Learning Discriminative Illumination and Filters for BTF Classification

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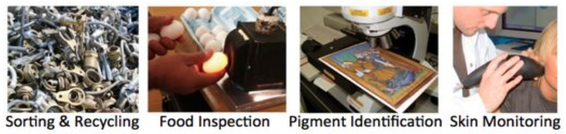
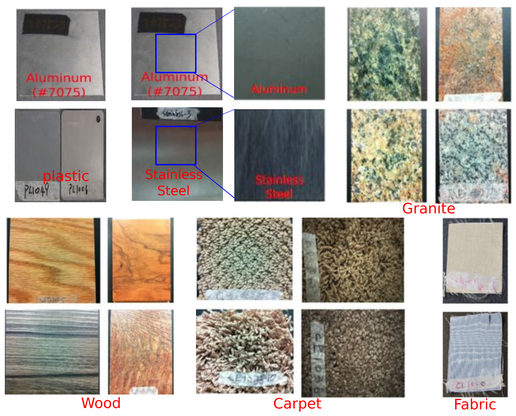
Raw material classification: motivation

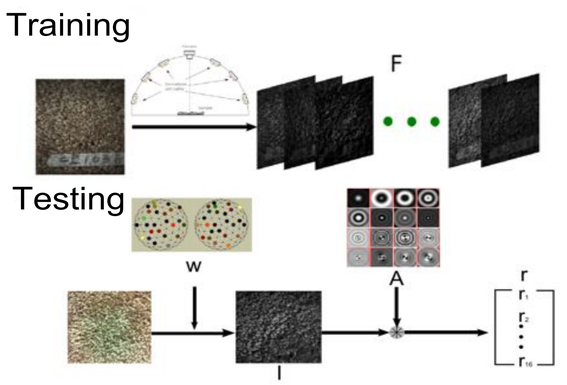
Raw material classification is needed in a variety of applications



Both BRDF and texture are important for material classification

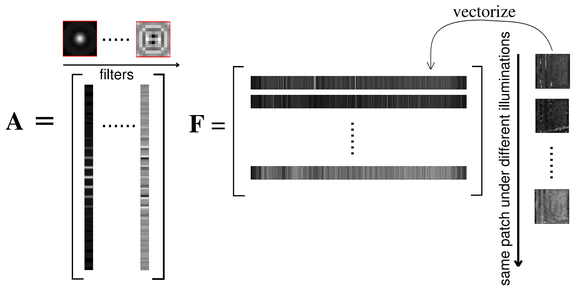


Overview of our method



Optimal filters and light pattern

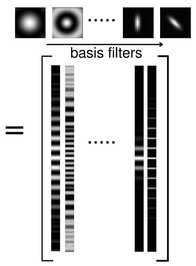
$$\mathbf{r} = \mathbf{A}^T \cdot \mathbf{F}^T \cdot \mathbf{w}$$



$\mathbf{w}$ is the vector of the illuminations

The filters are linear combinatinos of *Basis Filters*.

$$\mathbf{A} = \mathbf{B} \cdot \mathbf{W}$$



$$\mathbf{W} = [\boldsymbol{g}_1, \boldsymbol{g}_2, \ldots, \boldsymbol{g}_{m-1}, \boldsymbol{g}_m]$$

$\boldsymbol{g}_i$ is the vector of the weights for the *i*-th filter.

Texture desciptor for one patch

$$\mathbf{r} = \mathbf{W}^T \cdot \mathbf{B}^T \cdot \mathbf{F}^T \cdot \mathbf{w}$$

$\mathbf{w}$ and $\mathbf{W}$ are learned by maximizing the trace ratio:

$$\max_{\mathbf{W},\mathbf{w}} J = \frac{\mathbf{Trace}(\mathbf{S}_b)}{\mathbf{Trace}(\mathbf{S}_w)}, \quad \text{st.} \quad ||\mathbf{w}|| = 1$$

$\mathbf{S}_b$ and $\mathbf{S}_w$ are the between-class and within-class scatter matrix for $\mathbf{r}$.

Optimize W and w

We optimize w and W alternatively by
(1) fixing W, optimize w;
(2) fixing w,,optimize W.

By fixing W, the optimization problem becomes

$$\max_{\mathbf{w}} \mathbf{J} = \frac{\mathbf{Trace}(\mathbf{w}^T \mathbf{S_1} \mathbf{w})}{\mathbf{Trace}(\mathbf{w}^T \mathbf{S_2} \mathbf{w})}, \quad \text{st.} \quad ||\mathbf{w}|| = 1$$

This is a **Rayleigh quotient** problem.

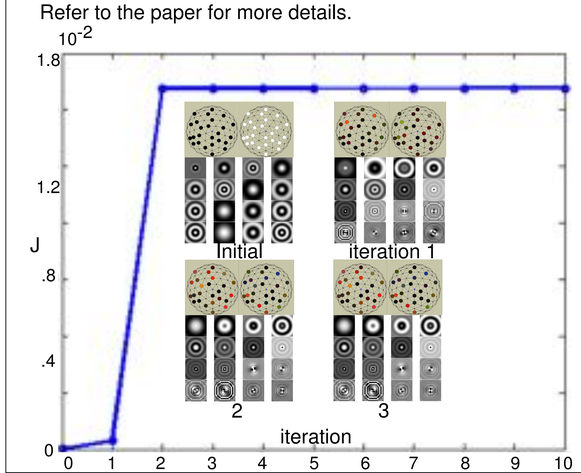
By fixing w, the optimization problem becomes

$$\max_{\mathbf{W}} \mathbf{J} = \frac{\mathbf{Trace}(\mathbf{W}^T \mathbf{S_3} \mathbf{W})}{\mathbf{Trace}(\mathbf{W}^T \mathbf{S_4} \mathbf{W})}$$

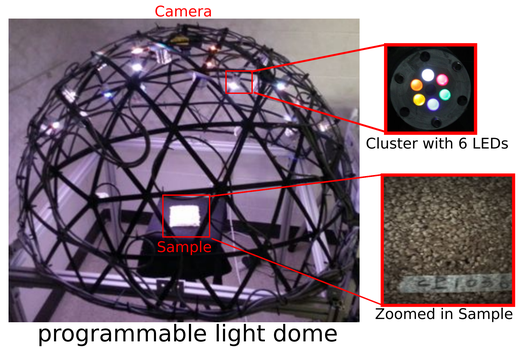
This is a **trace ratio** problem, which is solved by the method in [1].

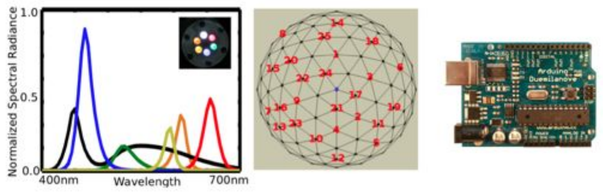
$\mathbf{S_1}$, $\mathbf{S_2}$, $\mathbf{S_3}$ and $\mathbf{S_4}$ are functions of $\mathbf{F}$ and $\mathbf{B}$

Refer to the paper for more details.



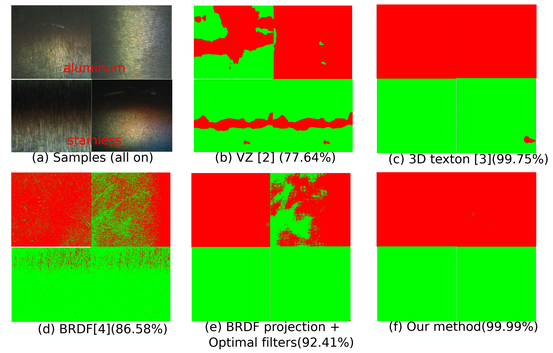
Experimental setup





Experimental results

aluminum vs. stainless steel



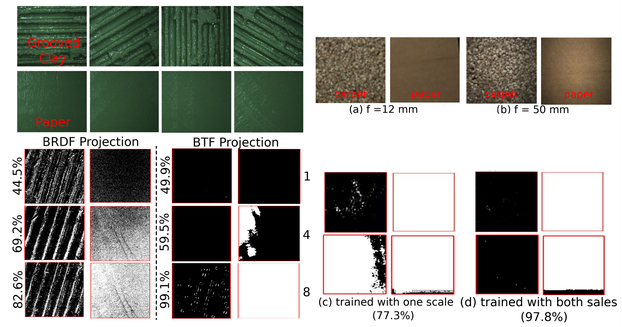
More than two classes:

	VZ [2]	BRDF[4]	Our
Aluminum vs. Granite vs. Plastic	79.25%	76.84%	89.13%
Aluminum vs. Granite vs. Stainless	73.15%	93.23%	97.13%
Aluminum vs. Plastic vs. Stainless	75.09%	92.99%	96.71%
Aluminum vs. Granite vs. Plastic vs. Stainless	73.67%	78.44%	90.49%
Carpet vs. Granite vs. Plastic vs. Stainless	65.98%	64.58%	74.11%
Aluminum vs. Granite vs. Stainless vs. Wood	63.28%	93.75%	97.66%

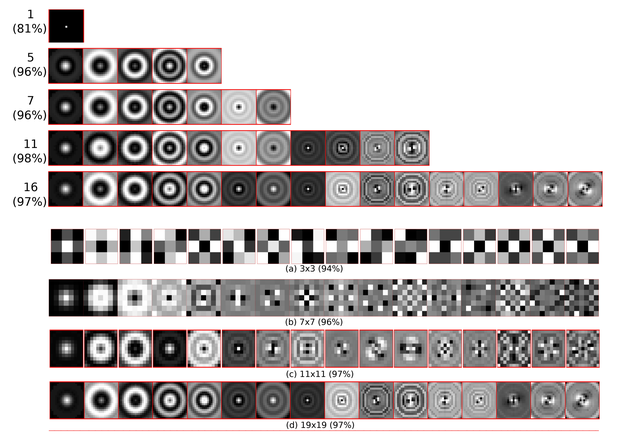
Please refer to the paper for more results

Experimental results: rotation & scaling

Increase the robustness to rotation and scaling by adding rotated/scaled samples into the training set



Size and number of filters



Database & Code

Database of samples under different illuminations is available at:
http://compimg1.cis.rit.edu/data/texture/

References

[1] H. Wang, et al. Trace ratio vs. ratio trace for dimensionality reduction CVPR 2007.
[2] M. Varma, et al. A statistical approach to texture classification from single images. IJCV 2005.
[3] T.Leung, et al. Representing and recognizing the visual appearance of materials using three-dimensional textures. IJCV 2001.

Acknowledgement

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