NeRD++: Improved 3D-mirror symmetry learning from a single image

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https://github.com/yanconglin/3D-mirror-symmetry-plane

Task: detecting mirror symmetry planes from single-view images
- Input: a single RGBA image
- Output: perspective mirror symmetry plane (wx+1=0)

(I) Contributions:
- Improved data-efficiency over sota NeRD [1]
  Solution space is a hemisphere - spherical convs for localization
- Improved compute efficiency (20x faster):
  Feature correlations indicate similarity between pixels and mirrors.

(II) Background knowledge

1. The bias (scale) can not be determined from an image.
2. Mirrors can be mathematically calculated [2].

(III) NeRD Recap

Given a candidate plane
For each point (pixel):
  Calculate its mirrors over depth;
  Concatenate the feats;

Construct an expensive 4D feature volumes [2C, D, H, W];
Apply learning and Classification (how likely the given plane is a symmetry plane);
Re-sample nearby points from the hemisphere

Iterate over 3 times (coarse-to-fine) to reach a desired resolution.

(III) NeRD++

However,
- a. computationally expensive: 4D feature volumes;
- b. data-hungry: massive training data/inferior results on subsets.

We propose:
- a. calculate feature correlations explicitly,
  Correlation indicates similarity ([D, H, W]);
- b. use another inductive prior:
  Solution space is a hemisphere, spherical convs.

(IV) Experiments

Two datasets: ShapeNet[3], Pix3D[4]
Evaluation: angular errors in the camera space (Angular Accuracy).

1. Data-efficiency on ShapeNet
   2. Pix3D (~5K images)
   3. Failure cases

(V) Limitations
- Rely on entirely on appearance features (textureless surface/repetitive patterns);
- Iterate over all possible depth;
- Detect only the dominant symmetry plane.

(V) Future work
- How to hanle occlusion explicitly?
- Downstream tasks using symmetries (depth, shape completion, 3D reconstruction).
- Detect intrinsic symmetries (of non-rigid objects).

Reference