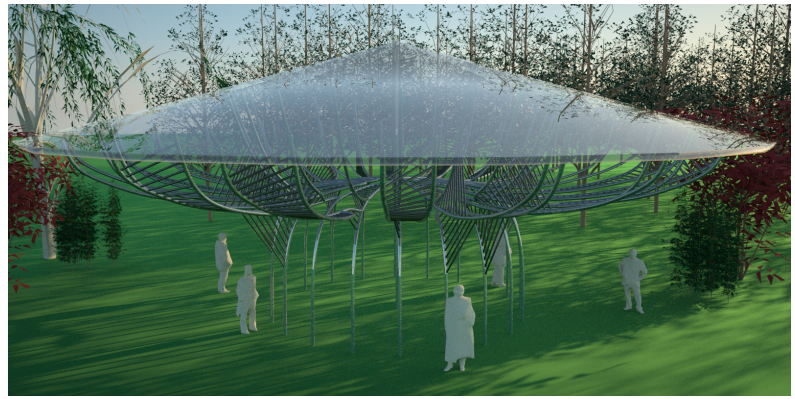
Introduction

Overview

We present two methods



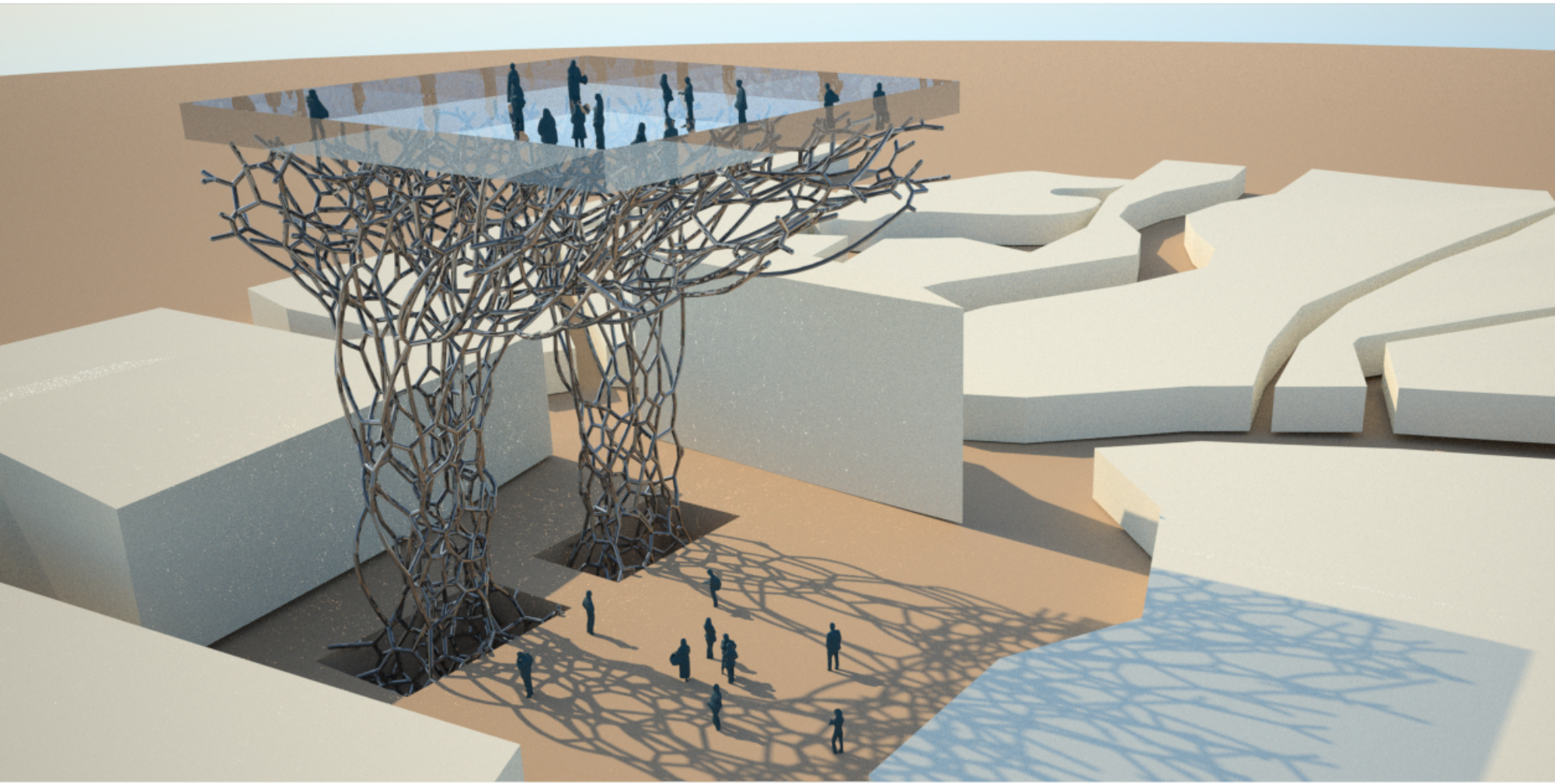
Voronoi Paths



Skeletonization[1]

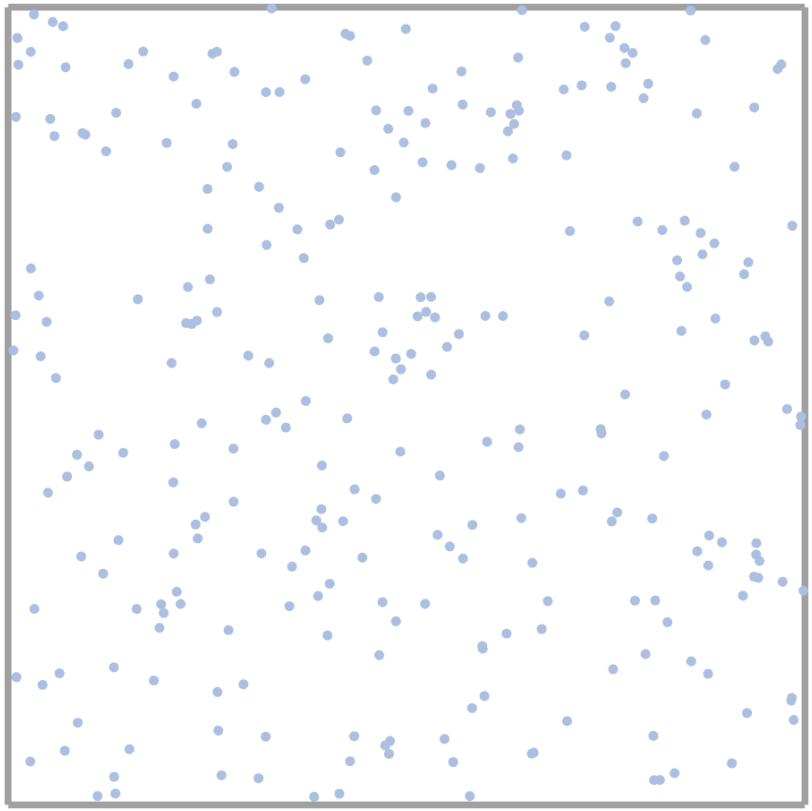
[1] Based on the work of Nicu D. Cornea, Deborah Silver, Xiaosong Yuan and Raman Balasubramanian, *Computing Hierarchical Curve-Skeletons in 3D*, The Visual Computer, Volume 21, 2005

Voronoi Paths



Voronoi Paths

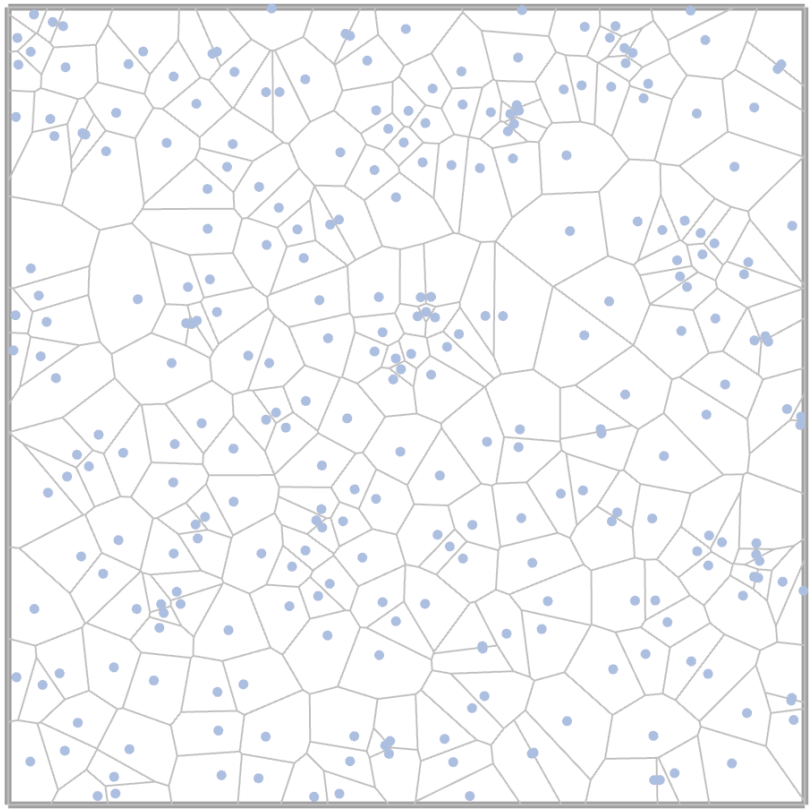
Algorithm



1. Place random points

Voronoi Paths

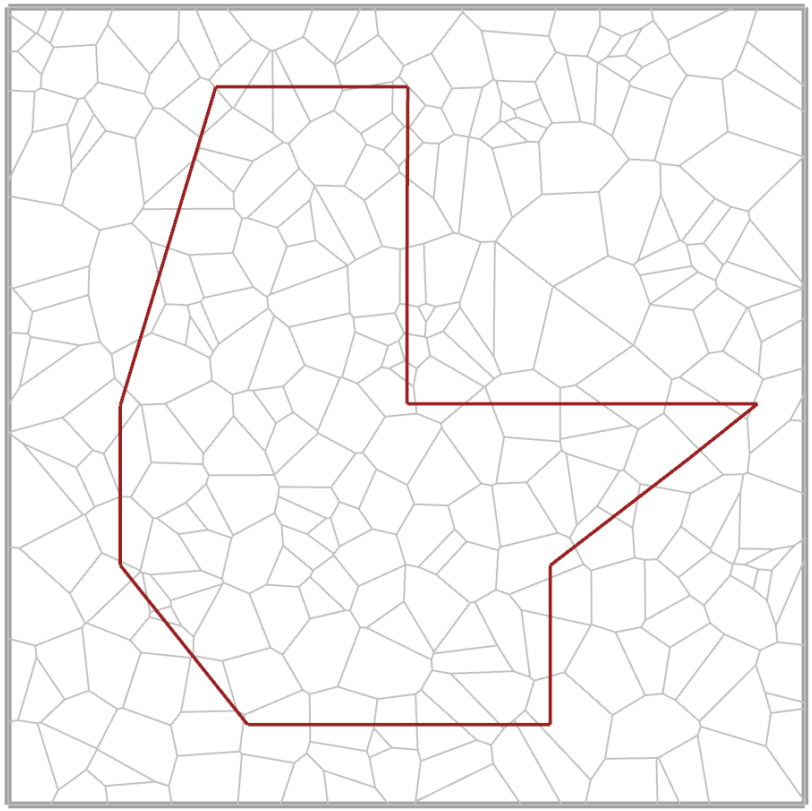
Algorithm



1. Place random points
2. Generate Voronoi tessellation

Voronoi Paths

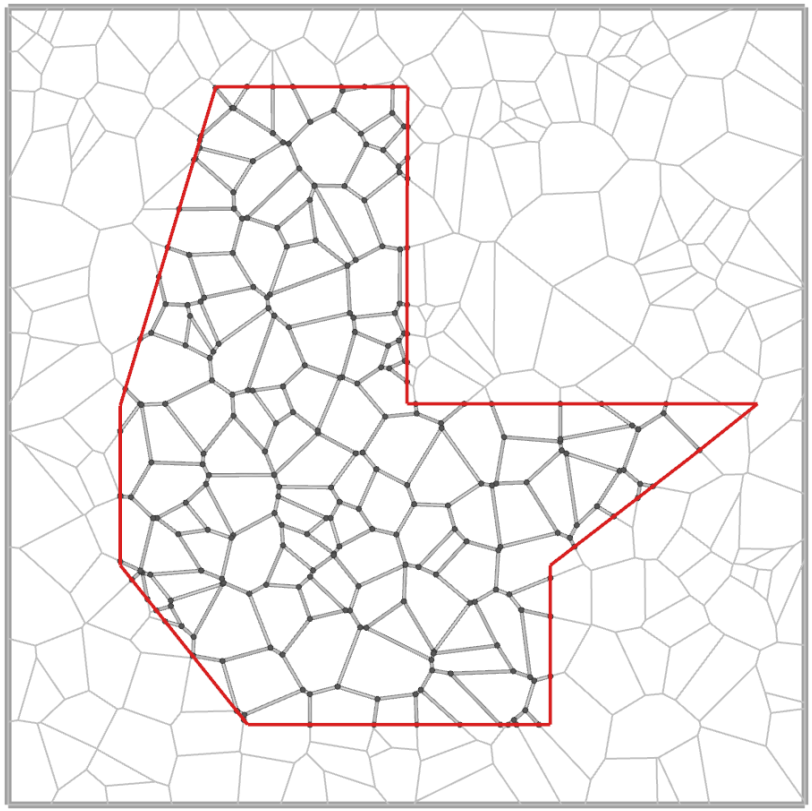
Algorithm



1. Place random points
2. Generate Voronoi tessellation
3. Crop tessellation at boundary

Voronoi Paths

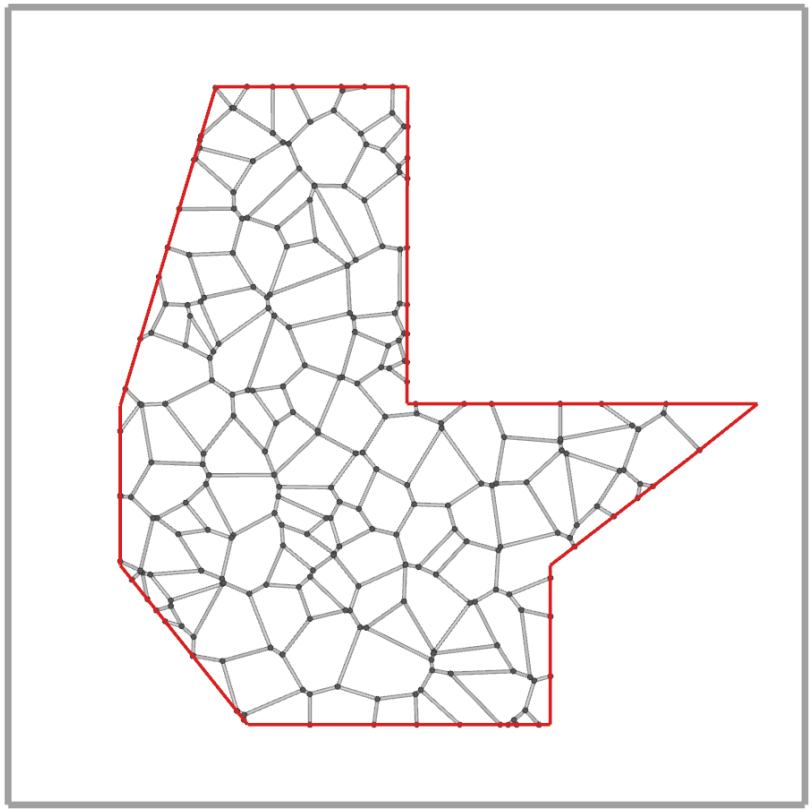
Algorithm



1. Place random points
2. Generate Voronoi tessellation
3. Crop tessellation at boundary

Voronoi Paths

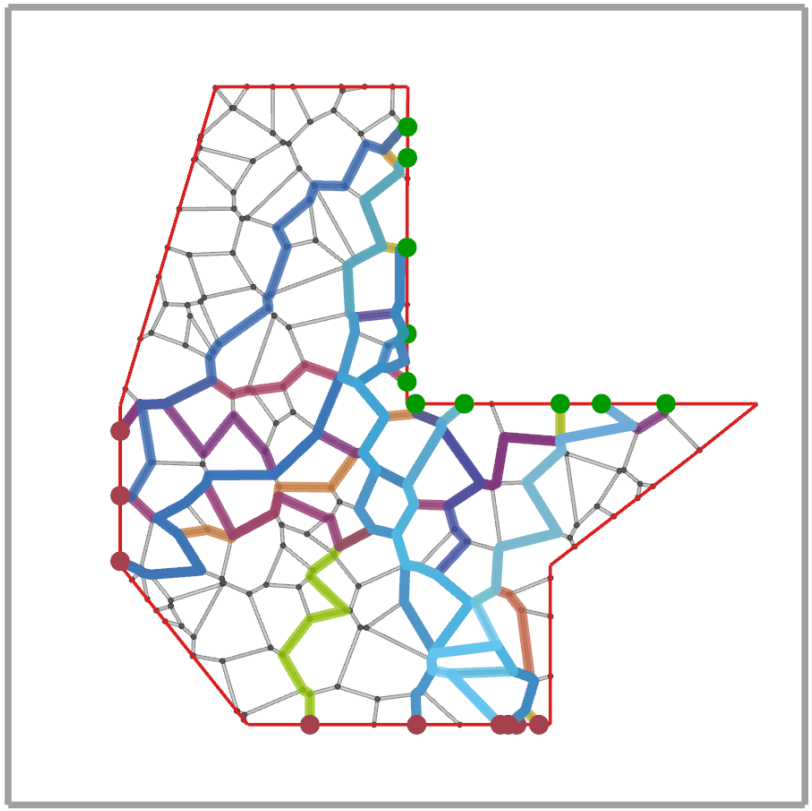
Algorithm



1. Place random points
2. Generate Voronoi tessellation
3. Crop tessellation at boundary

Voronoi Paths

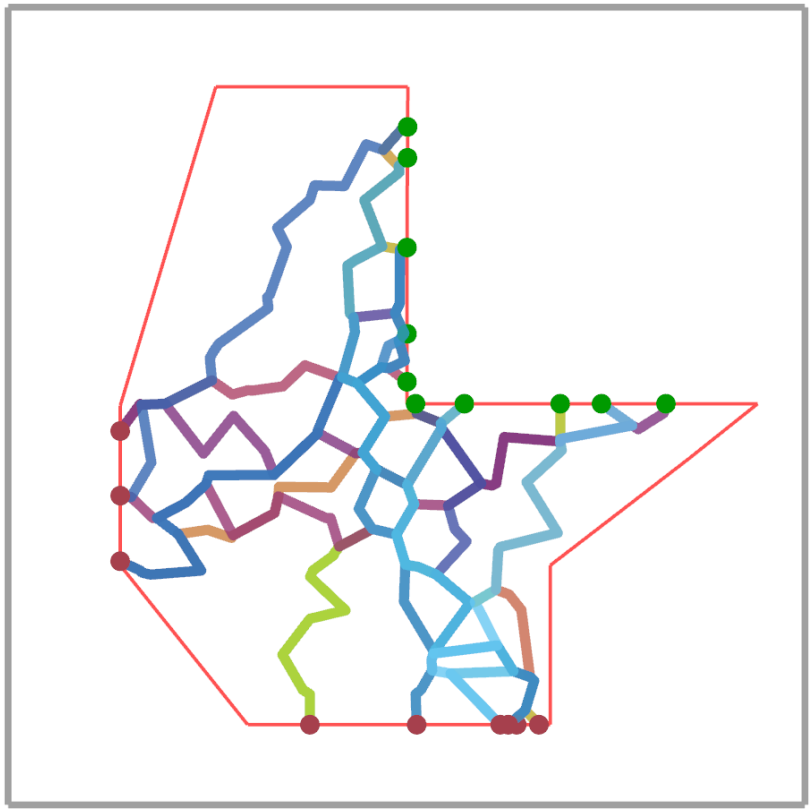
Algorithm



1. Place random points
2. Generate Voronoi tessellation
3. Crop tessellation at boundary
4. Find path between different support areas

Voronoi Paths

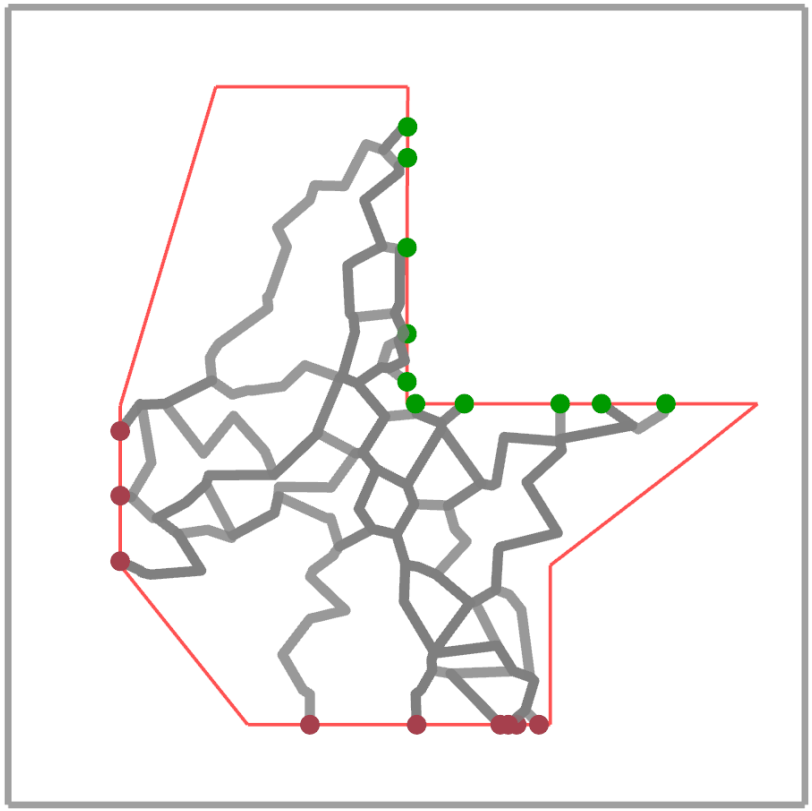
Algorithm



1. Place random points
2. Generate Voronoi tessellation
3. Crop tessellation at boundary
4. Find path between different support areas

Voronoi Paths

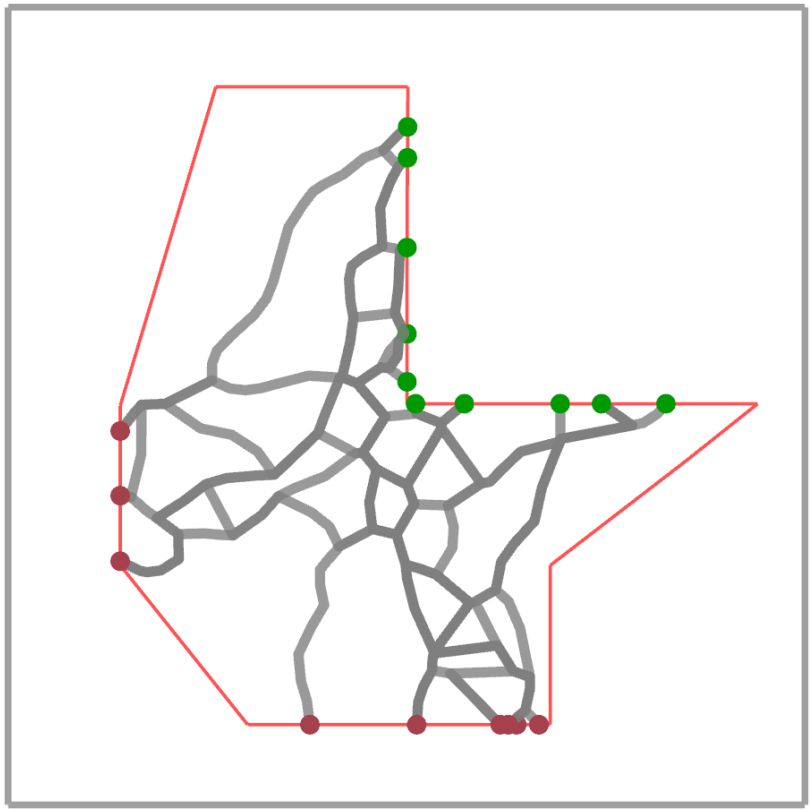
Algorithm



1. Place random points
2. Generate Voronoi tessellation
3. Crop tessellation at boundary
4. Find path between different support areas
5. Construct network

Voronoi Paths

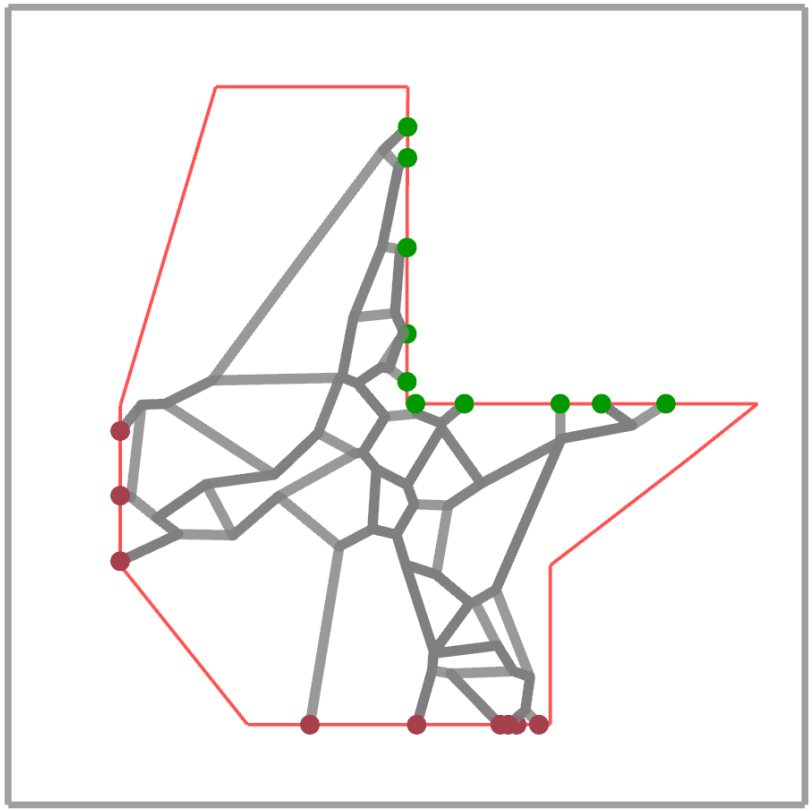
Algorithm



1. Place random points
2. Generate Voronoi tessellation
3. Crop tessellation at boundary
4. Find path between different support areas
5. Construct network
6. Smooth network

Voronoi Paths

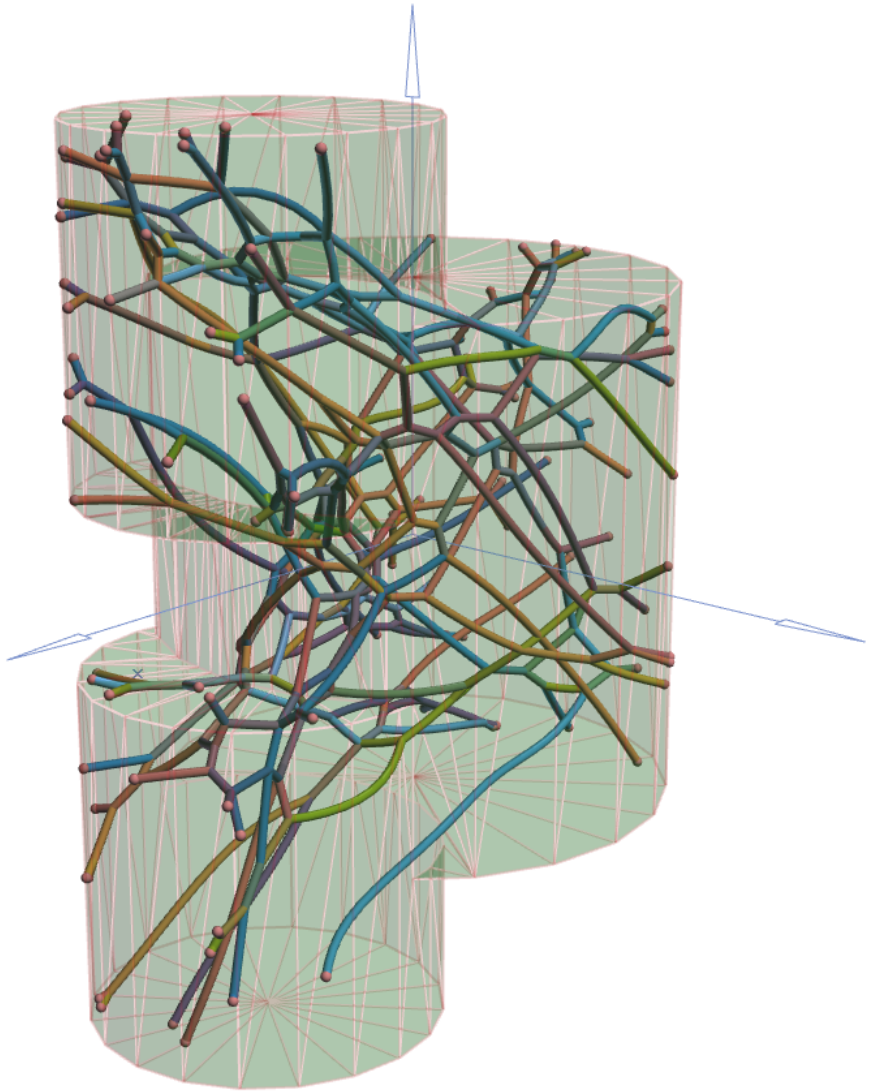
Algorithm



1. Place random points
2. Generate Voronoi tessellation
3. Crop tessellation at boundary
4. Find path between different support areas
5. Construct network
6. Smooth network

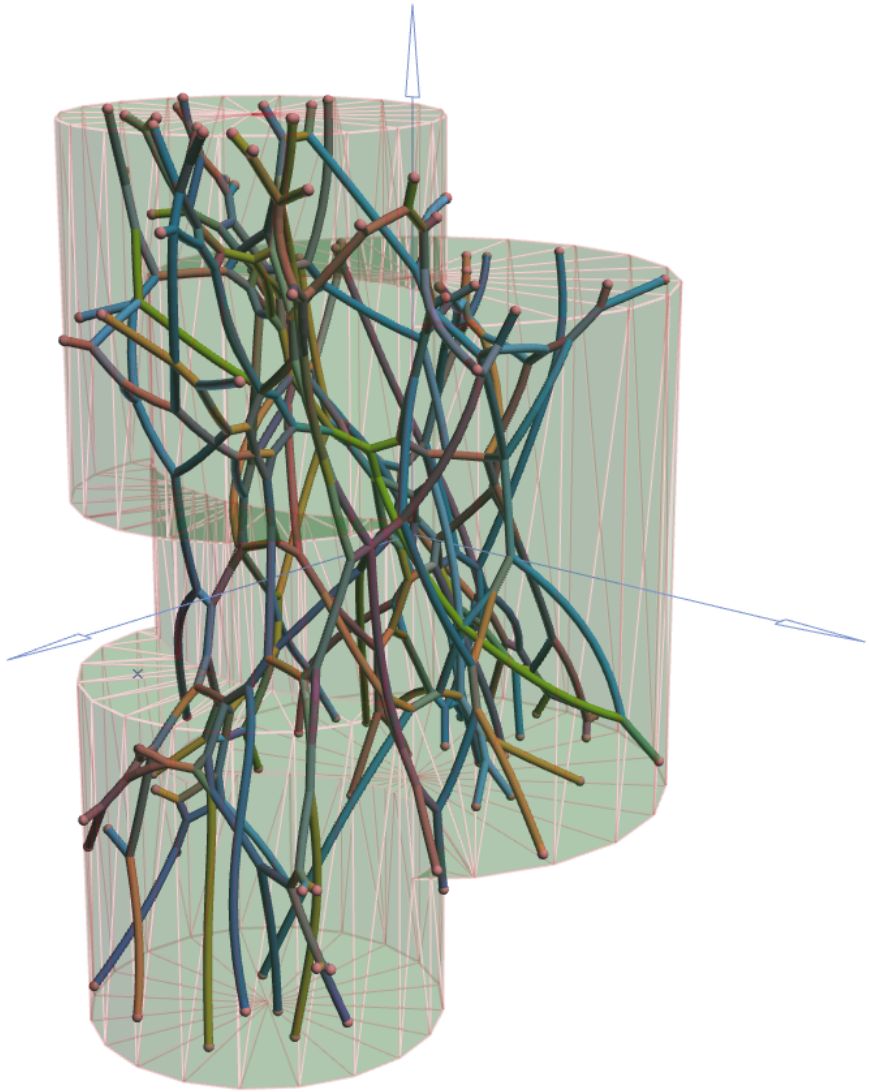
Voronoi Paths

Examples



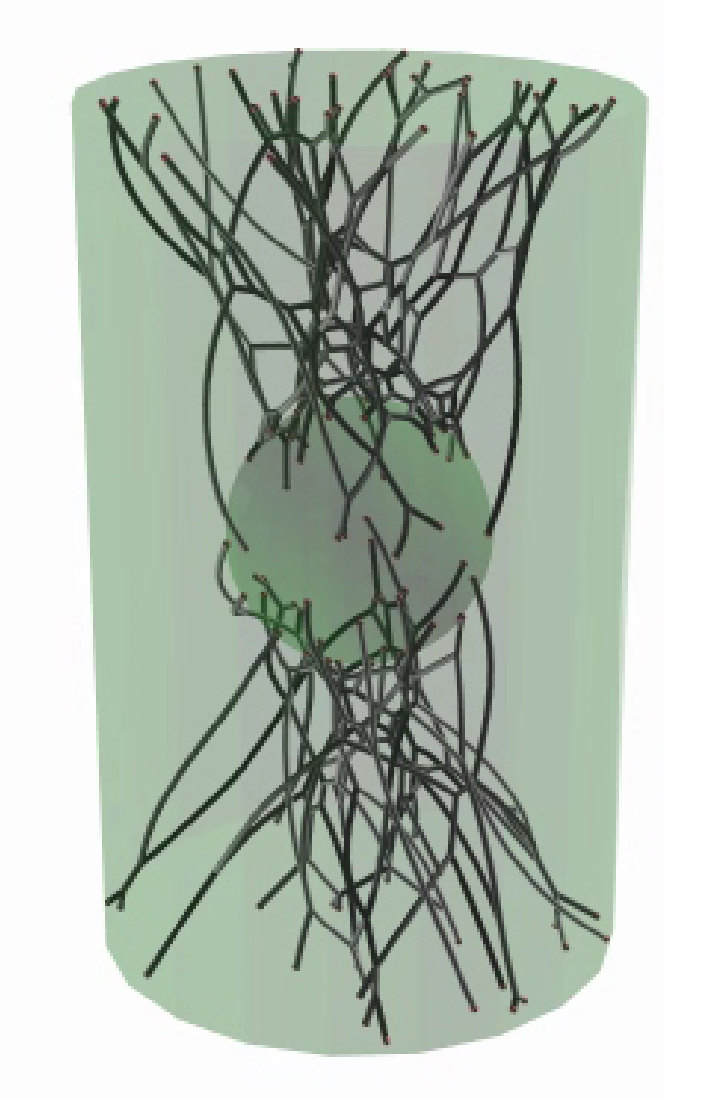
Voronoi Paths

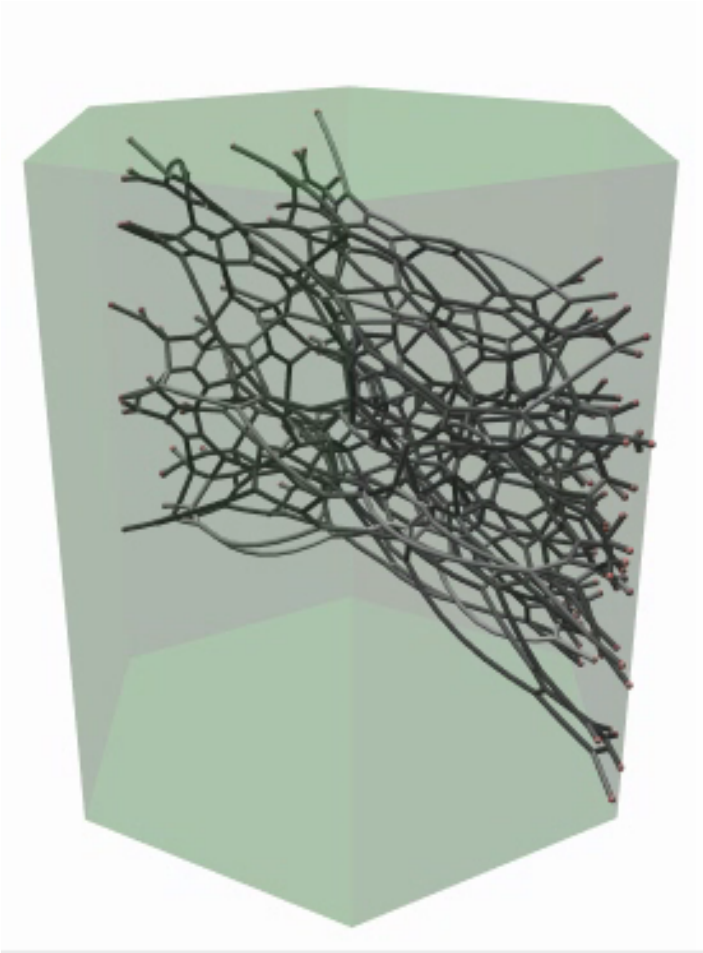
Examples



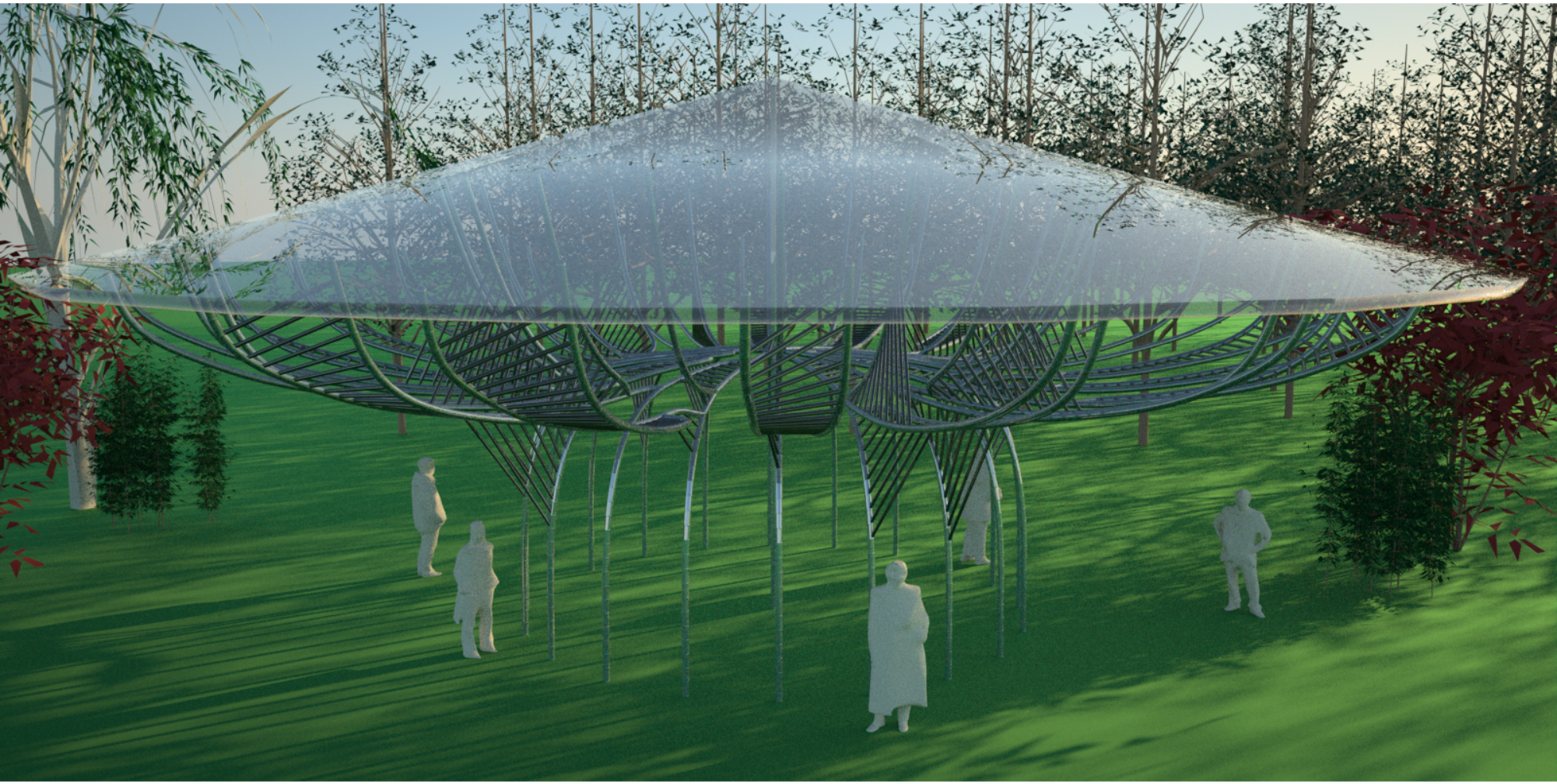
Voronoi Paths

Examples



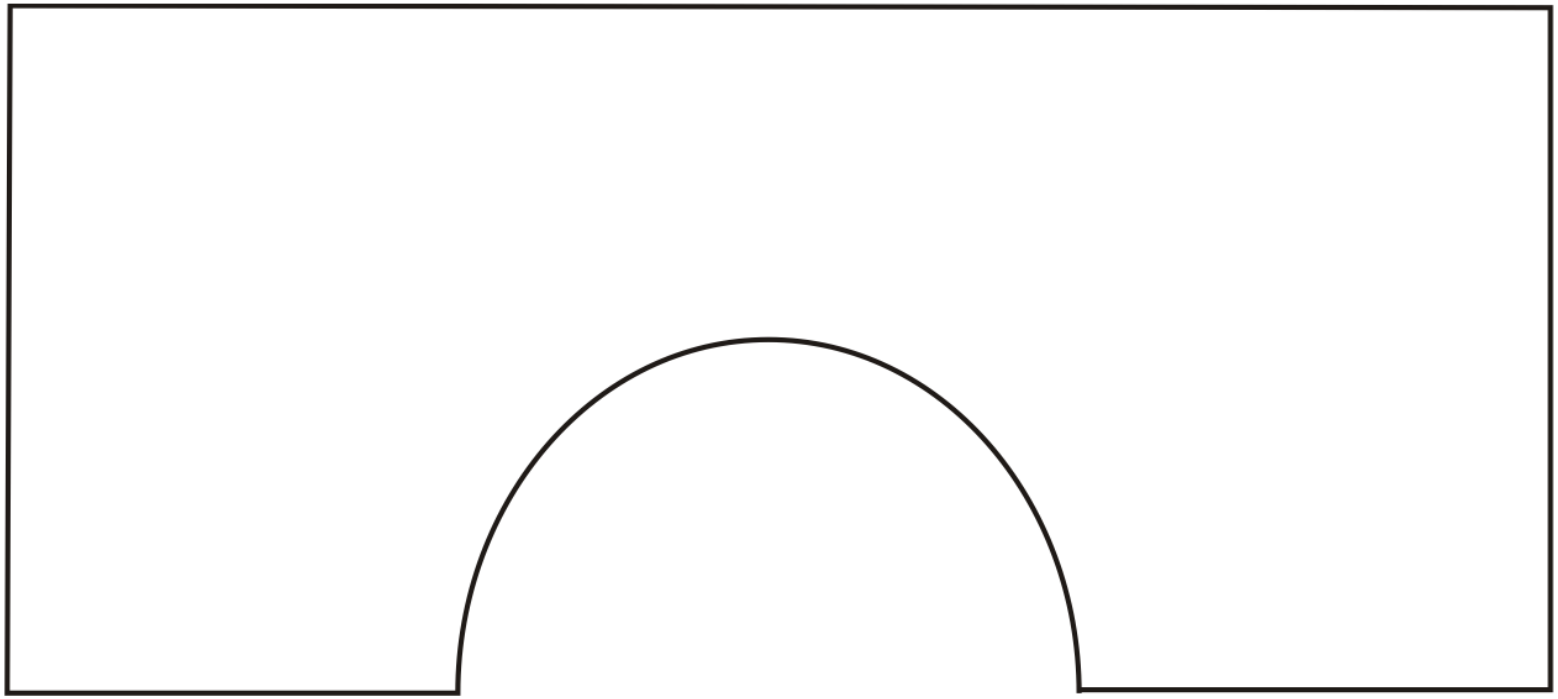


Skeletonization



Skeletonization

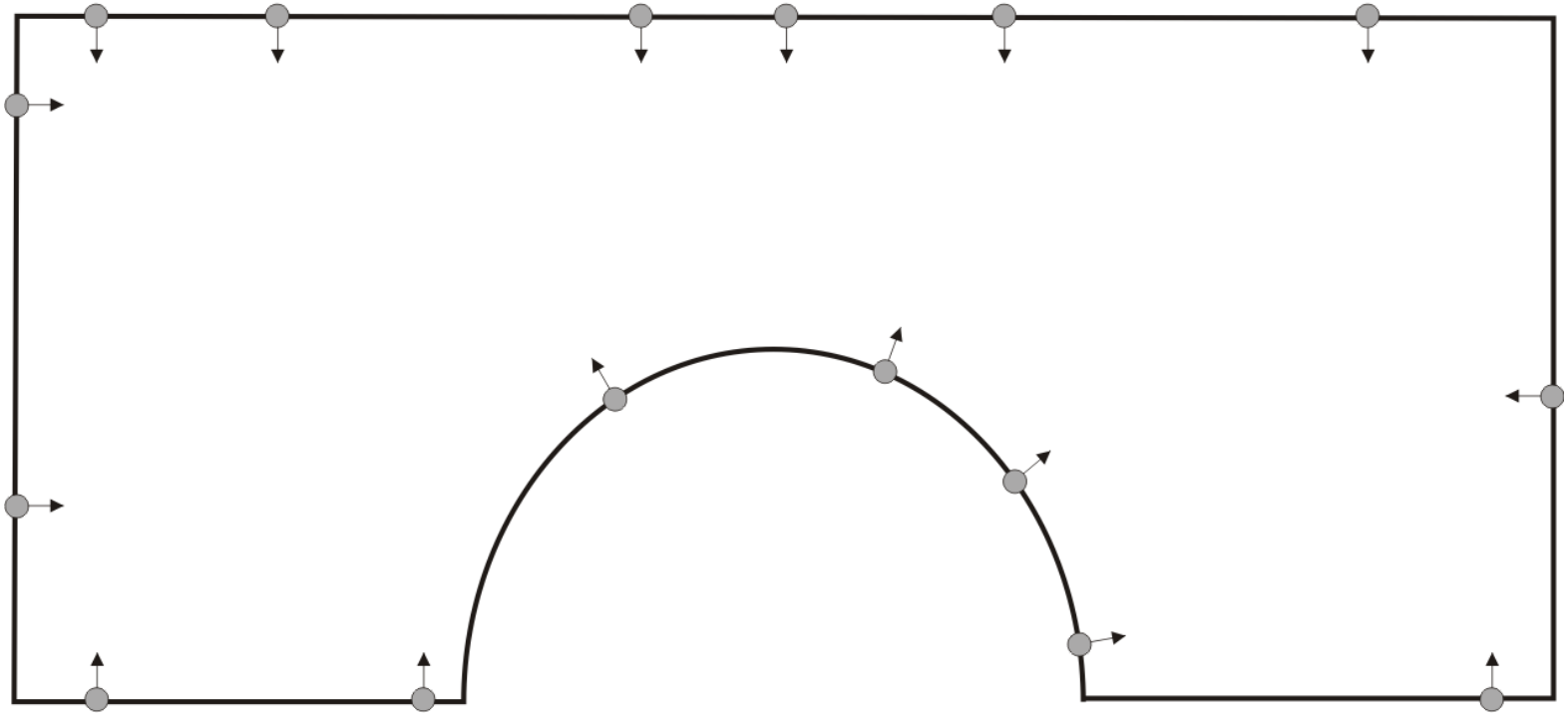
Algorithm



1. Distribute point charges on bounding surface

Skeletonization

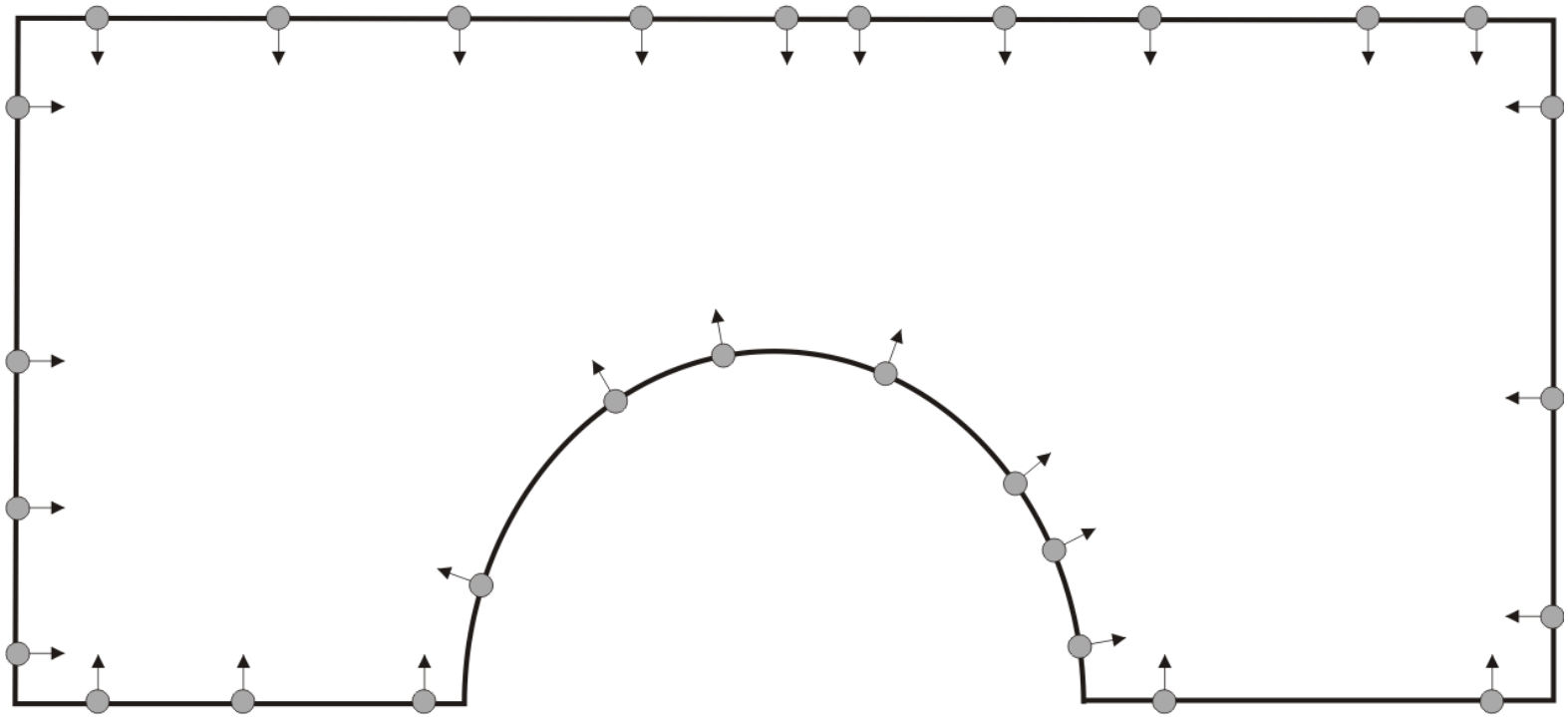
Algorithm



1. Distribute point charges on bounding surface

Skeletonization

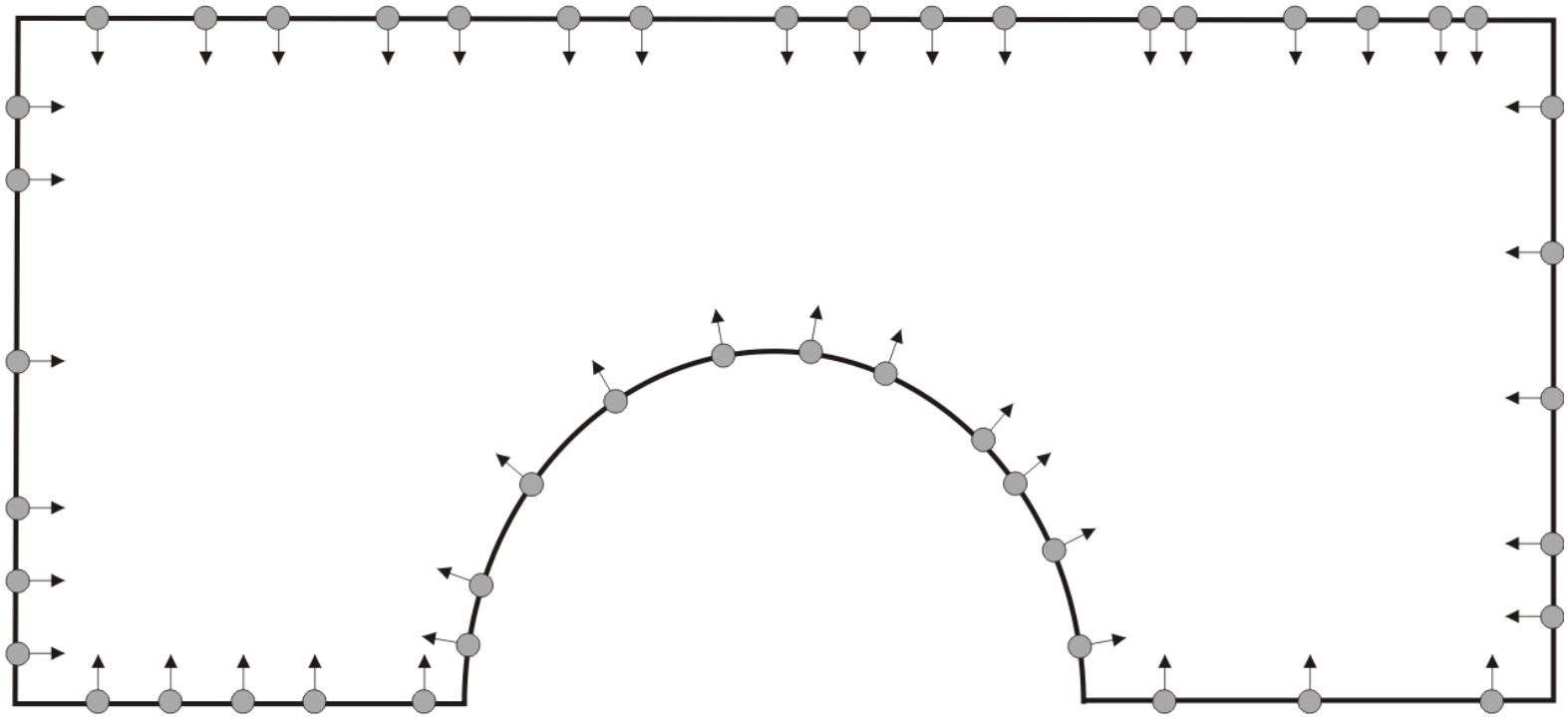
Algorithm



1. Distribute point charges on bounding surface

Skeletonization

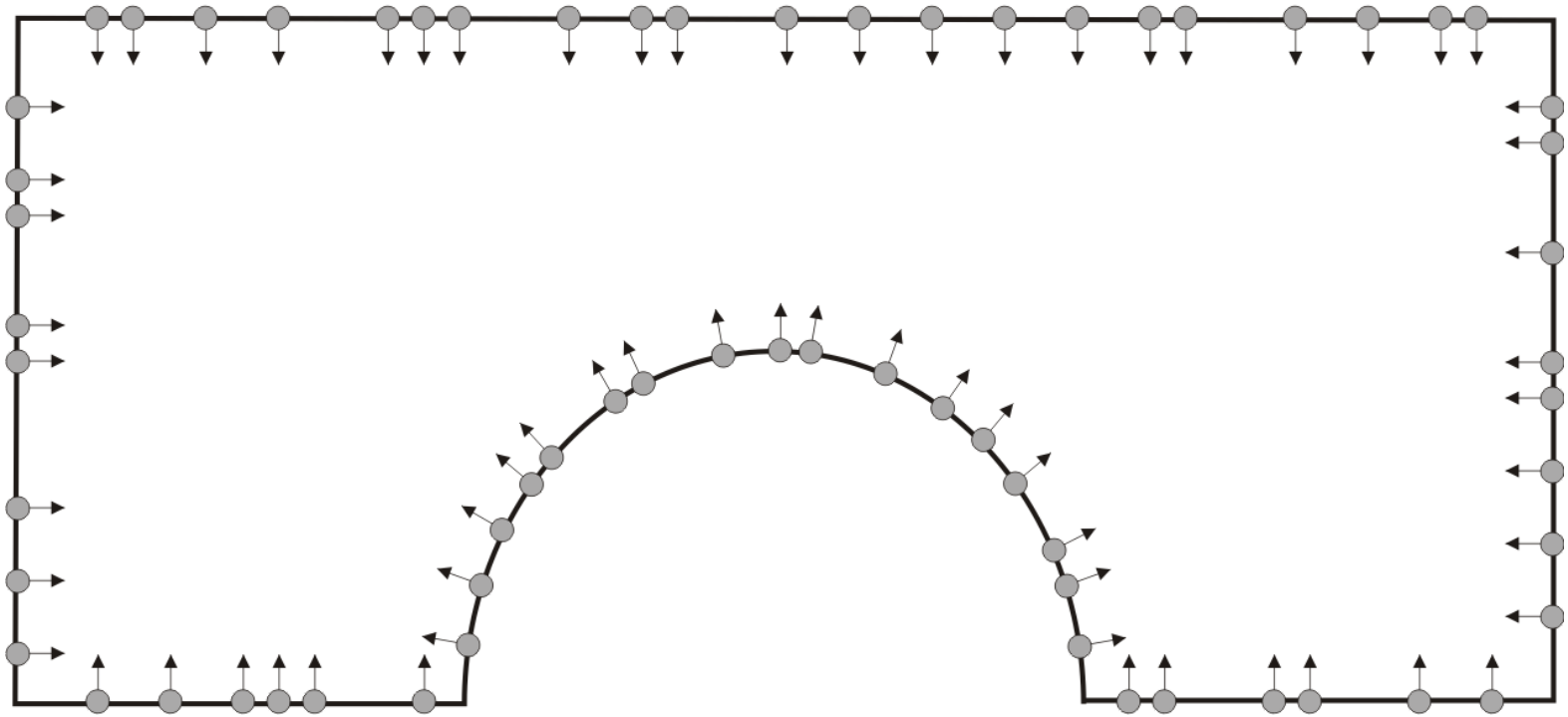
Algorithm



1. Distribute point charges on bounding surface

Skeletonization

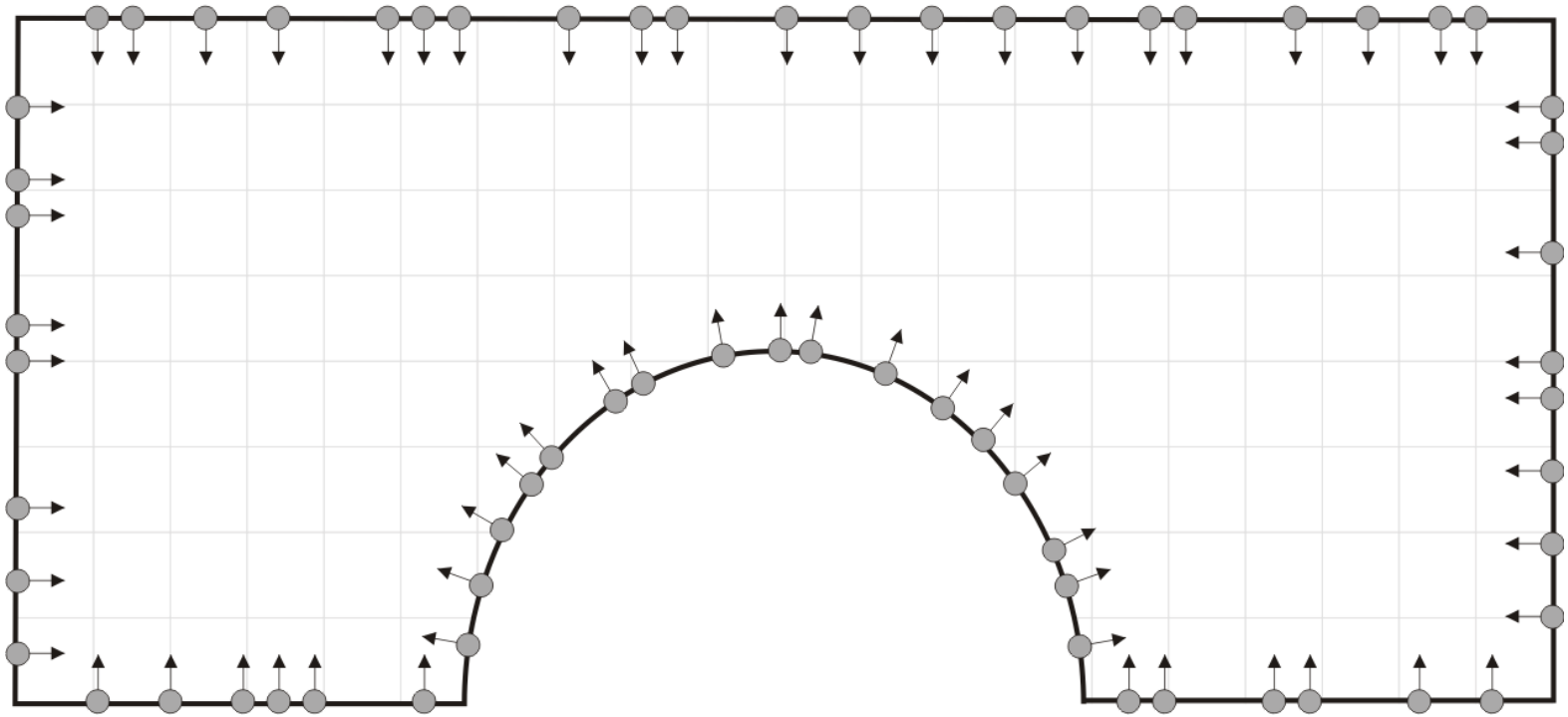
Algorithm



1. Distribute point charges on bounding surface

Skeletonization

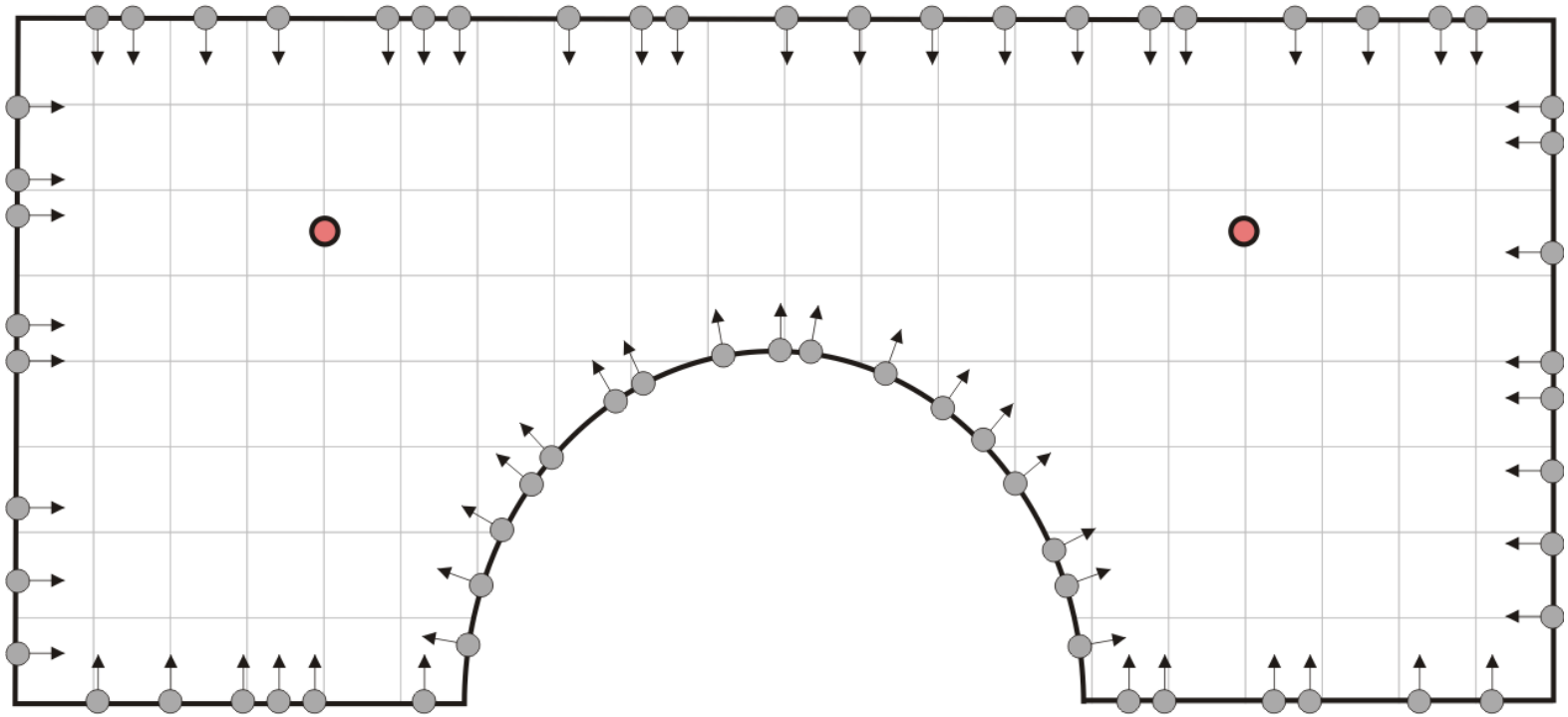
Algorithm



2. Calculate vector field

Skeletonization

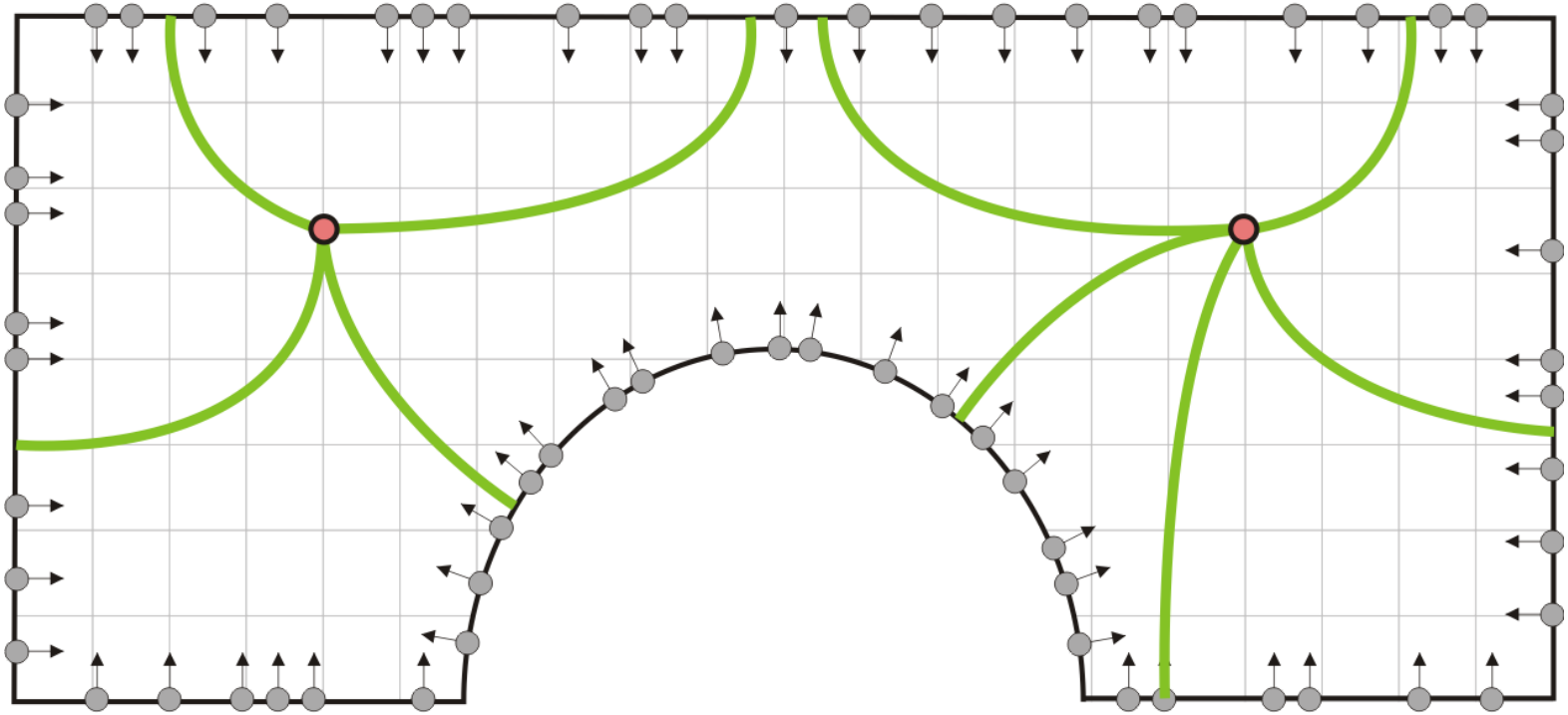
Algorithm



3. Locate critical points

Skeletonization

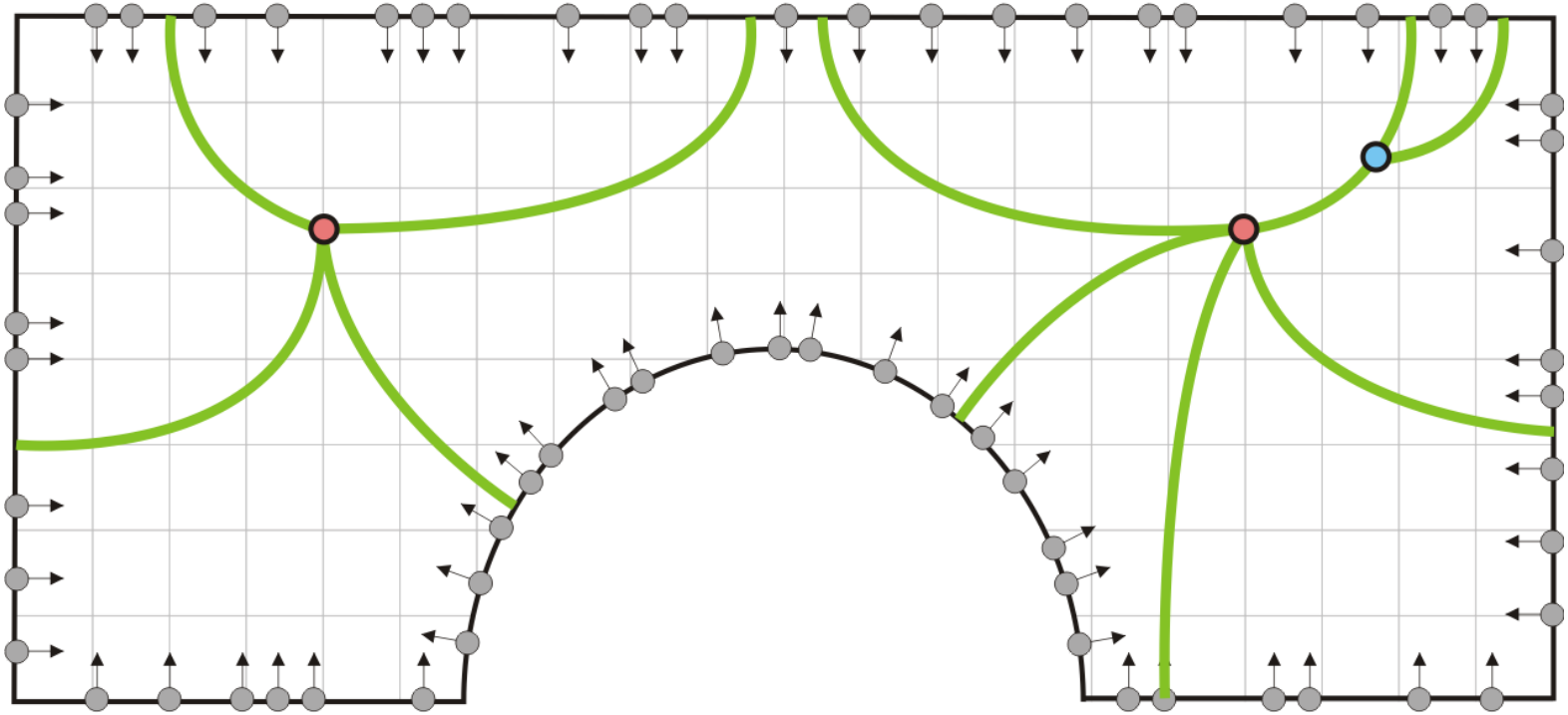
Algorithm



4. Place particles and calculate trajectory

Skeletonization

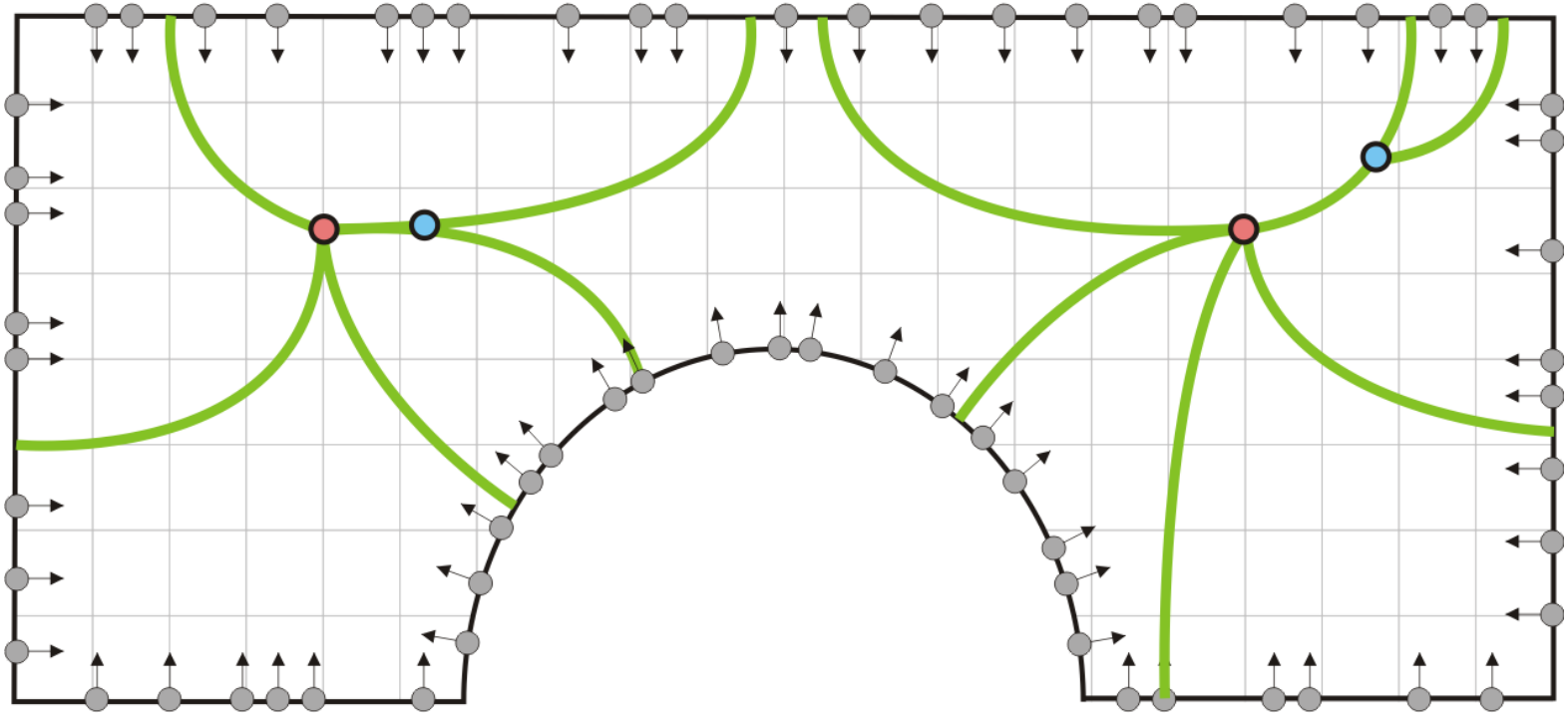
Algorithm



5. If new trajectory approaches an existing one, derminate calculation and connect them

Skeletonization

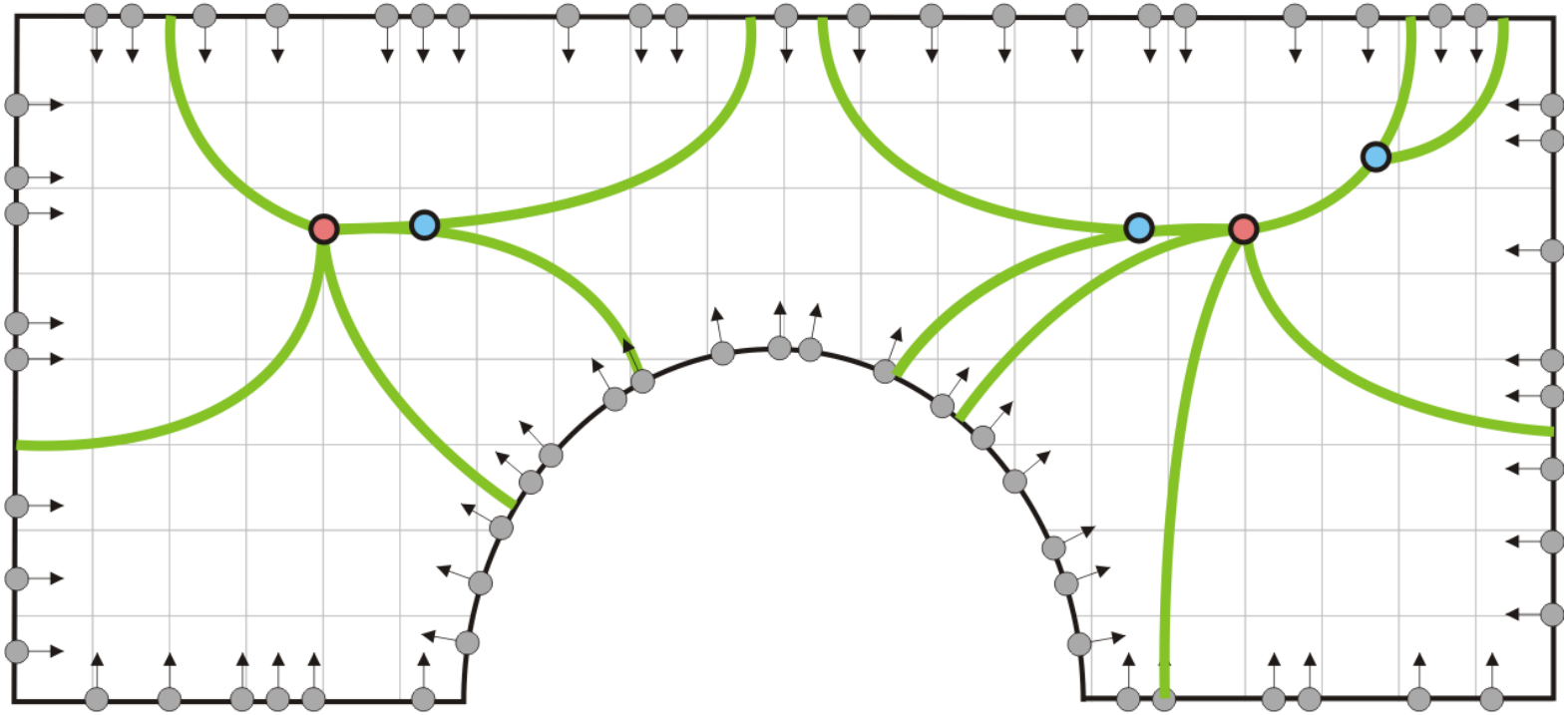
Algorithm



5. If new trajectory approaches an existing one, derminate calculation and connect them

Skeletonization

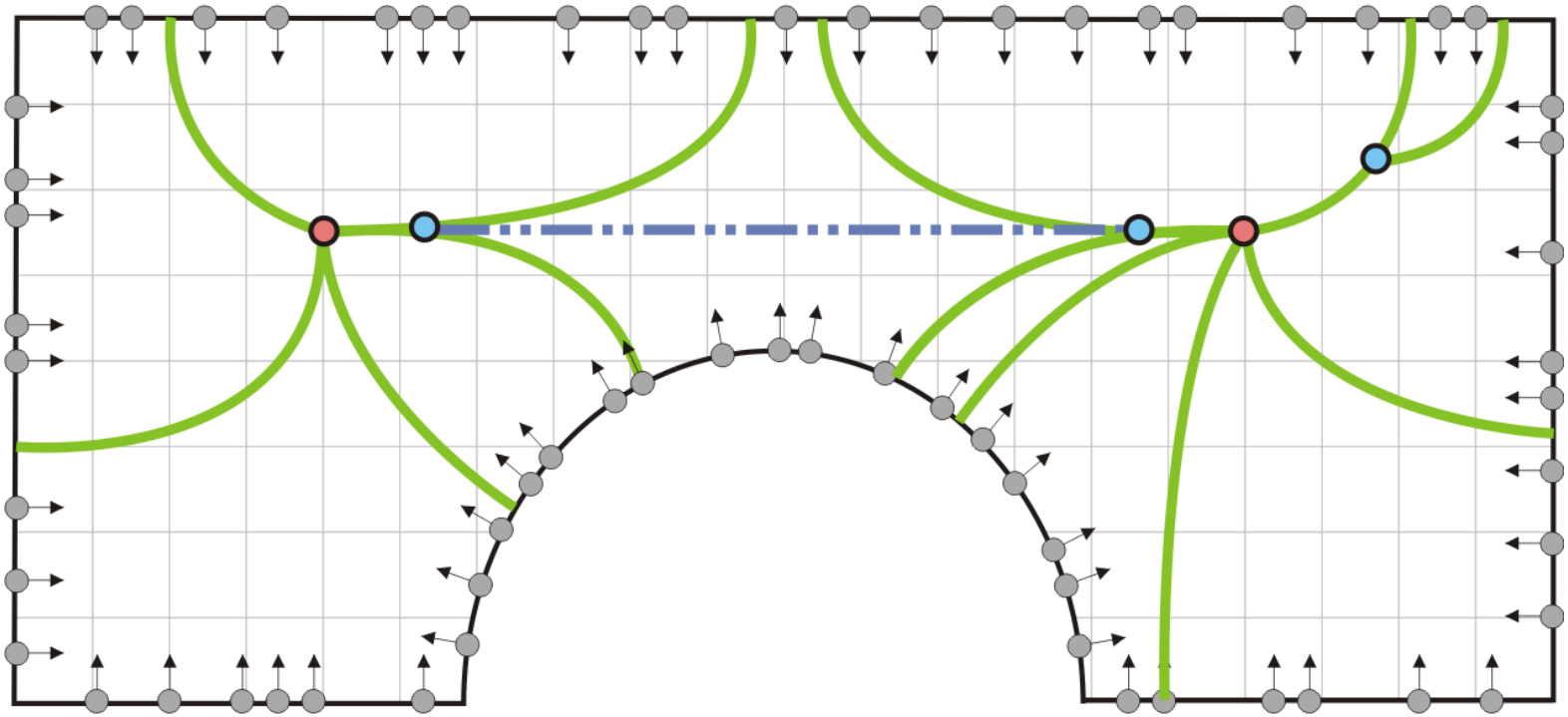
Algorithm



5. If new trajectory approaches an existing one, derminate calculation and connect them

Skeletonization

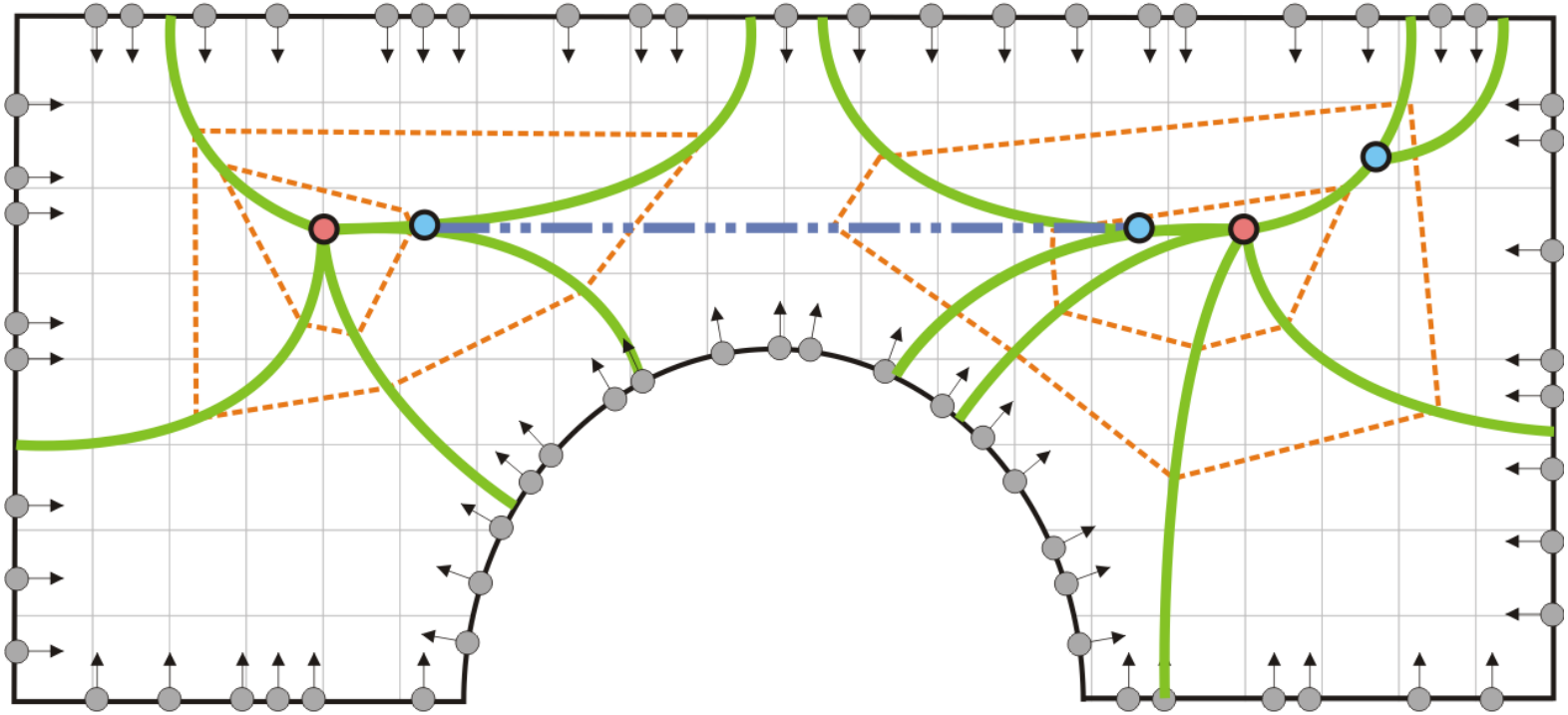
Algorithm



6. Link non-connected components

Skeletonization

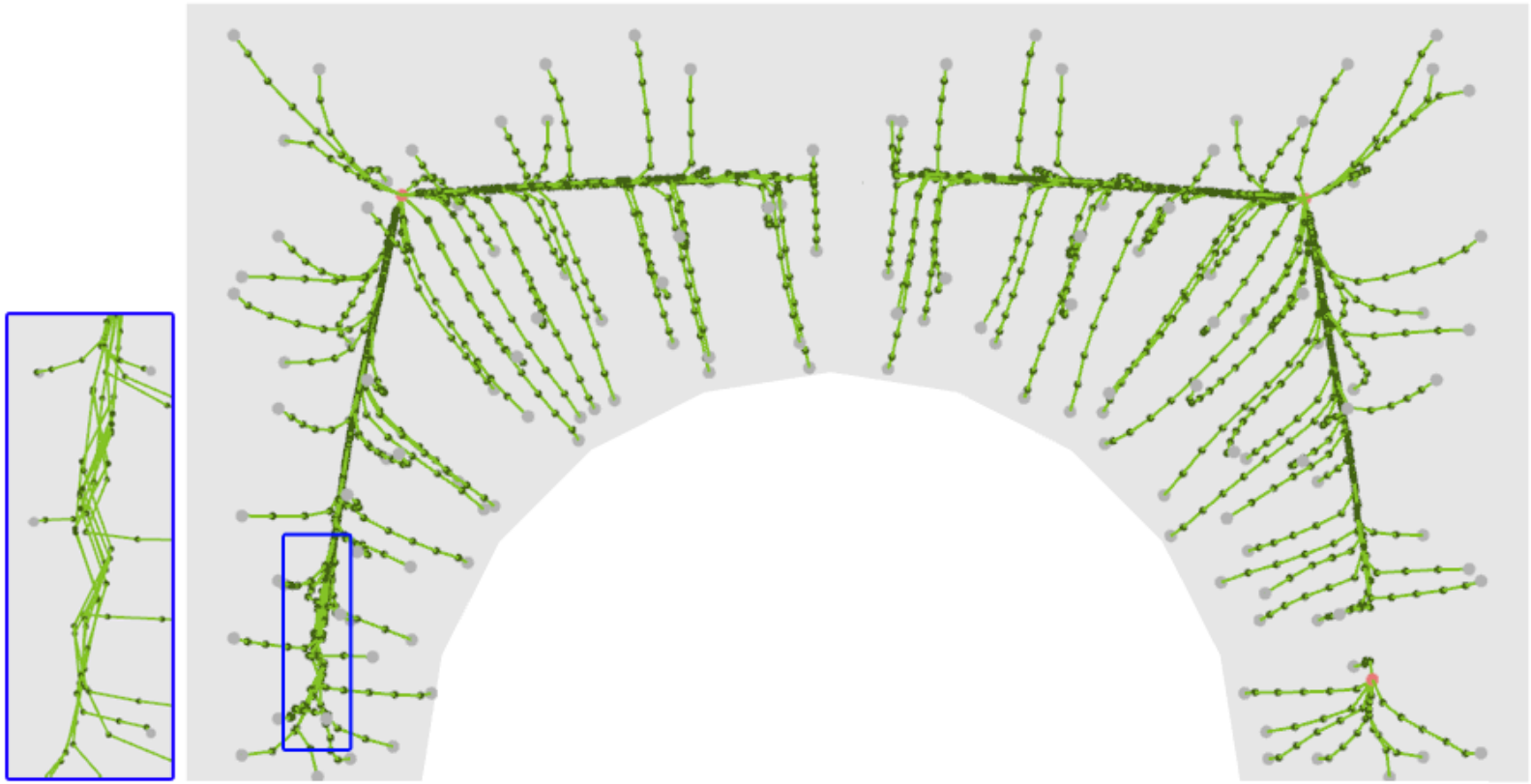
Algorithm



7. Add cross-links

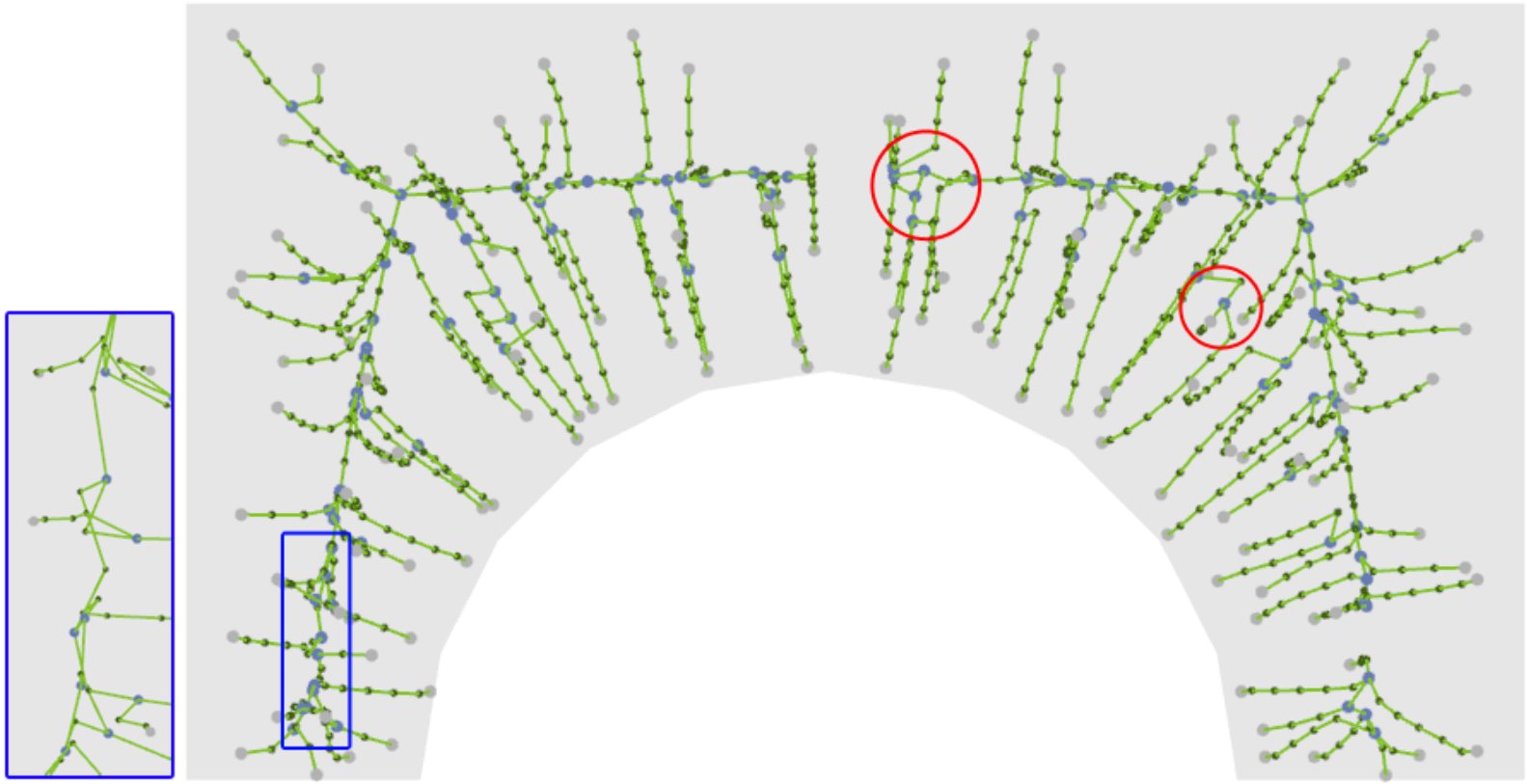
Skeletonization

Algorithm



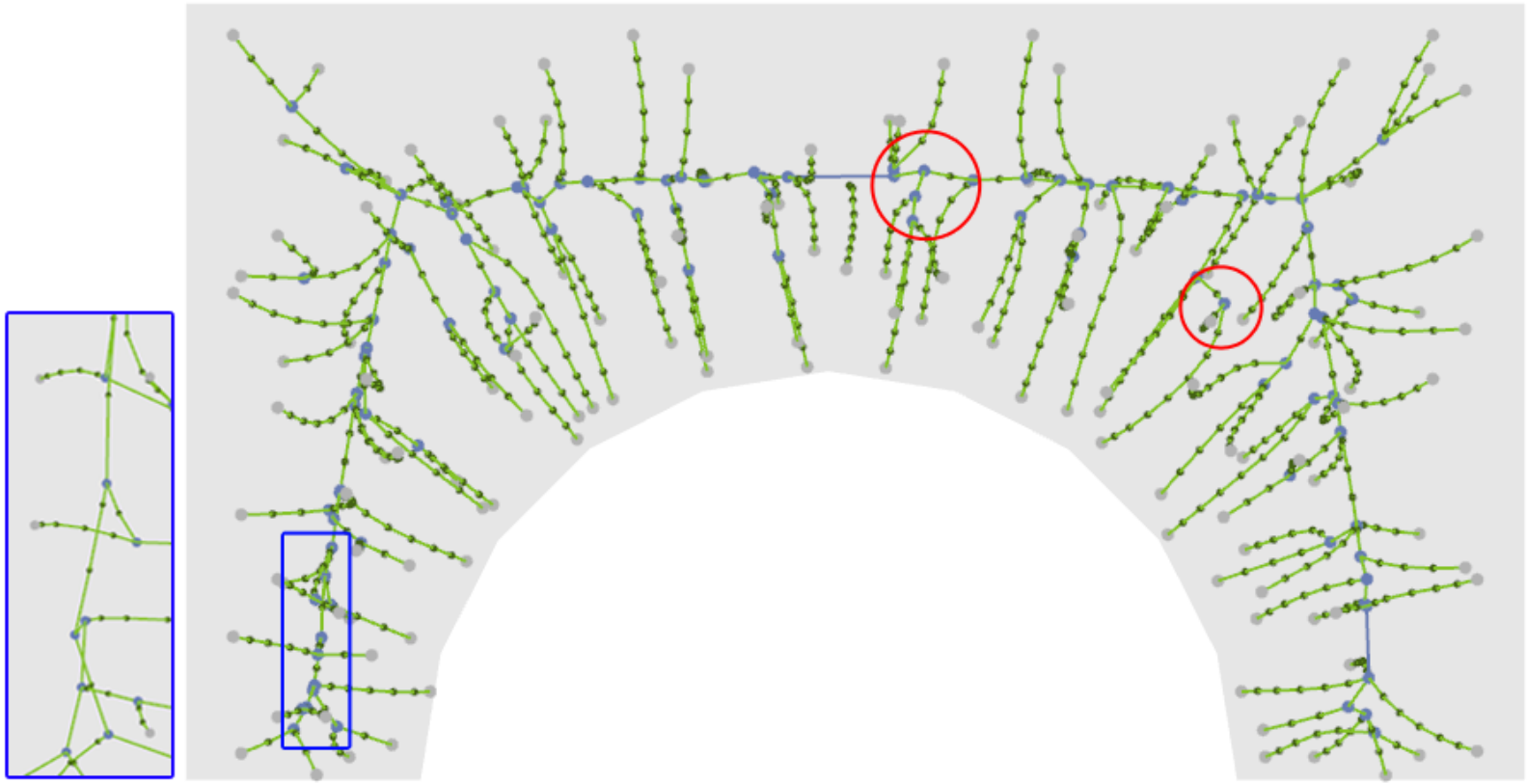
Skeletonization

Algorithm



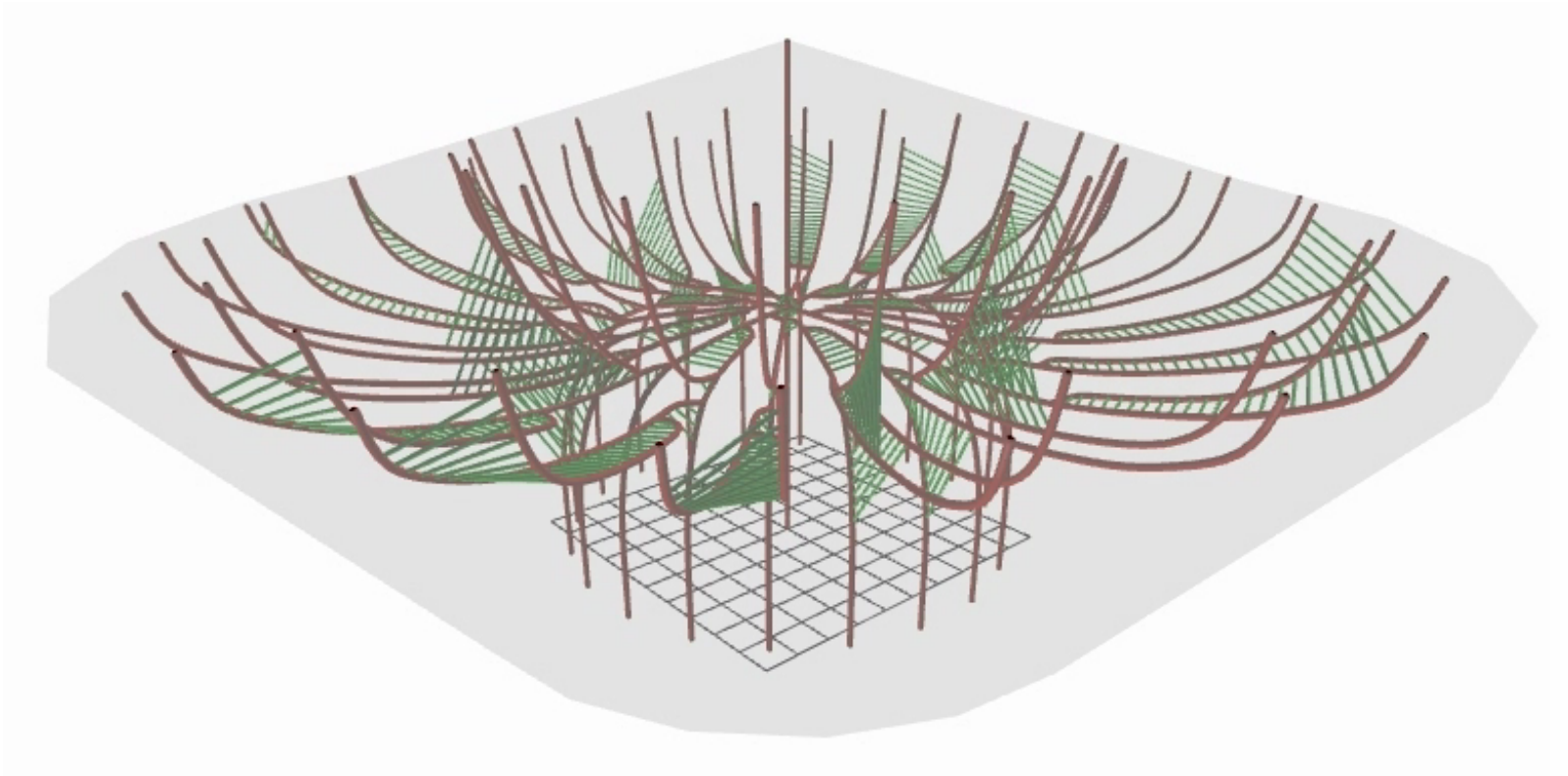
Skeletonization

Algorithm



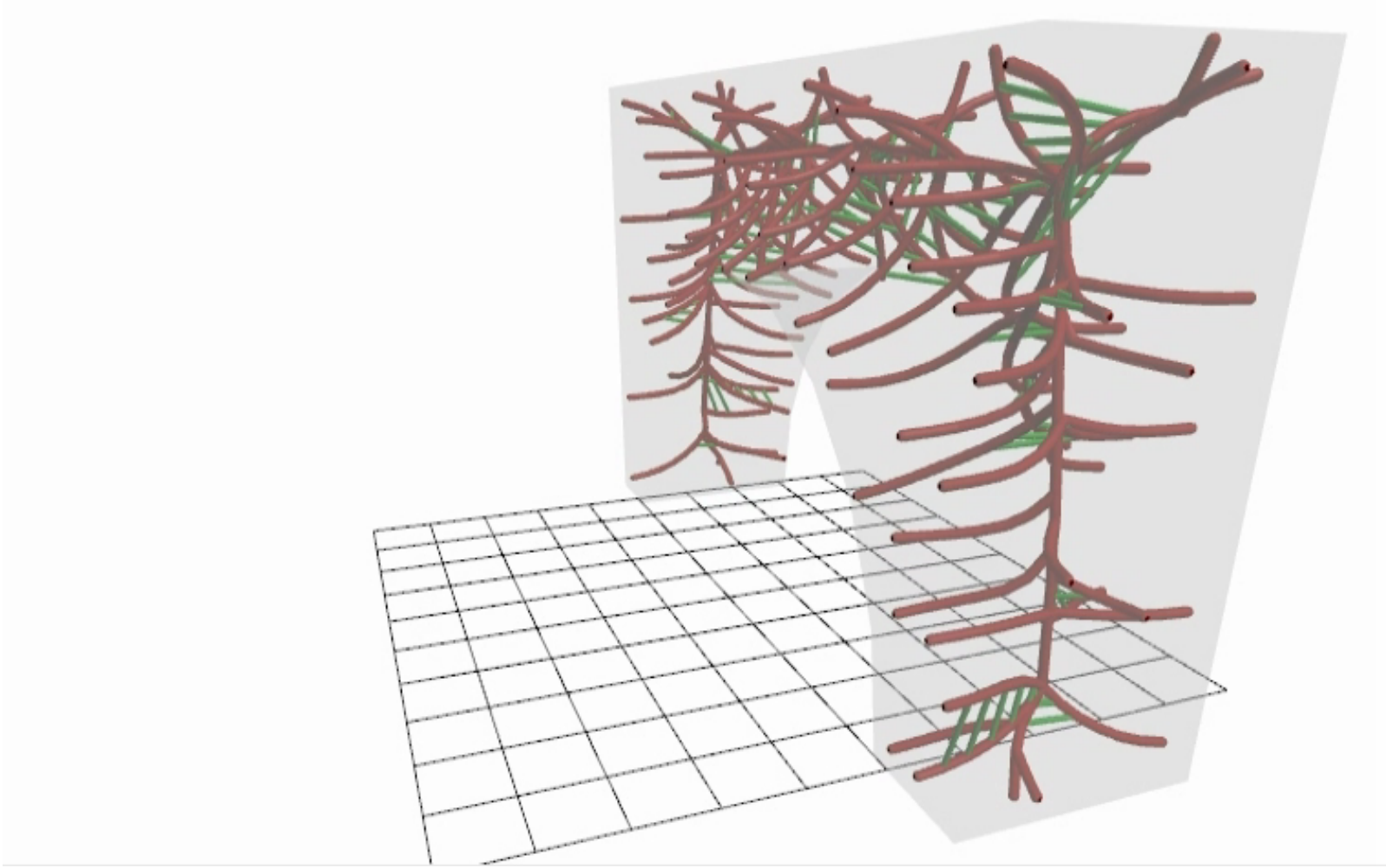
Skeletonization

Examples



Skeletonization

Examples



Thank you!

wallner.guenter@uni-ak.ac.at