MesoGen: Designing Procedural On-Surface Stranded Mesostructures
Supplementary Material

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This is the supplementary material for the paper "MesoGen: Designing Procedural On-Surface Stranded Mesostructures".

Table 1 presents a more complete view of the Table 1 from the original paper. Figures 1, 2, 3 and 6 show additional results, including mesostructure density control through macrosurface subdivision (Figure 1), variations based on the random seed (Figure 2), multilayer mesostructures (Figure 3) and a collection of examples on various kinds of macrosurfaces (Figure 6). The variety of mesostructure that can be created based on the same macrosurface is illustrated in the accompanying document *torus.pdf*.

Tile suggestion ablation study. Tables 2, 3 and 4 detail the experiments leading to the figures reported in Table 2 in the main paper. The macrosurfaces are shown in Figure 7, the tile sets were uniformly drawn with a maximum of 7 types of interface and 5 types of tiles (before the suggestion, which can add up to 10 tiles). The border constraint of each interface were also randomly drawn, as well as the assignment and orientation of each interface to each side of a tile.

In the consolidated statistics of Table 2, the amount N of new tiles is averaged with its value set to 10 when the success rate was 0% (the N/A entries). This makes the figure a lower bound of the actual average (which we cannot know because we stop the experiment after 10 new tiles) and avoids distorting the average with infinite or (very large) outlier values for N. The figure after the ± sign in Table 2 is the average of the standard deviations of the N of each experiment, and the standard deviation of success rates across experiments for R (which does not have a per-experiment deviation since it is a binary random variable).

Impact of the macrosurface quadrangulation. Figure 4 shows how variations of the way the macro-surface is meshed affects the mesostructure. A possible improvement of our work consists in including the possibility to edit this quadrangulation while designing the mesostructure. Edits can be local, leading to re-generation only in the neighborhood of the affected part of the macrosurface. The tile suggestion mechanism could then suggest either new tiles or local changes of the macro-surface. Another type of edit would be the specification of quad directions from which to infer a whole new quadrangulation.

Comparison with stamp-based approach. Figure 5 compares our interface-first authoring of the geometric content associated to the combinatorial information of a tile set with the method proposed by Section 3.1 of Cohen et al. [2003] paper. This shows that a stamp-based approach either allows discontinuities or leads to uniform patterns. Another possible use of the stamp-based approach is to stamp partial shapes that only span on 2 neighboring tiles, but in such a case the user must manually ensure the connection of the portions of shapes.

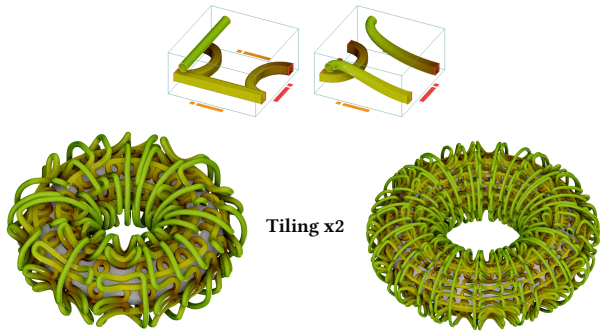

Figure 1: Our mesostructure model naturally handles tiling, here scaling it by two using a simple regular macrosurface subdivision.

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Macrosurface		Tile set		Mesostructure			Timing (ms)					
				Triangle Count	Memory (KB)		Mapping		Render		Solve	Suggest
Name	Quad Count	Tile Count	Sweep Count		GPU Buffers	Exported Mesh	CPU	GPU	CPU	GPU		
ninja	1 917	4	25	15 627 538	2 254	365 802						
shell	3 088	3	20	24 950 040	2 859	630 056						
lamp	840	5	28	10 907 520	2 230	273 392	0.7	0.2	0.1	3.5	12.8	
lamp	840	4	30	6 502 560	1 647	164 377	0.6	0.2	0.2	3.7	22.3	3.6
lamp	840	5	31	6 422 722	1 764	164 719	0.8	0.3	0.2	3.6	17.8	5
lamp	840	5	11	7 191 120	1 333	179 393	0.5	0.2	0.1	4	43.3	5.2
lamp	840	14	51	6 177 432	3 488	154 565	1.5	0.2	0.2	3.1	39.1	
lamp-sub1	3 360	6	36	48 372 480	4 628	1 212 430	1.1	0.1	0.2	5.8	139	
lamp-sub1	3 360	5	28	48 372 480	4 155	1 212 430	0.9	0.1	0.2	5.9	88	
lamp-sub2	26 880	5	28	202 974 720	12 058	5 087 450	2.8	0.3	0.1	24	1029	
lamp-sub2	26 880	6	36	202 974 720	12 530	5 087 450	2.8	0.3	0.1	22	3090	
shoe	2 984	4	25	24 325 206	2 956	613 703	1	0.1	0.1	5.1	87	
shoe	2 984	5	10	18 823 072	1 832	469 567	0.6	0.1	0.1	5.1	135	2.5
shoe	2 984	5	28	46 981 376	4 046	1 177 563	1	0.1	0.1	6.8	135	
shoe	2 984	9	42	29 758 940	4 179	745 506	1.5	0.1	0.2	5.8	279	3.5
tshirt	7 088	5	10	44 711 104	3 064	1 115 378	0.7	0.1	0.1	6	3212	3.1
tshirt	7 088	4	25	57 899 346	5 655	1 460 653	1.9	0.1	0.2	6.2	1132	
tshirt	7 088	4	25	271 156 236	9 114		1.5	0.1	0.2	30.6	1132	
tshirt	7 088	9	42	69 991 288	6 298	1 752 922	2.2	0.1	0.2	7.9	708	

Table 1: Various metrics for a series of test scenes, including the examples from Fig. 7. The second to last row is the same setting as the previous one but using a finer resolution when synthesizing the output mesh. It is used to stress test the rendering pipeline.

Figure 2: Two mesostructures generated using the exact same tileset but different random seeds.

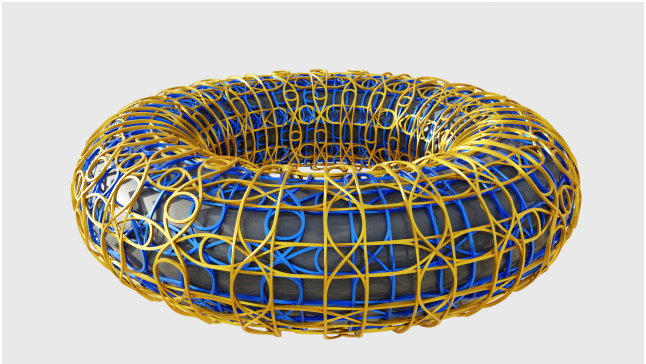

Figure 3: A multi-layer mesostrcture produced by varying the random seed and an offset of the shell space.

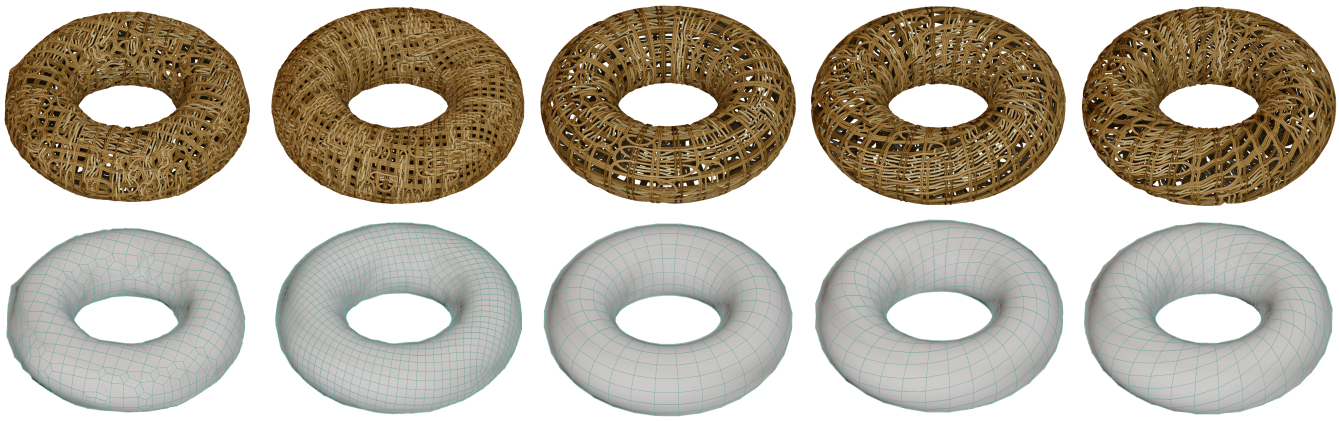

Figure 4: The same geometric shape (a torus here) can be represented by various meshes. This choice is one of the artistic input controls of our method.

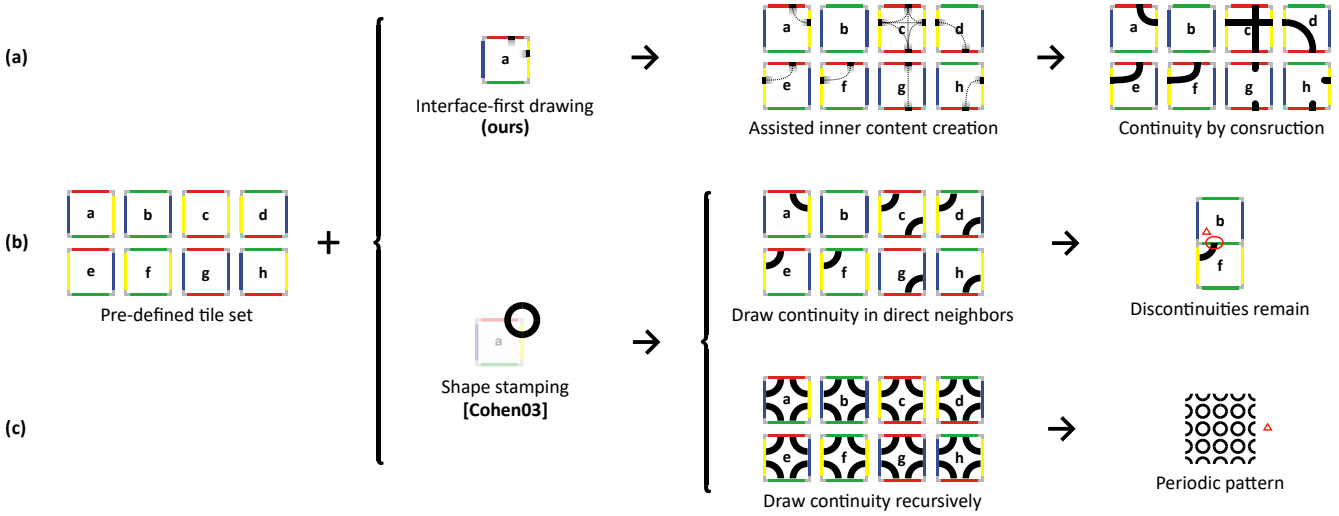

Figure 5: Comparison of our interface-first authoring (a) with stamp-based approaches (b) and (c). When stamped shape continuity is applied only in direct neighbors of the edited tile (b), we can still find valid tile assignment whose associated geometry is discontinuous. When repeatedly enforcing continuity (c), the tile set becomes uniform and can only produce periodic patterns.

Figure 6: Various other mesostructures generated using our tool. We can observe how simple cross sections coupled with boundary-aware tilling achieves great visual complexity.

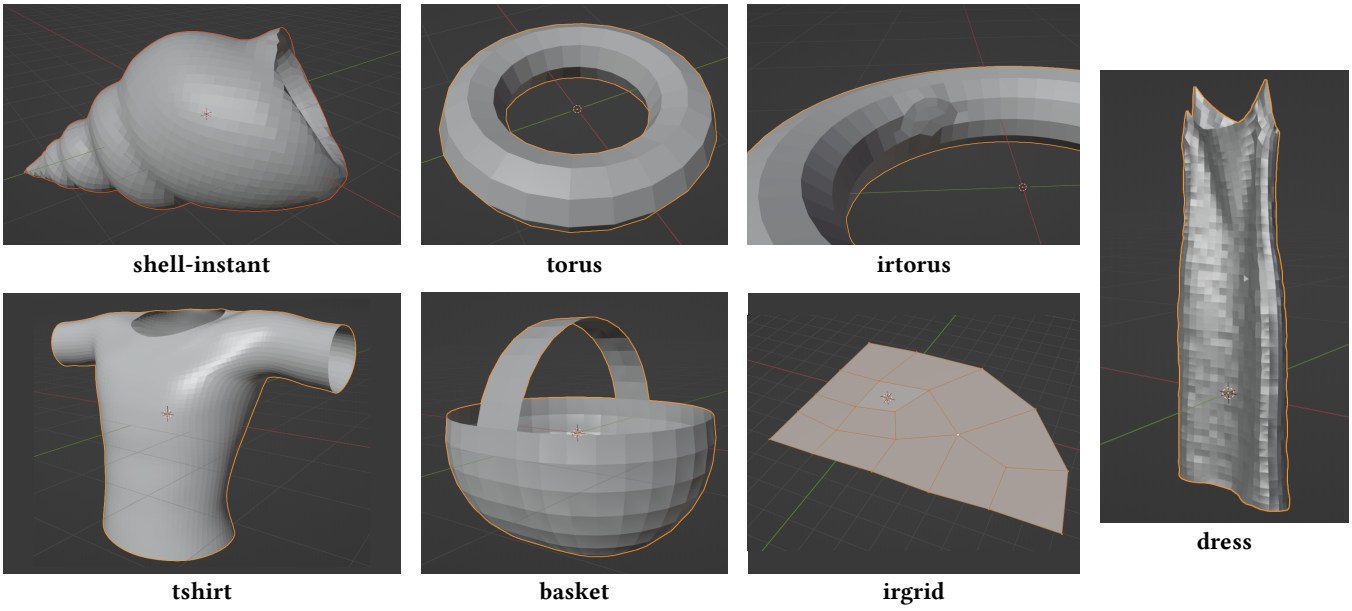

Figure 7: Macrosurfaces used for the evaluation of our tile suggestion mechanism.

Table 2: Success rate R and amount N of new tiles needed by different suggestion mechanisms to complete the tiling. A higher R is more important, then for equal R a lower N is better. Averaged over 100 runs, considered unsuccessful beyond 10 new tiles (part 1/3).

Experiment	Voting (ours)		Guided Random		Fully Random	
	R	N	R	N	R	N
tshirt_tileset.random0000	93%	5.9 ± 1.2	**96%**	**4.1 ± 2.0**	0%	N/A
irgrid_tileset.random0000	**100%**	**5.4 ± 0.5**	100%	6.0 ± 1.3	0%	N/A
basket_tileset.random0000	**100%**	**2.0 ± 0.0**	100%	2.3 ± 0.5	0%	N/A
dress_tileset.random0000	**100%**	**7.2 ± 0.5**	78%	7.8 ± 1.1	0%	N/A
shell-instant_tileset.random0000	**20%**	**2.9 ± 2.0**	17%	5.7 ± 2.6	0%	N/A
torus_tileset.random0000	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	3%	1.0 ± 0.0
irtorus_tileset.random0000	**100%**	**2.5 ± 0.7**	100%	3.3 ± 1.2	0%	N/A
tshirt_tileset.random0001	**99%**	**5.6 ± 1.7**	77%	3.4 ± 2.1	6%	1.2 ± 0.4
irgrid_tileset.random0001	100%	2.7 ± 0.5	**100%**	**2.3 ± 0.7**	2%	1.0 ± 0.0
basket_tileset.random0001	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	33%	1.0 ± 0.0
dress_tileset.random0001	**100%**	**2.6 ± 0.5**	76%	5.1 ± 2.3	0%	N/A
shell-instant_tileset.random0001	**1%**	**4.0 ± 0.0**	0%	N/A	0%	N/A
torus_tileset.random0001	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**
irtorus_tileset.random0001	**98%**	**2.4 ± 1.3**	92%	5.6 ± 1.9	0%	N/A
tshirt_tileset.random0002	**88%**	**7.3 ± 0.9**	79%	4.3 ± 1.9	0%	N/A
irgrid_tileset.random0002	**100%**	**4.6 ± 0.9**	100%	5.9 ± 1.5	0%	N/A
basket_tileset.random0002	**100%**	**2.0 ± 0.0**	100%	3.1 ± 0.8	1%	1.0 ± 0.0
dress_tileset.random0002	**87%**	**7.7 ± 0.8**	32%	7.8 ± 1.3	0%	N/A
shell-instant_tileset.random0002	3%	7.0 ± 2.2	**4%**	**6.0 ± 0.7**	0%	N/A
torus_tileset.random0002	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	18%	1.0 ± 0.0
irtorus_tileset.random0002	**100%**	**2.2 ± 0.9**	95%	5.1 ± 2.2	0%	N/A
tshirt_tileset.random0003	**100%**	**2.0 ± 0.0**	77%	3.6 ± 2.1	1%	1.0 ± 0.0
irgrid_tileset.random0003	**100%**	**4.0 ± 0.0**	100%	4.9 ± 1.5	0%	N/A
basket_tileset.random0003	100%	3.0 ± 0.0	**100%**	**2.0 ± 0.9**	5%	1.0 ± 0.0
dress_tileset.random0003	**100%**	**4.4 ± 1.1**	56%	7.0 ± 1.6	0%	N/A
shell-instant_tileset.random0003	**19%**	**6.4 ± 1.9**	9%	4.0 ± 3.0	0%	N/A
torus_tileset.random0003	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	13%	1.0 ± 0.0
irtorus_tileset.random0003	**100%**	**3.3 ± 1.0**	96%	4.6 ± 2.1	0%	N/A
tshirt_tileset.random0004	**100%**	**3.0 ± 0.0**	85%	2.9 ± 2.1	12%	1.3 ± 0.6
irgrid_tileset.random0004	100%	3.2 ± 0.4	**100%**	**3.0 ± 0.7**	2%	1.0 ± 0.0
basket_tileset.random0004	100%	2.0 ± 0.0	**100%**	**1.1 ± 0.3**	61%	1.0 ± 0.0
dress_tileset.random0004	19%	7.8 ± 1.0	**65%**	**5.0 ± 2.0**	0%	N/A
shell-instant_tileset.random0004	5%	7.2 ± 1.0	**8%**	**5.1 ± 2.0**	0%	N/A
torus_tileset.random0004	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**
irtorus_tileset.random0004	**100%**	**2.3 ± 1.1**	83%	5.1 ± 2.3	1%	4.0 ± 0.0
tshirt_tileset.random0005	**100%**	**3.0 ± 0.0**	82%	3.7 ± 2.0	0%	N/A
irgrid_tileset.random0005	**100%**	**3.2 ± 0.4**	100%	4.9 ± 1.6	0%	N/A
basket_tileset.random0005	100%	3.0 ± 0.0	**100%**	**2.5 ± 1.1**	2%	1.0 ± 0.0
dress_tileset.random0005	**99%**	**5.8 ± 1.1**	40%	6.1 ± 1.9	0%	N/A
shell-instant_tileset.random0005	**51%**	**5.6 ± 2.4**	8%	6.0 ± 2.4	0%	N/A
torus_tileset.random0005	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	10%	1.0 ± 0.0
irtorus_tileset.random0005	**100%**	**2.4 ± 0.5**	89%	4.8 ± 2.0	0%	N/A
tshirt_tileset.random0006	**99%**	**5.6 ± 1.4**	88%	3.4 ± 2.1	1%	1.0 ± 0.0
irgrid_tileset.random0006	**100%**	**2.0 ± 0.0**	100%	3.8 ± 1.2	1%	3.0 ± 0.0
basket_tileset.random0006	100%	2.0 ± 0.0	**100%**	**1.4 ± 1.0**	11%	1.0 ± 0.0
dress_tileset.random0006	**100%**	**4.4 ± 1.0**	64%	6.4 ± 1.9	0%	N/A
shell-instant_tileset.random0006	8%	7.8 ± 1.4	**12%**	**3.4 ± 1.3**	0%	N/A
torus_tileset.random0006	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	13%	1.0 ± 0.0
irtorus_tileset.random0006	**100%**	**2.5 ± 0.8**	92%	3.9 ± 2.0	0%	N/A

Table 3: Success rate R and amount N of new tiles needed by different suggestion mechanisms to complete the tiling. A higher R is more important, then for equal R a lower N is better. Averaged over 100 runs, considered unsuccessful beyond 10 new tiles (part 2/3).

Experiment	Voting (ours)		Guided Random		Fully Random	
	R	N	R	N	R	N
tshirt_tileset.random0007	65%	5.6 ± 1.7	**76%**	**4.2 ± 1.7**	0%	N/A
irgrid_tileset.random0007	**100%**	**5.3 ± 0.5**	100%	5.5 ± 1.3	0%	N/A
basket_tileset.random0007	100%	5.0 ± 0.2	**100%**	**3.1 ± 0.8**	0%	N/A
dress_tileset.random0007	**100%**	**6.0 ± 0.0**	44%	7.6 ± 1.3	0%	N/A
shell-instant_tileset.random0007	**7%**	**4.9 ± 1.8**	3%	4.7 ± 2.5	0%	N/A
torus_tileset.random0007	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	14%	1.0 ± 0.0
irtorus_tileset.random0007	**98%**	**2.9 ± 1.5**	89%	5.4 ± 2.1	0%	N/A
tshirt_tileset.random0008	*irrelevant (already solvable)*					
irgrid_tileset.random0008	*irrelevant (already solvable)*					
basket_tileset.random0008	*irrelevant (already solvable)*					
dress_tileset.random0008	*irrelevant (already solvable)*					
shell-instant_tileset.random0008	*irrelevant (already solvable)*					
torus_tileset.random0008	*irrelevant (already solvable)*					
irtorus_tileset.random0008	*irrelevant (already solvable)*					
tshirt_tileset.random0009	84%	4.9 ± 1.7	**90%**	**5.0 ± 1.5**	0%	N/A
irgrid_tileset.random0009	100%	3.2 ± 0.4	**100%**	**2.8 ± 0.7**	0%	N/A
basket_tileset.random0009	100%	2.1 ± 0.7	**100%**	**2.0 ± 1.0**	0%	N/A
dress_tileset.random0009	**97%**	**6.1 ± 1.0**	78%	6.8 ± 1.4	0%	N/A
shell-instant_tileset.random0009	**29%**	**6.5 ± 2.0**	7%	7.9 ± 0.8	2%	5.5 ± 2.5
torus_tileset.random0009	*irrelevant (already solvable)*					
irtorus_tileset.random0009	*irrelevant (already solvable)*					
tshirt_tileset.random0010	**100%**	**4.0 ± 0.0**	93%	4.7 ± 2.1	0%	N/A
irgrid_tileset.random0010	**100%**	**5.3 ± 0.5**	100%	5.4 ± 1.4	0%	N/A
basket_tileset.random0010	100%	3.0 ± 0.0	**100%**	**2.5 ± 0.6**	2%	1.0 ± 0.0
dress_tileset.random0010	**100%**	**5.9 ± 0.3**	57%	7.3 ± 1.4	0%	N/A
shell-instant_tileset.random0010	**48%**	**5.3 ± 2.3**	24%	5.1 ± 2.5	0%	N/A
torus_tileset.random0010	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	12%	1.0 ± 0.0
irtorus_tileset.random0010	**100%**	**2.4 ± 0.5**	100%	3.4 ± 1.1	0%	N/A
tshirt_tileset.random0011	**98%**	**5.9 ± 1.6**	56%	3.8 ± 1.6	0%	N/A
irgrid_tileset.random0011	**100%**	**3.0 ± 0.0**	96%	4.9 ± 2.0	0%	N/A
basket_tileset.random0011	**100%**	**1.0 ± 0.0**	100%	2.1 ± 1.0	5%	1.0 ± 0.0
dress_tileset.random0011	**100%**	**4.9 ± 0.9**	28%	6.2 ± 1.9	0%	N/A
shell-instant_tileset.random0011	**5%**	**5.2 ± 1.9**	1%	8.0 ± 0.0	0%	N/A
torus_tileset.random0011	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	46%	1.0 ± 0.0
irtorus_tileset.random0011	**100%**	**2.7 ± 0.8**	58%	5.0 ± 2.3	0%	N/A
tshirt_tileset.random0012	**99%**	**5.5 ± 1.0**	83%	2.9 ± 1.4	0%	N/A
irgrid_tileset.random0012	100%	5.4 ± 0.6	**100%**	**4.0 ± 1.4**	0%	N/A
basket_tileset.random0012	100%	3.0 ± 0.0	**100%**	**2.4 ± 0.6**	0%	N/A
dress_tileset.random0012	**100%**	**5.1 ± 0.3**	79%	6.5 ± 2.0	0%	N/A
shell-instant_tileset.random0012	**36%**	**4.0 ± 2.0**	1%	9.0 ± 0.0	0%	N/A
torus_tileset.random0012	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	20%	1.0 ± 0.0
irtorus_tileset.random0012	**100%**	**2.2 ± 0.9**	95%	5.2 ± 2.2	2%	1.0 ± 0.0
tshirt_tileset.random0013	**100%**	**2.0 ± 0.0**	86%	3.1 ± 1.9	0%	N/A
irgrid_tileset.random0013	100%	4.0 ± 0.0	**100%**	**2.9 ± 0.8**	0%	N/A
basket_tileset.random0013	**100%**	**1.0 ± 0.0**	100%	1.8 ± 1.2	0%	N/A
dress_tileset.random0013	**79%**	**6.6 ± 1.3**	60%	6.7 ± 1.8	0%	N/A
shell-instant_tileset.random0013	**8%**	**7.4 ± 1.3**	3%	6.3 ± 2.5	0%	N/A
torus_tileset.random0013	*irrelevant (already solvable)*					
irtorus_tileset.random0013	**100%**	**1.7 ± 0.8**	100%	2.7 ± 0.9	20%	6.2 ± 2.9

Table 4: Success rate R and amount N of new tiles needed by different suggestion mechanisms to complete the tiling. A higher R is more important, then for equal R a lower N is better. Averaged over 100 runs, considered unsuccessful beyond 10 new tiles (part 3/3).

Experiment	Voting (ours)		Guided Random		Fully Random	
	R	N	R	N	R	N
tshirt_tileset.random0014	**100%**	**2.0 ± 0.0**	67%	2.9 ± 1.7	18%	1.7 ± 0.9
irgrid_tileset.random0014	**100%**	**2.0 ± 0.0**	100%	2.6 ± 1.2	0%	N/A
basket_tileset.random0014	*irrelevant (already solvable)*					
dress_tileset.random0014	**100%**	**4.0 ± 1.7**	18%	4.9 ± 2.7	0%	N/A
shell-instant_tileset.random0014	**10%**	**5.7 ± 2.6**	0%	N/A	0%	N/A
torus_tileset.random0014	*irrelevant (already solvable)*					
irtorus_tileset.random0014	**95%**	**2.1 ± 1.9**	20%	5.6 ± 2.5	1%	4.0 ± 0.0
tshirt_tileset.random0015	**100%**	**3.1 ± 1.0**	100%	4.0 ± 2.1	4%	1.5 ± 0.5
irgrid_tileset.random0015	100%	5.5 ± 0.5	**100%**	**4.8 ± 0.9**	0%	N/A
basket_tileset.random0015	100%	2.0 ± 0.0	**100%**	**1.9 ± 0.7**	24%	1.0 ± 0.2
dress_tileset.random0015	38%	8.3 ± 0.7	**79%**	**7.8 ± 1.0**	0%	N/A
shell-instant_tileset.random0015	**7%**	**6.0 ± 1.7**	2%	8.5 ± 0.5	0%	N/A
torus_tileset.random0015	*irrelevant (already solvable)*					
irtorus_tileset.random0015	**100%**	**1.2 ± 0.8**	100%	2.7 ± 1.1	0%	N/A
tshirt_tileset.random0016	100%	3.9 ± 1.0	**100%**	**2.8 ± 1.8**	6%	1.5 ± 0.5
irgrid_tileset.random0016	100%	3.0 ± 0.1	**100%**	**2.3 ± 0.9**	1%	1.0 ± 0.0
basket_tileset.random0016	**100%**	**1.0 ± 0.0**	100%	1.1 ± 0.6	21%	1.0 ± 0.0
dress_tileset.random0016	**100%**	**2.5 ± 0.5**	100%	3.8 ± 1.6	0%	N/A
shell-instant_tileset.random0016	**52%**	**5.6 ± 2.4**	23%	5.9 ± 2.3	0%	N/A
torus_tileset.random0016	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	24%	1.0 ± 0.0
irtorus_tileset.random0016	**100%**	**2.4 ± 0.5**	100%	3.1 ± 1.2	1%	1.0 ± 0.0
tshirt_tileset.random0017	**93%**	**6.5 ± 1.4**	75%	4.2 ± 1.8	0%	N/A
irgrid_tileset.random0017	100%	7.0 ± 0.0	**100%**	**6.1 ± 0.9**	0%	N/A
basket_tileset.random0017	**100%**	**3.1 ± 0.3**	100%	3.6 ± 0.8	0%	N/A
dress_tileset.random0017	**82%**	**8.3 ± 0.6**	26%	8.3 ± 0.9	0%	N/A
shell-instant_tileset.random0017	**10%**	**6.0 ± 2.0**	7%	4.6 ± 2.2	0%	N/A
torus_tileset.random0017	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	10%	1.0 ± 0.0
irtorus_tileset.random0017	**100%**	**2.6 ± 0.9**	94%	4.0 ± 1.6	1%	1.0 ± 0.0
tshirt_tileset.random0018	**99%**	**5.2 ± 1.7**	88%	2.7 ± 1.7	0%	N/A
irgrid_tileset.random0018	**100%**	**2.0 ± 0.0**	100%	4.2 ± 1.1	0%	N/A
basket_tileset.random0018	100%	2.0 ± 0.0	**100%**	**1.5 ± 0.6**	3%	1.0 ± 0.0
dress_tileset.random0018	**100%**	**6.2 ± 0.7**	64%	6.4 ± 2.2	0%	N/A
shell-instant_tileset.random0018	**11%**	**7.4 ± 1.1**	4%	5.0 ± 2.5	0%	N/A
torus_tileset.random0018	**100%**	**1.0 ± 0.0**	**100%**	**1.0 ± 0.0**	5%	1.0 ± 0.0
irtorus_tileset.random0018	**100%**	**2.2 ± 0.6**	89%	5.0 ± 2.2	0%	N/A
tshirt_tileset.random0019	100%	3.3 ± 0.5	**100%**	**3.1 ± 1.5**	2%	1.5 ± 0.5
irgrid_tileset.random0019	**100%**	**1.0 ± 0.2**	100%	1.8 ± 0.8	9%	1.4 ± 0.7
basket_tileset.random0019	**100%**	**1.1 ± 0.3**	100%	1.6 ± 0.6	12%	1.0 ± 0.0
dress_tileset.random0019	**100%**	**2.6 ± 0.5**	100%	4.2 ± 1.5	1%	1.0 ± 0.0
shell-instant_tileset.random0019	**4%**	**6.0 ± 1.9**	3%	3.7 ± 0.5	0%	N/A
torus_tileset.random0019	*irrelevant (already solvable)*					
irtorus_tileset.random0019	100%	3.6 ± 1.2	**100%**	**3.2 ± 1.2**	3%	1.7 ± 0.9