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# Rule-based Strategies

Mesh Subdivision

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**ETH** zürich

**DARCH**

Departement Architektur



Institute of Technology in Architecture  
Faculty of Architecture / ETH Zurich

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# Christopher Alexander, Pattern Language

## A PATTERN LANGUAGE

TOWNS • BUILDINGS • CONSTRUCTION

*Christopher Alexander*

*Sara Ishikawa Murray Silverstein*

*with*

*Max Jacobson Ingrid Fiksdahl-King Shlomo Angel*

NEW YORK

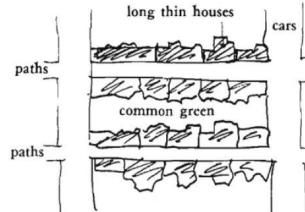
OXFORD UNIVERSITY PRESS

1977

Rectangular Snip

### TOWNS

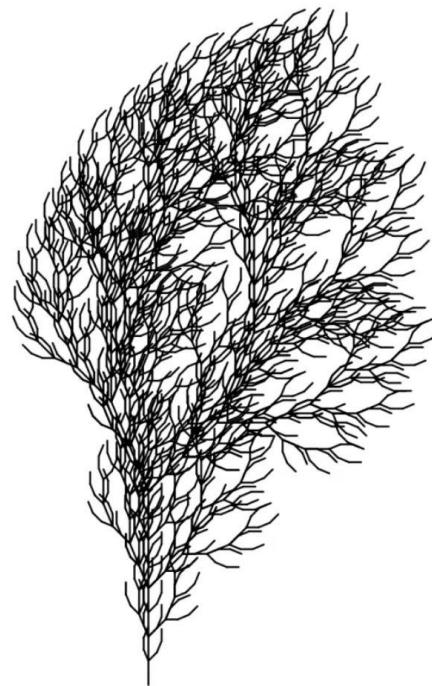
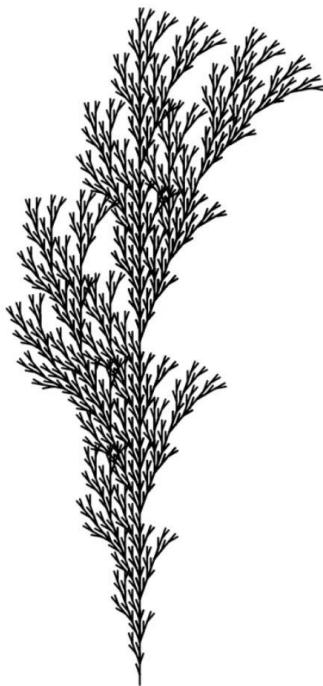
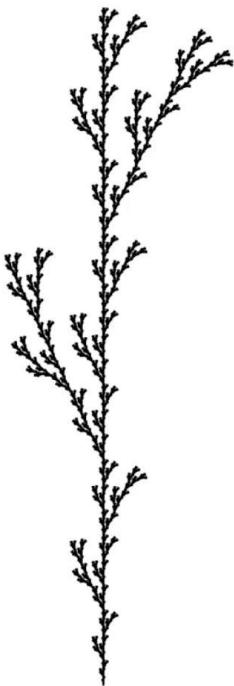
For row houses, place houses along pedestrian paths that run at right angles to local roads and parking lots, and give each house a long frontage and a shallow depth.



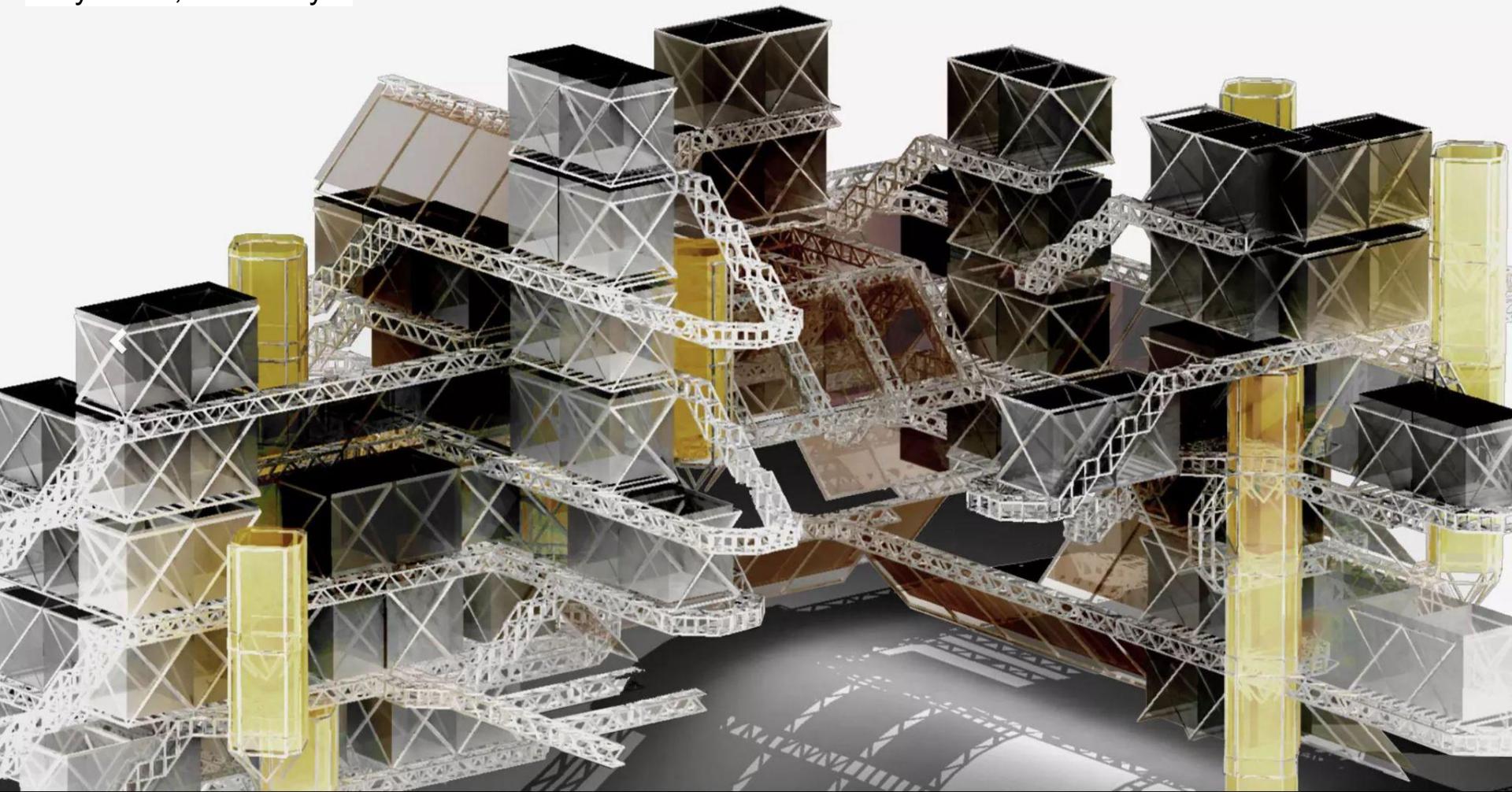
Make the individual houses and cottages as long and thin along the paths as possible—LONG THIN HOUSE (109); vary the houses according to the different household types—THE FAMILY (75), HOUSE FOR A SMALL FAMILY (76), HOUSE FOR A COUPLE (77), HOUSE FOR ONE PERSON (78); build roads across the paths, at right angles to them—PARALLEL ROADS (23), NETWORK OF PATHS AND CARS (52), with small parking lots off the roads—SMALL PARKING LOTS (103). In other respects build row houses in clusters—HOUSE CLUSTER (37), BUILDING COMPLEX (95). . . .

# L-System

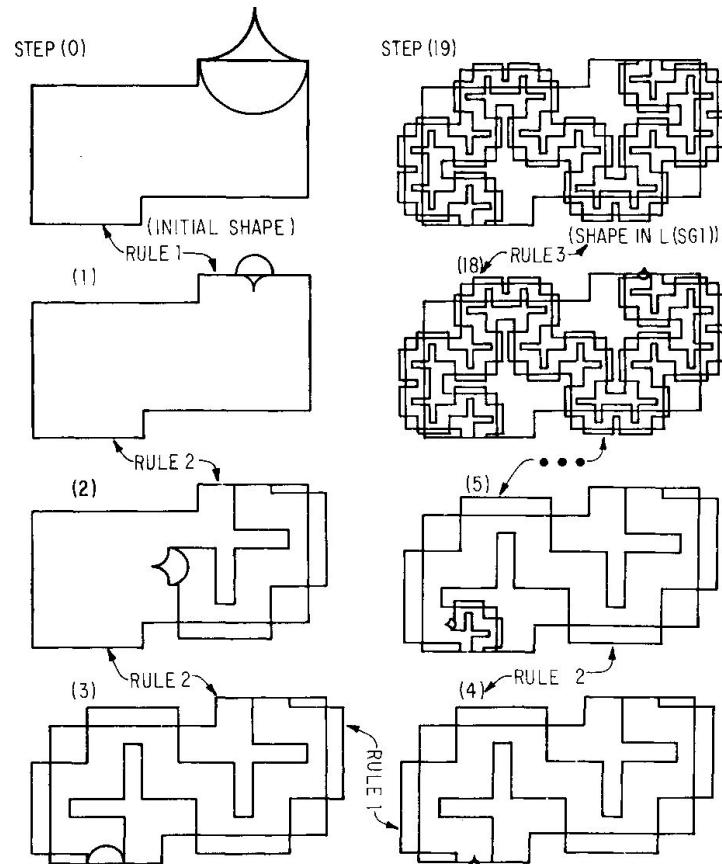
\* Rectangular Snip



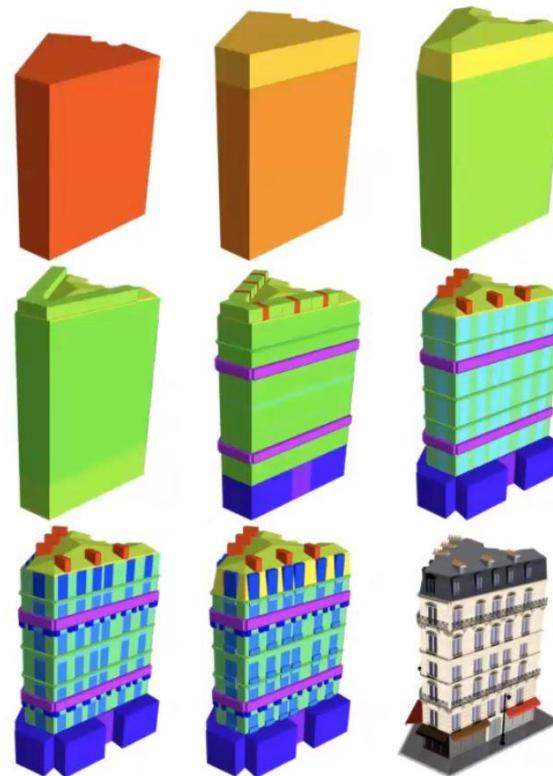
# L-Systems, Hansmeyer

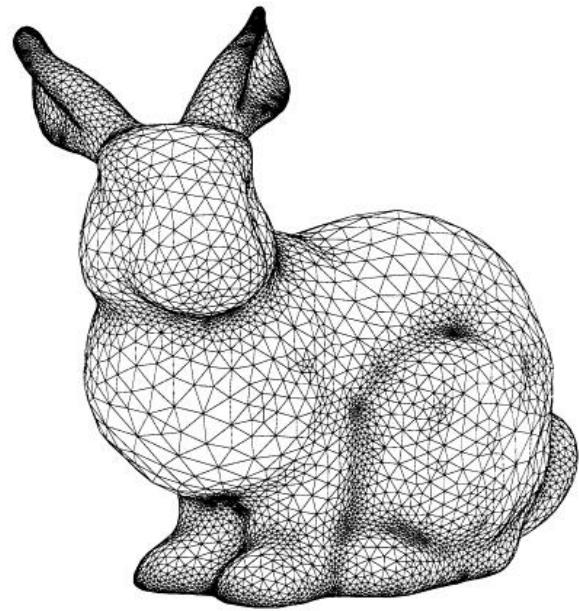


# Stiny and Gips, Shape Grammars

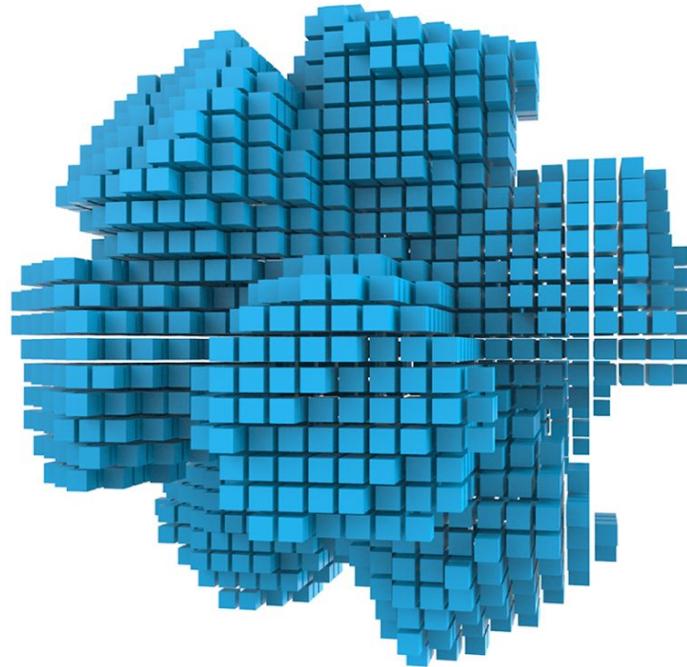


# Olivier Teboul, Haussmannian Grammar





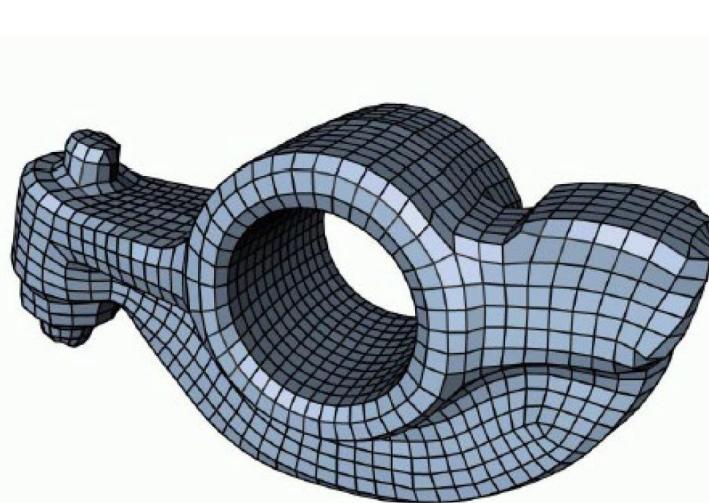
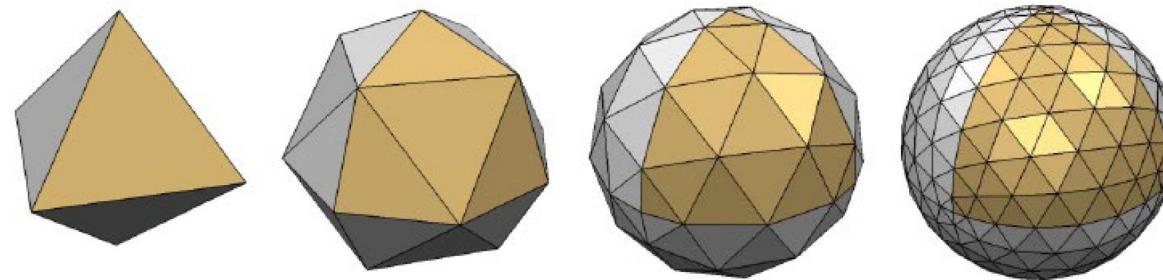
Mesh



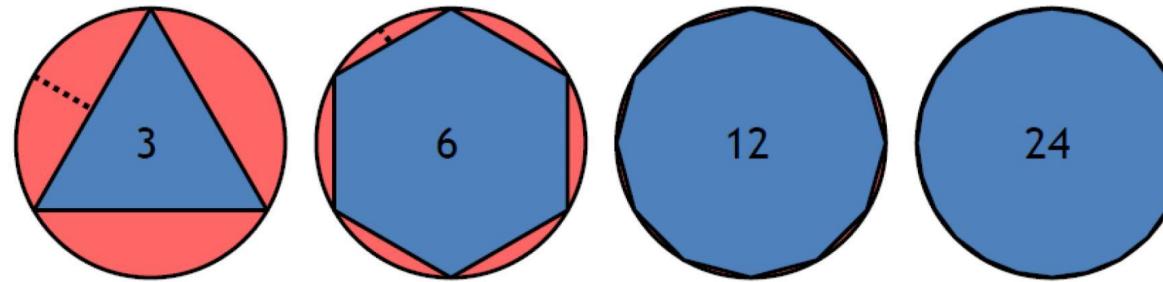
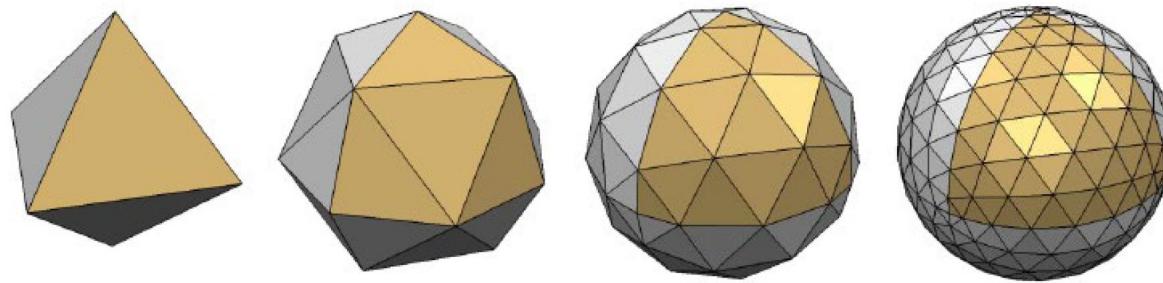
Voxel

# What is a mesh ?

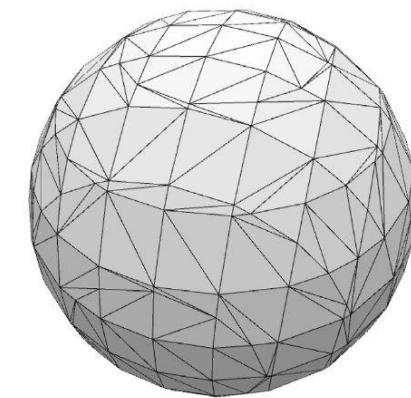
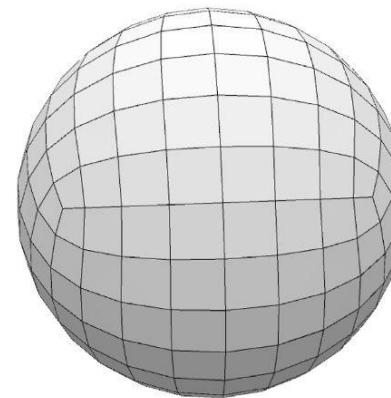
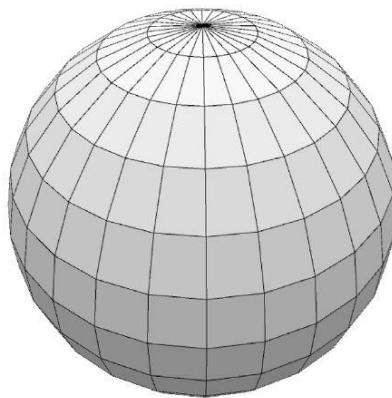
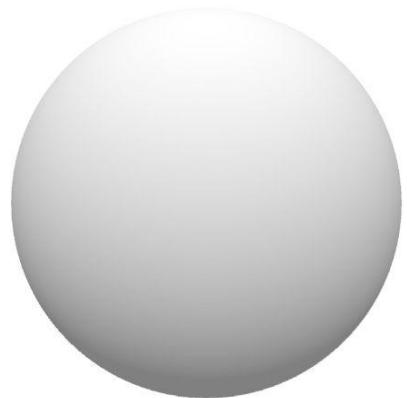
## Boundary representation



# Resolution

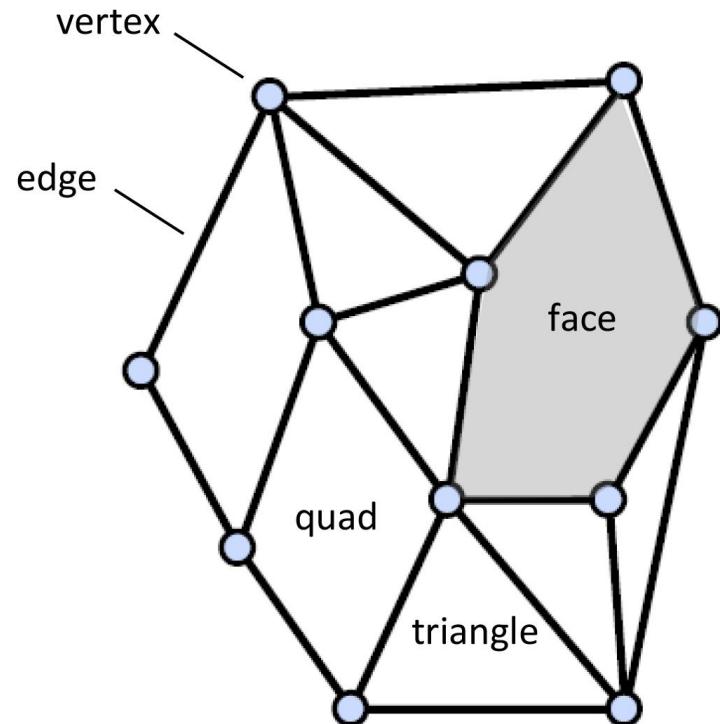


A sphere is a sphere

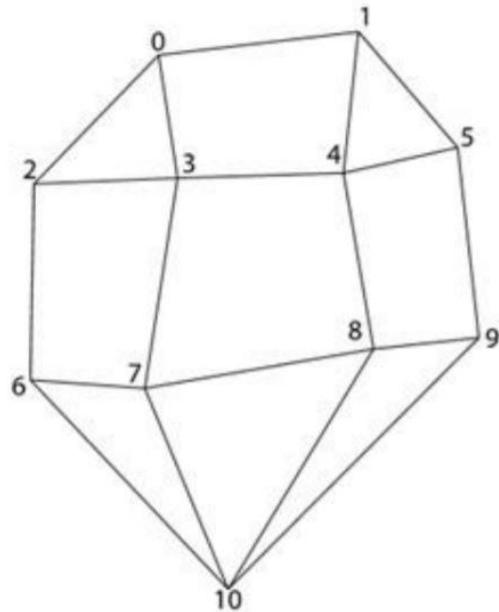


# Quiz!

## Basic concepts



Vertices.. Faces..



VERTICES

- 0: (-0.2, 1.5, 0)
- 1: (1.3, 1.7, 0)
- 2: (-1.1, 0.4, 0)
- 3: (0.0, 0.45, 1)
- 4: (1.1, 0.5, 1.2)
- 5: (2.1, 0.75, 0.2)
- 6: (-1.2, -1.0, 0.01)
- 7: (-0.3, -1.2, 2)
- 8: (1.3, -0.9, 3)
- 9: (2.0, -0.8, 1.2)
- 10: (0.4, -2.1, -1.1)

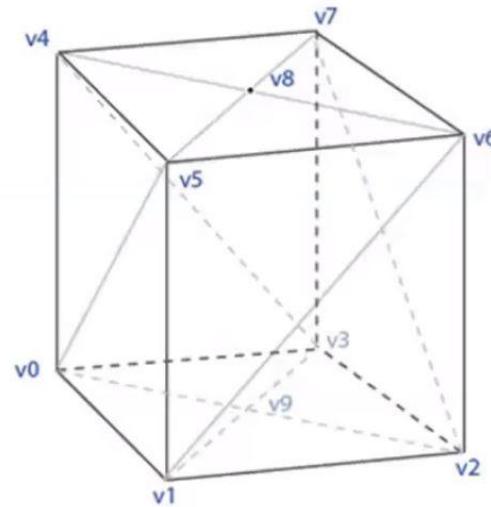
FACES

- 0: 0,2,3
- 1: 0,3,4,1
- 2: 1,4,5
- 3: 2,6,7,3
- 4: 3,7,8,4
- 5: 4,8,9,5
- 6: 6,10,7
- 7: 7,10,8
- 8: 8,10,9

## Vertex-Vertex Meshes (VV)

Vertex List

	0,0,0	v1 v5 v4 v3 v9
v0	0,0,0	v1 v5 v4 v3 v9
v1	1,0,0	v2 v6 v5 v0 v9
v2	1,1,0	v3 v7 v6 v1 v9
v3	0,1,0	v2 v6 v7 v4 v9
v4	0,0,1	v5 v0 v3 v7 v8
v5	1,0,1	v6 v1 v0 v4 v8
v6	1,1,1	v7 v2 v1 v5 v8
v7	0,1,1	v4 v3 v2 v6 v8
v8	.5,.5,1	v4 v5 v6 v7
v9	.5,.5,0	v0 v1 v2 v3



## Face-Vertex Meshes

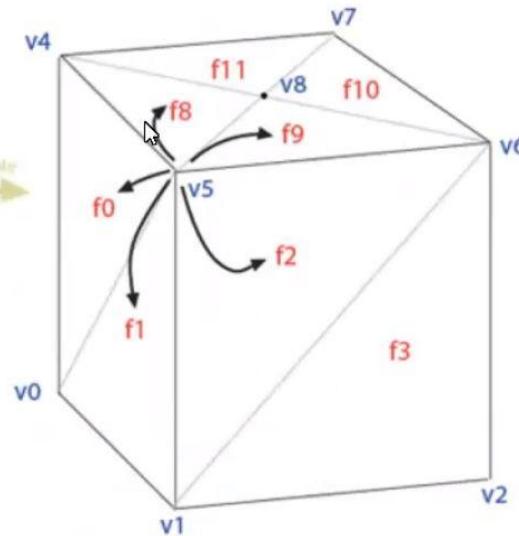
Face List

f0	v0 v4 v5
f1	v0 v5 v1
f2	v1 v5 v6
f3	v1 v6 v2
f4	v2 v6 v7
f5	v2 v7 v3
f6	v3 v7 v4
f7	v3 v4 v0
f8	v8 v5 v4
f9	v8 v6 v5
f10	v8 v7 v6
f11	v8 v4 v7
f12	v9 v5 v4
f13	v9 v6 v5
f14	v9 v7 v6
f15	v9 v4 v7

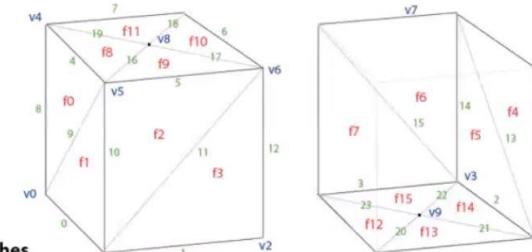
Vertex List

v0	0,0,0	f0 f1 f12 f15 f7
v1	1,0,0	f2 f3 f13 f12 f1
v2	1,1,0	f4 f5 f14 f13 f3
v3	0,1,0	f6 f7 f15 f14 f5
v4	0,0,1	f6 f7 f0 f8 f11
v5	1,0,1	f0 f1 f2 f9 f8
v6	1,1,1	f2 f3 f4 f10 f9
v7	0,1,1	f4 f5 f6 f11 f10
v8	.5,.5,0	f8 f9 f10 f11
v9	.5,.5,1	f12 f13 f14 f15

example



# Winged Edge

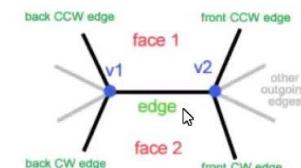


Winged-Edge Meshes

f0	4 8 9
f1	0 10 9
f2	5 10 11
f3	1 12 11
f4	6 12 13
f5	2 14 13
f6	7 14 15
f7	3 8 15
f8	4 16 19
f9	5 17 16
f10	6 18 17
f11	7 19 18
f12	0 23 20
f13	1 20 21
f14	2 21 22
f15	3 22 23

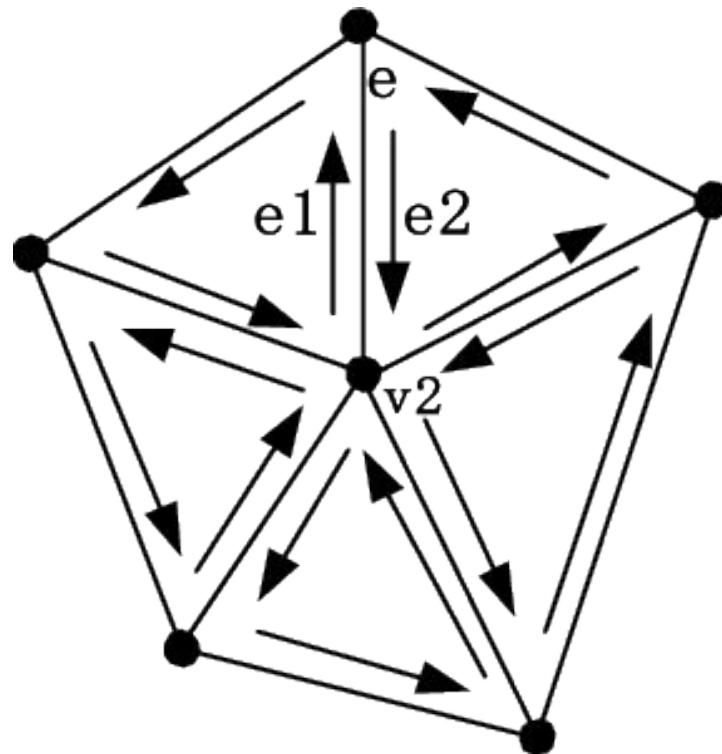
e0	v0 v1 f1 f12 9 23 10 20
e1	v1 v2 f3 f13 11 20 12 21
e2	v2 v3 f5 f14 13 21 14 22
e3	v3 v0 f7 f15 15 22 8 23
e4	v4 v5 f0 f8 19 8 16 9
e5	v5 v6 f2 f9 16 10 17 11
e6	v6 v7 f4 f10 17 12 18 13
e7	v7 v4 f6 f11 18 14 19 15
e8	v0 v4 f7 f10 3 9 7 4
e9	v0 v5 f0 f1 8 0 4 10
e10	v1 v5 f1 f2 0 11 9 5
e11	v1 v6 f2 f3 10 1 5 12
e12	v2 v6 f3 f4 1 13 11 6
e13	v2 v7 f4 f5 12 2 6 14
e14	v3 v7 f5 f6 2 15 13 7
e15	v3 v4 f6 f7 14 3 7 15
e16	v5 v8 f8 f9 4 5 19 17
e17	v6 v8 f9 f10 5 6 16 18
e18	v7 v8 f10 f11 6 7 17 19
e19	v4 v8 f11 f8 7 4 18 16
e20	v1 v9 f12 f13 0 1 23 21
e21	v2 v9 f13 f14 1 2 20 22
e22	v3 v9 f14 f15 2 3 21 23
e23	v0 v9 f15 f12 3 0 22 20

v0	0,0,0	8 9 0 23 3
v1	1,0,0	10 11 1 20 0
v2	1,1,0	12 13 2 21 1
v3	0,1,0	14 15 3 22 2
v4	0,0,1	8 15 7 19 4
v5	1,0,1	10 9 4 16 5
v6	1,1,1	12 11 5 17 6
v7	0,1,1	14 13 6 18 7
v8	5,5,0	16 17 18 19
v9	5,5,1	20 21 22 23



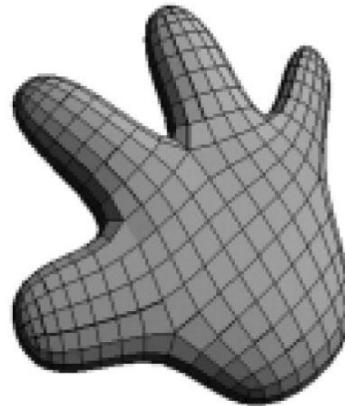
Winged Edge Structure

## Half Edge

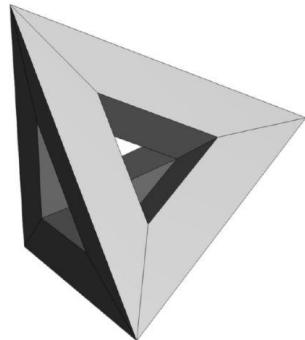


# Mesh Subdivision

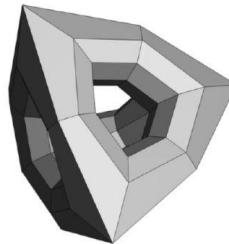
Catmull



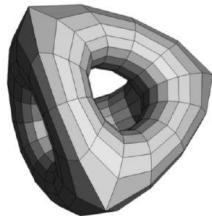
# Subdivision Surfaces in Character Animation



(a)



(b)



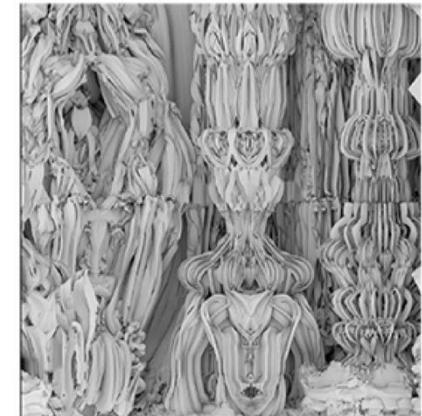
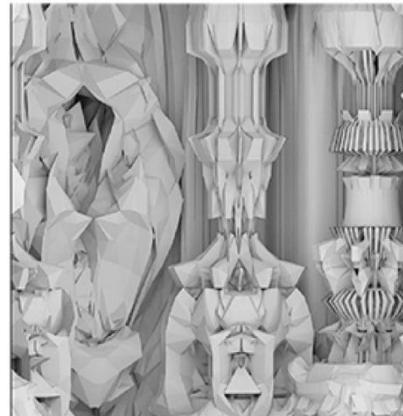
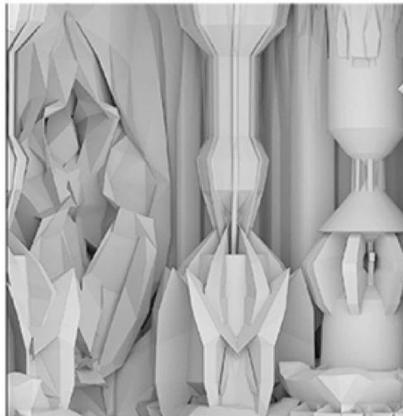
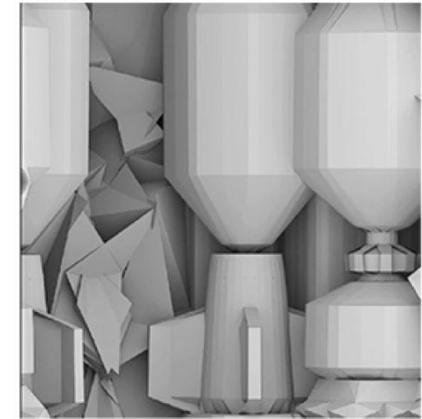
(c)



(d)



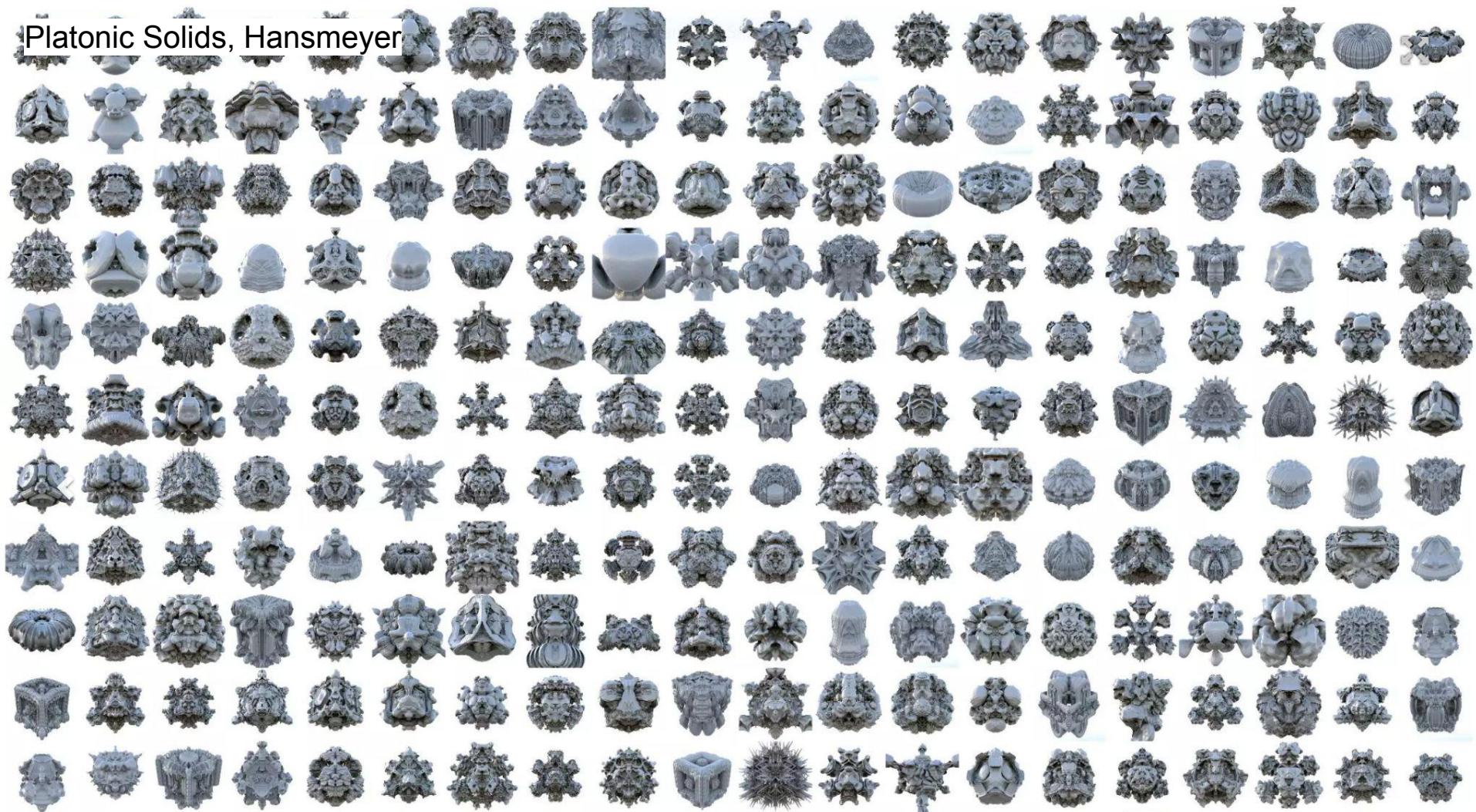
# Digital Grotesque, Hansmeyer/Dillenburger



Digital Grotesque, Hansmeyer/Dillenburger

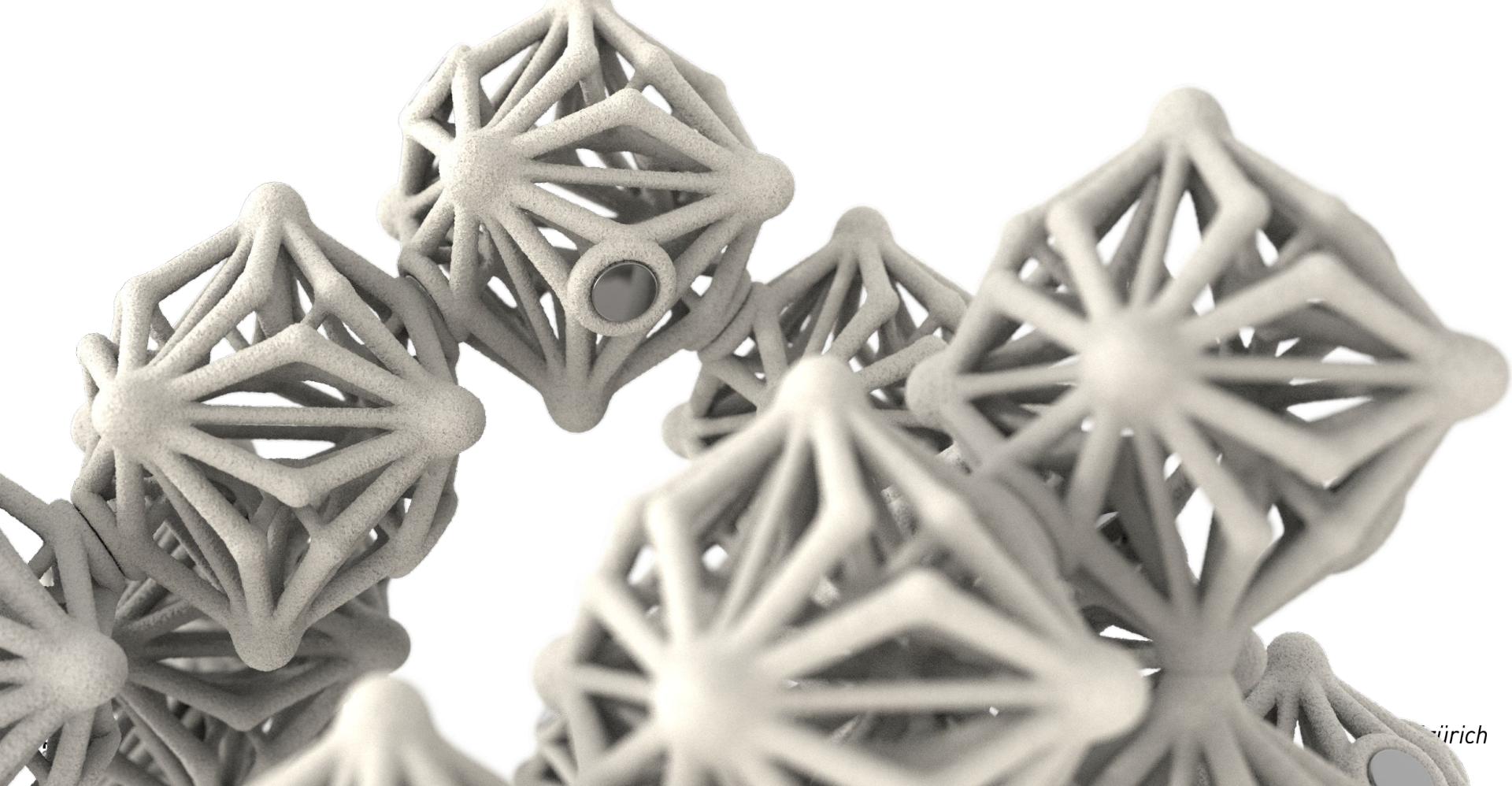


# Platonic Solids, Hansmeyer



# Bricks?

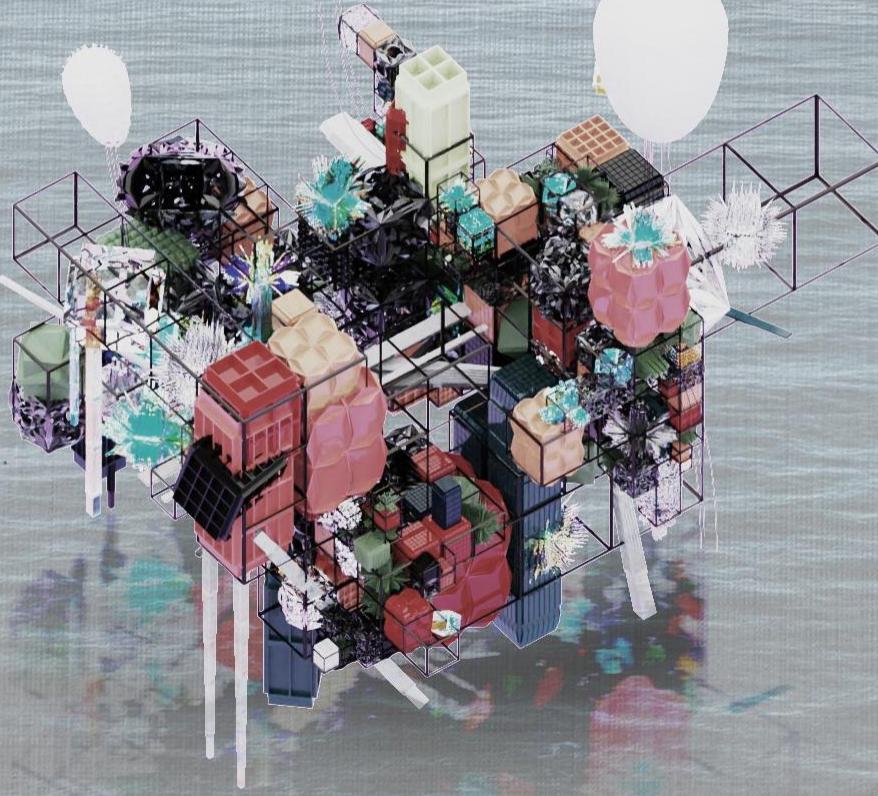
Ilaria Giacomini, Chengyuan Wei (MAS Dfab 2020-2021)



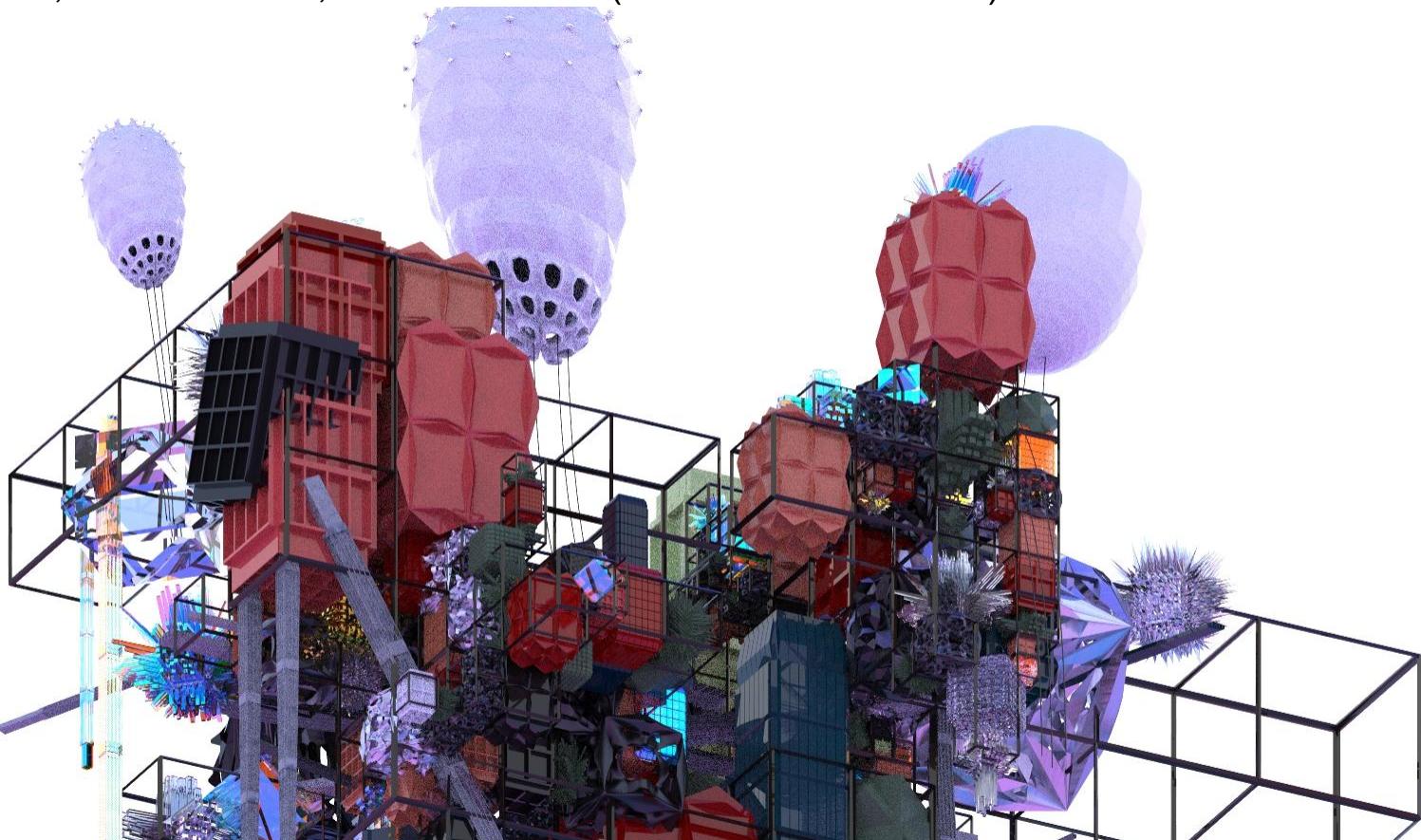
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Artemis Maneka, Foteini Salveridou, Priyank Soni (MAS Dfab 2020-2021)

Wei-Ting Chen, Yen-Fen Chan, Simon Griffioen (MAS Dfab 2020-2021)



Wei-Ting Chen, Yen-Fen Chan, Simon Griffioen (MAS Dfab 2020-2021)



Josien Heleen Lieke de Koning (ACDC 2021)

