Characterizing the shape and texture of natural objects using Active Appearance Models

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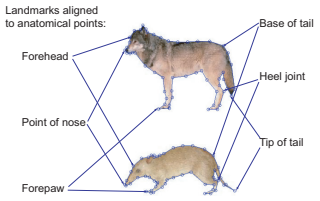
Animal image set: Extracting shape and texture

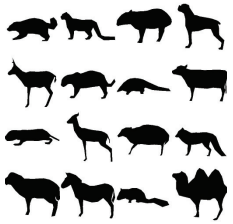
Image set

265 animal images, matched for pose

Annotated shape

52 landmark points along outline of body

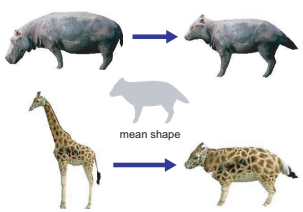




Examples of texture-free shapes

Shape-free texture

Created by warping each animal's shape onto the mean shape



Examples of shape-free textures

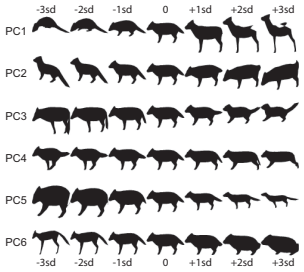
Reference

Cootes, T. F., Edwards, G. J., and Taylor, C. J. (1998). Active Appearance Models. In H. Burkhardt and B. Neumann (Eds.), *Proc. Fifth European Conf. Computer Vision 1998*, Vol. 2 (pp. 484-498). Springer-Verlag.

Principal components analysis of shape and texture

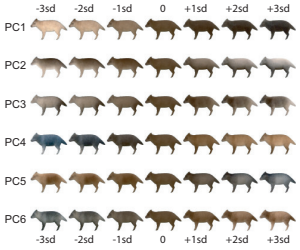
Principal components of shape

16 components account for 95% of variance



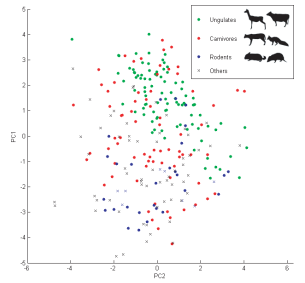
Principal components of texture

140 components account for 95% of variance



Shape space and categorization

Distribution of animal types along first two axes of shape space



Human categorization of animal images

Hierarchical grouping task

3 conditions:

shape-only images (N=10),
texture-only images (N=9),
shape+texture images (N=10)

Observers sort images into 2, then 4, then 8 groups using any strategies they wish

One observer's sorting strategy for shape+texture images

Grouping task results

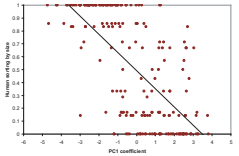
More reliance on a single feature when only shape information available

Semantic strategies about equally common with shape-only and shape+texture images, but not used with texture-only images

Relationship to principal components of shape

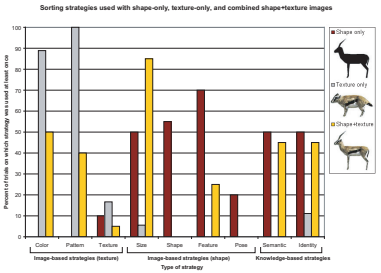
Most popular strategy for sorting animal images was size (used on 85% of trials)

Correlation between human size sorting pattern and PC1 is .69 ($p < .001$)



Considered together, PCs of shape predict 72% of variance in human size sorting pattern; PC1 alone predicts 47% of variance

Sorting strategies



Definition of strategy types

Image-based (texture)
Color: overall color (ie, brown vs. gray)
Pattern: patterns (solid, spots, stripes)
Texture: apparent texture (furry vs. smooth)

Image-based (shape)
Size: real-life size
Shape: overall body shape (ie, thick vs. thin)
Feature: presence/absence or size of a single feature (horns, ears, tail)
Pose: body pose (ie, head position)

Knowledge-based
Semantic: strategies using real-world knowledge (ie, sorting by habitat, predators vs. prey)
Identity: sorting known animal groups (ie, dogs vs. cats, deer vs. primates)

Most-used sorting strategies

Shape-only images	% trials	Texture-only images	% trials	Shape+texture images	% trials
Feature: presence/absence of tail	55	Pattern: solid vs. patterned	94	Size: large vs. small	85
Size: large vs. small	50	Color: light vs. dark	78	Pattern: solid vs. patterned	40
Shape: long-legged vs. squat	45	Pattern: stripes/spots vs. irregular pattern	50	Color: light vs. dark	35
Feature: presence/absence of horns	40	Color: brown vs. grey	39	Semantic: wild vs. domesticated	35

Future applications

Construction of image sets with very fine-grained variation for experiments examining perception, memory, or concepts

Holistic decomposition (analogous to eigenfaces), so could be used as a control image set in any experiment looking at face processing

Could be used to automatically identify/reconstruct animal images that have already been segmented (ie, through motion in video clips)

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