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# Digital Elevation Model Approximation from Stream Networks: A Reversed Approach

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# OUTLINE



1. Overview

2. Fundamental Geometric Structures

3. Background

4. Proposed Method

5. Conclusions & Future Work

# 1. Overview


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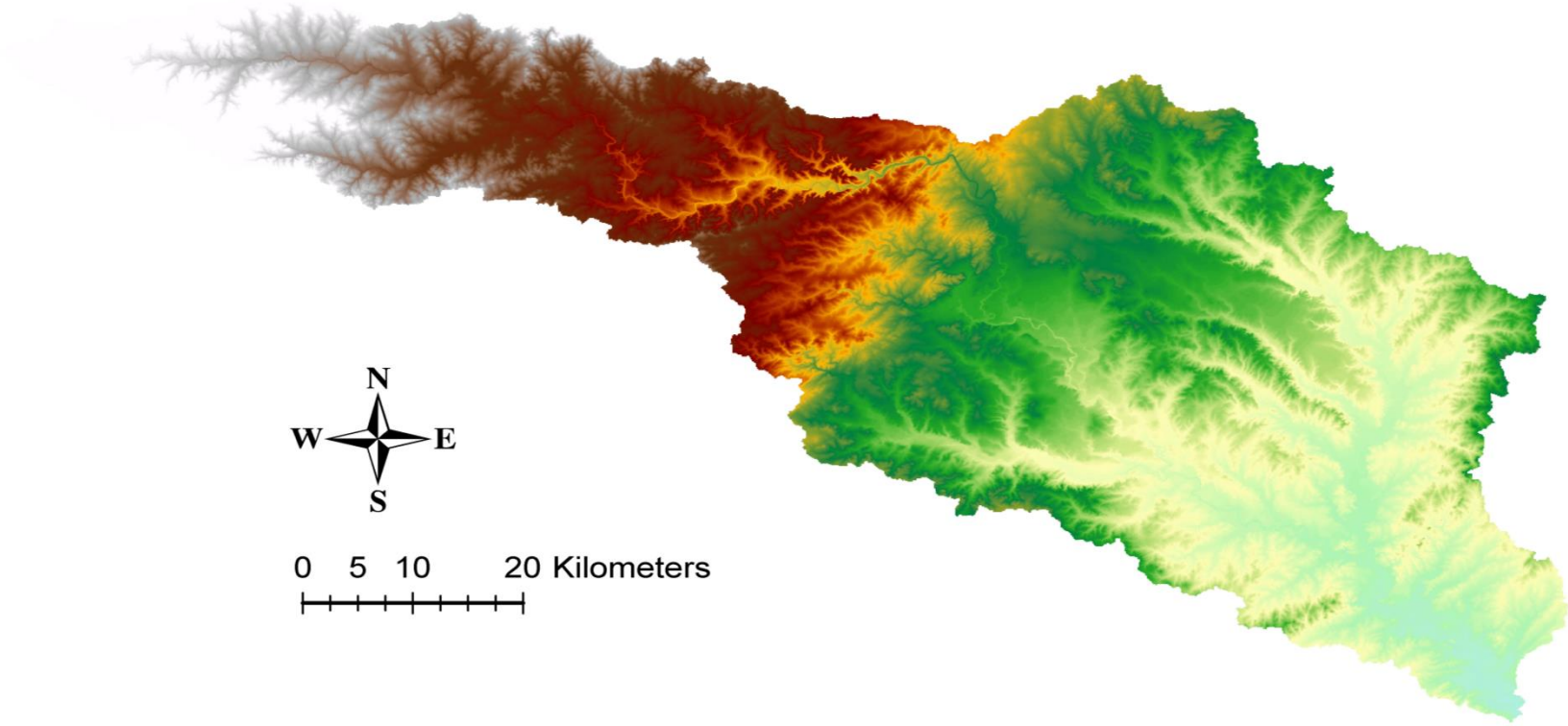
# Digital Elevation Model (DEM)



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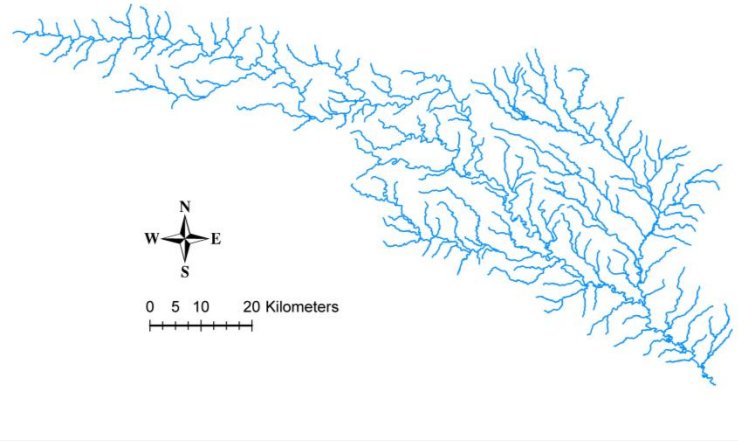
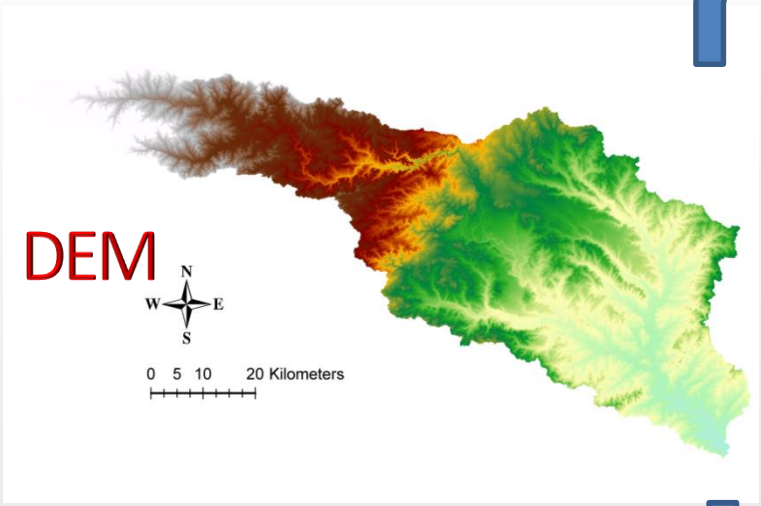
# 1. OVERVIEW

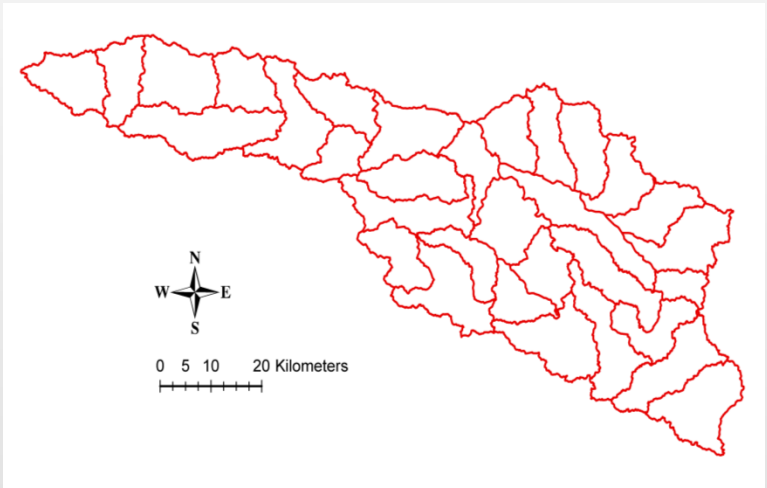


Stream Networks




Catchment Areas




**Digital Elevation Model Approximation from Stream Networks: A Reversed Approach**

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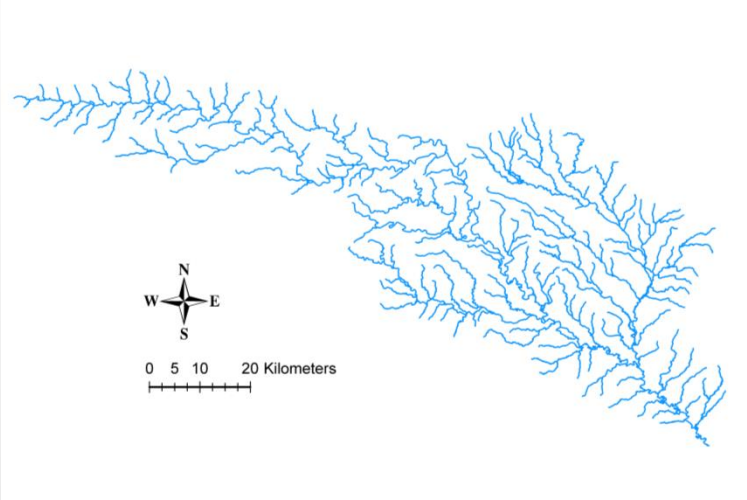
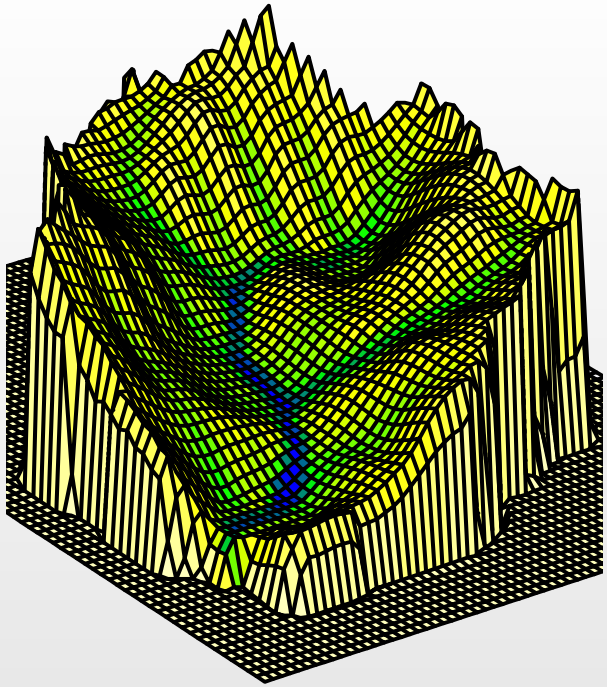
# A Reversed Approach



# An Approximation



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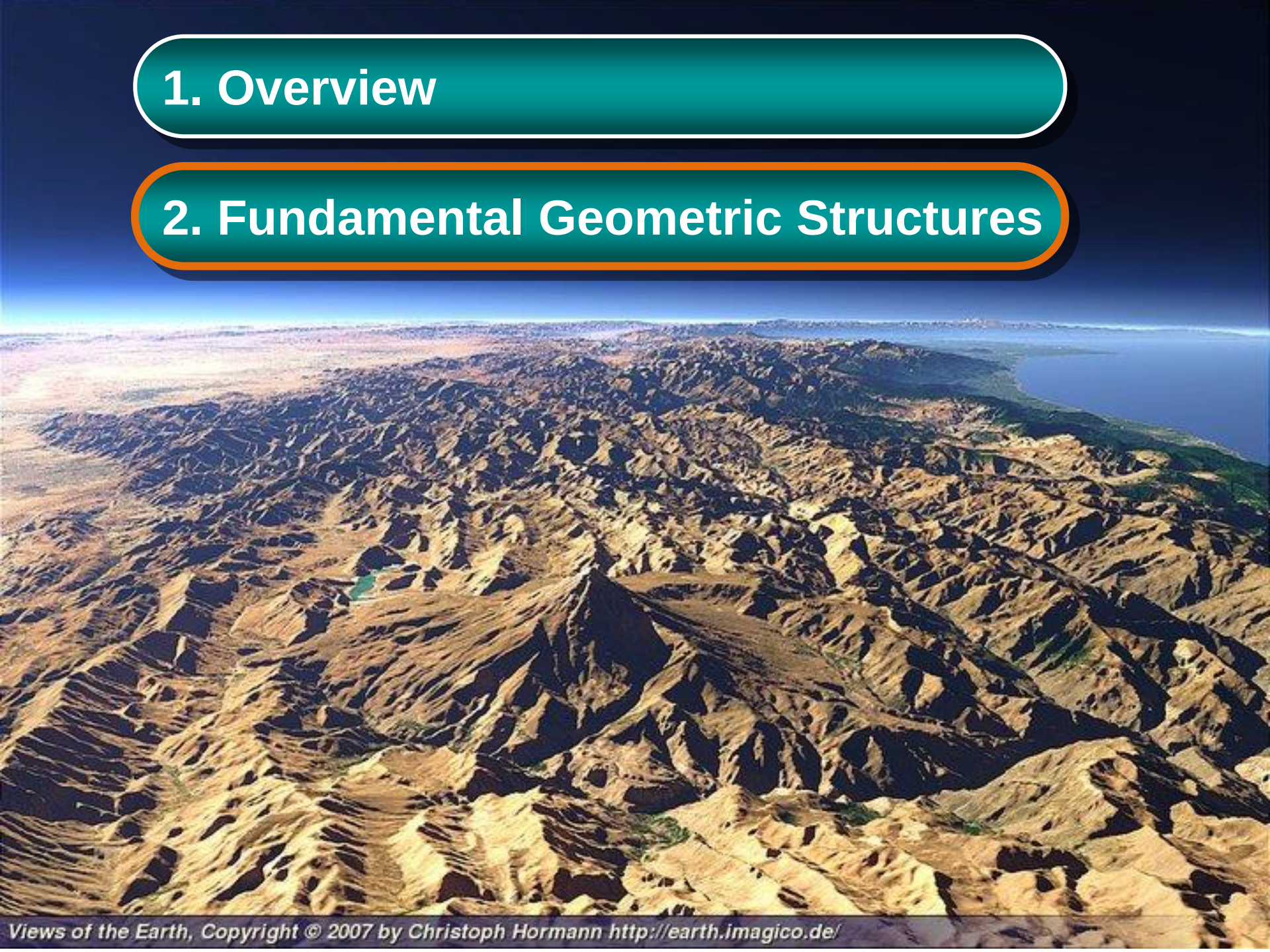
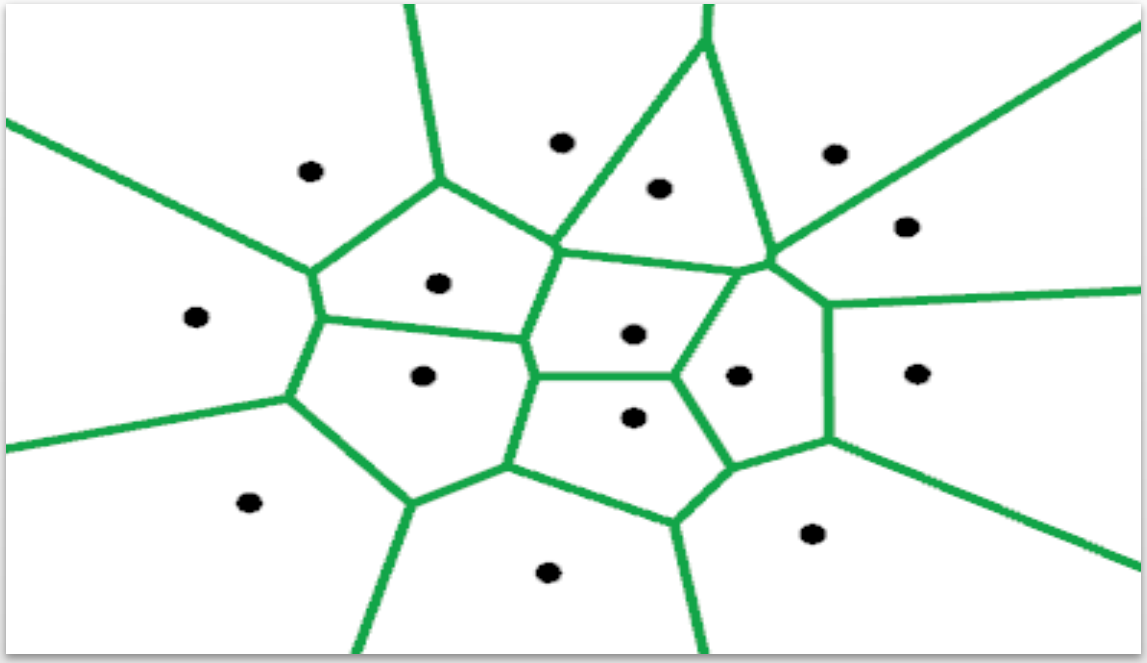
# 1. Overview

# 2. Fundamental Geometric Structures



# Voronoi Diagram



Georgy Voronoi
1868-1908



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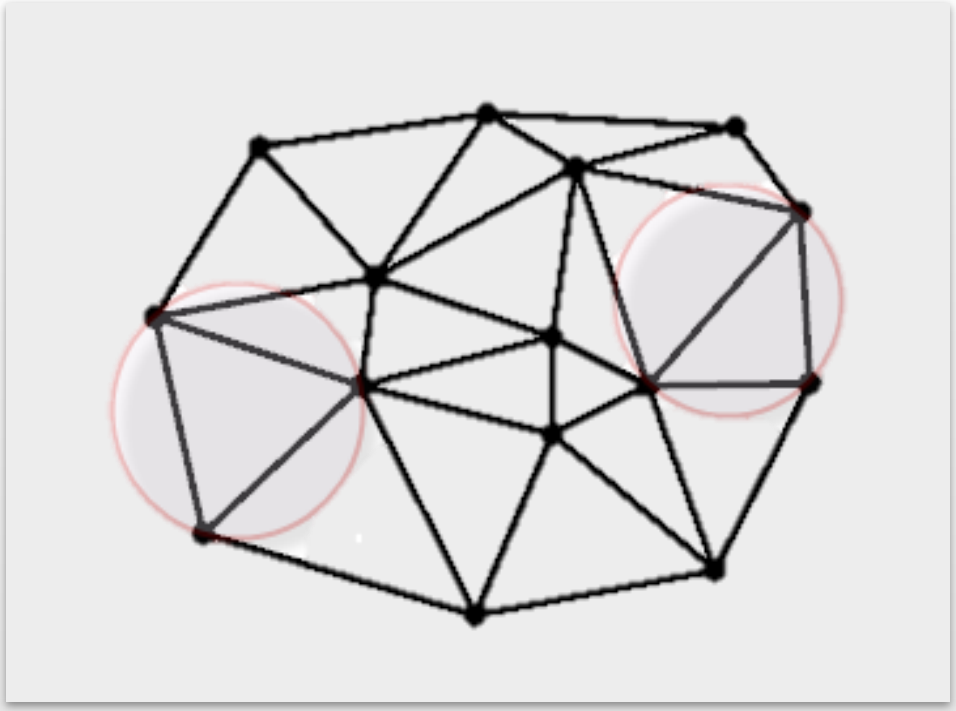
# Delaunay Triangulation



B.N. Delaunay
1890-1980



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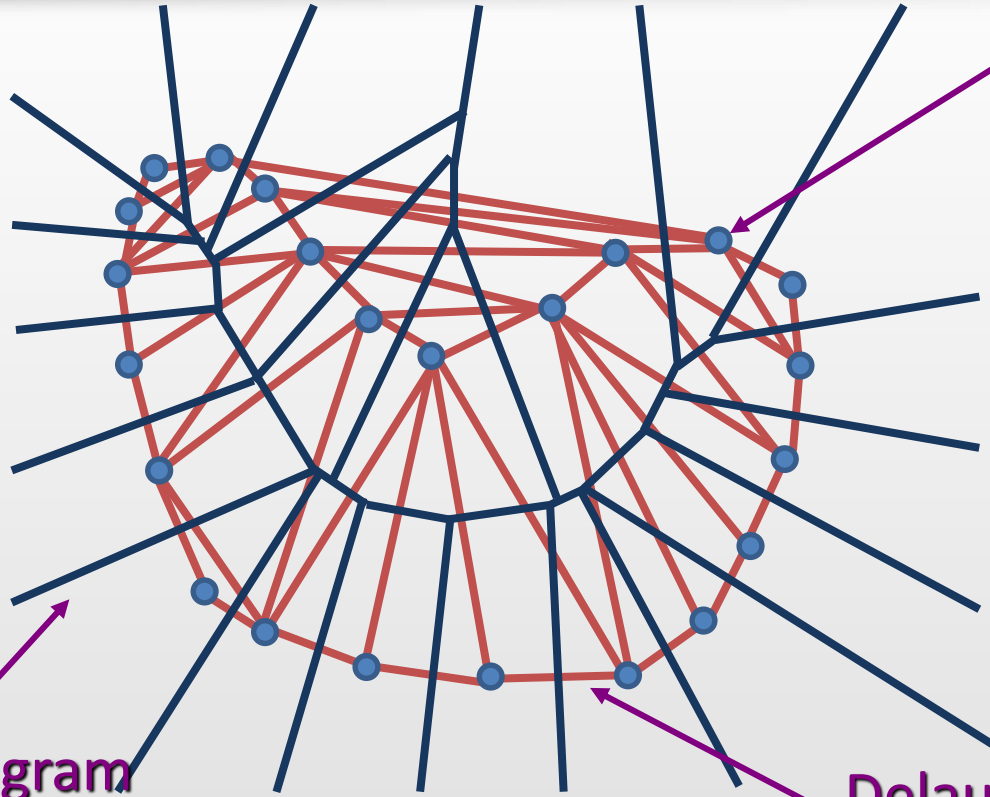
## Duality



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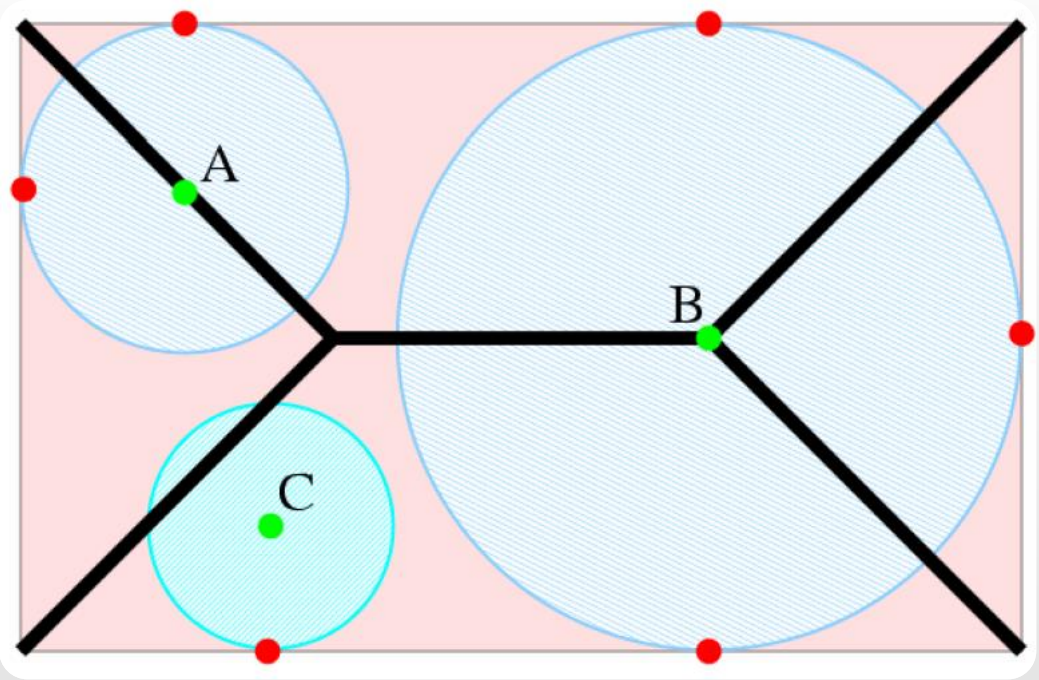
# Skeleton (Medial Axis)



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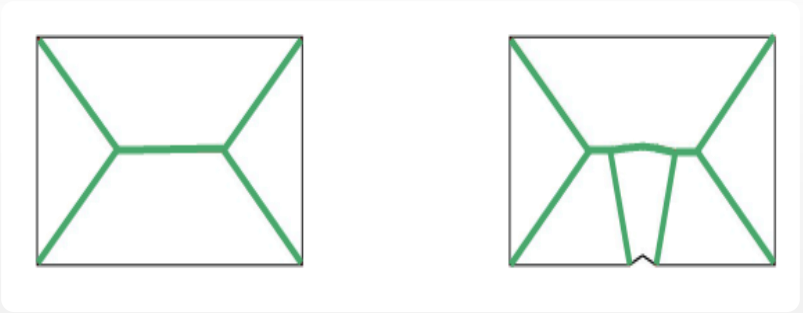
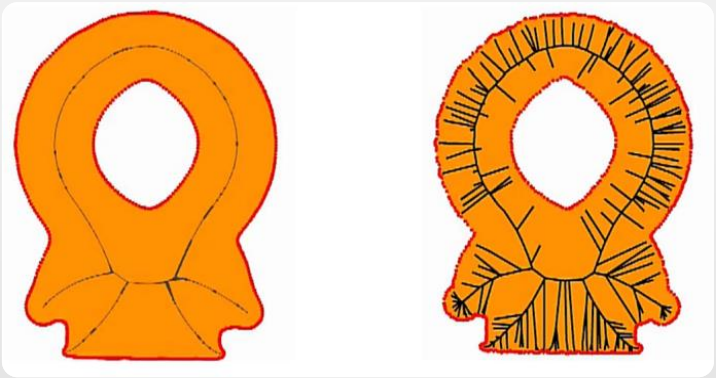
# Instability of Skeleton







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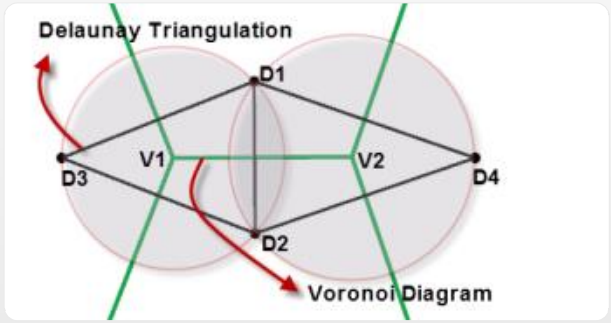
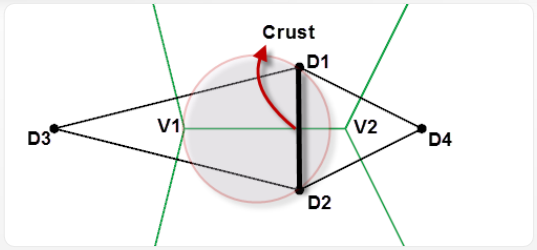
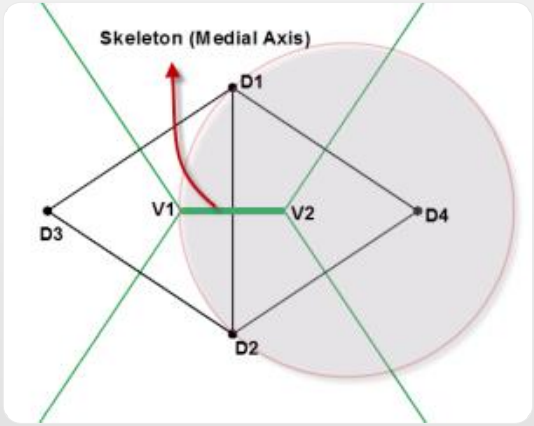
# One Step Crust and Skeleton Algorithm

Christopher Gold and Maciek Dakowicz (2000)



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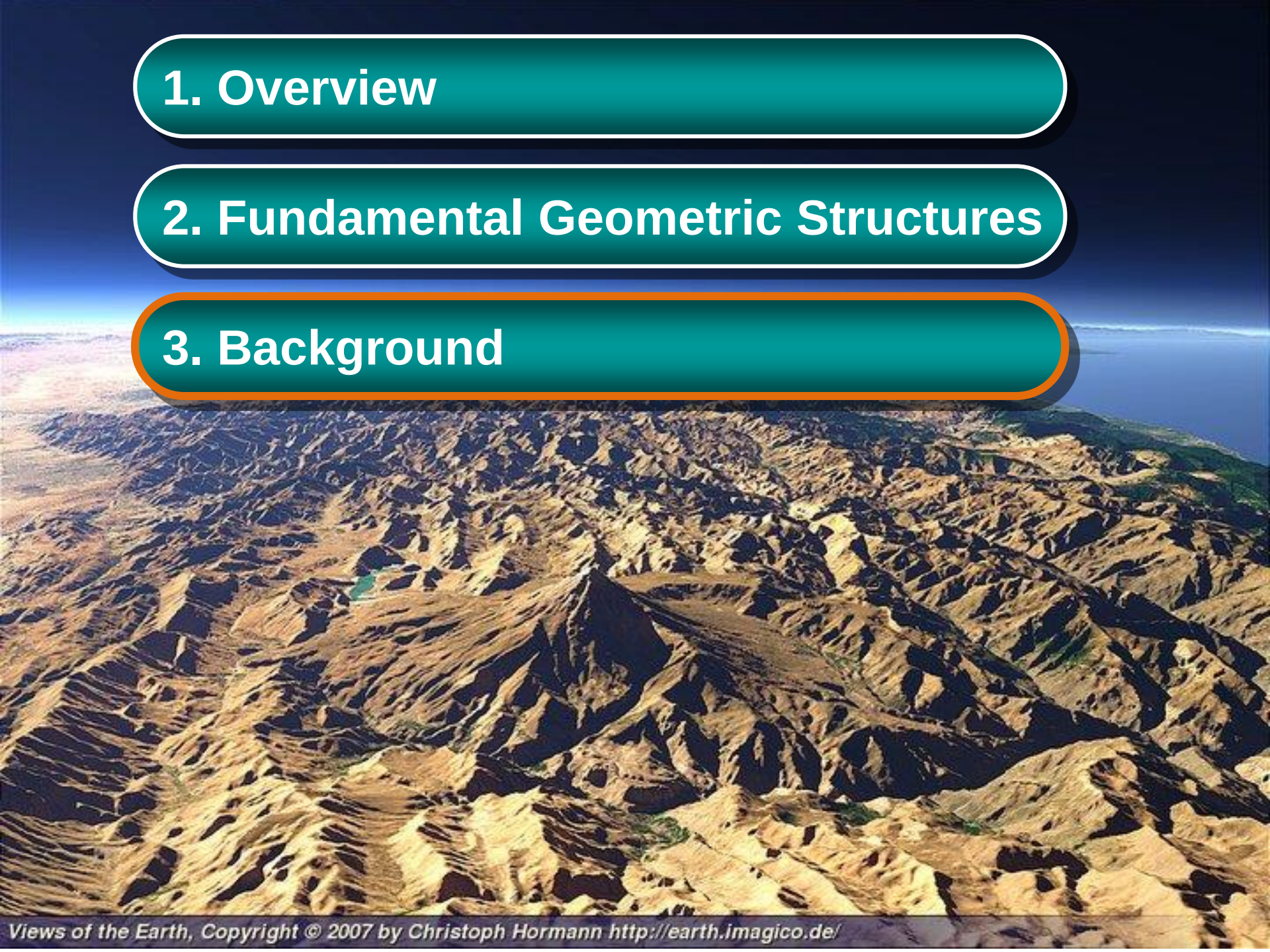
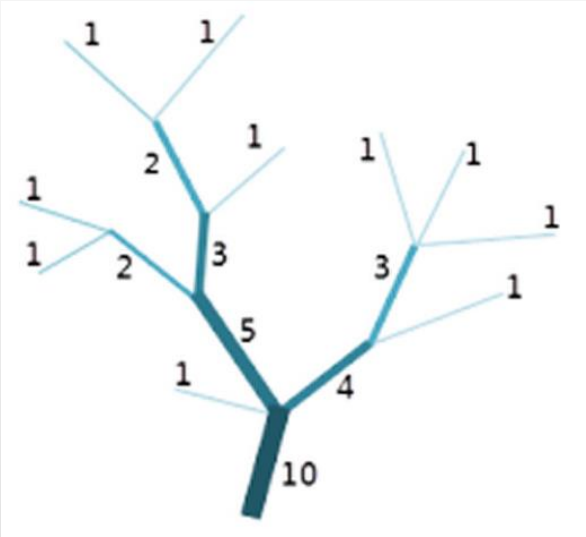


# Stream Network Topology

- Stream network topology: Horton (1945), Strahler (1957), Shreve (1966), and Tokunaga (1978)
- Stream order methods



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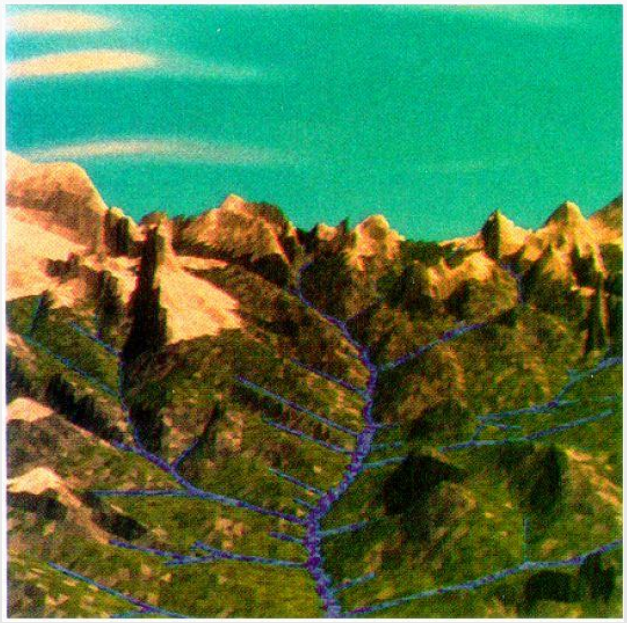
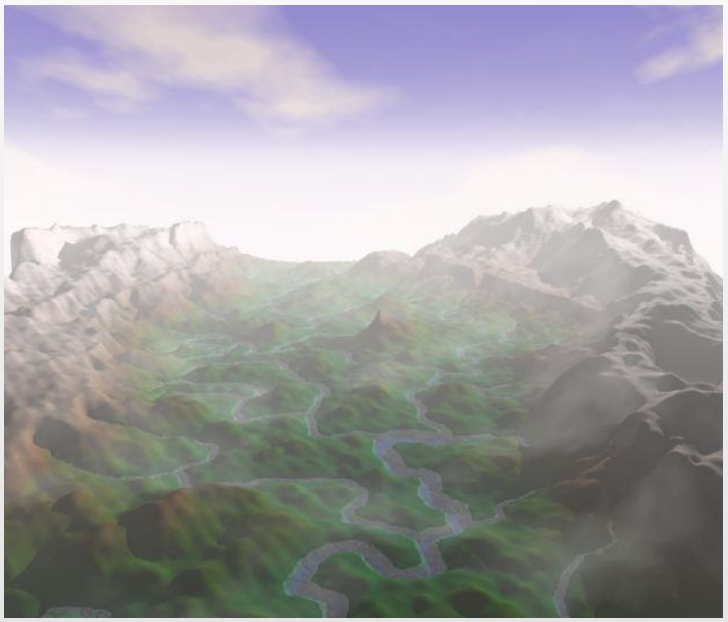
# Modeling of Stream Erosion

- Branching structure of stream networks







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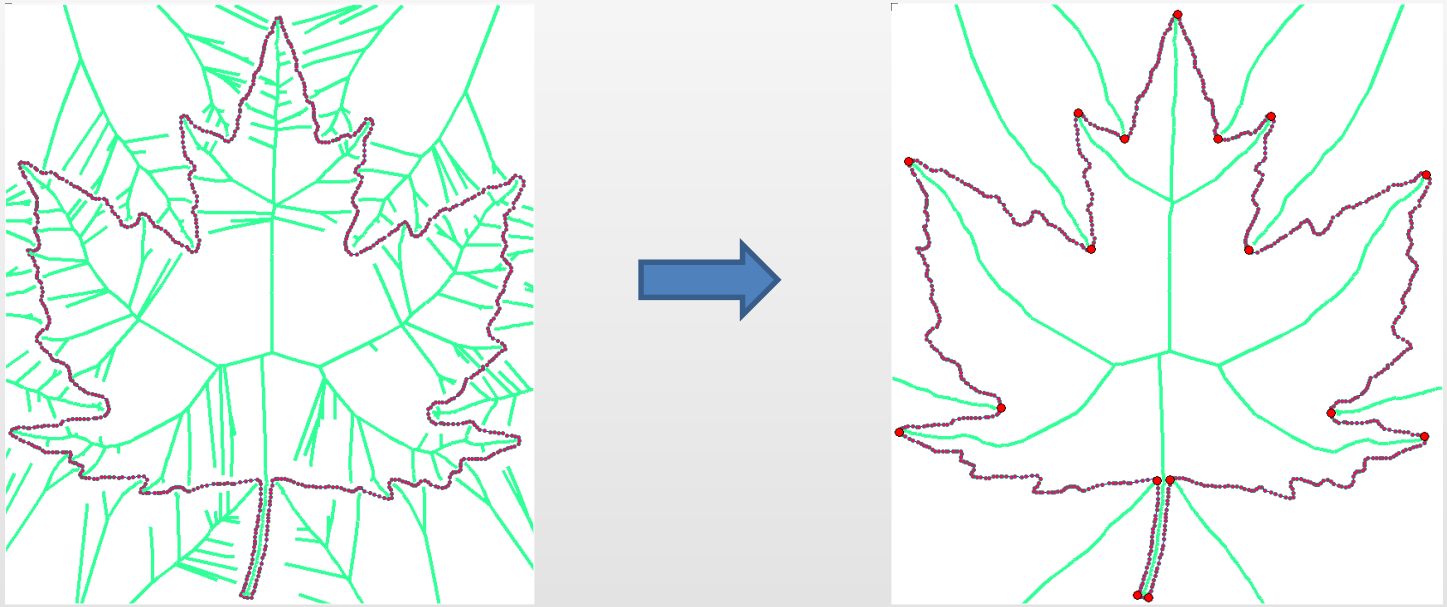
# Modified Skeleton

- A stable voronoi-based algorithm for skeleton extraction through labeling sample points (Karimipour and Ghandehari, 2012) .





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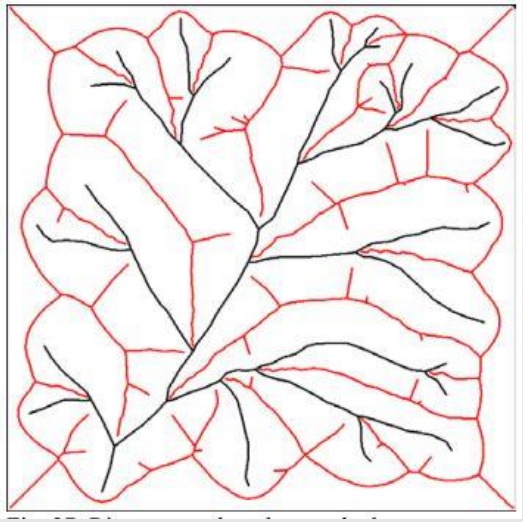
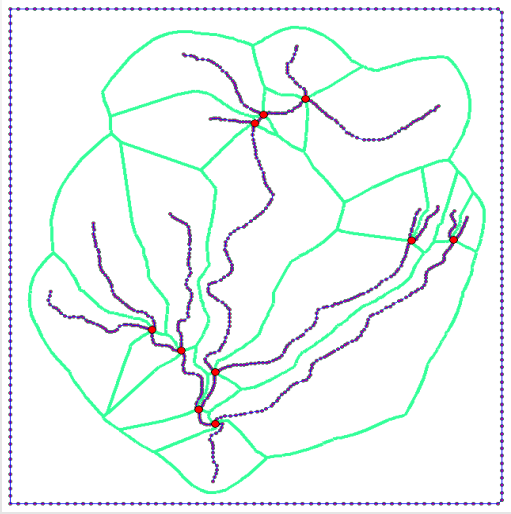
## Catchment Area Delineation

- Catchment area delineation from the skeleton of stream networks



(Gold and Snoeyink, 2005)



(Karimipour, Ghandehari, and Ledoux, 2013)



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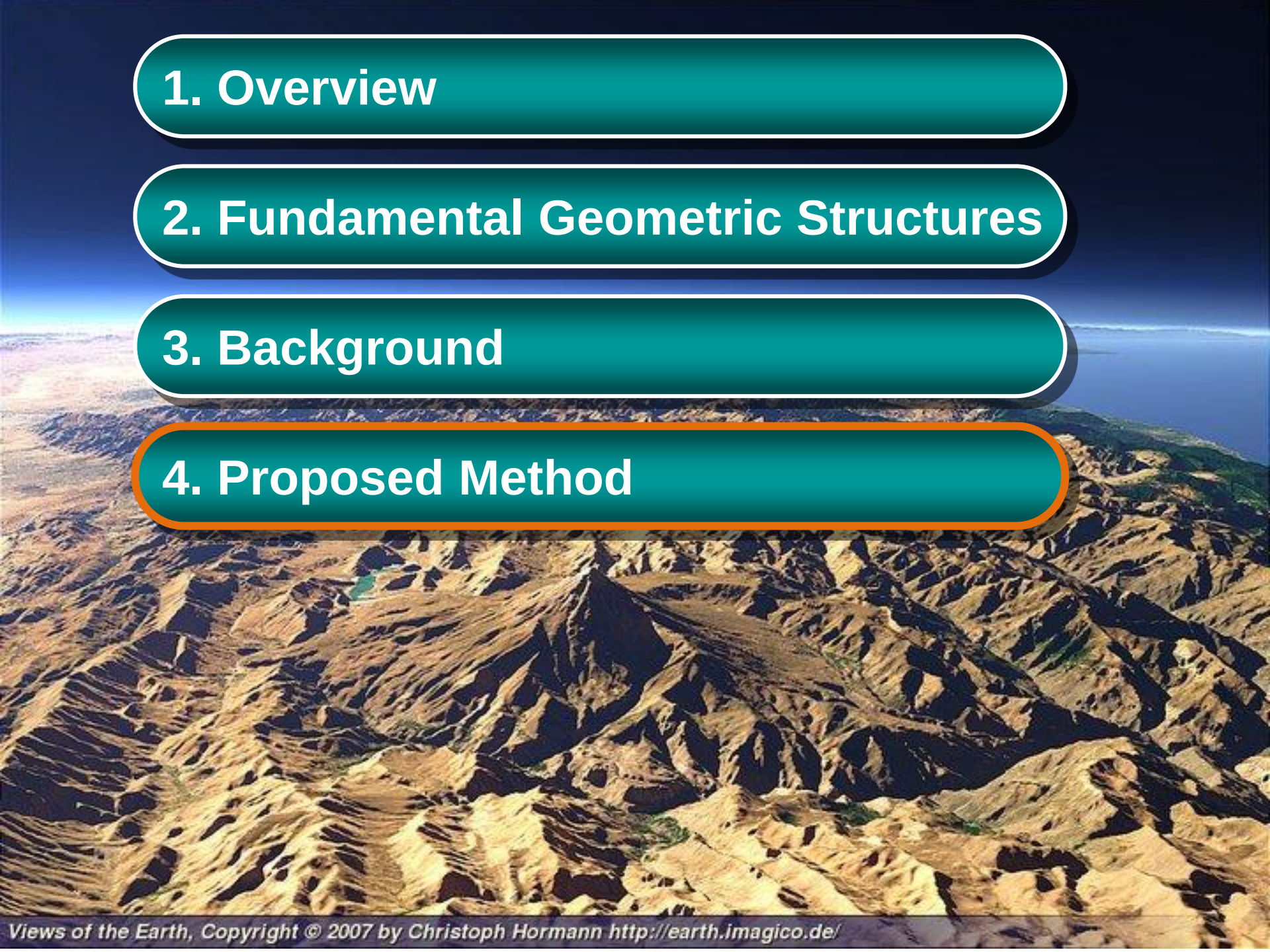
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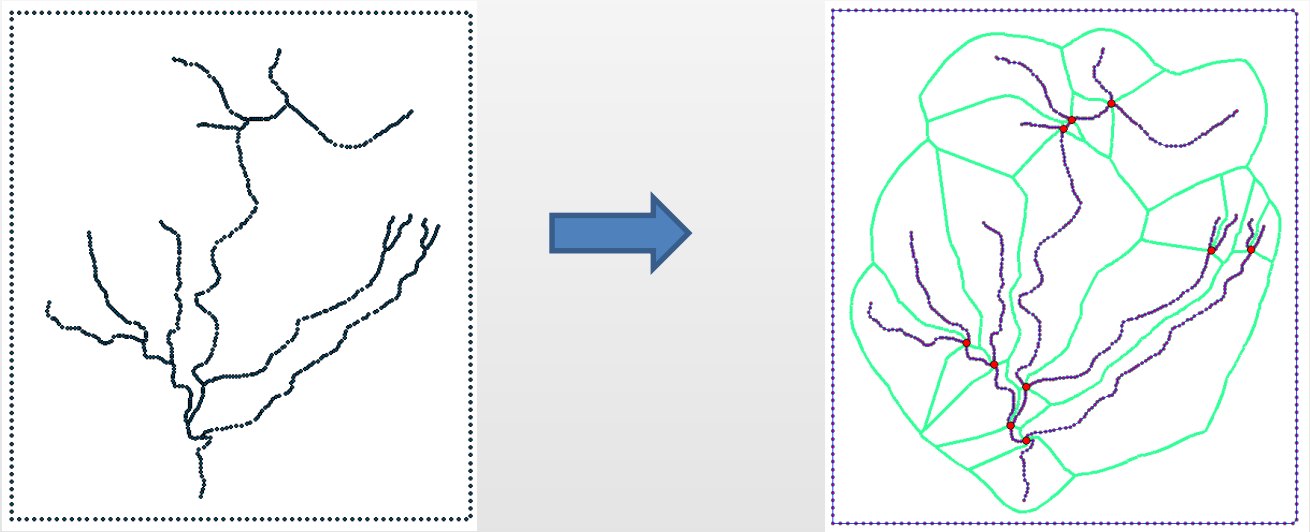
# Skeleton Extraction of Stream Networks

- Sampling
- Improved one step crust and skeleton algorithm





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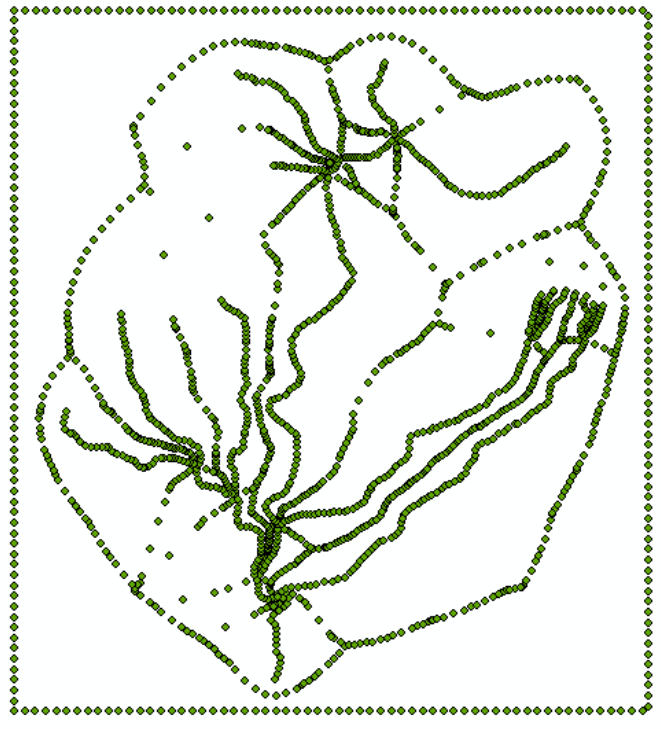
# Extraction of Elevation Points





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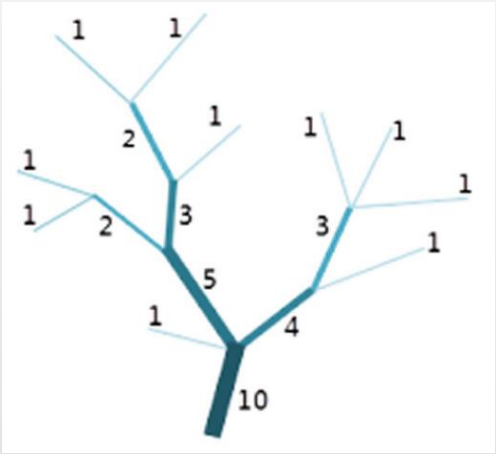
# Stream Ordering

- A global parameter
- Shreve method
- The NVS Vector Stream tool
- The modified elevations are computed using the following formula:

$$H_c(p) = H_0(p) + \frac{H_{mean}}{Order(p)}$$

where Hc (p) = the modified elevation of point p
H0 (p) = the initial elevation of point p
Hmean = is the mean elevation of all elevation points
Order (p) = the order of point p



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## DEM Interpolation

- Inverse Distance Weighting (IDW)
- Ordinary Kriging
- Natural Neighbor



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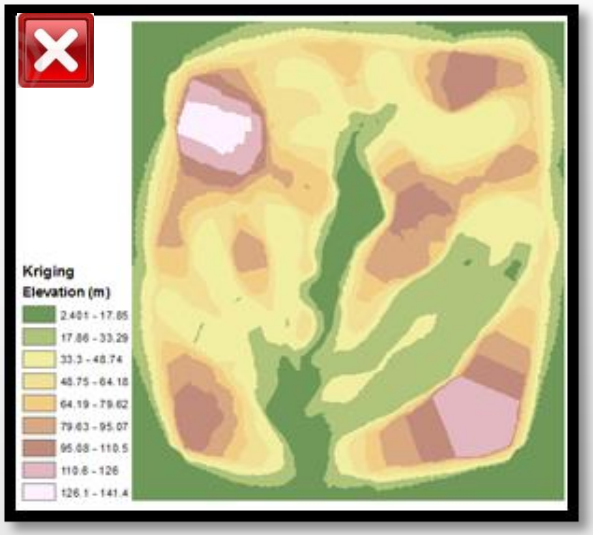
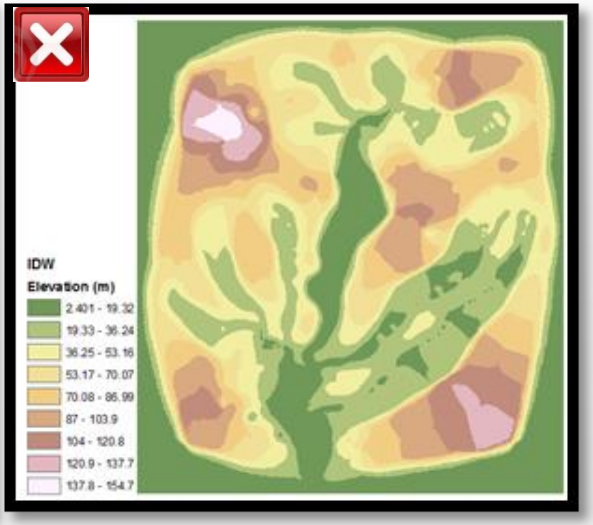
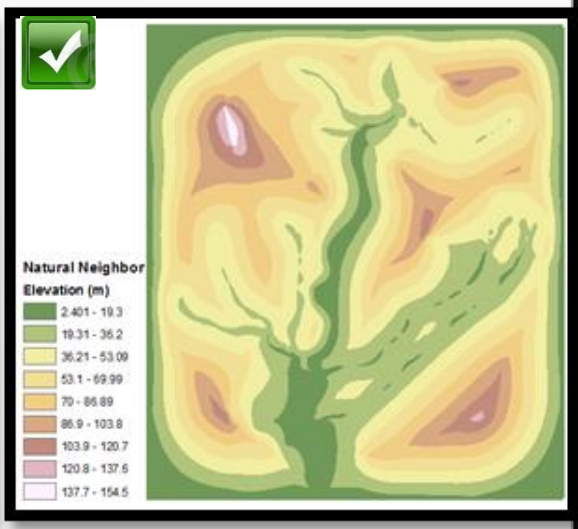
# DEM Interpolation (Cont.)




IDW




Kriging




Natural Neighbor



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# DEM Interpolation (Cont.)

IDW

Kriging

Natural Neighbor



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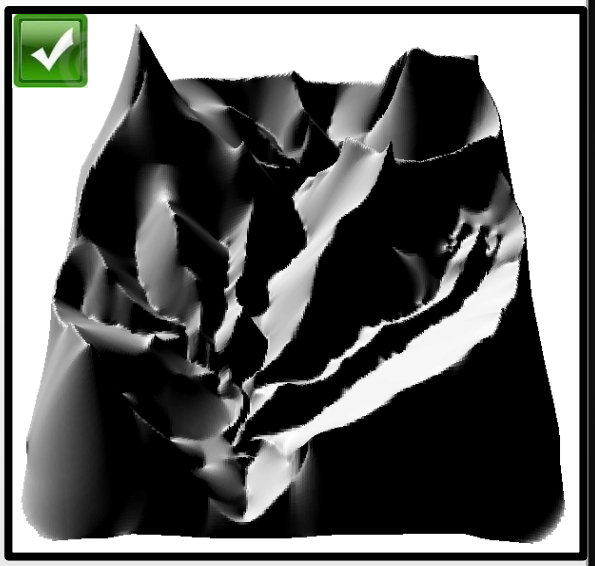
# DEM Interpolation (Cont.)

IDW

Kriging



Natural Neighbor



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# DEM Interpolation (Cont.)

- Natural Neighbor
  - A well-defined set of neighbors (spatial adjacency relationships )
  - A well-behaved weighting function
  - A continuous model
  - Low computational requirements
  - A smooth interpolation
  - Well-defined stream banks



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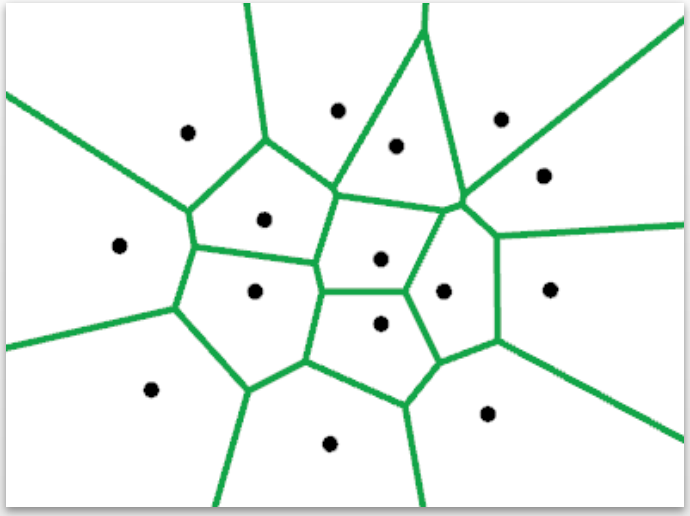



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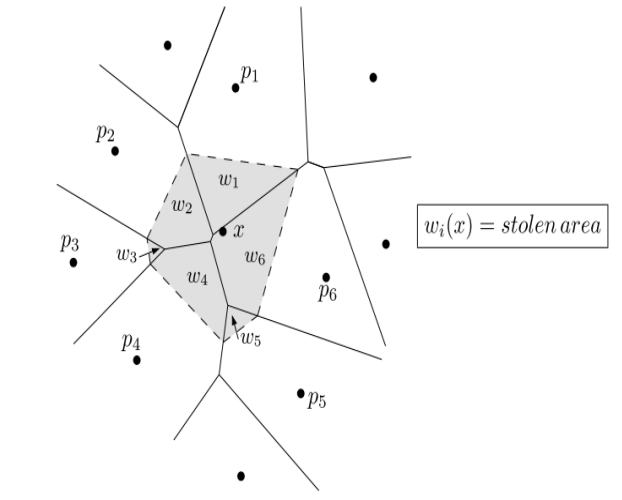




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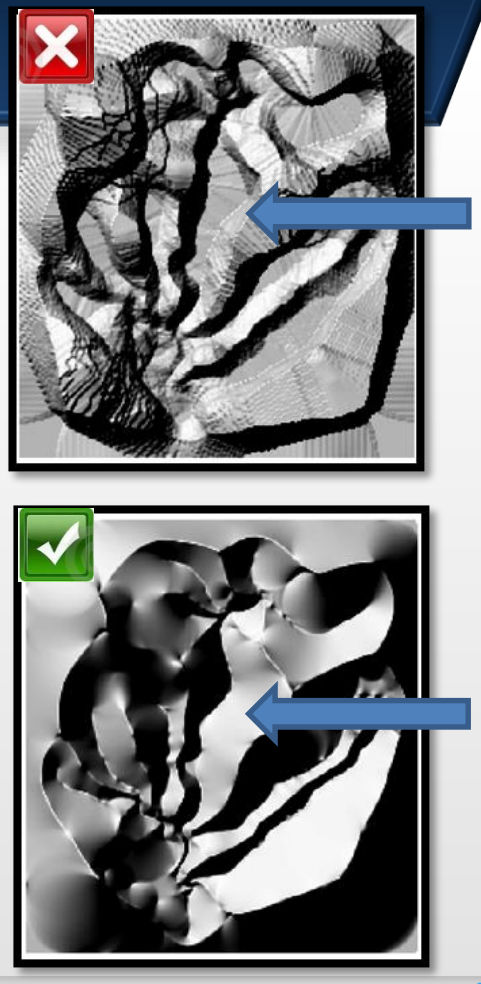



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***O (n log n)***



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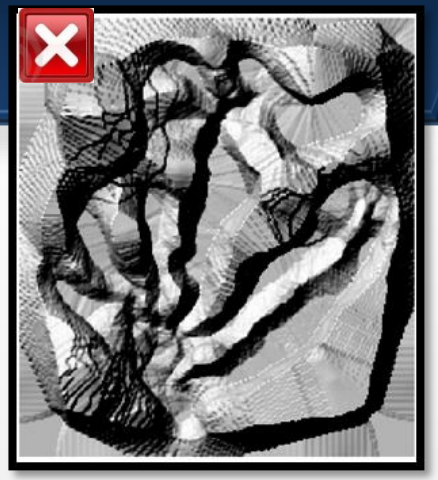



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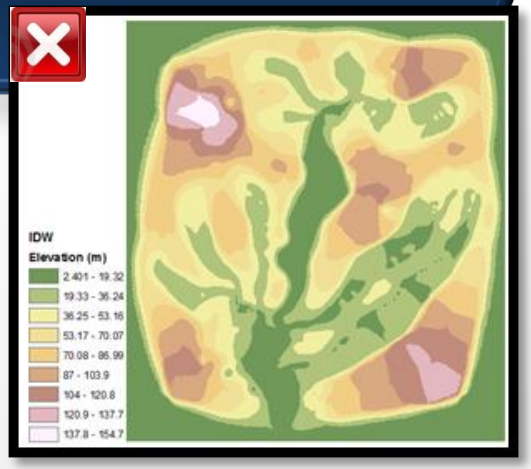


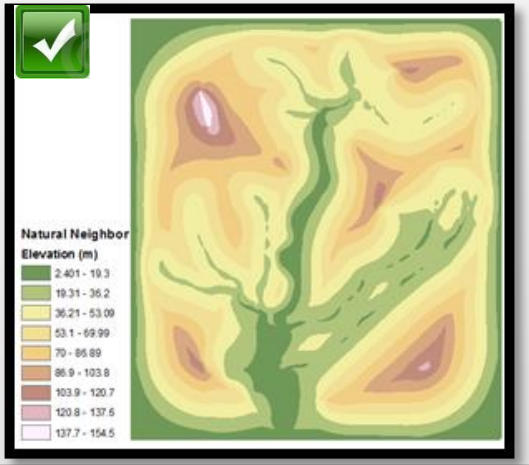




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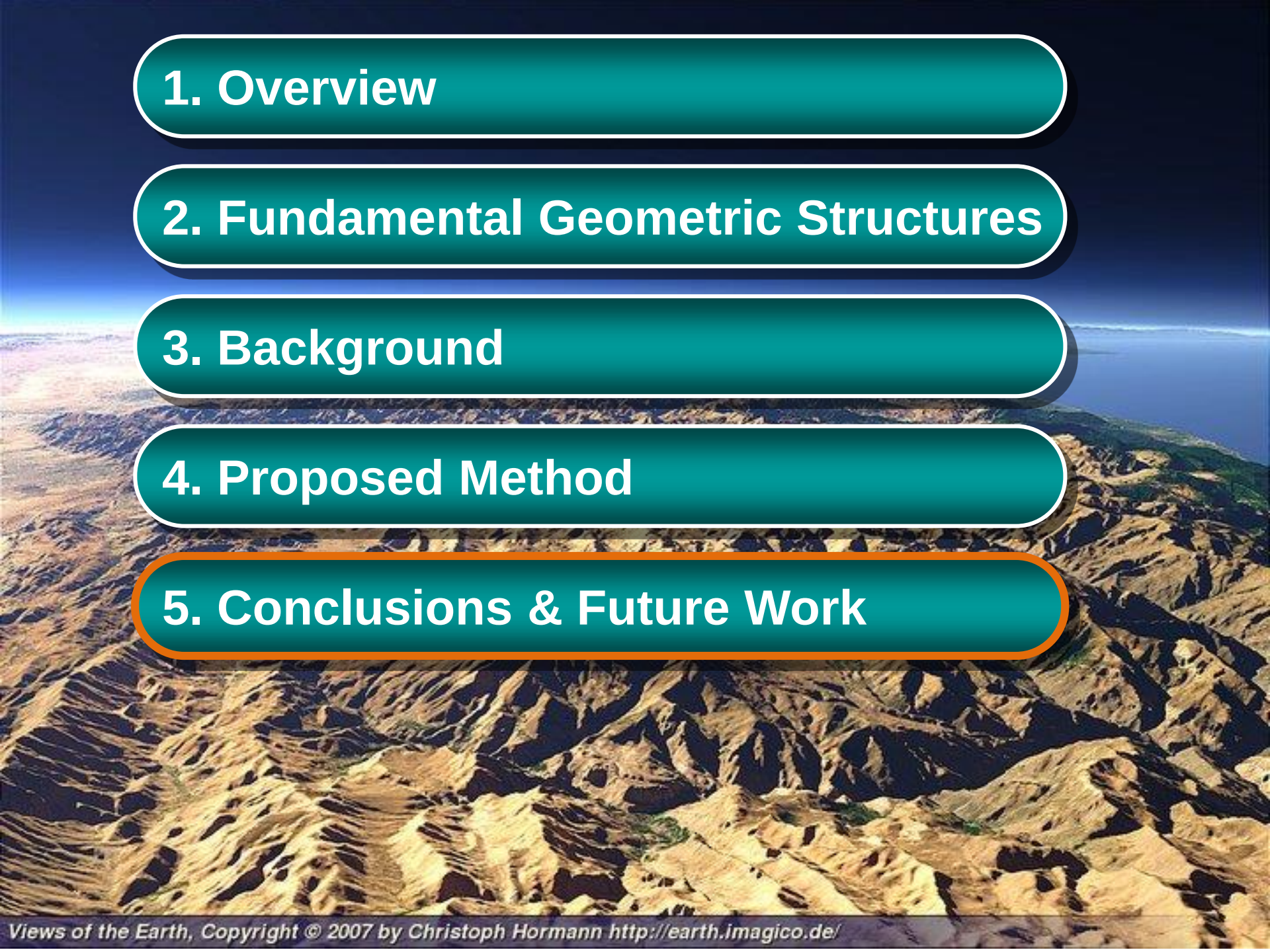
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# Conclusions

- Automatic catchment area delineation using only the vector-based stream network
- Extracting elevation information implicitly on the basis of stream network properties
- Using the skeleton and order of stream networks to approximate the DEM
- Although our approach is not appropriate for accurate terrain analysis, for non-exact large-scale analysis, it is fast, efficient and yields good results.
- By Using well-known data structures, retrieving the original data, constructing topology and improving of the proposed method can all be done easily.



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# Recommendation & Future Work

- Using supplementary data
- Making a better simulation of water flows
- Introducing new applications for the produced DEM
  - Hydrological analysis
  - 3-D terrain reconstruction



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# Thanks for your attention