Can the classifier trained to separate surface texture from specular infer geometric consistency of specular highlight?

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Introduction

We can easily and rapidly recognize whether the specular highlight is consistent or inconsistent to object's surface. However, highlight inconsistent images do not exist in the real world. Therefore, it is unlikely that the highlight inconsistency detection mechanism exists in the visual system. Instead, rather simple existing mechanisms in the visual system contribute to detect highlight inconsistency. We hypothesize two following mechanisms:

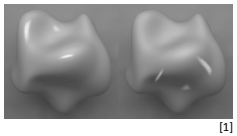
- **Glossiness perception (directionality of reflectance)**
- **Lightness perception (albedo estimation)**

Because if the highlight components are rotated or shifted to incorrect position, perceived glossiness is decreased[1-5].

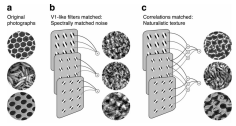
We investigated whether the highlight inconsistency detection is possible by mechanisms contributing to glossiness and lightness perception.

1. Developing the classifier to separate glossiness and pigmentation
2. Verification the highlight inconsistency in the classifier

We used higher-order image statistics (PS statistics) [6]
by Portilla & Simoncelli (2000) as a cue to verify our hypothesis.


[1]


[2]


[7]

Texture analysis and synthesis by 744 dimensions of PS statistics [6,7]

- Represent difference V1 and V2 using PS stats. by Physiology, fMRI study and Psychophysics [7]
- Explain natural texture selectivity of V4 neurons [8]

Exp.1: developing the classifier

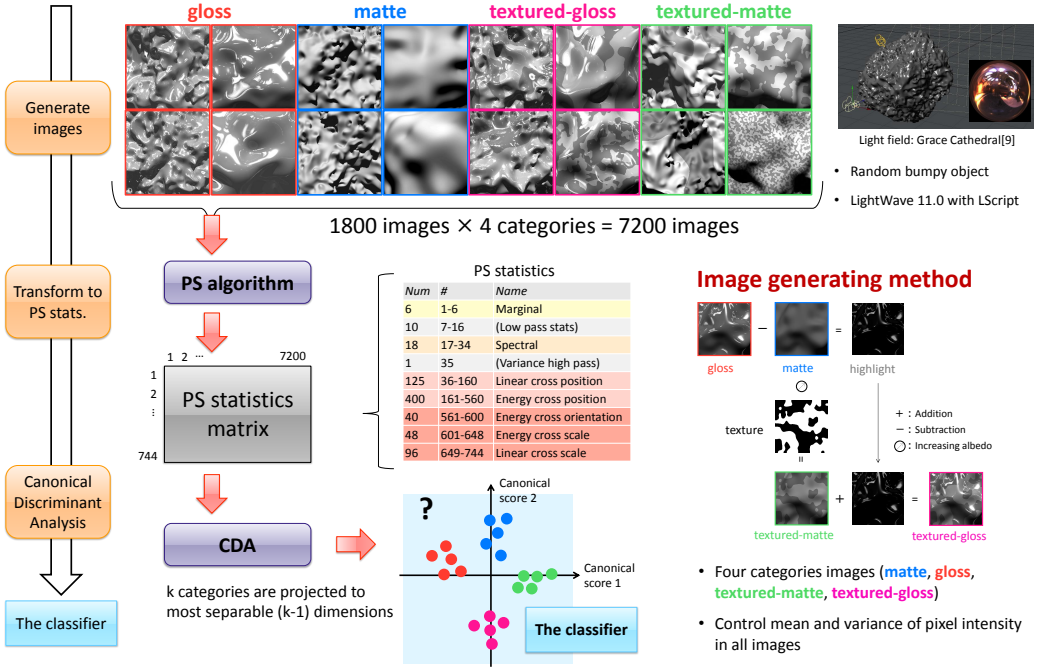


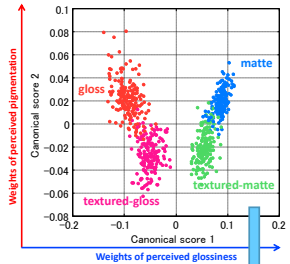
Image generating method

- Four categories images (matte, gloss, textured-matte, textured-gloss)
- Control mean and variance of pixel intensity in all images

Exp.1: result

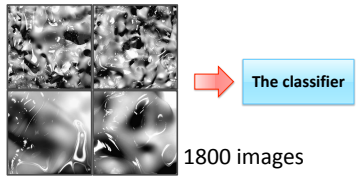
- All images were distributed and clustered four categories
- Confirm stability of this model by 10-fold cross validation
- The higher-order image statistics termed "Linear cross position" and "Energy cross position" contributed to separate them

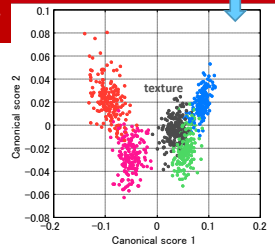
We could develop the classifier to separate gloss and pigment only from the image statistics.



Exp.2: verification the highlight inconsistency

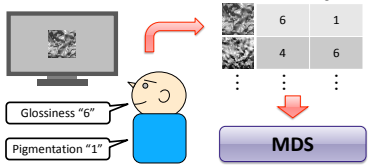
Testing the classifier

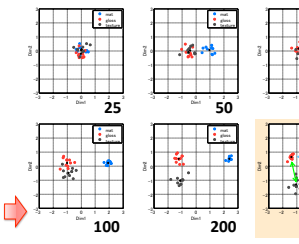


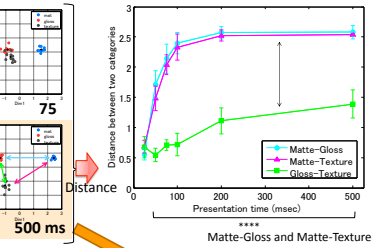


It suggested that highlight inconsistency (gloss and texture) could be detected only two simple mechanisms.

Psychophysics (rating perceived glossiness and pigmentation)







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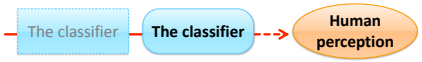
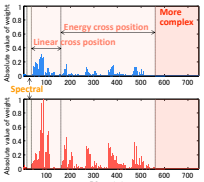
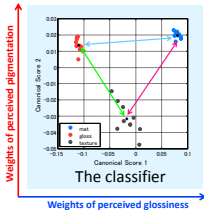
Matte-Gloss and Matte-Texture judgements were rapid (< 200 ms)

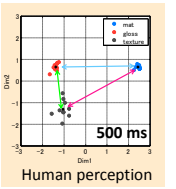
The classifier vs. human perception

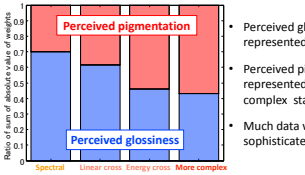


Output space of the classifier was rotated and rescaled to fit the human data









- Perceived glossiness was represented by V1-like statistics?
- Perceived pigmentation was represented by V2-like or more complex statistics?
- Much data would lead to more sophisticated classifier?

The classifier: complexity of statistics
Human perception: Information processing time

Conclusion

The highlight inconsistency detection is possible by mechanisms contributing glossiness and lightness perception.

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Reference

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2. Yang et al., 2011
3. Kim et al., 2011
4. Marlow et al., 2011
5. Kim et al., 2014
6. Portilla & Simoncelli, 2000
7. Freeman et al., 2013
8. Okazawa et al., 2014
9. Debevec, 1998