GEOMETRY-AWARE AR FEATURES

In this section, we list all ideas from our brainstorming sessions and discuss their depth representation requirements, use cases, and whether each is implemented in DepthLab [5]. Note that ideas 9, 21, 24, 25 are not available as open source code yet, but can be easily reproduced with the provided algorithms.

Depth Representation Requirement: Localized Depth

1. **3D oriented cursor**: Render a 3D cursor centered in the screen center. The 3D cursor should change its orientation and scale according to the surface normal and distance when moving along physical surfaces. Implemented in DepthLab: Yes.

2. **Laser reflection**: Render a virtual laser from the user to physical objects along the camera’s principle axis by touching the screen. The laser should be reflected when reaching a surface. The hit and reflection algorithms should be reusable for mobile AR developers. Implemented in DepthLab: Yes.

3. **Physical measurement**: Measure the distance and height of an arbitrary physical point in meters by touching a pixel on the phone screen. Implemented in DepthLab: Yes.

4. **Avatar path planning**: Navigate a virtual object to move naturally between two points in physical environments. Implemented in DepthLab: Yes.

5. **Collision-aware placement**: Test if a virtual object’s volume collides with observed environment surfaces. Implemented in DepthLab: Yes.

Depth Representation Requirement: Surface Depth

6. **Virtual shadows**: Render geometry-aware shadows [11] that are cast onto physical surfaces. The shadow may be integrated with any mobile AR application with virtual objects. Implemented in DepthLab: Yes.

7. **Environmental texturing**: Re-texture physical surfaces with other materials, e.g. lava, grids, grass. This technique could also be used to replace the ceiling with the star map of your location or generate a terrain with grass, vegetation, or rock. Implemented in DepthLab: Yes.
8. **Physical simulation:** Simulate physical phenomena for augmented reality objects, e.g. collision. Implemented in DepthLab: Yes.

9. **AR graffiti:** Allow the user to touch on the screen and sketch/spray/paint virtual drawings onto physical objects. Implemented in DepthLab: Yes.

10. **AR paintballs:** Allow the user to throw color balloons onto physical objects. The balloons should explode as texture decals onto the surfaces they hit. Implemented in DepthLab: Yes.

11. **AR flooding:** Detect empty ground regions and render water-flooding effects in the physical environment. The water mesh is procedurally generated where the environment’s elevation is lower than the predefined water level. Implemented in DepthLab: Yes.

12. **Mesh freezing:** Allow the user to freeze a portion of the screen-space mesh, change its material, and observe it from another perspective. Implemented in DepthLab: Yes.

13. **Object-triggered geometry-aligned tags:** Anchor labels on top of the recognized object by using object recognition models, operating as a virtual label printer. Implemented in DepthLab: No. Could be implemented by looking for the highest surface of the object and attaching virtual tags to it. However, this method would be best implemented with semantic segmentation algorithms.

14. **Perspective illusion art:** Capture an image of the environment from a single point of view, then decompose the image into a 3D pattern when the user shifts the viewpoint. Project a texture on the depth map and keep the original 6-DoF pose of the projection. Implemented in DepthLab: No.

**Depth Representation Requirement: Dense Depth**

15. **Object occlusion:** Occlude virtual objects placed behind physical objects. This component is useful for almost all mobile AR application with virtual objects. Implemented in DepthLab: Yes.

16. **3D-anchored focus and aperture effect:** Render “depth-of-field” effects that simulate a DSLR camera. The user may anchor the focus point to a physical object and set the focal plane. The pixels that are outside the simulated depth of field are blurred out. Implemented in DepthLab: Yes.

17. **Relighting effects:** Relight the physical environment with virtual light sources. The user may adjust the virtual light intensity, color, and position. Implemented in DepthLab: Yes.

18. **Snow effects:** Generate snow particles randomly outside the screen space and make them fall to the ground with random velocity. Each particle vanishes when it lands on a surface. Implemented in DepthLab: Yes.

19. **Rain effects:** Similar in behavior to the snow effect, the rain particles should also splat on the surface using the estimated normal vector from the localized depth. Implemented in DepthLab: Yes.

20. **Fog effects:** Render screen-space post-processing effects, where far objects are overlaid with thicker fog. The user may interactively adjust the fog intensity in real time. Implemented in DepthLab: Yes.

21. **Edge highlighting:** Highlight the edges of the observed environment according to the depth map. Unlike edge detection in a color image, highlighting depth edges may offer a clean segmentation of physical objects regardless of their texture. Implemented in DepthLab: Yes.

22. **Depth-based segmentation:** Segment the foreground, background, or objects between a certain range of depth values from the color image. It may be useful for teleconferencing tasks. Implemented in DepthLab: Yes.

23. **False-color visualization and animated transition effects:** Visualize the depth map based on a specific transfer function and animate the transition from close to far, or far to close. Implemented in DepthLab: Yes.

25. Design a “hide and seek” game: Spawn virtual avatars, occluded behind physical obstacles. The user may look around and tap on the avatar on the phone screen to catch them. Implemented in DepthLab: Yes.

26. Render wigglegram and kinetic-depth images (3D photos) [3]: Aid the visualization of the three-dimensional structure of a scene by leveraging the motion of the mobile device in the rendering. Implemented in DepthLab: Yes.

27. Remove objects with depth-based image in-painting: Dense depth map may assist image-based Poisson blending or deep-learning techniques for object removal. Implemented in DepthLab: No.

28. Compress video for teleconferencing with depth data: After segmenting out the background with the dense depth map, the application may only transmit the foreground pixels for video conferencing. Implemented in DepthLab: No.

Depth Representation Requirement: Persistent Voxels
All ideas with dynamic voxels are not supported by DepthLab so far.

29. Scan commodity objects or humans as 3D models [7]: The 3D model may be further used for online shopping, virtual design, and entertainment industries. The user would be required to take photographs from every perspective of the object.

30. Segment physical objects with user-guided strokes [9]: This method requires the system to keep track of the strokes and currently segmented portion of the mesh.

31. Music visualization: Visualize music by animating the point cloud of the physical world1.

32. Semantic object labelling: Label physical objects with semantic classes [6] and colorize each object based on its corresponding label or overlay text next to the object.

33. Virtual mirrors: Render virtual mirrors with photorealistic reflections [10]. The system must memorize persistent meshes around the user.

34. Generate occlusion-aware spatial sound effects: Leverage ambient sound propagation techniques [13] to simulate the spatial sound with persistent reconstructed meshes.

Depth Requirement: Dynamic Voxels
All ideas with dynamic voxels are not implemented in DepthLab so far, but may be reproduced on mobile phones with time-of-flight sensors.

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1Example concept of music visualization with voxels in VR: [https://www.shadertoy.com/view/wsSXzh](https://www.shadertoy.com/view/wsSXzh)
REFERENCES


