

# *gTangle*: a Grammar for the Procedural Generation of Tangle Patterns

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Figures grammars

For better readability, we will omit the information about the group id assigned to the resulting shapes produced by the rules application. Thus, the formalism is reduced to

$$O(\{p_o\}) : t_m \rightarrow [\langle t_0 \rangle, \dots, \langle t_k \rangle]$$

## Tree grammar

1.  $ungroup() : big\_poly \rightarrow [\langle ung\_big\_poly \rangle]$
2.  $regularSplit(line, 75, 0) : ung\_big\_poly \rightarrow [\langle medium1\_poly \rangle]$
3.  $regroup(3) : medium1\_poly \rightarrow [\langle reg\_medium\_poly \rangle]$
4.  $place(10, 20) : reg\_medium\_poly \rightarrow [\langle small\_ball \rangle, \langle small\_reminder \rangle]$
5.  $regularSplit(line, 10, 0) : reg\_medium\_poly \rightarrow [\langle small\_poly \rangle]$
6.  $outline(15) : reg\_medium\_poly \rightarrow [\langle small1\_poly \rangle, \langle small1\_outline \rangle]$
7.  $outline(5) : small1\_poly \rightarrow [\langle small2\_poly \rangle, \langle small2\_outline \rangle]$
8.  $outline(2.5) : small2\_poly \rightarrow [\langle small3\_poly \rangle, \langle small3\_outline \rangle]$
9.  $regularSplit(line, 20, 0) : small3\_poly \rightarrow [\langle tiny\_poly \rangle]$
10.  $regularSplit(line, 10, 0) : small\_ball \rightarrow [\langle tiny\_ball \rangle]$
11.  $regularSplit(line, 50, 1) : ung\_big\_poly \rightarrow [\langle medium3\_poly \rangle]$
12.  $outline(5) : medium3\_poly \rightarrow [\langle small\_poly \rangle, \langle small\_outline \rangle]$
13.  $outline(3) : medium3\_poly \rightarrow [\langle small5\_poly \rangle, \langle small\_outline \rangle]$
14.  $regularSplit(line, 13, 0) : small5\_poly \rightarrow [\langle small\_slice \rangle]$
15.  $place(50, 100) : medium3\_poly \rightarrow [\langle small\_ball \rangle, \langle remainder \rangle]$
16.  $regularSplit(line, 50, 0) : ung\_big\_poly \rightarrow [\langle medium2\_poly \rangle]$
17.  $regularSplit(line, 25, 0) : medium2\_poly \rightarrow [\langle small4\_poly \rangle]$
18.  $regularSplit(line, 10, 0) : small4\_poly \rightarrow [\langle smallNNN\_poly \rangle]$
19.  $invert() : remainder \rightarrow [\langle term \rangle, \langle term \rangle]$
20.  $invert() : small\_poly \rightarrow [\langle term \rangle, \langle term \rangle]$
21.  $invert() : small\_reminder \rightarrow [\langle term \rangle, \langle term \rangle]$
22.  $invert() : small2\_outline \rightarrow [\langle term \rangle, \langle term \rangle]$

## Albert grammar

1.  $ungroup() : big\_poly \rightarrow [\langle ung\_big\_poly \rangle]$
2.  $place(25, 50) : ung\_big\_poly \rightarrow [\langle final \rangle, \langle med\_reminder \rangle]$
3.  $place(10, 10) : med\_reminder \rightarrow [\langle final \rangle, \langle final\_reminder \rangle]$
4.  $regularSplit(line, 25, 0) : ung\_big\_poly \rightarrow [\langle med\_slice\_poly \rangle]$
5.  $regularSplit(line, 10, 0) : med\_slice\_poly \rightarrow [\langle term \rangle]$
6.  $outline(10) : ung\_big\_poly \rightarrow [\langle medium3\_poly \rangle, \langle term \rangle]$
7.  $regularSplit(line, 25, 1) : medium3\_poly \rightarrow [\langle grid\_poly \rangle]$
8.  $invert() : grid\_poly \rightarrow [\langle term \rangle, \langle term \rangle]$
9.  $regularSplit(line, 15, 0) : ung\_big\_poly \rightarrow [\langle med\_slice\_poly\_2 \rangle]$
10.  $place(13, 20) : med\_slice\_poly\_2 \rightarrow [\langle blobs \rangle, \langle final\_reminder2 \rangle]$
11.  $outline(3) : blobs \rightarrow [\langle final\_reminder \rangle, \langle term \rangle]$
12.  $regularSplit(line, 20, 0) : ung\_big\_poly \rightarrow [\langle med\_slice\_poly\_3 \rangle]$
13.  $regularSplit(line, 20, 0) : med\_slice\_poly\_3 \rightarrow [\langle med\_slice\_poly\_4 \rangle]$
14.  $place(13, 20) : med\_slice\_poly\_4 \rightarrow [\langle blobs \rangle, \langle final\_reminder \rangle]$
15.  $outline(3) : blobs \rightarrow [\langle final\_reminder \rangle, \langle term \rangle]$
16.  $outline(10) : ung\_big\_poly \rightarrow [\langle medium1\_poly \rangle, \langle medium1\_outline \rangle]$
17.  $ungroup() : medium1\_poly \rightarrow [\langle ung\_medium1\_poly \rangle]$
18.  $place(15, 40) : ung\_medium1\_poly \rightarrow [\langle final \rangle, \langle final\_reminder \rangle]$
19.  $regularSplit(line, 45, 1) : ung\_big\_poly \rightarrow [\langle medium2\_poly \rangle]$
20.  $regularSplit(line, 30, 0) : medium2\_poly \rightarrow [\langle triangles \rangle]$
21.  $regroup(2) : triangles \rightarrow [\langle reg\_triangles \rangle]$
22.  $outline(3.6) : reg\_triangles \rightarrow [\langle small\_tri \rangle, \langle outline \rangle]$
23.  $regularSplit(line, 5, 0) : small\_tri \rightarrow [\langle term \rangle]$
24.  $regularSplit(line, 10, 0) : reg\_triangles \rightarrow [\langle term \rangle]$
25.  $invert() : final\_reminder \rightarrow [\langle term \rangle, \langle term \rangle]$

## Tiger grammar

1.  $ungroup() : big\_poly \rightarrow [\langle ung\_big\_poly \rangle]$
2.  $outline(15) : ung\_big\_poly \rightarrow [\langle medium\_poly \rangle, \langle medium\_outline \rangle]$
3.  $regularSplit(line, 30, 1) : medium\_poly \rightarrow [\langle quads \rangle]$
4.  $stipling() : ung\_big\_poly \rightarrow [\langle medium\_split2 \rangle, \langle medium\_split2 \rangle]$
5.  $regularSplit(line, 10, 0) : ung\_big\_poly \rightarrow [\langle medium\_split \rangle]$
6.  $regularSplit(line, 10, 0) : medium\_split \rightarrow [\langle term \rangle]$
7.  $regularSplit(line, 10, 0) : medium\_split \rightarrow [\langle term \rangle]$
8.  $regularSplit(line, 30, 0) : ung\_big\_poly \rightarrow [\langle slanted\_slices \rangle]$
9.  $regroup(2) : slanted\_slices \rightarrow [\langle reg\_slanted\_slices \rangle]$
10.  $regularSplit(line, 10, 0) : reg\_slanted\_slices \rightarrow [\langle term \rangle]$
11.  $regularSplit(line, 10, 0) : reg\_slanted\_slices \rightarrow [\langle term \rangle]$
12.  $regularSplit(line, 80, 1) : ung\_big\_poly \rightarrow [\langle medium2\_poly \rangle]$
13.  $streamlineSplit(smooth, 6.2) : medium2\_poly \rightarrow [\langle slice \rangle]$
14.  $regularSplit(line, 25, 0) : ung\_big\_poly \rightarrow [\langle med\_poly \rangle]$
15.  $regularSplit(line, 45, 0) : med\_poly \rightarrow [\langle brick \rangle]$
16.  $outline(7) : brick \rightarrow [\langle inner\_brick \rangle, \langle term \rangle]$
17.  $regularSplit(line, 20, 0) : ung\_big\_poly \rightarrow [\langle med\_slice\_poly\_2 \rangle]$
18.  $place(17, 30) : med\_slice\_poly\_2 \rightarrow [\langle blobs \rangle, \langle blobs\_reminder \rangle]$
19.  $regularSplit(line, 10, 0) : blobs\_reminder \rightarrow [\langle final\_reminder \rangle]$
20.  $outline(4) : blobs \rightarrow [\langle term \rangle, \langle term \rangle]$
21.  $invert() : final\_reminder \rightarrow [\langle term \rangle, \langle term \rangle]$
22.  $place(80, 100) : ung\_big\_poly \rightarrow [\langle medium1\_poly \rangle, \langle reminder \rangle]$
23.  $outline(10) : medium1\_poly \rightarrow [\langle small1\_poly \rangle, \langle small\_outline \rangle]$
24.  $place(10, 15) : small\_outline \rightarrow [\langle tiny\_blobs \rangle, \langle tiny\_reminder \rangle]$
25.  $outline(10) : small1\_poly \rightarrow [\langle tiny1\_poly \rangle, \langle tiny\_outline \rangle]$
26.  $regularSplit(line, 8, 1) : tiny1\_poly \rightarrow [\langle dots \rangle]$
27.  $invert() : ung\_big\_poly \rightarrow [\langle term \rangle, \langle term \rangle]$
28.  $invert() : remainder\_b \rightarrow [\langle term \rangle, \langle term \rangle]$
29.  $invert() : slice\_b \rightarrow [\langle term \rangle, \langle term \rangle]$
30.  $invert() : dots \rightarrow [\langle \rangle, \langle \rangle]$
31.  $invert() : reminder \rightarrow [\langle term \rangle, \langle term \rangle]$
32.  $invert() : tiny\_reminder \rightarrow [\langle term \rangle, \langle term \rangle]$
33.  $invert() : outline \rightarrow [\langle term \rangle, \langle term \rangle]$

## Teaser grammar

1.  $place(35, 45) : big\_poly \rightarrow [\langle 0\_medium\_poly \rangle, \langle 0\_medium\_reminder \rangle]$
2.  $outline(5) : 0\_medium\_poly \rightarrow [\langle inv \rangle, \langle 0\_small\_outline \rangle]$
3.  $place(7, 15) : 0\_medium\_reminder \rightarrow [\langle 0\_tiny\_poly \rangle, \langle inv \rangle]$
4.  $outline(12) : big\_poly \rightarrow [\langle 1\_med\_poly \rangle, \langle 1\_outline \rangle]$
5.  $regularSplit(line, 7, 1) : 1\_med\_poly \rightarrow [\langle inv \rangle]$
6.  $regularSplit(line, 20, 0) : 1\_outline \rightarrow [\langle 1\_slices \rangle]$
7.  $outline(3) : 1\_slices \rightarrow [\langle inv \rangle, \langle 1\_tiny\_outline \rangle]$
8.  $place(30, 60) : big\_poly \rightarrow [\langle 2\_tiny\_poly \rangle, \langle 2\_tiny\_reminder \rangle]$
9.  $regularSplit(line, 10, 0) : 2\_tiny\_poly \rightarrow [\langle 2\_slices \rangle]$
10.  $regularSplit(line, 5, 0) : 2\_slices \rightarrow [\langle term \rangle]$
11.  $outline(3) : 2\_tiny\_reminder \rightarrow [\langle 2\_tiny\_poly \rangle, \langle inv \rangle]$
12.  $outline(8) : big\_poly \rightarrow [\langle 6\_med\_poly \rangle, \langle 6\_outline \rangle]$
13.  $outline(8) : 6\_med\_poly \rightarrow [\langle 6\_med\_poly\_1 \rangle, \langle 6\_outline\_1 \rangle]$
14.  $place(8, 15) : 6\_outline \rightarrow [\langle 6\_blobs \rangle, \langle inv \rangle]$
15.  $place(8, 15) : 6\_outline\_1 \rightarrow [\langle inv \rangle, \langle inv\_1 \rangle]$
16.  $regularSplit(line, 15, 0) : 6\_med\_poly\_1 \rightarrow [\langle 6\_slices \rangle]$
17.  $place(8, 16) : big\_poly \rightarrow [\langle 3\_blobs \rangle, \langle inv \rangle]$
18.  $ungroup() : 3\_blobs \rightarrow [\langle 3\_ung\_blobs \rangle]$
19.  $regularSplit(line, 8, 0) : 3\_ung\_blobs \rightarrow [\langle term \rangle]$
20.  $outline(4) : 3\_ung\_blobs \rightarrow [\langle inv \rangle, \langle term \rangle]$
21.  $outline(12) : big\_poly \rightarrow [\langle 7\_med\_poly \rangle, \langle 7\_outline \rangle]$
22.  $outline(4) : 7\_outline \rightarrow [\langle 7\_strip \rangle, \langle inv \rangle]$
23.  $regularSplit(line, 7, 0) : 7\_strip \rightarrow [\langle inv \rangle]$
24.  $regularSplit(line, 10, 0) : 7\_med\_poly \rightarrow [\langle term \rangle]$
25.  $place(35, 70) : big\_poly \rightarrow [\langle 5\_medium\_poly \rangle, \langle 5\_medium\_reminder \rangle]$
26.  $outline(5) : 5\_medium\_poly \rightarrow [\langle inv \rangle, \langle 5\_small\_outline \rangle]$
27.  $place(7, 15) : 5\_medium\_reminder \rightarrow [\langle 5\_tiny\_poly \rangle, \langle inv \rangle]$
28.  $regularSplit(line, 71, 0) : big\_poly \rightarrow [\langle big\_poly\_2\_4 \rangle]$
29.  $regularSplit(line, 80, 0) : big\_poly\_2\_4 \rightarrow [\langle 4\_quads \rangle]$
30.  $outline(6) : 4\_quads \rightarrow [\langle 4\_med\_poly \rangle, \langle 4\_outline \rangle]$
31.  $ungroup() : 4\_med\_poly \rightarrow [\langle 4\_ung\_med\_poly \rangle]$
32.  $regularSplit(line, 15, 0) : 4\_ung\_med\_poly \rightarrow [\langle 4\_slices \rangle]$
33.  $regroup(2) : 4\_slices \rightarrow [\langle 4\_reg\_slanted\_slices \rangle]$
34.  $regularSplit(line, 10, 0) : 4\_reg\_slanted\_slices \rightarrow [\langle term \rangle]$
35.  $regularSplit(line, 10, 0) : 4\_reg\_slanted\_slices \rightarrow [\langle 4\_final \rangle]$
36.  $outline(3) : 4\_final \rightarrow [\langle term \rangle, \langle term \rangle]$
37.  $invert() : inv \rightarrow [\langle term \rangle, \langle term \rangle]$

## Figure 6 grammar

1. *regularSplit*(*line*, 200, 1) : *big\_poly* → [*medium\_poly*]
2. *ungroup*() : *medium\_poly* → [*ung\_med\_poly*]
3. *regularSplit*(*line*, 15, 0) : *ung\_med\_poly* → [*⟨⟩*]
4. *regularSplit*(*line*, 15, 0) : *ung\_med\_poly* → [*⟨⟩*]
5. *regularSplit*(*line*, 30, 1) : *ung\_med\_poly* → [*⟨⟩*]
6. *regularSplit*(*line*, 30, 1) : *ung\_med\_poly* → [*tiny\_poly*]
7. *invert*() : *tiny\_poly* → [*⟨⟩*, *⟨⟩*]
8. *outline*(30) : *ung\_med\_poly* → [*⟨⟩*, *⟨⟩*]
9. *streamlineSplit*(*smooth*, 30) : *ung\_med\_poly* → [*small\_poly*]
10. *streamlineSplit*(*smooth*, 30) : *ung\_med\_poly* → [*small\_poly*]
11. *regularSplit*(*circ*, 25) : *outline2* → [*⟨slices⟩*]
12. *streamlineSplit*(*smooth*, 30) : *ung\_med\_poly* → [*small\_poly*]
13. *regularSplit*(*line*, 15, 0) : *outline3* → [*⟨slices3⟩*]
14. *invert*() : *slices3* → [*⟨⟩*, *⟨⟩*]

Figure 7 grammar

1.  $regularSplit(line, 400, 0) : big\_poly \rightarrow [\langle mega\_split \rangle]$
2.  $regroup(2) : mega\_split \rightarrow [\langle reg\_mega\_split \rangle]$
3.  $place(5, 10) : reg\_mega\_split \rightarrow [\langle blobs \rangle, \langle rem\_blobs \rangle]$
4.  $regularSplit(line, 18, 0) : reg\_mega\_split \rightarrow [\langle quads \rangle]$
5.  $place(20, 25) : quads \rightarrow [\langle blobs \rangle, \langle rem\_blobs \rangle]$
6.  $place(20, 45) : big\_poly\_0 \rightarrow [\langle small\_ball \rangle, \langle reminder1 \rangle]$
7.  $place(10, 12) : reminder1 \rightarrow [\langle small\_ball \rangle, \langle reminder \rangle]$
8.  $regularSplit(line, 50, 1) : big\_poly\_1 \rightarrow [\langle medium\_poly \rangle]$
9.  $place(50, 150) : medium\_poly \rightarrow [\langle small\_ball \rangle, \langle reminder \rangle]$
10.  $place(35, 45) : big\_poly\_2 \rightarrow [\langle small\_rect \rangle, \langle reminder \rangle]$
11.  $place(35, 45) : big\_poly\_3 \rightarrow [\langle small\_rect \rangle, \langle reminder \rangle]$
12.  $outline(10) : big\_poly\_4 \rightarrow [\langle blobs \rangle, \langle outline2 \rangle]$
13.  $place(10, 15) : outline2 \rightarrow [\langle small\_ball \rangle, \langle reminder \rangle]$
14.  $invert() : reminder \rightarrow [\langle \rangle, \langle \rangle]$
15.  $invert() : outline \rightarrow [\langle \rangle, \langle \rangle]$



## Figure 10 grammar

1. *regularSplit*(line, 50, 0) : *big\_poly* → [*(big\_polyZ)*]
2. *place*(100, 150) : *big\_poly* → [*(big\_polyZ)*, *(big\_polyZ)*]
3. *ungroup*() : *big\_polyZ* → [*(ung\_big\_poly)*]
4. *regularSplit*(line, 50, 0) : *big\_poly* → [*(big\_polyS)*]
5. *regularSplit*(line, 50, 0) : *big\_poly* → [*(big\_polyS)*]
6. *regroup*(3) : *big\_polyS* → [*(ung\_big\_poly)*]
7. *regularSplit*(line, 100, 1) : *big\_poly* → [*(big\_polyD)*]
8. *regroup*(3) : *big\_polyD* → [*(ung\_big\_poly)*]
9. *place*(25, 50) : *ung\_big\_poly* → [*(final)*, *(med\_reminder)*]
10. *place*(10, 10) : *med\_reminder* → [*(final)*, *(invert)*]
11. *regularSplit*(line, 25, 0) : *ung\_big\_poly* → [*(med\_slice\_poly)*]
12. *regularSplit*(line, 7, 0) : *med\_slice\_poly* → [*(term)*]
13. *regularSplit*(line, 10, 0) : *med\_slice\_poly* → [*(term)*]
14. *outline*(10) : *ung\_big\_poly* → [*(medium3\_poly)*, *(term)*]
15. *regularSplit*(line, 25, 1) : *medium3\_poly* → [*(invert)*]
16. *regularSplit*(line, 15, 0) : *ung\_big\_poly* → [*(med\_slice\_poly\_2)*]
17. *place*(13, 20) : *med\_slice\_poly\_2* → [*(blobs)*, *(invert)*]
18. *outline*(3) : *blobs* → [*(invert)*, *(term)*]
19. *outline*(10) : *blobs* → [*(invert)*, *(term)*]
20. *outline*(10) : *ung\_big\_poly* → [*(medium1\_poly)*, *(medium1\_outline)*]
21. *ungroup*() : *medium1\_poly* → [*(ung\_medium1\_poly)*]
22. *place*(15, 40) : *ung\_medium1\_poly* → [*(final)*, *(invert)*]
23. *regularSplit*(line, 45, 1) : *ung\_big\_poly* → [*(medium2\_poly)*]
24. *regularSplit*(line, 30, 0) : *medium2\_poly* → [*(triangles)*]
25. *regroup*(2) : *triangles* → [*(reg\_triangles)*]
26. *outline*(5) : *reg\_triangles* → [*(small\_tri)*, *(outline)*]
27. *regularSplit*(line, 5, 0) : *small\_tri* → [*(term)*]
28. *invert*() : *invert* → [*(term)*, *(term)*]