

Games and Simulation

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Game Design

- Conceptualization: the Idea
- Storytelling: the Narrative
- Game Mechanics: the Experience
- **Level Design: Creating the World**
- **Interface: Establishing the Connection**
- **Documentation: Clarifying and Communicating**
- **Testing: Playtesting**

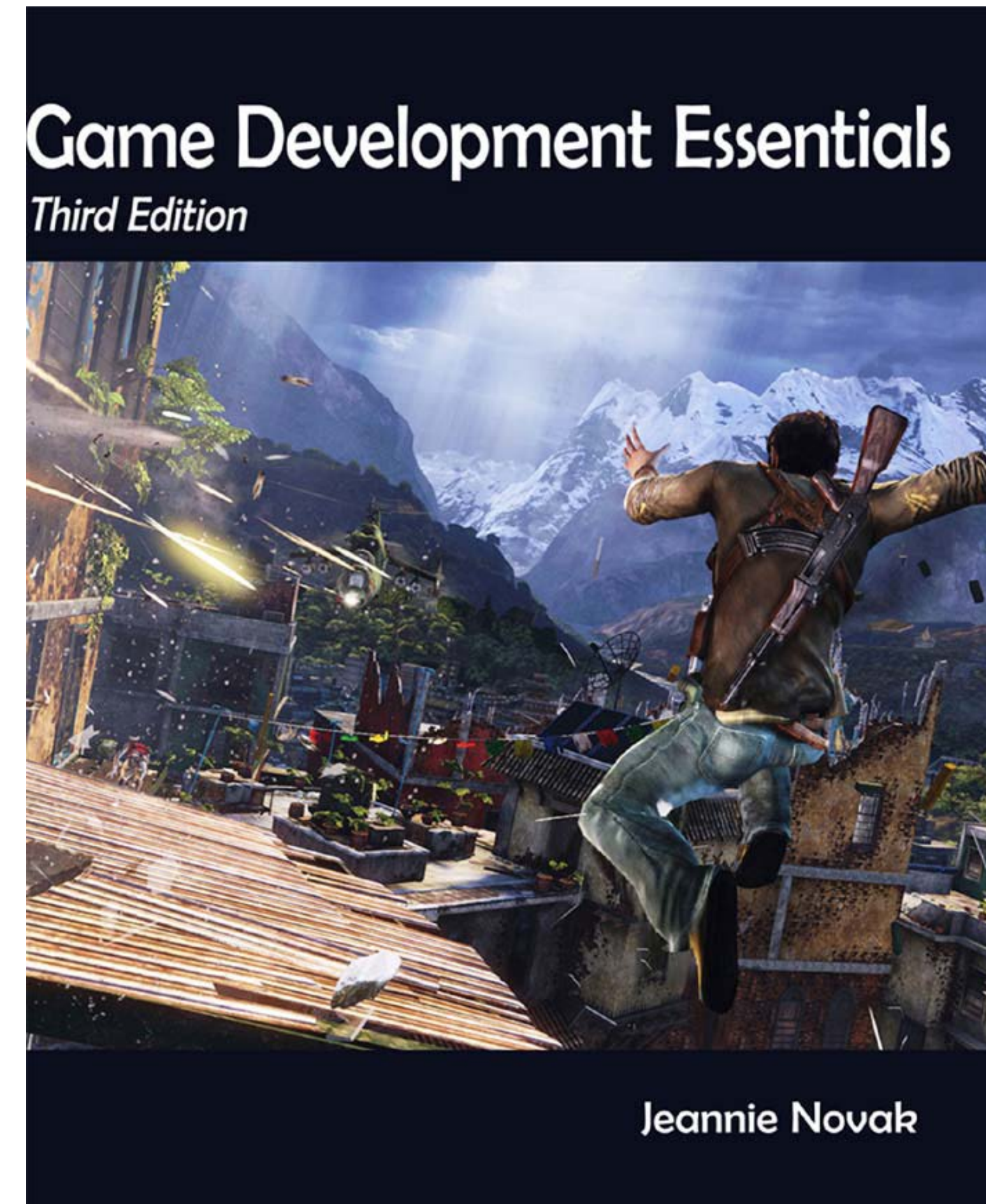
Level Design

References

Game Development Essentials
3rd Edition

Jeannie Novak, 2012

ISBN-13:
978-1111307653



Level Design

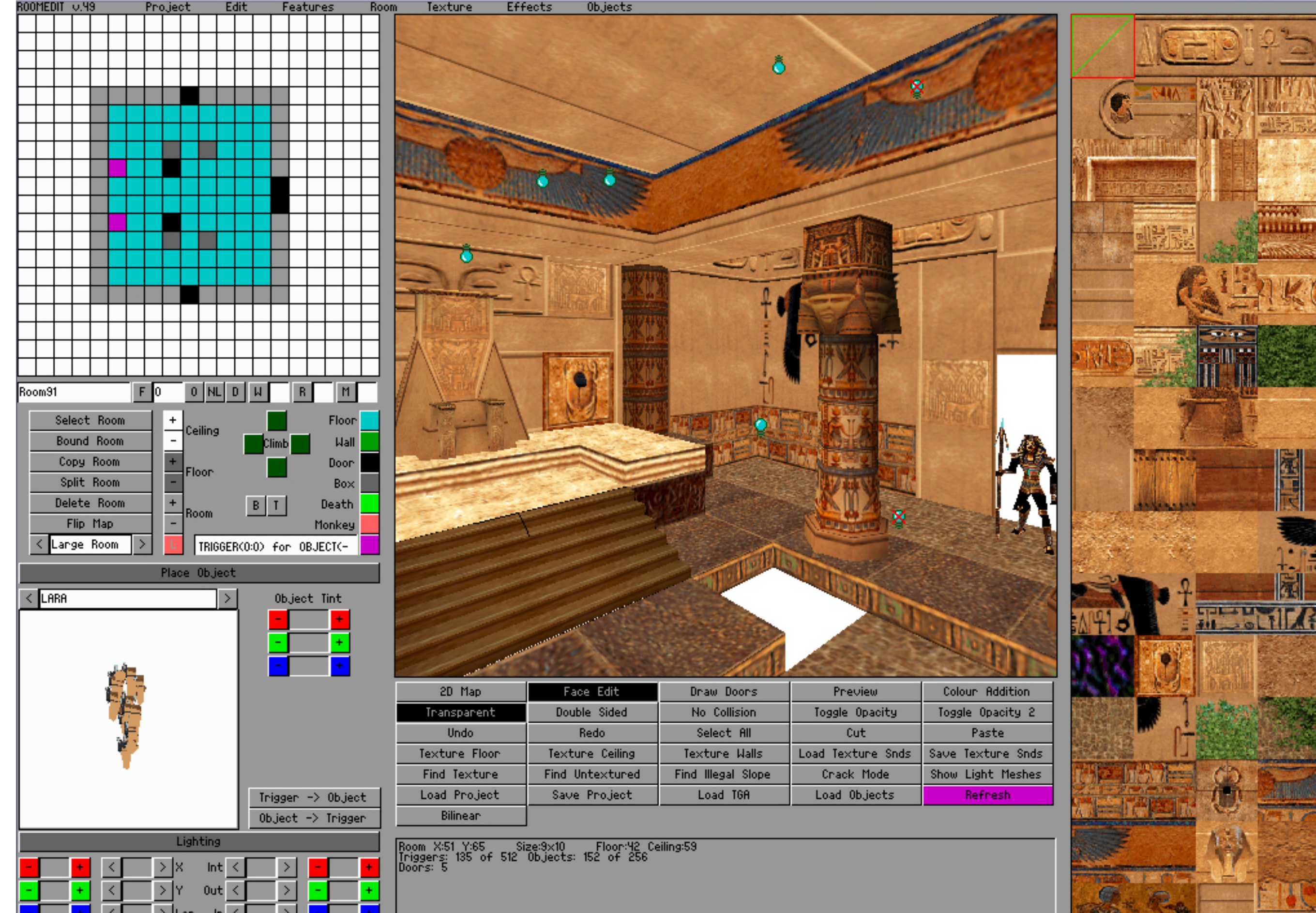
- “*Level design* is defined as the creation of environments, scenarios, or missions in an electronic game.”

In Jeannie Novak, “Game development Essentials”

- Introduces a new characters or objects
- Focus on a plot point (such as discovering a secret or preventing an attack)
- Create a mood through visuals or storyline
- Centers around an idea that becomes a unifying theme.

Level Design

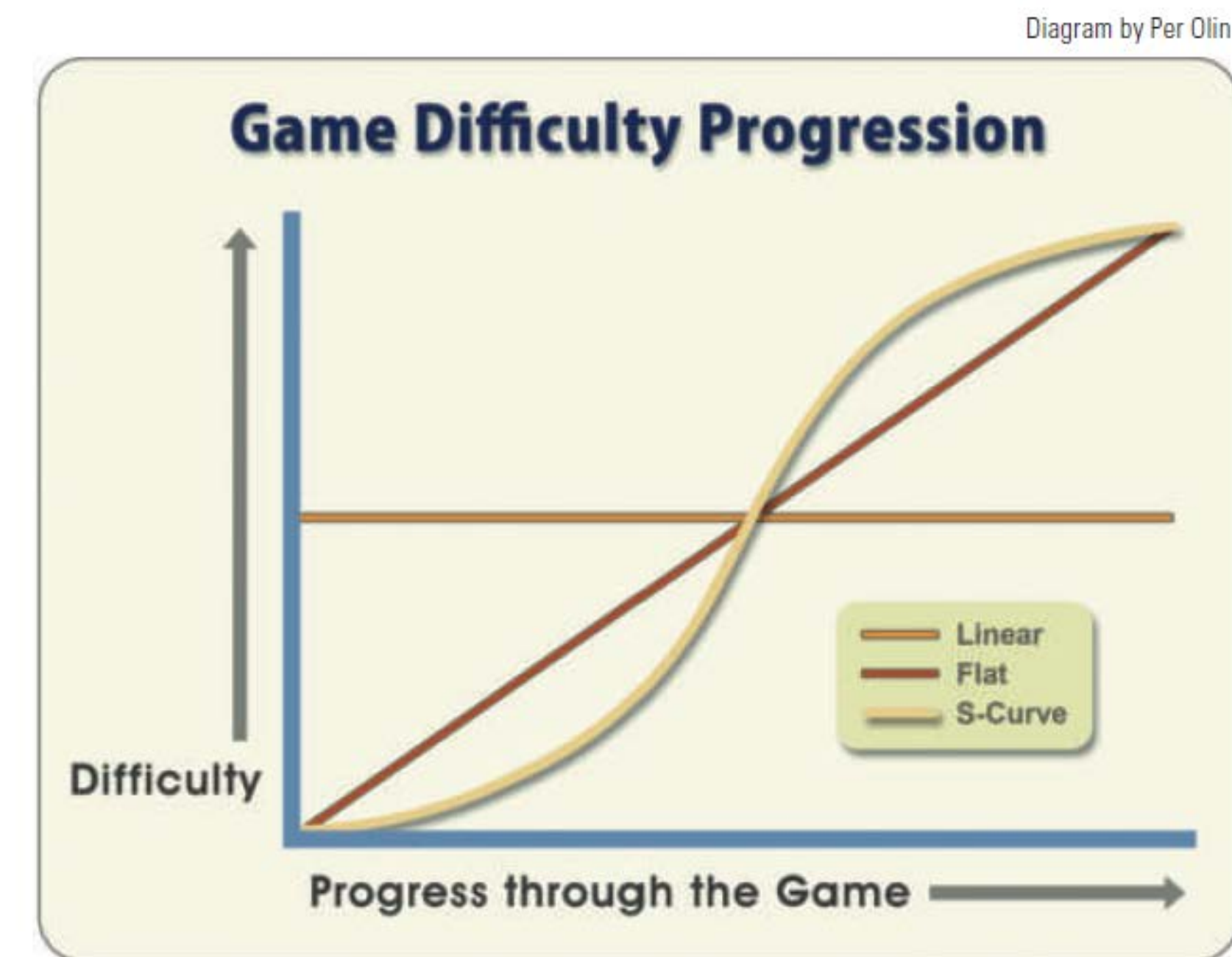
- **Level Design Tools:** Limited set of options within the game
Ex: Valve Hammer Editor, EA World Builder
- **Game Engines:** Generic unlimited possibilities of editing
Ex: Unity 3D, Unreal Engine
- **3D modelling and media authoring tools:** specialized tools to edit 3D mesh, character skeletons, textures, audio
Ex: 3DS Max, Maya, Blender, Audacity



[Tomb Raider level editor, 1996]

Structure

- Levels structure a game into effective subdivisions, organize progression and enhance gameplay.
- When creating levels consider:
 - Previously defined goals according to story
 - Flow of the mechanics and story: direct player to follow the main plot
 - Duration (mini-game 15 min, regular console game 45 minutes of a 60 hours game)
 - Availability: How many levels? How many simultaneous paths?
 - Relationship with story and gameplay.
 - Difficulty: how difficult is the game progression.



Comparison of linear, flat, and s-curve progressions.

Time

- “Game Time” can move slower, faster or real-time.
- **Authentic:** time is the real-world time
Ex: World of Warcraft
- **Limited:** time is part of the mechanics,
Ex: gameplay is limited for some time as in FarmVille.
- **Variable:** when it is not important Time goes faster
- **Player-Adjusted:** the player can adjust the total time. Ex: sports games
- **Altered:** The player can slowdown time to perform a task. Ex. Prince of Persia or Max Payne.



[Max Payne slowing Time]

Space

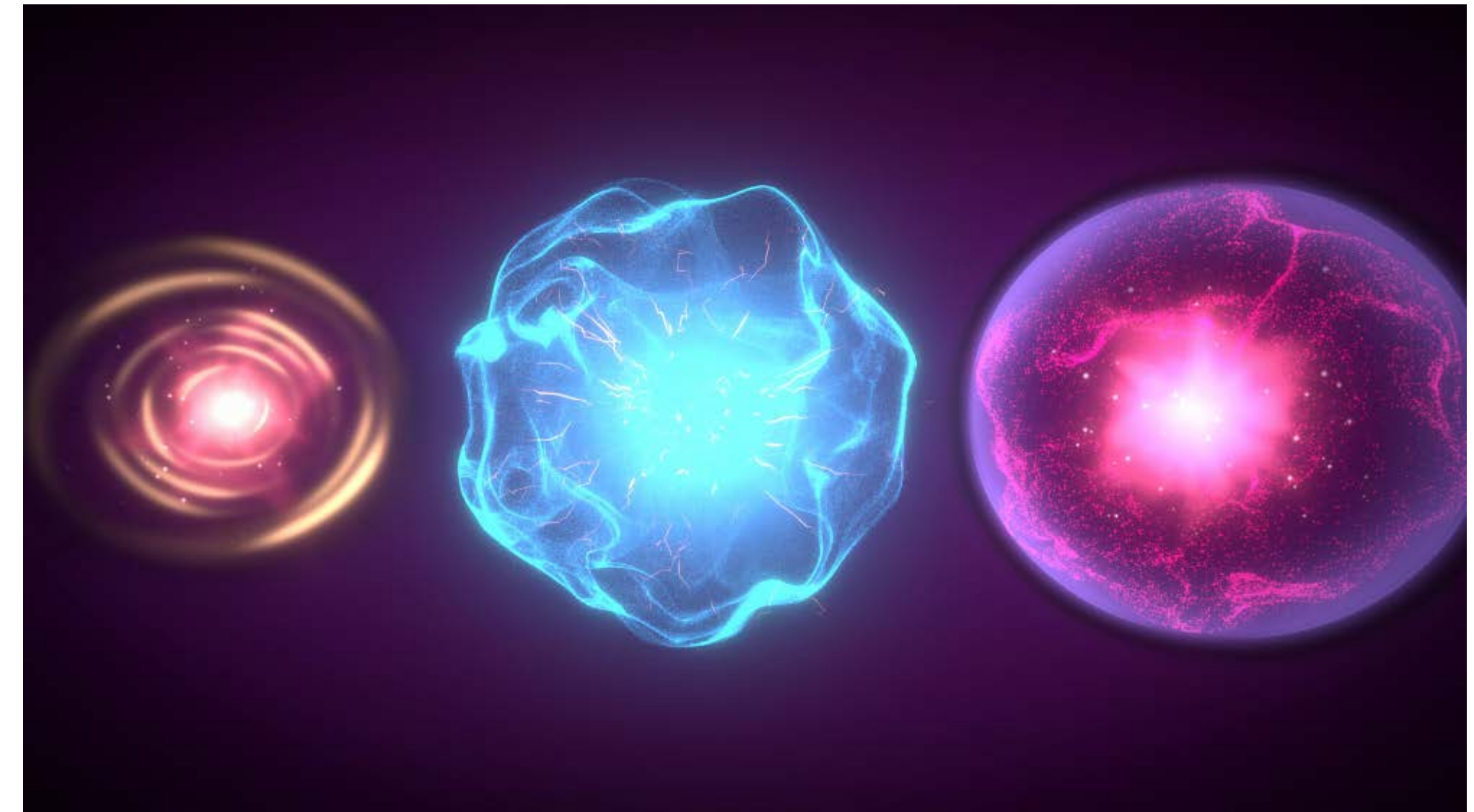
- Physical environment of the game – including its perspective, scale, boundaries, structures, terrain, objects, style and lighting.
- Camera
 - Aerial (Top-Down)
 - Isometric
 - Side-scrolling (Flat/ Side View)
- Orthographic vs Perspective



[StarCraft, 1998]

Other Aspects

- Things to consider while creating a game level
 - Terrain and Materials
 - Radiosity and Effects
 - Lighting
 - Audio
 - Character Animation

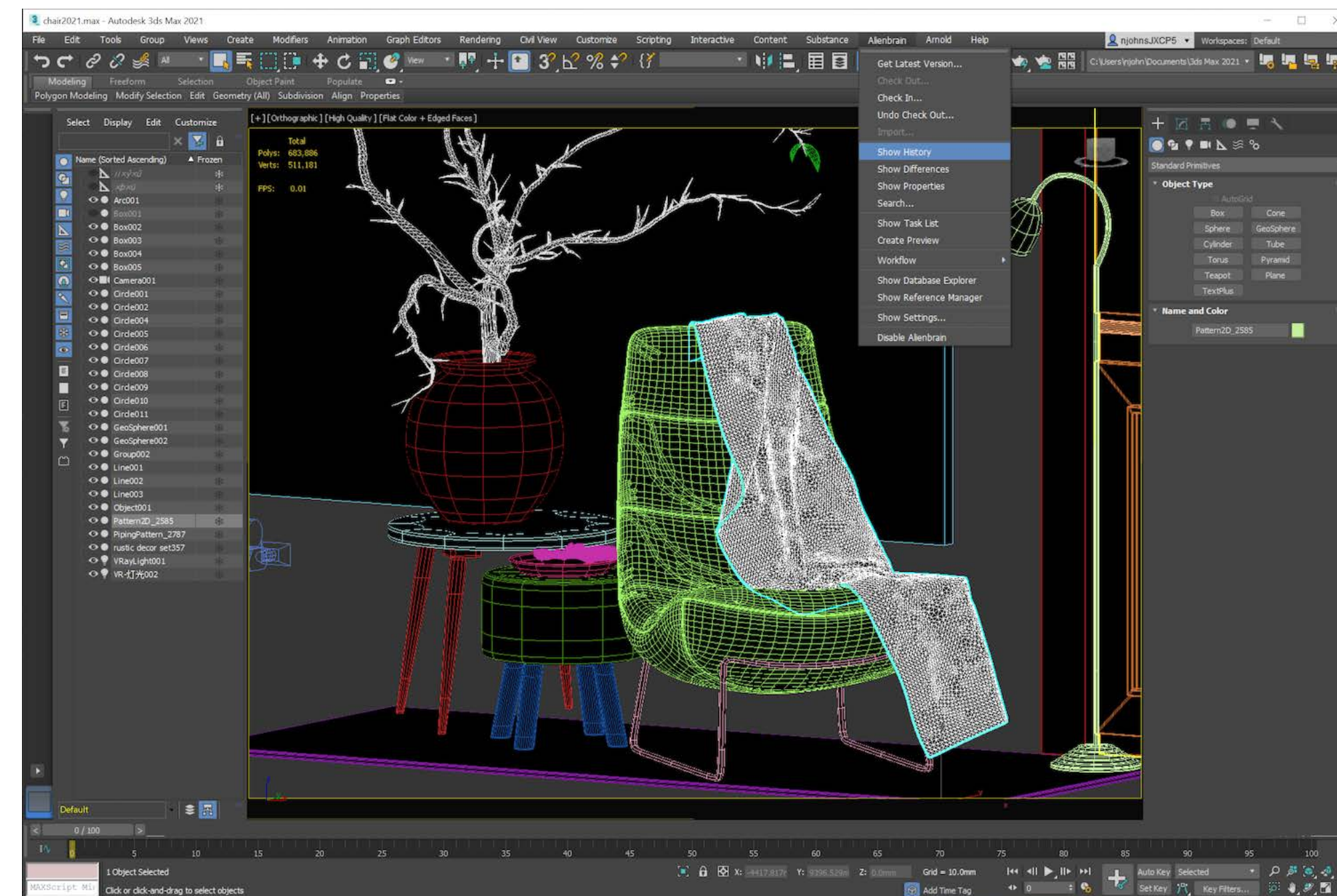


3D Modelling

- 3D modelling tools allow the creation of assets: objects, structures and worlds
- Main file formats for 3D meshes with textures:
 - .fbx Autodesk format (used in: Unity3D, 3DS MAX)
 - .dae COLLADA kronnos groups (used in: Sketch UP)
 - .obj legacy 3D Studio format (widely used)
 - .wrl VRML markup format
 - .3ds, .blend, proprietary formats that are widely used.

Autodesk

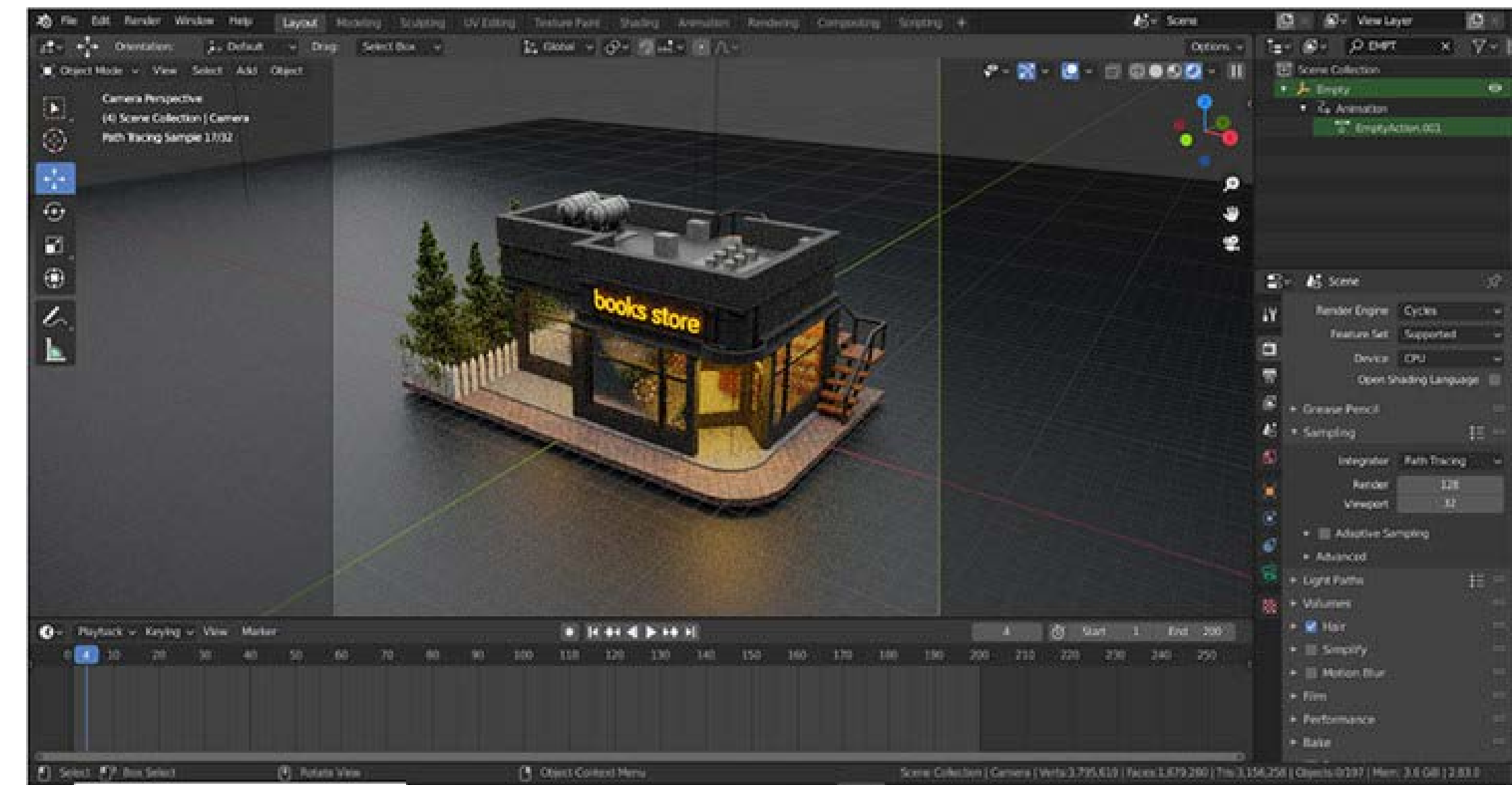
- Autodesk specializes in 3D modeling offering a variety of software with different specialties:
 - 3D Studio MAX: mesh modeling
 - Maya: cinema and rendering
 - Fusion 3D: 3D printing
 - AutoCAD: architecture
 - Recap: photogrammetry



[Autodesk 3D Studio Max]

Blender 3D

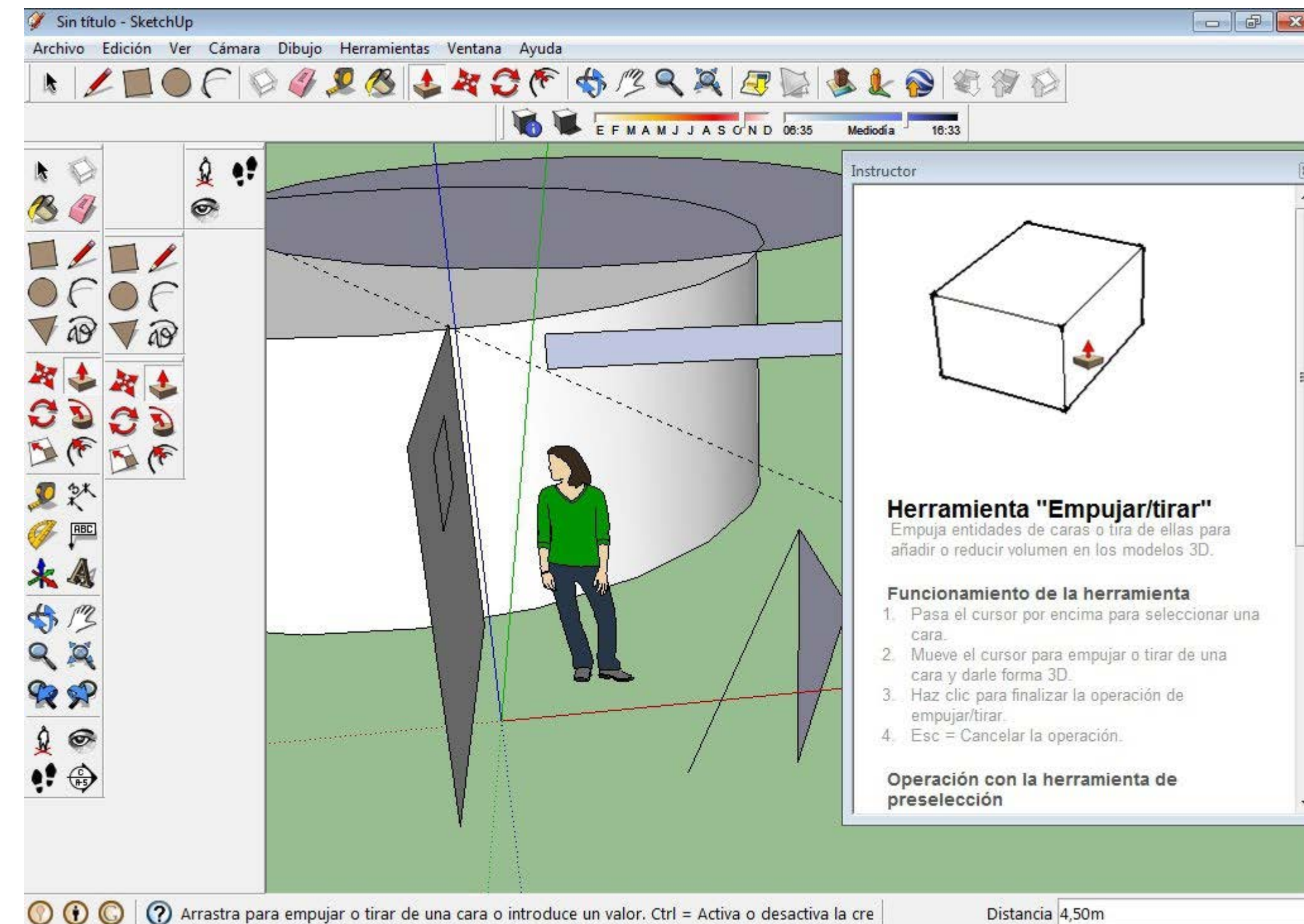
- Blender is an open-source alternative capable of mesh modelling, rendering and animation.
- Python scripting language.
- Character animation plugins
- Integration with several softwares.



[Blender 3D]

SketchUp

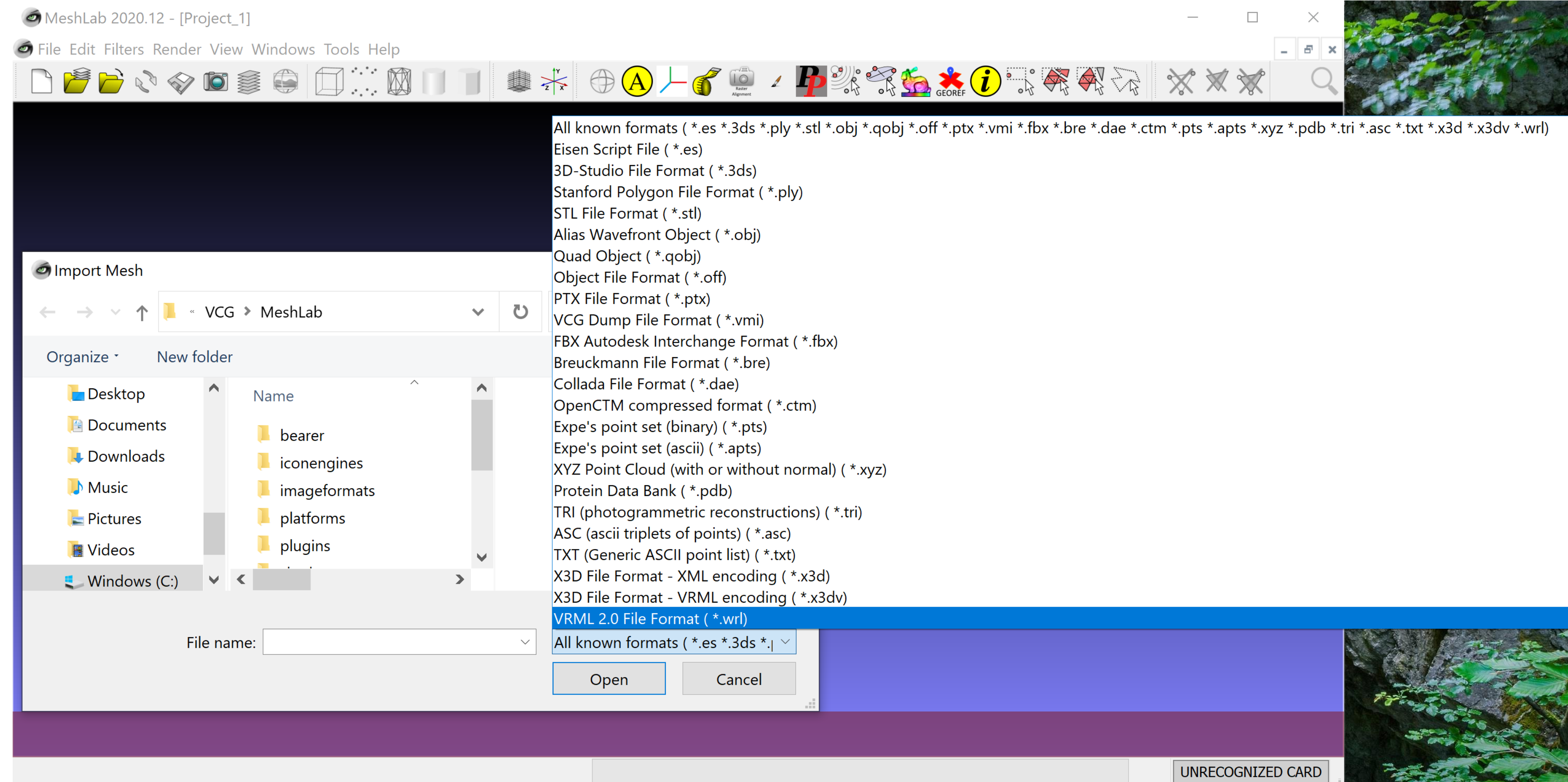
- Sketch based modeling.
- Initially used by Google to create assets for Google Earth.
- Fast development of simple models.
- SketchUp 8 free to use.



[SketchUp 8]

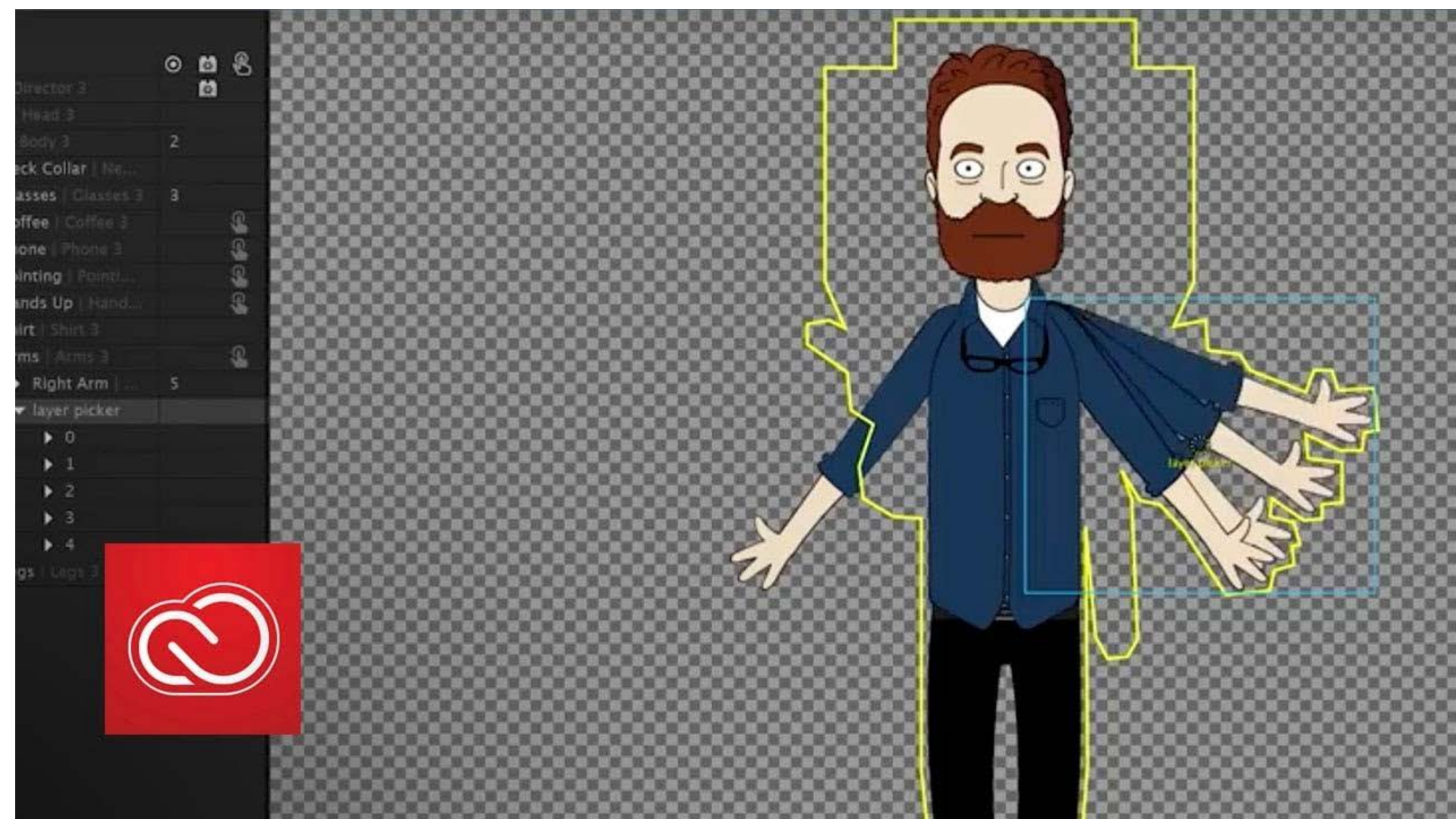
MeshLab

- 3D Format conversion tool



Character Animation

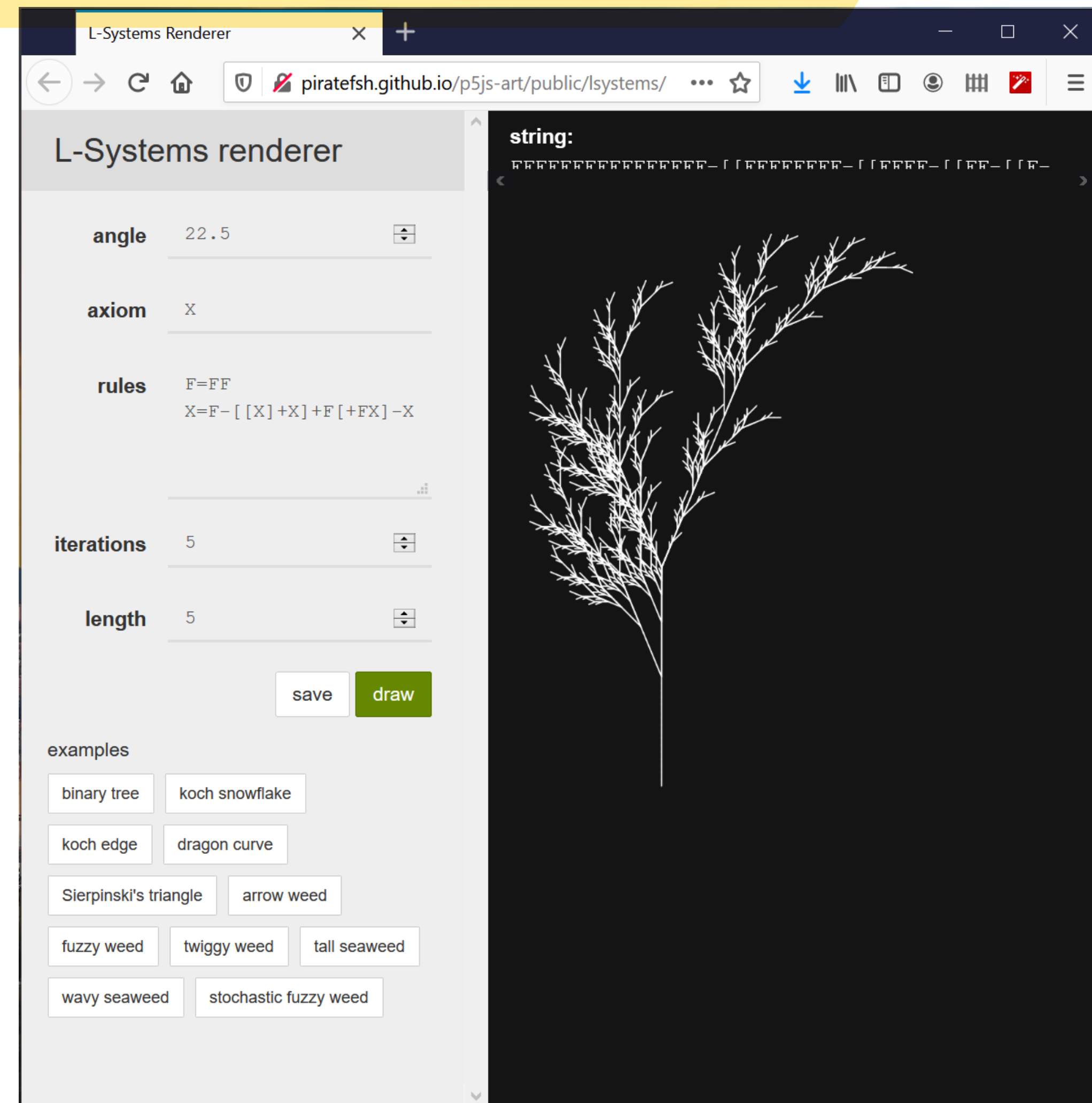
- Specialized tools for characters
 - MakeHuman
 - Adobe Character Animator



[Adobe Character Animator]

Procedural Content Generation

- Create content using rules and parameters
- Meshes can be created in the beginning of the level or continuously in real-time
- Common uses:
 - Infinite world/game level generation
 - Random terrain
 - Realistic trees, roads and rivers
 - Urban environments, rule-based architecture.
 - Repeating textures



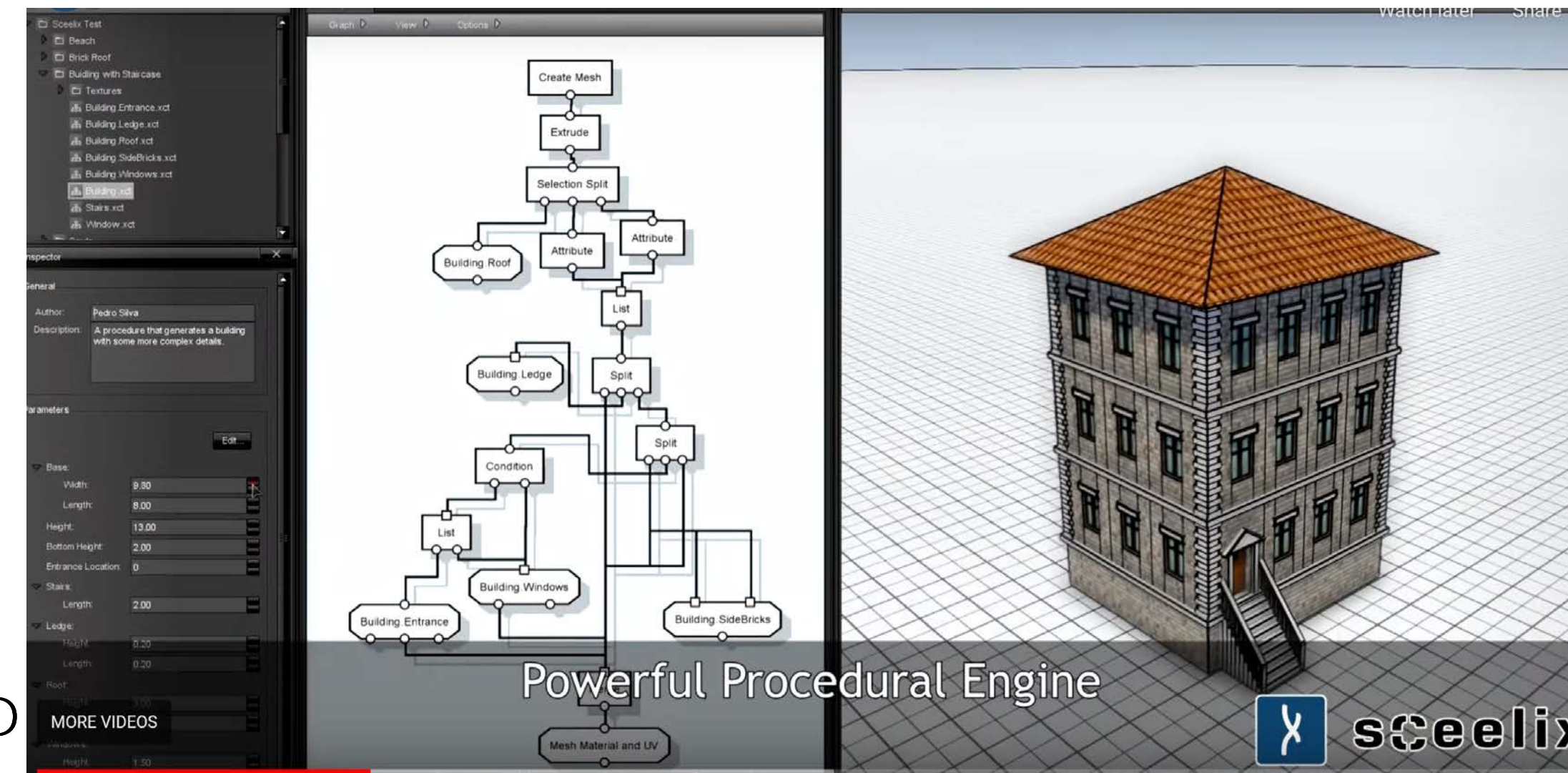
[PCG using [L-Systems](#)]

Procedural Content Generation

- Advantages:
 - Occupies less space
 - Scales easily according to the rules
 - Good for fictitious locations
- Disadvantages:
 - More processing time
 - Tends to have some repetition
 - Not good for known locations.



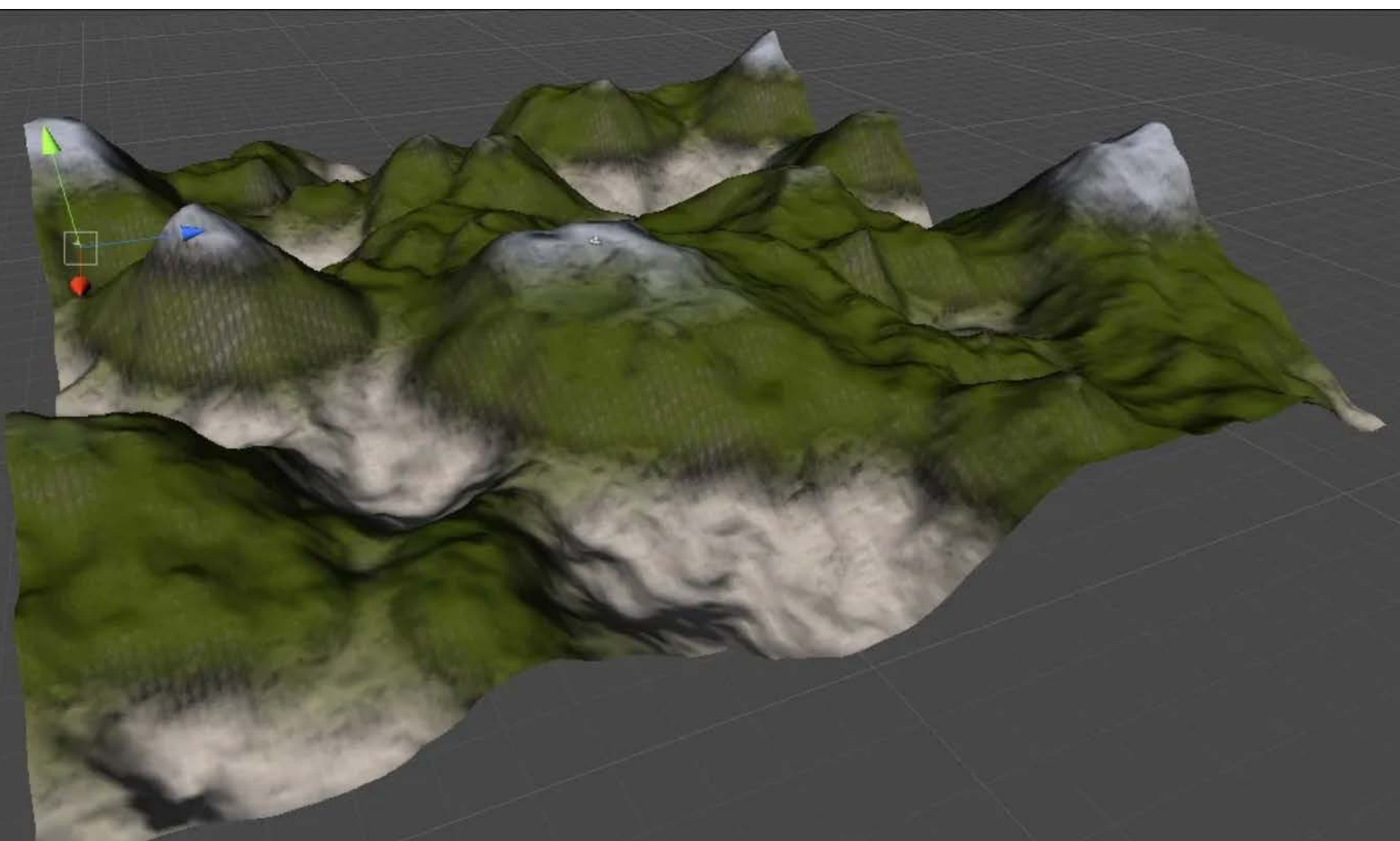
[[.kriegger 96KB, 2004](#)
a game using less than 96KB]


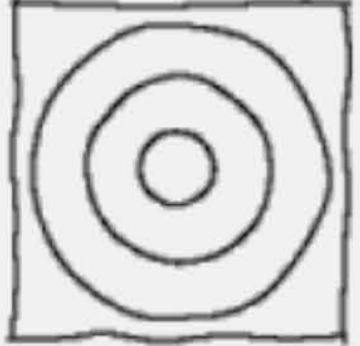
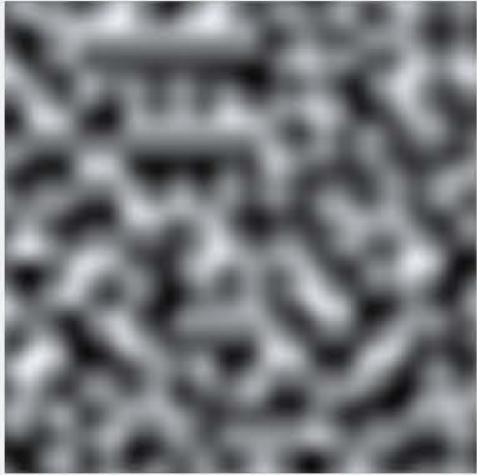
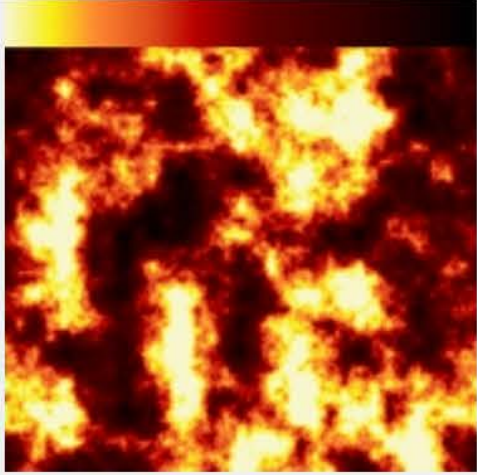
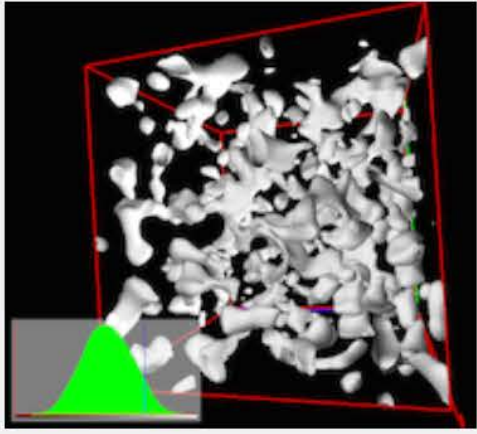



[Sceelix, 2017]

Terrain Generation

- Noise can be used to create natural and organic features
- Using Perlin Noise it is possible to create a pseudo-random realistic terrain.
Example in [Unity](#).

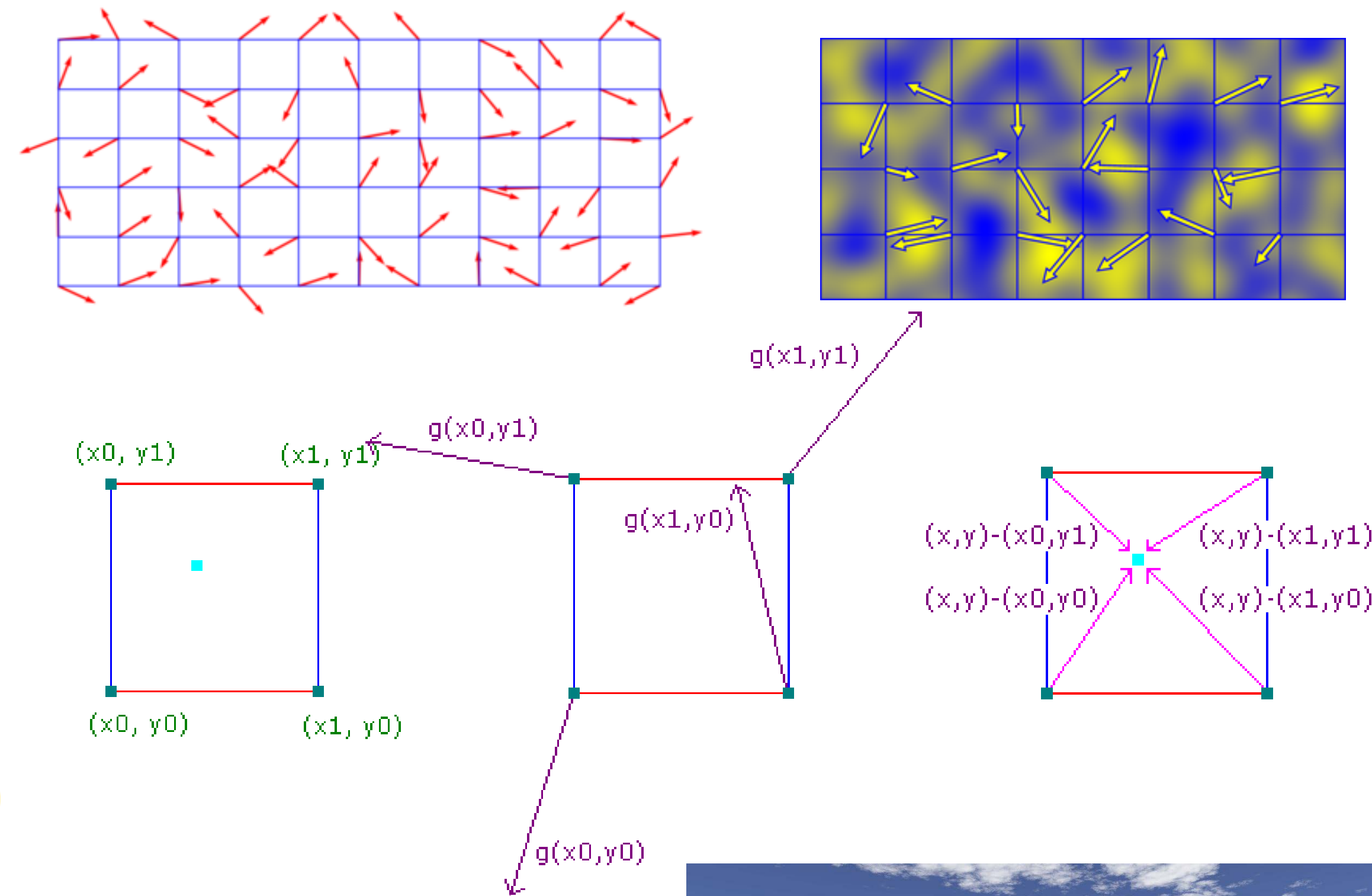


Noise Dimension	Raw Noise (Grayscale)	Use Case
1		 Using noise as an offset to create handwritten lines.
2		 By applying a simple gradient, a procedural fire texture can be created.
3		 Perhaps the quintessential use of Perlin noise today, terrain can be created with caves and caverns using a modified Perlin Noise implementation.

[Adrian's soapbox, <https://adrianb.io/2014/08/09/perlinnoise.html>]

Terrain Generation

- Perlin Noise Algorithm – *simplified version*:
- Step 1: Define grid with random gradient vectors in each intersection
- Step 2: For each candidate (blue dot) compute 4 (2D) or 8 (3D) influence vectors by doing a Dot Product between each distance and the nearest gradient g vector
- Step 3: Interpolate the value $[-1,1]$ of the point using the 4 influence vectors and a smooth function
- Step 4 do this to every point in the map
- Examples [1](#) and [2](#)



Photogrammetry

- Photogrammetry is the use of photography in surveying and mapping to ascertain measurements between objects.
- Using several photos it is possible to do 3D reconstruction using photogrammetry
- Used in games to create realistic natural worlds, natural textures or realistic scenes from the real world.



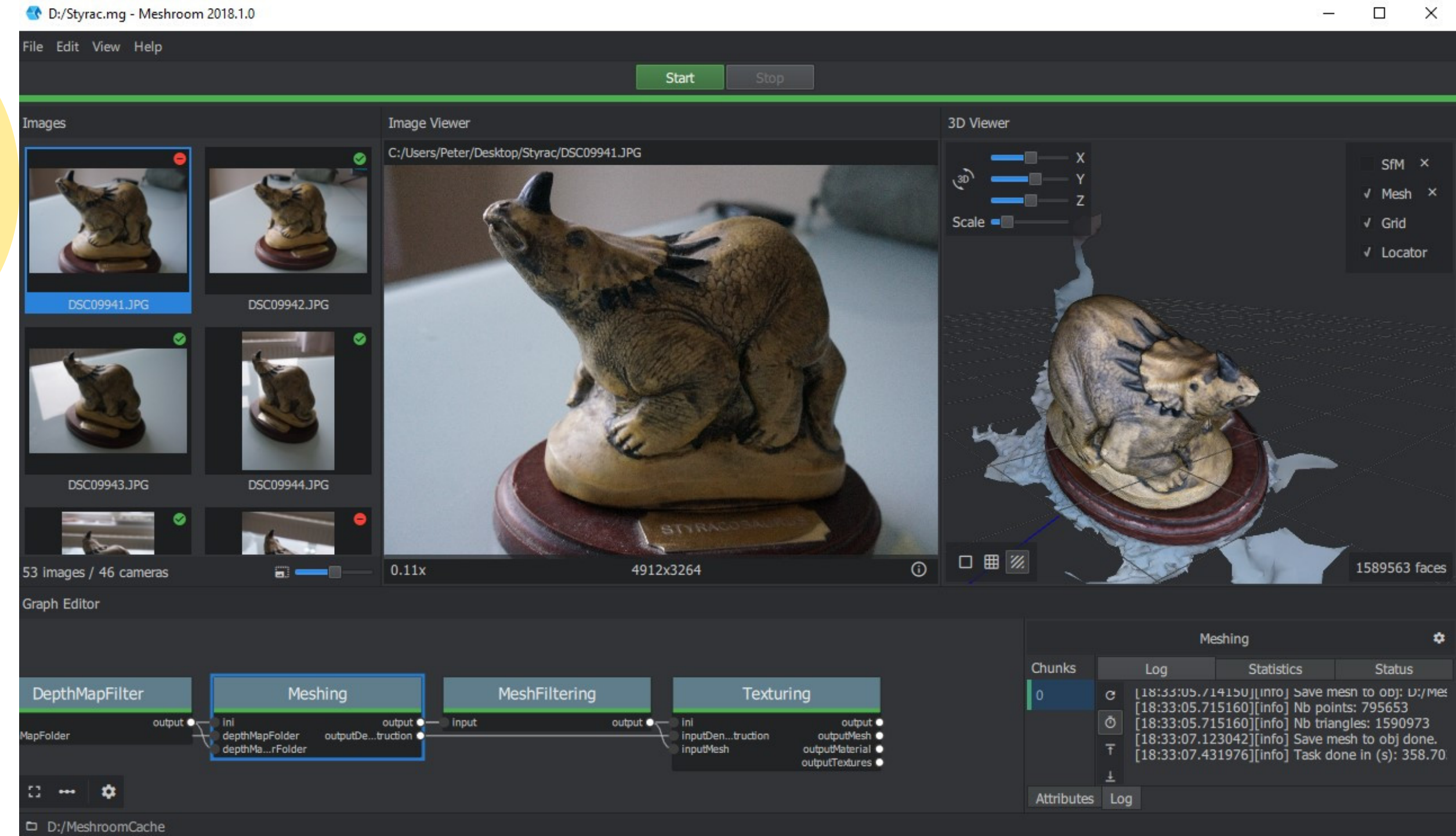
[Star Wars BattleFront 2, 2017]

[New York 3D reconstruction Google Earth]



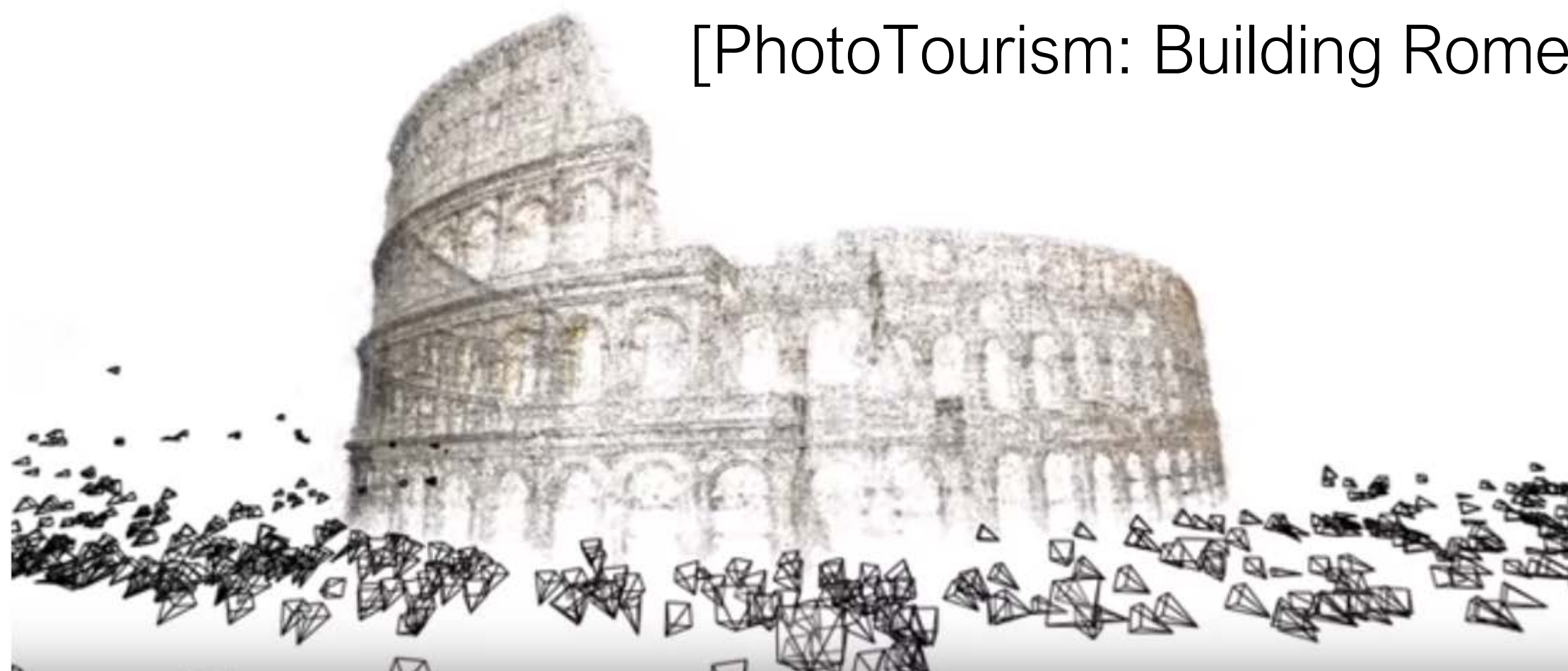
Photogrammetry

- Pro: reduces creation time
- Cons: requires manual post-processing and cleaning.
- Some software:
 - Autodesk Recap
 - Agisoft Metashape
 - AliceVision Meshroom



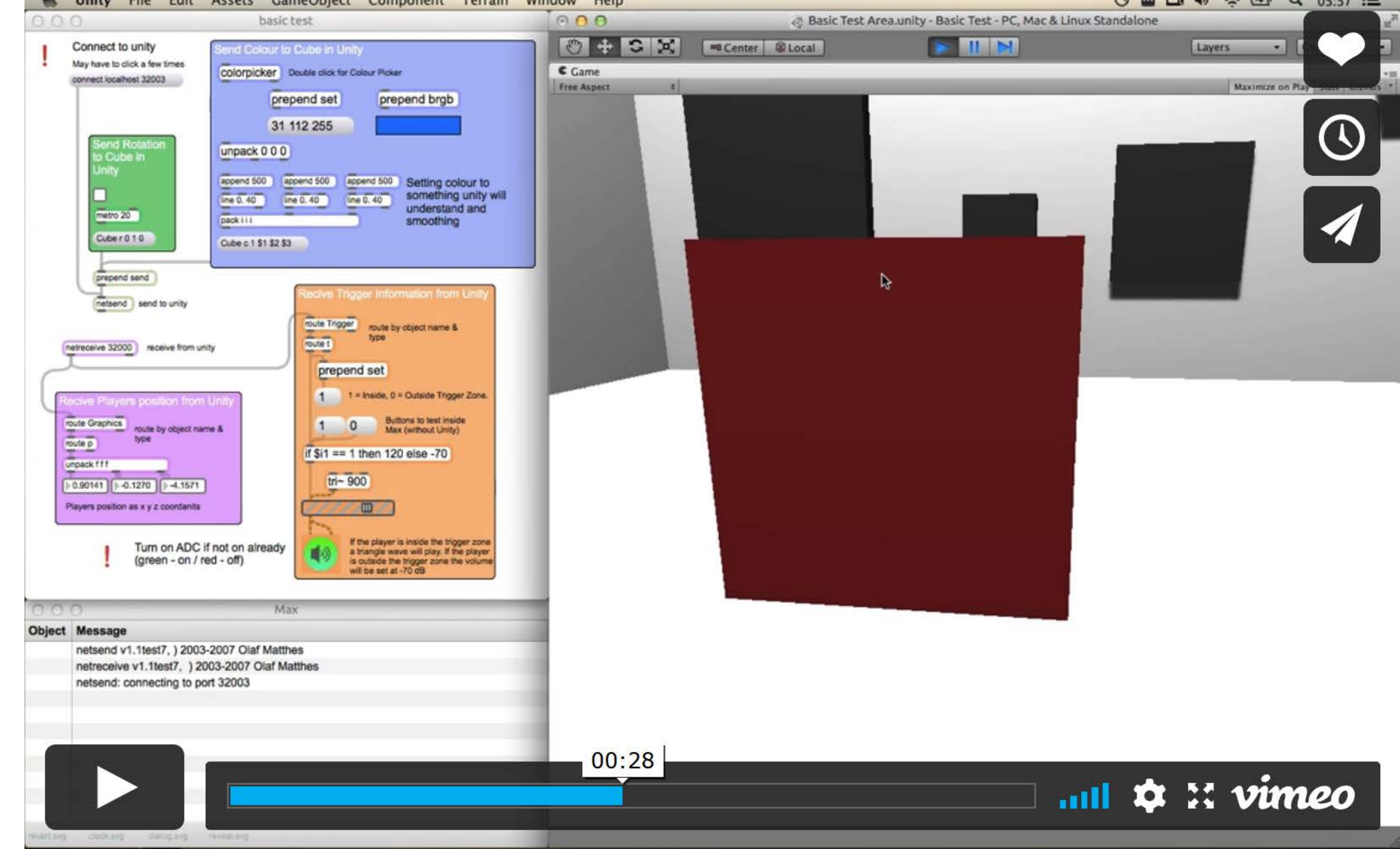
[AliceVision Meshroom, 2018]

[PhotoTourism: Building Rome in a Day, 2009]



Audio

- Used in background music and sound effects (SFX)
- **Event-driven:** something happens, sound is played
- **Procedurally Generated:** audio depends on game parameters such as steps or amount the door is open.
- Applications: Audacity, Adobe Audition, Reaper, Max MSP



[Max MSP + Unity]

Audio

- **Nyquist–Shannon sampling theorem**

- If a function $x(t)$ contains no frequencies higher than B hertz, it is completely determined by giving its ordinates at a series of points spaced $1 / (2 B)$ seconds apart.

- PCM (pulse-code modulated) audio (.wav, cd audio)

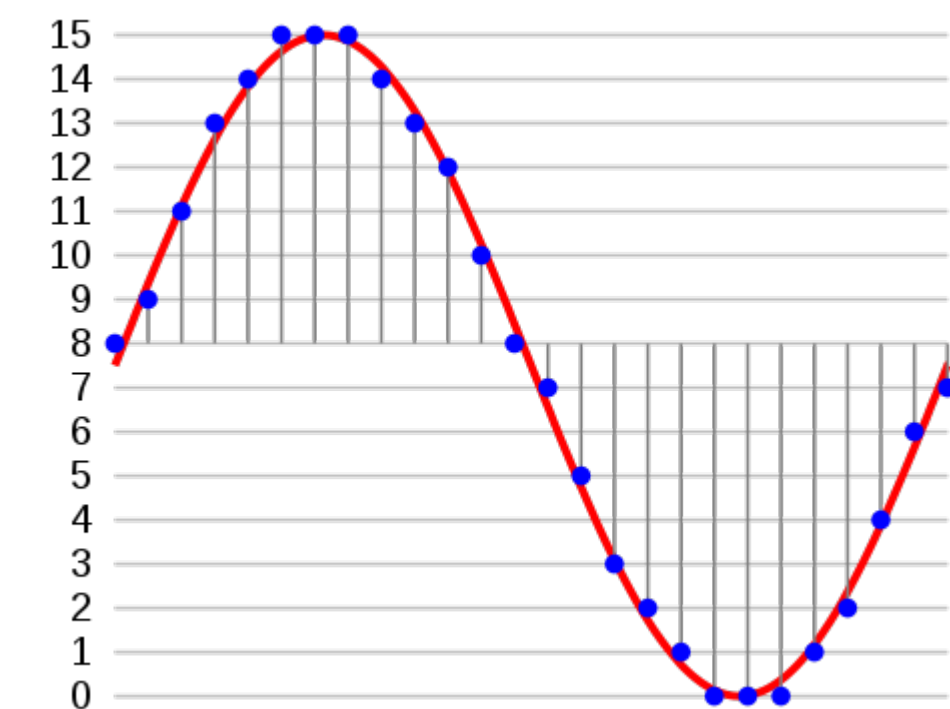
- Frequency Hz (22 kHz, 44kHz)

- Bits per sample (8 bit, 16 bit, 24 bit)

- Channels (mono, stereo, ambisonics (4 channels), 5.1 Surround)

- CD Audio: 44.1 kHz, 16bit, stereo

- MP3 audio: using properties of the Fourier Transform stores audio frequencies instead of raw values. Occupies much less space but loses quality in the encoding/decoding process



[26Hz 4 bits sampling of a 1Hz wave]

Images

- Used to create Textures and Sprites
 - Resolution: usually square powers of 2 (256x 256, 512x512)
 - Color Mode: defines number of channels and the color function (Grayscale, RGB, RGBA, HSV)
 - Color Depth: defines the bits per channel, usually 8bits (each color value belongs to [0,255]. HDR uses 16 bit. RGBA is a 4-channel mode with 32-bit color depth.
 - DPI: dots per inch, relation between pixels and real-world measurements. Mainly relevant for printing or relating with screen monitor size.

No compression: .bmp, .raw

Lossless compression: .png (lossless mode), .tiff, run-length encoding methods

Lossy compression: .jpg, .png, .gif (8bit color).

.jpg is better for complex pictures where the changes from the encoding/decoding process can be hidden.

Pixel Art

- Sprites are squared segments of a texture
- Pixel Art is the art of designing objects with a limited number of pixels and colors
- Makes use of:
 - Exaggerated features
 - Defined outlines
 - High-contrast colors
 - Dithering instead of gradients colors

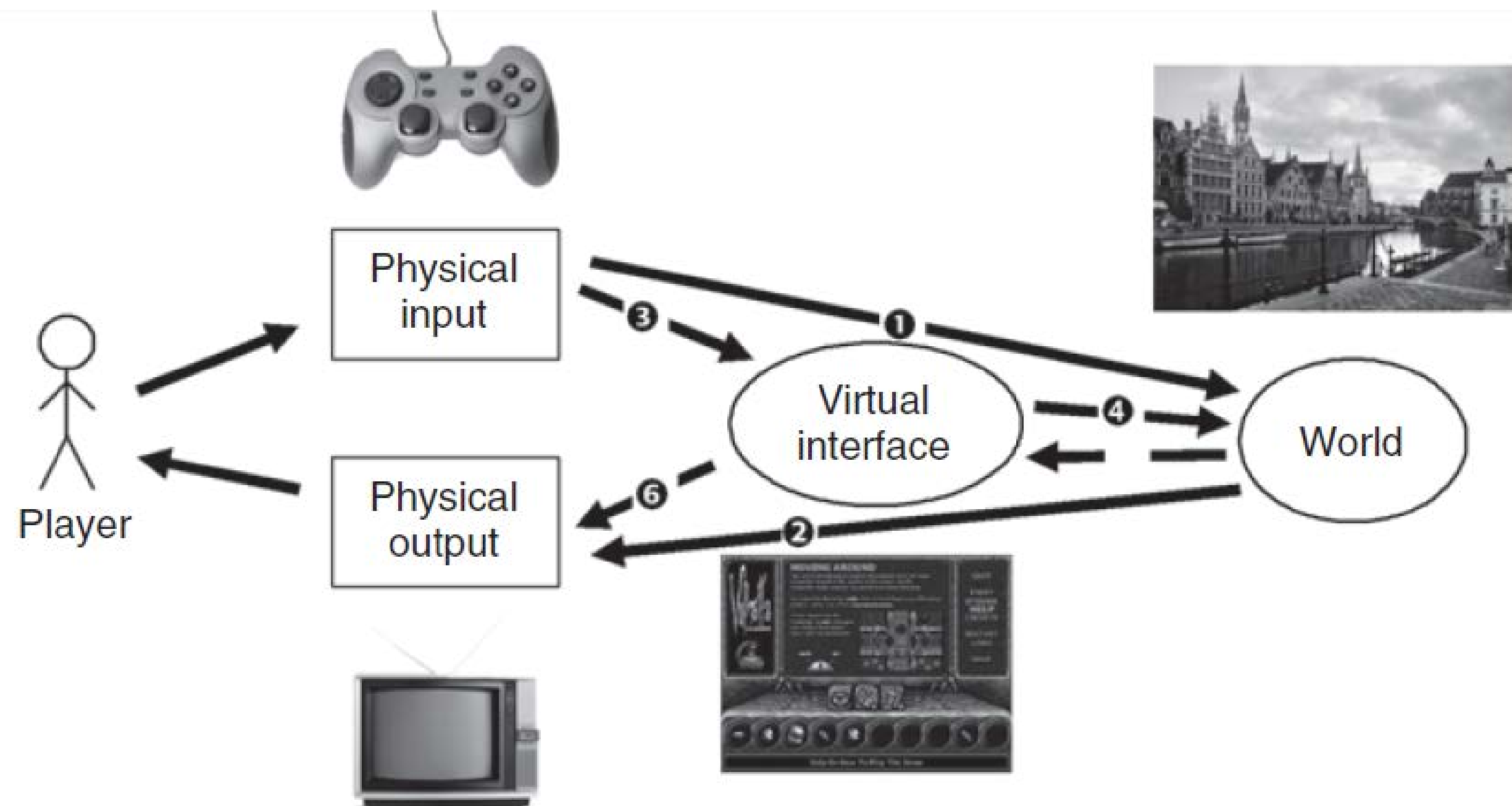


[Single texture with multiple sprites, Super Mario World]

Interface

Interface Design

- The Interface is the connection between the player and the game.
- Physical Interface (Input): gamepad, keyboard, mouse, joystick etc.
- Visual (Virtual) Interface: Buttons, Billboards, Visual Information, Diegetic vs non-diegetic information etc.
- The interface provides input but also sensory feedback (output).



Interface Transparency

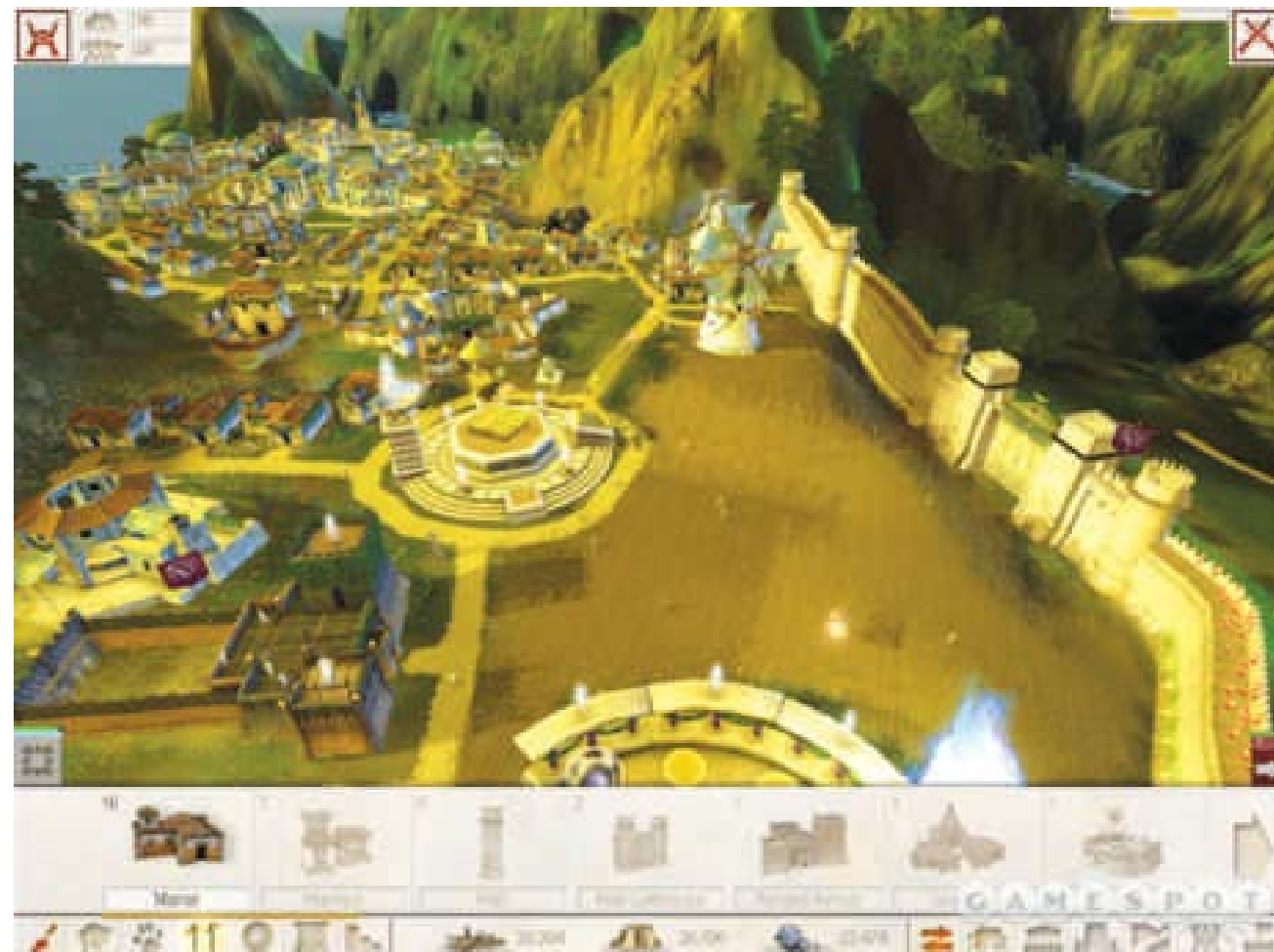
- Does the interface let the players do what they want?
- Do new players find the interface intuitive?
- Can players learn to use it without thinking?
- Is the interface over-confusing?
- Can players continue to use the interface well in stressful situations?
- Does something confuse players about the interface? On which of the six interface arrows is it happening?

Player-Centered Design

- Modified version of user-centered design
- You should create an interface for something because the player needs it...
- ... not because the system may provide it!



[Character Personalization, Lord of the Rings]



[Black & White 2, the interface uses mouse gestures and no buttons]

Physical Interfaces

- Arcade Games: custom physical interface for each game
- Computer Games: mouse and keyboard available
- Console Games: gamepad
- Mobile Games: Touchscreen
- VR: Headset and wands
- Motion Sensing: Gestures
- Others: Balance boards, dance carpets...



Visual Interfaces

- Active: Players can interact – menus , options, customizations, buttons, sliders etc.
- Passive: Player cannot interact – screen displays, informational panels and billboards, status, goal information etc.
- Typical components: score, lives & power, map, character config, start screen, status panels, goals list, inventory, simulation panel etc.
- Audio is sometimes considered to be a passive interface.

Visual Interfaces

- Visible: Players can see the interface – menus , options, customizations, buttons, sliders etc.
- Hidden: Player have to know the interface – keyboard keys, mouse gestures, swipe gestures
- May require tutorials for the player to learn!



[Street Fighter IV, 2008]

Visual Interfaces

- Diegetic vs non-Diegetic
A **diegetic interface** is when a **game's interface elements** exist inside the World
- Example: [Diegesis Theory](#)

[Word of Warcraft, non-diegetic interface]



[Far Cry 2, diegetic interface]



Documentation

Documentation

- Documentation is created along the development
- Main purposes:
 - Ensure that team member understand their roles
 - Convince companies to invest/fund development
 - Document for future developers
- No standard exists!

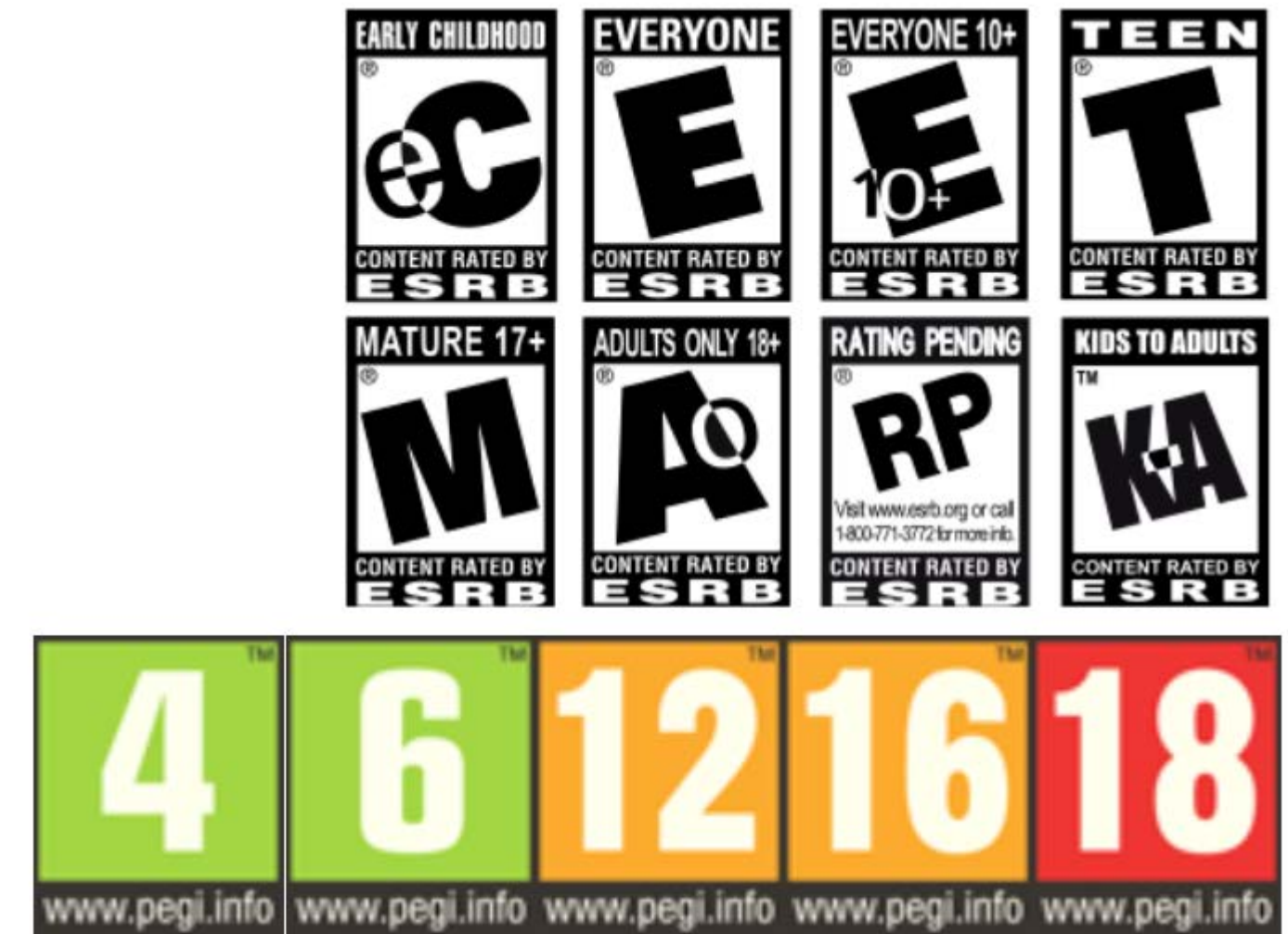
Concept Document (I)

Convey the goal and purpose of the game.

- **Premise (high concept):** The summary of the game purpose. (1-2 sentences)
- **Player motivation:** The game's victory condition. What will drive the player to keep to play the game to the end.
- **Unique selling Proposition (USP):** Why would anyone choose this game over competition.
- **Target market:** The portion of the game-playing audience the game is aimed at.
- **Genre:** What will be the primary genre for the game?

Concept Document (II)

- **Target rating:** age target, PEGI / ESRB rating for the game.
- **Target platform and HW requirements:** Choose the platform (or platforms) for the game.
- **License:** Licensing information.
- **Competitive analysis:** Select 5 successful titles for a comparative analysis.
- **Goals:** What are the expectations for this game as an experience? Discuss how the game will achieve these goals?



Game Proposal

Describes the components of the the concept with further detail. Include:

- Title, Hook, Goals
- Story Synopsis, Backstory, Characters
- Gameplay and Mechanics
- Technology, Online Features
- Art and Audio Features, Concept Art
- Production Details (Team, roles, budget, schedule)
- Risk Analysis, Marketing, intellectual property

Game Design Document

The large reference guide to the development process with a definitive version of what was proposed in the Game Proposal

- Story : Story Bible
- Game Interface
- Character Abilities and Items
- Game World: Game Level Design for each level
- Game Engine: Technical Design Document, Diagrams, Technical drawings and schematics
- Concept Art
- Project Plan: Team, Roles, budget, schedule, milestones
- Test Plan