Shadow Detection And Removal

Team: Fourier and Dual
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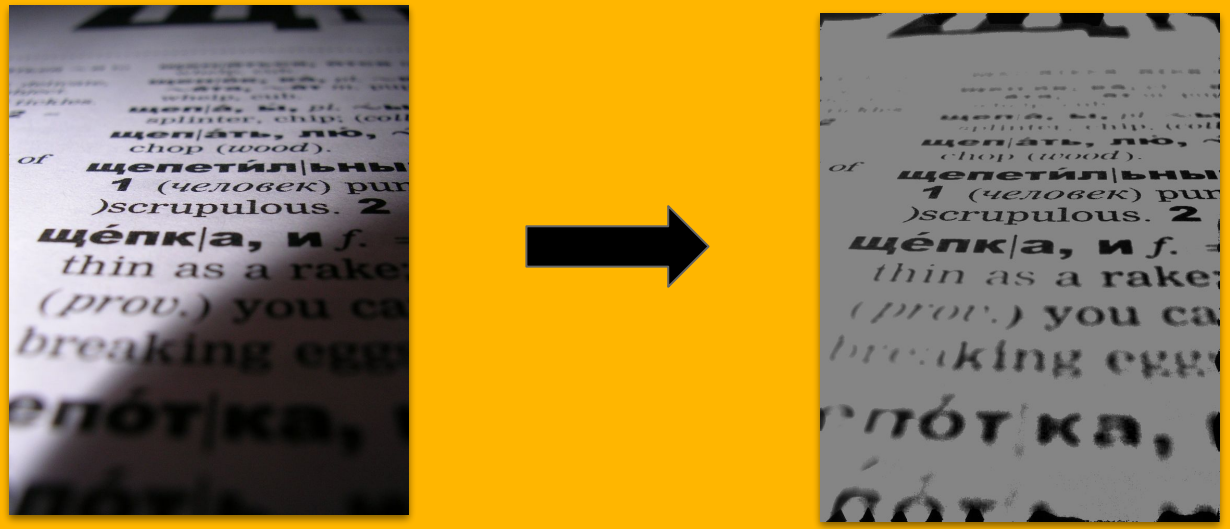
Modules

1. Document Shadow Removal
2. Natural Image Shadow Detection
    a. Interactive Detection
    b. Automatic Detection
3. Natural Image Shadow Removal



Document Shadow Removal

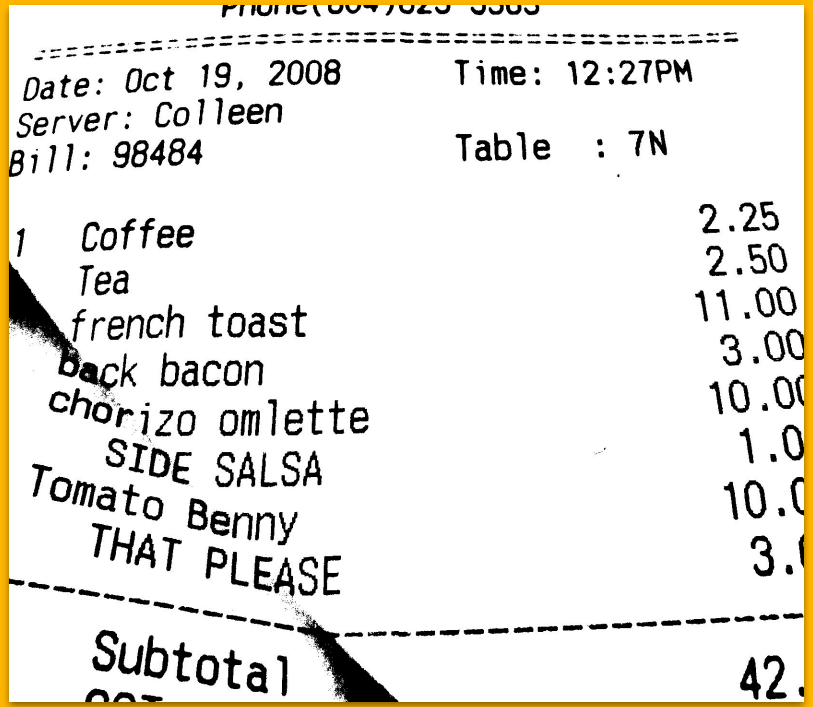
Removing shadows from a document and returning an image with even illumination.

Image Binarization

- Binarize the Image into Foreground **F** with text and Background **B**
- Use Adaptive Thresholding for this
- Bradley's Adaptive Thresholding was used
- Low threshold set to avoid text being lost

Date: Oct 19, 2008 Time: 12:27PM
Server: Colleen
Bill: 98484 Table : 7N

1	Coffee	2.25
1	Tea	2.50
	french toast	11.00
	back bacon	3.00
	chorizo omlette	10.00
	SIDE SALSA	1.0
	Tomato Benny	10.0
	THAT PLEASE	3.
	Subtotal	42.



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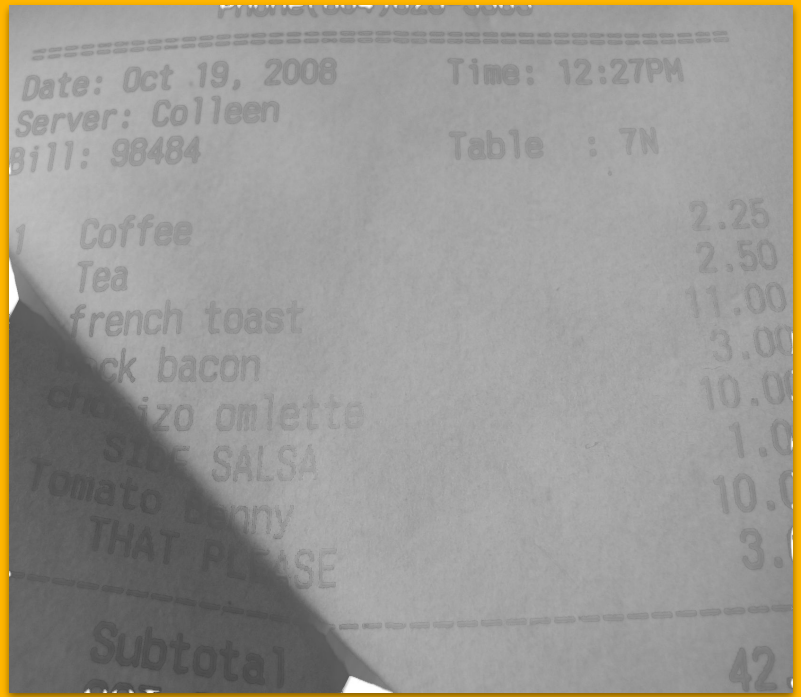
Reflectance and Shading Estimation

- Estimate **R** and **L** such that Image **I(x) = R(x)S(x)**
- **R** captures the properties of the material and **S** the illumination properties.
- If **(x,y)** is in background, **S(x,y) = I(x,y)**. Else compute **S(x,y)** by interpolating background pixels around it.
- Compute **R(x,y)=I(x,y)/S(x,y)**
- **R** is generally free of shadows.



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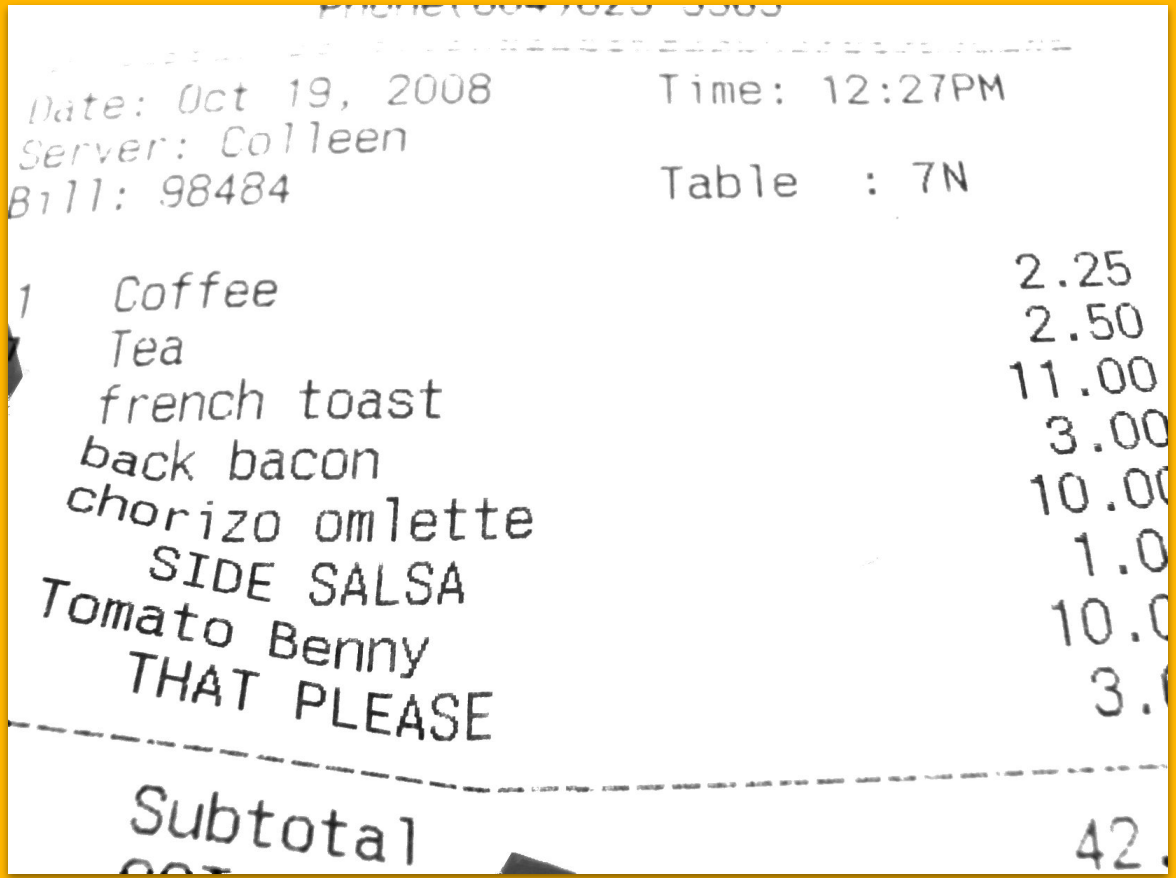
Iterative Step

- When hard shadows are present, the reflectance image computed is not free of shadows.
- The reflectance image is passed back to the binarization stage and this process is done for a few iterations.
- The resulting image is shadow free.



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Tone Mapping

- Compute global **gm** of the Image.
- Compute Final Image **I_final(x) = I(x) gm**
- This step preserves the original tone and texture of the original image.

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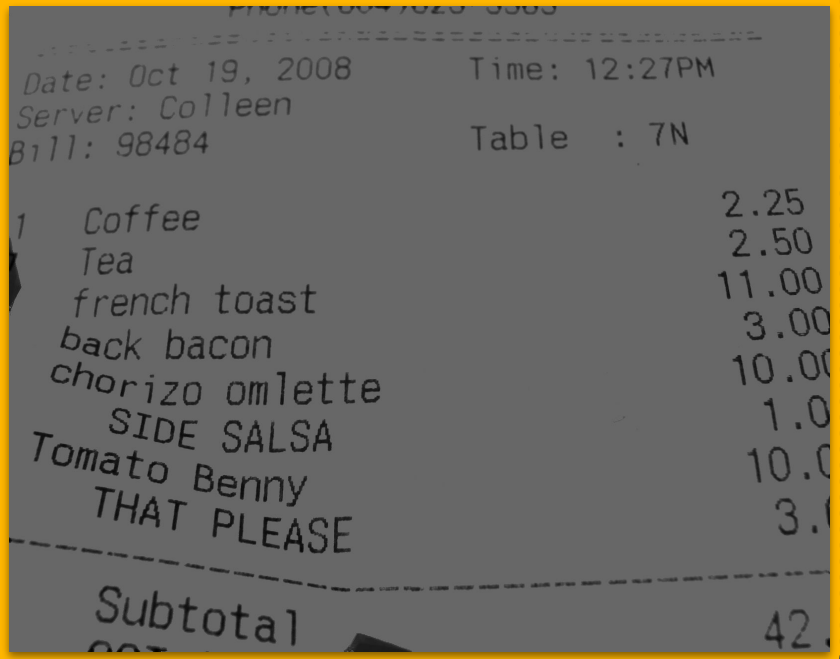
Subtotal 42.



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2

Interactive Detection

Finding the shadow mask given an image and a point **P** in its shadow.

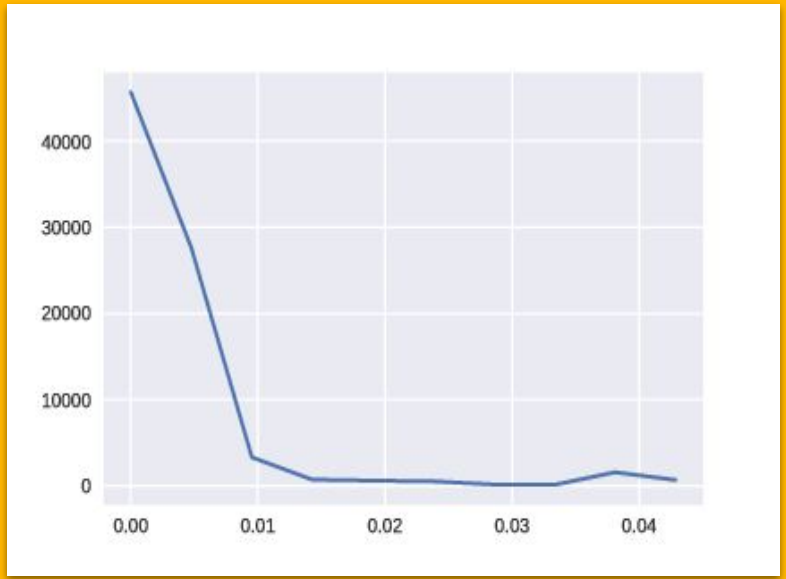
Shadow Seed Growth

- Grow from **P**
- Area on same surface, surely under shadow
- RGB based growth
- Estimate for median colour of shadowed surface

Shadow Seed Surface

- Calculate illumination-invariant distance measure between median and other pixels
- Pixels before threshold after peak in histogram part of surface
- Use following metric with median of shadow seed in RGB:

$$|1 - \cos\theta|$$


40000
30000
20000
10000
0
0.00
0.01
0.02
0.03
0.04


35000
30000
25000
20000
15000
10000
5000
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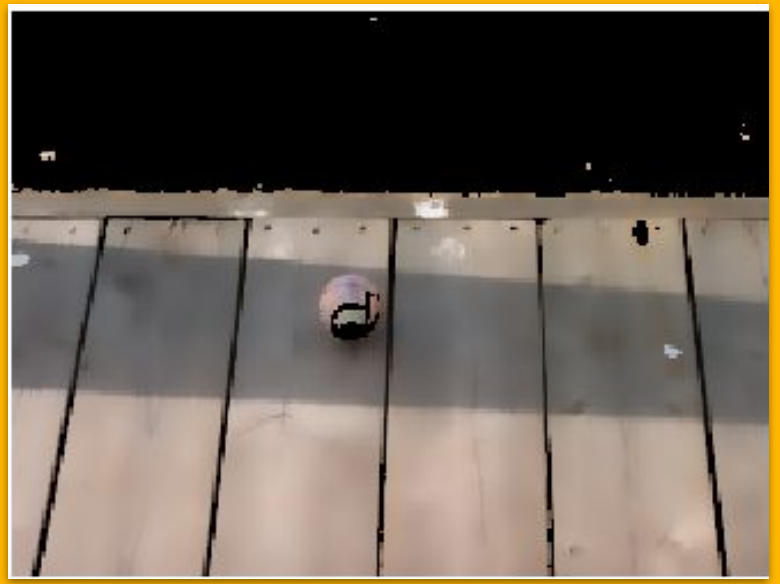
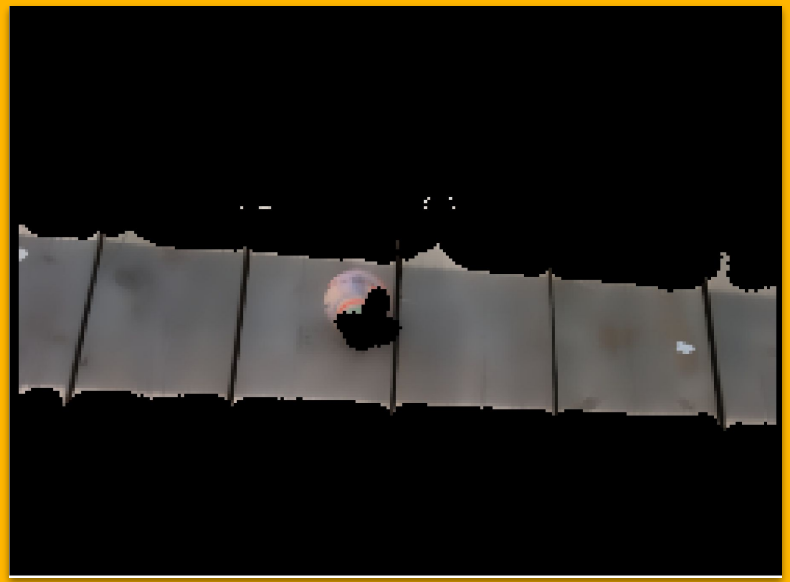
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175



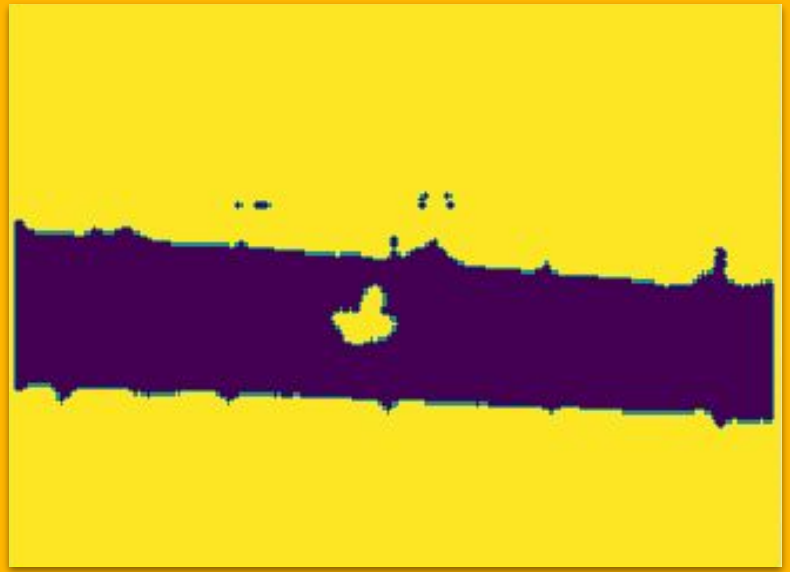
Obtaining M_s, M_l

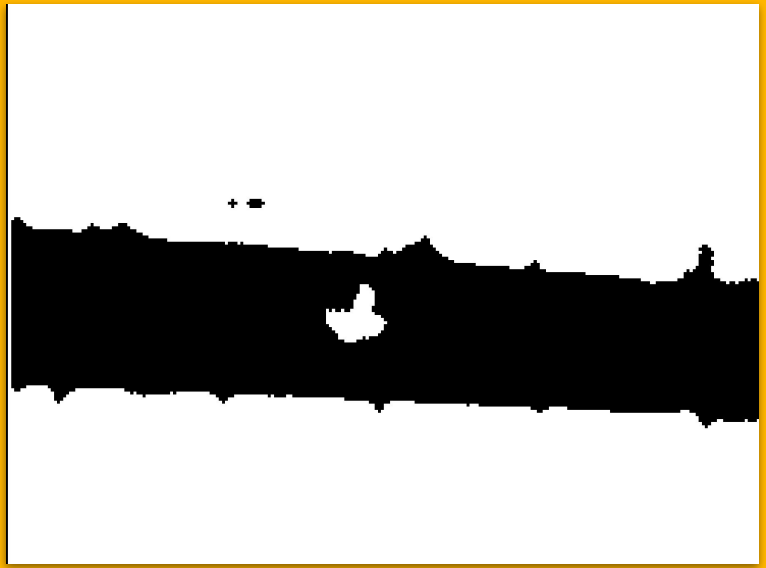
- Initial approximate of M_s as Shadow Seed
- Add closest pixels iteratively, in terms of luma and chrome, till **SD**(M_s) > **SD**(M_l)
- Get intersection of both M_s estimates as final M_s estimate



Matting and M_{shadow}

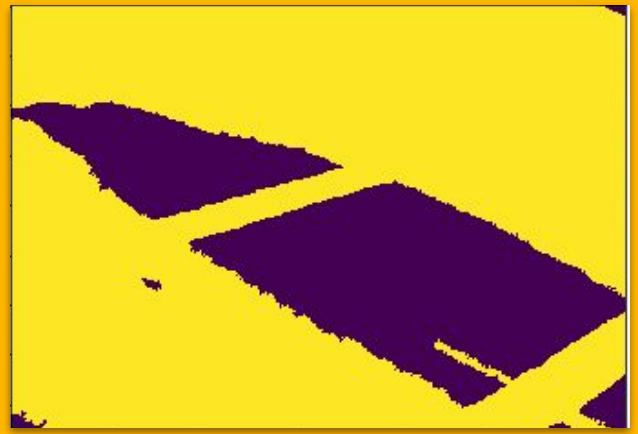
- Trimap is built from M_s and M_l
- Alpha matting is performed on this trimap to get the final shadow mask M_{shadow}





Failure cases

- This method isn't adapted for soft shadows
- The RGB similarity technique used does not need to be valid (if complex lighting is involved)



3

Automatic Detection

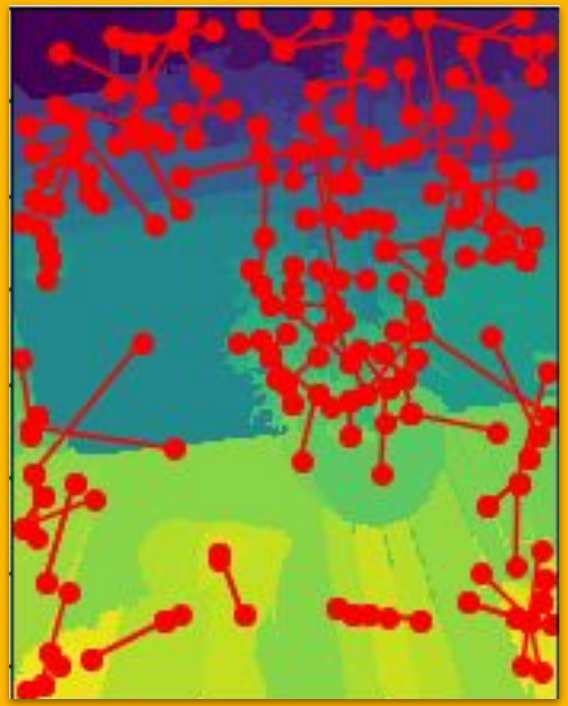
Finding the shadow mask given only an image.

Segmentation

- Mean shift segmentation is used to partition the image into various segments
- At the end, any two pixels in the same segment will be either both shadowed or both unshadowed

"Nearest" Segment

- The distance between each pair of segments is calculated
- Sum of gradient vector, texture vector and centroid distance
- Nearest assigned to the closest **j** for each **i**



Shadow Initialization

- Using pre-presented results, the initial segments of sure shadows are formed
- If segment mean luma is less than a **0.6** factor of image mean luma, the segment is shadowed

Gaussian Iteration

- Represent Gaussian on **H/I** for shadowed and not shadowed, initially clustering with KMeans
- In each iteration take most shadow-like unshadowed region, and make it a shadow
- If its nearest segment is further from it than a threshold, set nearest to non-shadowed
- End with rechecking between close segments of different class

Failure Cases

- The simplified methods become too simple when various images are used on the algorithm
- Nearest neighbours distance would have to be trained to be a more accurate measure than hard-coded thresholds
- Dark objects in a light background

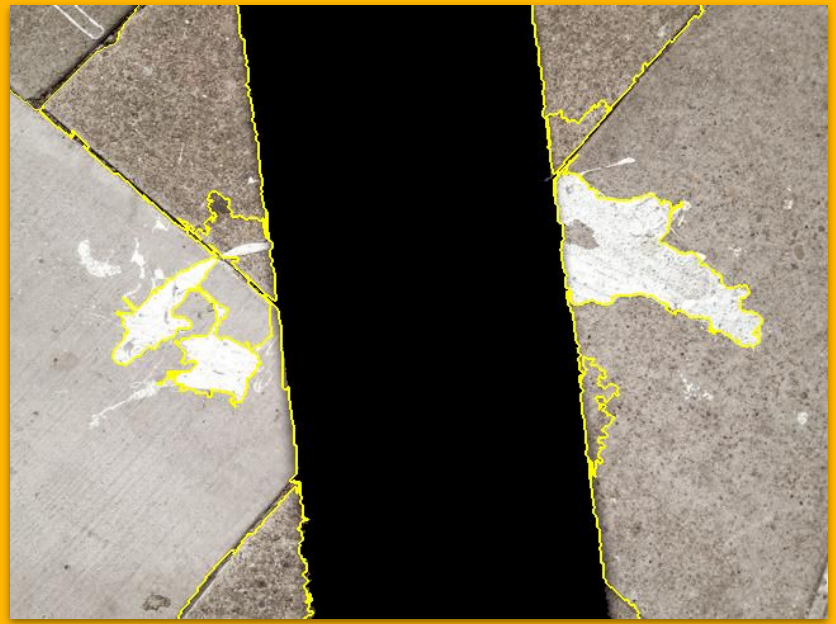
3

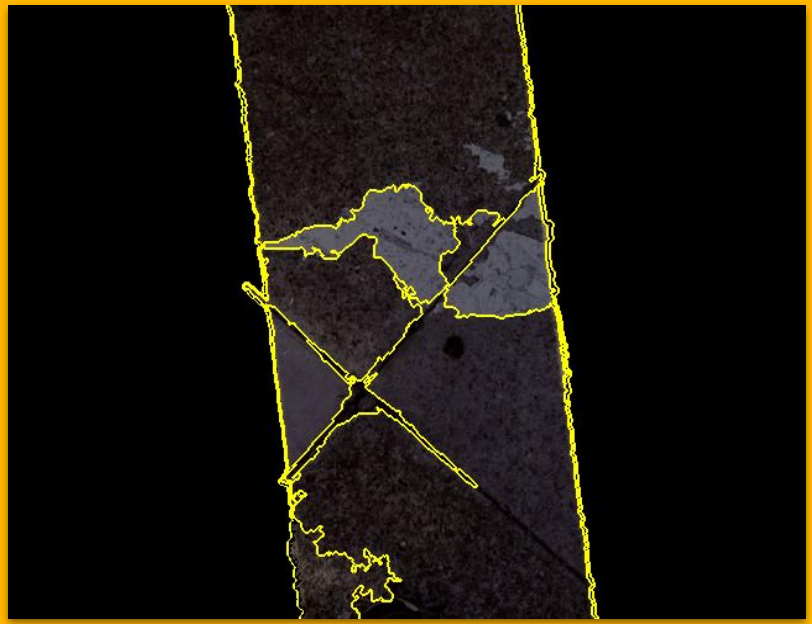
Shadow Removal

Returning a Shadow Free Image given a shadowed Image and Shadow Mask

Segmentation

- Graph cut based segmentation is used to partition the shadowed and unshadowed regions into various segments





Sub-Region Matching

- Every region in the shadowed area is mapped to a region in the unshadowed area.
- This is done using a distance function which is a sum of the distance between centroids and texture features.

Image Relighting

- We perform an illumination transfer for every shadowed region by using the corresponding region.
- This transformation is done in the LAB colour space.

Boundary Processing

- The resulting image has boundary artifacts.
- We create a boundary mask and then inpaint these regions using PatchMatch-based Content Aware Fill.