Computer Graphics from a Neuroscientist's Perspective

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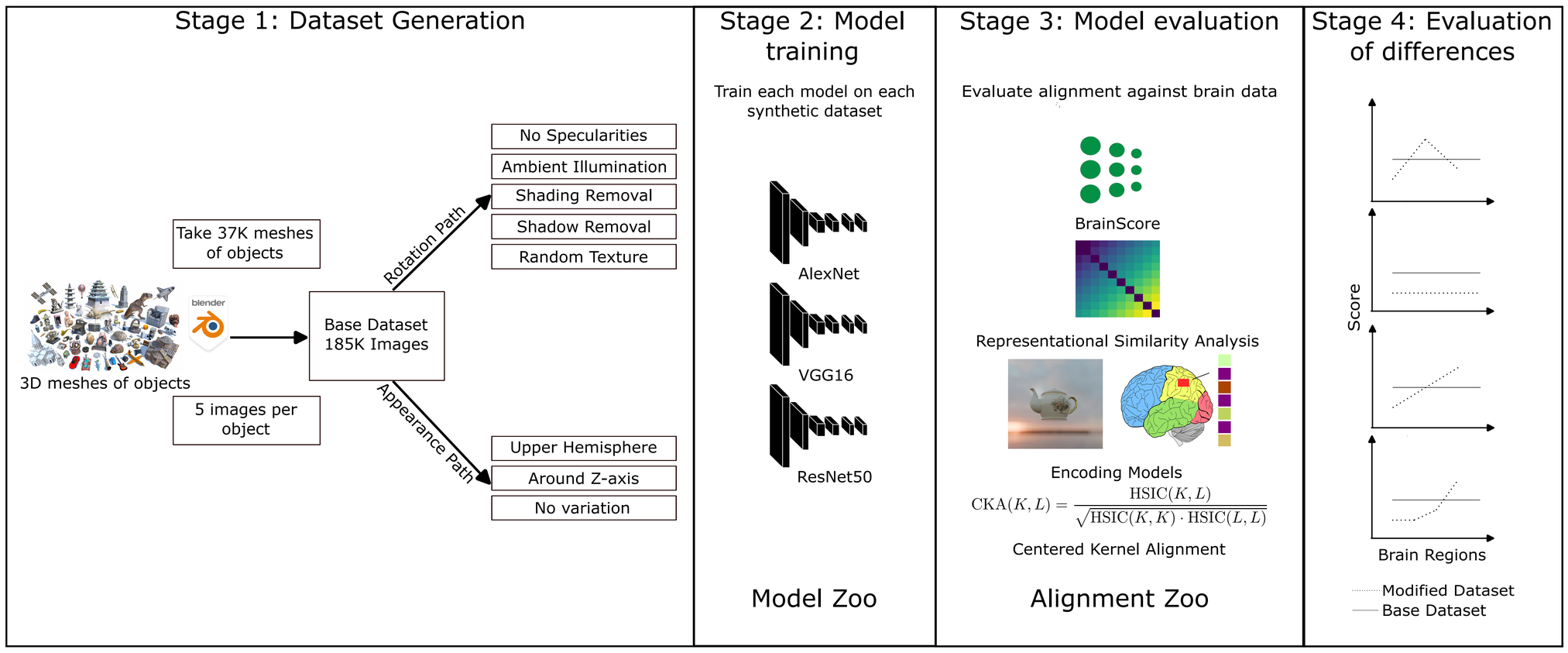
Hypothesis and Introduction

- Computer Graphics can be used to study the perception of appearance and rotation effects in the brain.
- By generating controlled stimuli, we can explore how the alignment between neural networks and brain data changes.
- Training machine learning models by only changing the training data without controlling the loss function or the architecture gives a direct way to control its internal representations.

Comparing CNNs to the Brain

- We assume CNNs form a good model of the visual system.
- Modifying the training diet of a deep neural network changes its match to a particular brain region when evaluated using techniques such as Representational Similarity Analysis (RSA) and Centered Kernel Alignment (CKA).
- We compare representations learned by CNNs to representational dissimilarity matrices (RDMs) from fMRI data (NSD, Natural Scenes dataset) and electrode recordings from Majaj et. al. 2018 available on BrainScore.

Pipeline

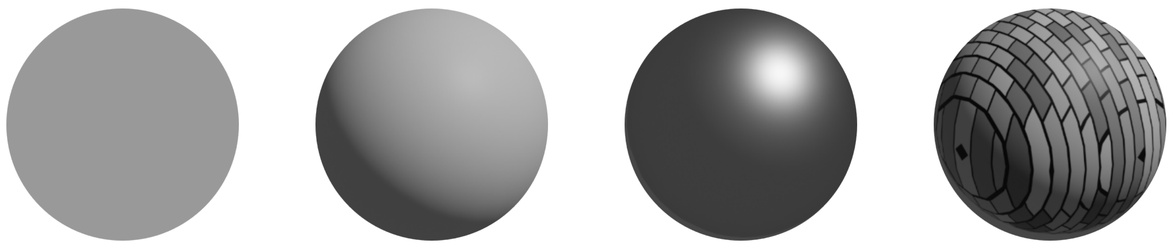


This figure highlights the pipeline of our work. In this work, we made use of a blender rendering engine to synthesize datasets with variations in appearance and rotation effects. We trained a zoo of models which are evaluated using a series of alignment metrics. The difference in alignment metrics are then visualized down the visual hierarchy (V1-V4).

Appearance Effects

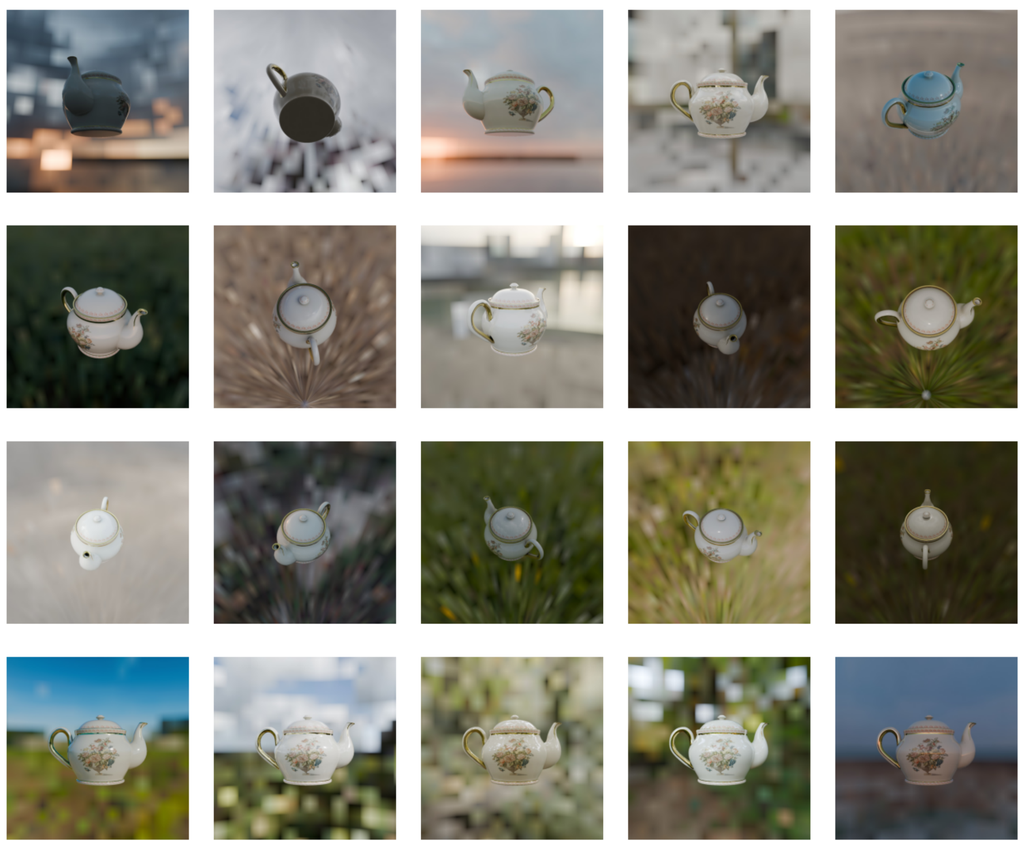
(a) Scene with all appearance effects *(b) Scene with only ambient illuminatioin* *(c) Textures of the mesh replaced* *(d) Shadows removed from the scene* *(e) Shading removed from the scene*

Illumination Cues



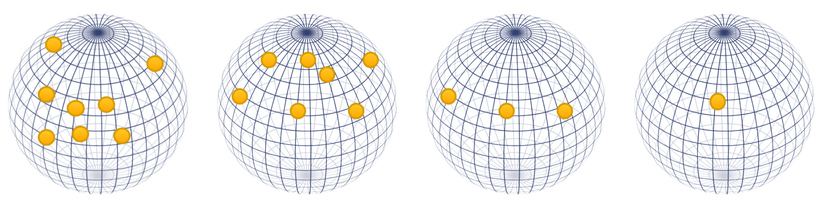
(a) Unshaded sphere *(b) Shaded sphere* *(c) Specular sphere* *(d) Textured sphere*

Camera Viewpoints



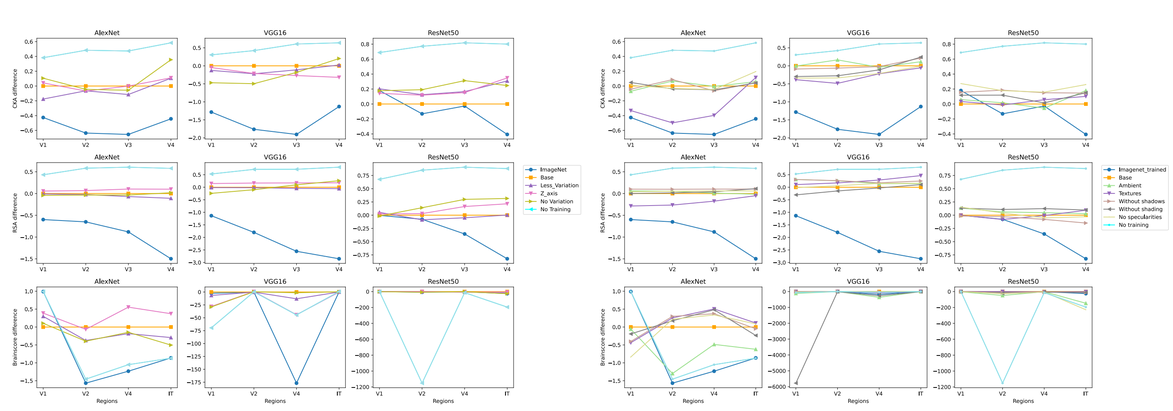
(a) Full Variation of the camera angle (along a sphere) (b) Less Variation of the camera angle (along a hemisphere) (c) Variation along z-axis (d) No variation

Sampling Camera Viewpoints



(a) Sampling along a Sphere (b) Hemisphere, (c) Z-axis, (d) One viewpoint

Results



Trends in the score for the Base vs Modified datasets. The alignment metrics were compared against RDMs from the NSD dataset. Left: rotation effects. Right: illumination effects. Scores are normalized differences: Base − Modified.

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