**Random tree**

To graphically model a tree (or its visual concept) I chose the following strategy.

1. **Trunk and branches.** A tree is made up of a trunk and a set of branches. This starting point allows for identifying the relevant concepts. The trunk and the branches are in the relationship of parent and child repeating for entire generations of offshoots. Child branches connect to their parents under some angle and are shorter by a factor smaller than 1. Which obviously allows the process to end where branches shrink below a given size.
2. **Random parameters:** By using random parameters different outcomes of the same “kind” are generated each time the program is run. And by assigning specific random seeds identical instances can be produced. To create diversity then, fixed numerical parameters are often replaced by random values chosen from a given range.
3. **Recursive structure:** the preliminary model of 1. suggests a recursive structure with the offshoots branching off the trunk in a number of generations. In short, the tree is made up of smaller trees connected to the trunk. “Smaller” is defined by some contraction (random) coefficient, and “branching out” happens at a (random) angle to the given branch.

The first attempt along these lines created this image:

A picture containing fireworks, outdoor object

Description automatically generated**random tree with straight branches, fixed angles, fixed contraction**

This example also illustrates the way visual modelling happens in subsequent turns of raising questions and finding answers provoke further issues.

1. **Sections and inflections.** Branches are made up of a series of sections each with given inflections relative to the horizontal. Consecutive sections are shortened by a (random) contraction factor and can be drawn at a width proportionate to their length.
2. **Curving lines:** Branches might bend for greater lifelikeness. This is achieved by section inflections diverting somewhat from those of the previous ones. Figure 1. uses straight lines with constant inflections. Inflections can be controlled by random values in various ways. If the actual inflections are taken randomly (order 0) sections will connect in zig-zags. Alternatively, minute random differences can be given for subsequent section inflections (order1) or even smaller changes of these differences (order 2). Especially in the latter cases the overall image is quite sensitive to the actual values of increments, requiring careful fine-tuning.

A picture containing black

Description automatically generated

**order 0**

**order 1**

**order 2**

**upward bending**

1. **Angles.** As opposed to inflections angles are used to determine the starting directions of new branches relative to their parents. Of course, they can have definite values or chosen randomly.
2. **Random contraction:** The process of drawing is governed by a contraction factor for the consecutive sections of the branches. A fixed contraction can result in too regular “cauliflower” shapes, which can be handled with random values. The fact that the shape of the tree greatly depends on the careful choice of the value is easy to explain. The overall size has to do with the value

*h \* (1 + q + q2 + q3 +…) = h / (1 – q)*

with *h* denoting the first section (or trunk). Note that with *q* close to *1,* a small adjustment *delta* of its value can alter *1 - q* and therefore the whole fraction by a significantly larger proportion. (Say, at *q = 0.95,* the difference is 20-fold.)

1. **Random branching:** The recursive structure of the tree is created by the branches having outgrowths at irregular intervals. The new branch diverts from the old one by an angle chosen randomly with uniform distribution between -0.25pi and 0.25pi. And the positions of the new outgrowth are determined by an overall probability. I chose it to be 27%.
2. **Upward bending.** In a more sophisticated version we can multiply the second order angle difference with the sign of (*pi/2* minus the actual branch angle), which will cause each branch to eventually bend upwards towards the “sky”.

A picture containing outdoor object, fireworks

Description automatically generated

**random tree with second order curving branches and random contraction**