Advanced Computer Graphics

Geometric Modeling- Project Presentation

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Technical Overview

- Procedural Plants (Okulmus)
- Terrain Generation based on Stream Erosion (Spiss, Mildenberger)

Procedural Plants

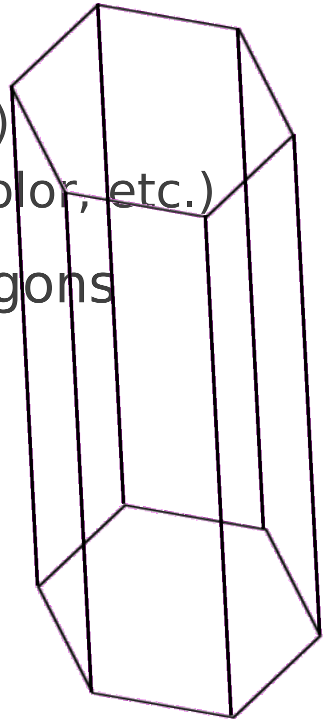
- Based on L-Systems, from Aristid Lindenmayer (in 1968)
- Idea: Plantlife growth is based on simple reoccuring rules
- A formal grammar that defines “production rules”

```
w: a
r1: a -> ab
r2: b -> a
```

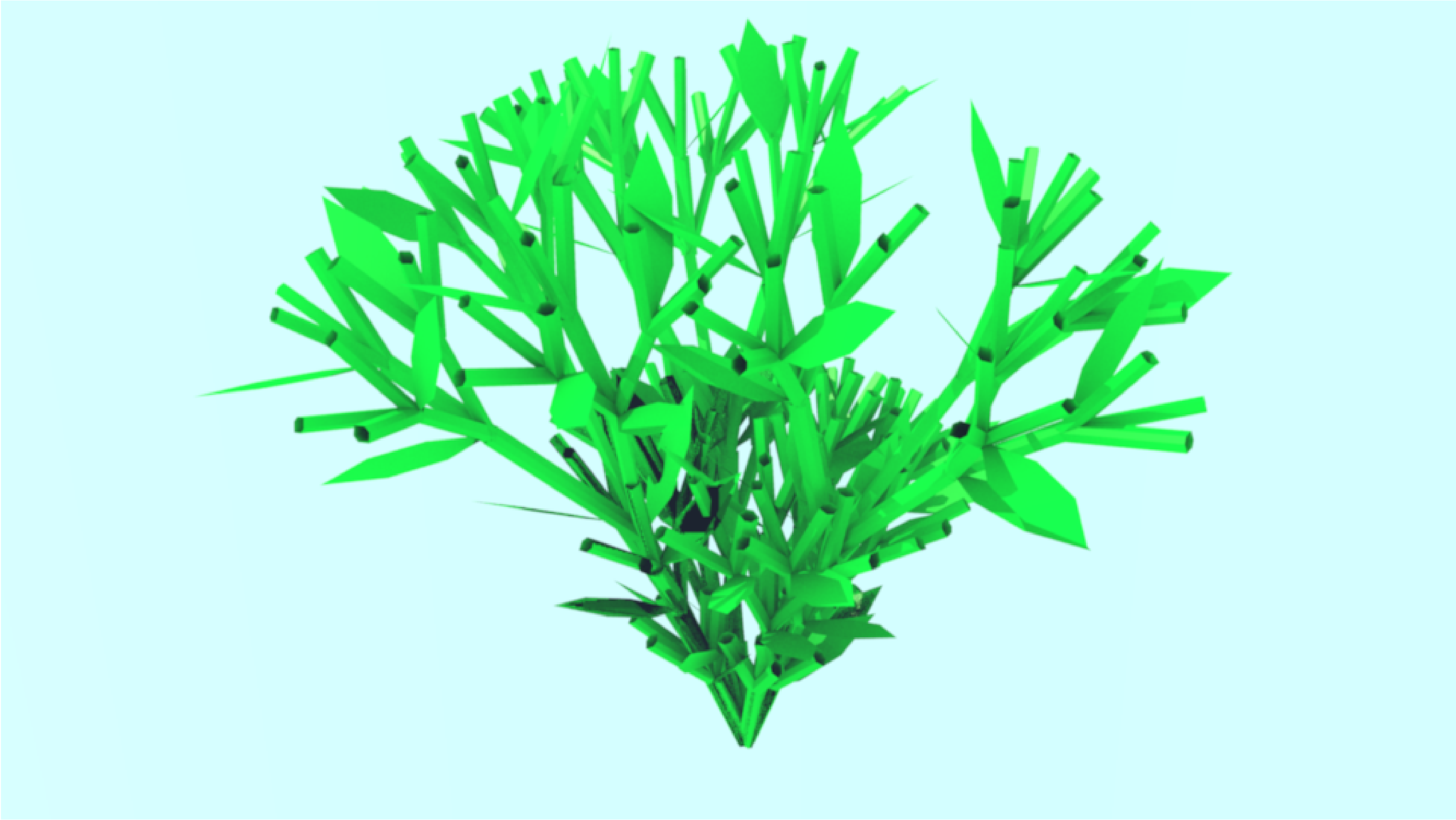
```
w: A
r1: A -> C+[A+G]--//[--E]C[++E]-[AG]++AG
r2: C -> FD[//&&E][//^^E]
r3: C -> C
r4: D -> DFD
r5: D -> D
r6: D -> D[//&&E][//^^E]FD
r7: E -> ['{+f-ff-f+|+f-ff-f}]
r8: G -> [&&&H'/B////B////B////B////B]
r9: H -> FF
r10: B -> ['^F][{&&&&-f+f|-f+f}]
```

3D Turtle Graphics

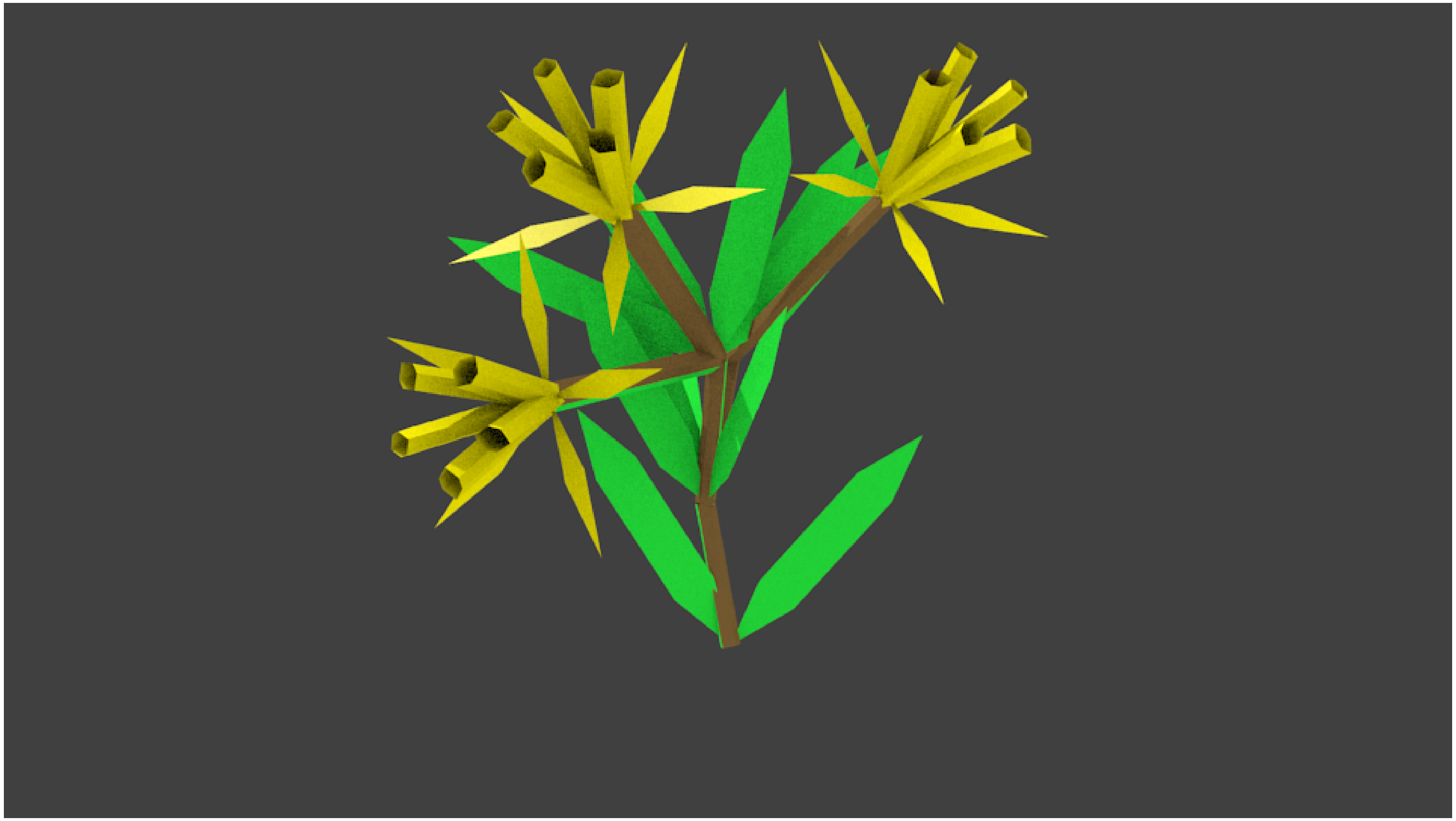
- Renders a given L-System string to a 3D mesh
- Needs a simple interpretation of symbols to
  - Move forward
  - Orientate in space (yaw,pitch,roll)
  - Start a branch (push/pop state to/from stack)
  - Change other state properties (line radius, color, etc.)
- 3D lines are generated by combining to hexagons



Results Procedural plants

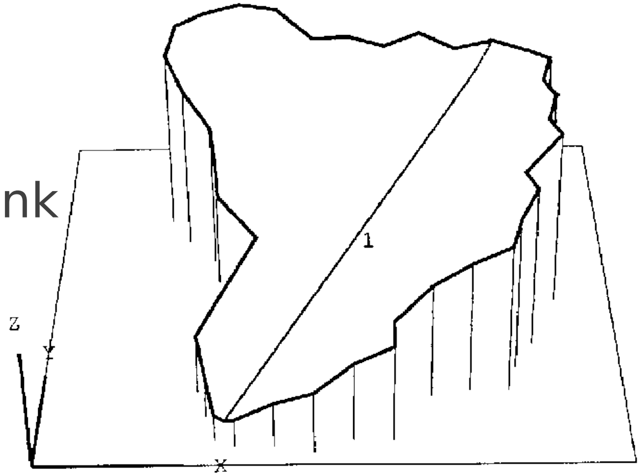


Results Procedural plants



Terrain Generation based on Stream Erosion

- Based on a Geometric Model of Erosion by a Stream Network.
- Initially an outline(which is in 2D) represents the “drainage basin”, and a link(edge) represents the main Stream
- The areas connected to the the link are called “drainage areas”
- A drainage area contributes water to a link
- The algorithm presented by Kelley[1] recursively splits the links until the drainage areas aren't “strong” enough to support a new stream
- This is determined with a constant C = A/L where A is the drainage area and L the length of the stream/link

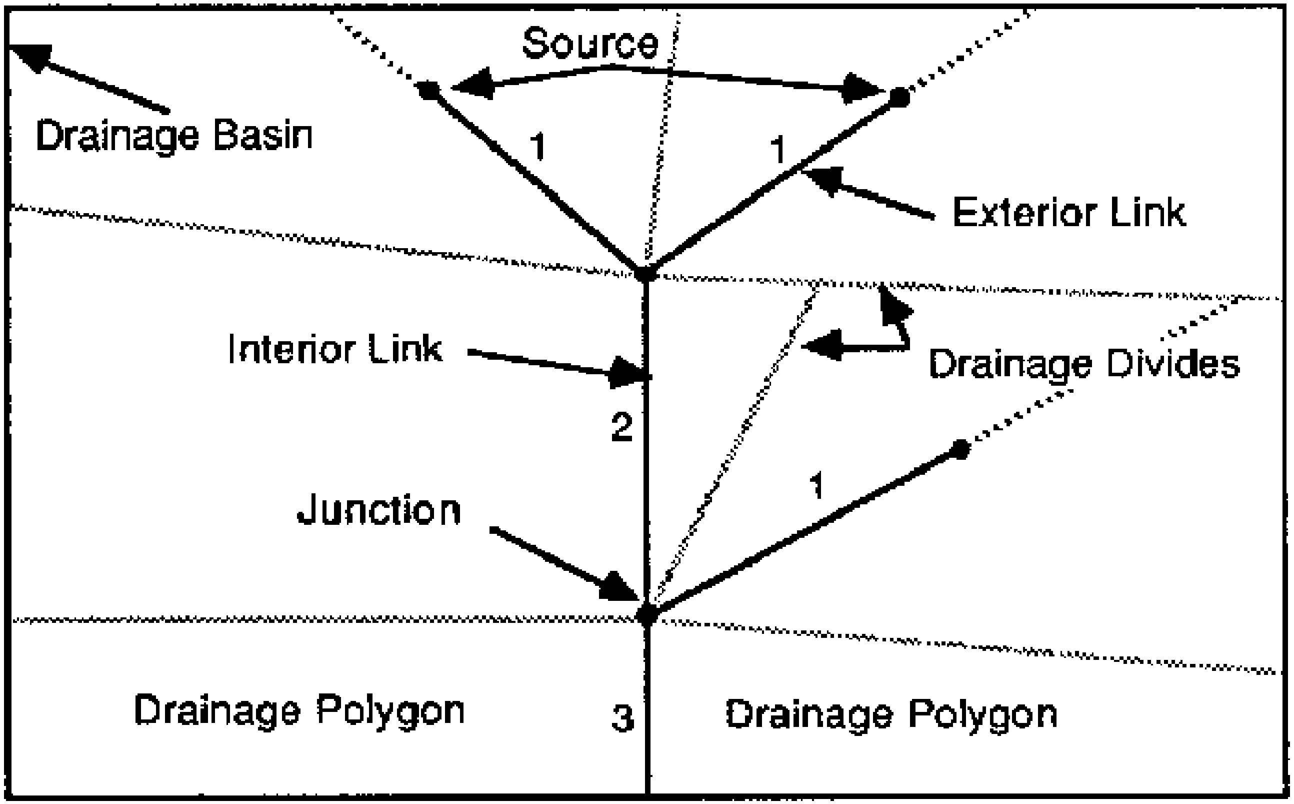


Initial Drainage System [1]

Adding a link/stream

- The algorithm recursively adds a link until A/L < C
- With adding a link, additional drainage areas have to be inserted, this is achieved by splitting the drainage area between the new link and the neighbors
- The resulting edges are called “drainage divides”
- The Stream is in Shreve Order, thus every link has an ordinal number, which is defined recursively: $S_n = S_{n+1} + S_m$ where n is the current stream and $n+1$ and m are the upper streams. The so called exterior links(source links) have the ordinal number 1

Schematic Overview



Explanation of specific terms[1]

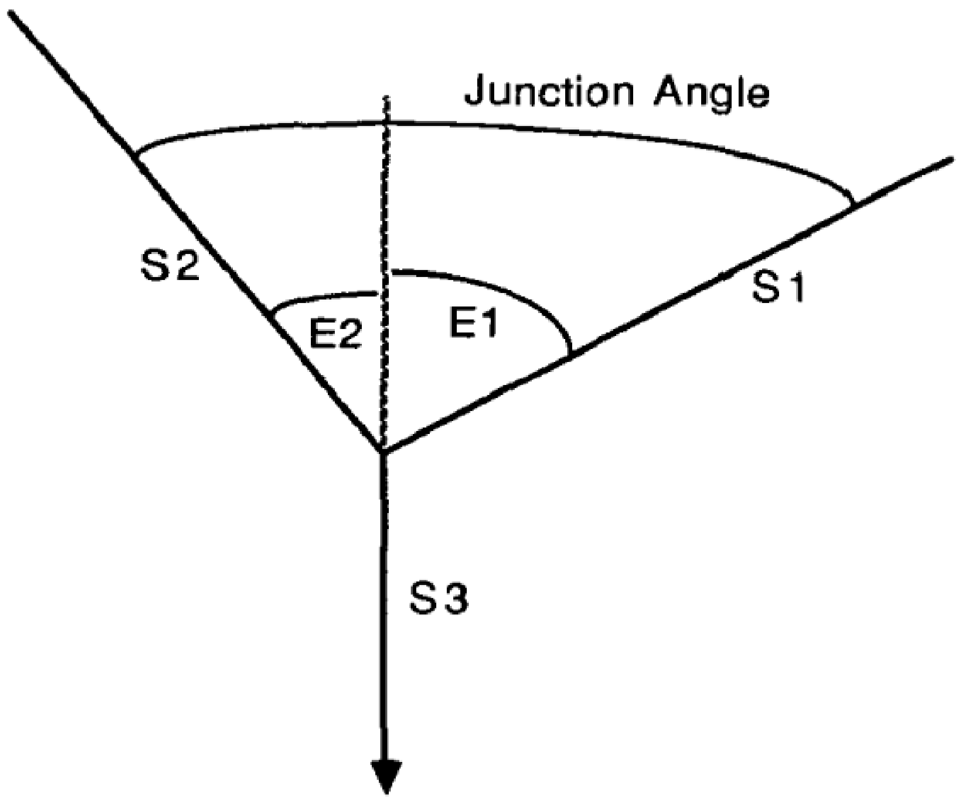
Determining the link length

- The junction where the split occurs is determined using the following formula:
- Junction = MeanJunction + rand() * DeltaJunction
- MeanJunction is the mean length until a link splits
- Rand() * DeltaJunction is a perturbating factor, to add some randomness into the length
- Exterior link lengths are determined the same way, using specific values(MeanLength and DeltaLength)

Determining the junction angles

- The slope tangents oft the links are determined with the shreve order u, a factor q which is between -0.37 and -0.837 and the meanLength(p) of the exterior links, with the following formula:
- $Slope = p(2u-1)^q$
- The Junction angle is then determined with:
- $angle = E_1 + E_2$ where:
- $\cos(E_1) = S_3/S_2$ and $\cos(E_1) = S_3/S_1$

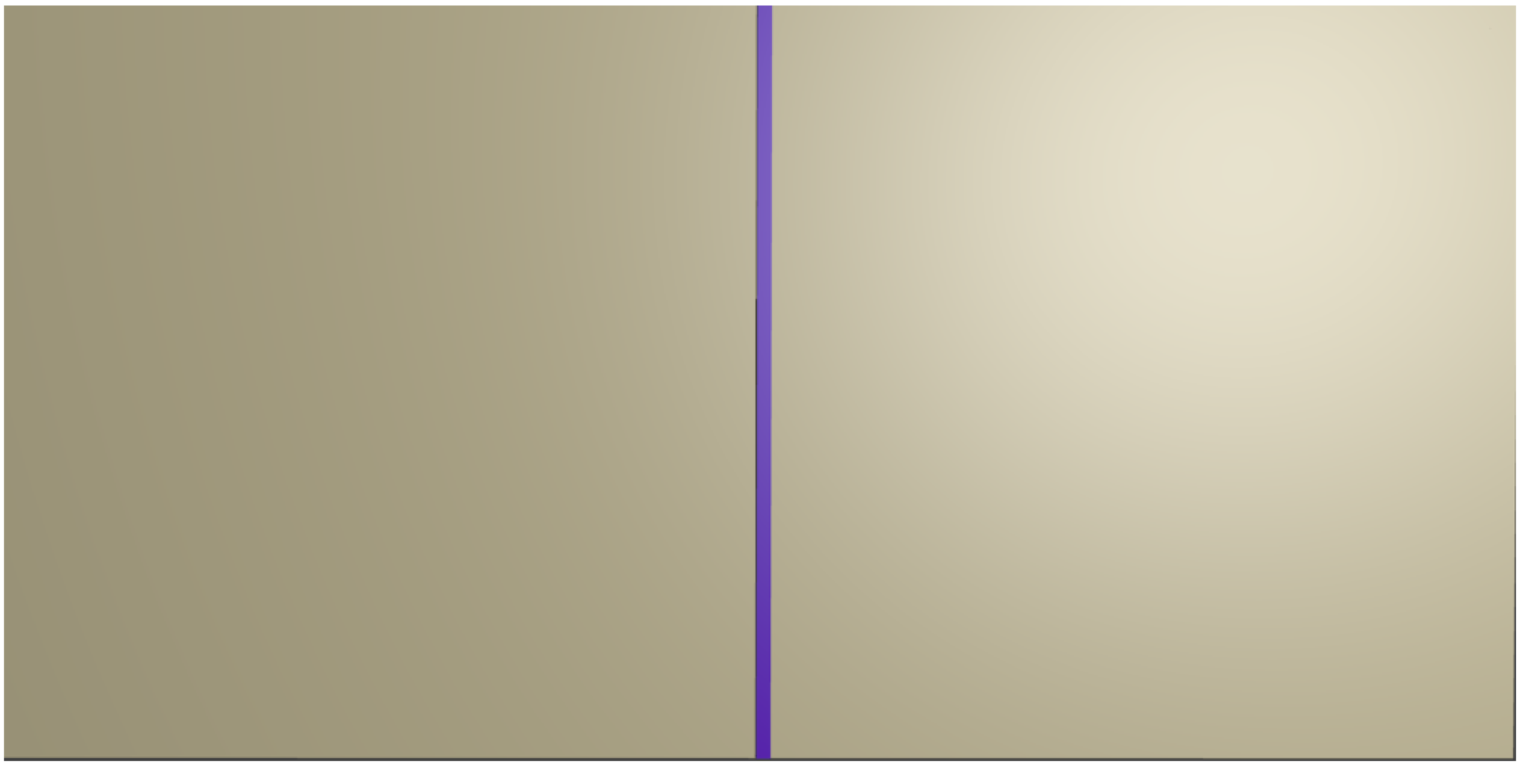
Junction Angles Overview



Drainage Divides

- The drainage divides are calculated based on the slope tangents of the links
- In our Implementation the drainage valley slopes are calculated with a random factor between 0 and 90 degrees
- The drainage divides seperate the drainage areas for every link
- For further information: [2]

Example of the addition of links



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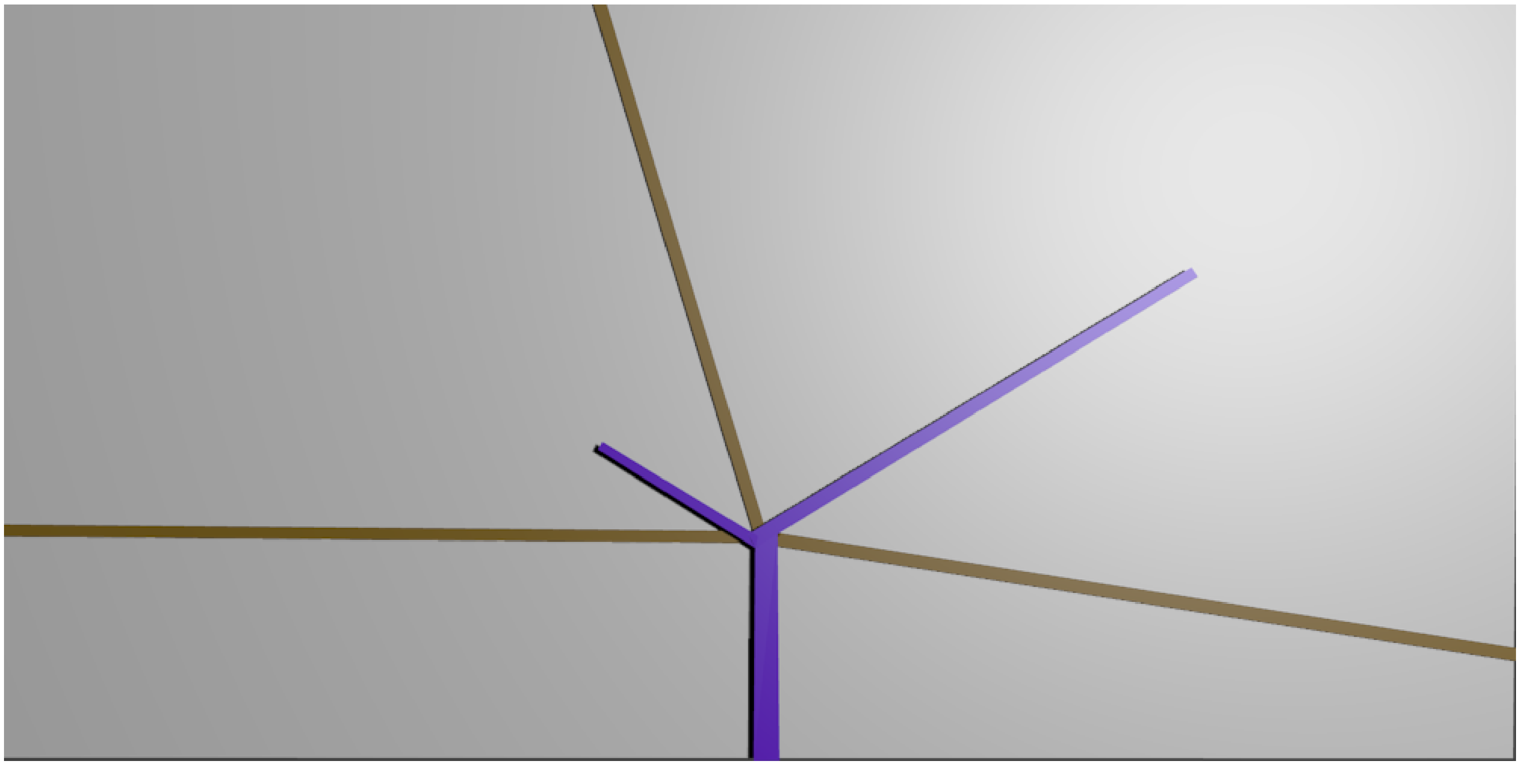

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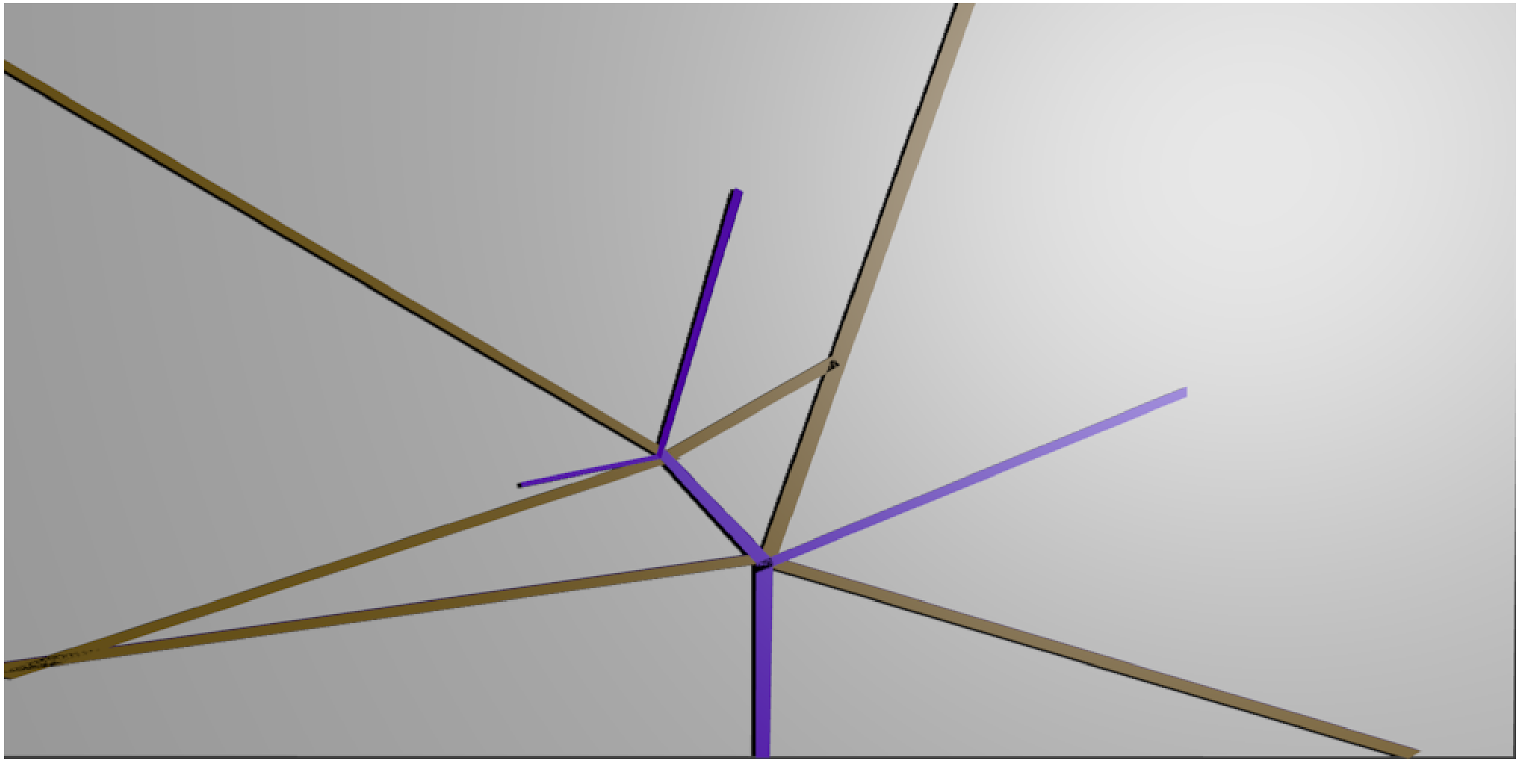

Calculation of the height

- The height is calculated using a recursive algorithm, starting from the outlet(root) at the base elevation:
- $h_{upstream} = h_{downstream} + S * L$
- Where h is the height, S the slope tangient and L the length of th link
- The height of the valley sidewalls are calculated using a similar model by using the slope tangients of the valleys
- Further information for the valley sidewalls in [2]

References

- [1] Alex D Kelley, Michael C Malin, and Gregory M Nielson. *“Terrain simulation using a model of stream erosion”*, volume 22. ACM, 1988.
- [2] Athol D Abrahams. *“Divide angles and their relation to interior link lengths in natural channel networks”*, volume 12. Wiley Online Library, 1980.