Threads of Ancestry and Community / Complex Threading

Principia Textilica : Project Documentation

Felicitas Höbelt

April 1, 2015

1 Principia Textilica

1.1 Context

In the course "Principia Textilica" we explored intersections of computational algorithms and textile craft, including pattern generation algorithms, weaving techniques, knot theory, hands-on experience with textile maschines, history lessons and more. For the final project each student was encouraged to find a subject to implement some of the methods and techniques we got to see during the course.

1.2 Motivation

I study Computer Science and Media, which means my background is more algorithmic/technical than art-related. Nevertheless I am familiar with a few textile techniques such as knotting (Macramé), weaving, sewing, felting and embroidery.
For inspiration I looked at two topics that have fascinated me for years: Modeling "Living" Things (plants/fungi/insects/animals) and complexity.
Complexity is often mistaken for complicatedness because the result looks complicated. However, the system that produces a complex result is itself very simple. It consists of a certain number of elements and a few elemantary rules which are applied to those elements.
My goal was to use both, complexity and modeling simple "life", to create a (textile) pattern.

2 Idea

2.1 The Pond/Fish Tank

I decided to go with a swarm model, which means I have a number of individuals which are controlled by a set of rules concerning themselves, their dynamic environment (e.g.

the other members of the swarm) and their static environment (e.g. boundaries of the tank). The metaphor I chose was a school of fish moving around in a pond or glass tank.

The desired pattern would be generated by the movements of the individuals. I wanted to start with the rules and continuously adapt them depending on the outcome.
I did not settle for a specific textile technique, at this point I only thought about assigning each of the individuals a thread. With this premise in mind, favourable textile techniques were embroidery and knotting.

2.2 Rules

My fish program is in 2D and has two main elements: the tank and the fish.

The tank started out as rectangular, but I found a circle to be more aesthetically pleasing as well as more fitting for an embroidery hoop. The circle embodies the simple inside/outside world that I need.

The swarm rules below share some similarities with the "Boids" program by Craig Reynolds [TODO ref], he developed an agent-based algorithm to simulate the flocking behaviour of birds.

There is no randomness in my program. The behaviour of the fish is essentially determined by four principles:

Company Each fish will follow other fish.

Privacy Each fish needs a minimum of private space.

Security Each (non-predatory) fish will avoid any predators.

Boundary Each fish will stay inside the tank.

3 Implementation

For implementing my idea I chose Processing 2.0 [TODO link/ref], because I am already familiar with Java. Additionally, Processing is one of the tools we got to try out during the course, so all participants know how to look into my code and adapt it if they want to.

In this section I will focus more on algorithms and data flow rather than implementation details. There are four ways of running the program represented by the combination of mechanisms that are used on top of the basic behavioural rules (predator/fear and birth/death): 1. both predator/fear and birth/death 2. only predator/fear 3. only birth/death 4. none of them

It is worth noting that the code still includes all methods and parameters that I ended up not using for the textile piece or the parameter variations, but I will restrict the explanations to the version I actually used (3. only birth/death). In this version each

fish will have two children when it dies. The resulting pattern is made of straight lines connecting parents with their children. The movement of the fish is influenced by all living fish as well as all dead fish. I start with one fish and stop at 6 or 7 generations.

3.1 Algorithm

Class	responsible for
class Fish	- parameters (id, color, speed, position, direction...) - updating the state (position, direction) - drawing (body, connections to other fish, traces for the traces-visible-mode) - computing new direction regarding tank borders and neighboring (visible) fish - contribute to log file
class Tank	- updating and saving images (traces and frequency) - drawing the tank
public methods and variables	- keeping track of all elements (fish, tank, variables for drawing modes) - initial setup - drawing, includes animation and timing - receiving key presses (for saving or pausing) - log file (.txt) - vector operations (e.g. normalizing, computing the scalar product, turning, computing a reflection vector)

3.2 Exporting the Values

To be able to extract all important positions and values from the program I implemented several logging methods. The program produces a simple text-file, where the parameter values are noted as well as the positions of the fish (original coordinates plus coordinates scaled to fit the textile application), their id and their children. The tank class produces an image where the positions of the fish are noted pixelwise, the image shows their complete movement. I also export an SVG-file with a straight line connecting the end position of each fish with their children. This export can be done with additional text output directly within the SVG-file (the id of each fish above its "grave").

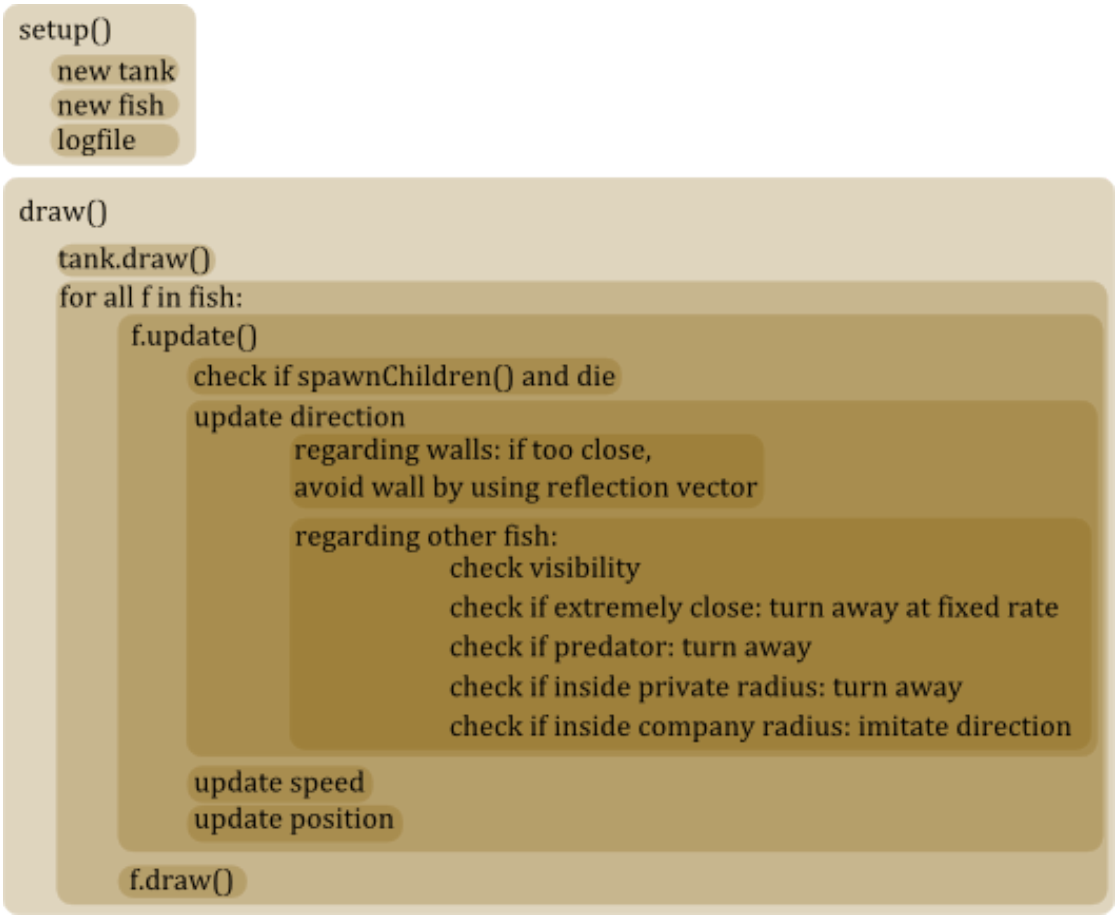


Figure 1: Essential structure of the program

```
tank cx,cy,radius: 300.0 300.0 300.0
starter fish: 1
start dir: 0.0 -1.0
start pos: 300.0, 300.0
wall/neighbor 0.9/0.1
maxGenerations 6
maxChildren 2

spawnTime 6000ms
spawnAnglesDegree 135.0 -135.0
turnSpeed 0.011/ms
private radius / company radius 30.0 / 70.0

fish:
0 g:0 born 300.0 590.0 : 140 275 c:
0 g:0 died 300.0 410.82532 : 140 192 c: 1 2
1 g:1 died 331.64142 237.63405 : 155 111 c: 3 4
2 g:1 died 264.66016 238.89192 : 124 111 c: 5 6
3 g:2 died 375.58804 65.089584 : 175 30 c: 7 8
...
```

Figure 2: The text-based log file consists of all important parameters as well as the coordinates of each fish, g: denotes the generation while c: denotes the ids of its descendents.

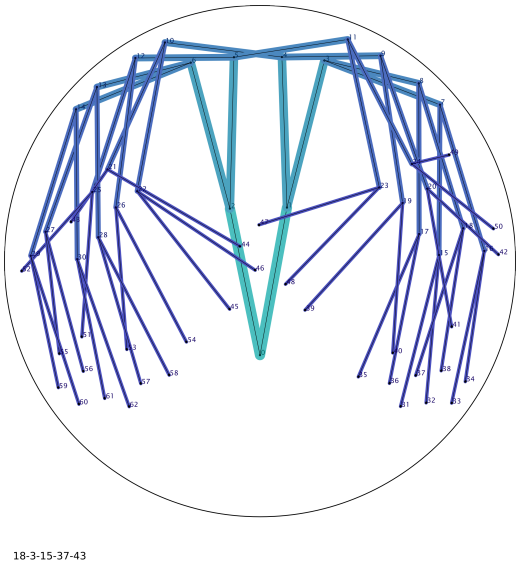


Figure 3: Connection lines between (dead) fish of 6 generations

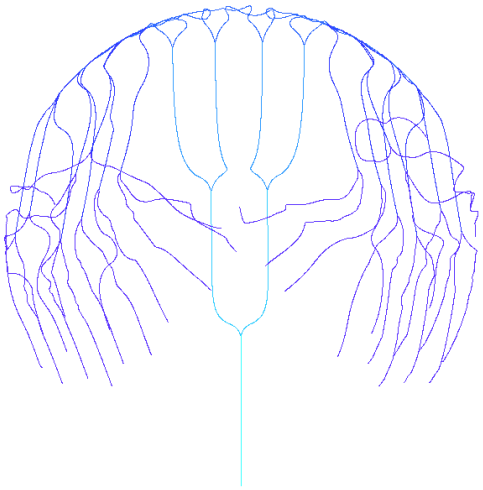


Figure 4: Traces of the movement of the fish while living

3.3 Parameters and Variations

There are several more, but some of the most important fish parameters/properties are:

privateRadius

companyRadius

interpolationSpeed (speed of turns)

timetoSpawn

spawnAnglesDegree

The following images show the different outcomes for variations of the parameters. On the left you see the connections between related fish, on the right there are their movement traces (actual paths). When varying one parameter the others are set to a default value to cleanly separate the effects of the change. The "baseline" setting with all parameters set to default is included in each of the variation series, the natural order of the parameter sizes detemines its placement within the series (ordered by increasing values). Table 1 shows the used integer values.

Parameters	Default value	Variation
privateRadius	30	20 30 40 50
companyRadius	70	50 70 90 120
interpolationSpeed	100	50 100 150 200 250 350
timetoSpawn	6000	3000 4000 5000 6000 8000
spawnAnglesDegree (+/-)	135	0 20 45 90 135 180

Table 1: Used parameter values

On the left is the image with the connection lines, on the right the image with the movement traces.

3.3.1 Variations of "privateRadius"

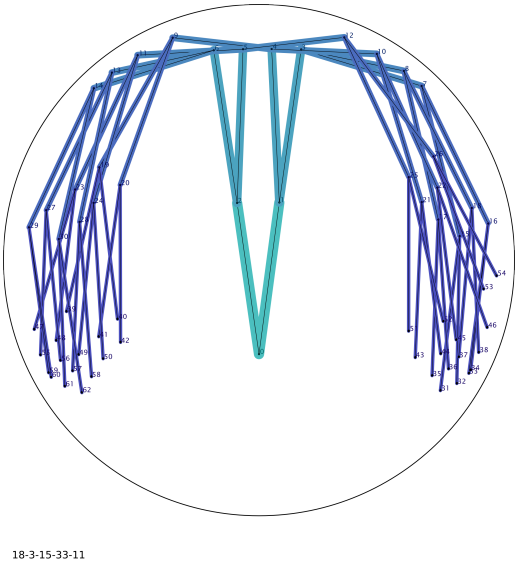


Figure 5: privateRadius = 20

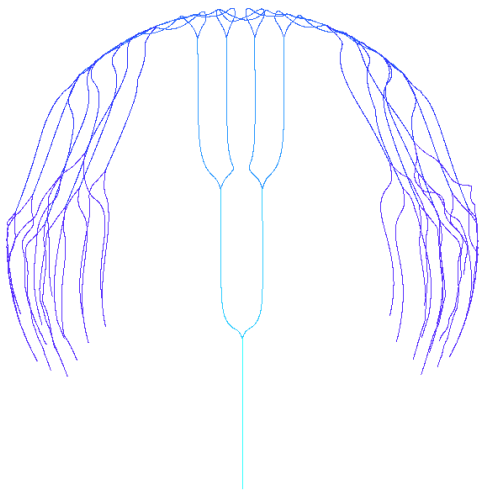
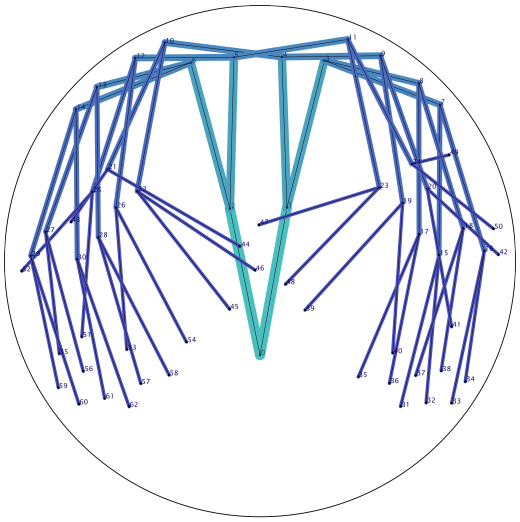


Figure 6: privateRadius = 20



18-3-15-37-43

Figure 7: privateRadius = 30 (default)

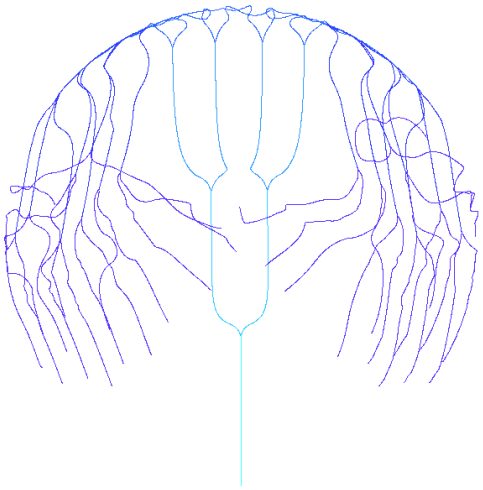
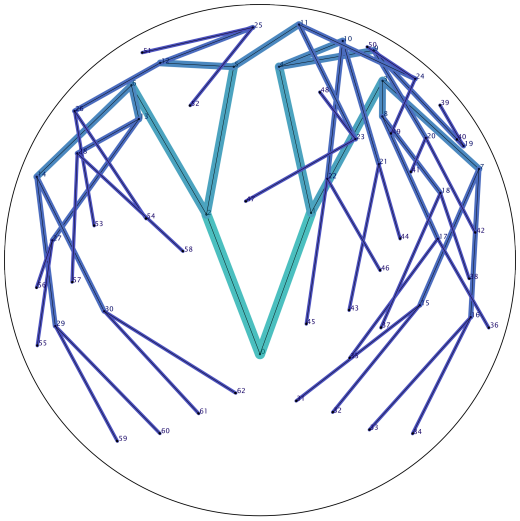


Figure 8: privateRadius = 30 (default)



18-3-15-34-9

Figure 9: privateRadius = 40

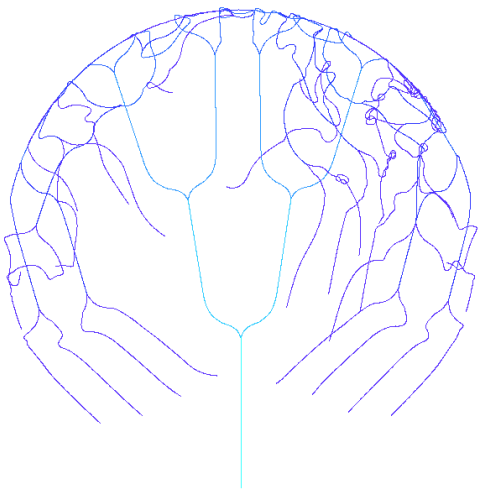


Figure 10: privateRadius = 40

18-3-15-35-1

Figure 11: privateRadius = 50

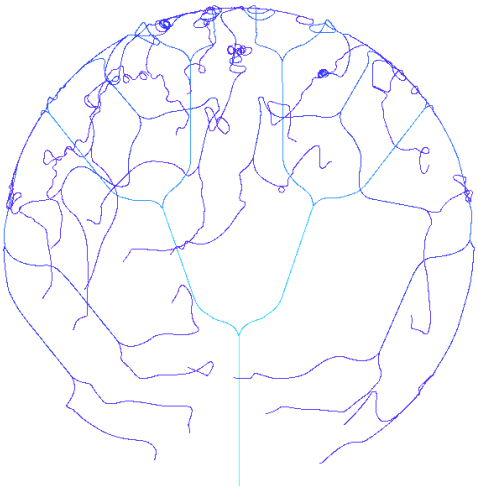
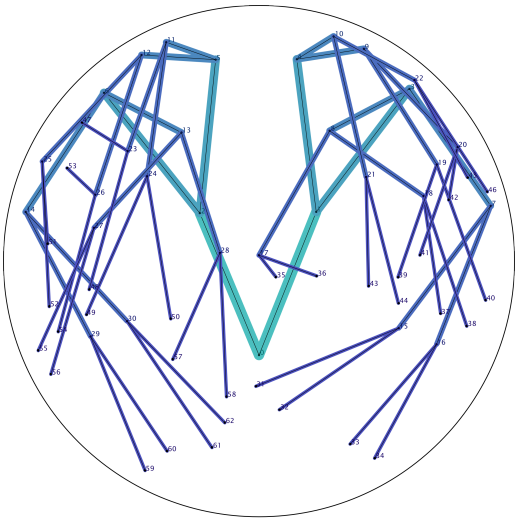


Figure 12: privateRadius = 50

3.3.2 Variations of "companyRadius"



18-3-15-30-2

Figure 13: companyRadius = 50

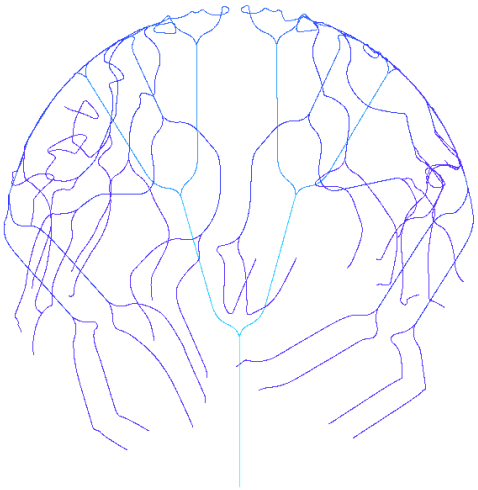
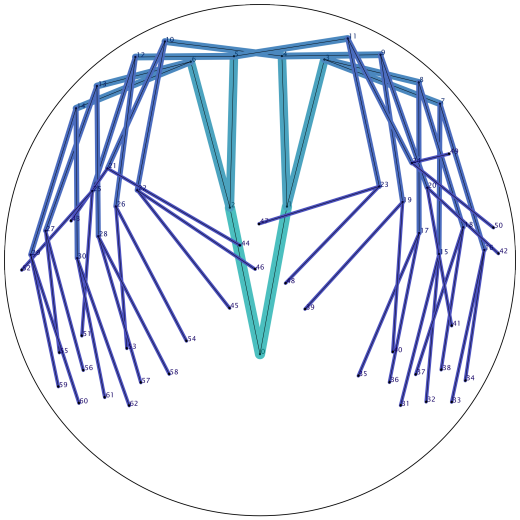


Figure 14: companyRadius = 50



18-3-15-37-43

Figure 15: companyRadius = 70 (default)

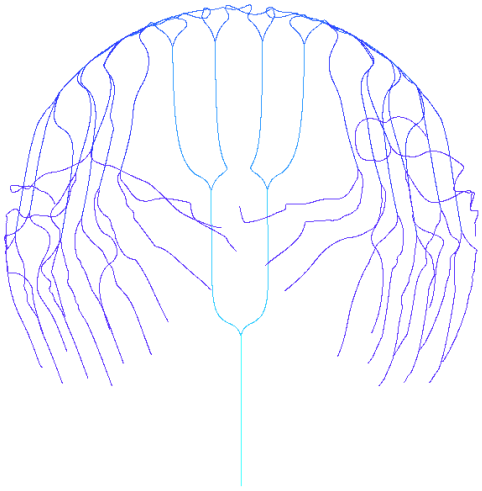
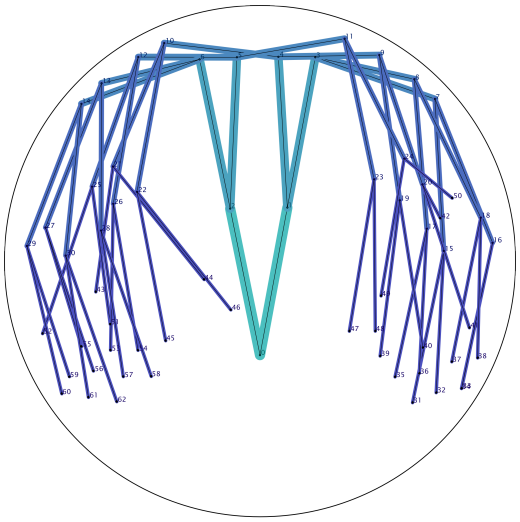


Figure 16: companyRadius = 70 (default)



18-3-15-30-53

Figure 17: companyRadius = 90

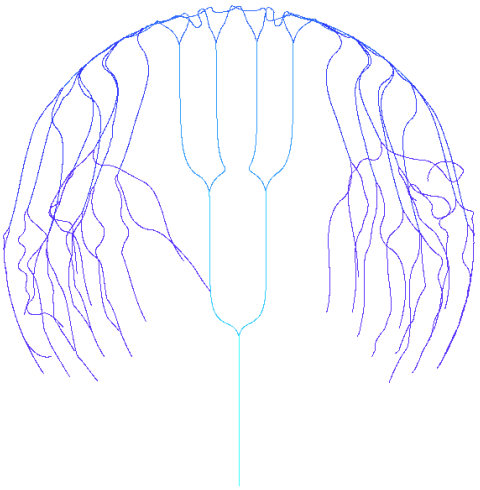
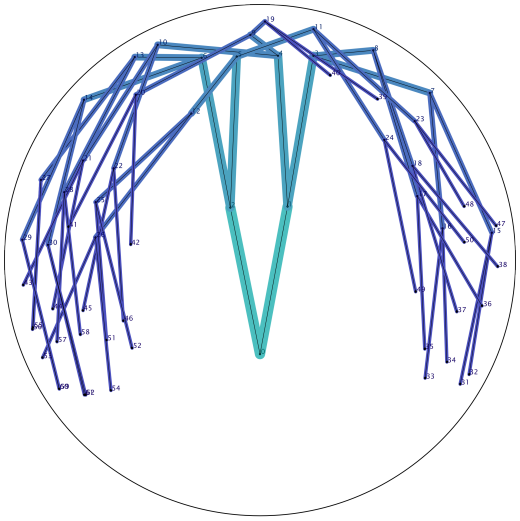


Figure 18: companyRadius = 90



18-3-15-31-57

Figure 19: companyRadius = 120

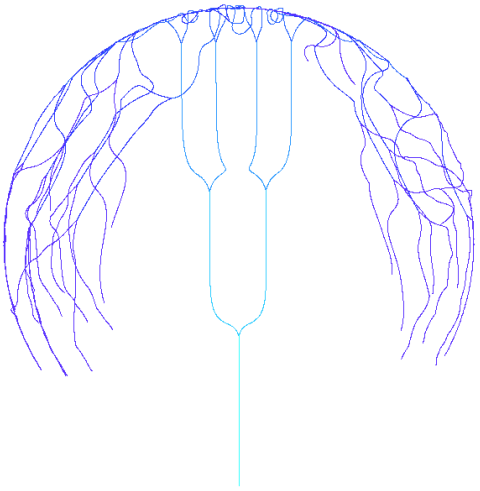


Figure 20: companyRadius = 120

3.3.3 Variations of "interpolationSpeed"

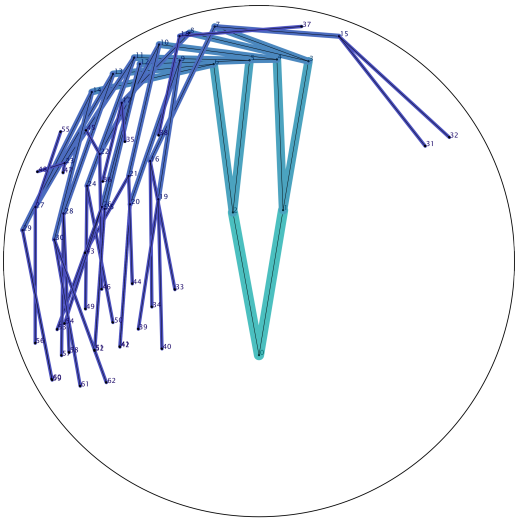


Figure 21: interpolationSpeed = 50

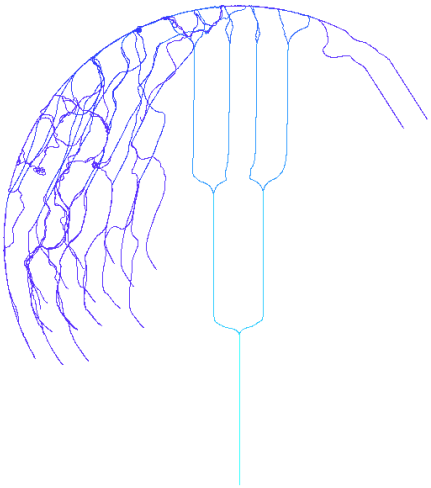


Figure 22: interpolationSpeed = 50

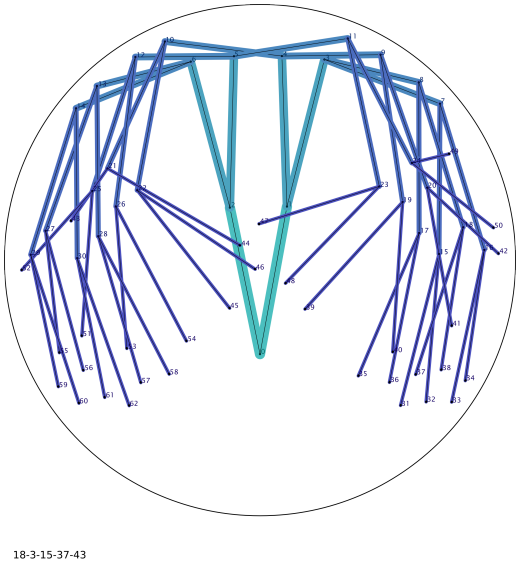


Figure 23: interpolationSpeed = 100 (default)

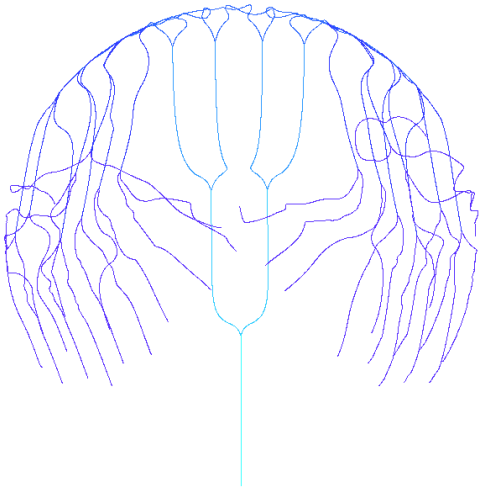
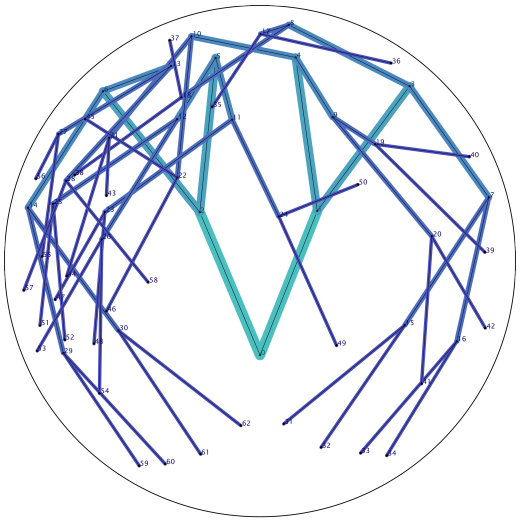


Figure 24: interpolationSpeed = 100 (default)



18-3-15-25-27

Figure 25: interpolationSpeed = 150

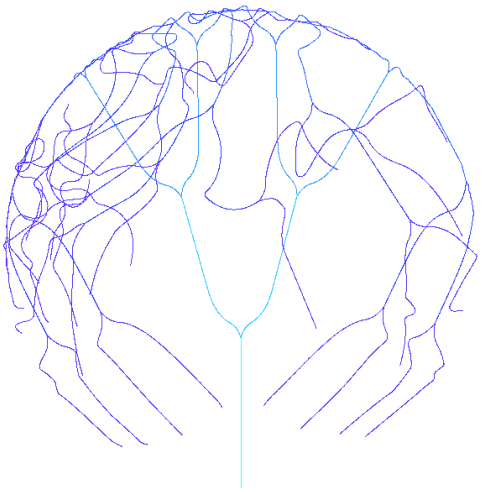
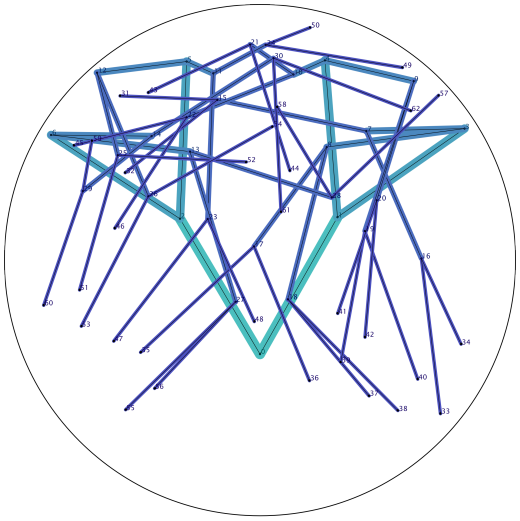


Figure 26: interpolationSpeed = 150



18-3-15-26-31

Figure 27: interpolationSpeed = 200

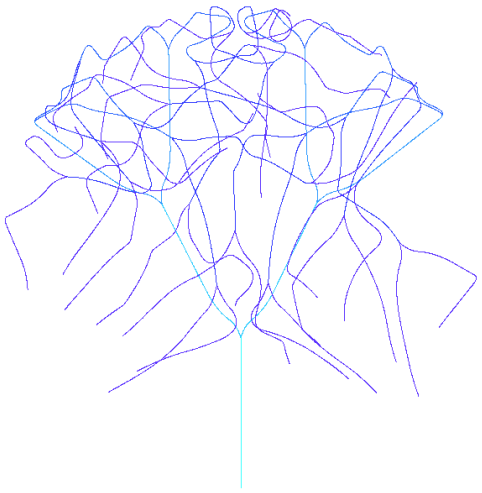
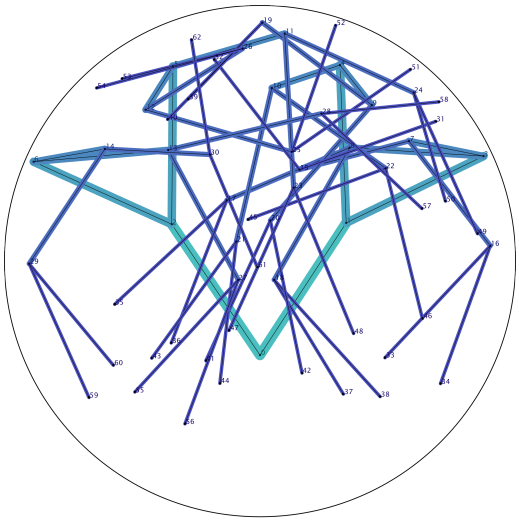


Figure 28: interpolationSpeed = 200



18-3-15-27-26

Figure 29: interpolationSpeed = 250

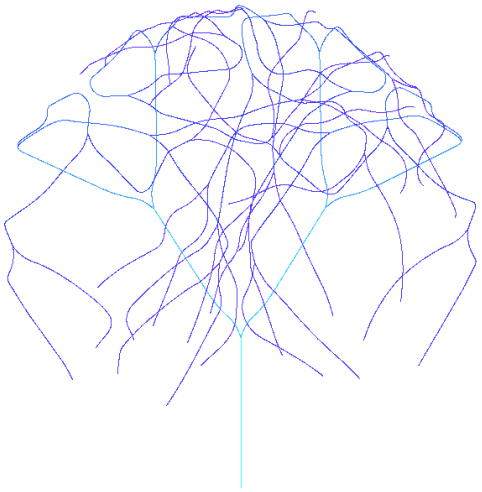
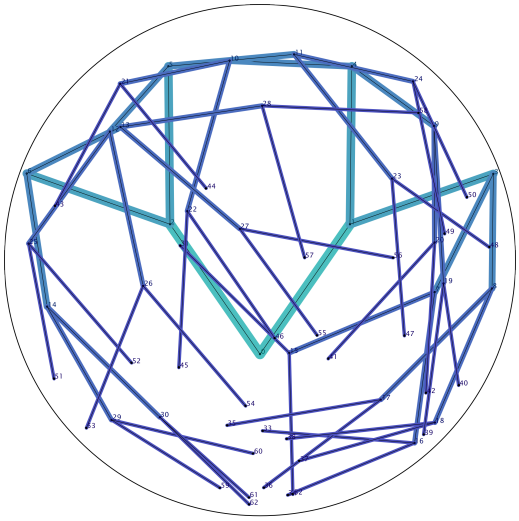


Figure 30: interpolationSpeed = 250



18-3-15-28-27

Figure 31: interpolationSpeed = 350

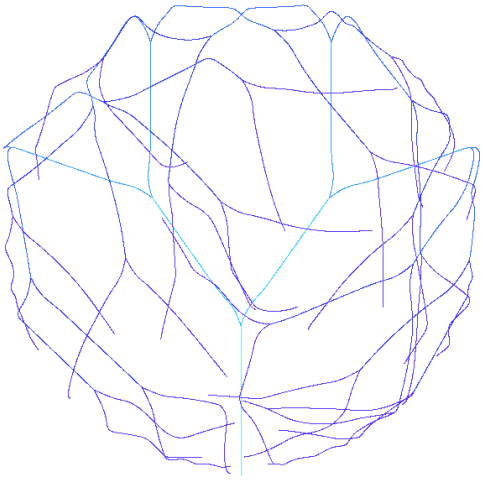
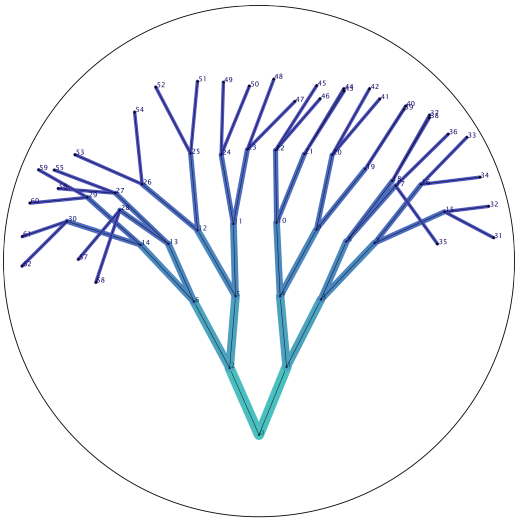


Figure 32: interpolationSpeed = 350

3.3.4 Variations of "timetoSpawn"



18-3-15-21-0

Figure 33: timetoSpawn = 3000

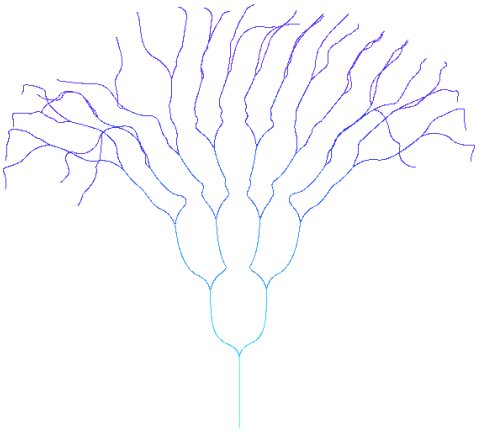
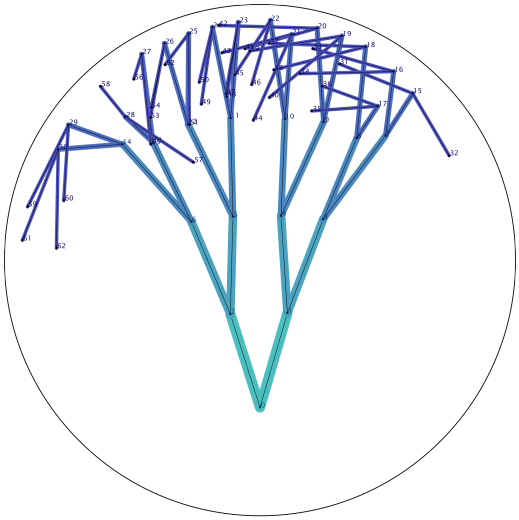


Figure 34: timetoSpawn = 3000



18-3-15-21-37

Figure 35: timetoSpawn = 4000

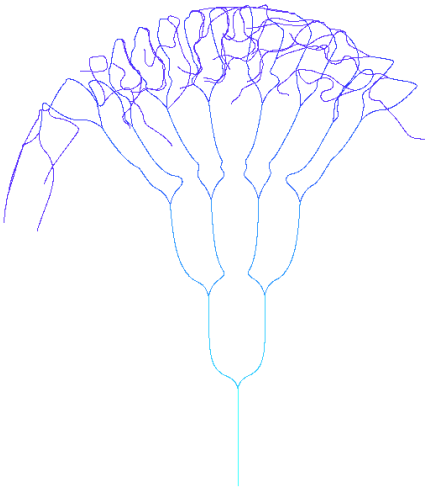
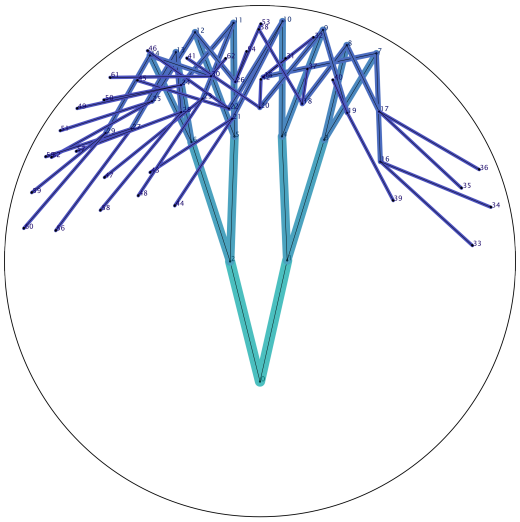


Figure 36: timetoSpawn = 4000



18-3-15-22-17

Figure 37: timetoSpawn = 5000

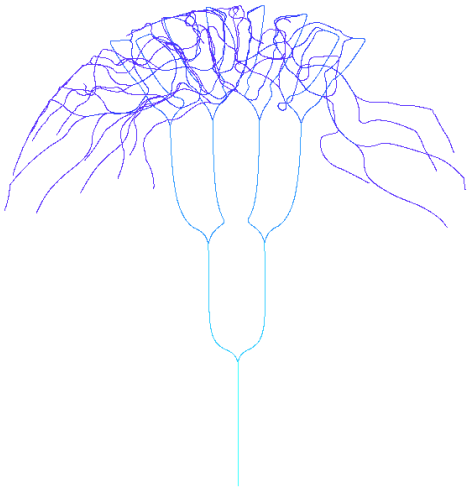
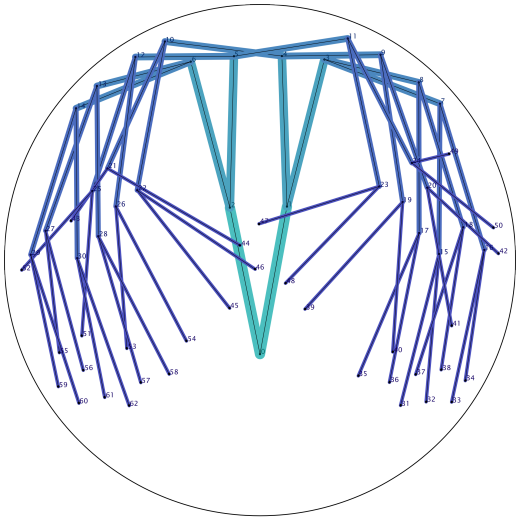


Figure 38: timetoSpawn = 5000



18-3-15-37-43

Figure 39: timetoSpawn = 6000 (default)

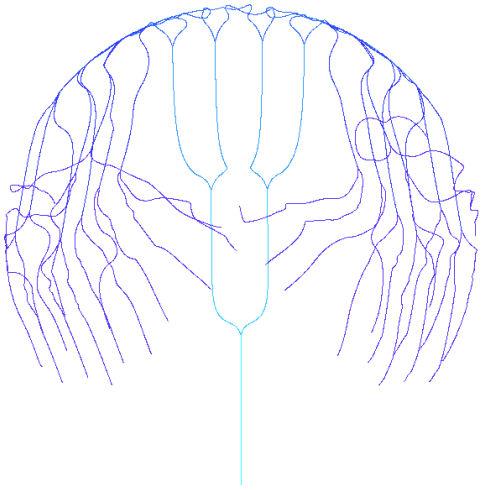
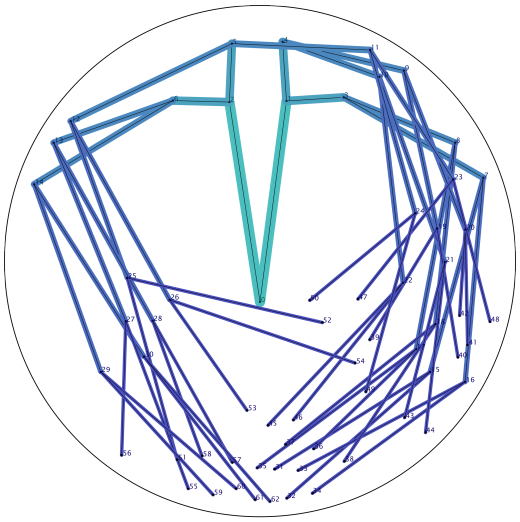


Figure 40: timetoSpawn = 6000 (default)



18-3-15-23-3

Figure 41: timetoSpawn = 8000

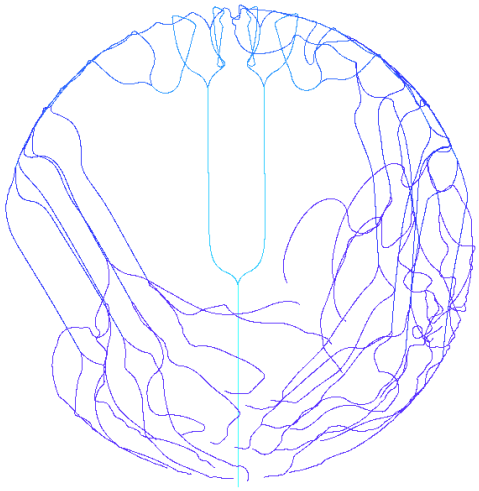
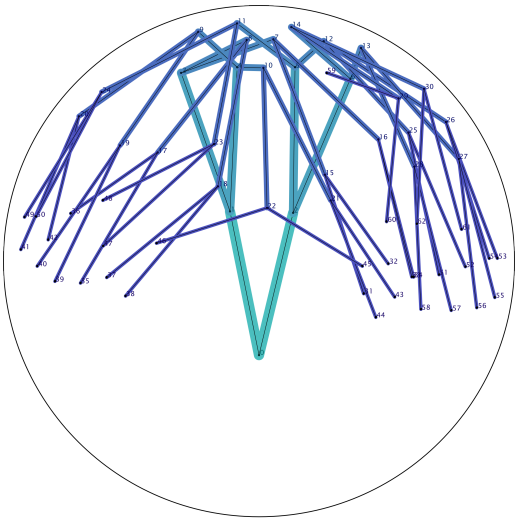


Figure 42: timetoSpawn = 8000

3.3.5 Variations of "spawnAnglesDegree"



18-3-15-11-3

Figure 43: spawnAnglesDegree = +/-0

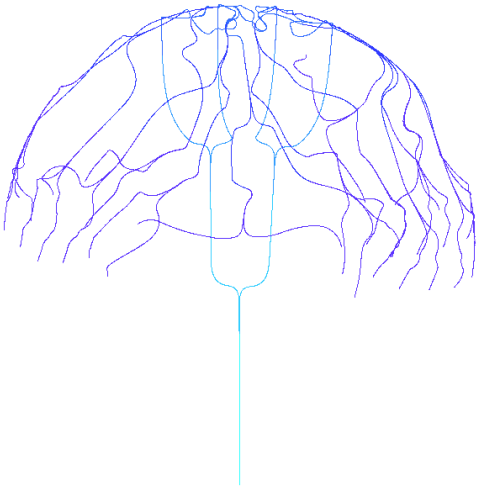
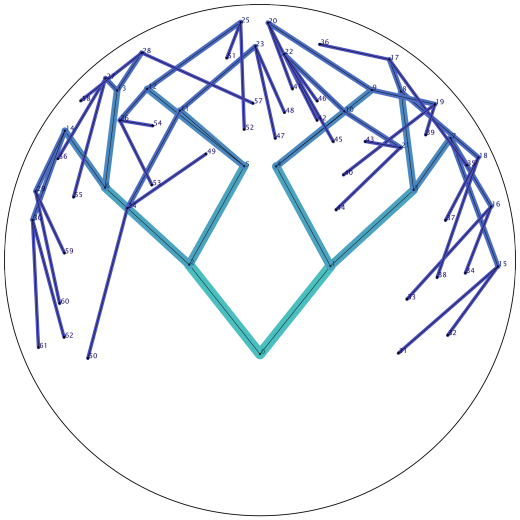


Figure 44: spawnAnglesDegree = +/-0



18-3-15-14-31

Figure 45: spawnAnglesDegree = +/-20

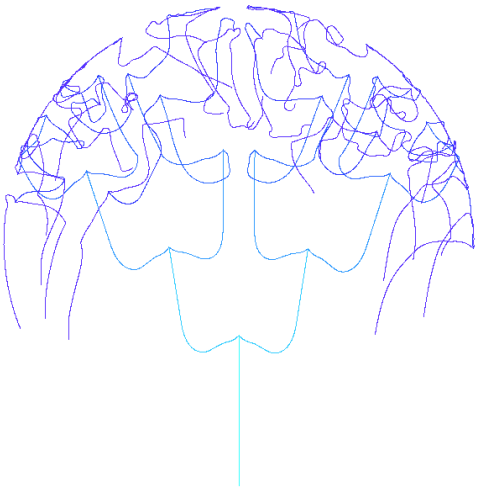
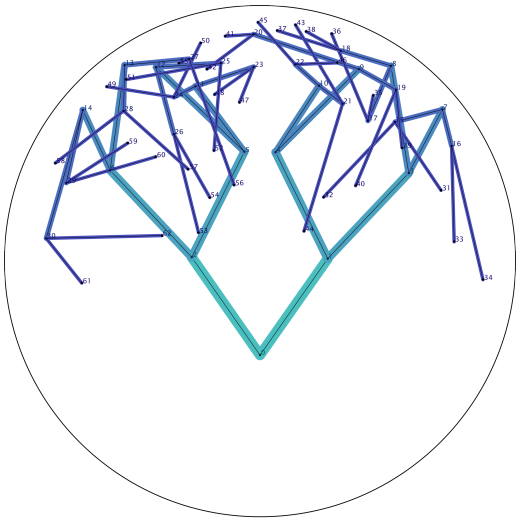


Figure 46: spawnAnglesDegree = +/-20



18-3-15-15-25

Figure 47: spawnAnglesDegree = +/-45

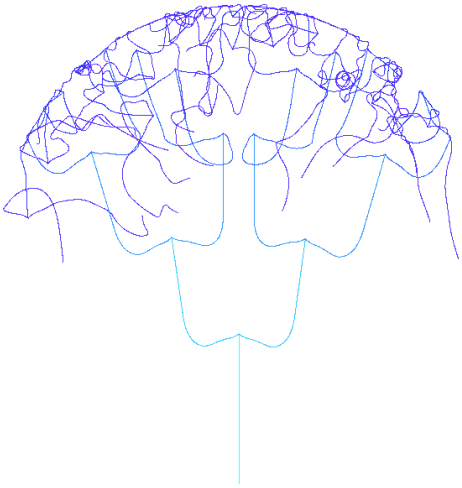
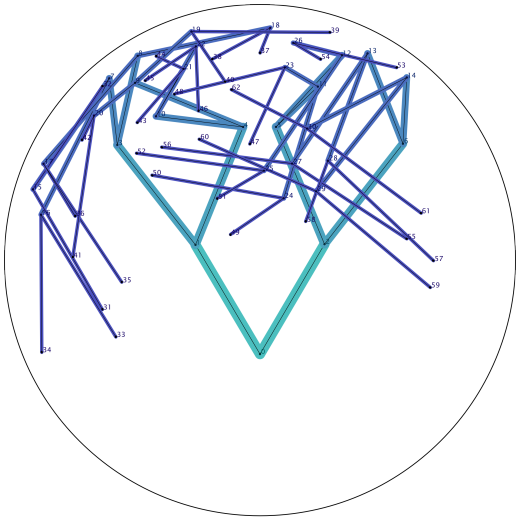


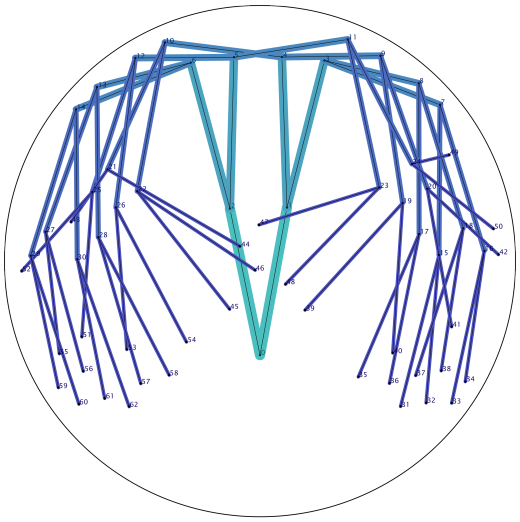
Figure 48: spawnAnglesDegree = +/-45



18-3-15-17-32

Figure 49: spawnAnglesDegree = +/-90

Figure 50: spawnAnglesDegree = +/-90



18-3-15-37-43

Figure 51: spawnAnglesDegree = +/-135 (default)

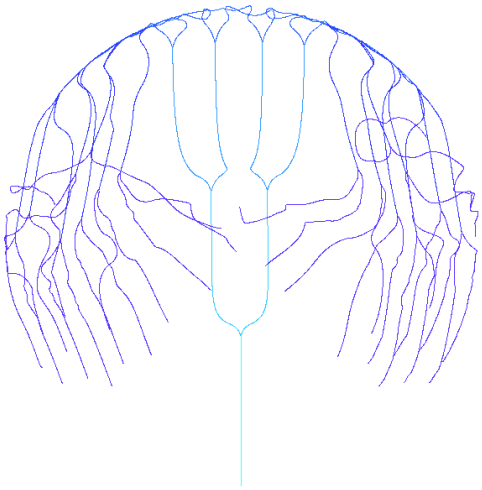
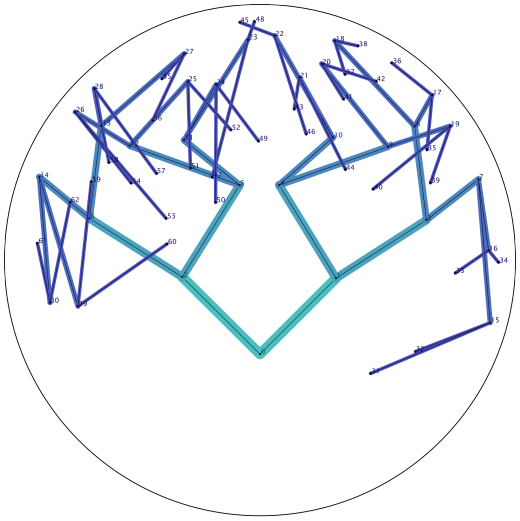


Figure 52: spawnAnglesDegree = +/-135 (default)



18-3-15-19-23

Figure 53: spawnAnglesDegree = +/-180

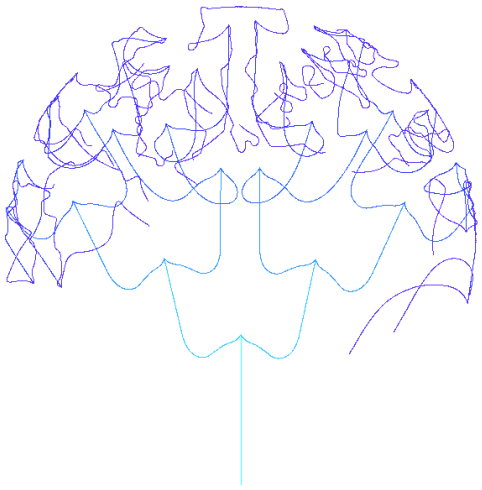


Figure 54: spawnAnglesDegree = +/-180

4 Textile Implementation

4.1 Thoughts on Goals

Throughout the whole development of the algorithms and parameter variations I played with several ideas on how to go from digital to textile. The basic idea was to use threads as entities or individuals. However, I was very indecisive about the details. Early ideas included just embroidering the movement of the fish or use the movements to (pseudo-) weave. I also came up with a Macramé-related knotting scheme, that resembled an RPG: each thread could win or lose in a fight against other threads.

None of those concepts was interesting enough. All of them had a building or producing element in common, so I tried to turn that element upside down. Working with textiles is usually constructing something, still there will be steps you have to reverse, because you made a mistake or the material was flawed. You have to untie the knot, unweave your cloth or just untangle the mess. Yet these unwanted destructive processes happen in favor of the final product.

I wanted to exaggerate the principle of destruction for my textile piece. Still adhering to the threads as individuals it meant deconstructing the elements itself: one thread contains other, thinner threads. The parent-child-relation between the fish in my tank fits in seamlessly with the construction-by-deconstruction-concept. The parent fish contains all the material needed to form the children, which then again contain everything for their children.

I will use a thread and split it up into subthreads, which match the connection between parent and children.

4.2 Textile Piece I

4.2.1 Method and Tools

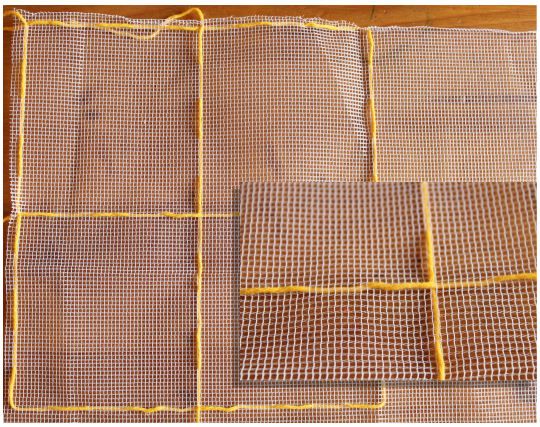


Figure 55: Base material as canvas

For my first practical trial run I used even-weave with approximately 2mm per unit. To limit the size I scaled down the computed positions to fit a 100 by 100 grid (resulting in appr. 20cm by 20cm for the finished piece). The yellow thread was used as a counting help.

Figure 56: Applied material

Because my generations of fish are based on the number 2, I also need thread based on number 2. So I used cotton wool threads each already containing 8 ($= 2^3$) sub-threads when feazed.
To be able to manage the threads and associate them with one fish id I simply attached some paper to the string groups. The positions are directly read from the text in the log file.

```
tank cx,cy,radius: 300.0 300.0 300.0
starter fish: 1
start dir: 1.0 1.0
start pos: 300.0, 300.0
wall/neighbor 0.9/0.1
maxGenerations 7
maxChildren 2

spawnTime 5000ms
spawnAnglesDegree 135.0 -135.0
turnSpeed 0.0051/ms
private radius / company radius 40.0 / 75.0

fish:
0 g:0 born 300.0 300.0 : 140 140 c:
0 g:0 died 409.58185 409.58185 : 191 191 c: 1 2
1 g:1 died 434.7048 547.7104 : 203 256 c: 3 4
2 g:1 died 547.1275 435.0458 : 255 203 c: 5 6
3 g:2 died 299.06696 479.5542 : 140 224 c: 7 8
4 g:2 died 290.70502 579.7467 : 136 271 c: 9 10
5 g:2 died 578.5094 290.45987 : 270 136 c: 11 12
6 g:2 died 474.91296 301.06262 : 222 140 c: 13 14
...
```

Figure 57: First part of the used log file

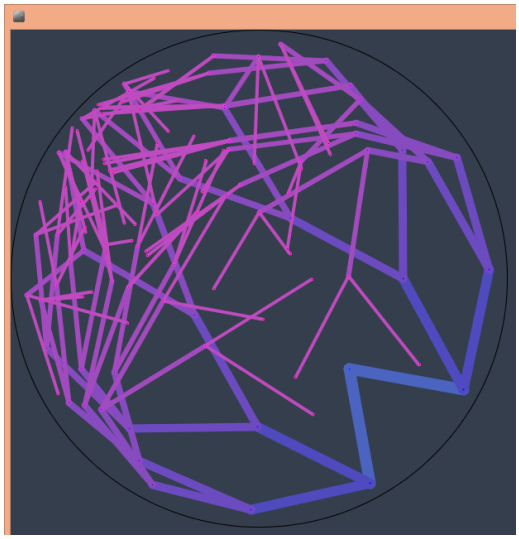


Figure 58: Connection lines between (dead) fish of 7 generations

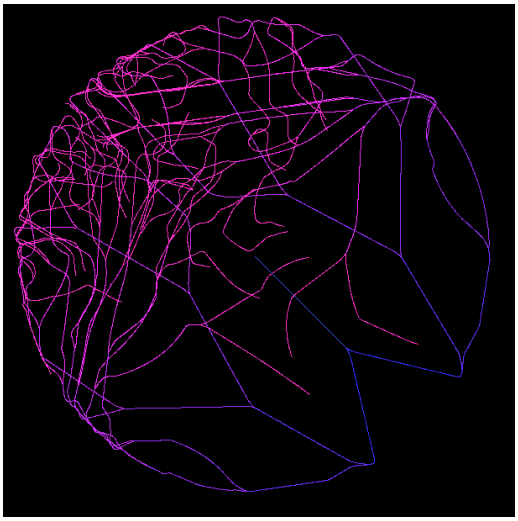


Figure 59: Traces of the movement of the fish while living

Figure 60: Total view of the experiment and details on the back. For 7 generations of fish, each having 2 children I need 2^7 threads (128). Using the 2^3 cotton strings, I need 16 strings in total - which is quite thick. I tried to fit it through one "grid point" - even when I succeeded the accuracy of the grid was physically compromised, so I decided to dilute the positions for the first maybe also for the second generation of fish. The starting point for the fish is 50/50. After dividing the thick 16-strings-cord into 4 subcords with 4 strings each, the starting points are 51/50, 49/50, 50/49, 50/51.

4.2.2 Outcome and Conclusion

The left of Fig.60 shows the state of the first experiment when I decided I was not getting anywhere near to what I wanted. One reason was a simple mistake when determining the thread count: For 7 generations I actually would only have needed 2^6 instead of 2^7 single threads in the end, because I forgot to start counting at 2^0. This would have reduced the thickness of the starting thread by half and also changed the appearance significantly. A more serious problem for me was that the visual outcome was somehow off. Maybe I chose the evenweave's units too large or the wrong color, but most importantly the intermediate result did not have the properties I expected it to have: it was neither 2D nor 3D, neither did I get the threads to be stiff and straight enough for the connections of the fish nor did they show the actual movement of a fish during its life cycle. This first piece was an unsatisfying accumulation of imprecise craftsmanship, so I thought about other possibilities to work with the pattern in the material world.

4.3 Textile Piece II

4.3.1 Method and Tools

4.3.2 Outcome and Conclusion

5 Summary

Trial/Error runs? Unused parameters?

First (implemented) sketched out idea:

- (explain main mechanism: finding the direction vector in each step, no randomness involved) - Other alterations/ playing with ideas: start with one fish that can spawn children (keep on moving or die after spawning)

Intermediate result: - Tracking positions in pixels : image with traces on picture (pixels, not lines) - Image with connecting lines (data = lines)

Role of Textiles in this? - Threads/knots as small part with defined behaviour (1. idea) - Errors over time, two tanks with same starting population grow apart (2. Idea, did not quite work, funny because with handcraft that happens : no identical pieces) - Connections to ancestors (3. Idea, without predators) - Connections to ancestors should limit the "life" of the fish somehow (3. idea) : threads also limited, no infinite resource in real life, limited freedom? - -¿ include death somehow? Maybe the thread becomes limited depending on how close you were when your ancestor died : shorter thread? - New connections to fish you are close to for a longer time : frienships/partnerships (different color/weight?) Textile finished piece: - Embroidery: pixelated image to threaded image (boring) - Connections to threaded image(series) (better? Development of generations) - Tree (knots/perls? = fish, length of edge is also determined by fish-bowl-movement) / graph : flexible

Code