A Perception Experiment on Rotated Billboards

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Abstract

In realistic art, multiple perspectives in a single image are not exceptional deviations, but are common. Renaissance artists often used a collage of carefully rendered object-by-object perspectives, the non-unity of which is not noticed by most viewers. Imitating the cartoon-based compositional practices of Renaissance artists with the added advantage of three dimensional manipulation, we are investigating how an image can contain rotated billboards that approximate object rotation, treating billboards as flexible modelling primitives. An experiment measures how perceptible are distortions from billboard rotation and identifies key object features.

Fig. 1: The School of Athens of Raphael, c. 1510 - painting and full-scale collage.

Experiment Design

Goal: Identify by how much billboards can be rotated while remaining satisfactory depictions of objects.

Stimuli: Scenes containing three objects, one of which is constructed by billboard rotation.

Task: To identify the distorted object by comparing it to the other two.

Object: Meshed natural objects (chair/horse) with suggestive contours; wireframe geometric objects (cube/parallelepiped) with hidden lines removed.

Orientation: The three objects contained in each stimuli are oriented at $30°, 0°$ and $-30°$ wrt a canonical view.

Billboard Rotation: Six are used, $0°, 15°, -20°, 26°, -32°$ and $45°$.

Total Number of Trials:
$6048 = 14 \times 432 = 14$ participants $\times$(4 objects $\times$ 3 billboard positions $\times$ 6 orientation orders $\times$ 6 billboard rotations).

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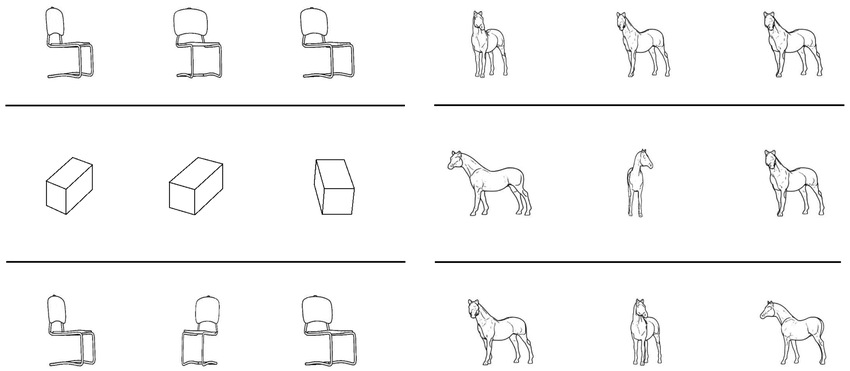
Stimuli



Results

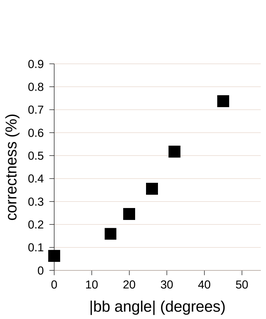


Fig. 2: Correctness as a function of absolute billboard angle.

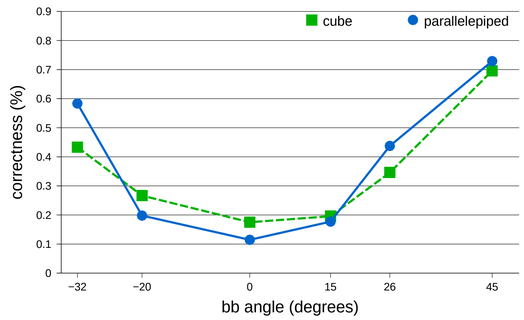


Fig. 3: Correctness for the two geometric objects as a function of to billboard angle.

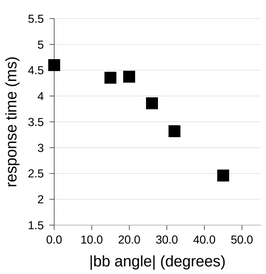


Fig. 4: Response time as a function of absolute billboard angle.

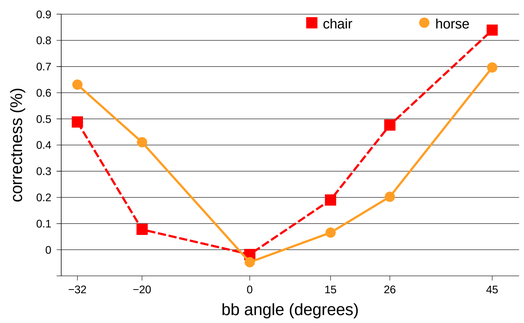


Fig. 5: Correctness for the two natural objects as a function of billboard angle.

Analysis

Fig. 2 - Correctness increases with billboard rotation. Smallest billboard rotation, $15°$, close to no rotation (difference = marginally significant).

Fig. 4 - Faster response for better correctness. No speed-accuracy trade-off.

Figs. 3 & 5 - Correctness varies differently for object categories.

- Geometric objects: symmetric wrt sign of the billboard rotation.
- Natural objects: asymmetric wrt direction of billboard rotation (horse more distorted when head faces viewer; chair more distorted when open side faces viewer).

Investigation of response bias to different orientations using signal detection theory.

		Billboard Orientation			
	i*/*j	$-30°$	$0°$	$30°$	m_{ik}
Selected	$-30°$	0.582	0.251	0.262	1.095
Orientation	$0°$	0.143	0.523	0.15	0.816
	$30°$	0.275	0.226	0.588	1.089
		1.0	1.0	1.0	$\sum m_{ii} = 1.693$

Table. 1: Normalized contingency table of responses (selected orientation vs. the billboard orientation)

	∀object	horse	chair	cube	parallelepiped
p_s	0.347	0.327	0.343	0.353	0.374
p_{-30}	0.382	0.166	0.376	0.514	0.457
p_0	0.240	0.346	0.253	0.171	0.187
p_{30}	0.379	0.486	0.371	0.315	0.355

Table. 2: Probability of identify billboard, p_s, and probabilities guessing other orientations, p_θ.

Table 1 - Impact of orientation: canonical view is guessed least frequently.

Table 2 - Canonical view is most natural for every object, except the horse.

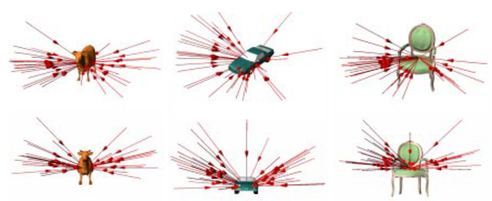


Fig. 6: Blanz et al. experiment on view selection for best impression of 3D objects.

Conclusions

- For objects with a well-chosen canonical view, billboard rotation approximation to object rotation produce negligeable visible distortion for rotations less than $20°$.
- Geometic objects are symmetrical wrt the sign of the billboard rotation angle, in contrast to natural objects.
- Orientation preferences when guessing are strongly related to the canonical view.