INNOPOLIS UNIVERSITY

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Introduction to 3D modeling

Motivation

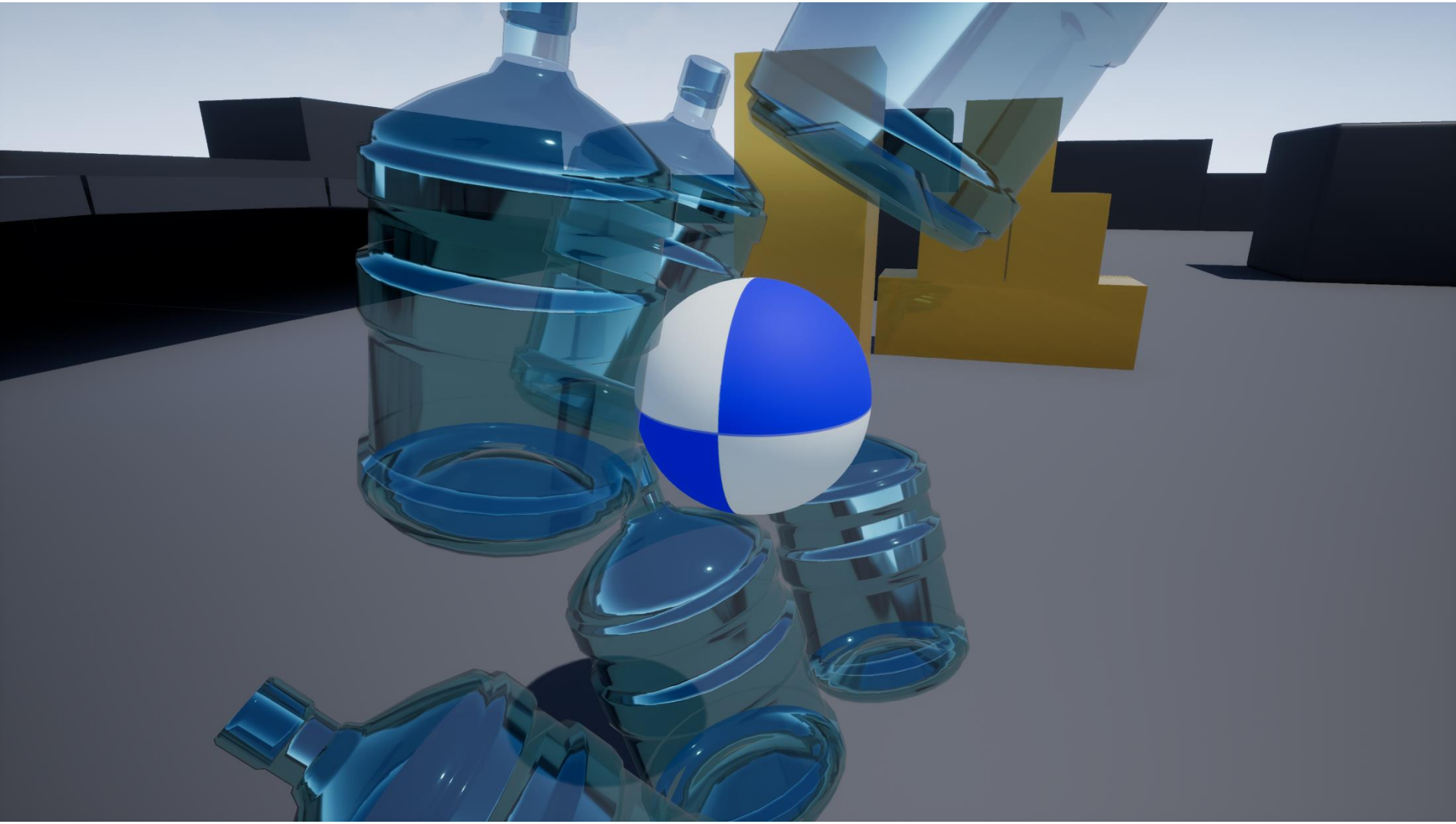
Why should everyone learn 3d modeling?

Where 3D modeling is used?

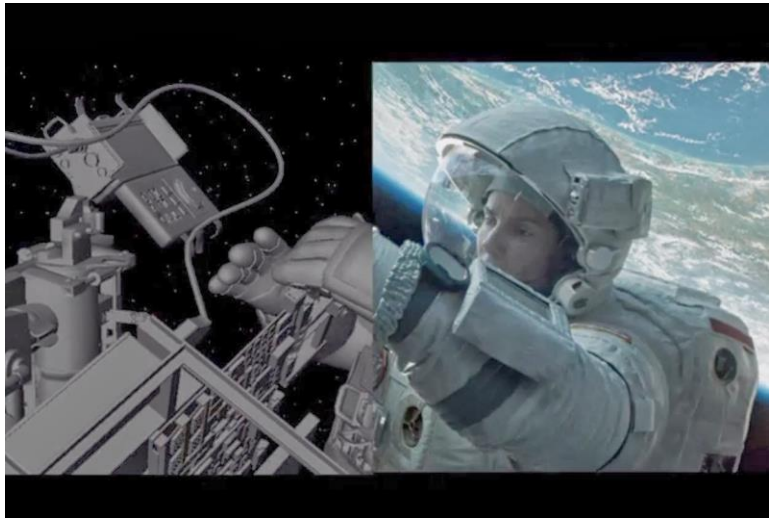
Some terms that will be explained further:
CGI – Computer Generated Image
PBR – Physically Based Rendering
CAD – Computer-Aided Design

Note: most pictures used here are taken from google and various sites

Second Part of Workshop

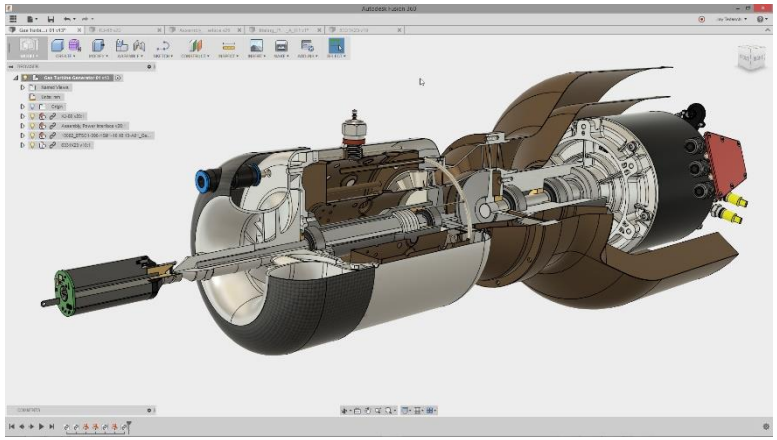


Fields of application



Gravity (2013) “CGI Breakdown”

Gleb Alexandrov “Modeling as art”

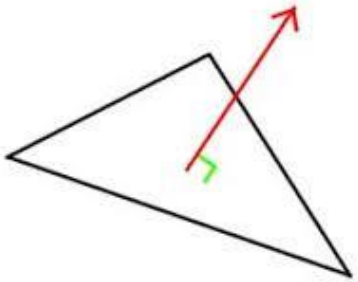


CAD “Professional precision modeling”

Witcher 3 “Visual Component”

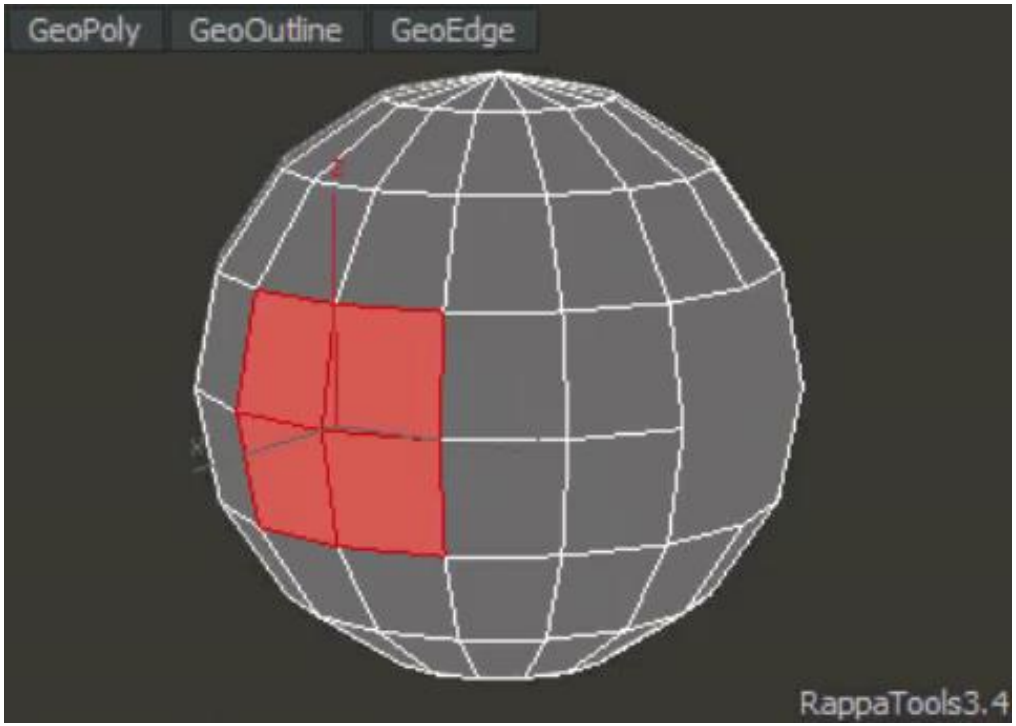
So what is 3D computer world about in polygonal modeling?

- point in space is called **vertex**
- line segment that connects two vertices called **edge**
- if there is loop of edges we can fill it thus creating **polygon**
- polygon has no thickness, but has two sides
- only one of this sides is visible, the one associated with **normal**



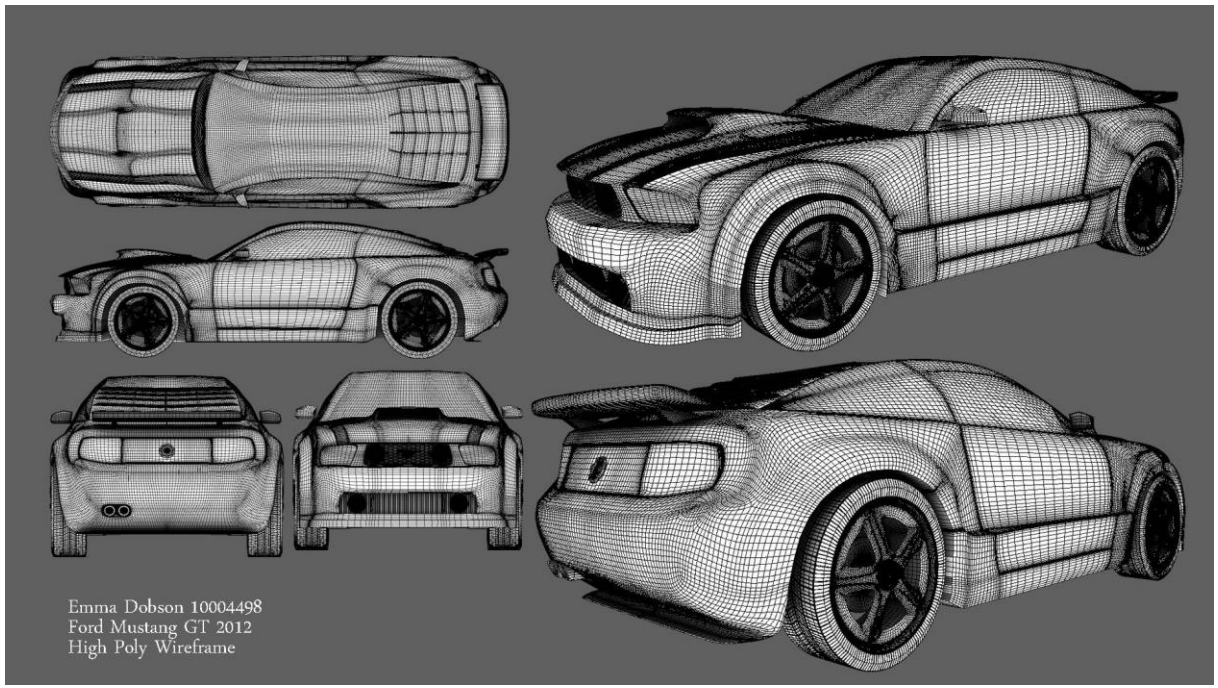
- opposite side is invisible, this is called **backface culling**
- most 3d modelling software provide simple way to turn sides, it's called **flipping normal**
- Set of polygons (with shared edges) is called **mesh**

So, modeling is about moving vertices, edges and polygons…

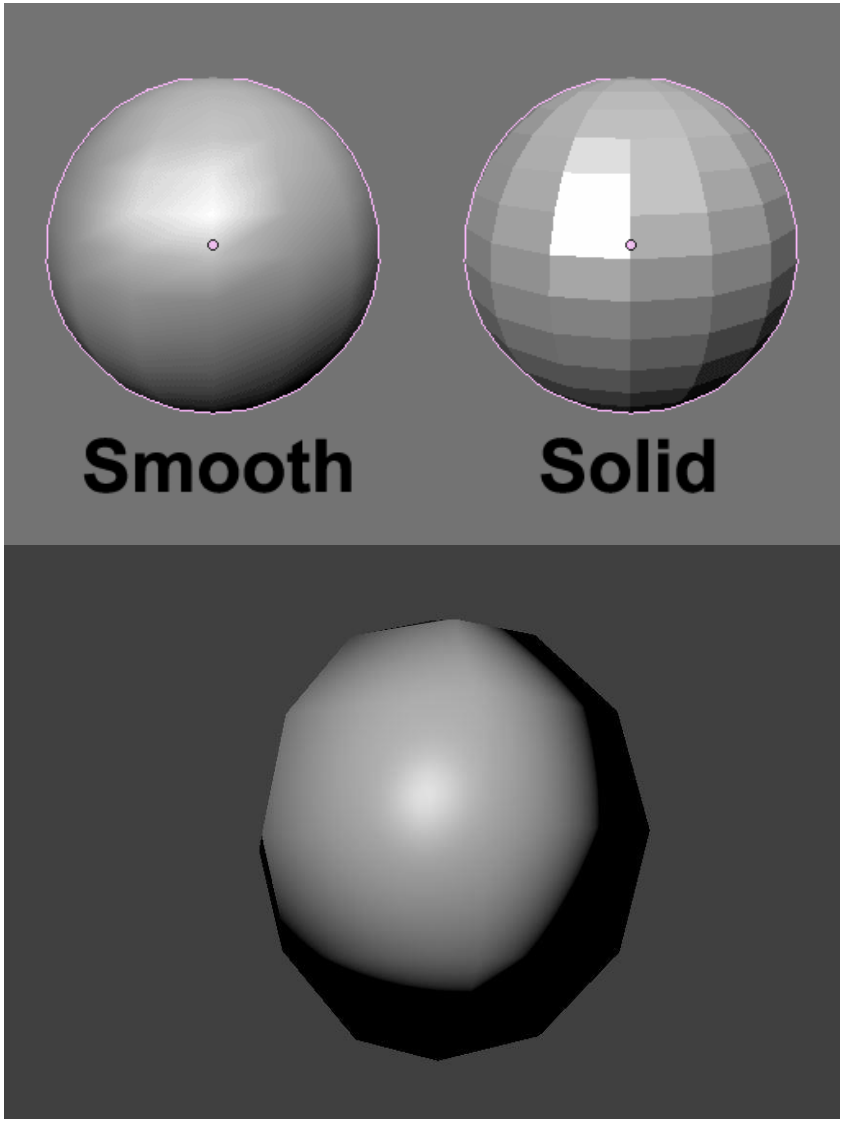


Performance issues

- Computers are weak, sadly
- How about processing image on screen with resolution of 576 megapixels (i.e. 32000x18000 screen)?

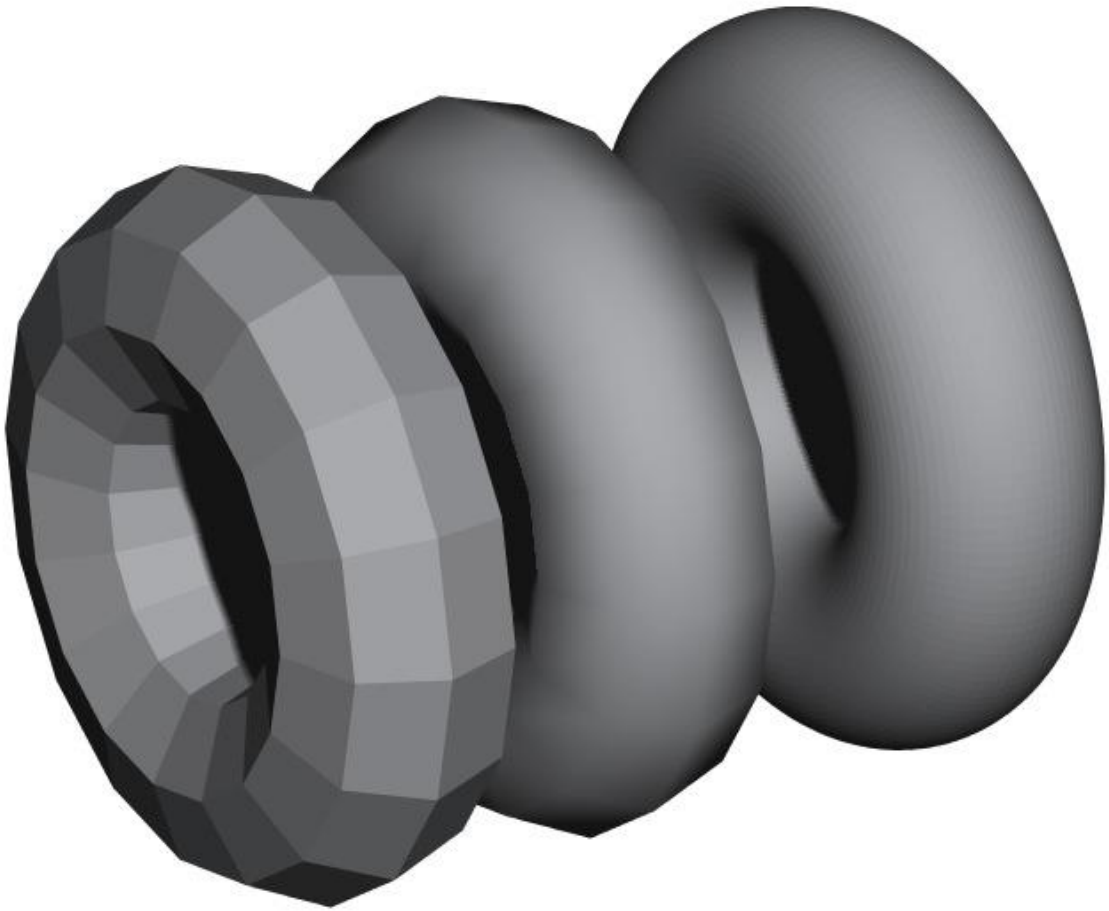


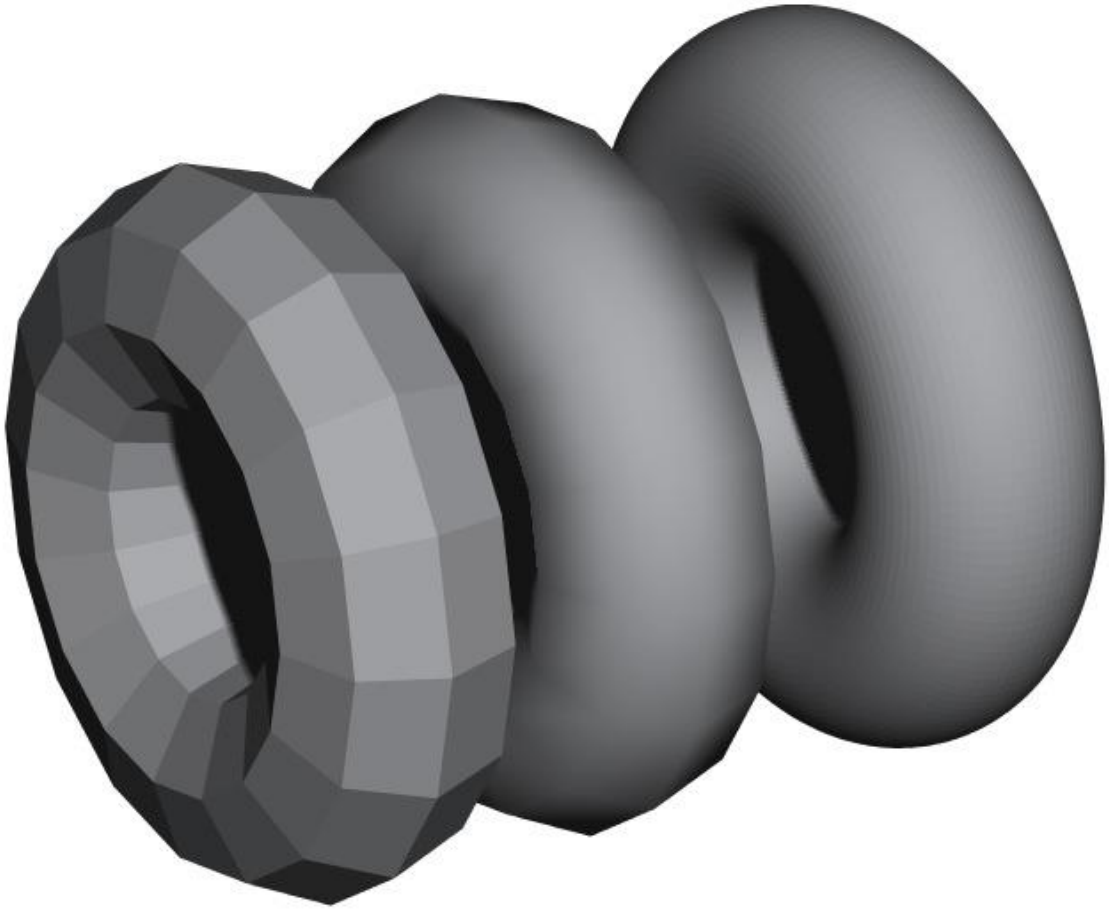
Beginning of crunch building – imitated shading



Instead of increasing polygon count we apply a little trick – “smooth shading”, now it looks slightly better!

However if you look closely you can see a problem with edges, we’ll see later how to fix it!





128 polygons - 128 polygons - 11680 polygons

Smooth Shading Article Link

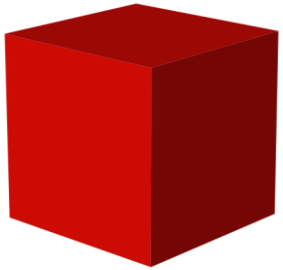
Texturing

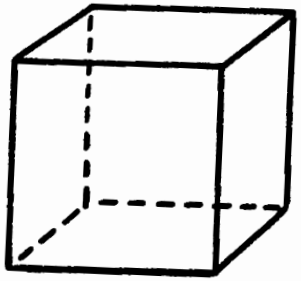
Model constructed of polygons is nice, we can even apply **materials** (using wonderful shaders), thus making it suitable for scaling.

But we also need to create drawn materials to make models look more like real world.

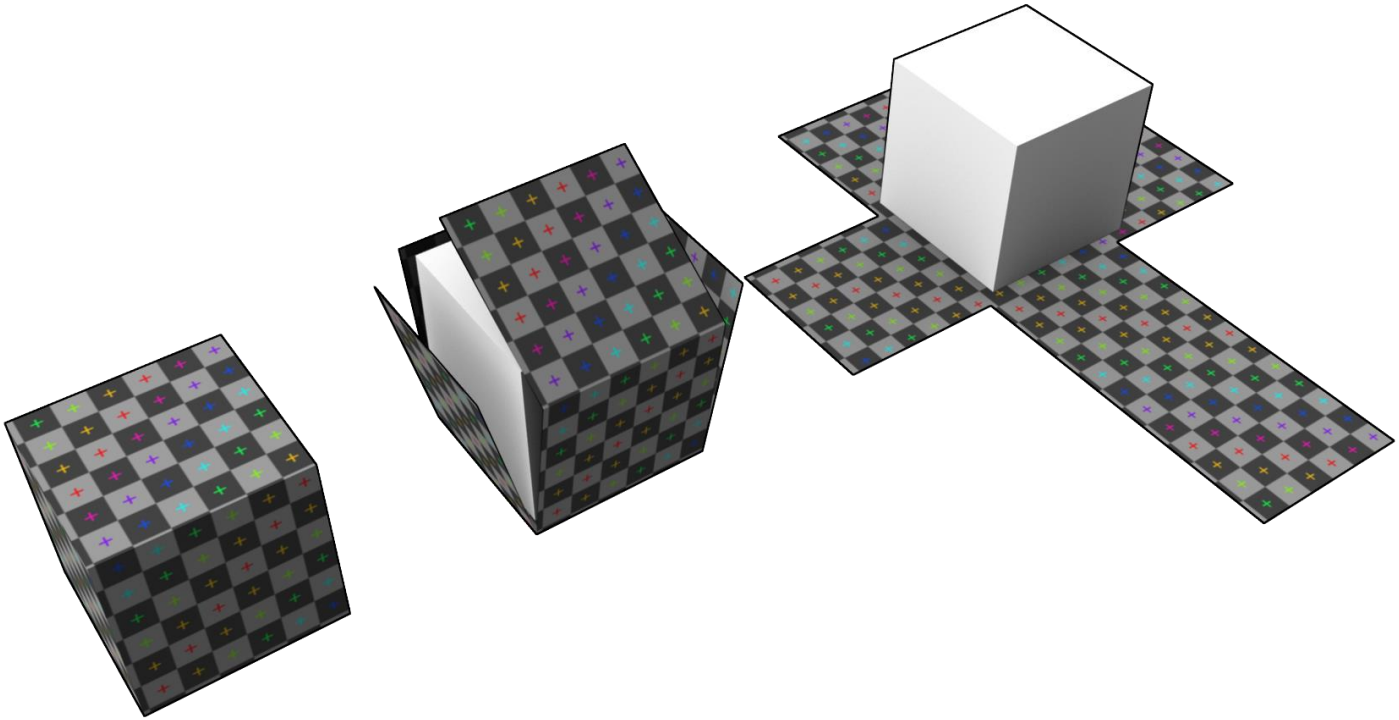
It can be achieved by applying 2d **bitmap images** to our 3d objects, but how can we do it actually?

At first let's look at model of cube for example:

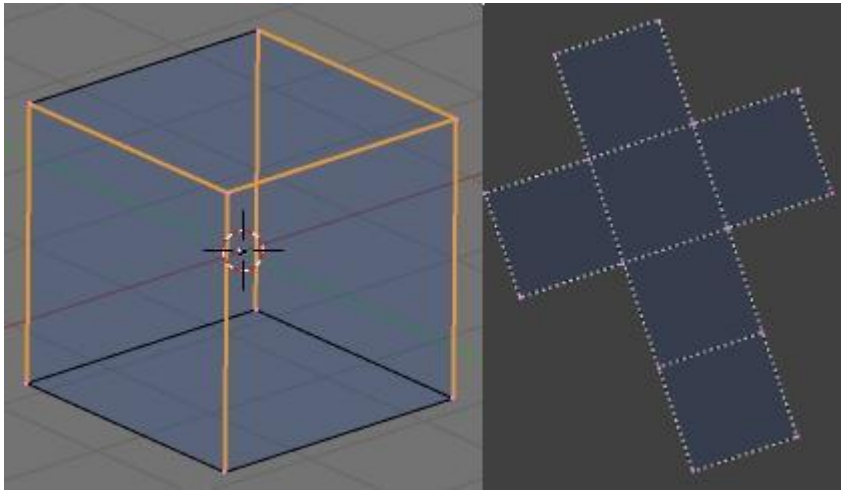




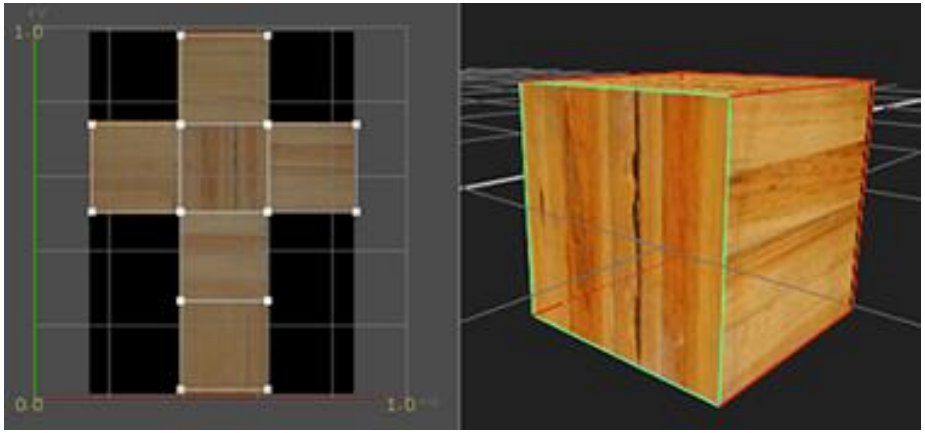
We can **unwrap** all its polygons onto 2d surface, absolutely identical to making cube model out of paper



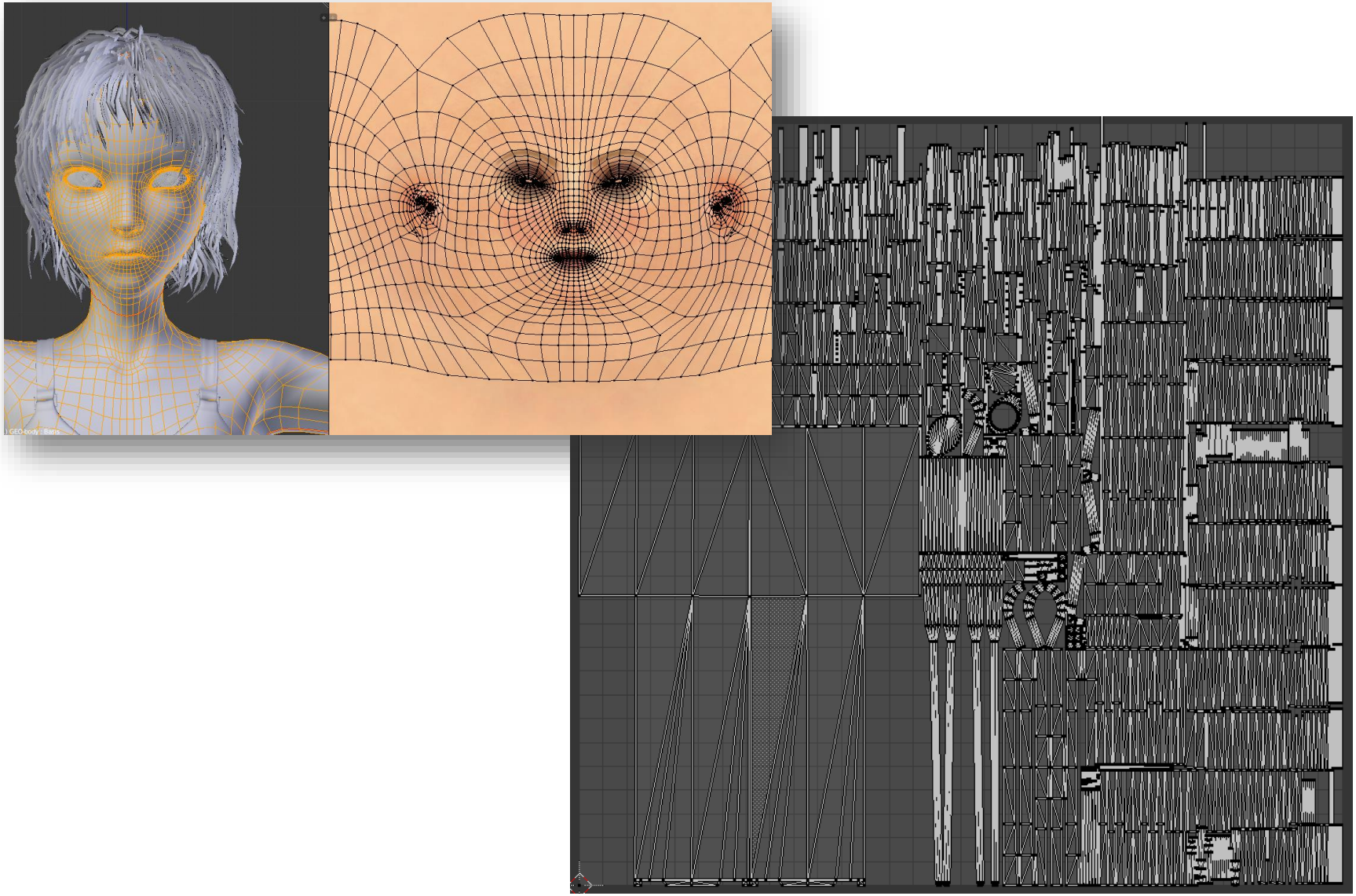
Let’s look at the result:



Apply texture to cube outline and wrap it again into cube, at this point let’s call color layer **diffuse texture**:



All complex objects are unwrapped in the same way…



Unwrapping is usually done by modeler

Creation of textures for the unwrapped object is done by another person – **texture artist**

3ds max, Maya and much software do not provide any texture creation workflow out-of-box

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Blender has full featured texture creation suit, not the best but it does what it has to perfectly, *to be upgraded in future ;)*

There are tons of specialized software like:

Substance Painter, 3D-coat, Quixel Suit and etc.

Back to our muttons! Next step after smooth shading – normal mapping

Now we know how to wrap 2d bitmaps on 3d objects, so let's think how can we use texturing to help our objects look better…

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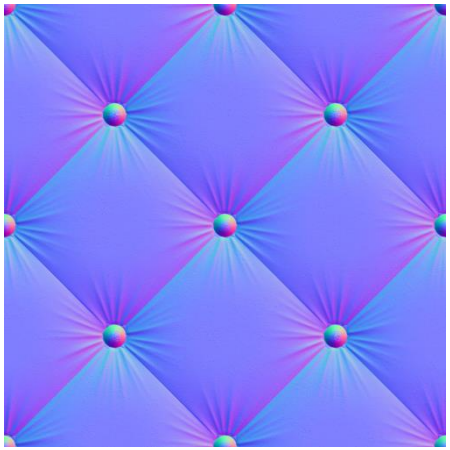
The idea is to create second map very similar to actual fancy bitmap texture, but use it not for colors but for shading imitation, do not confuse with light maps.

Back to our muttons! Next step after smooth shading – normal mapping

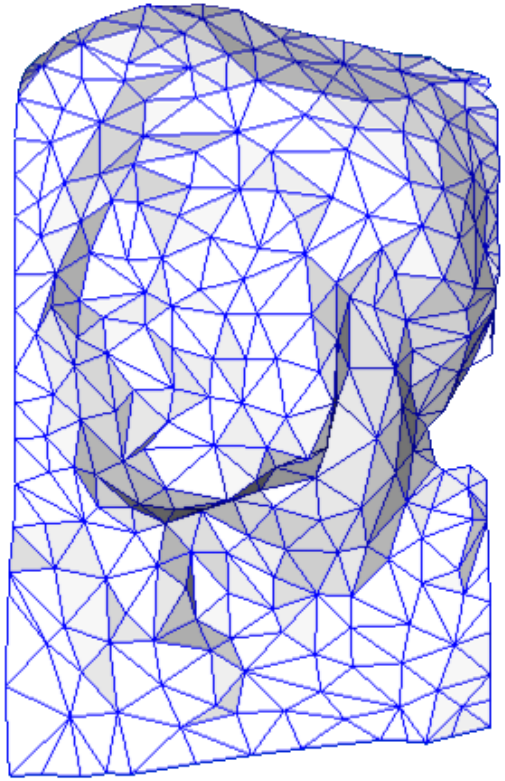
Now we know how to wrap 2d bitmaps on 3d objects, so let's think how can we use texturing to help our objects look better…

The idea is to create second map very similar to actual fancy bitmap texture, but use it not for colors but for shading imitation, do not confuse with light maps.

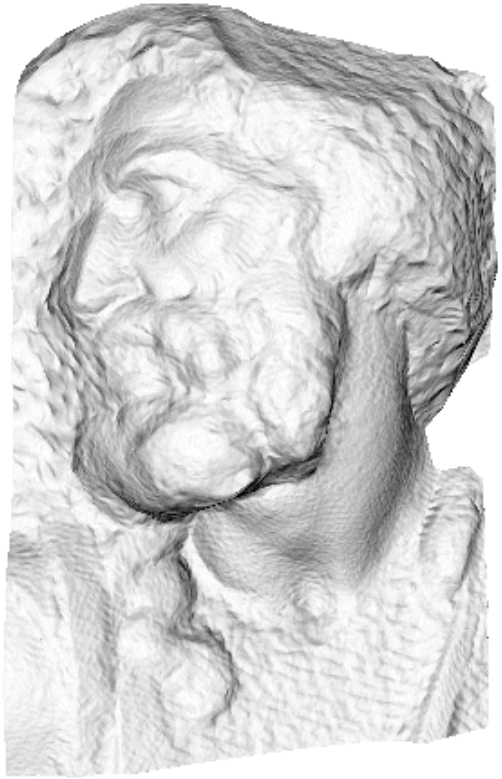
In other words apply texture (called **map**) that contains information about more detailed shape of object



original mesh
4M triangles



simplified mesh
500 triangles



simplified mesh
and normal mapping
500 triangles

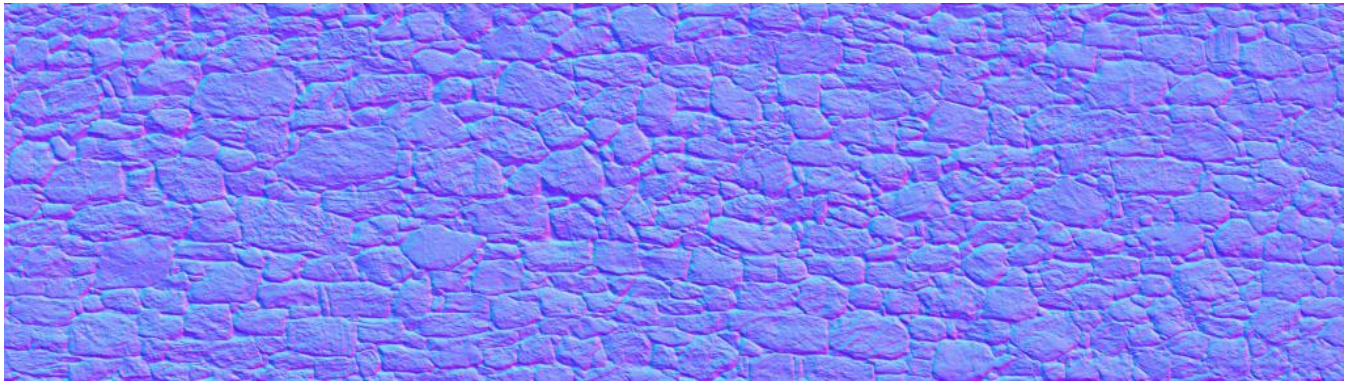
Physically-Based Rendering

Next iteration of normal mapping, uses several types of **maps:**

Albedo map (**plain color** aka base color, in true PBR albedo ≠ diffuse):

Roughness map (how **reflexive** and **glossy** object is):

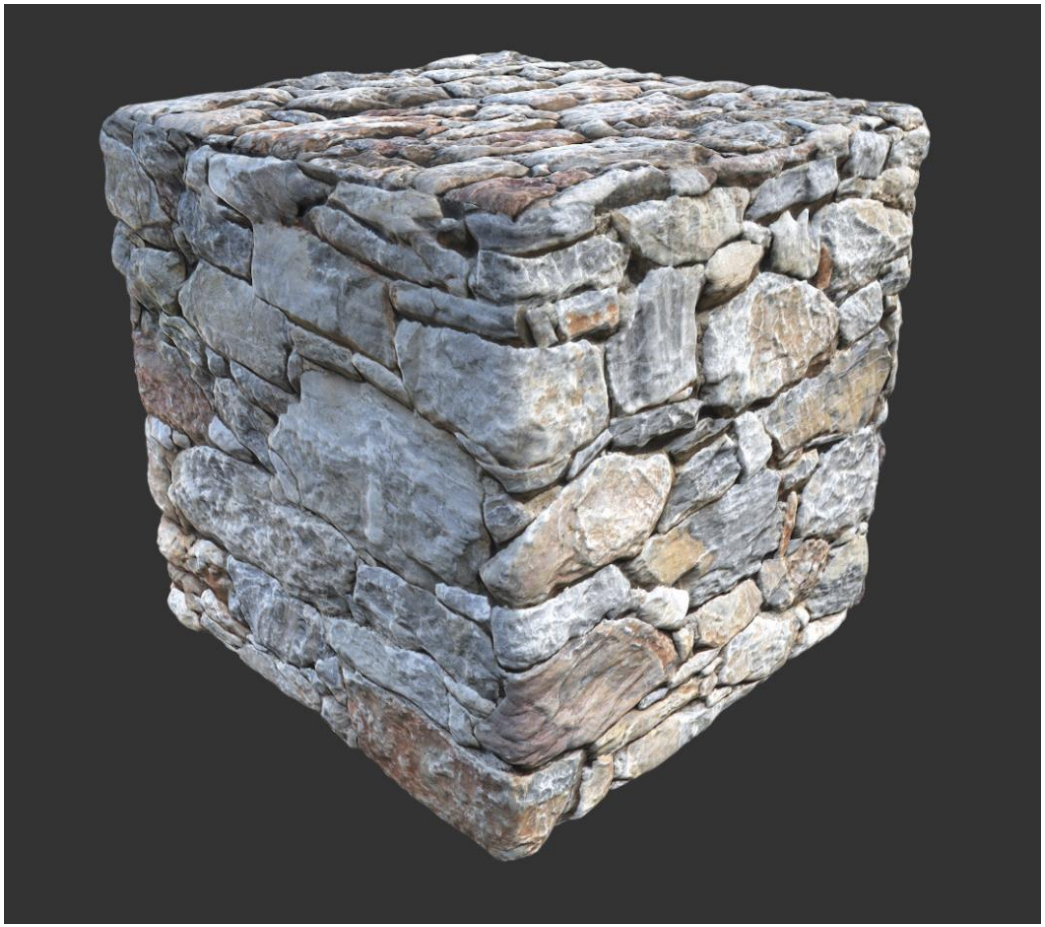
Normal map (aka bump map):



Ambient Occlusion (premade detailed shadow):

Also there is “Metalness Map”, but it’s not used here

So let’s look at maps combined together:

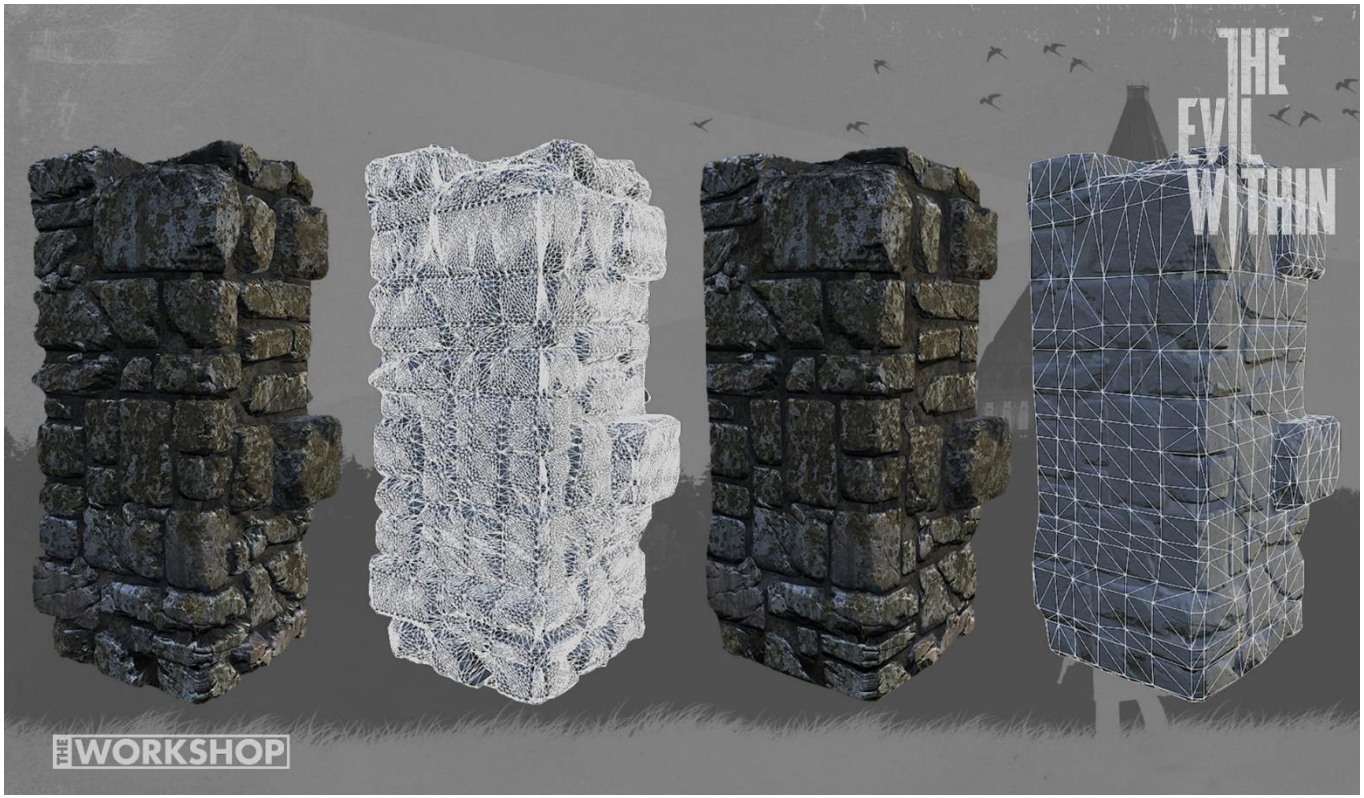


Presented maps are taken from

Did we forget something? Mind the edges!

Displacement mapping

Tessellation



A

Displacement Map

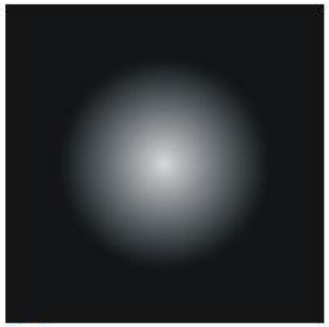


Fig 1

Fig 2 - Geometry altered

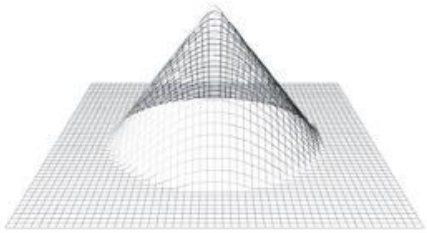


Fig 3 - Geometry altered

B

Displacement Map

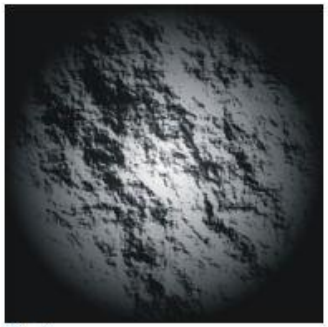


Fig 4

Fig 5 - Geometry altered

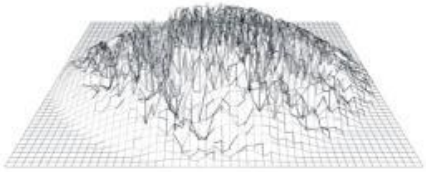


Fig 6 - Geometry altered

C

Bump Map

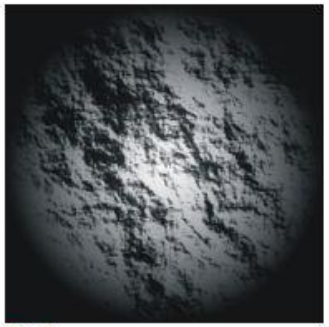


Fig 7

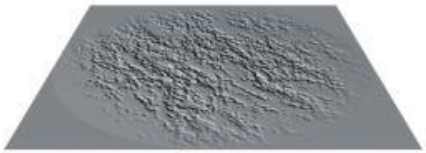


Fig 7 - Geometry intact

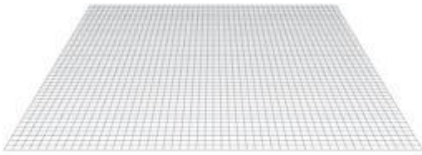
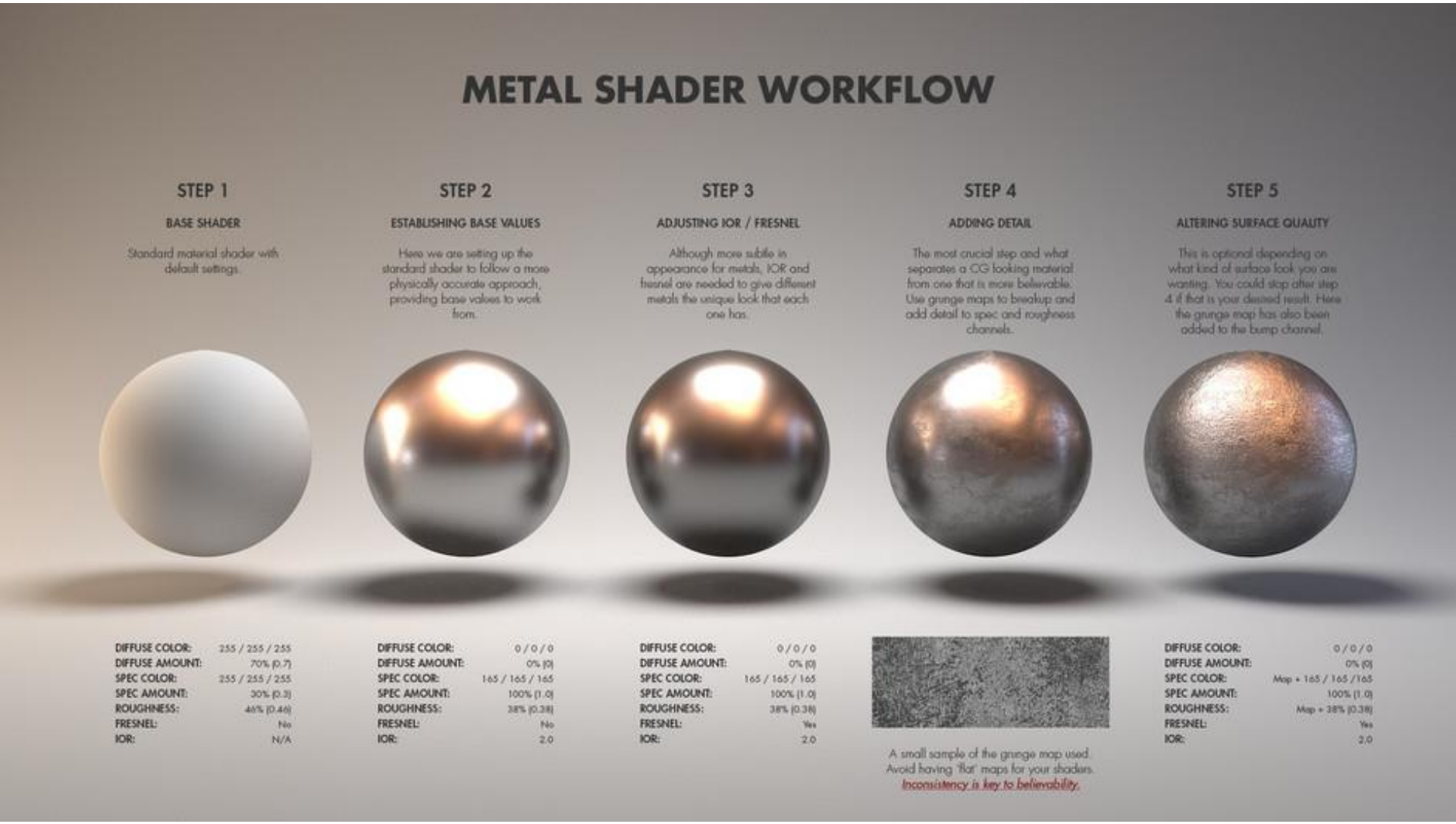
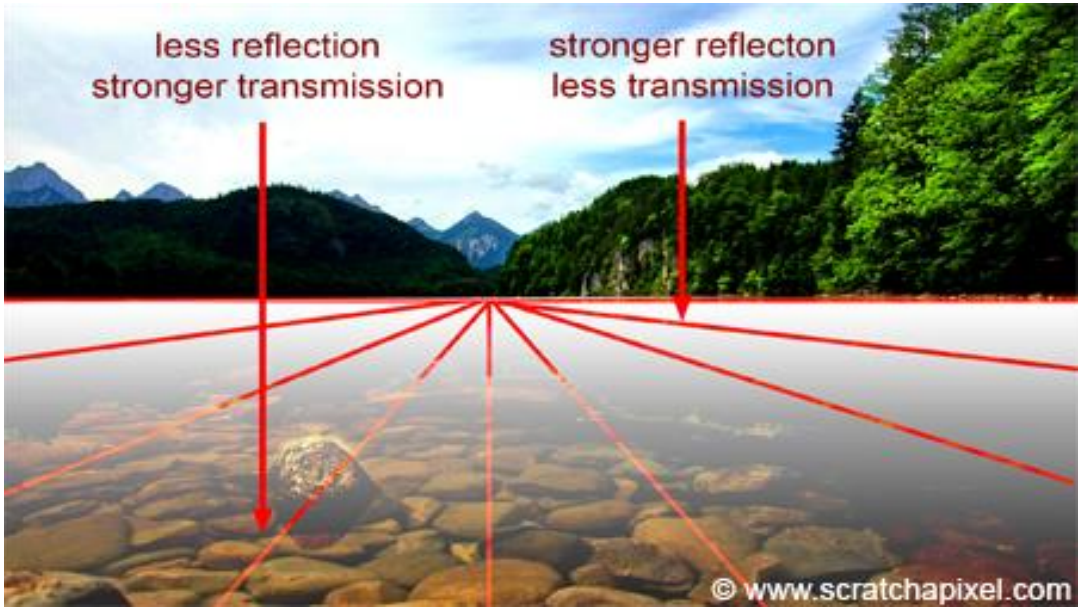


Fig 8 - Geometry intact



https://www.artstation.com/artwork/Prber

Fresnel reflections



At near-grazing incidence, media interfaces can be mirror-like, despite being poor reflectors at normal incidence.

https://en.wikipedia.org/wiki/Fresnel_equations
https://en.wikipedia.org/wiki/Bidirectional_scattering_distribution_function

Lighting

We cannot really calculate behavior of photons in rational time (probably in future)

Choice of lighting technologies for a project depends on how much time can be given to rendering single image

Games (or other realtime apps): e.g. 50 frames per second

- very rough approximation

Movie VFX and still renders: e.g. one frame - hours, days, months? (must be reasonable anyway)

- rough approximation

Nice video about lighting technologies (in Russian)

https://www.youtube.com/watch?v=3tlTMJCyEnk

Rendering

- Actually generating resulting image

(or frame if there are many, e.g. in animated movie)

- Requires lots of processing power
- Has to be quick in real-time

Goals:

- Produce good looking outcome
- Reduce image defects

Cloud platforms help to render projects

Render farms provide paid servers with lots of processing power

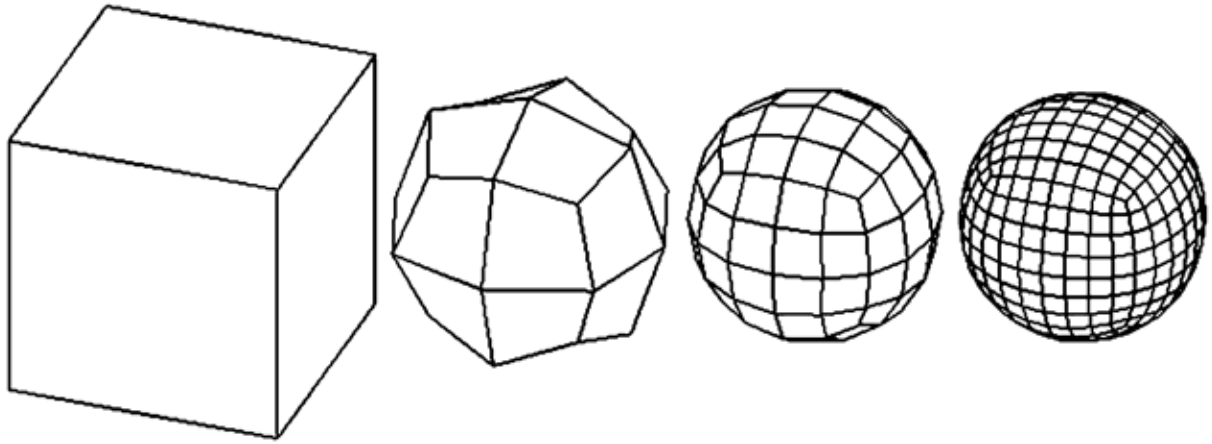
(real-time cloud services also exist,

gaming cloud services like Geforce Now)

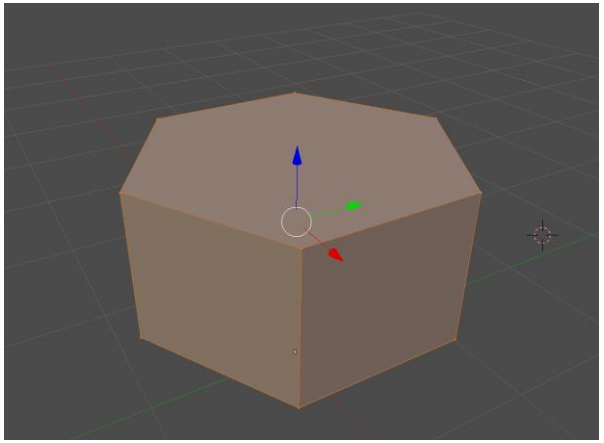
Subdivision techniques

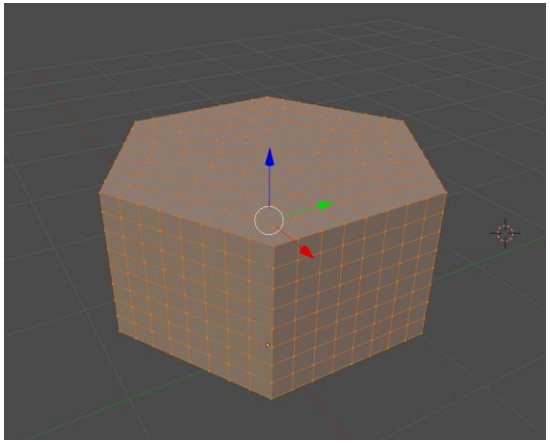
Catmull-Clark subdivision:

(key difference – it changes geometry, making it smooth):



Simple subdivision (similar to tesselation):

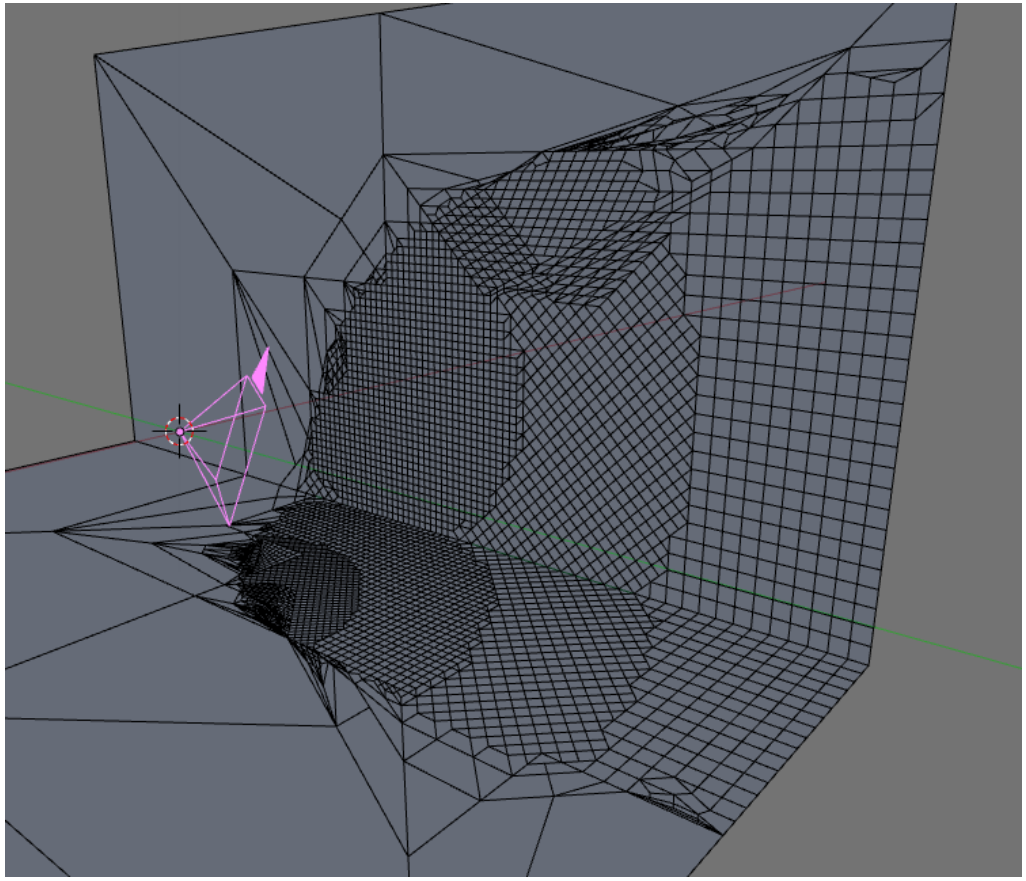


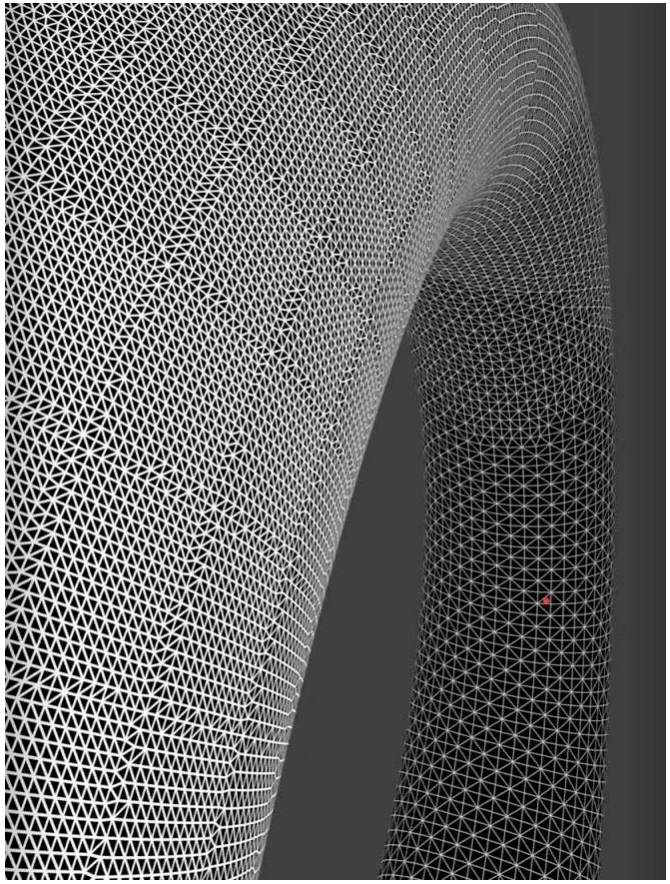


Adaptive subdivision

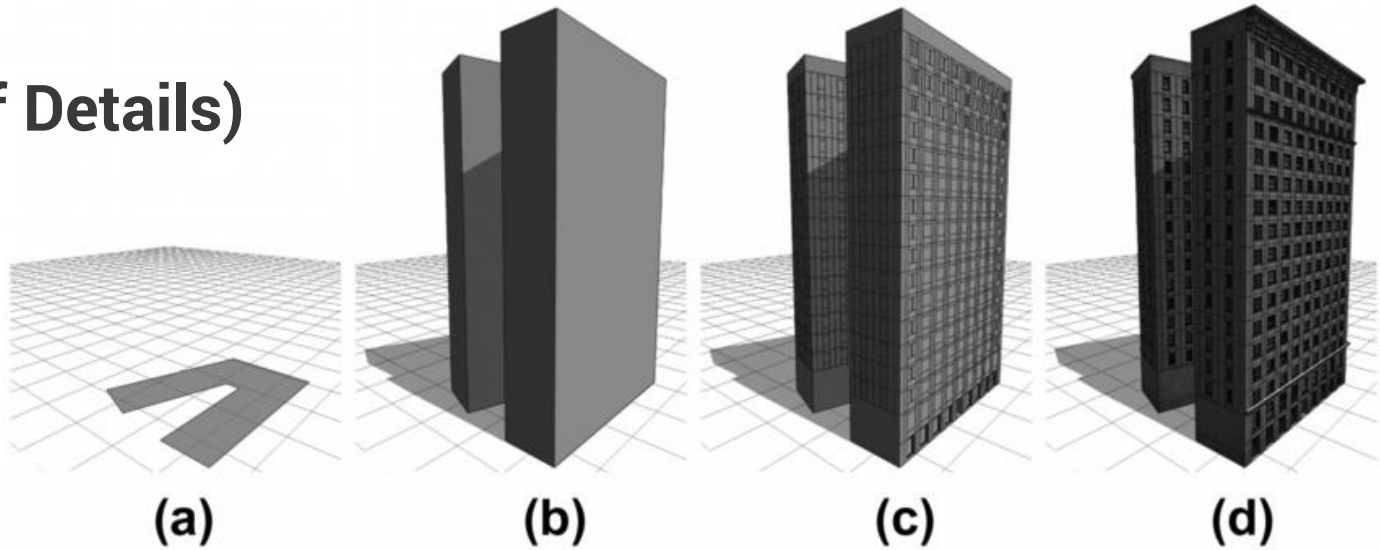
Special technique in 3d graphics

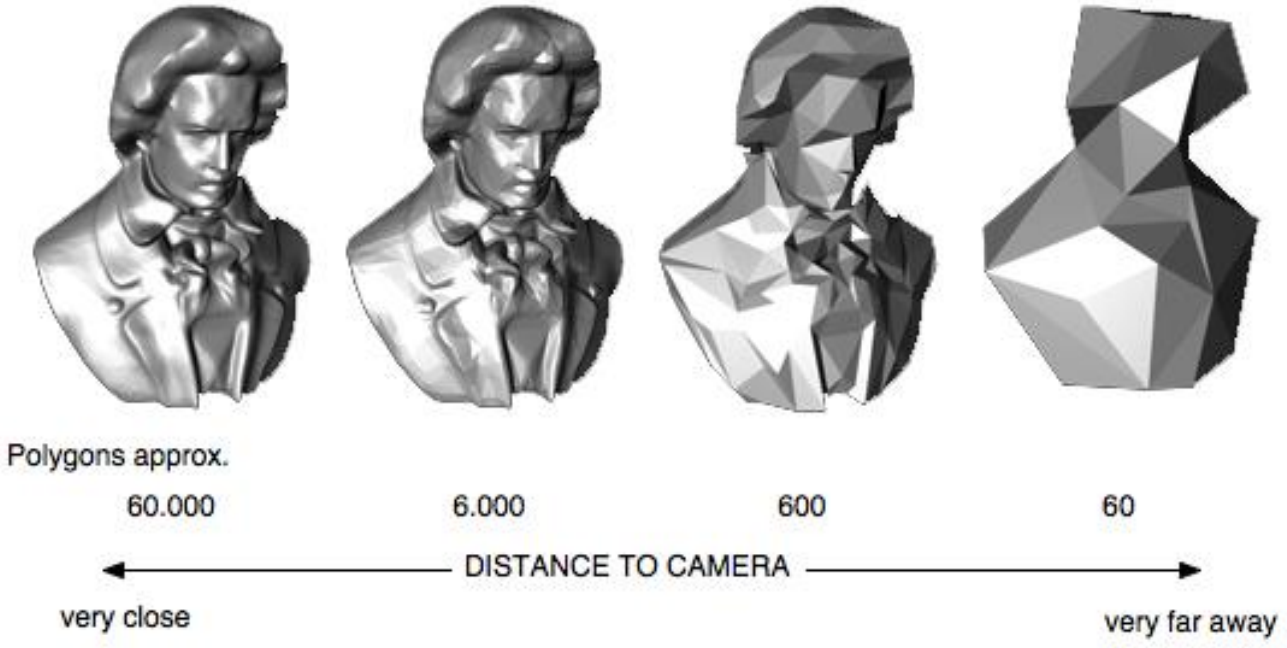
Reduces redundancy of subdivision on objects that are far from viewing point (e.g. camera)





LOD (Level Of Details)





Notes about 3D scene building for Games

- Minimize redundant polygons count– “if player can’t see that polygons thay’re not needed”
- Use LOD’s
- Prefer Maps instead of real polygons
- Choose set of PBR Maps for concrete project
- Triangulation

Person who builds scenes (levels) using models(made by asset creation team) is **Level Designer**

Person who prepares variants of concepts for future look of assets and levels is **Concept Artist**

Think about the principle:

"It doesn't matter how it's made, until it looks good and doesn't issue performance."

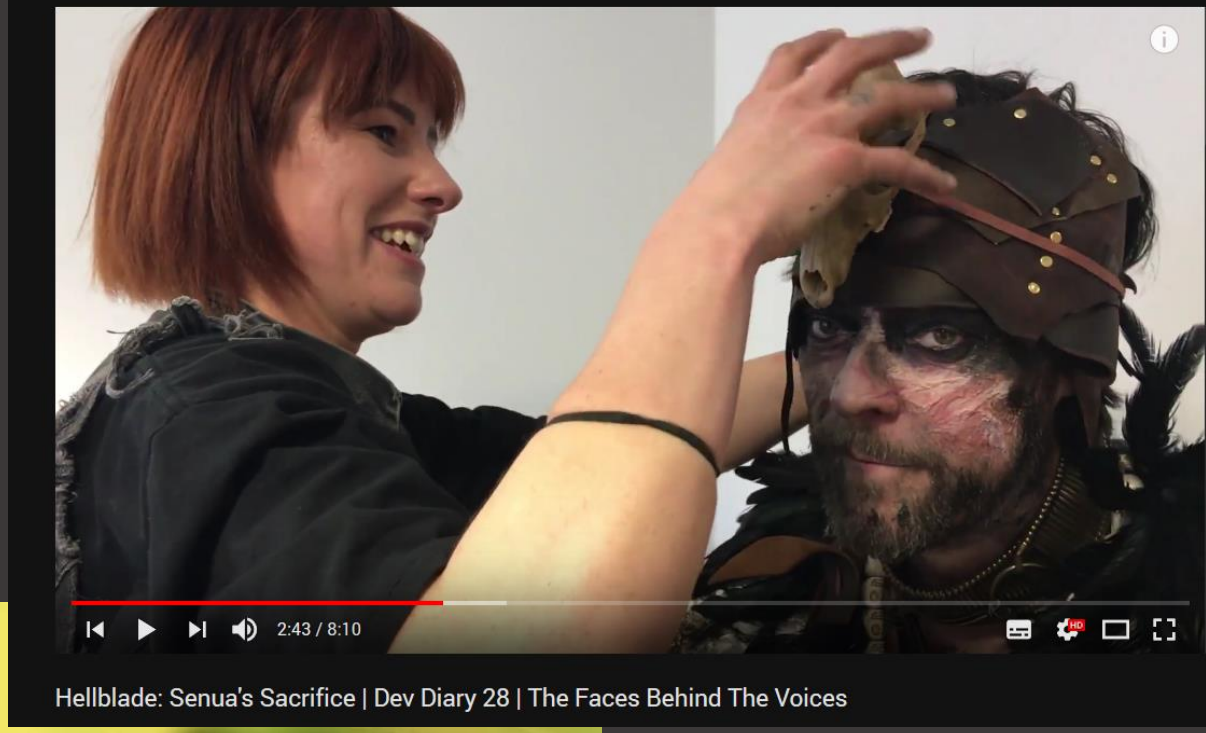
Is it true?

Result is more important than process

Remember old games,

for example TES II: Daggerfall

Hellblade: Senua's Sacrifice

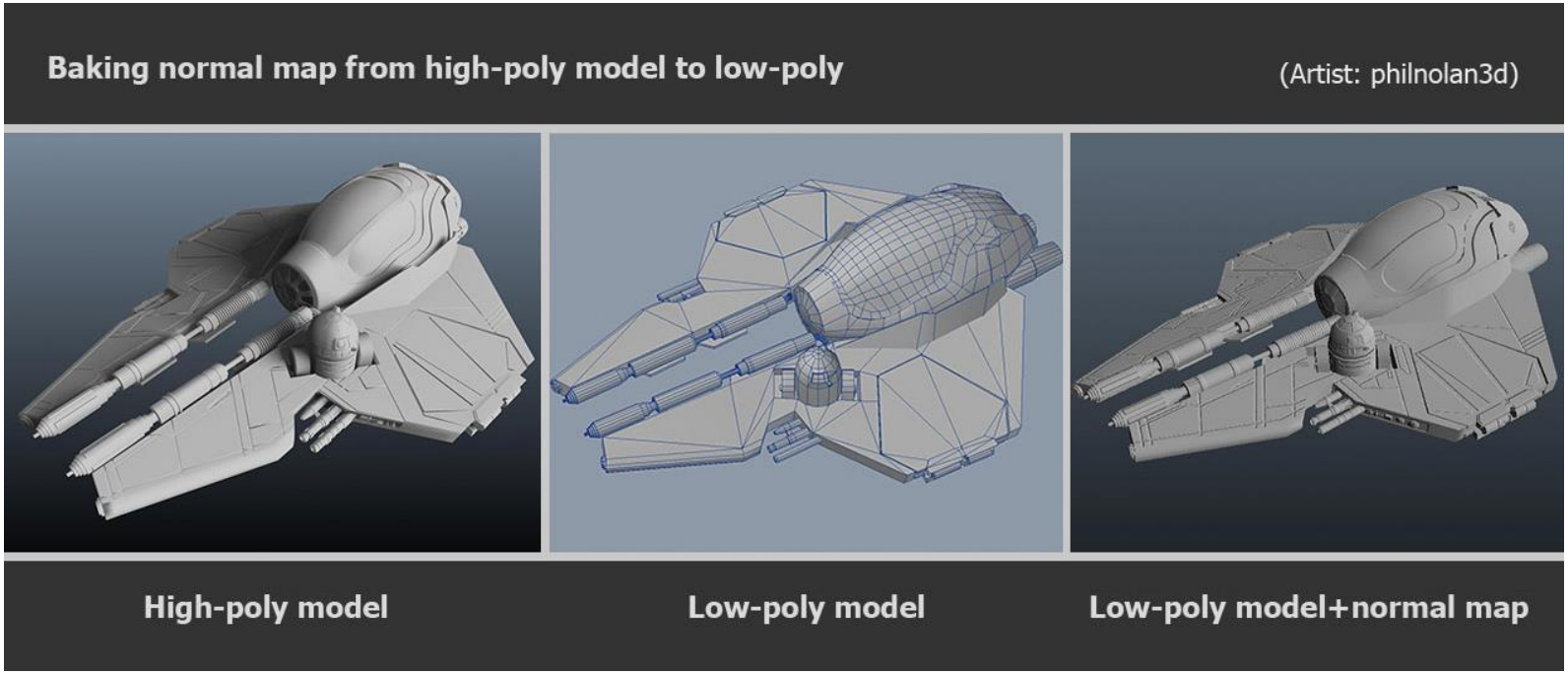



LIGHTING NEEDS TO BE REBUILT (224 unbuilt object(s))

Where to get Normal Maps?

One approach is to make them from scratch using Painting Software like GIMP/Photoshop or use texturing software that provides convenient workflow for PBR maps creation.
(Substance Painter, Quixel and etc)

Another approach is to create **detailed hi-poly mesh** and generate normal maps automatically, this is called **baking.**



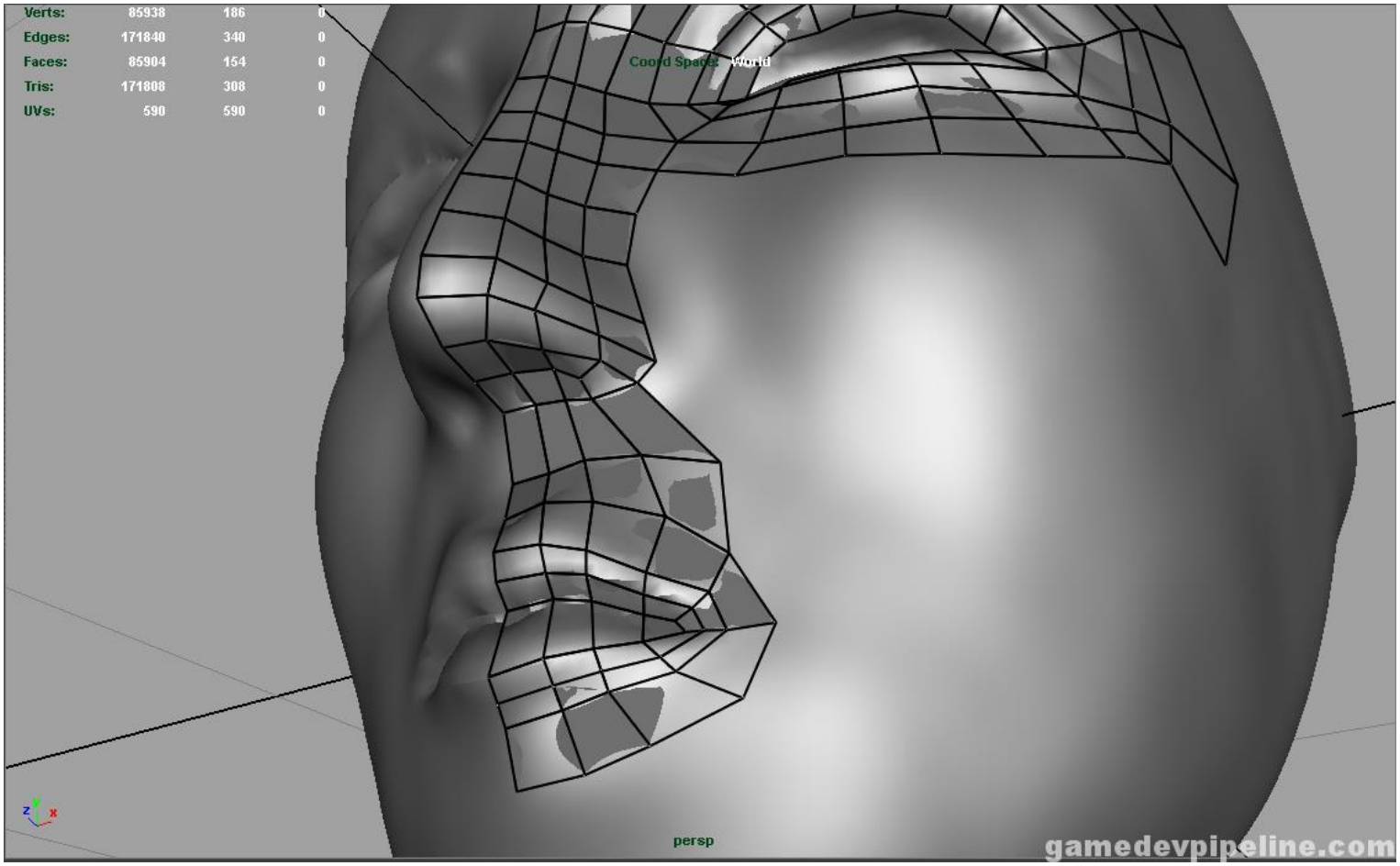
Artistic Approach: Sculpting

Concept of sculpting differs from traditional modeling, ~~because its literally sculpting…~~

Ismael Fuentes - Blender Sculpting

Retopology

Creating low-detail mesh from sculpted mesh



Links

Computer graphics:

Tessellation (Nvidia Article)

Brief History of Graphics Cards

Learning blender:

Blender Guru

Gleb Alexandrov

CG Cookie

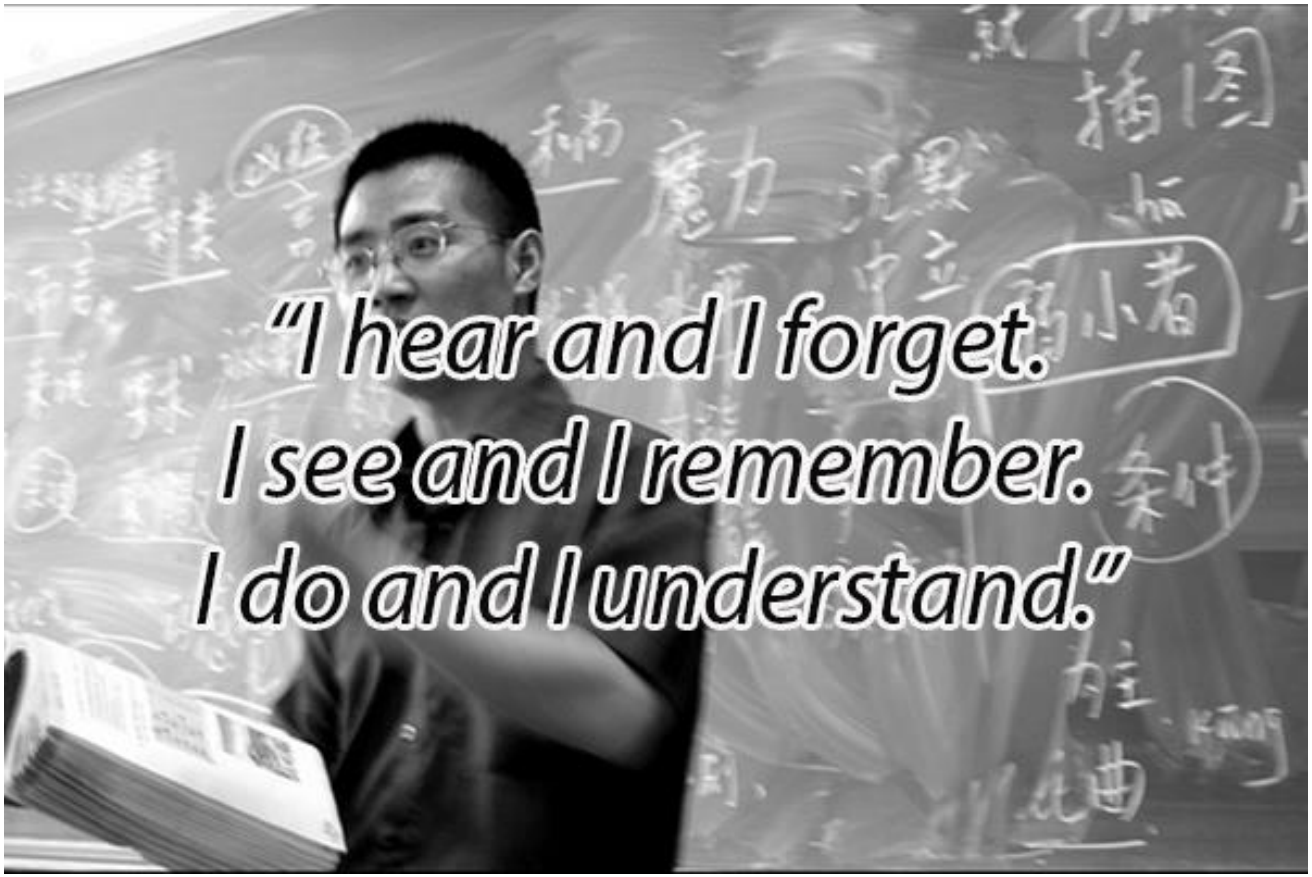
Andrew Price - Ingredient to Photorealism (Filmic color management)

Additional Interesting stuff:

TheConceptPainter - Zbrush Concept Sculpting

BlenderCon - Television VFX

BlenderCon - Composition Secret (Primary, Secondary, Tertiary Shapes Rule)


"I hear and I forget.
I see and I remember.
I do and I understand."

Thanks for your attention!