3D TEXTURING

THEORY – 1

Unit-1.0 Introduction to Texturing and UV Mapping

Overview of Texturing:

Importance of textures in 3D modeling and how they enhance realism

1. Add Surface Detail Without Extra Geometry

Modeling every tiny scratch, crack, or pore would require millions of polygons. Instead, textures simulate these details efficiently.

- **Diffuse/Albedo maps** add base color.
- **Normal maps** simulate bumps and dents without extra geometry.
- **Displacement maps** create real geometric depth.
- **Roughness/Specular maps** control how light reflects.

2. Improve Lighting Interaction

Real-world materials react differently to light. Textures define:

- How shiny or matte a surface is
- How translucent or opaque it appears
- How reflective it behaves

3. Create Material Identity

Textures help viewers instantly recognize materials:

- Wood grain
- Rusted metal

- Rough concrete
- Smooth plastic
- Skin pores and fabric fibers

Without textures, a wooden table and a metal table might look nearly identical if they share the same shape.

4. Add Environmental Storytelling

Textures can show:

- Dirt and wear
- Scratches and aging
- Water stains or burn marks

5. Enhance Realism in Characters

For characters, textures define:

- Skin tone variation
- Wrinkles and pores
- Hair details
- Fabric patterns

◇ Example: Brick Wall

Instead of modeling every brick and crack:

- A **normal map** adds depth to the mortar lines.
- A **displacement map** slightly raises bricks for realism.
- A **roughness map** makes cement look dull and bricks slightly varied.

2. Realistic Lighting Interaction

◇ Example: Metal vs. Plastic Sphere

If you create two identical spheres in Blender:

- The **metal sphere** uses high metallic and low roughness values → sharp reflections.
- The **plastic sphere** uses low metallic and medium roughness → softer highlights.

3. Creating Material Identity

◇ Example: Wooden Table vs. Glass Table

Both may have identical geometry:

- Wood texture shows grain patterns and uneven color.
- Glass texture includes transparency, reflection, and smoothness maps.

4. Environmental Storytelling

◇ Example: Old Abandoned Car

Textures can add:

- Rust patches
- Scratches and chipped paint
- Dirt buildup

Without these textures, the car would look brand new and unrealistic. Games like The Last of Us Part II use heavy texture detailing to make environments feel lived-in.

5. Character Realism

◇ Example: Human Face

A 3D character in God of War Ragnarök includes:

- Skin pores via normal maps
- Subtle color variation (redness around nose and cheeks)
- Roughness variation (oily vs. dry areas)

Without these textures, the character would look like smooth plastic.

UV Mapping: Meaning of UVs and their relation with Model's geometry

What Is UV Mapping?

UV mapping is the process of projecting a 2D image (texture) onto a 3D model's surface.

- **U and V** are the 2D texture coordinates (like X and Y in 2D space).
- They tell the software exactly **where each pixel of a texture should appear** on a 3D object.

Think of it like cutting and unfolding a cardboard box so you can paint it flat — then folding it back into 3D.

Why UV Mapping Is Important

Without UV mapping:

- Textures would stretch randomly
- Patterns wouldn't align correctly
- Materials would look distorted

Proper UV mapping ensures:

- Accurate texture placement
- No stretching or seams
- Efficient use of texture space

UV mapping is used in tools like Blender and Autodesk Maya.

Simple Example

Real-World Examples

1. Character Face

When creating a human character:

- The face is carefully unwrapped.
- Eyes, lips, and skin details are painted in exact positions.
- Proper UV mapping ensures the eyes don't appear on the forehead.

In games like God of War Ragnarök, accurate UV mapping is critical for realistic facial textures.

2. Brick Wall

If UVs are stretched:

- Bricks look long and distorted.

If UVs are evenly scaled:

- Bricks look proportional and realistic.

Game engines like Unreal Engine rely on clean UVs for proper texture display.

Types of UV Mapping Methods

- **Planar Mapping –** Projects texture from one direction (good for flat surfaces).
- **Cylindrical Mapping –** Wraps around round objects like bottles.
- **Spherical Mapping –** Used for spheres like planets.
- **Automatic/Smart UV Unwrap –** Software calculates seams automatically.

What Are UV Seams?

Seams are edges where the model is "cut" during unwrapping.

Good seam placement:

- Hides texture breaks
- Reduces visible lines
- Improves realism

Example: On a human model, seams are often placed behind the ears or under arms.

UV Layout (UV Map)

After unwrapping, you get a flat 2D layout showing:

- All faces of the model
- Their arrangement inside the texture space (0–1 space)

Artists paint textures directly onto this layout.

Common UV Problems

- Stretching
- Overlapping UVs

- Wasted texture space
- Visible seams

Proper UV mapping fixes these issues and improves final quality.

Meaning of UVs

UVs are 2D texture coordinates assigned to a 3D model.

- **U** = horizontal axis in texture space
- **V** = vertical axis in texture space

(They use U and V instead of X and Y to avoid confusion with 3D axes.)

UVs tell the software exactly **which part of a 2D image (texture) appears on each part of a 3D model**.

Relationship Between UVs and Model Geometry

A 3D model is made of:

- Vertices (points)
- Edges (lines)
- Faces/Polygons (surfaces)

Each **vertex in 3D space (X, Y, Z)** also has a corresponding **UV coordinate (U, V)**.

So every point on your model has:

- A position in 3D space
- A position in 2D texture space

This connection allows the texture image to wrap correctly around the geometry.

Simple Concept

Think of it like this:

3D Geometry → Defines shape
UVs → Define how the texture sticks to that shape

If geometry is the body, UVs are the skin layout.

Important Concept: UVs Do NOT Change Shape

UVs:

- Do NOT affect the 3D shape.
- Only affect how textures are applied.

You can:

- Move UVs → Texture shifts.
- Move geometry → Shape changes.

They are connected but control different things.

What Happens If UVs Are Incorrect?

- Texture stretching
- Visible seams
- Misaligned patterns
- Overlapping textures

Even perfect geometry will look bad with poor UVs.

Unfolding UVs in Maya: Unfolding UVs to prepare for efficient texturing.

◇ Unfolding UVs in Autodesk Maya

Step 1: Select the Object

- Go to **UV Editing Workspace**
- Select your model
- Switch to **Face Mode**

Step 2: Cut UV Seams

- Select edges where you want to "cut" the mesh
- Go to:
  `UV Toolkit → Cut`

Seams should be placed:

- Along hidden areas
- Behind objects
- Under arms (for characters)

Step 3: Unfold

- Select the UV shell
- Click **Unfold** in the UV Toolkit
- Maya relaxes the UVs to reduce stretching

Maya uses an algorithm that tries to preserve proportions while flattening the geometry.

Step 4: Layout

- Click **Layout** to automatically arrange UV shells inside the 0–1 UV space
- Adjust spacing and scaling if needed

Step 5: Check Distortion

- Apply a **checker texture**
- Look for stretched or squashed squares

If distorted → Cut more seams and unfold again.

◇ Unfolding UVs in Blender

Step 1: Enter Edit Mode

- Select object
- Press **Tab** → Edit Mode
- Switch to **Edge Select**

Step 2: Mark Seams

- Select edges
- Right-click → **Mark Seam**

Blender uses seams exactly like real-world cuts.

Step 3: Unwrap

- Select all faces (A)
- Press **U → Unwrap**

Blender calculates and flattens the UVs.

Alternative options:

- **Smart UV Project** (automatic)
- **Project from View**
- **Follow Active Quads**

Step 4: Adjust in UV Editor

- Open UV Editor
- Scale (S), Move (G), Rotate (R) UV shells
- Pack UVs using **UV → Pack Islands**

Step 5: Check with Checker Map

- Apply a test grid texture
- Ensure squares look even

◇ Key Differences Between Maya and Blender

Feature	Maya	Blender
Main Tool	UV Toolkit	UV Editor
Relax Tool	Unfold	Unwrap
Auto Layout	Layout	Pack Islands
Auto Method	Automatic mapping tools	Smart UV Project

Both follow the same principle:
Cut → Unfold → Optimize → Check

- Seam placed along the inside arm
- Unfold flattens the cylinder shape
- UV shell looks like a long rectangle
- Texture (skin) applies evenly

Without proper unfolding:

- Skin pores stretch
- Patterns distort
- Lighting looks incorrect

🔹 Step-by-Step Process for Efficient UV Preparation

1️⃣ Analyze the Geometry

Before cutting seams, understand the shape:

- Organic model? (Character, creature)
- Hard surface? (Prop, vehicle, building)
- Symmetrical?
- Repeating parts?
- This determines which unfolding method to use.

2️⃣ Place Seams Strategically

Seams are where the model is "cut" before flattening.

- Good seam placement:
- Hidden areas (under arms, inside legs)
- Hard edges (corners of boxes)
- Natural breaks in clothing or objects
- Poor seam placement causes:
- Visible texture breaks
- Hard-to-paint layouts

3️⃣ Unfold / Relax the UVs

Use:

- **Unfold / Relax** in Maya
- **Unwrap (Angle Based)** in Blender

The goal:

- Even distribution
- Minimal distortion
- Natural flattening

4️⃣ Check for Distortion

Apply a checker texture.

Look for:

- Perfect squares → Good UVs
- Rectangles or stretched shapes → Needs fixing
- This ensures textures won't warp during painting.

5 Maintain Consistent Texel Density

Texel density = texture resolution per unit of geometry.
Example:

- A character's face should not have tiny UV space.
- Important areas should receive more UV space.
- Consistent density ensures:
- Equal sharpness across the model
- No blurry parts

6 Optimize and Pack UVs

After unfolding:

- Scale islands proportionally
- Rotate to use space efficiently
- Pack into the 0–1 UV space
- Leave padding between islands
- Efficient packing:
- Maximizes texture resolution
- Reduces wasted space

◇ Organic vs Hard Surface Approach

Organic Models	Hard Surface Models
Seam-based unwrap	Projection + cut
Relax to reduce stretch	Straighten UV edges

Focus on smooth transitions	Focus on clean alignment

- ## ◇ Key Goals of Efficient UV Unfolding

- ✓ Low distortion
  ✓ Logical seam placement
  ✓ Even texel density
  ✓ Efficient space usage
  ✓ Clean, paint-friendly layout

UV Layout Optimization: Techniques to minimize stretching and distortion in UV maps

UV Layout Optimization

UV Layout Optimization is the process of arranging UV islands efficiently inside the 0–1 UV space to maximize texture resolution, reduce wasted space, and improve rendering performance.

Techniques to Minimize Stretching and Distortion in UV Maps (Practical Guide)

When texturing a 3D model, **UV stretching** makes textures look warped or blurry. Minimizing distortion is essential for realistic, clean results. Below are **practical techniques** used in production.

1 Proper Seam Placement

What it does:
Seams are "cuts" in the model where the 3D surface unfolds into 2D. Correct seam placement reduces stretching.

Practical Tips:

- Place seams in **hidden areas** (back of arms, inner legs, behind ears)
- Follow **natural geometry breaks** (edges of clothing, corners, panel lines)
- Avoid cutting across important texture details (face, logos)

Example:
For a human character's torso, place seams along the sides and underarms, not across the chest, to prevent stretching over muscles.

2 Use Relax / Unfold Tools

What it does:
These tools automatically adjust UVs to reduce stretching.

In Maya:

- Use **Unfold** and **Optimize** in the UV Toolkit
- Relax UVs iteratively for smoother distribution

In Blender:

- Select faces → **Unwrap (Angle Based)**
- Use **Minimize Stretch** in the UV Editor

Tip: Always check with a **checker texture** to verify square distortion.

3️⃣ Maintain Consistent Texel Density

What it does:
Even spacing of UVs ensures uniform texture resolution, avoiding “stretched” or “squashed” areas.

Practical Approach:

- Scale UV islands proportionally to the 3D surface area
- Use “Average Island Scale” in Blender or “Normalize UVs” in Maya

Example:
A character’s face should occupy more UV space than the back of the head for sharper detail.

4️⃣ Avoid Overlapping UVs (Unless Intentional)

What it does:
Overlapping islands can cause textures to repeat in unintended ways.

Practical Approach:

- Check for overlapping islands in UV Editor
- Stack UVs only for **mirrored identical parts** (arms, legs)

5️⃣ Use Correct Projection Methods

Different geometry types need different projection types:

Geometry Type	Recommended UV Method	Tip
Flat wall	Planar Mapping	Project from front view
Cylinder (arms, pipes)	Cylindrical	Align seam along back
Sphere (planets, balls)	Spherical	Place seam along poles
Complex organic	Seam-based Unwrap	Combine with relax tools

6 Add Supporting Edge Loops

What it does:
Extra geometry around curved or stretched areas helps UVs relax more naturally.

Example:

- Model a character's elbow: add extra loops so the arm bends without extreme texture stretching.

7 Checker / Test Textures

Practical Check:

- Apply a **checkerboard pattern** to the model
- Look for:
  - Stretched squares → UV needs adjustment
  - Squashed squares → scale UV islands
- Iteratively adjust seams, relax, and scale

8️⃣ Use UV Packing Carefully

- Pack UV islands without forcing them into small areas
- Avoid extreme scaling that distorts texel density
- Leave proper padding to prevent bleeding

🔷 Real-World Example

Character Arm:

- Seam along the inner arm
- Cylindrical unwrap
- Relax UVs → checker pattern shows even squares
- Scale to maintain texel density
- Result → skin texture wraps naturally over elbow without stretching

Practical Application: Creating a simple UV map for a basic model (e.g., a cube or a basic object) and apply a texture.

1️⃣ Practical Application in Autodesk Maya

Step 1: Create a Basic Model

- Go to **Create → Polygon Primitives → Cube**.
- Place it in the scene.

Step 2: Open the UV Editor

- Go to **UV → UV Editor**.
- Select the cube to see its default UVs.

Step 3: Apply Automatic UVs

- With the cube selected, go to **UV → Automatic**.
- Maya generates a UV map for all six faces.
- Alternative for better control: **UV → Planar/Cylindrical/Spherical Mapping**, depending on the shape.

Step 4: Check UVs

- Open the **UV Editor** to see islands.
- Make sure each face is represented and not overlapping.
- Scale/rotate islands to fit efficiently in the 0–1 space.

Step 5: Apply a Texture

1. Open the **Hypershade**.
2. Create a **Lambert or Phong material**.
3. Assign a **file texture** (e.g., checkerboard or brick image) to the **Color slot**.
4. Assign the material to the cube.

Step 6: Preview the Texture

- Press **6** in the viewport to see textures.
- Use the **checker texture** to verify no stretching.

☑ Result

- Each cube face is mapped correctly.
- Texture appears without stretching.
- Ready for further editing or export.

2 Practical Application in Blender

Step 1: Create a Basic Model

- Press **Shift + A → Mesh → Cube**.
- Cube appears at the origin.

Step 2: Enter Edit Mode

- Select the cube → **Tab** to enter Edit Mode.
- Select all faces (**A**).

Step 3: Mark Seams

- For simple cubes, seams along edges help flatten faces.
- Select edges → **Right-click → Mark Seam**.
- Typical: select one vertical edge and three edges to unwrap sides.

Step 4: Unwrap

- Select all faces (**A**) → press **U → Unwrap**.
- Blender generates UV islands in the **UV Editor**.

Step 5: Check UV Layout

- Open **UV Editor** → check islands.
- Scale/rotate islands to fit in the 0–1 space efficiently.

Step 6: Apply a Texture

1. Switch to **Shading workspace**.
2. Create a **new material** → assign **Base Color → Image Texture**.
3. Load a texture image (checkerboard, brick, etc.).
4. Connect it to the **Principled BSDF Shader**.
5. Assign the material to the cube.

Step 7: Preview the Texture

- Switch viewport to **Material Preview** or **Rendered** mode.
- Verify the texture is mapped correctly without stretching.