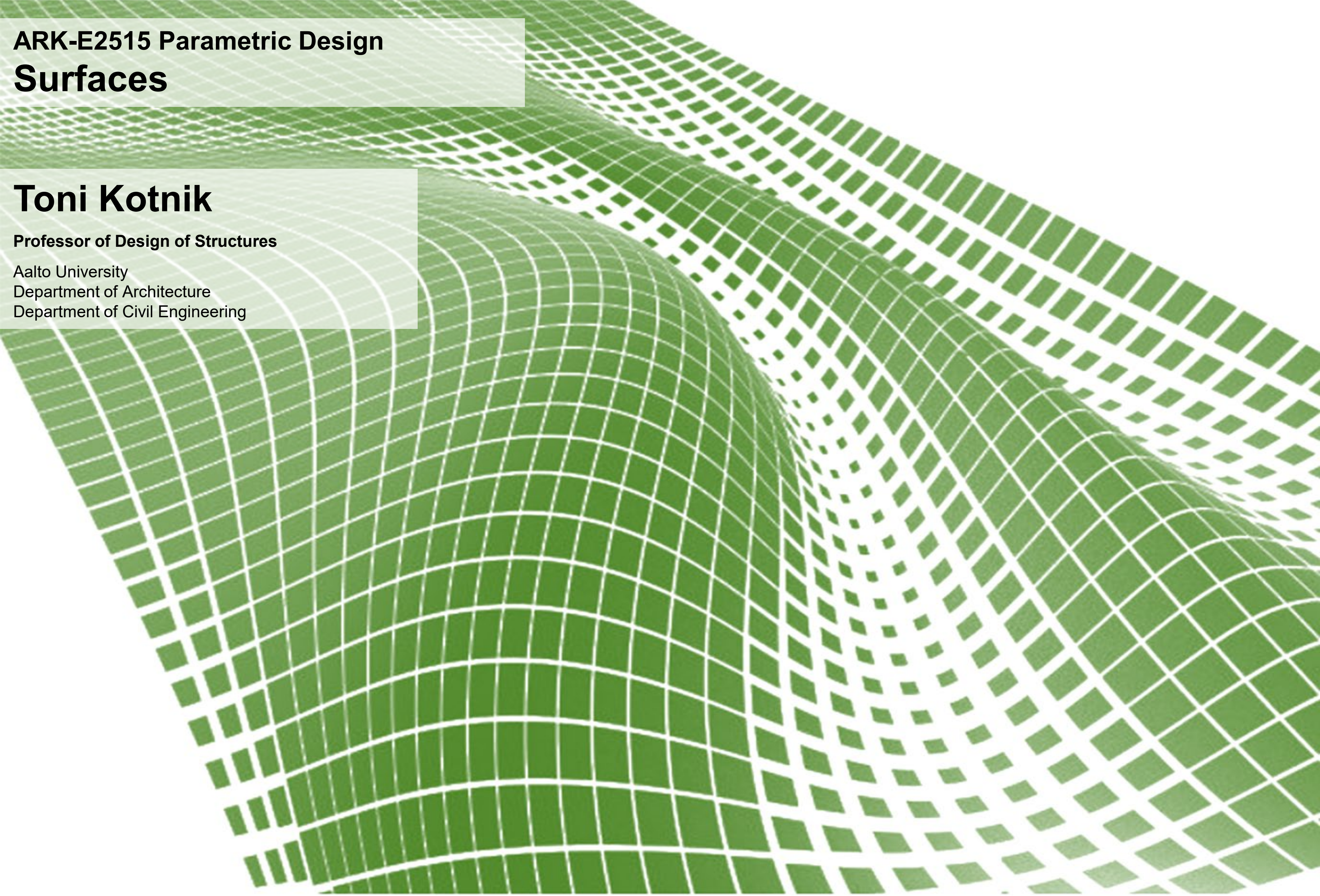


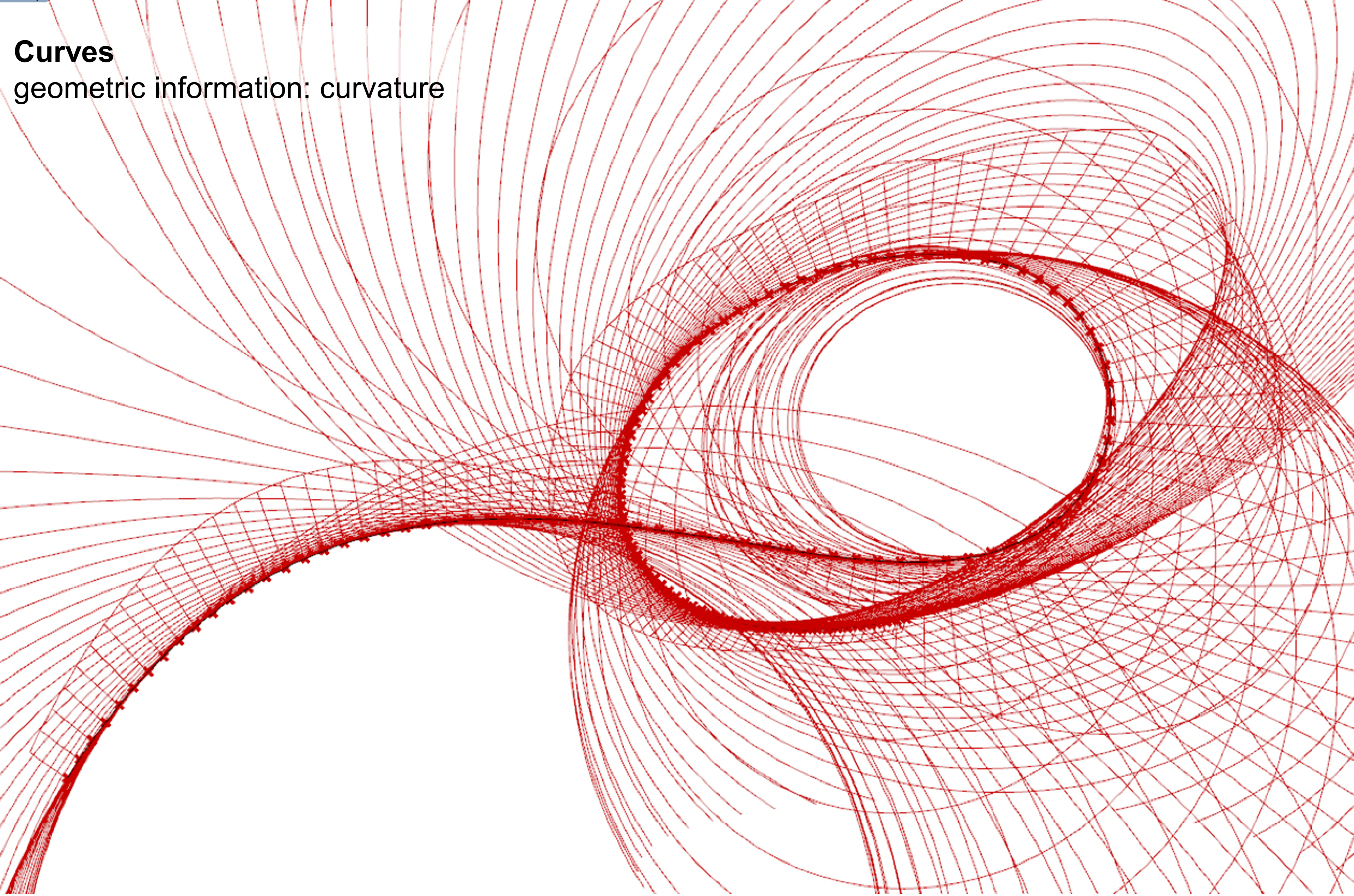
ARK-E2515 Parametric Design
Surfaces

Toni Kotnik

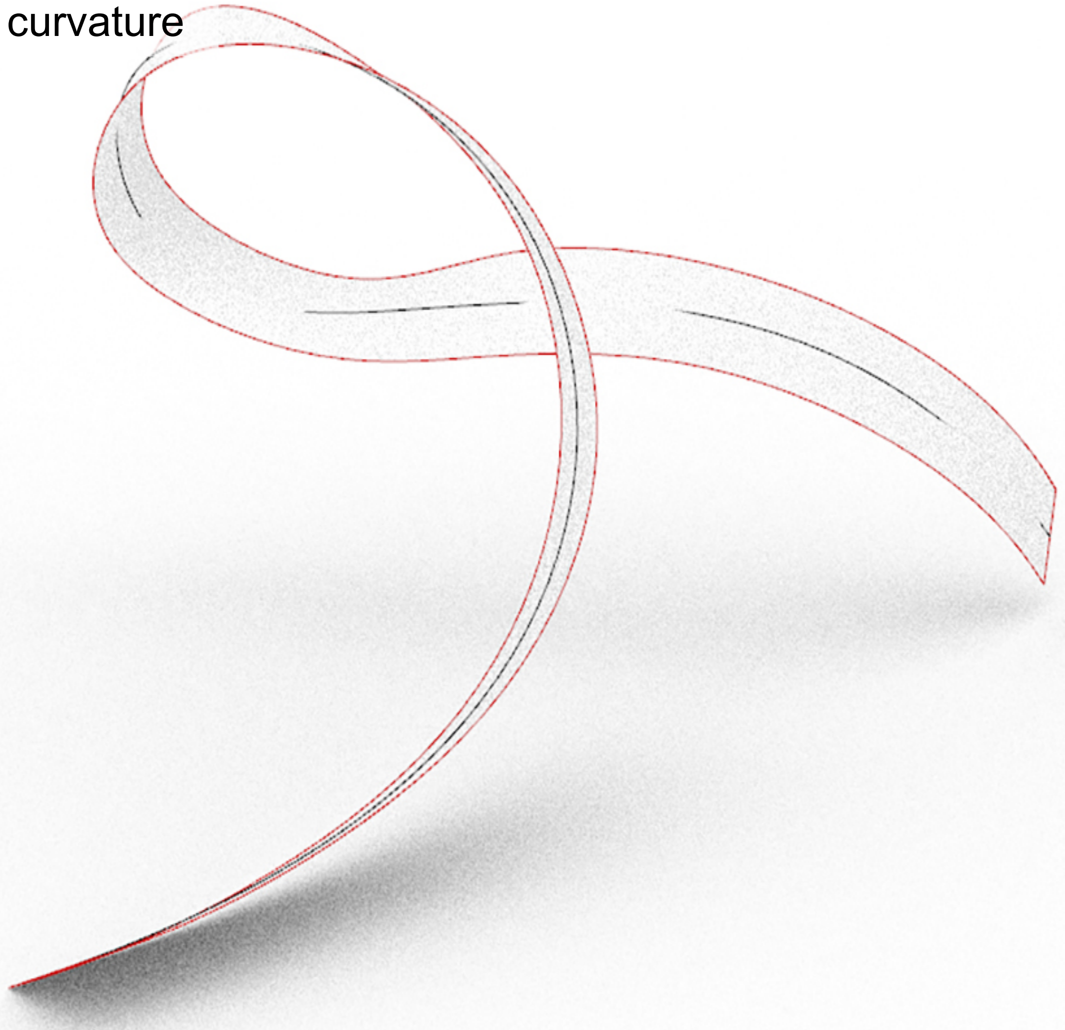
Professor of Design of Structures

Aalto University
Department of Architecture
Department of Civil Engineering

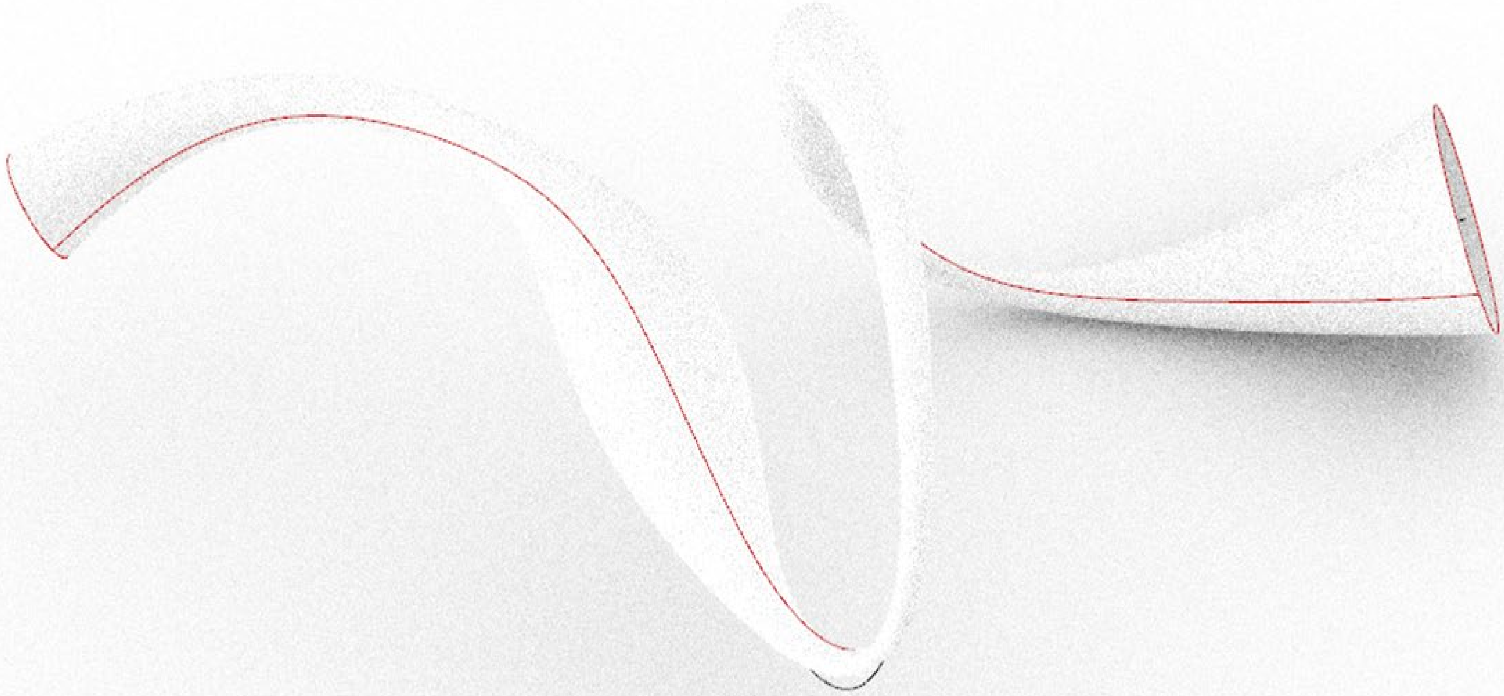
Curves
geometric information: curvature



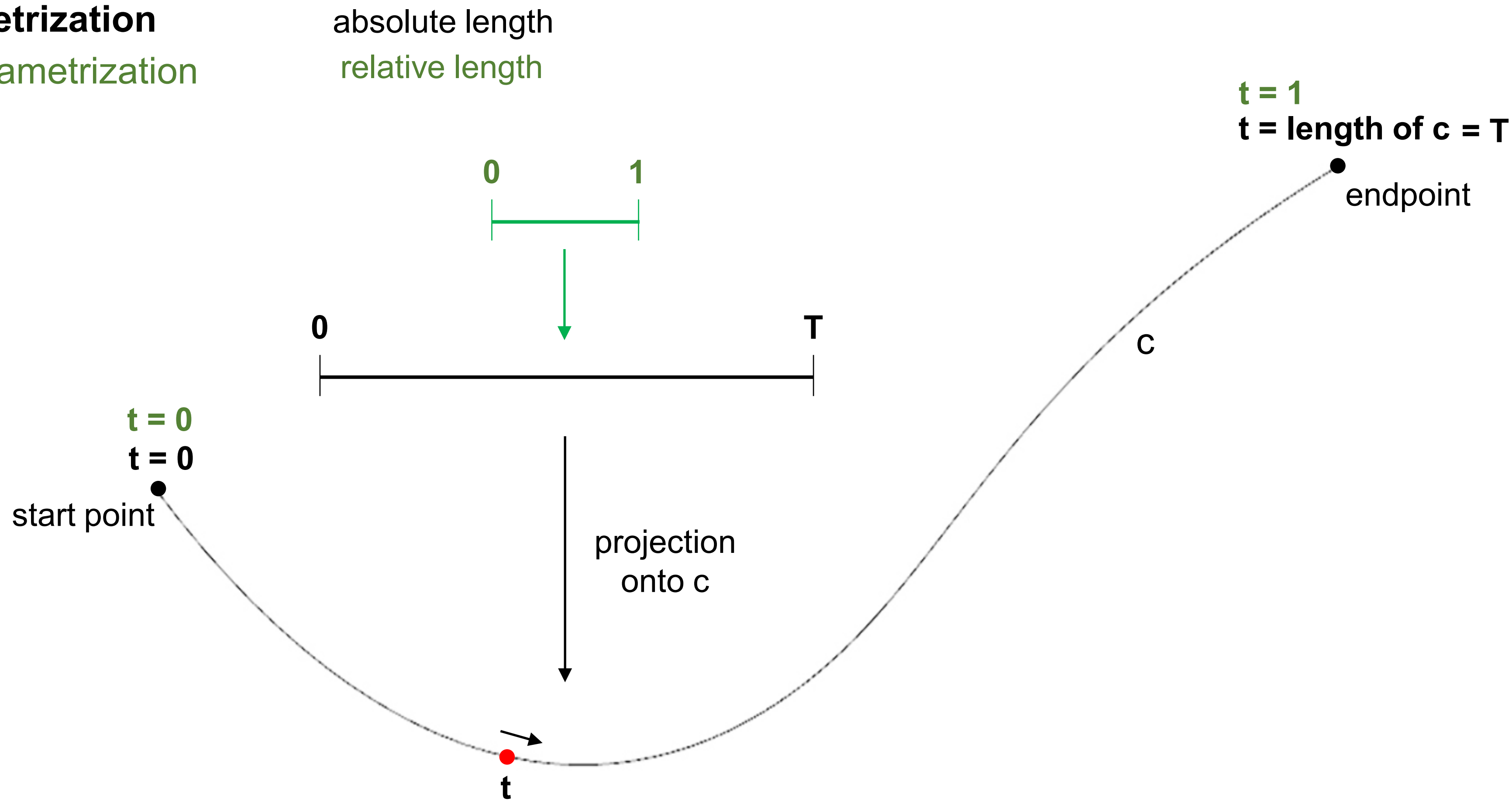
From Curves to Surfaces
geometric information: curvature



From Curves to Surfaces
geometric information: curvature

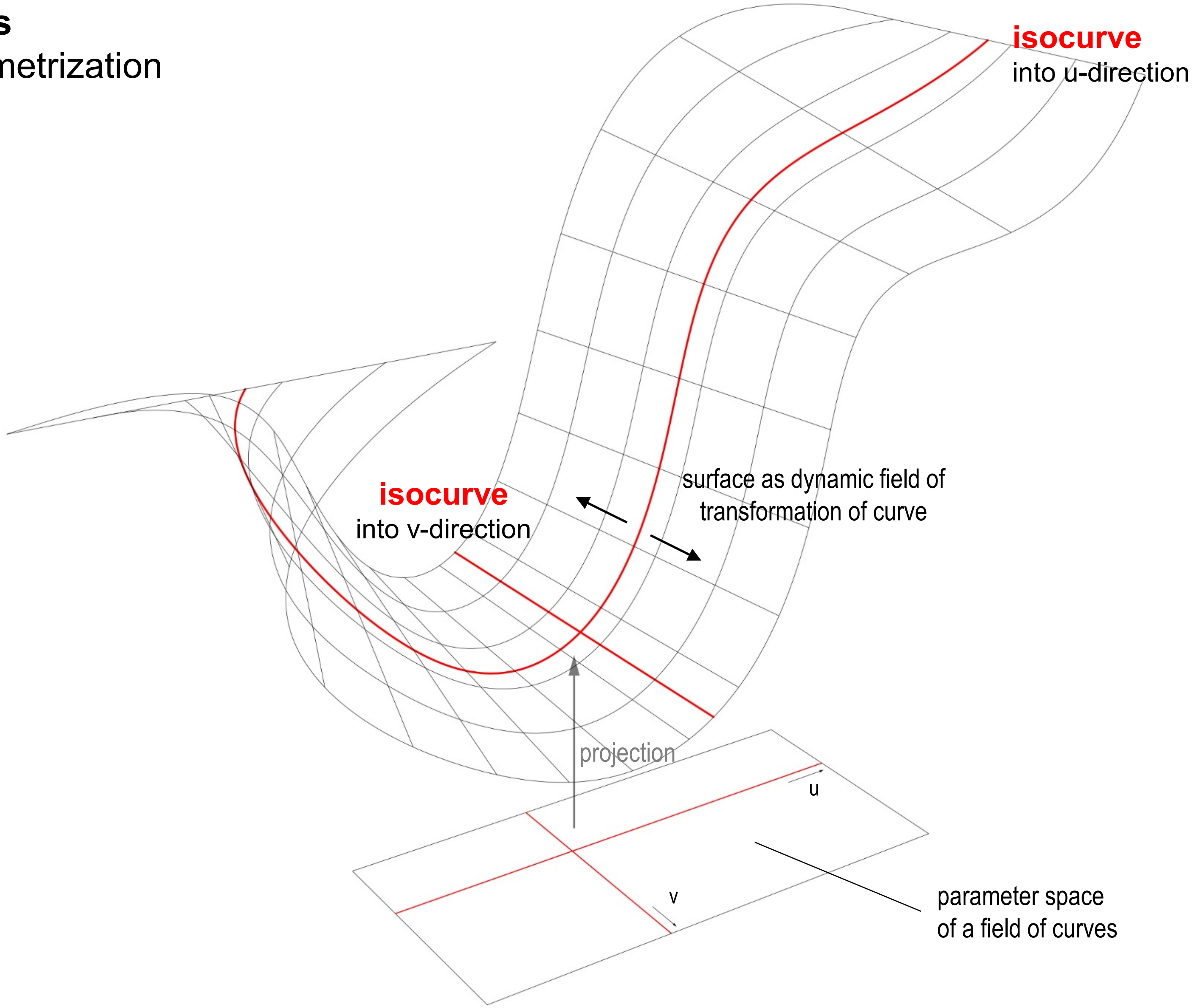


Parametrization
Re-Parametrization



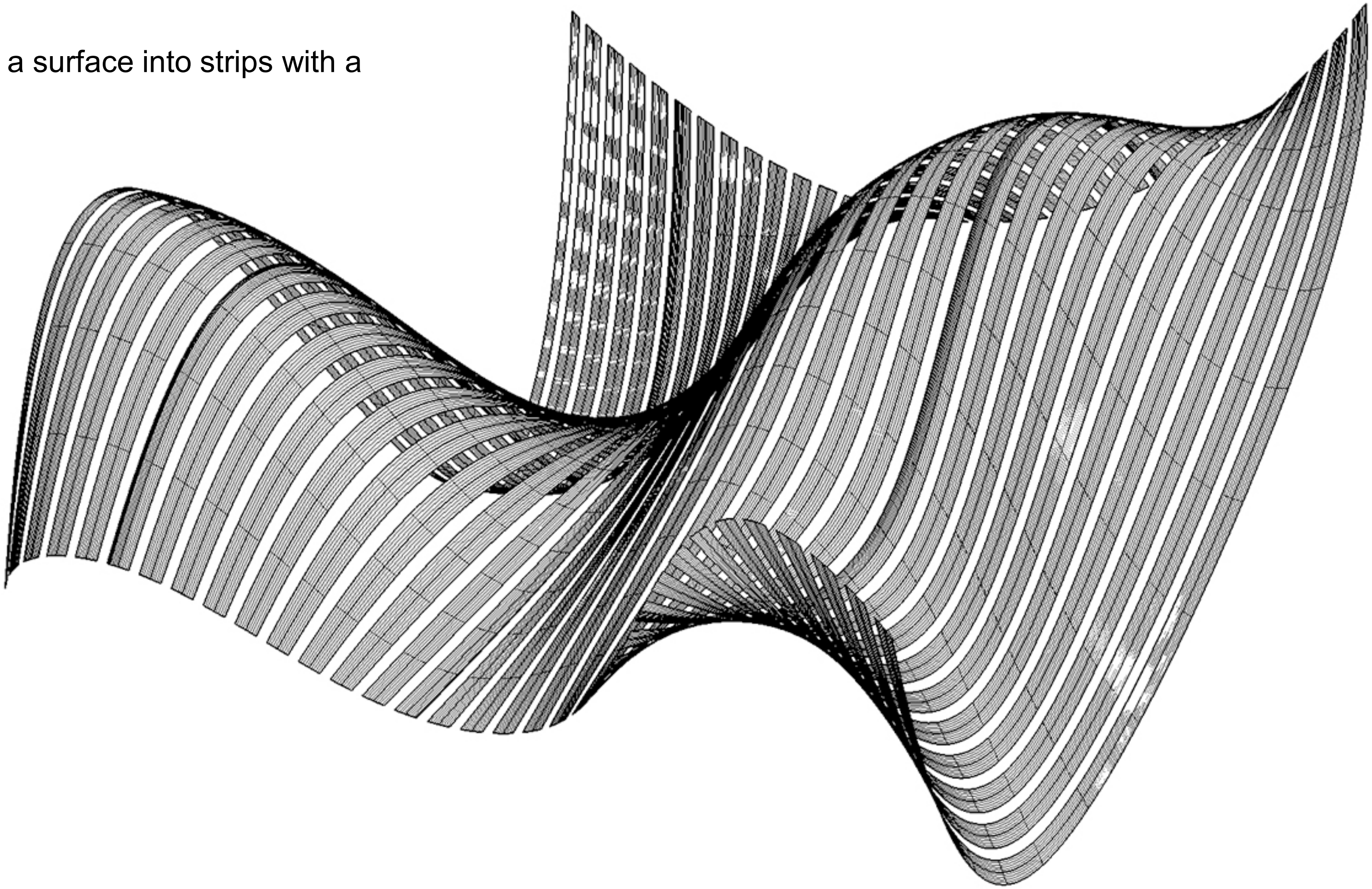
curve as trajectory of a point moving
from start point to endpoint

Surfaces
uv-Parametrization

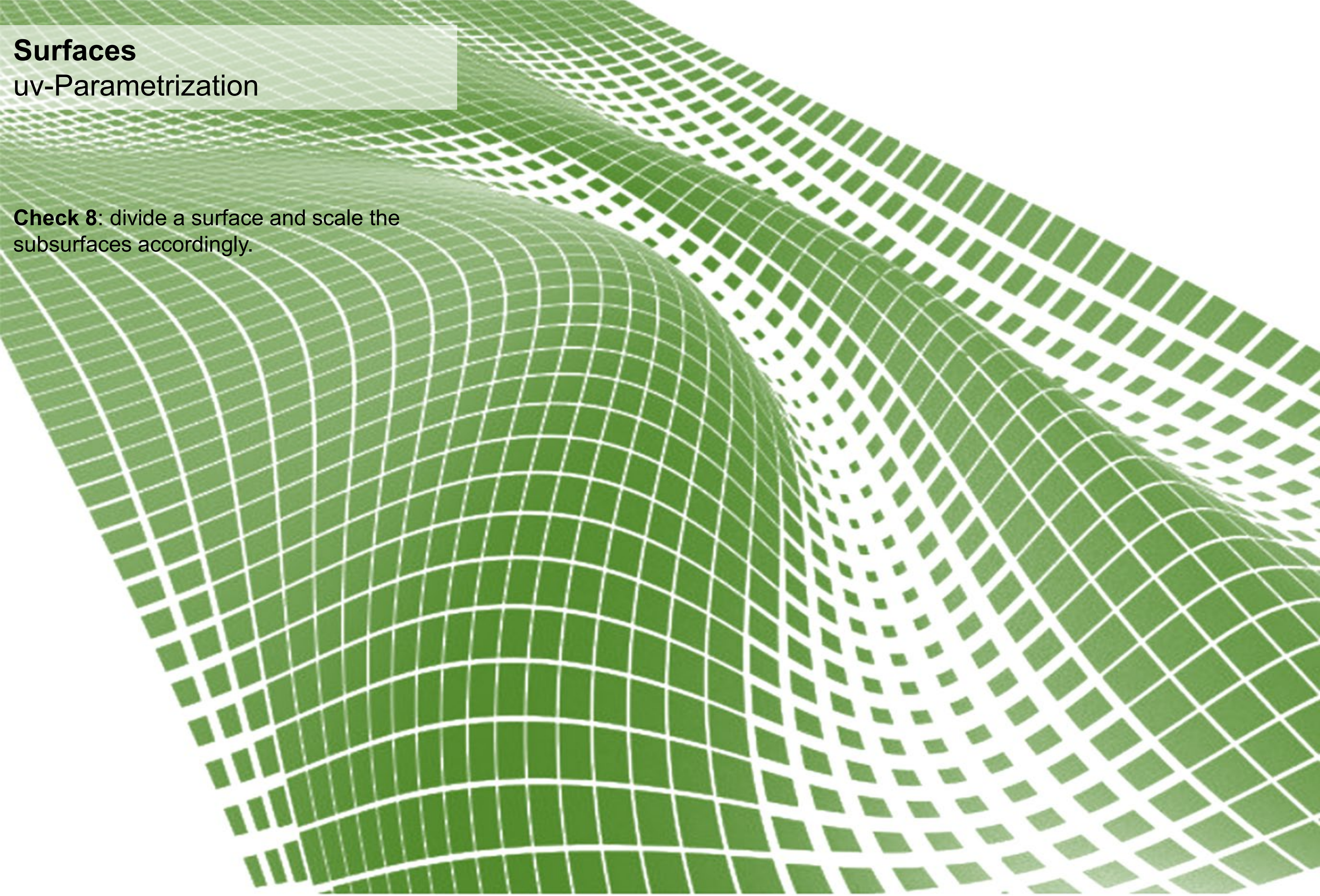


Surfaces
uv-Parametrization

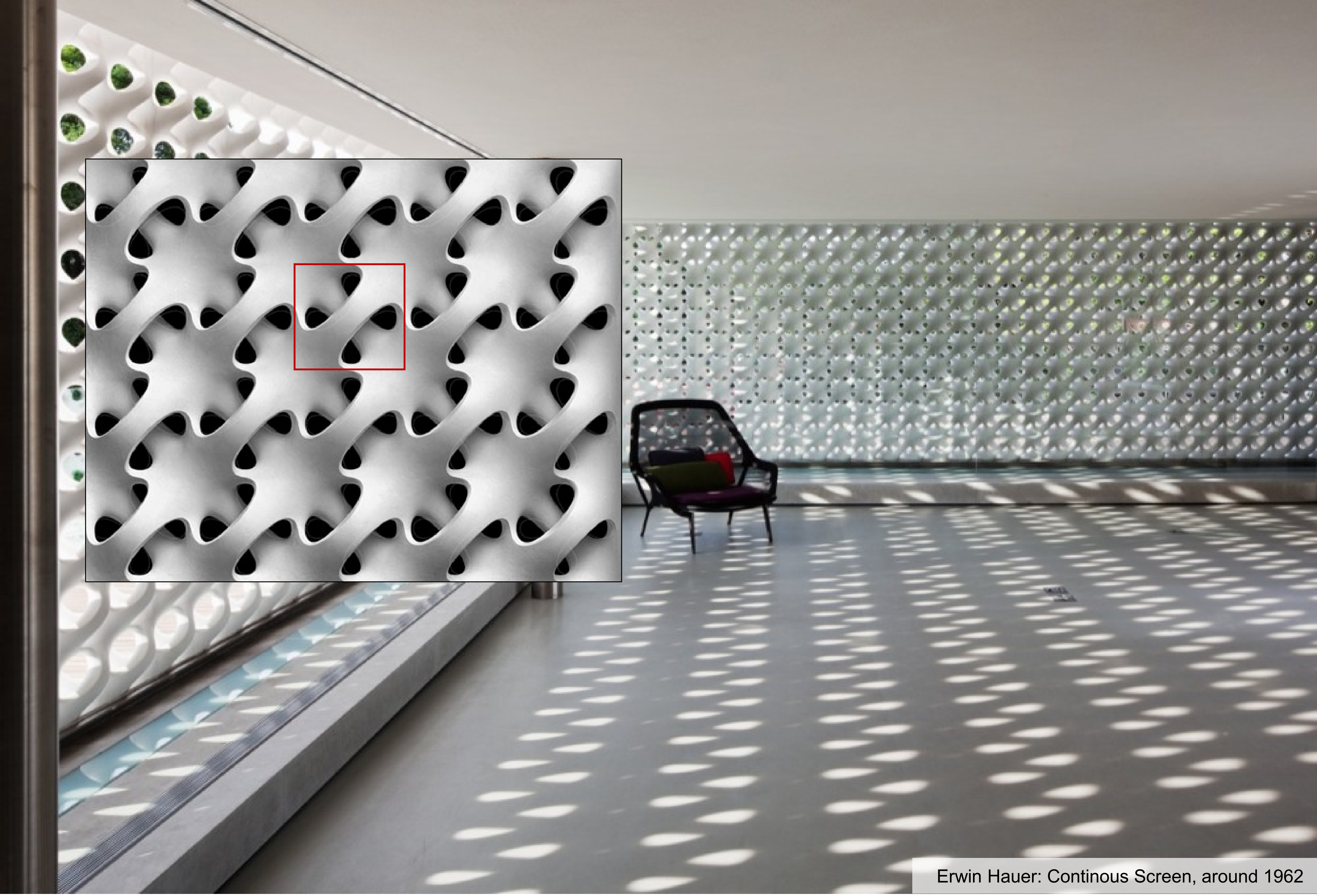
Check 7: divide a surface into strips with a gap in-between.



Surfaces
uv-Parametrization



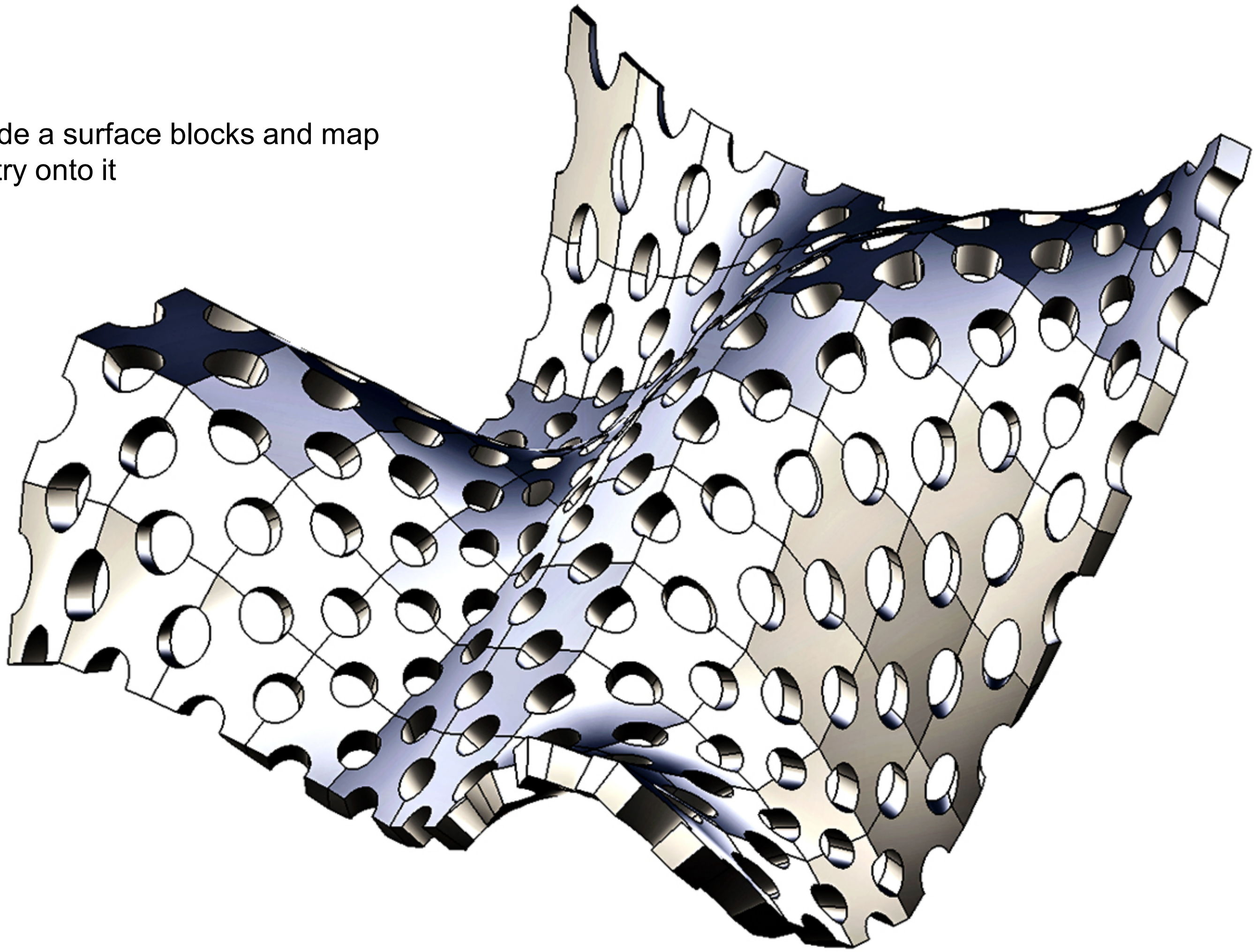
Check 8: divide a surface and scale the subsurfaces accordingly.



Erwin Hauer: Continous Screen, around 1962

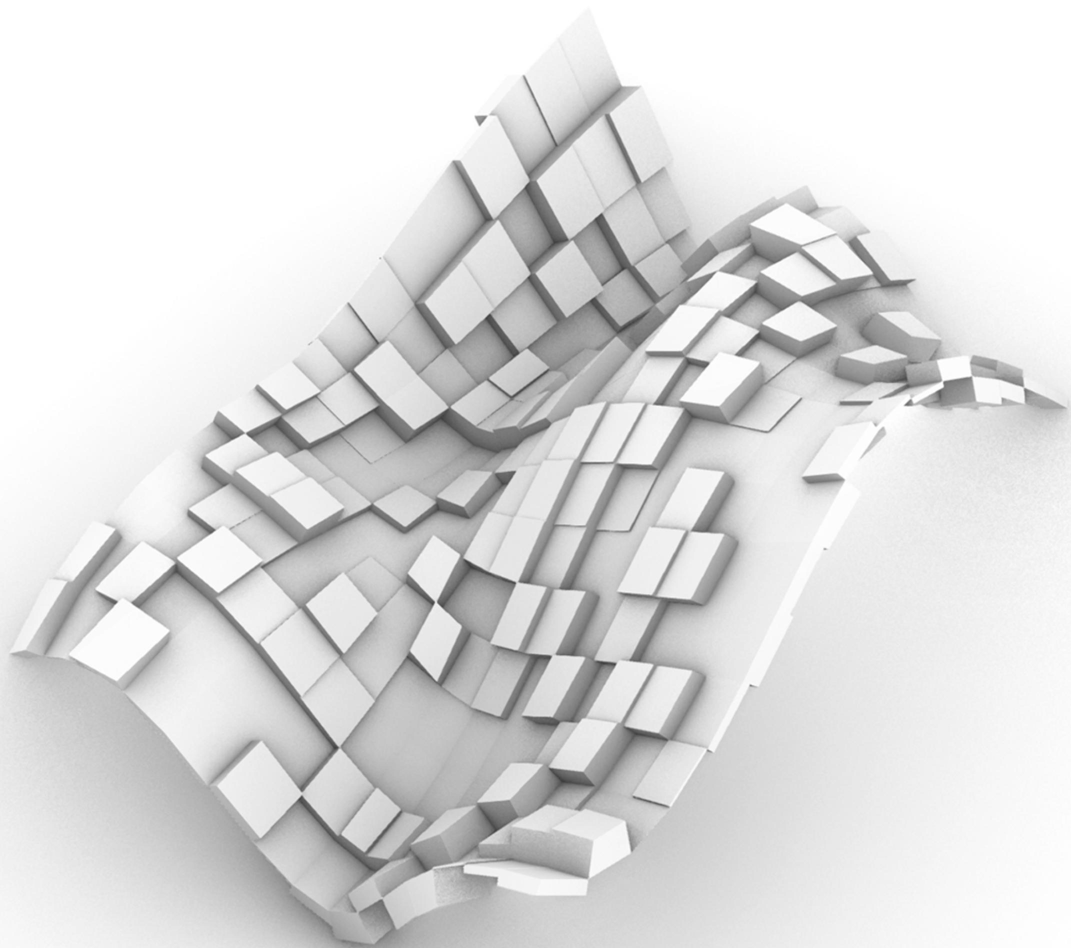
Component Mapping

Check 9: divide a surface blocks and map some geometry onto it



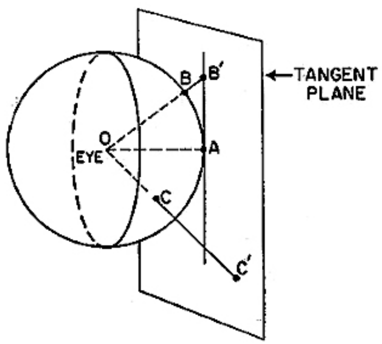
Component Mapping

Exercise 4: divide a surface into blocks of arbitrary height

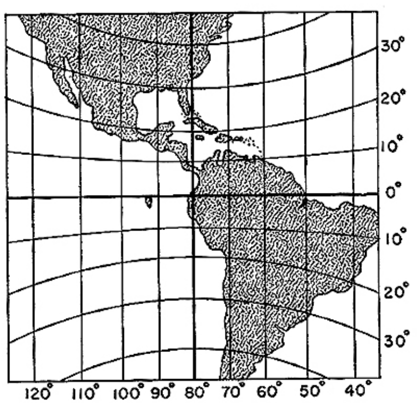


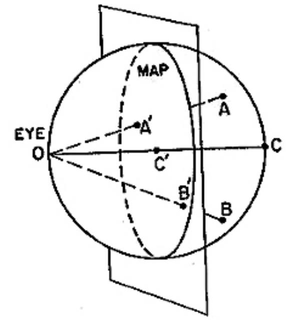
Mapping

Mathematically, the problem of making a map is related to projecting figures from a sphere into the flat. The major difficulty arises out of the fact that a sphere cannot be laid out flat without distorting geometric properties like distance, angle, or area. Because of this it is impossible to represent exactly the geometric properties that exist on a sphere.

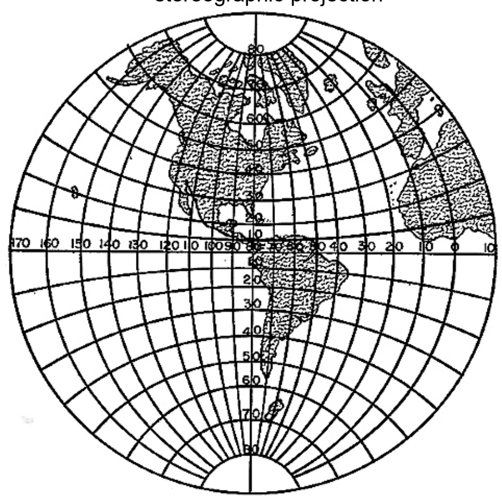


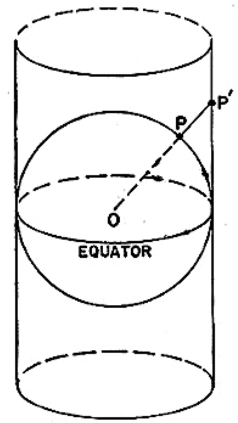
gnomic projection



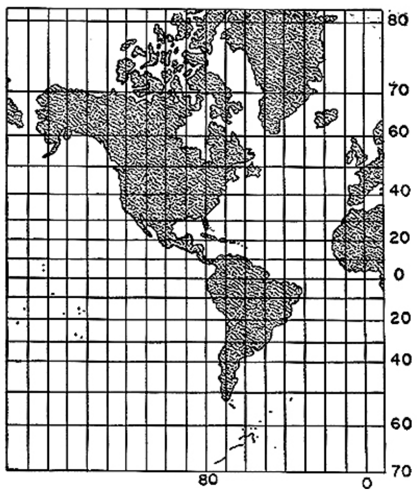


stereographic projection





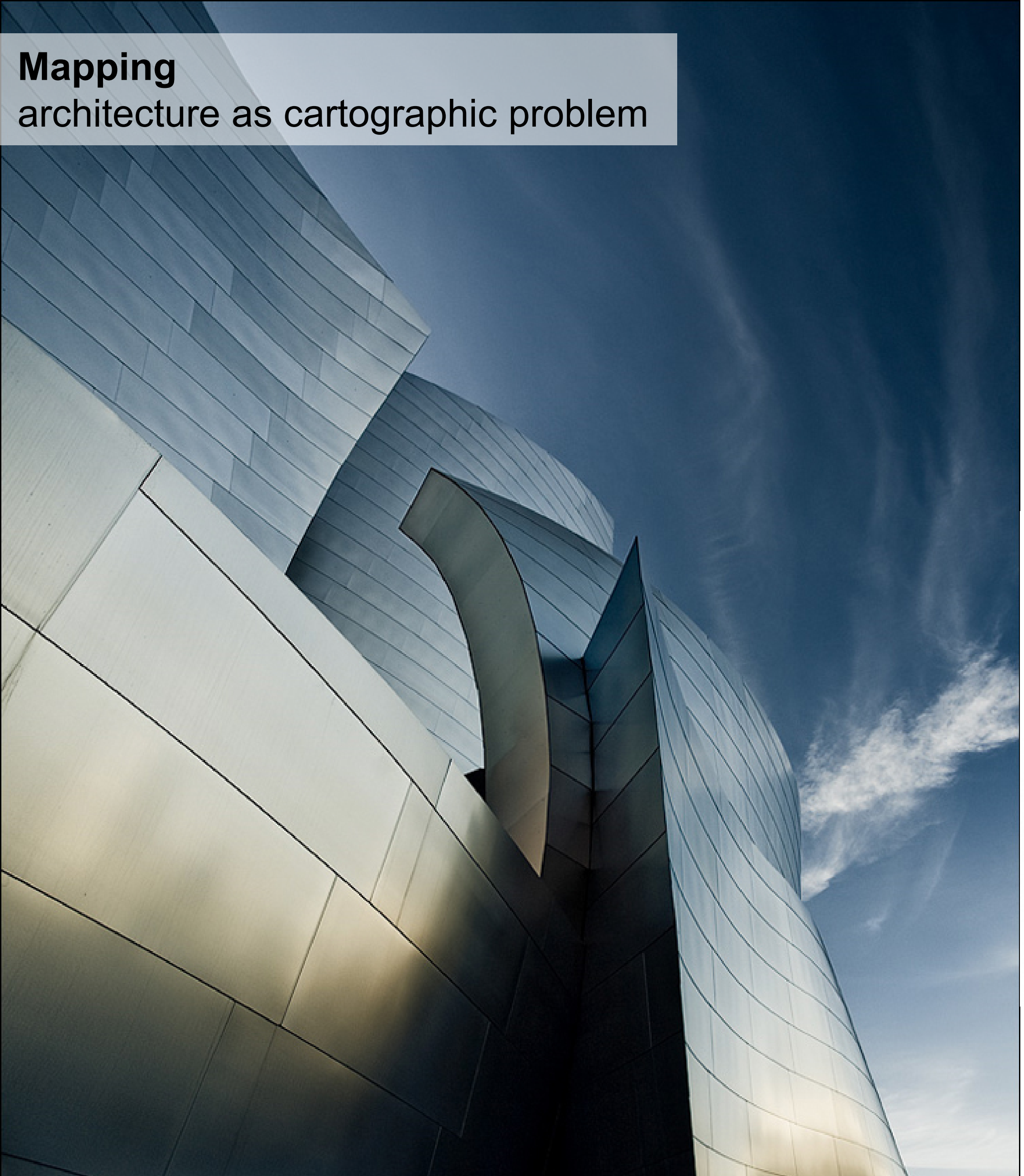
perspective cylindrical projection



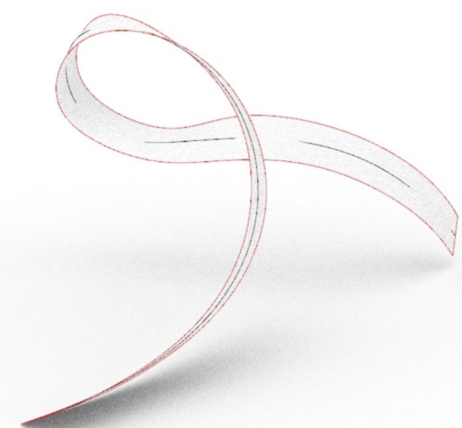
A”DS Aalto University
Design of Structures

Toni Kotnik, Professor of Design of Structures

Mapping
architecture as cartographic problem

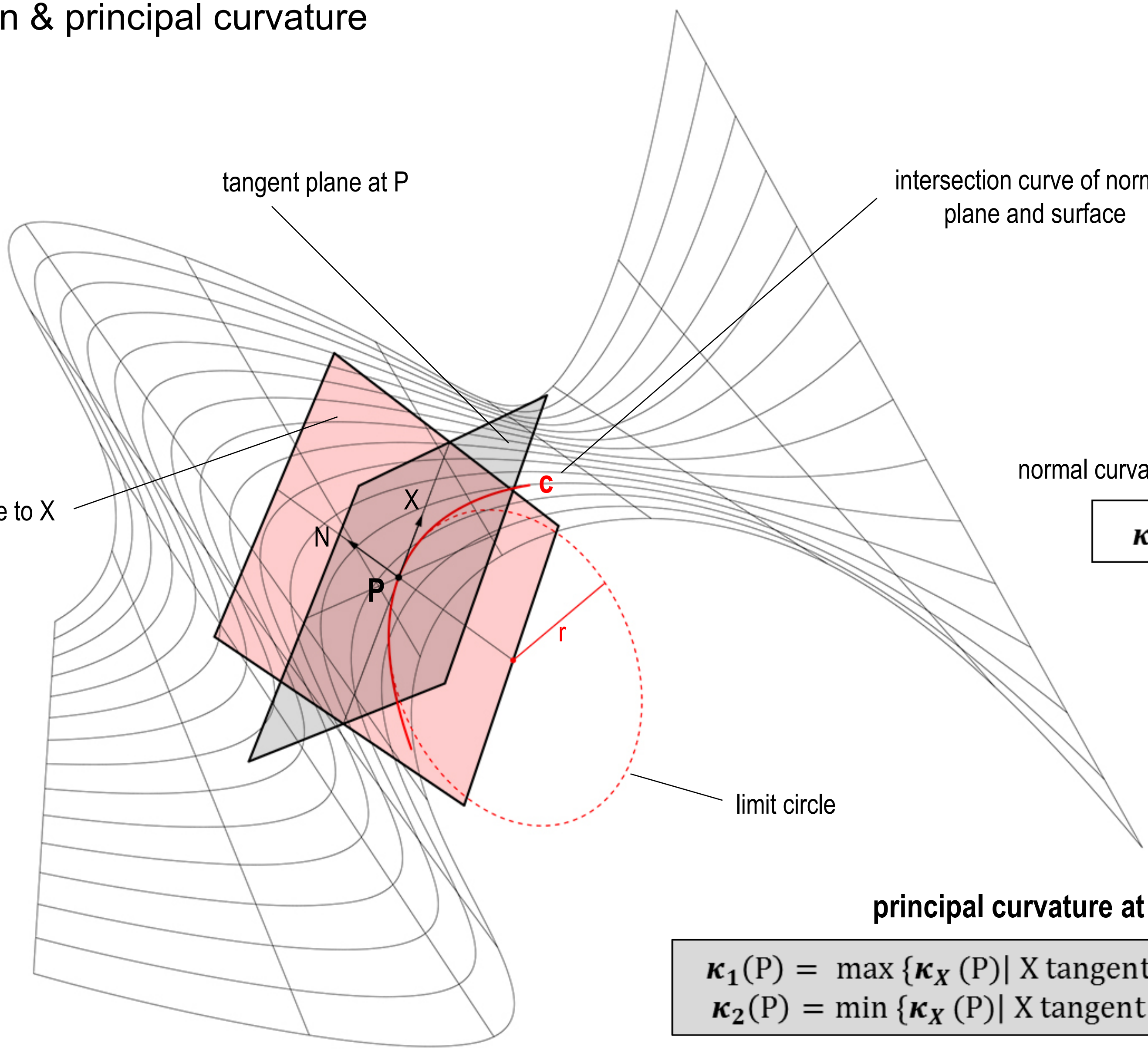


The cartographic problem of distortion is immanent to the construction of curvilinear architecture. Most building material is planar. This means only surfaces that can be mapped without any distortion – so called developable surfaces - can be fabricated and assembled relatively easy.



Frank Gehry: Walt Disney Concert Hall
Los Angeles, USA, 1999-2003

Surfaces
normal direction & principal curvature



normal curvature at P into direction X

$$\kappa_X(P) = {}^1/_r$$

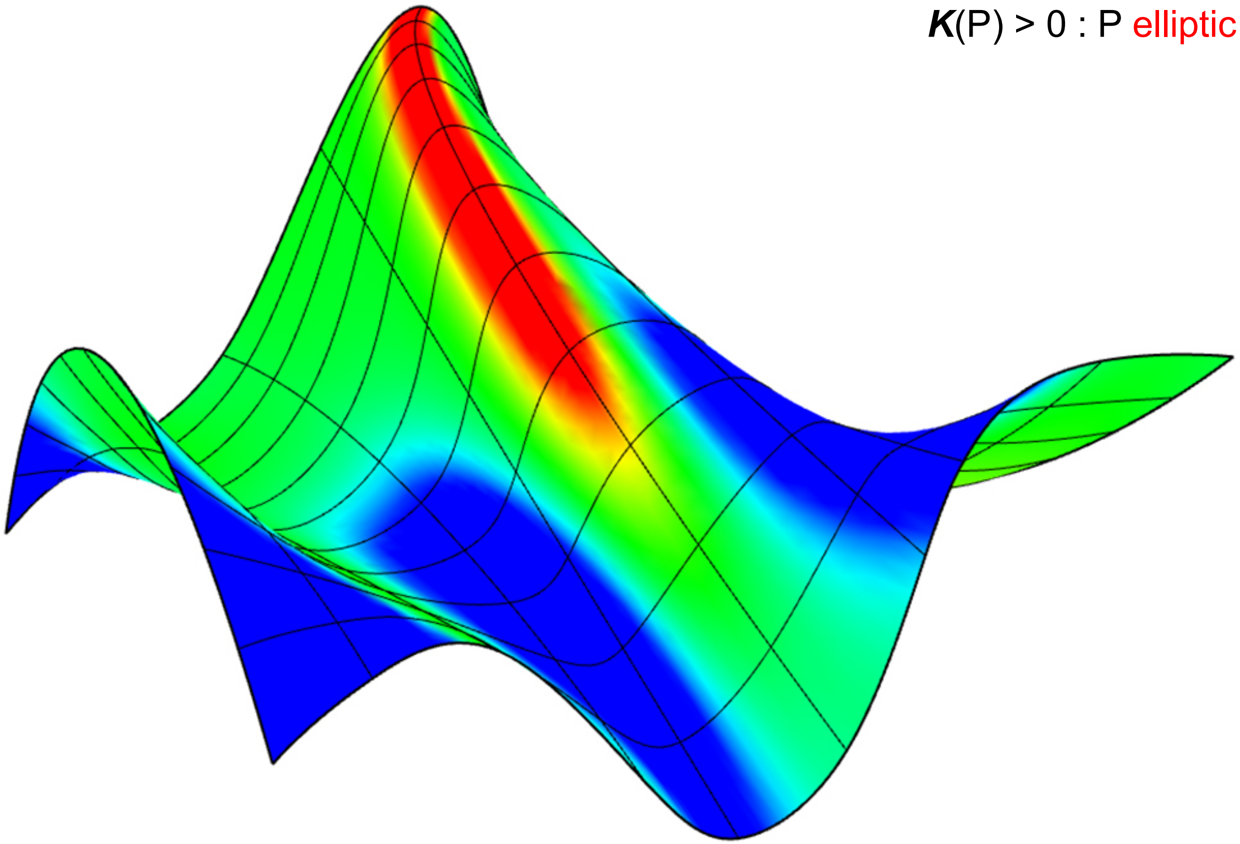
principal curvature at P

$$\kappa_1(P) = \max\{\kappa_X(P) \mid X \text{ tangent vector in } P\}$$
$$\kappa_2(P) = \min\{\kappa_X(P) \mid X \text{ tangent vector in } P\}$$

Surfaces
Gaussian curvature

$$K = \kappa_1 \kappa_2$$

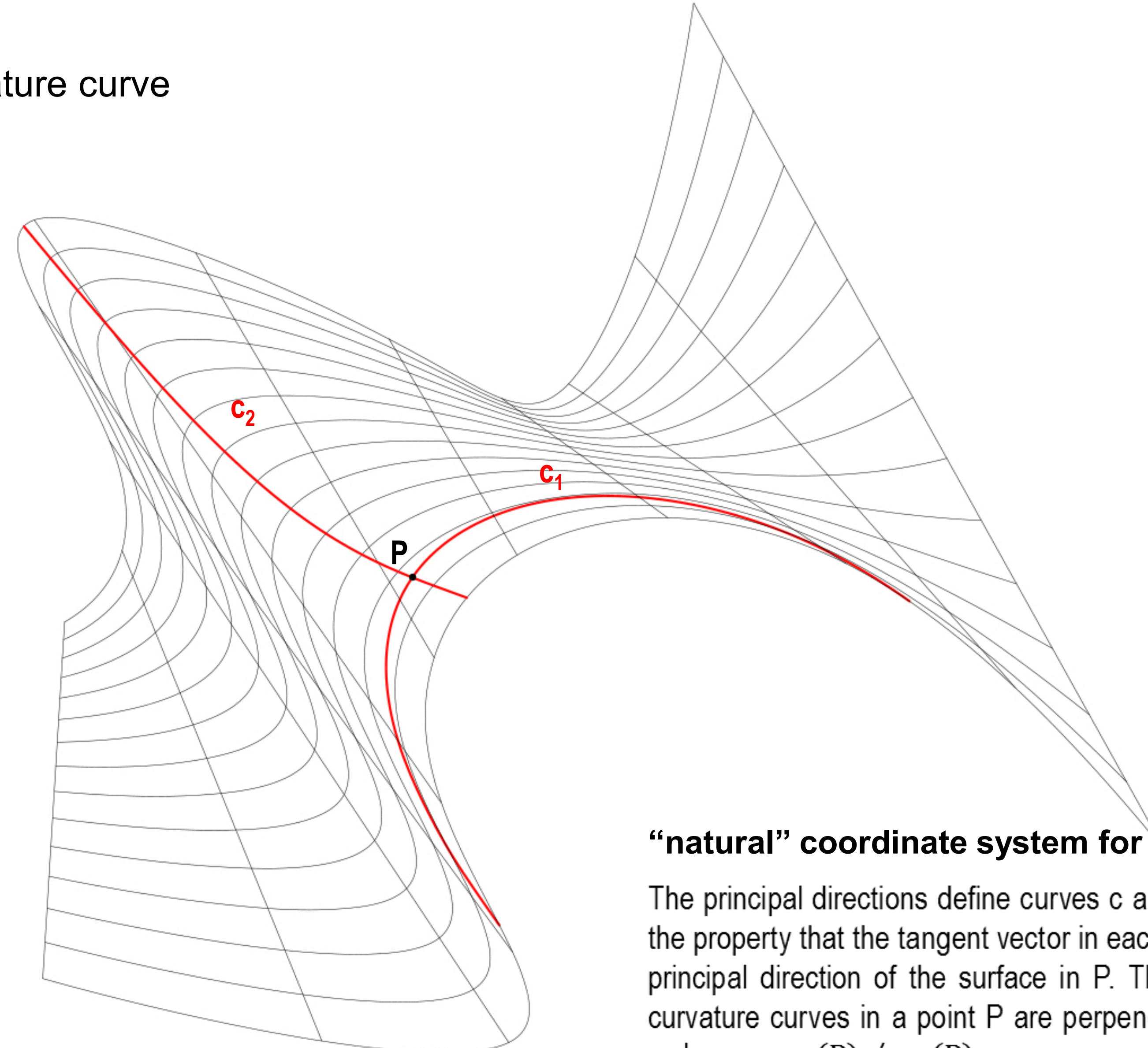
$K(P) < 0$: P hyperbolic point
$K(P) = 0$: P parabolic point
$K(P) > 0$: P elliptic point



a developable surface is a surface where every point is a parabolic point, e.g. a paperstrip

Frank Gehry: Walt Disney Concert Hall
Los Angeles, USA, 1999-2003

Surfaces
principal curvature curve



“natural” coordinate system for surfaces

The principal directions define curves c along the surface with the property that the tangent vector in each point P = c(t) is the principal direction of the surface in P. The resulting principal curvature curves in a point P are perpendicular to each other as long as $\boldsymbol{\kappa_1}(\mathrm{P}) \neq \boldsymbol{\kappa_2}(\mathrm{P})$.

Principal Curvature Curve

Peter Cook & Colin Fournier: Art Museum
Graz, Austria, 2002-03

Principal Curvature Curve

Peter Cook & Colin Fournier: Art Museum
Graz, Austria, 2002-03

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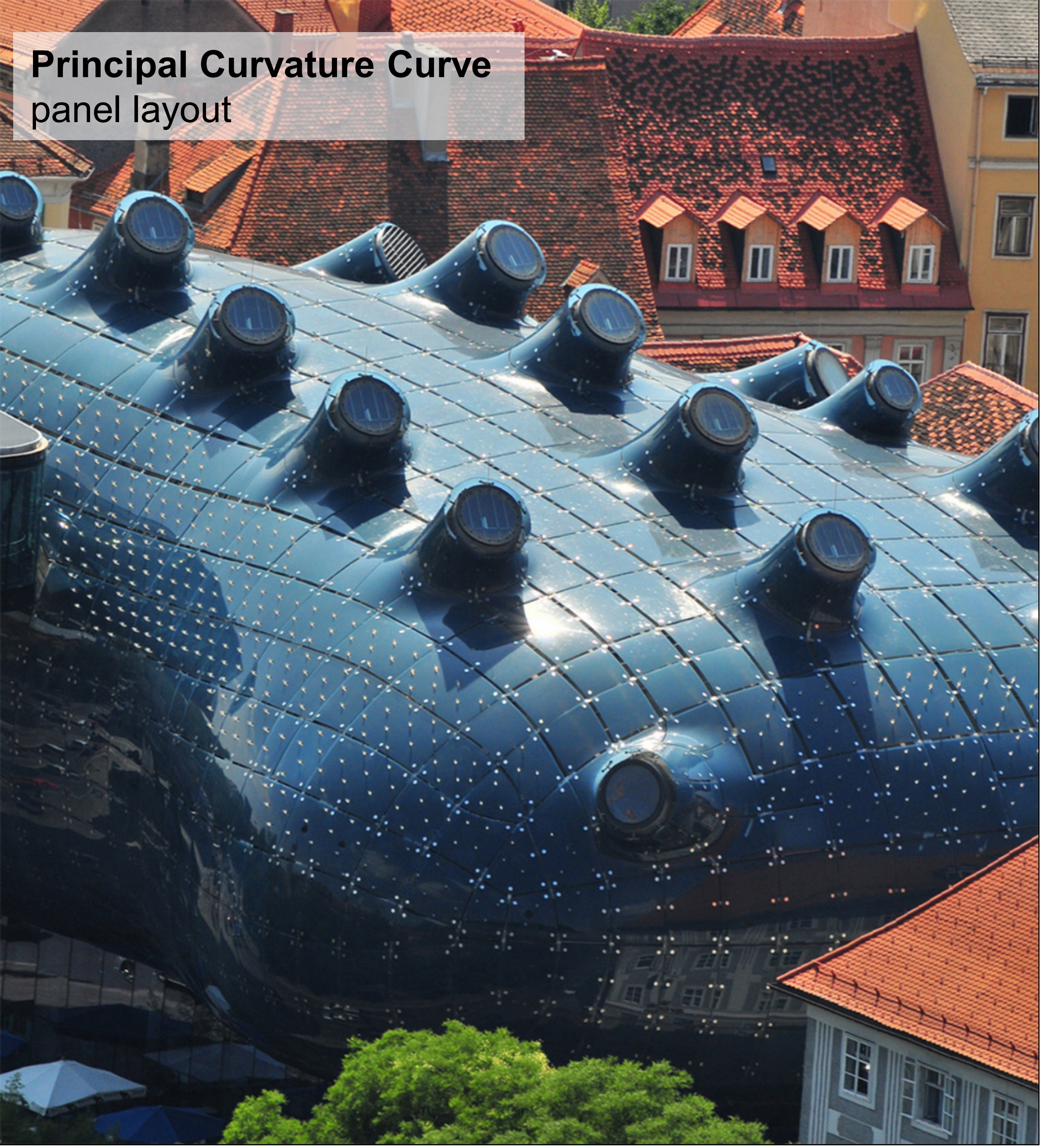
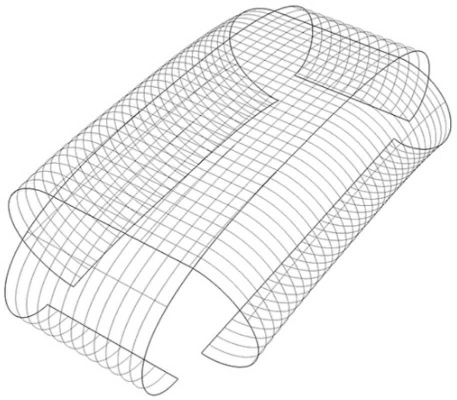
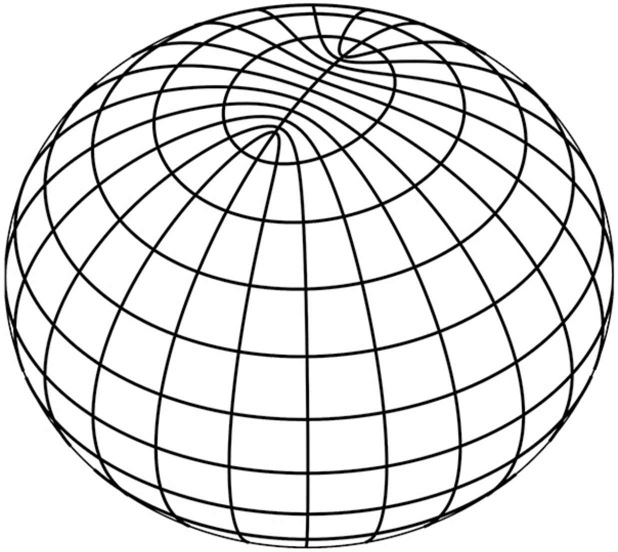


Principal Curvature Curve
panel layout



subdivision with respect to coordinate axis
results in unresolved corner



principal curvature curves for an ellipsoid

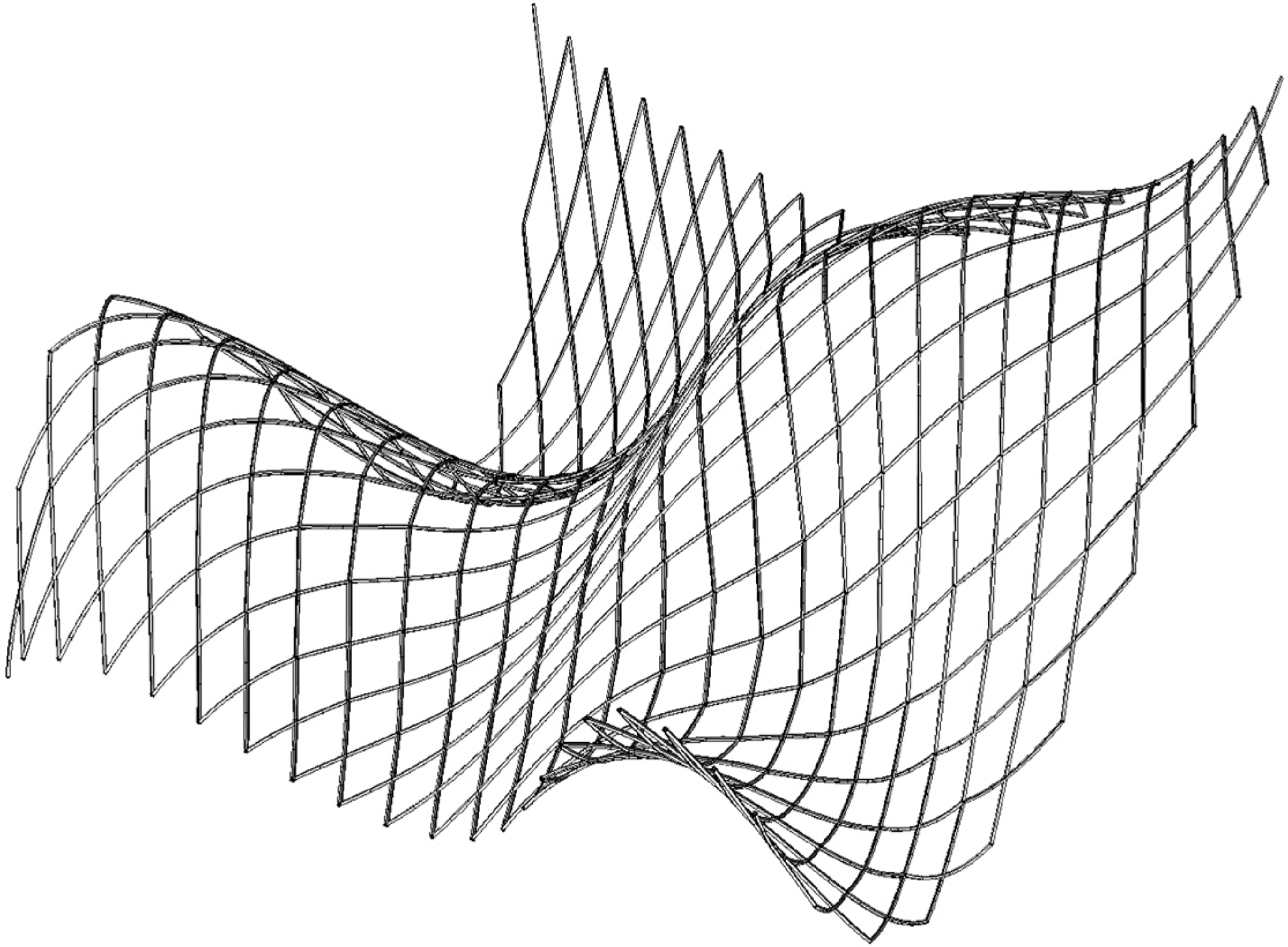
Peter Cook & Colin Fournier: Art Museum
Graz, Austria, 2002-03

diagrid

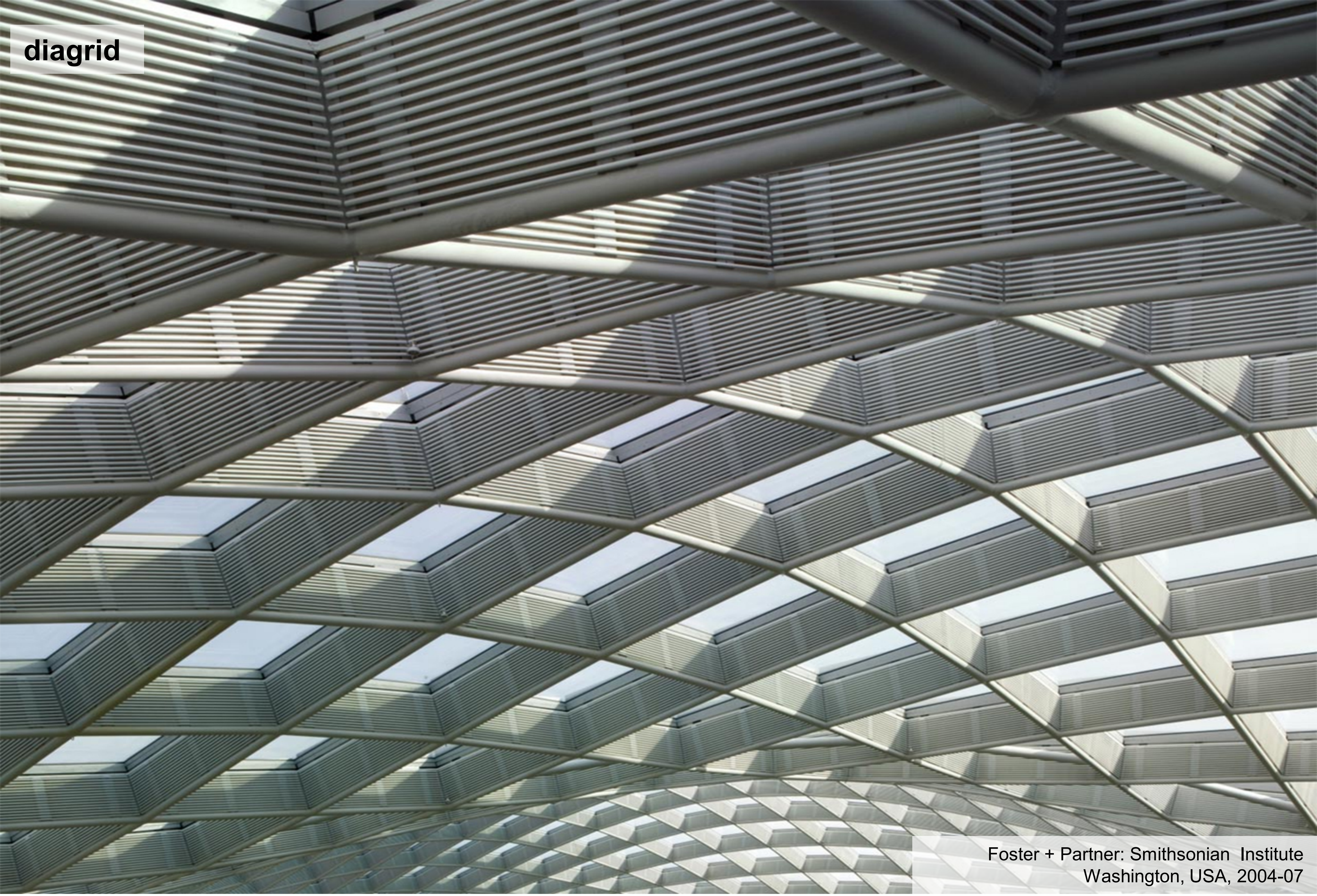
Foster + Partner: Smithsonian Institute
Washington, USA, 2004-07

diagrid

Check 10: divide a surface into a diagrid



diagrid

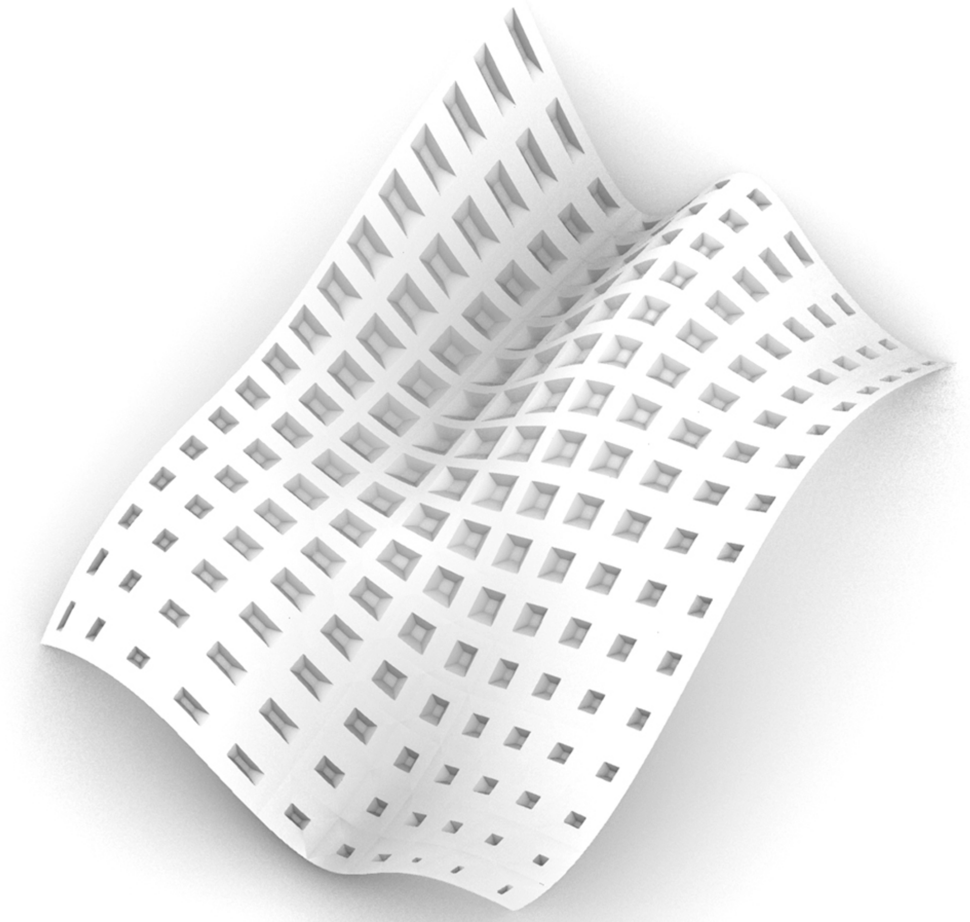


Foster + Partner: Smithsonian Institute
Washington, USA, 2004-07

diagrid

Foster + Partner: Smithsonian Institute
Washington, USA, 2004-07

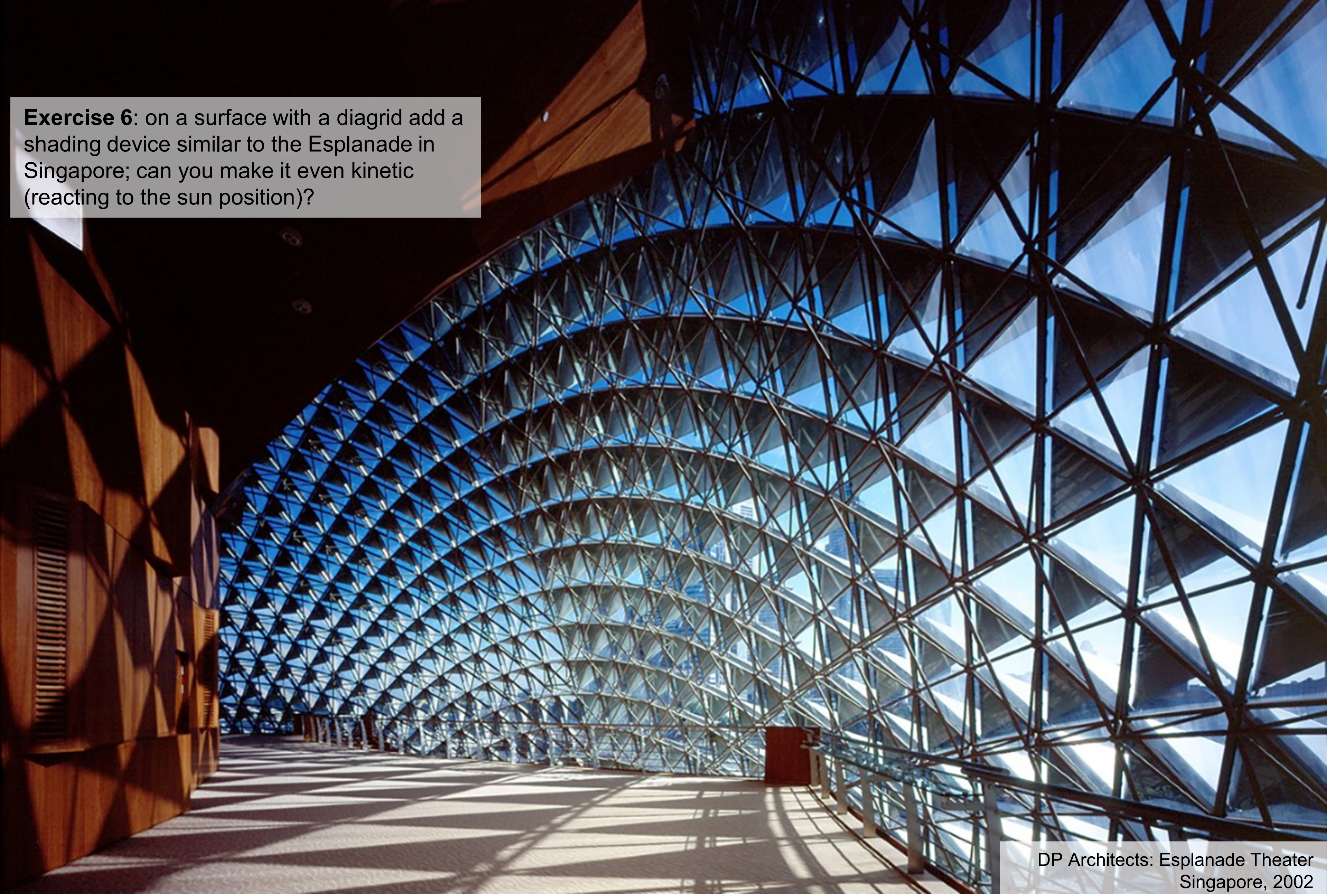
Exercise 5: construct a roof with varying size of opening with the variation controlled by the curvature of the surface.



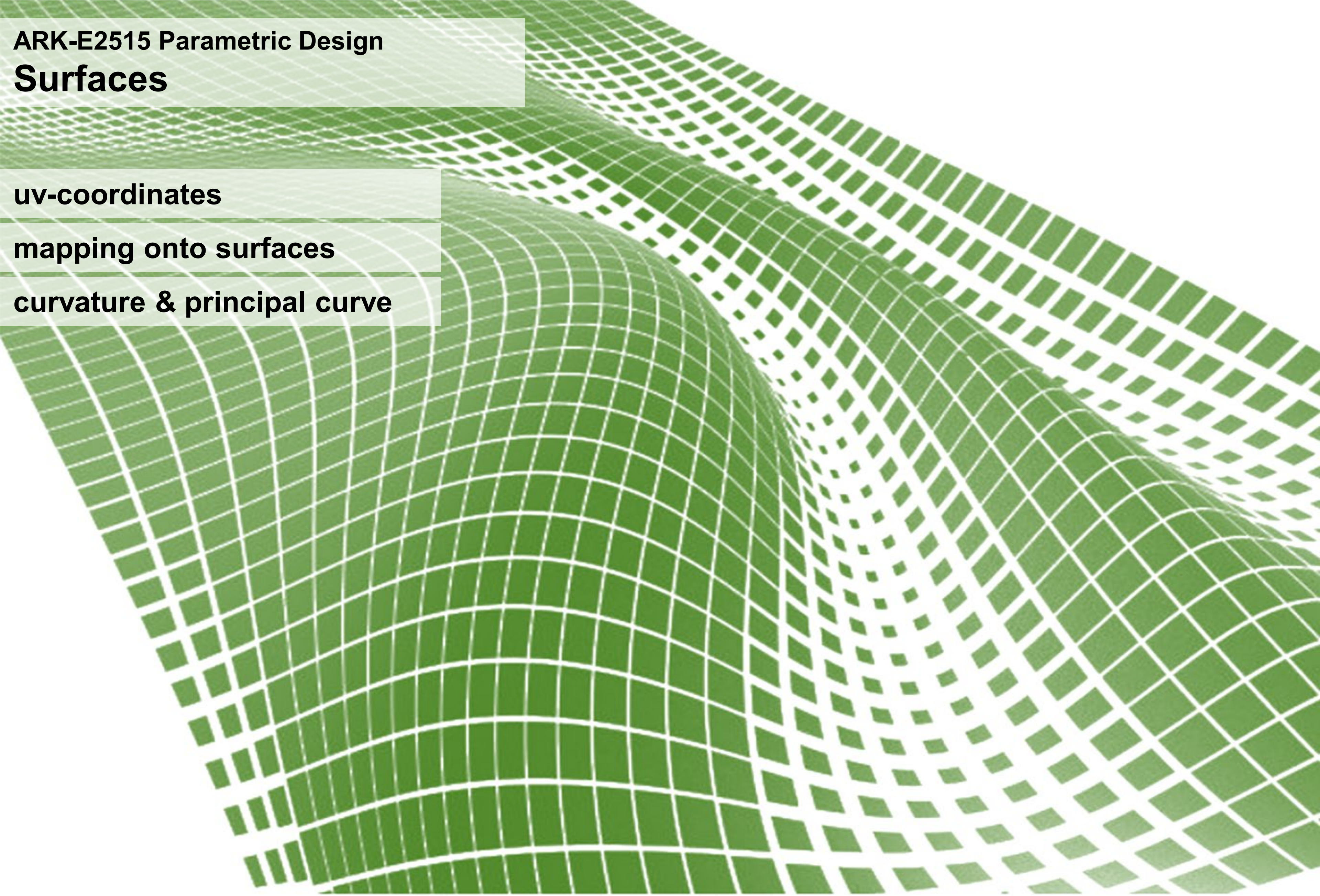
DP Architects: Esplanade Theater
Singapore, 2002

DP Architects: Esplanade Theater
Singapore, 2002

Exercise 6: on a surface with a diagrid add a shading device similar to the Esplanade in Singapore; can you make it even kinetic (reacting to the sun position)?



DP Architects: Esplanade Theater
Singapore, 2002



ARK-E2515 Parametric Design
Surfaces

uv-coordinates
mapping onto surfaces
curvature & principal curve