3D Virtual Try-On: T-Shirt on Body Mesh

1. Approach

The core approach involved aligning, rotating, scaling, and translating a t-shirt mesh to fit a 3D human body mesh. First, we determined the tallest axis of the body to ensure proper orientation, rotating it as needed to make the Y-axis the vertical height. We used axis-aligned bounding boxes (AABB) for both body and shirt to estimate centers, extents, and scale. The t-shirt mesh was normalized to Y-up orientation, scaled to match the body width (with a 20% buffer), and translated to chest height using 63% of the body's Y-extent. A final 180-degree flip was applied to ensure the t-shirt faced forward correctly.

2. Assumptions

- The t-shirt is symmetric and front-facing after proper rotation.
- The body mesh is upright and centered in world space.
- Chest height is approximately 63% up the body’s Y-extent.
- Meshes are clean, manifold, and have proper topology (especially in GLB format).

3. Challenges

- **GLB Format Handling:** GLB meshes required loading via Trimesh and conversion to Open3D format.
- **Inconsistent Mesh Orientations:** Both body and shirt had unknown coordinate bases and needed inspection and adjustment.
- **Size Mismatch:** Body and t-shirt meshes varied greatly in size and position.
- **Chest Alignment:** No explicit chest landmark; required heuristic estimation.

4. Solutions

- Used `trimesh.load` to extract GLB geometry and converted it into Open3D format.
- Applied conditional rotation logic to align Y-axis as vertical for both body and t-shirt.
- Used bounding box dimensions to compute a scale factor that matched the shirt width to the body’s, with a margin.
- Estimated chest height as `min_y + 0.63 * height` for shirt placement.

5. Suggestions for Future Improvements

- **Cloth Simulation:** Integrating Blender’s cloth physics or PyBullet for more realistic draping.
- **UV Mapping:** Applying textures via UV projection for realism.
- **SMPL-X Integration:** Leveraging SMPL-X for dynamic body morphing and pose adjustment.
- **Collision Handling:** Preventing interpenetration using shrinkwrapping or soft-body physics.

6. Bonus Areas & Future Exploration 🧠

- **Cloth Simulation:** While not implemented here, tools like `Blender`, `PyBullet`, or `NVIDIA Flex` could be used to simulate realistic cloth draping and movement over the body mesh.
- **UV Mapping:** Texture projection and UV unwrapping could significantly improve realism. The pipeline could include baking textures or using procedural shaders mapped to the t-shirt surface.
- **SMPL-X Body Manipulation:** I'm aware of SMPL-X, which enables parametric control over human body pose and shape. This could allow dynamic avatar customization and better fitting accuracy.
- **Collision Handling:** Mesh intersection issues can be handled using soft-body physics, cloth constraints, or shrinkwrapping algorithms to better conform the t-shirt mesh to the body without clipping.

This project demonstrates a fundamental pipeline for static mesh-based virtual try-on, suitable for visualization and prototyping tasks.