

Fighting Fake News: Image Splice Detection via Learned Self-Consistency

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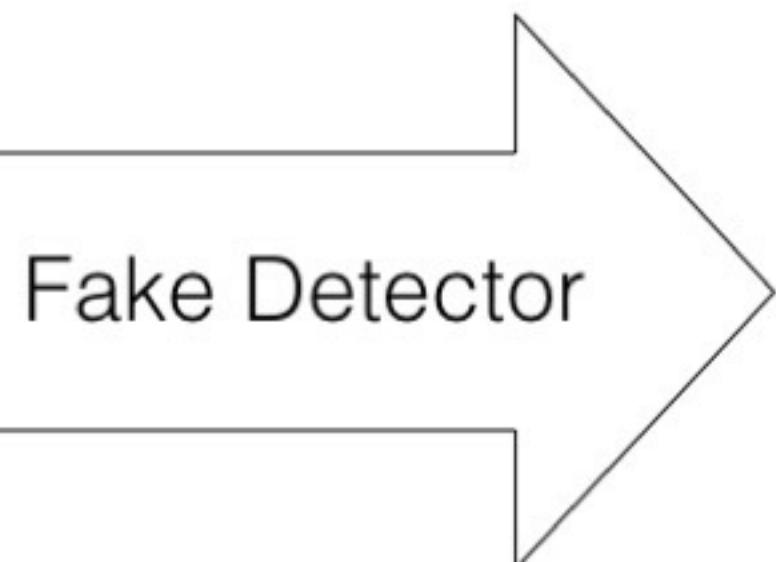
UC Berkeley¹

Andrew Liu^{*1}

Carnegie Mellon University²

Andrew Owens¹

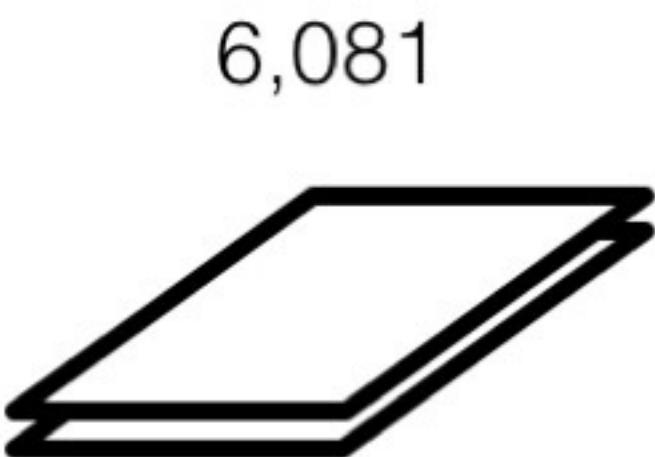
Alexei A. Efros¹





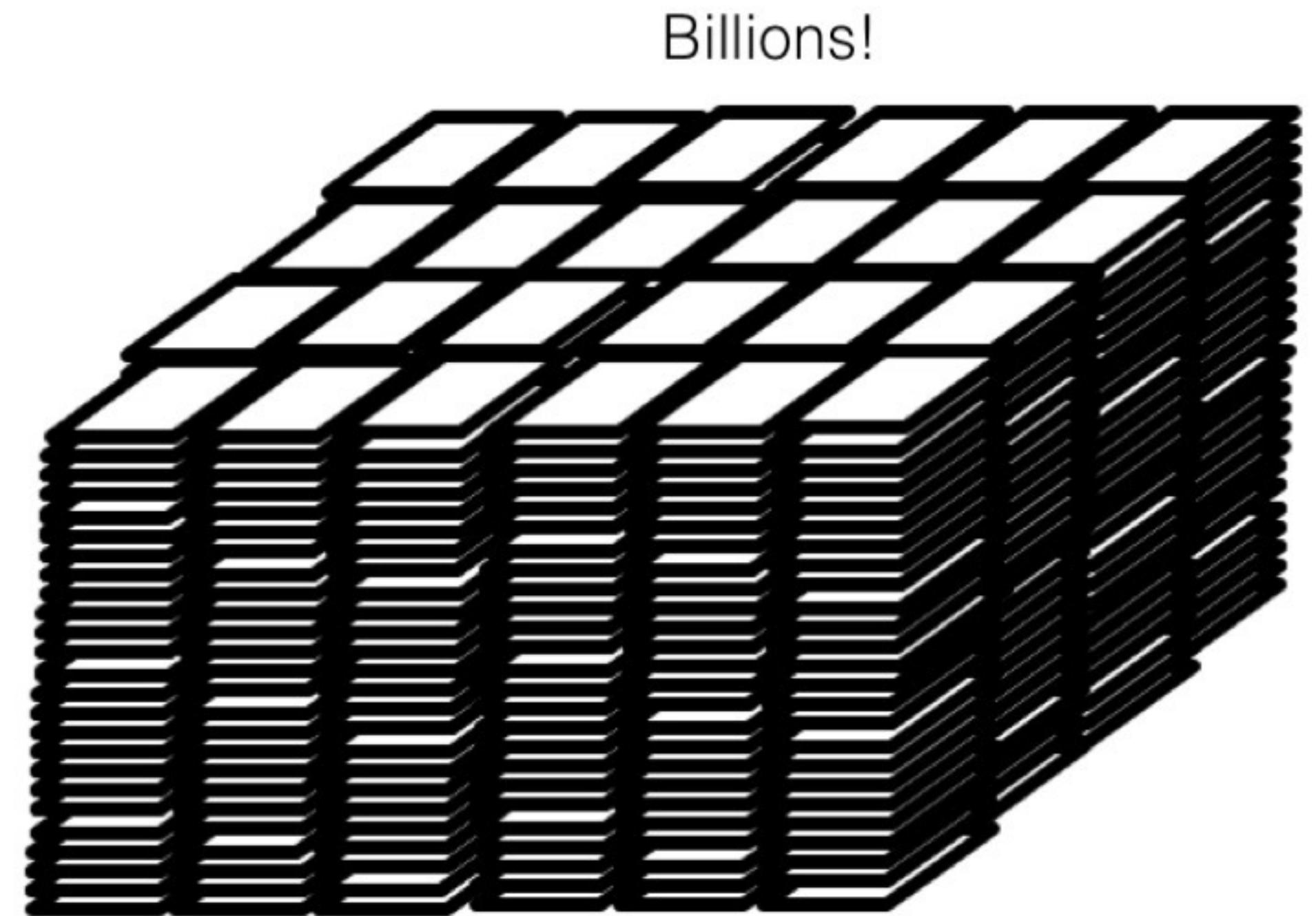


Self-Consistency



6,081

Labeled Splice
Datasets

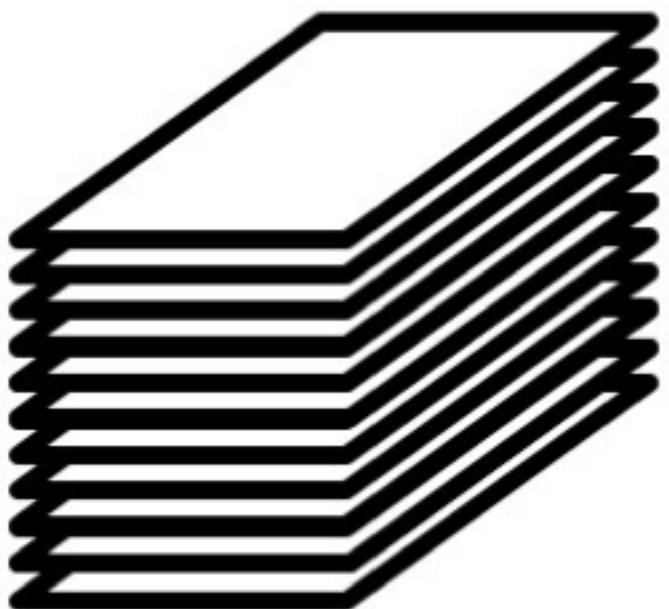


Billions!

Natural Images

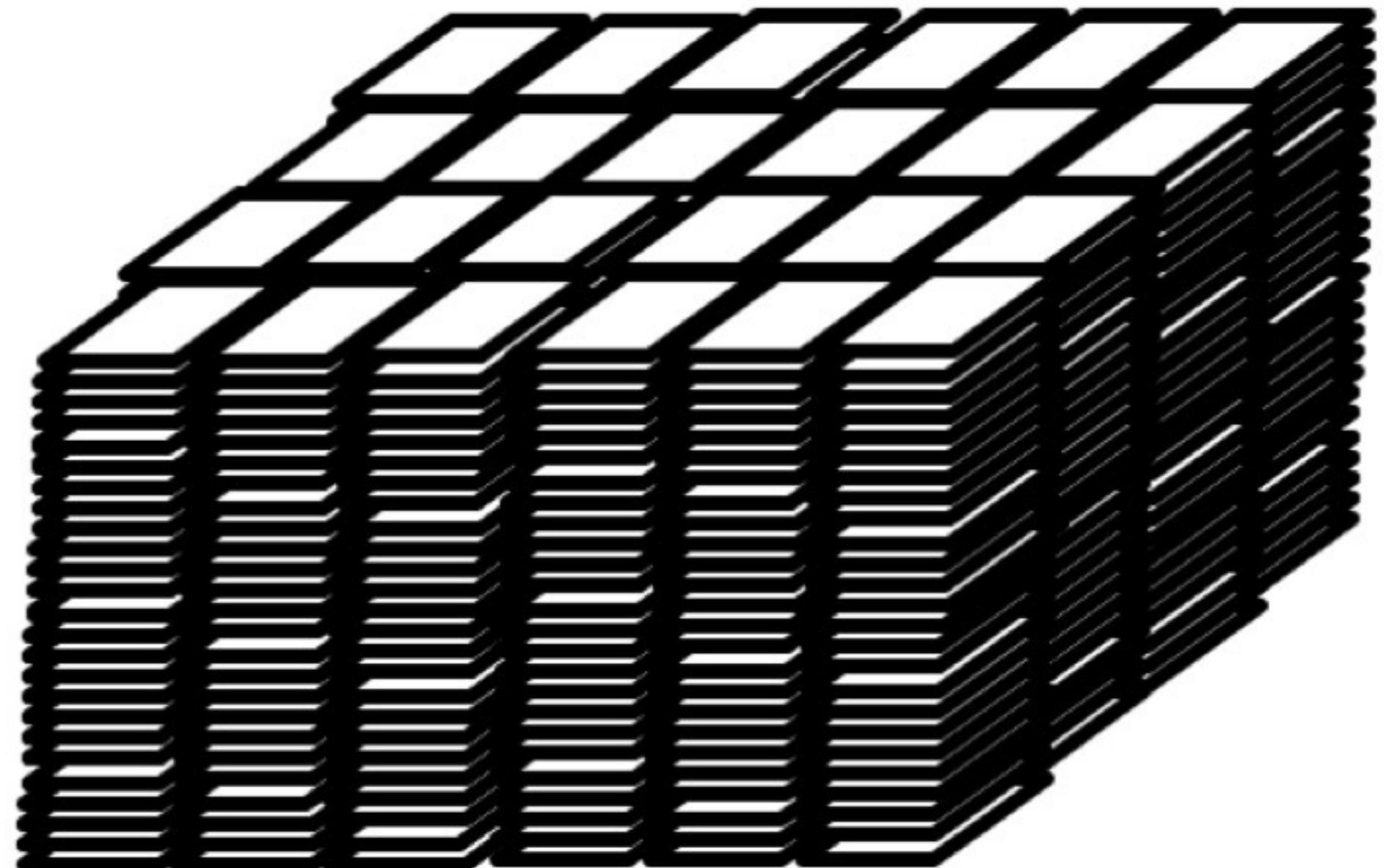
Self-Consistency

$6,081 \times 5 = 30,405$



Labeled Splice
Datasets

Billions!

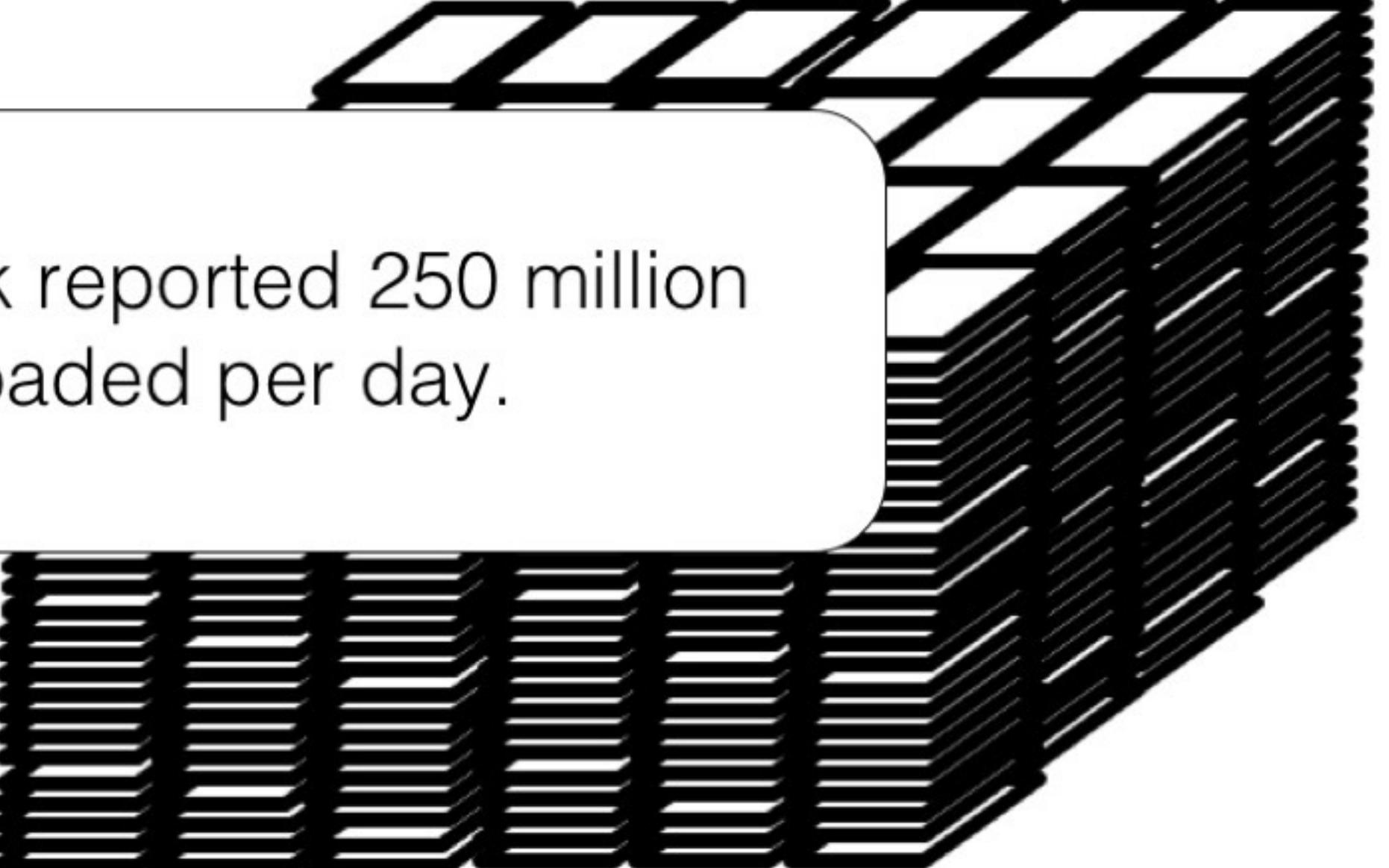
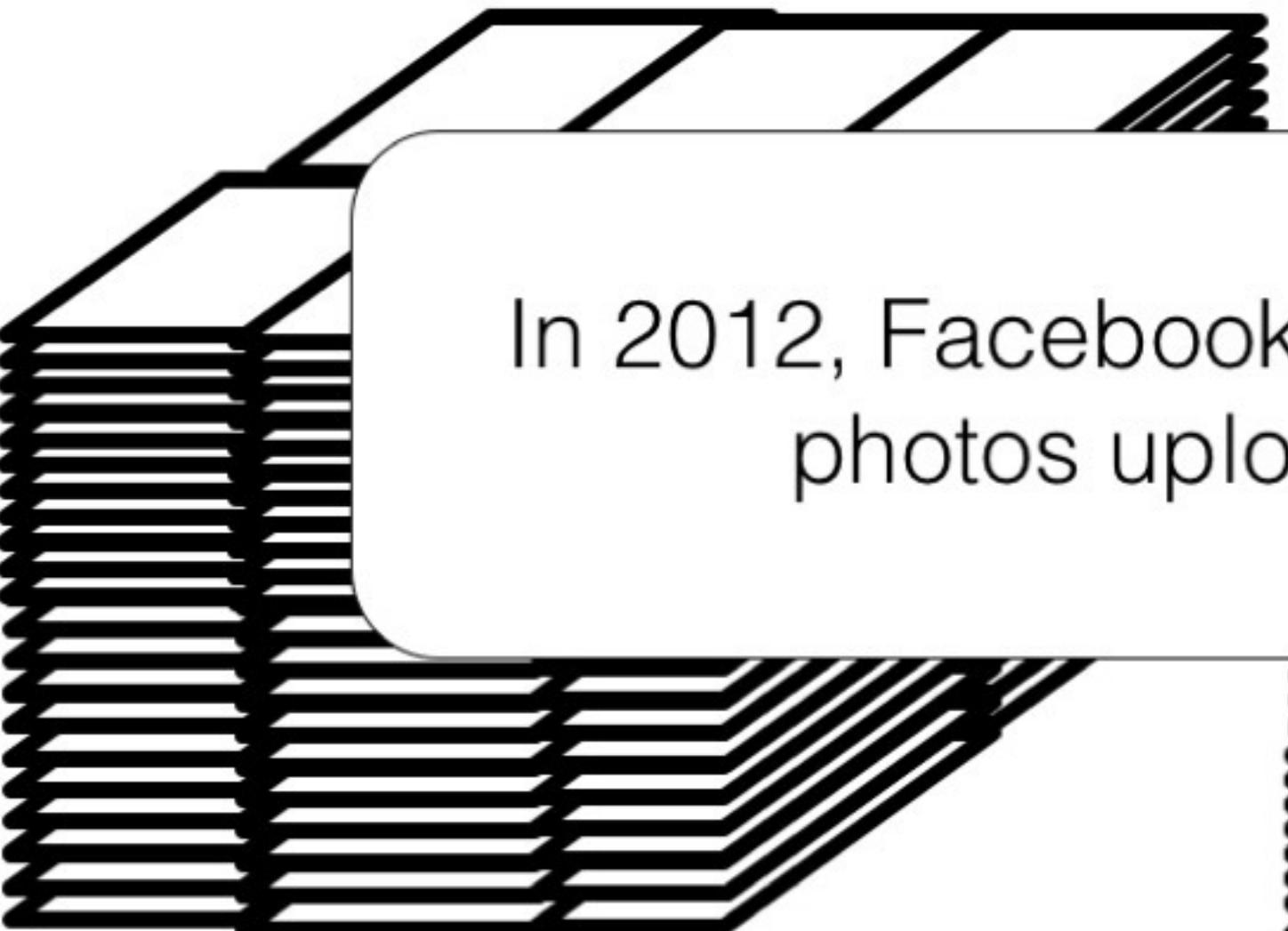


Natural Images

Self-Consistency

$$6,081 \times 100 = 608,100$$

Billions!



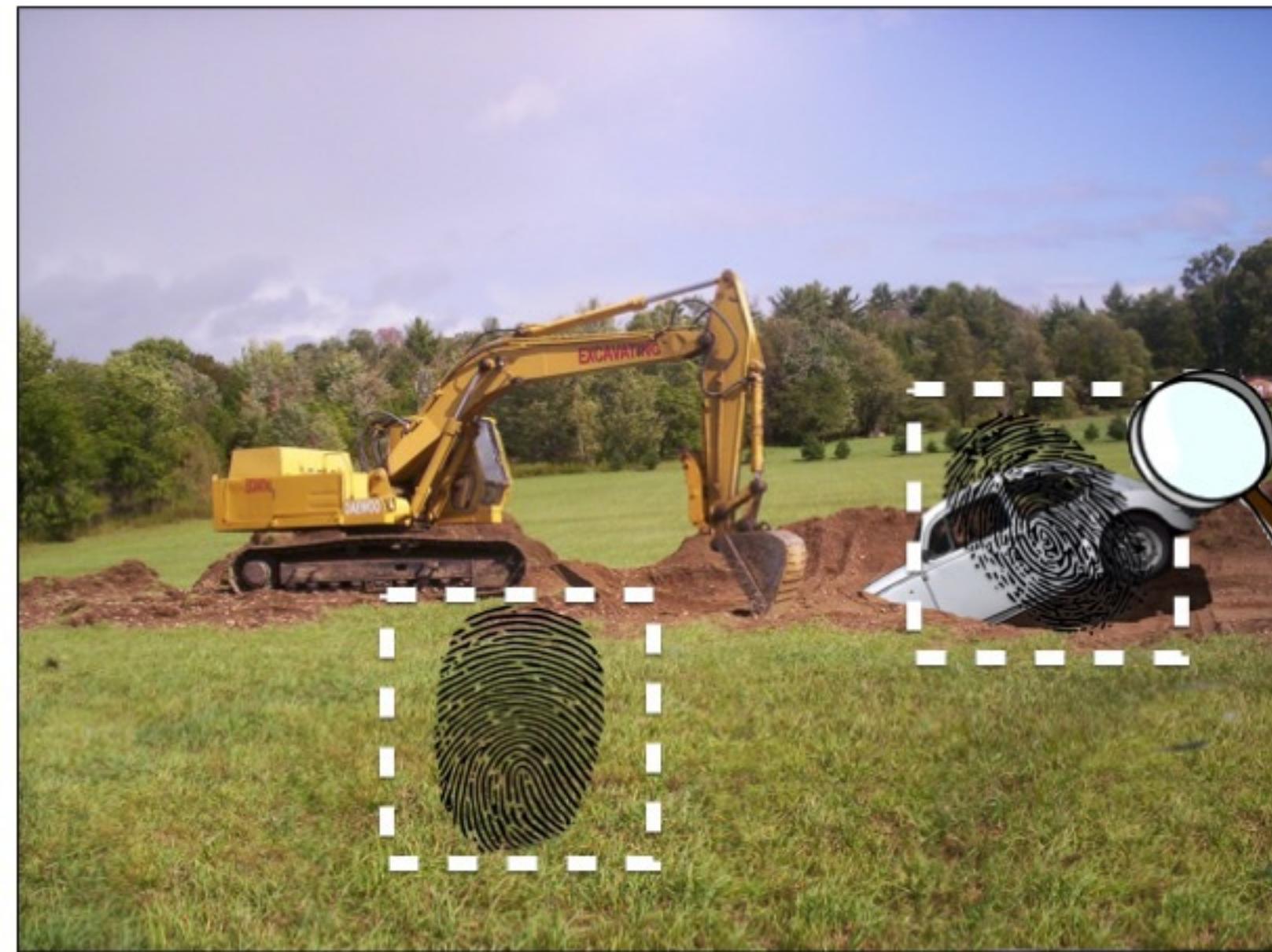
In 2012, Facebook reported 250 million photos uploaded per day.

Labeled Splice
Datasets

Natural Images

Self-Consistency









Inconsistent



Consistent



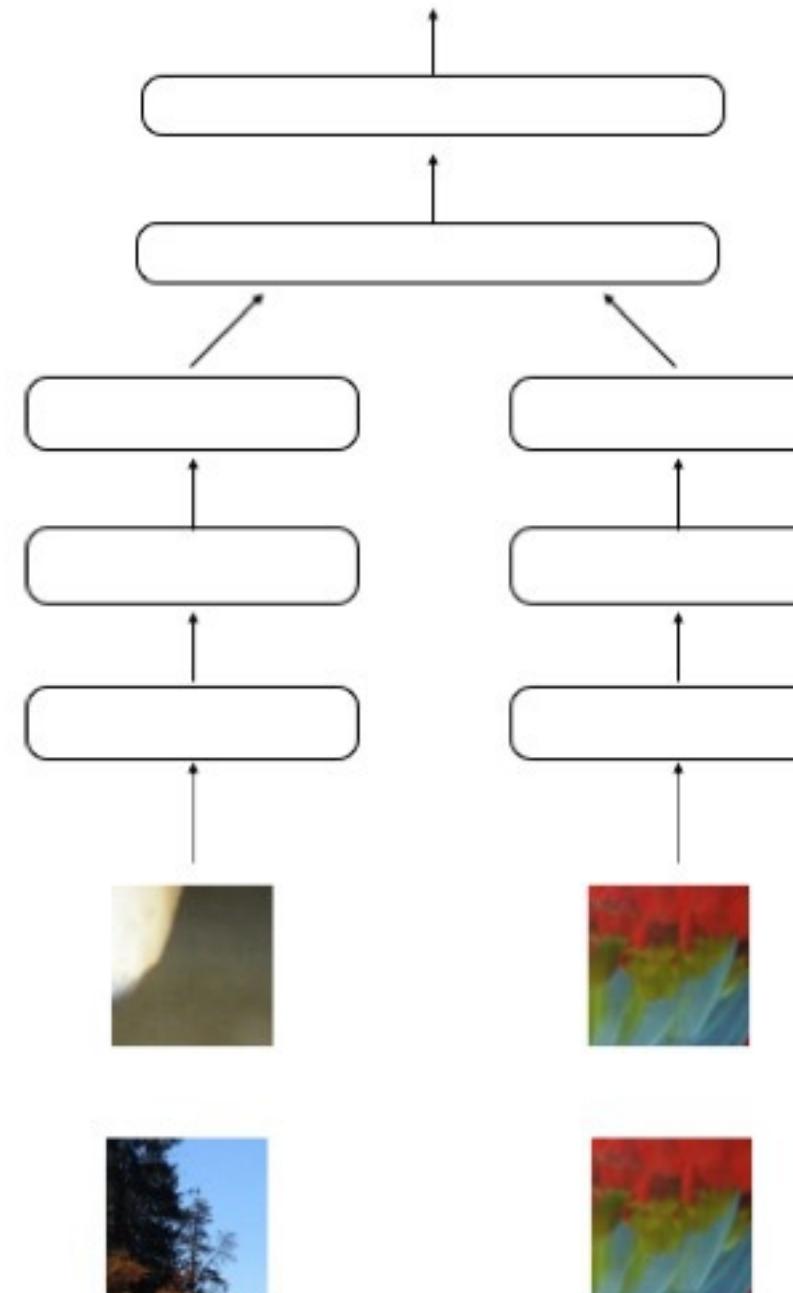
Learning self-consistency



Consistent

Inconsistent

Same Imaging Pipeline?

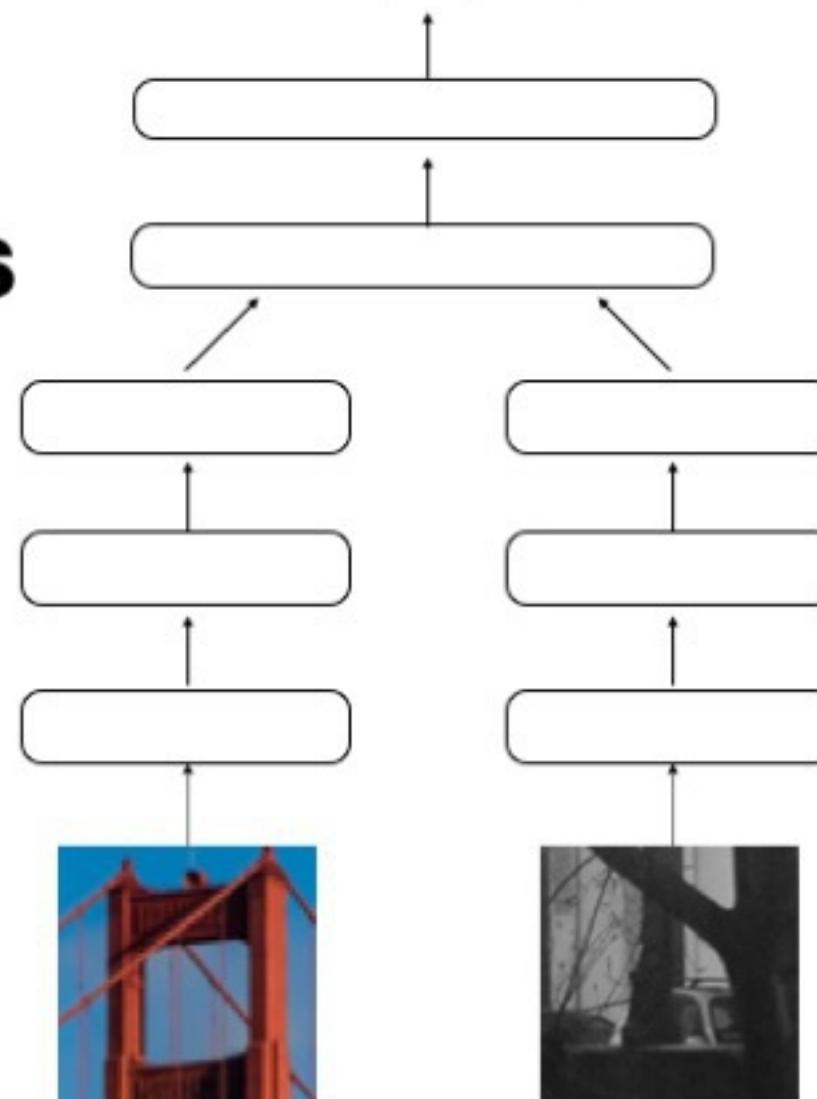


Self-consistency not enough

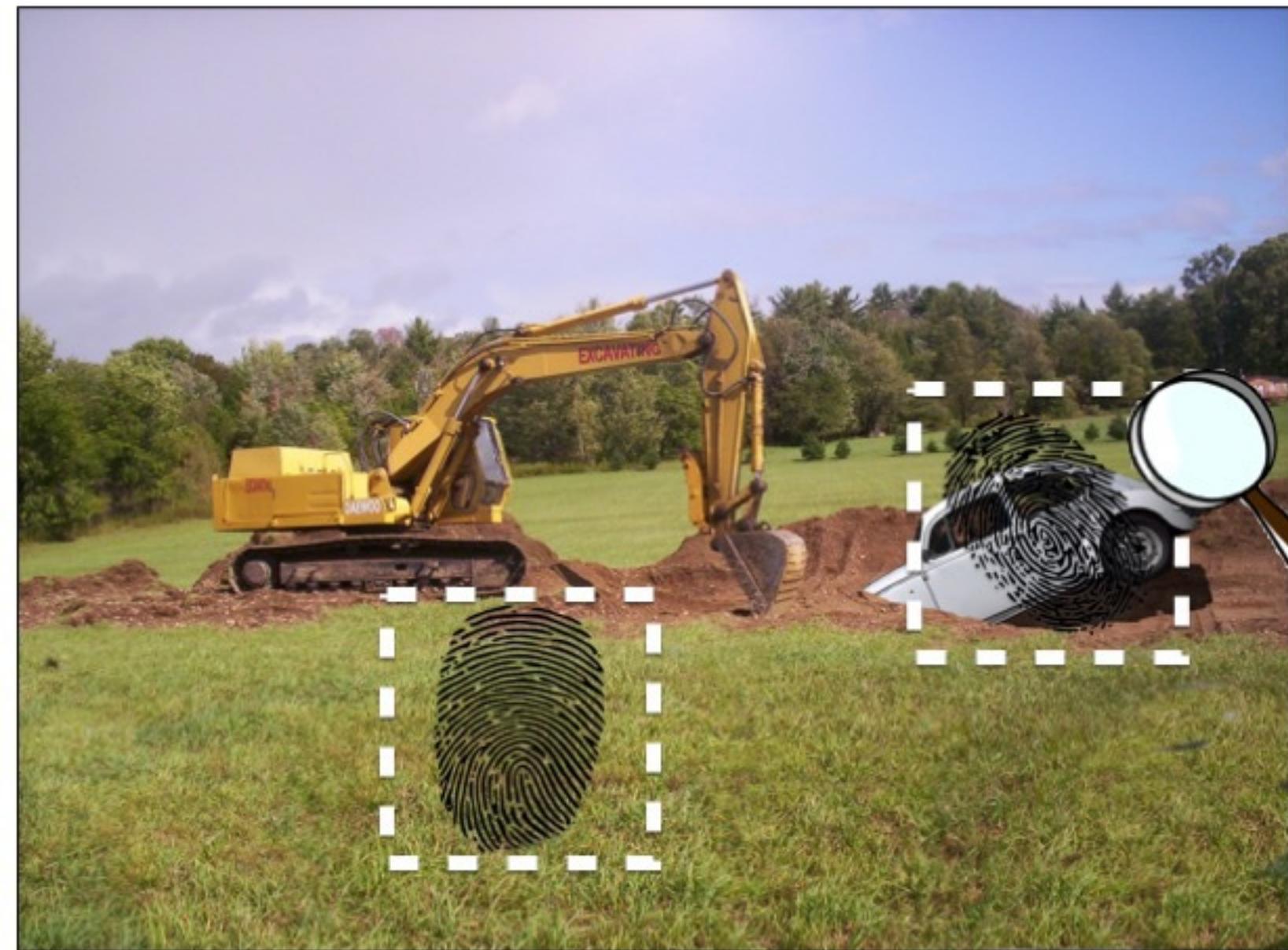


**Negative examples
are too easy!**

Same Imaging Pipeline?



EXIF metadata



CameraMake: NIKON CORPORATION
CameraModel: NIKON D5300
ColorSpace: sRGB
ExifImageLength: 3947
ExifImageWidth: 5921
Flash: No
FocalLength: 31.0mm
WhiteBalance: Auto
CompressedBitsPerPixel: 2
...



CameraMake: EASTMAN KODAK COMPANY
CameraModel: KODAK EASYSHARE CX7300
ColorSpace: sRGB
ExifImageLength: 1544
ExifImageWidth: 2080
Flash: No (Auto)
FocalLength: 5.9mm
WhiteBalance: Auto
CompressedBitsPerPixel: 181/100
...

Learning self-consistency

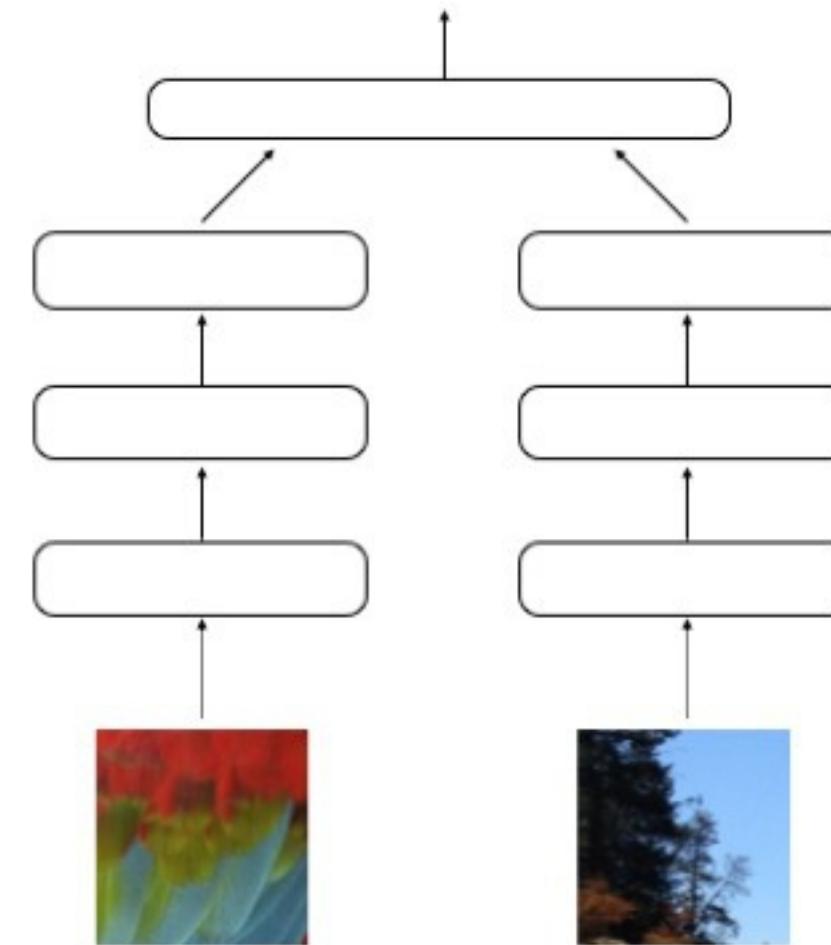


```
CameraMake: NIKON CORPORATION
CameraModel: NIKON D3200
ColorSpace: Uncalibrated
ExifImageLength: 2472
ExifImageWidth: 3091
Flash: Flash did not fire
FocalLength: 90
WhiteBalance: Auto
ExposureTime: 1/100
...
...
```

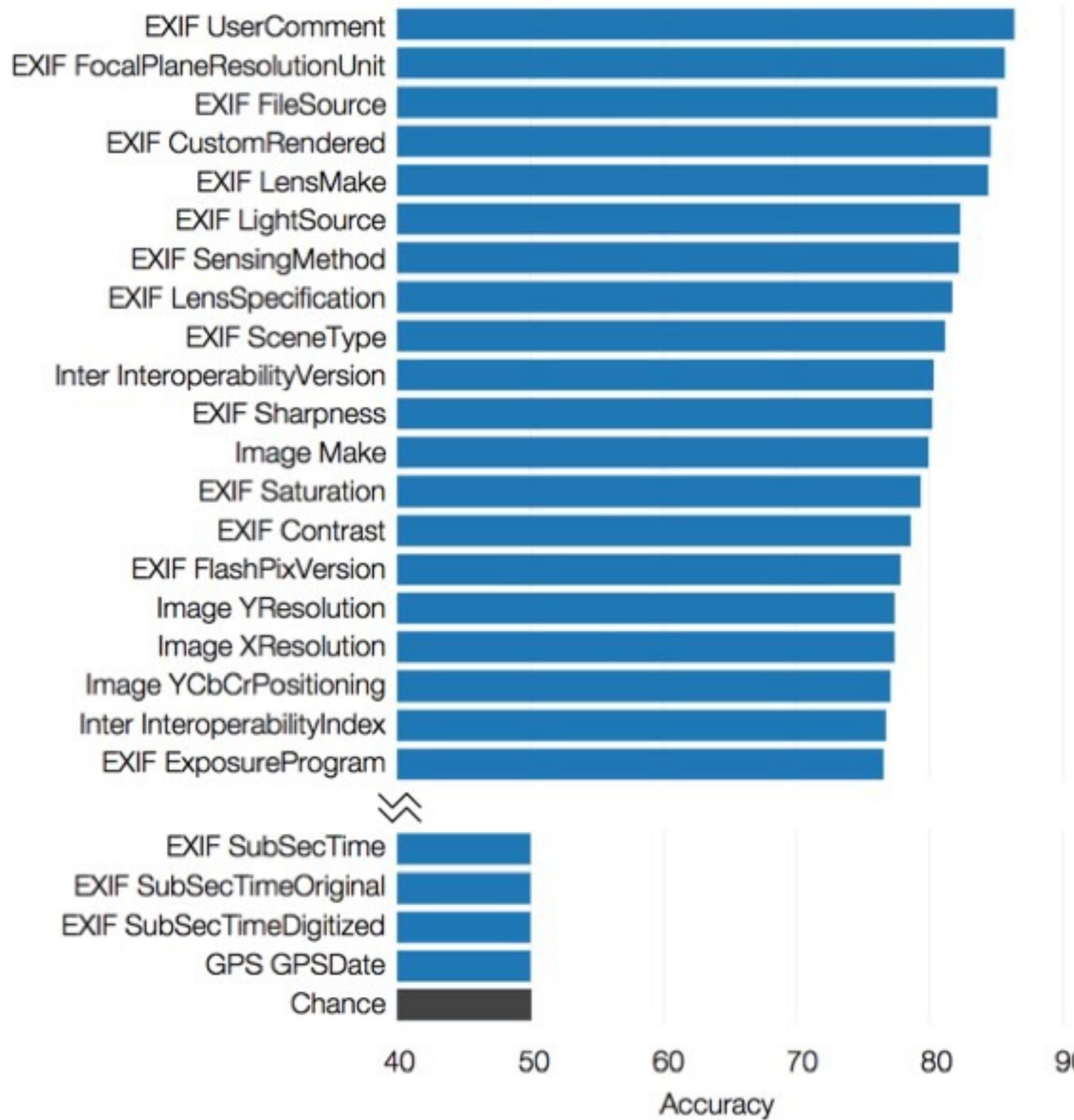


```
CameraMake: Apple
CameraModel: iPhone 4s
ColorSpace: sRGB
ExifImageLength: 2448
ExifImageWidth: 3264
Flash: Flash did not fire
FocalLength: 107/2
WhiteBalance: Auto
ExposureTime: 1/2208
...
...
```

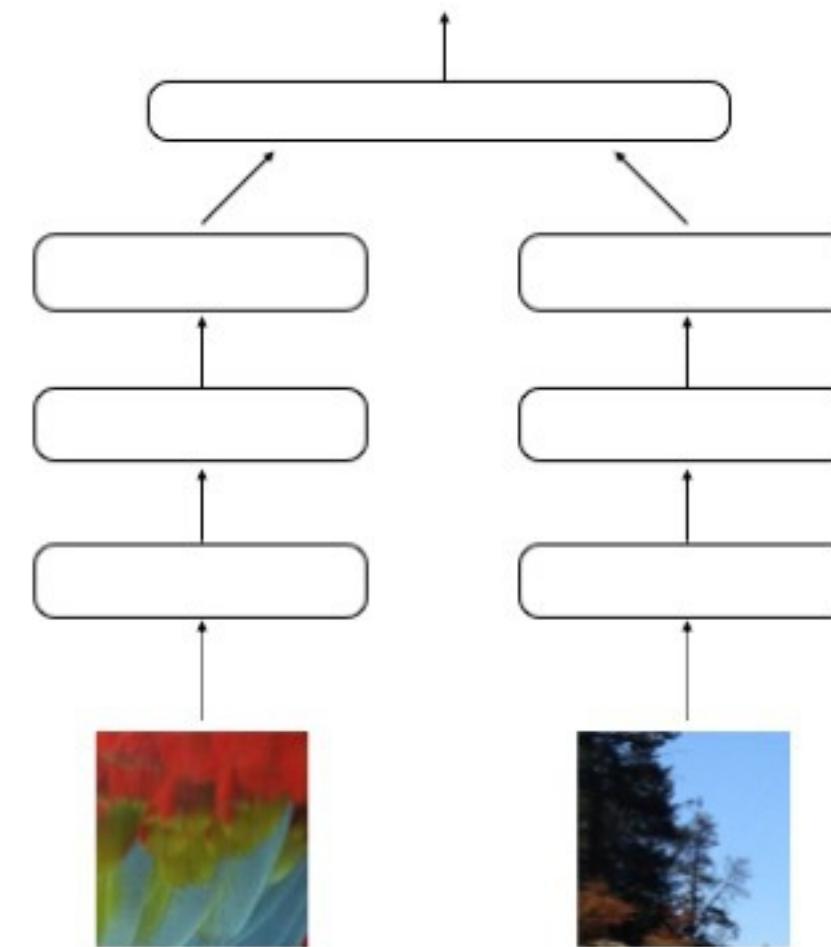
Same Camera Model? **Different**
Same WhiteBalance? **Same**
Same vs. different EXIF attributes



Learning self-consistency



Same vs. different EXIF attributes

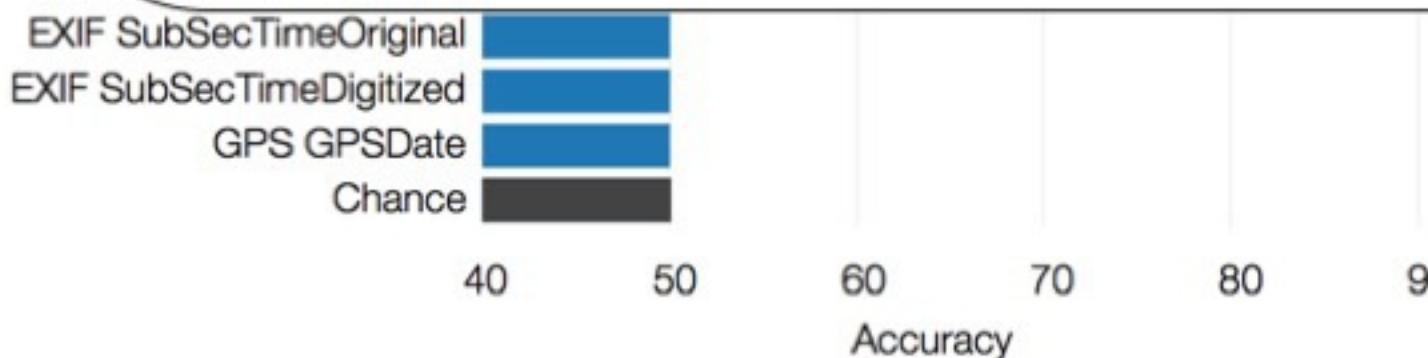


Learning self-consistency



EXIF UserComment: A generic field for writing keywords or comments.

- “Processed with VSCO with c8 preset”
- “Edited with Afterlight”
- Automated Binary Signatures
- ...

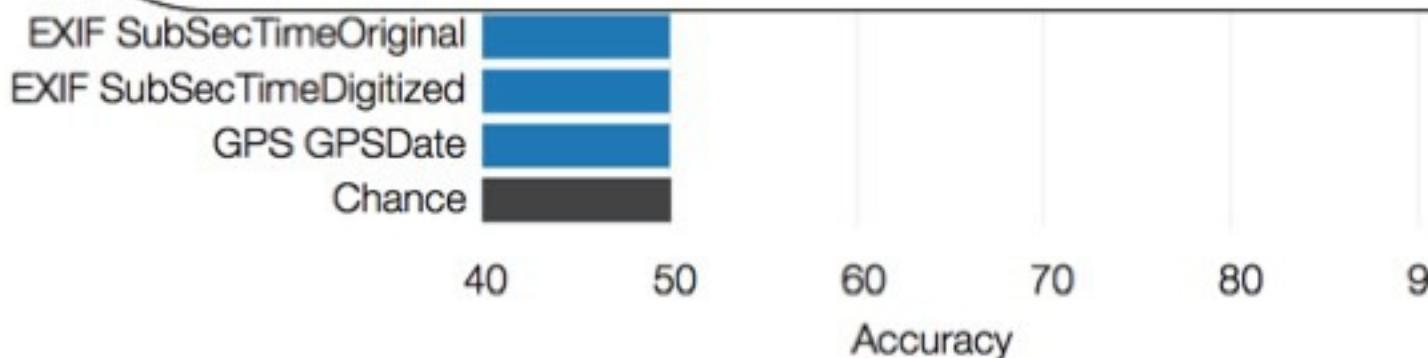


Learning self-consistency

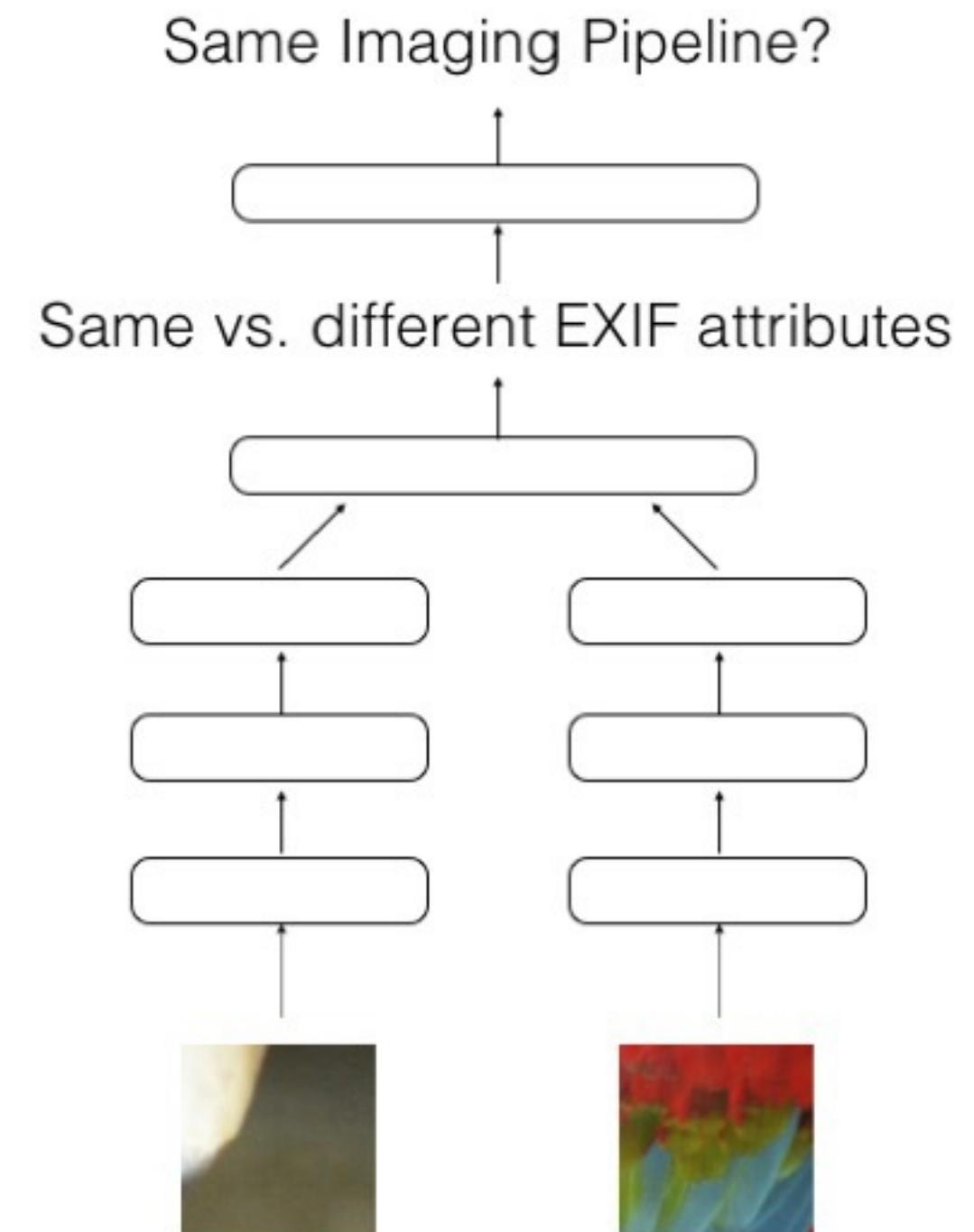


Image Make: The company manufacturer of the camera used to shoot the image.

- “Apple”
- “Nokia”
- “Canon”
- “Sony”
- ...

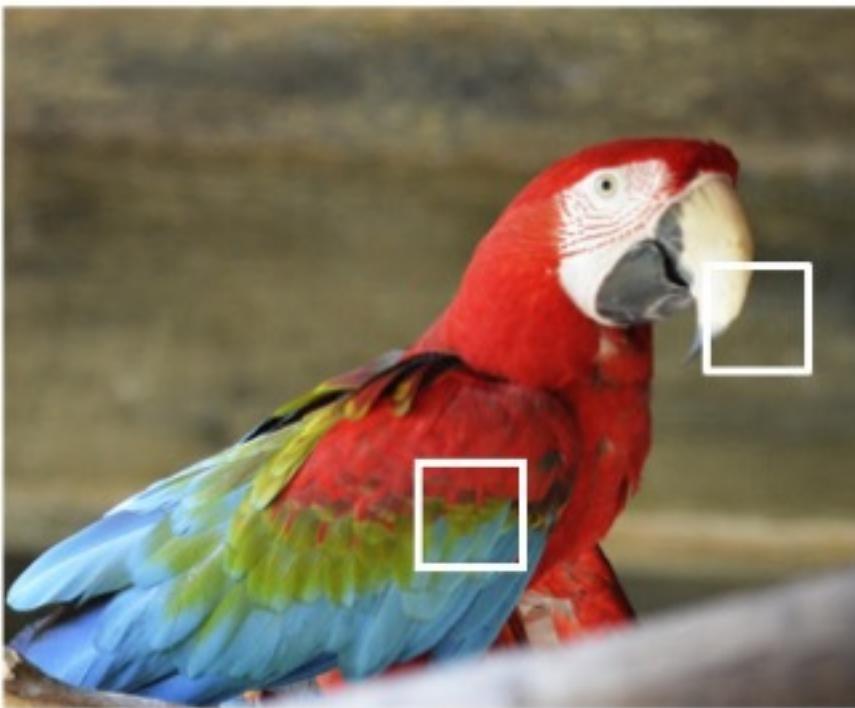


Learning self-consistency

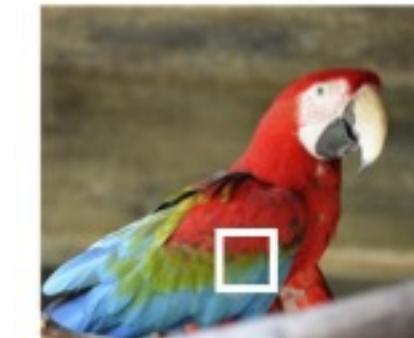


Other forms of self-consistency

Image Consistency



EXIF Consistency



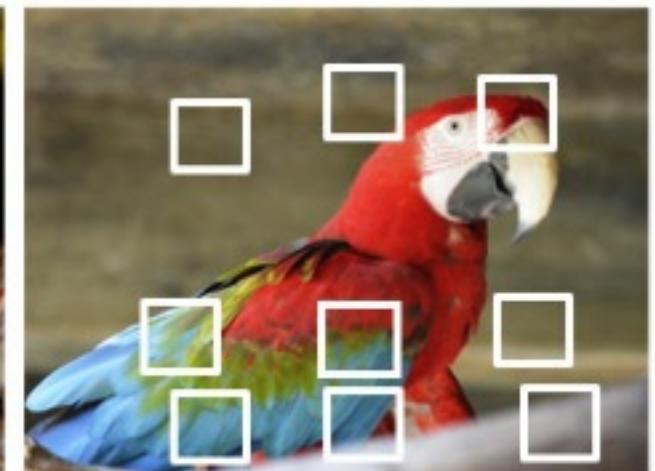
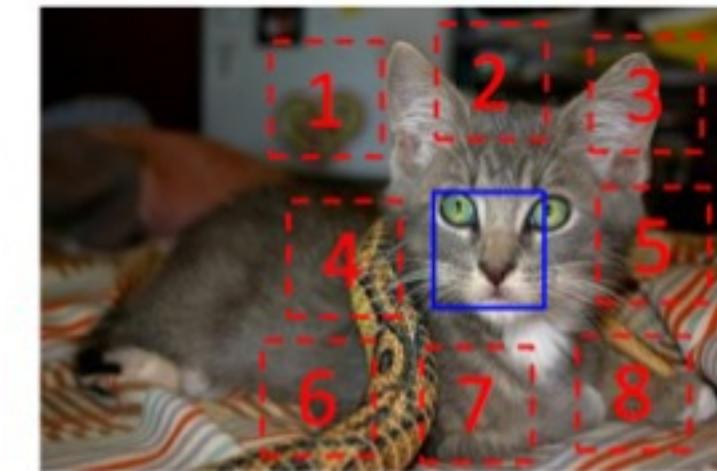
```
CameraMake: NIKON CORPORATION  
CameraModel: NIKON D3200  
ColorSpace: Uncalibrated  
ExifImageLength: 2472  
ExifImageWidth: 3091  
Flash: Flash did not fire  
FocalLength: 90  
WhiteBalance: Auto  
ExposureTime: 1/100
```

```
CameraMake: Apple  
CameraModel: iPhone 4s  
ColorSpace: sRGB  
ExifImageLength: 2448  
ExifImageWidth: 3264  
Flash: Flash did not fire  
FocalLength: 107/2  
WhiteBalance: Auto  
ExposureTime: 1/2208
```

Post-processing Consistency



Spatial Consistency



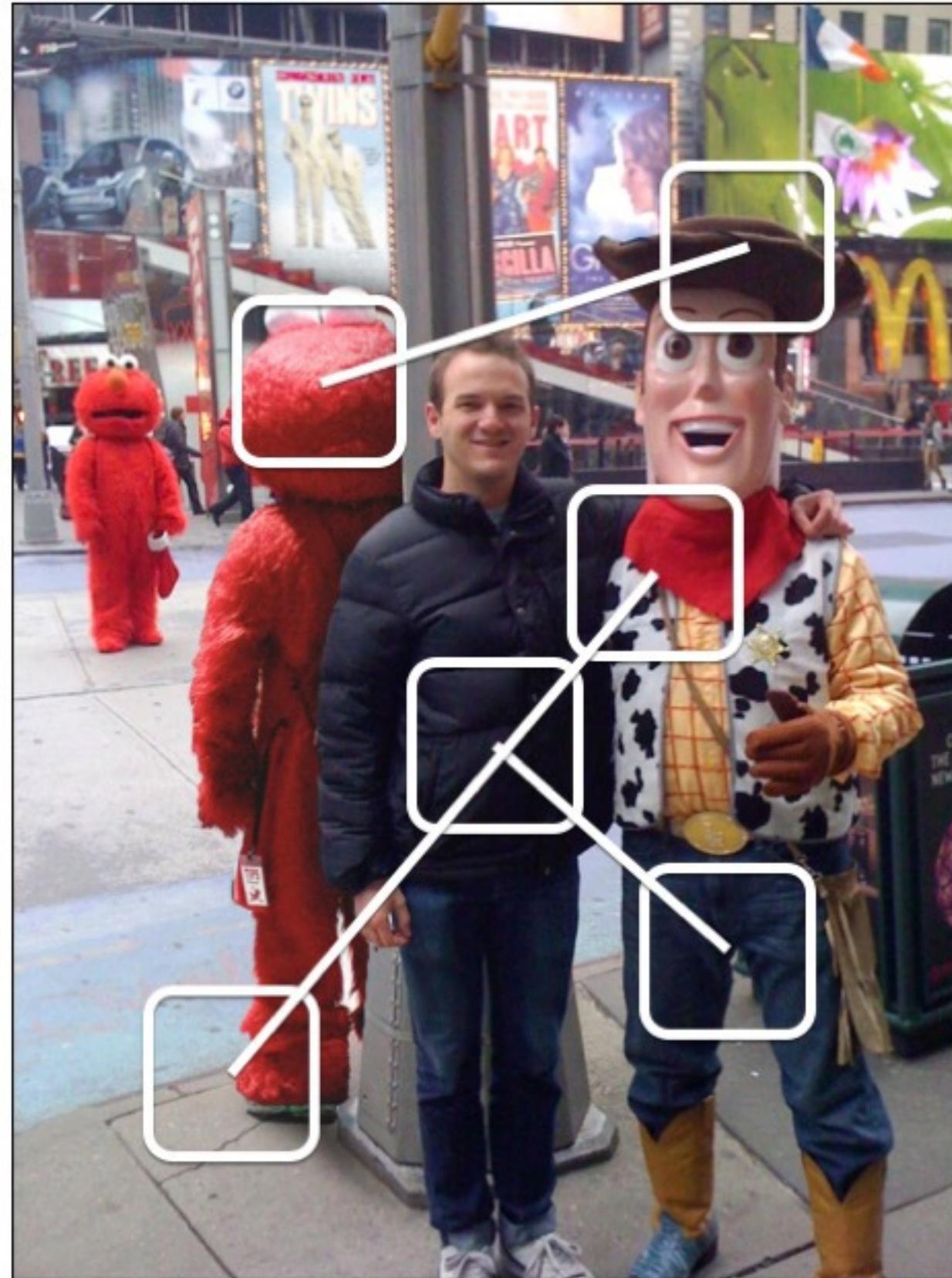
Unmanipulated Image



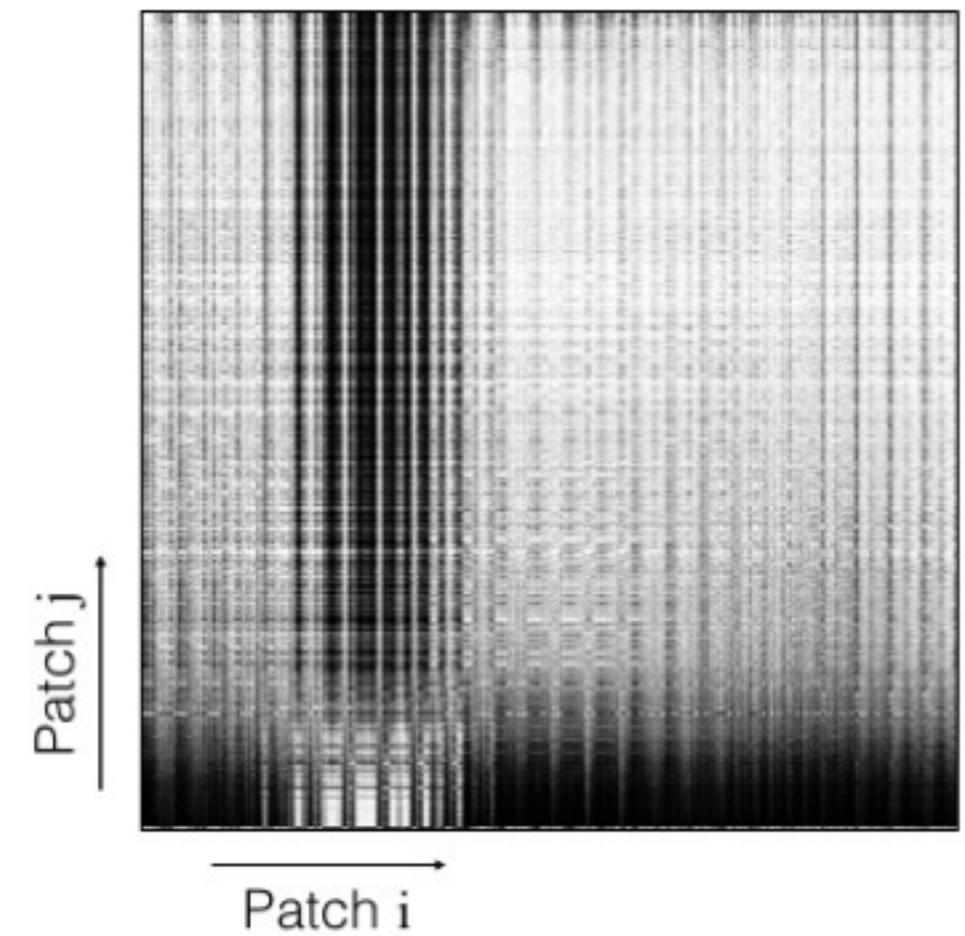
Manipulated Image



Manipulated Image



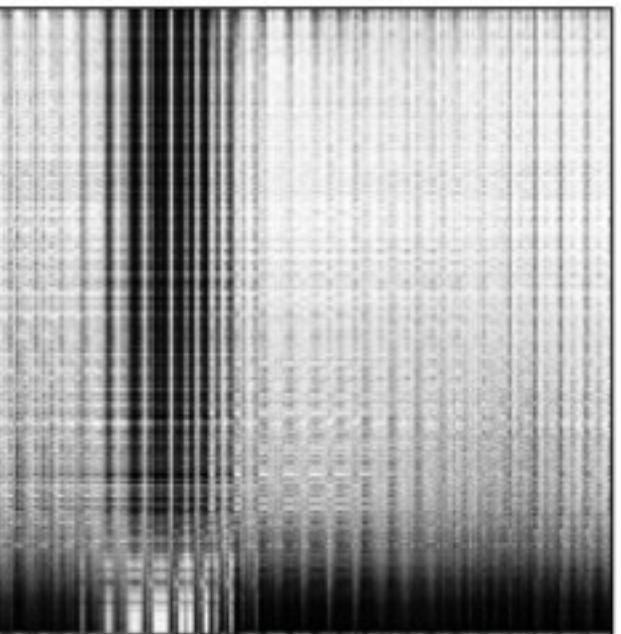
Affinity Matrix



Manipulated Image



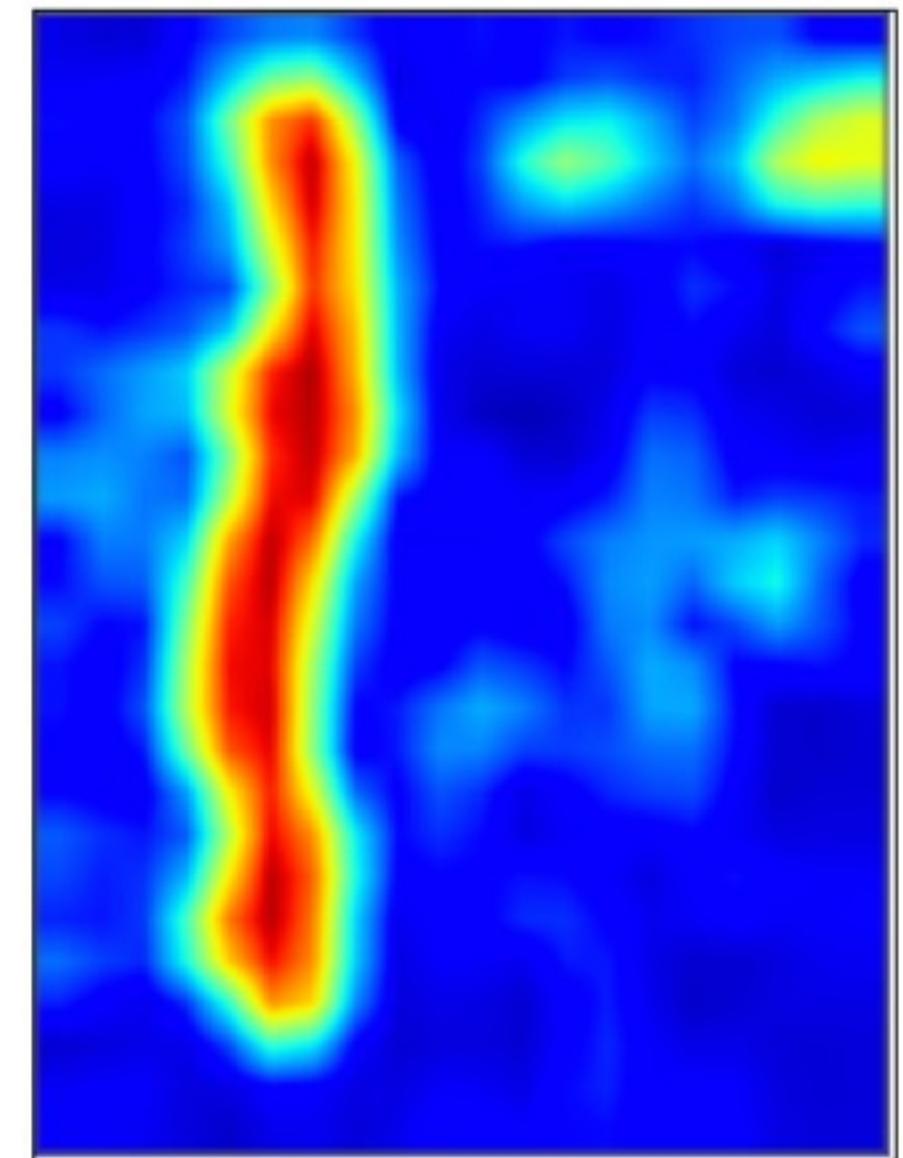
Affinity Matrix



Mean Shift



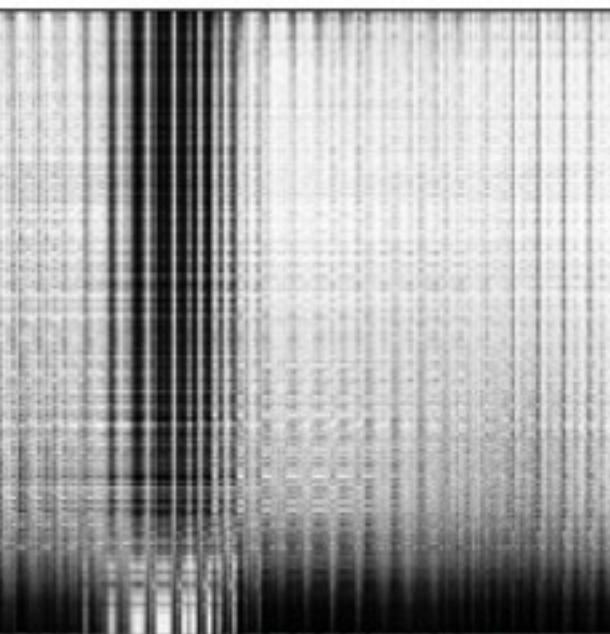
Consistency Map



Manipulated Image



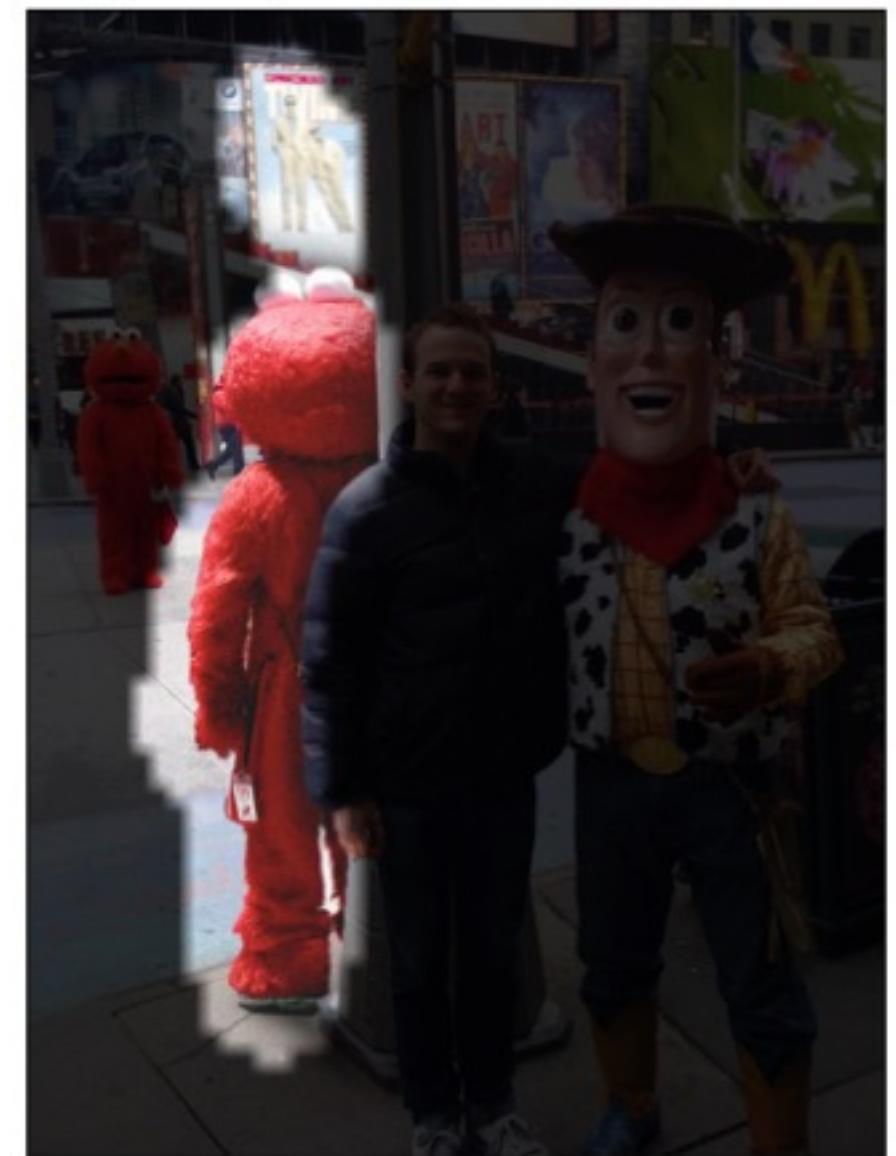
Affinity Matrix



Normalized Cuts



Manipulated Region



Input Image



Manipulated Region

Our detection



Ground Truth



Input Image



Manipulated Region

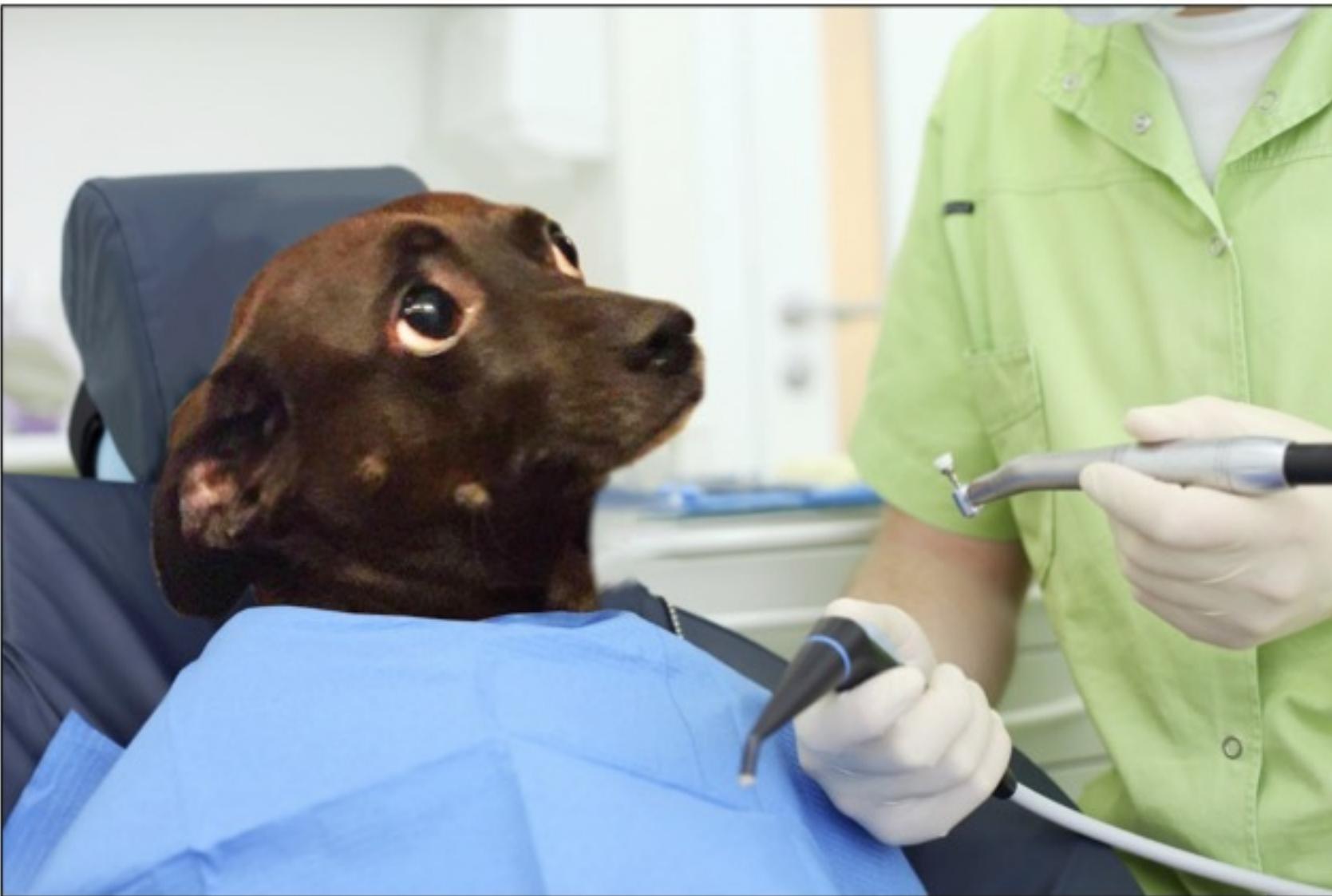
Our detection



Ground Truth

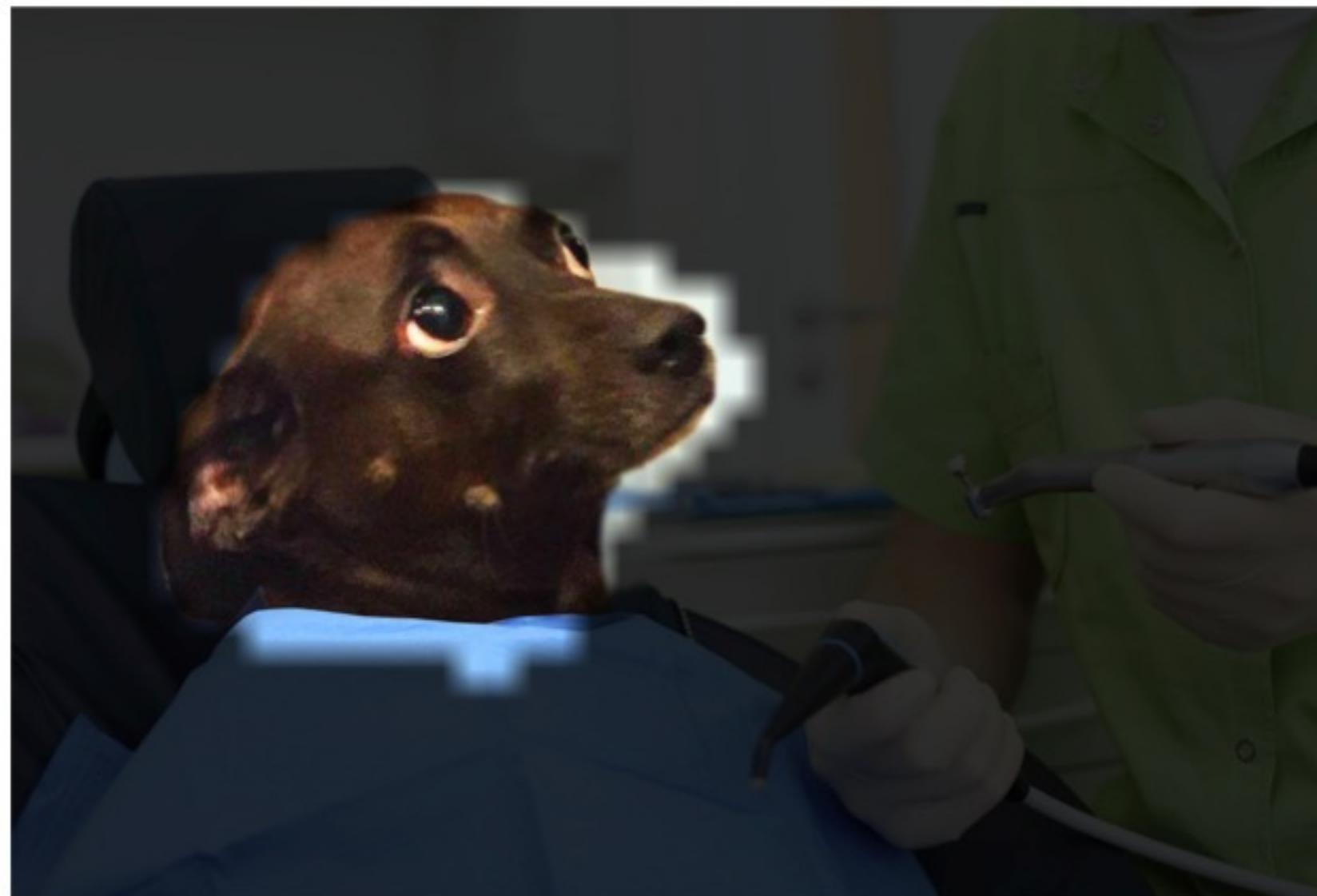


Input Image

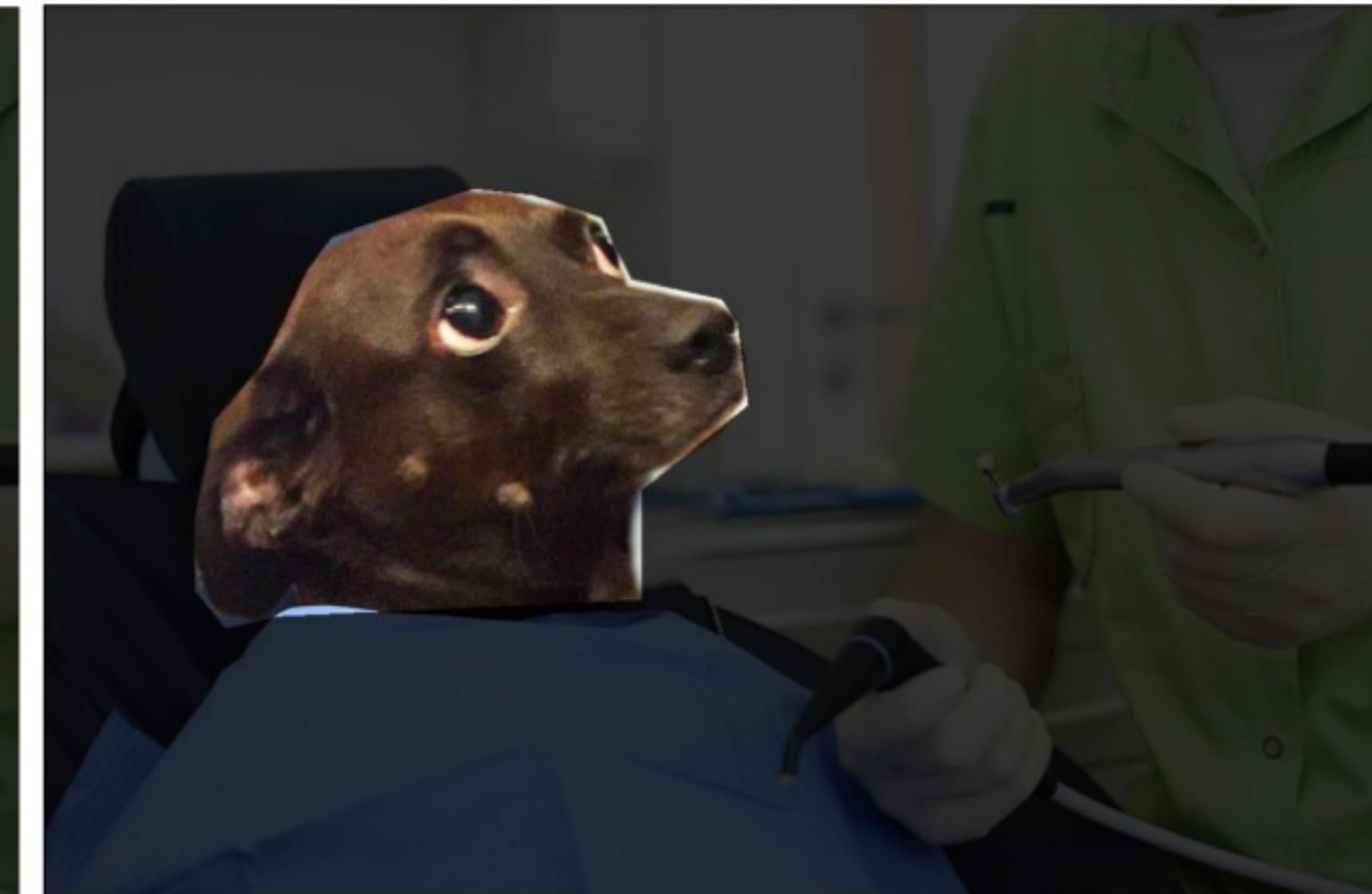


Manipulated Region

Our detection



Ground Truth



Input Image



Manipulated Region

Our detection



Ground Truth



Input Image



Manipulated Region

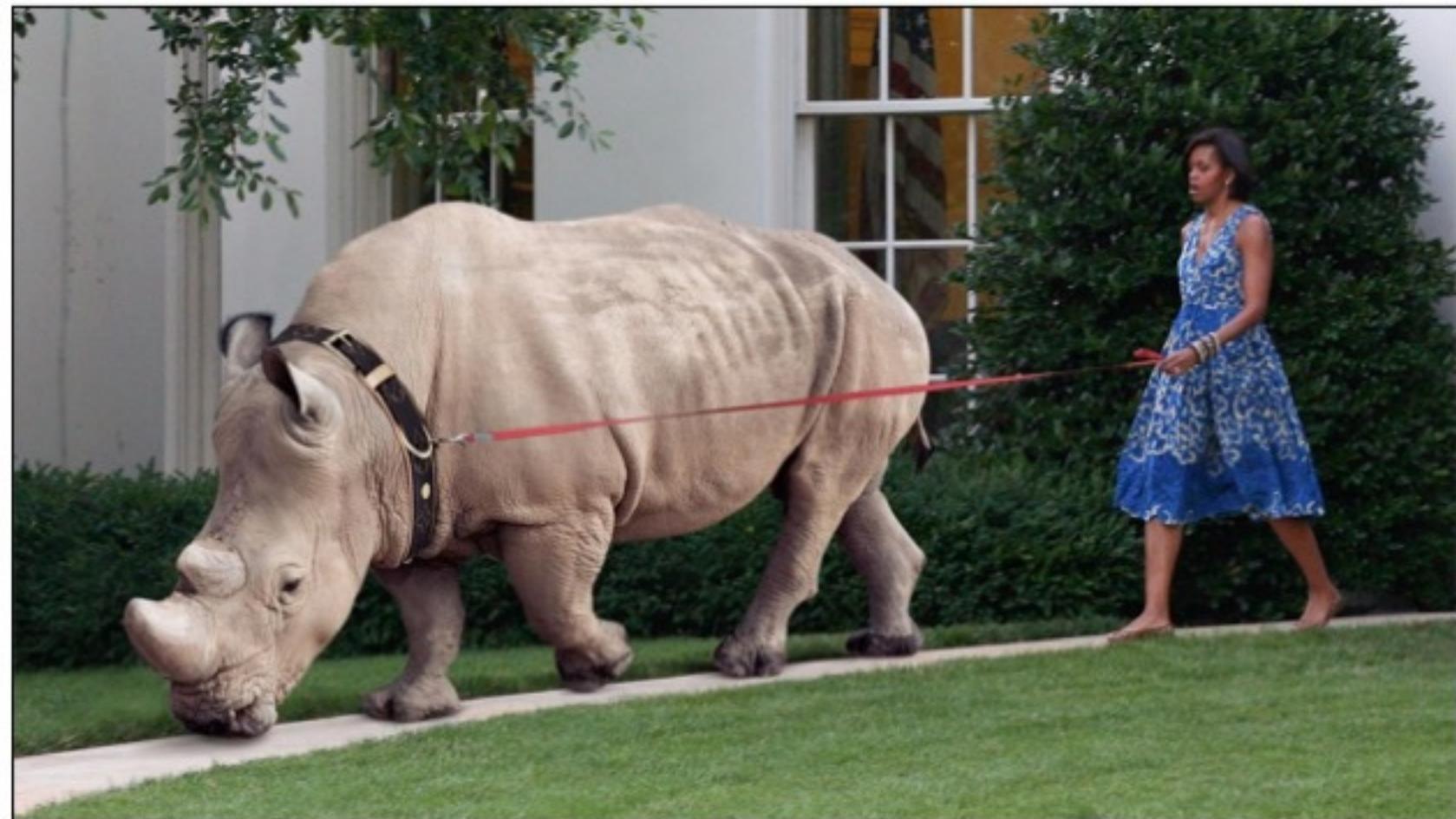
Our detection



Ground Truth

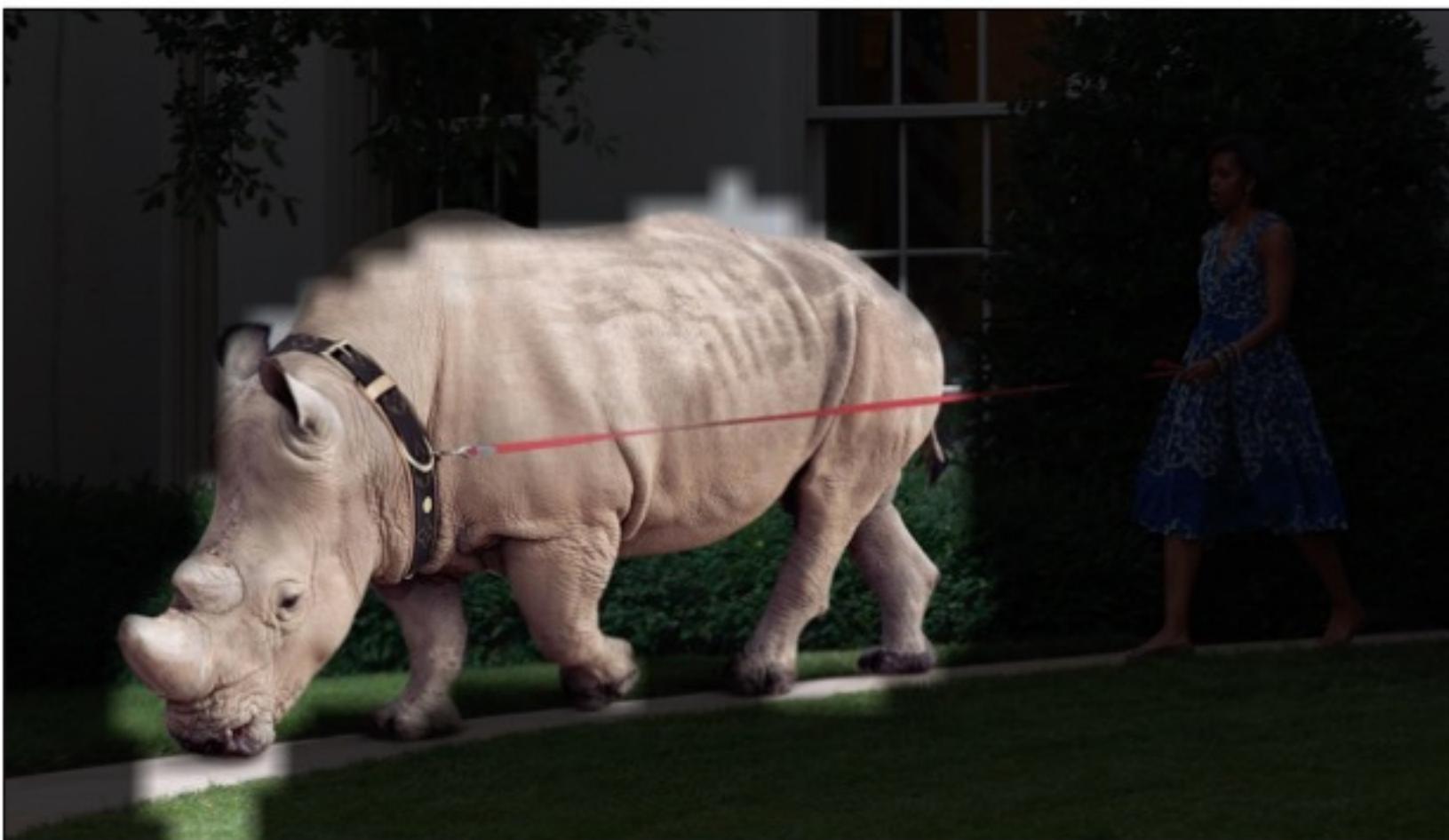


Input Image

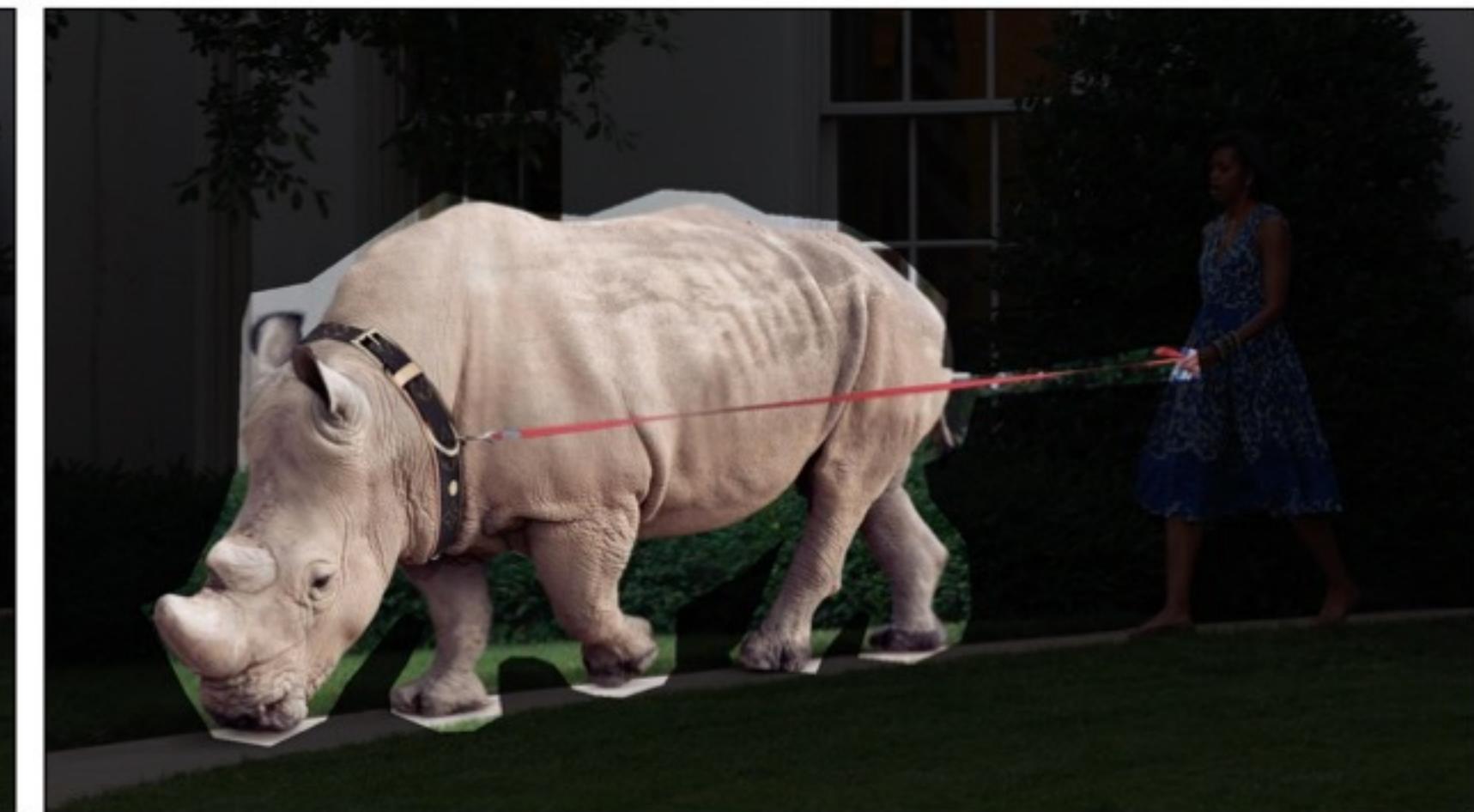


Manipulated Region

Our detection



Ground Truth



Input Image

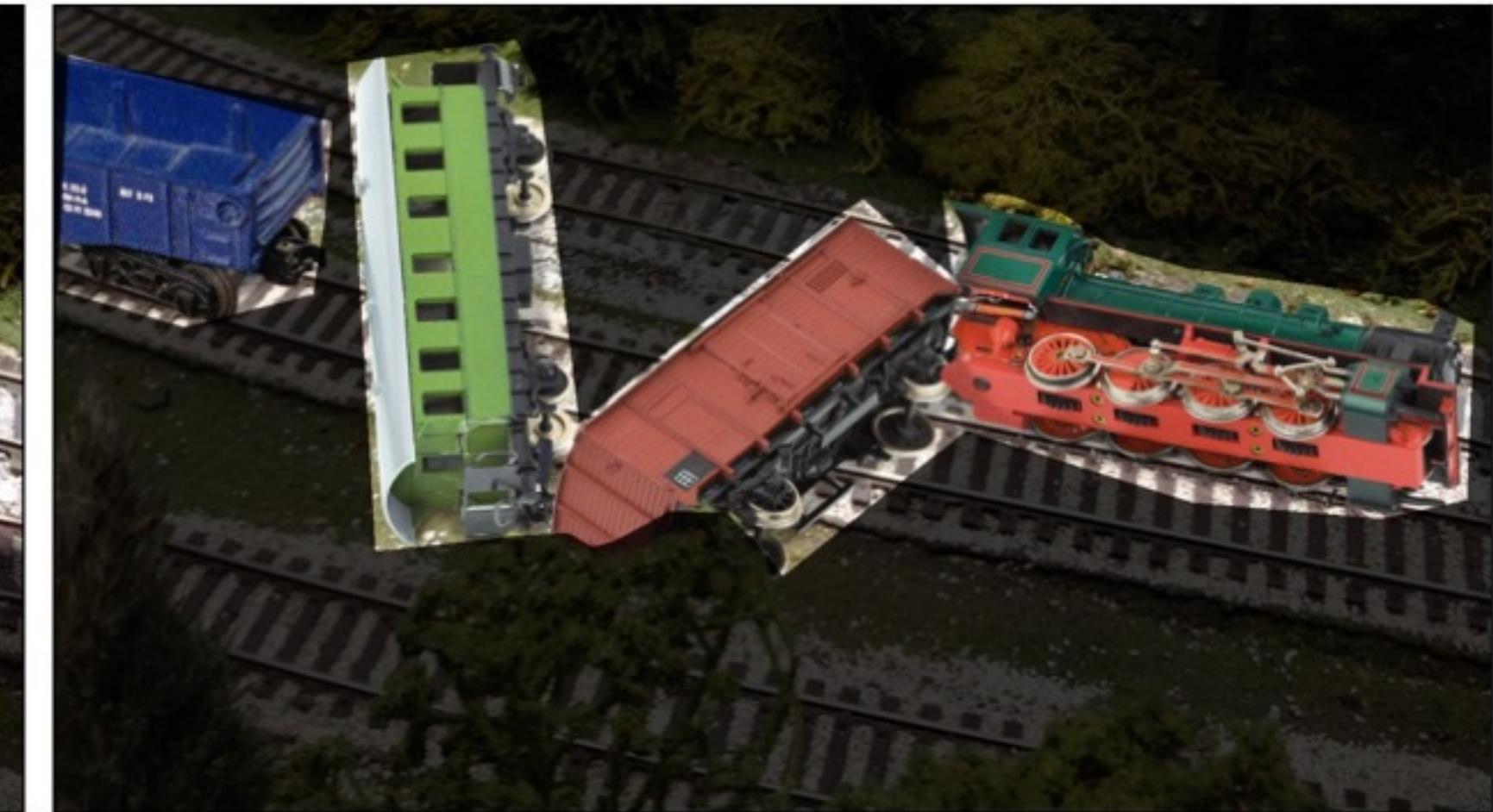


Manipulated Region

Our detection



Ground Truth



Input Image



Manipulated Region

Our detection



Ground Truth



Original Images



Ground Truth



Manipulated Region

Our detection



Ground Truth

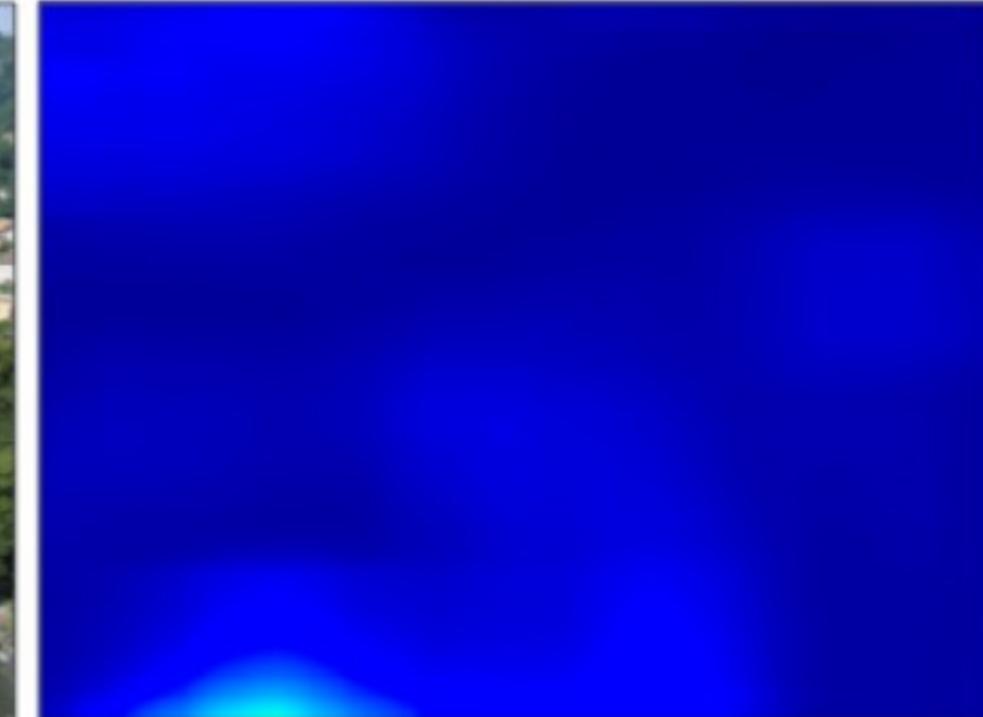
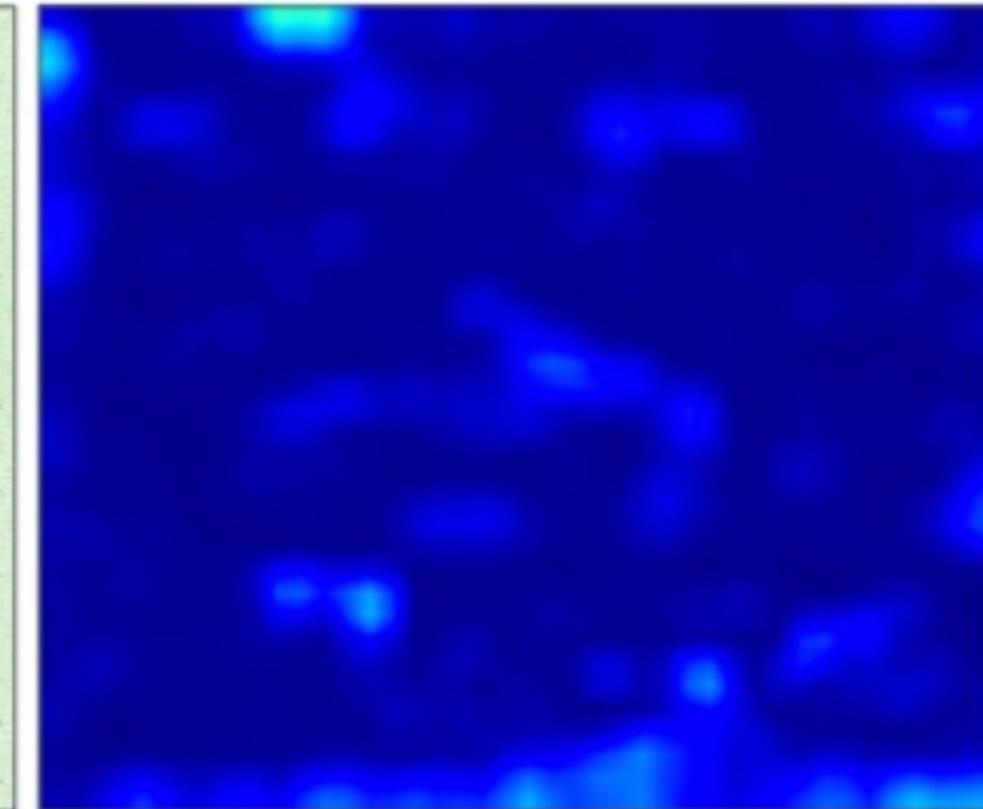


Authentic Images

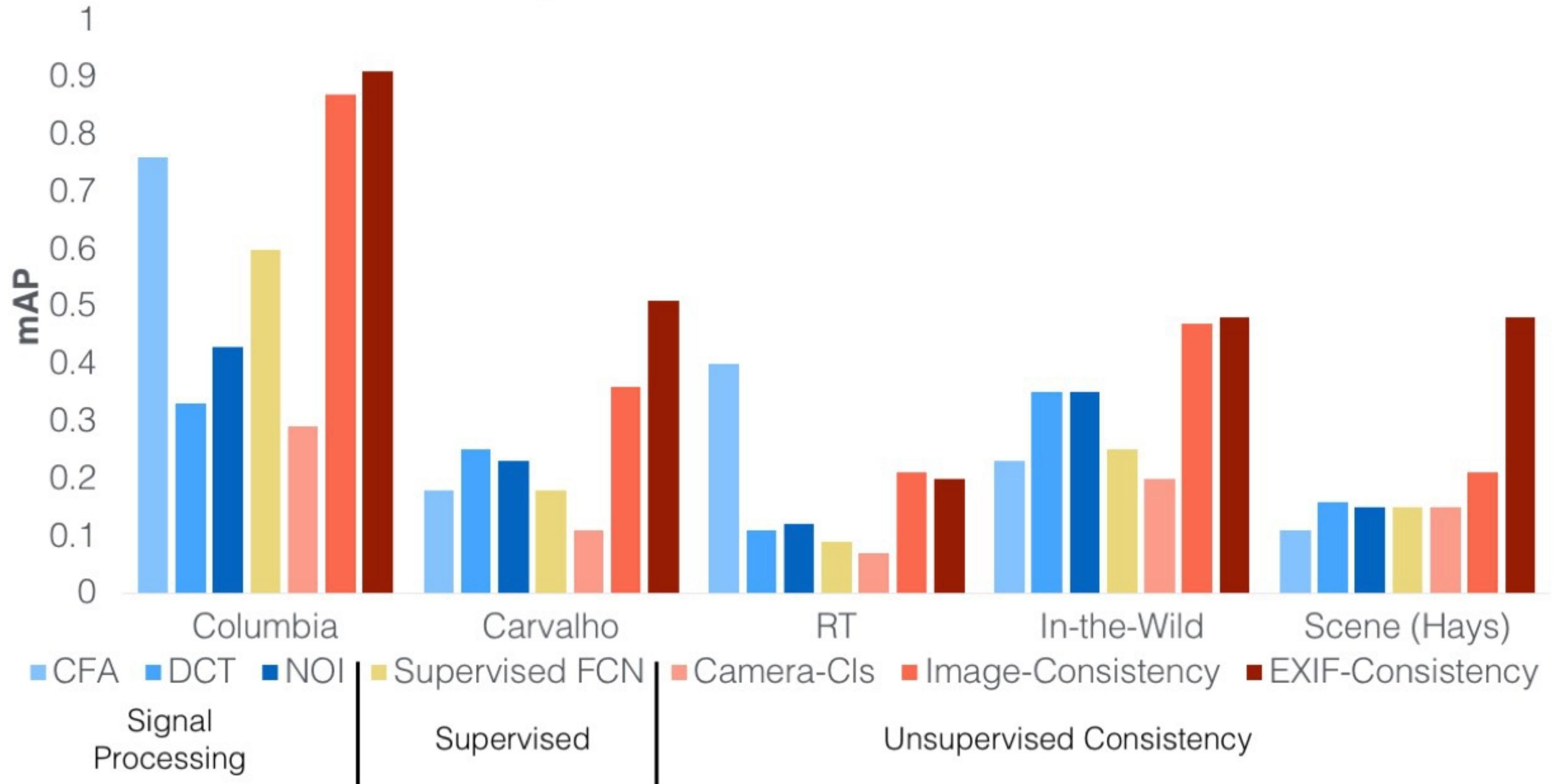
Image

STATE OF HAWAII			CERTIFICATE OF LIVE BIRTH			DEPARTMENT OF HEALTH		
						FILE NUMBER 151 61 10641		
1a. Child's First Name (First or given)	1b. Middle Name	1c. Last Name	2a. Sex	2b. Day of Birth	2c. Month	2d. Year	2e. Hour	2f. Minute
BARACK	MUHAMMAD	OBAMA, II	Male	2 Aug	Aug	1961	2:24 P.M.	
Place of Birth: City, Town or Rural Location			Honolulu, Oahu, Hawaii					
Name of Hospital or Institution (If not in Hospital or Institution, give name address)			Kapiolani Maternity & Gynecological Hospital					
3a. Name and Street or Foreign Country			3b. City and State or Foreign Country					
Name of Mother			Honolulu, Hawaii					
4a. Street Address			4b. City and State or Foreign Country					
6085 Kalanianaole Highway			Honolulu, Hawaii					
5a. Mother's Mailing address			5b. City and State or Foreign Country					
5c. Name of Father			5d. Name of Father					
BARACK			AFRIQUE					
6a. Age of Father			6b. Workplace (City, Town or Foreign Country)					
25 Kenya, East Africa			6c. Type of Occupation Outside Home During Pregnancy					
7a. Full Maiden Name of Mother			7b. Name of Mother					
STANLEY			DOROTHY					
8a. Age of Mother			8b. Workplace (City, Town or Foreign Country)					
18 Wimberly, Kansas			8c. Type of Occupation Outside Home During Pregnancy					
I certify that the above named			8d. Name of Signature					
is my child and that I have no knowledge			Signature: <i>Barack Obama</i> Date: 8-7-61					
of any other person having any right			Signature: <i>David A. Sommers</i> Date: 8-7-61					
to the birth of this child.			Signature: <i>U.S. Dept.</i> Date: 8-7-61					
10. Name Approved by Local Reg. Off. Signature of Local Registrar			11. Name Approved by State Board of Health					
BIR - S 681			BIR - S 681					
12. Evidence for Federal Filing or Alteration								

Consistency Map

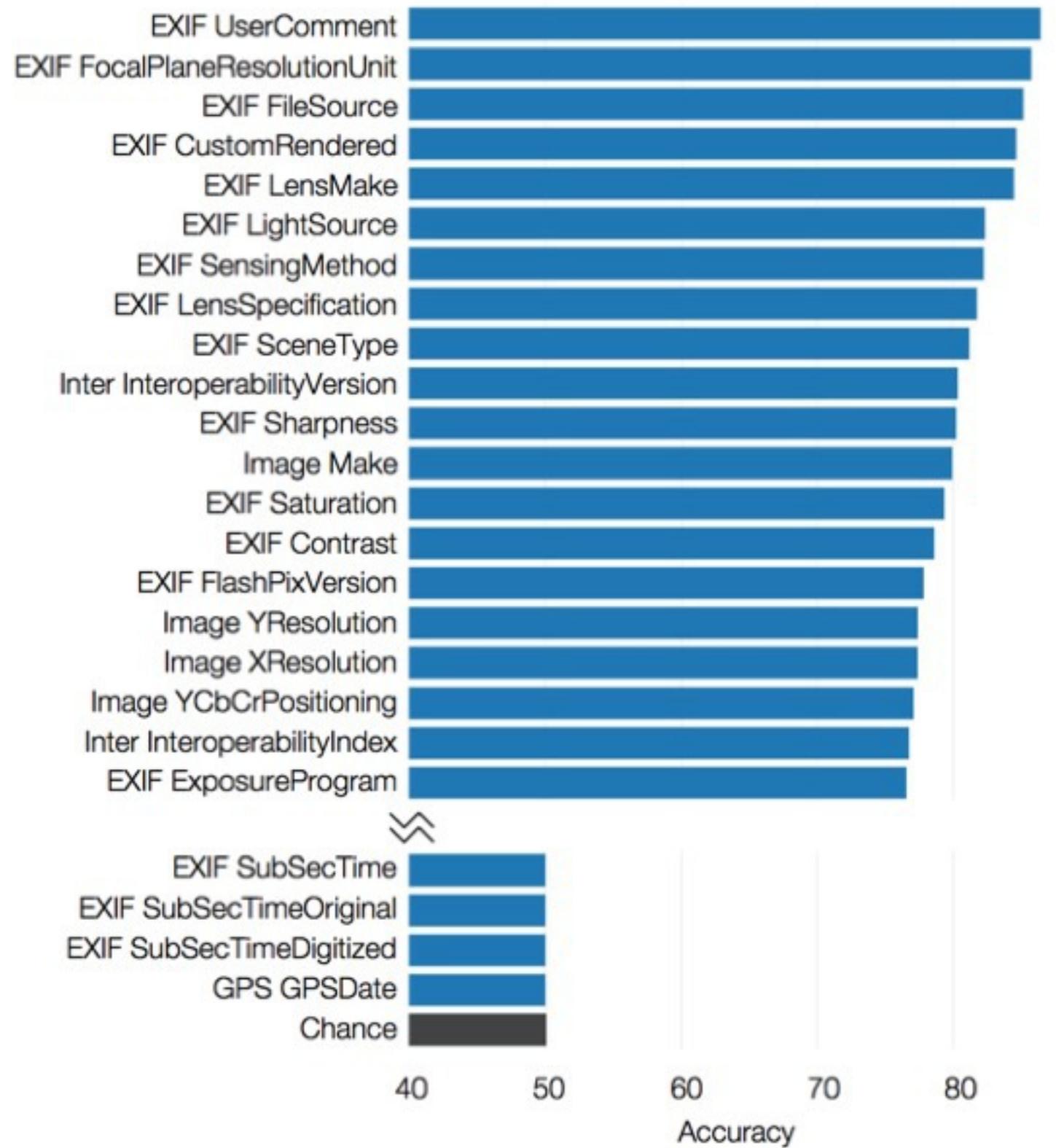


Splice Localization

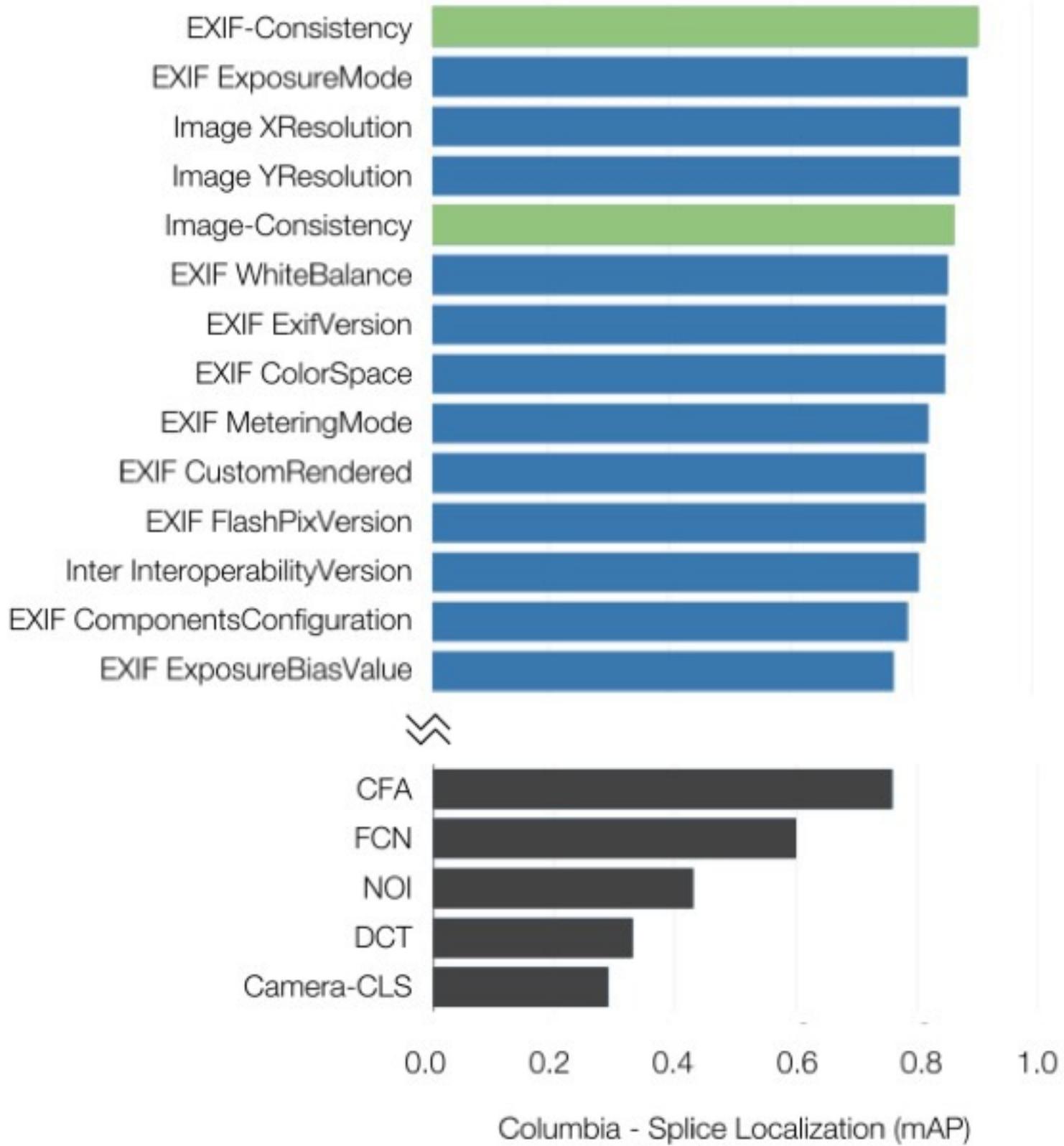


EXIF Analysis

Distinguishable EXIF



Localizable EXIF



EXIF Analysis

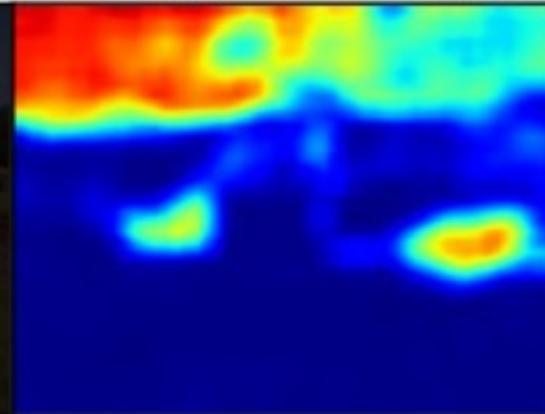
Tampered



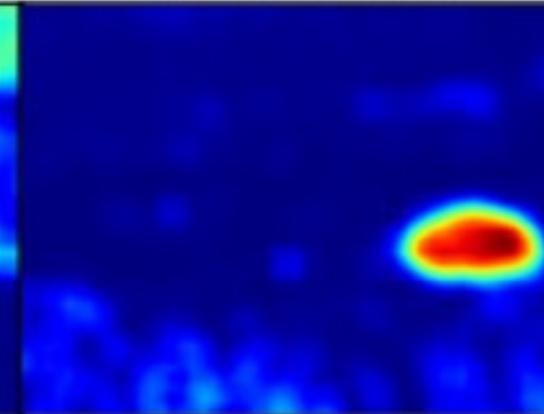
Ground Truth



Image-Consistency



EXIF-Consistency



EXIF DigitalZoomRatio

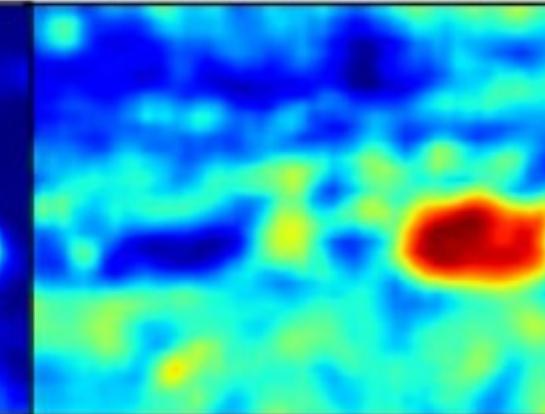
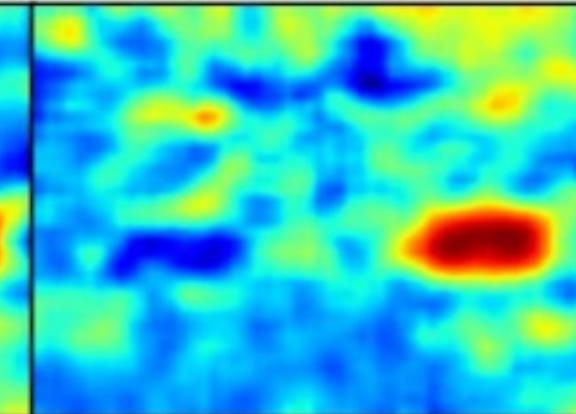
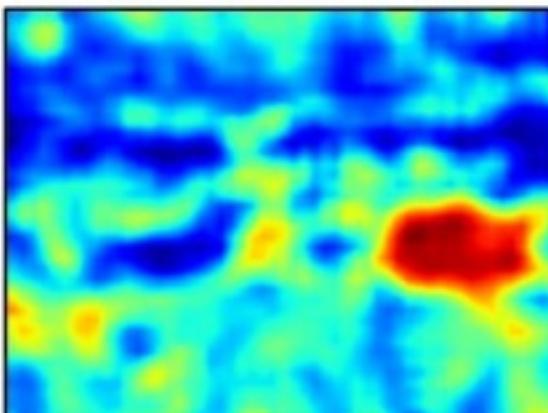


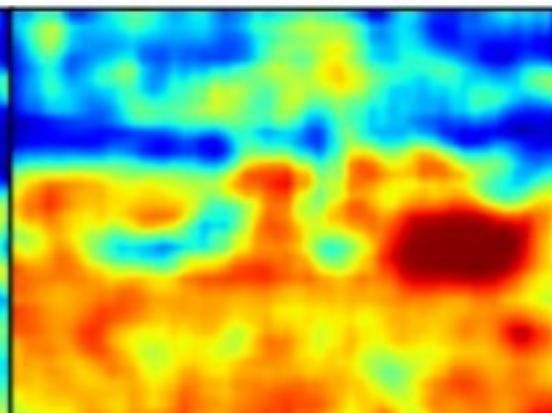
Image Model



EXIF GainControl



EXIF FNumber



EXIF ISOSpeedRatings

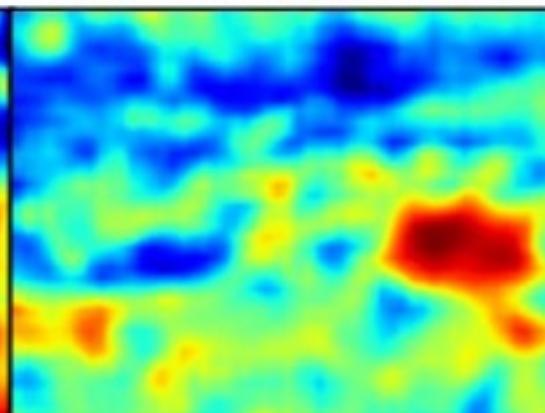
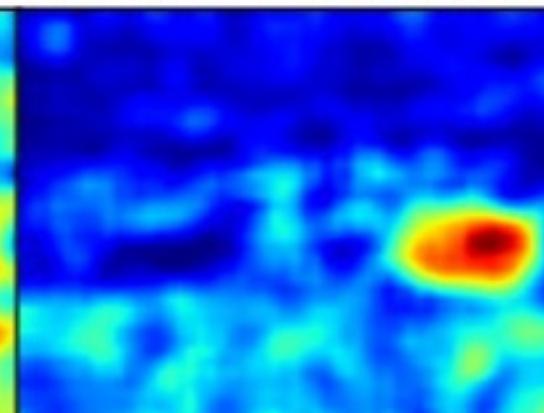
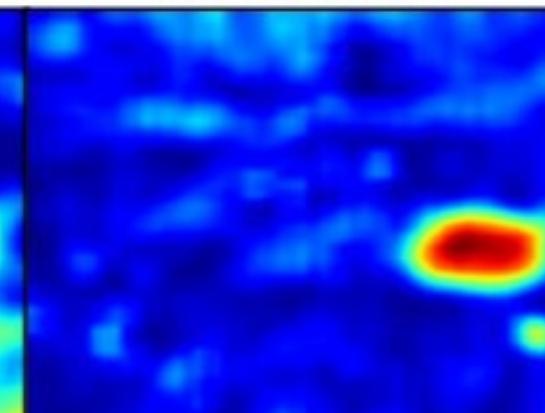


Image YCbCrPositioning



EXIF ExifVersion



EXIF ColorSpace

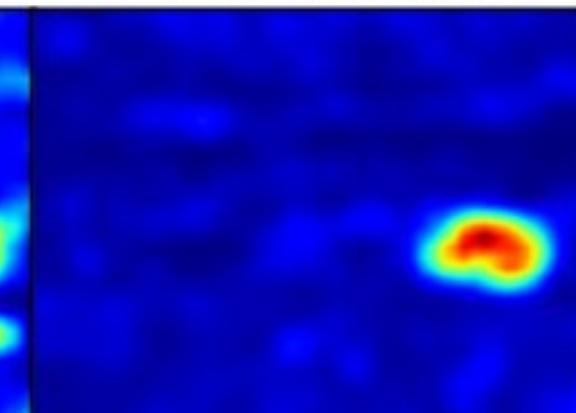
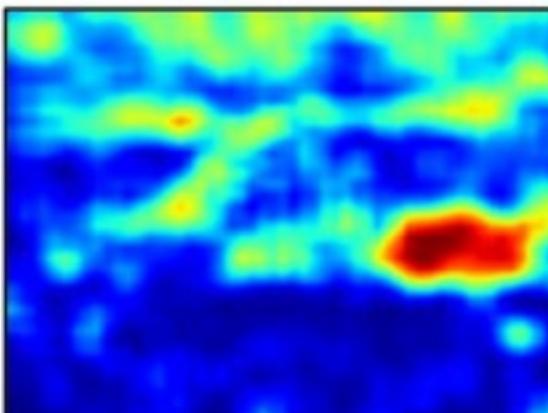
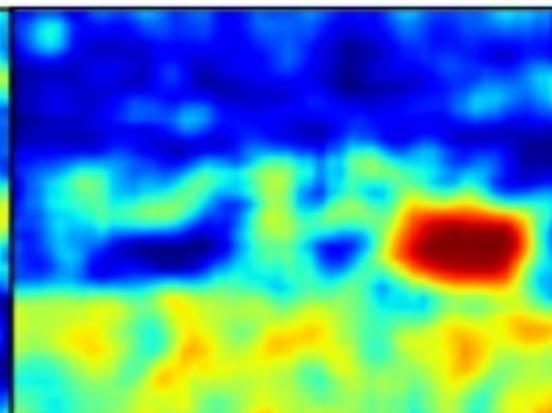


Image Make

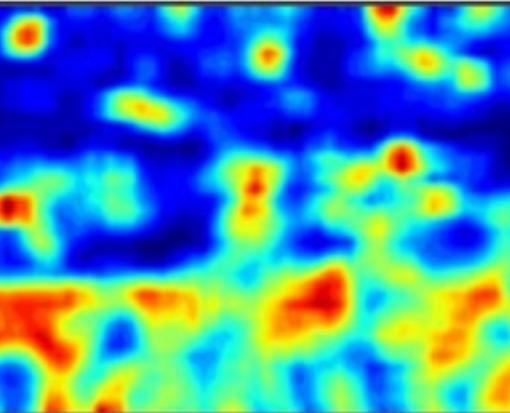


EXIF ExifImageWidth



• • •

GPS GPSDate



EXIF FileSource

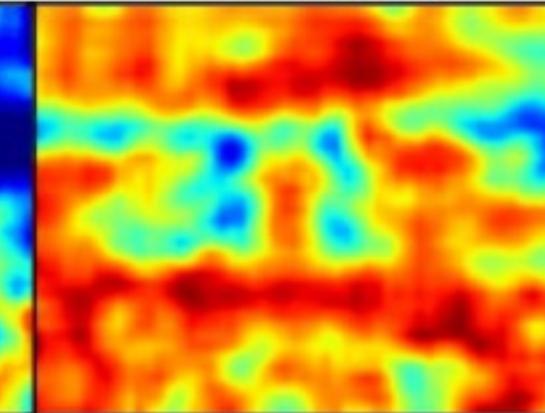
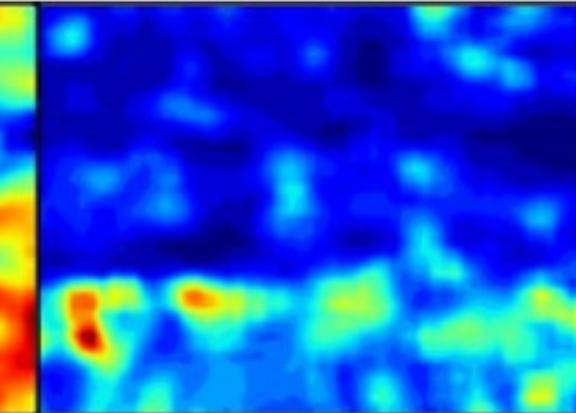


Image GPSInfo

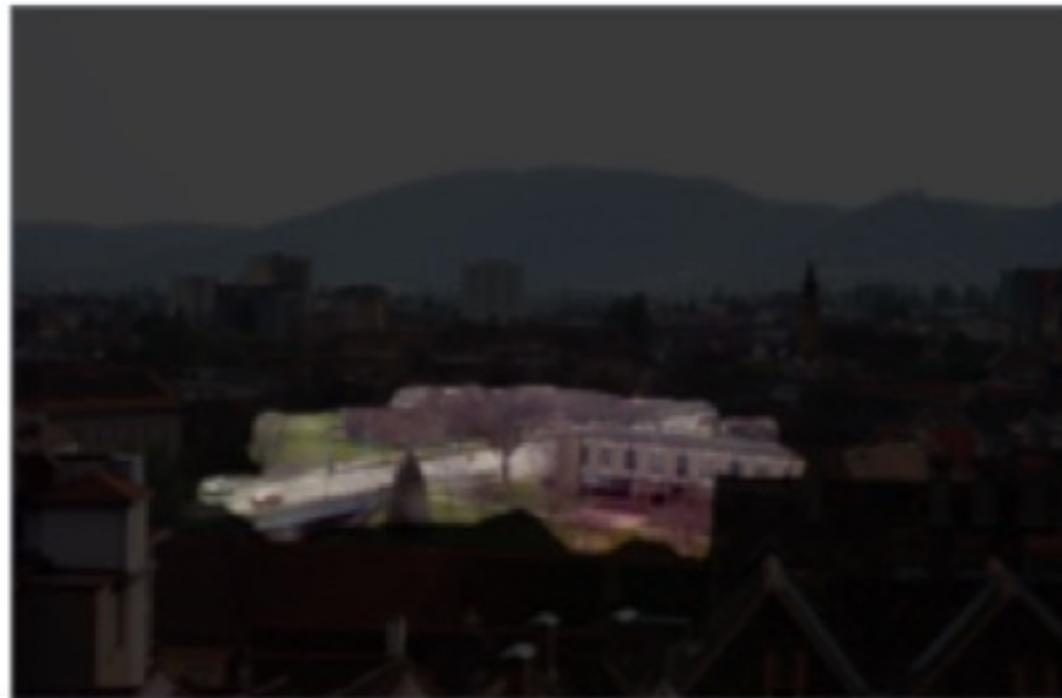


Failures

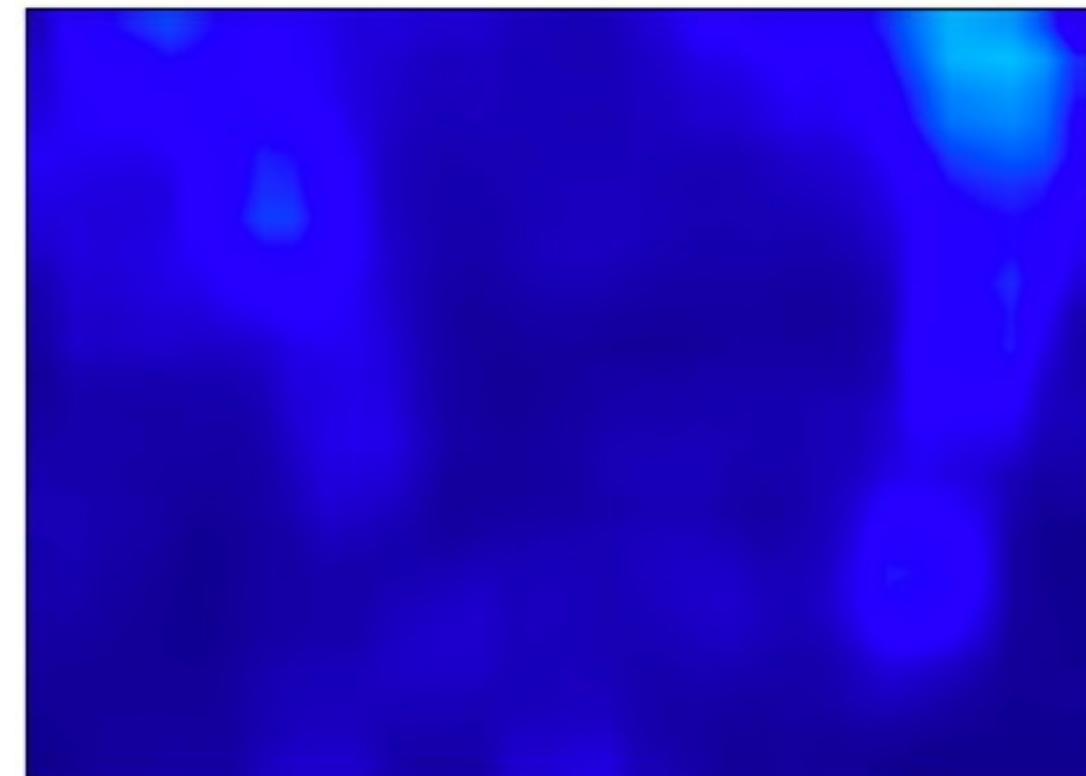
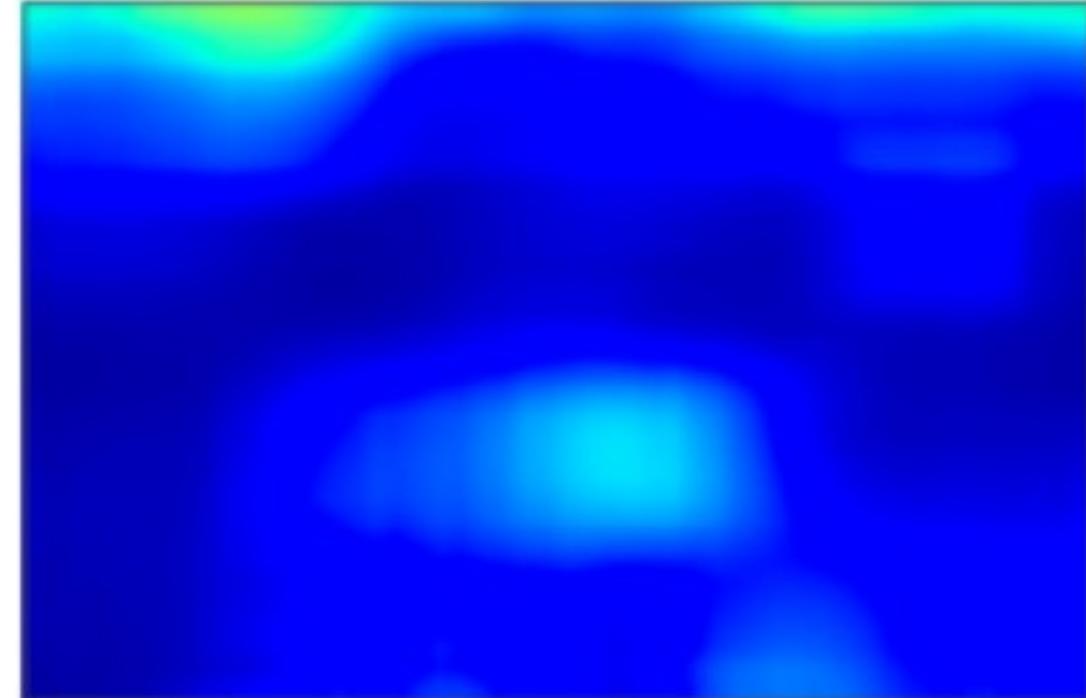
Image



Ground Truth



Consistency Map



Thank you!

<https://minyoungg.github.io/selfconsistency>