# Image Splicing Detection via Camera Response Function Analysis

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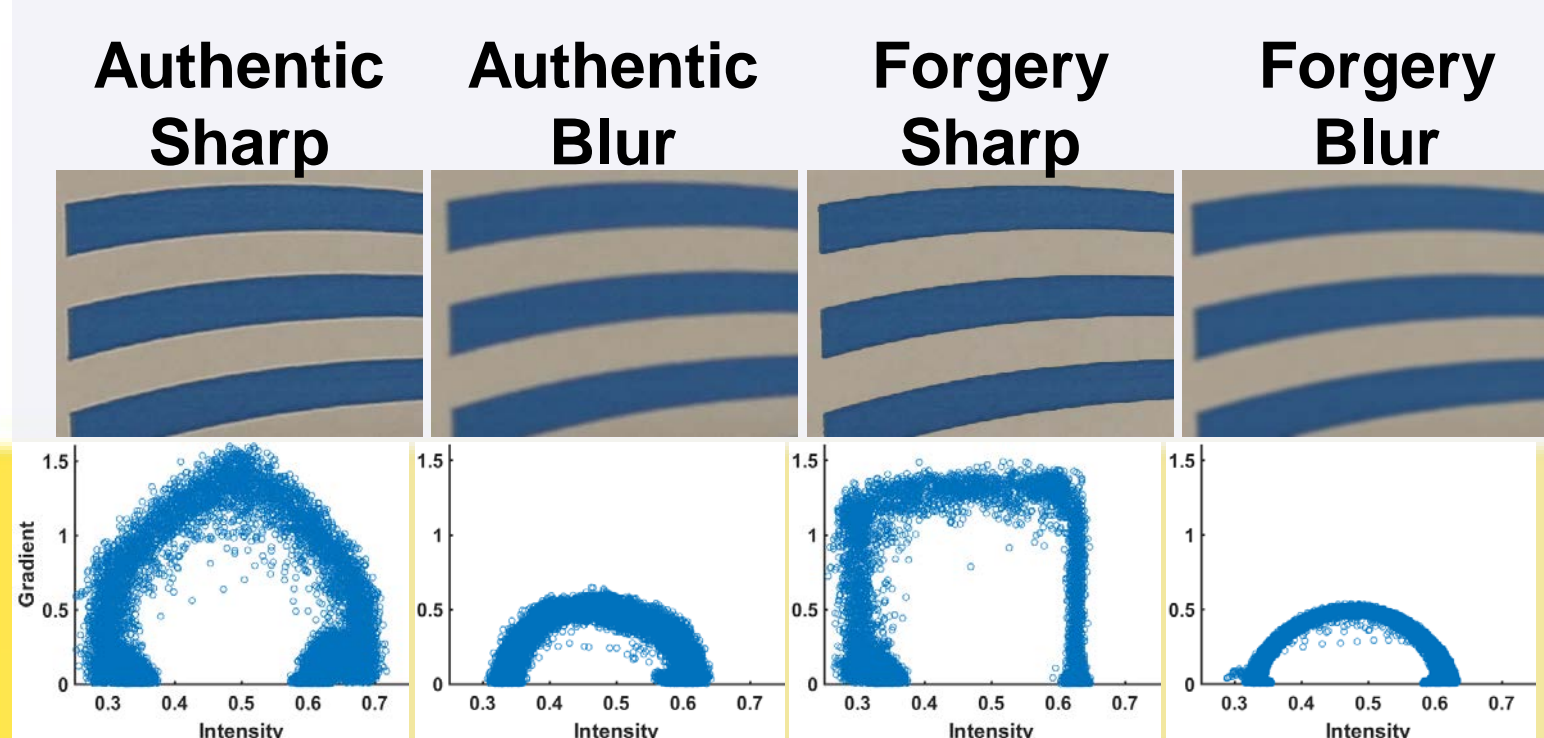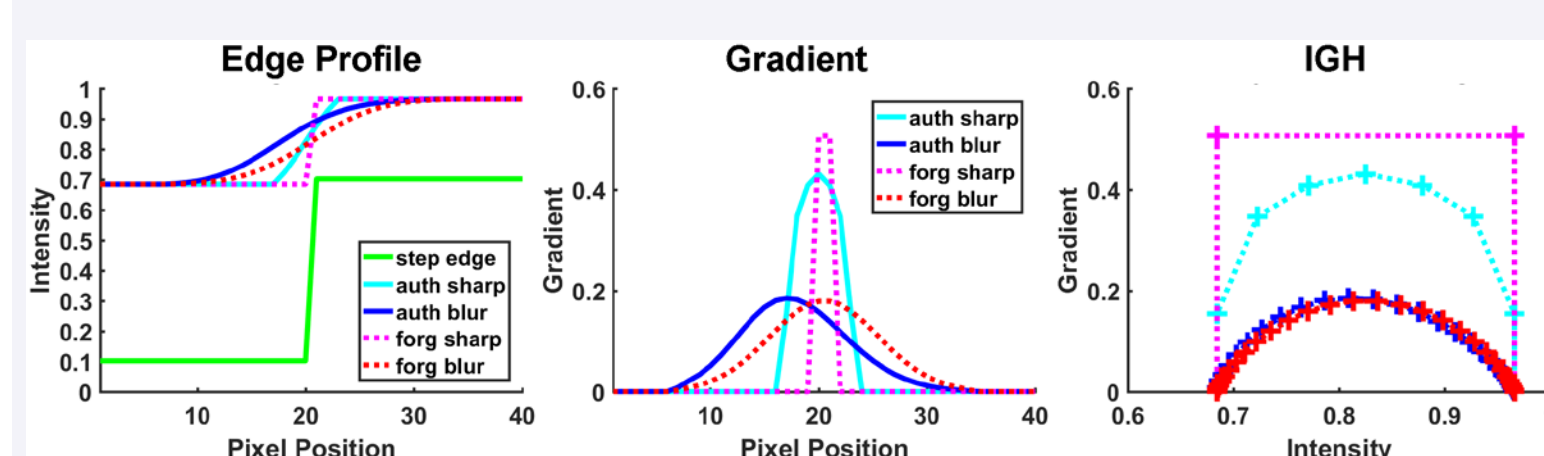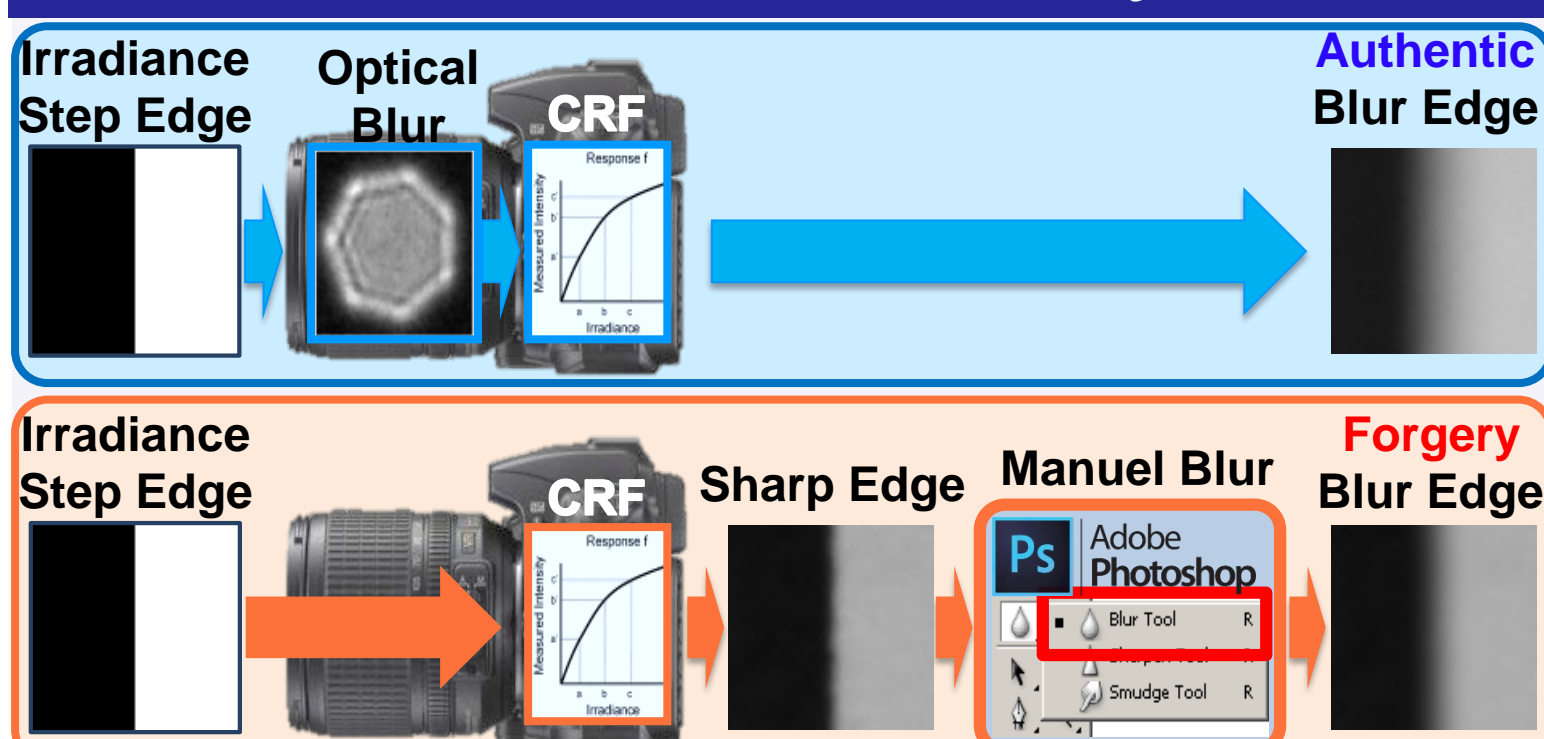
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## Colon and Splicing

- Splicing: contents are extracted from one image and then copied into a new image.
- Fake blur to hide and smooth harsh boundary.

Authentic   Forgery   www.photoshopbattle.com

## Previous Splicing Detection Approaches

- **CRF Inconsistency**
  - Check the estimated CRFs consistency between the image segments.
  - No guarantee CRF estimation accuracy;
  - Can't detect segments from same camera or blurred splicing boundary.

- **Blur Inconsistency**
  - Check blur type (motion or defocus), the extent of blur, or direction of blur.
  - No guarantee blur kernel estimation accuracy;
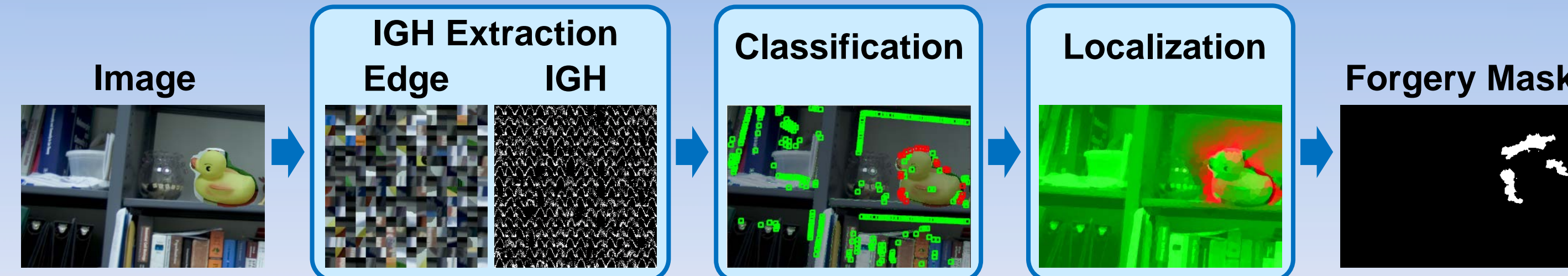  - High false alarm rate with spatially-varying blurred authentic images.

## Intensity Gradient Histogram

Irradiance Step Edge — Optical Blur — CRF — Authentic Blur Edge

Irradiance Step Edge — CRF — Sharp Edge — Manuel Blur (Adobe Photoshop, Blur Tool, Smudge Tool) — Forgery Blur Edge

- CRF is a non-linear operator, it's not commutative.
- $CRF(Blur(edge)) \neq Blur(CRF(edge))$

Edge Profile   Gradient   IGH

- **Authentic Blur**
$$I_{ab} = f\left(K_g(x) * H_{step}(x)\right)$$
$$\nabla I_{ab} = (b-a)\, f'\left(f^{-1}(I_{ab})\right) \cdot K_g(x-c)$$

- **Authentic Sharp**
$$I_{as} = f\left(K_s(x) * H_{step}(x)\right)$$
$$\nabla I_{as} = (b-a)\, f'\left(f^{-1}(I_{ab})\right) \cdot K_s(x-c)$$

- **Forgery Blur**
$$I_{fb} = K_g(x) * f\left(H_{step}(x)\right)$$
$$\nabla I_{fb} = (b-a)\, f'(b) \cdot K_g(x-c)$$

- **Forgery Sharp**
$$I_{fs} = f\left(H_{step}(x)\right)$$

Authentic Sharp   Authentic Blur   Forgery Sharp   Forgery Blur

## Our Pipeline

Image → IGH Extraction (Edge / IGH) → Classification → Localization → Forgery Mask

- **Color Variance Check**
  - $variance(C_L) < thresh_{cv},\ variance(C_H) < thresh_{cv}$
- **Color Difference Check**
  - $|mean(C_H) - mean(C_L)| < thresh_{cd}$

- **Edge Range Check**
  - $max(C_E) < max(C_H),\ \min(C_E) < \min(C_L)$
- **Area Difference Check**
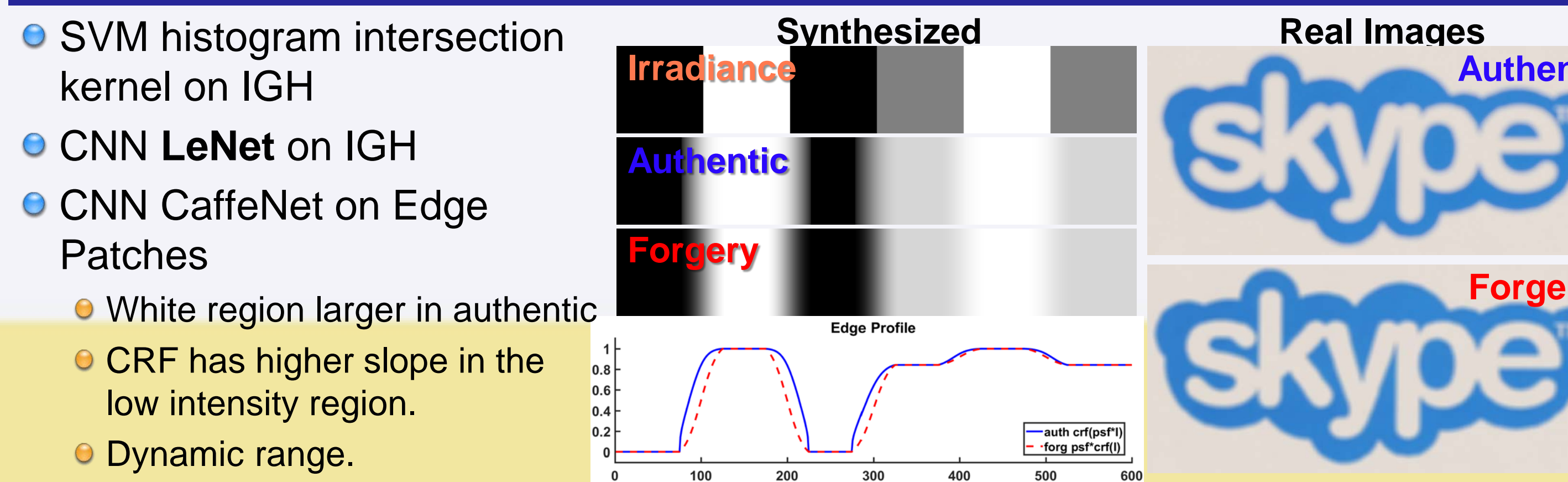  - $\|C_H\| - \|C_L\| < 0.5 * (\|C_H\| + \|C_L\|)$

### Mask Generation

- Propagate edge classification results
- A threshold of 50% red is set to generate the final forgery mask.

Image → Superpixel → Superpixel image → Propagate → Forgery Mask

Edge Classification
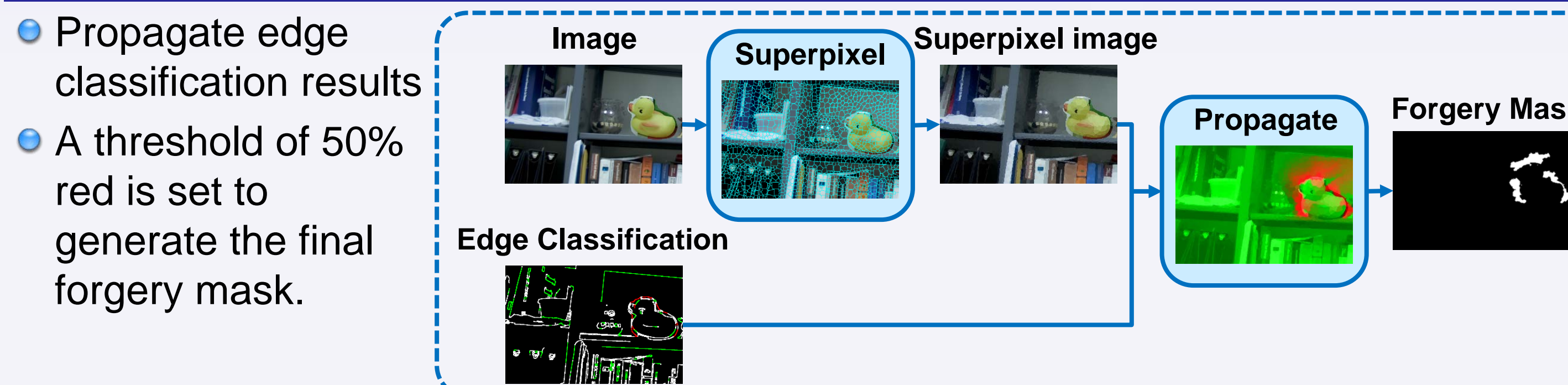
### Handling Large Blur

- Multi-scale scheme in case of large amounts of blur.
  - Kernel size may be larger than some of the structures in the image.
  - Downsample to ¼.

IGH   Mutli-scale IGH

### Classifying IGH

- SVM histogram intersection kernel on IGH
- CNN **LeNet** on IGH
- CNN CaffeNet on Edge Patches
  - White region larger in authentic
  - CRF has higher slope in the low intensity region.
  - Dynamic range.

Synthesized   Real Images

Irradiance   Authentic   Forgery   Authentic   Forgery (skype)

Edge Profile

## Experimental Results

- Splicing Logo Dataset (**SpLogo**) containing 1533 authentic images and 1277 forged blur images of logos with different colors and different amounts of blur.

Table 1. Patch Classification Accuracy.

| Classifier | Image | | | IGHnoV | | | IGH | | |
|---|---|---|---|---|---|---|---|---|---|
| | CUISDE | SpLogo | Combine | CUISDE | SpLogo | Combine | CUISDE | SpLogo | Combine |
| SVM | - | - | - | 0.924 | 0.972 | 0.937 | 0.940 | 0.972 | 0.951 |
| CNN | 0.888 | 0.896 | 0.891 | 0.943 | 0.972 | 0.979 | **0.97** | **0.99** | **0.978** |

Table 2. Patch Accuracy on CUISDE.

| Classifier | Precision | Recall | Accuracy |
|---|---|---|---|
| CRF SVM [15, 13] | 0.7 | 0.7 | 0.87 |
| IGH SVM | 0.93 | 0.94 | 0.94 |
| IGH CNN | **0.95** | **0.95** | **0.97** |

Auth sharp  Auth blur  Forg sharp  Forg blur

- Authentic Sharp (dark green)
- Authentic Blur (bright green)
- Forgery Sharp (bright red)
- Forgery Blur (dark red)

SVM IGH   CNN image   CNN IGH
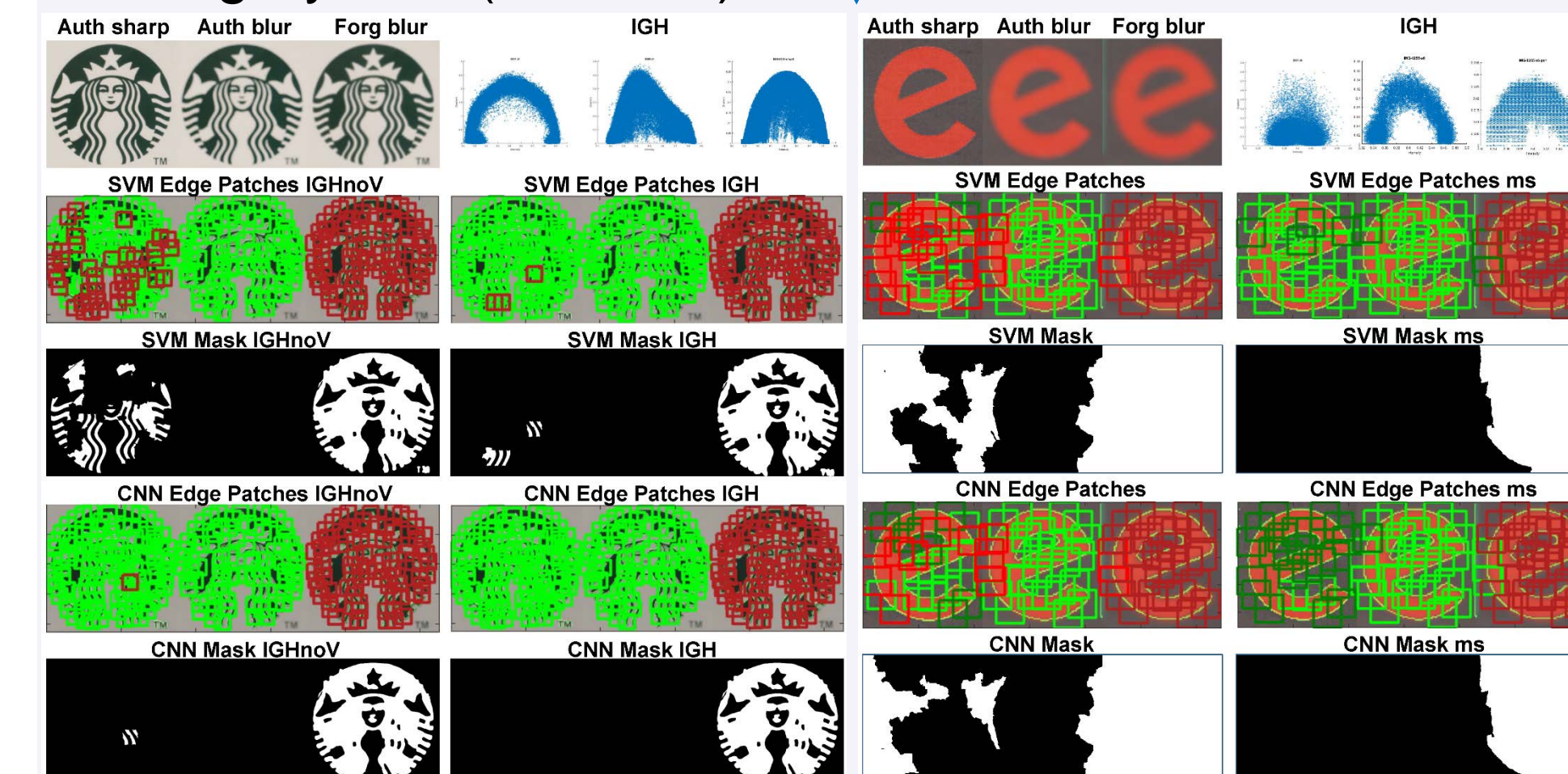
- Both SVM classification and CNNs applied to the patches give false negatives on forged sharp edges, which are reduced significantly by applying the CNN to our IGH feature.

Image   Ground truth   PS

SVM IGH   CNN Image   CNN IGH