

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

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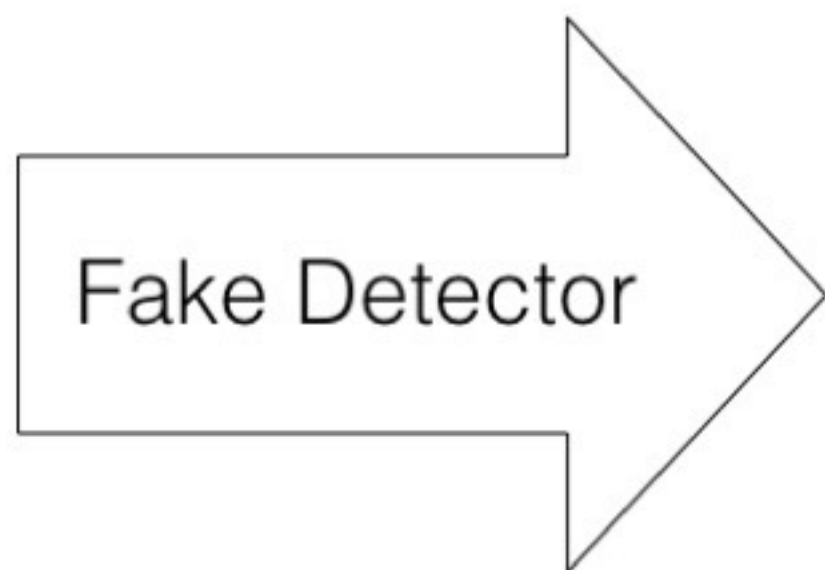
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Andrew Owens<sup>1</sup>

Alexei A. Efros<sup>1</sup>

UC Berkeley<sup>1</sup>

Carnegie Mellon University<sup>2</sup>



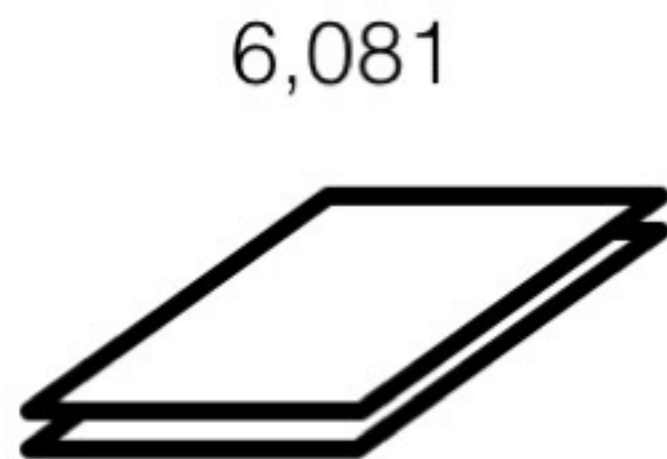
BERKELEY ARTIFICIAL INTELLIGENCE RESEARCH



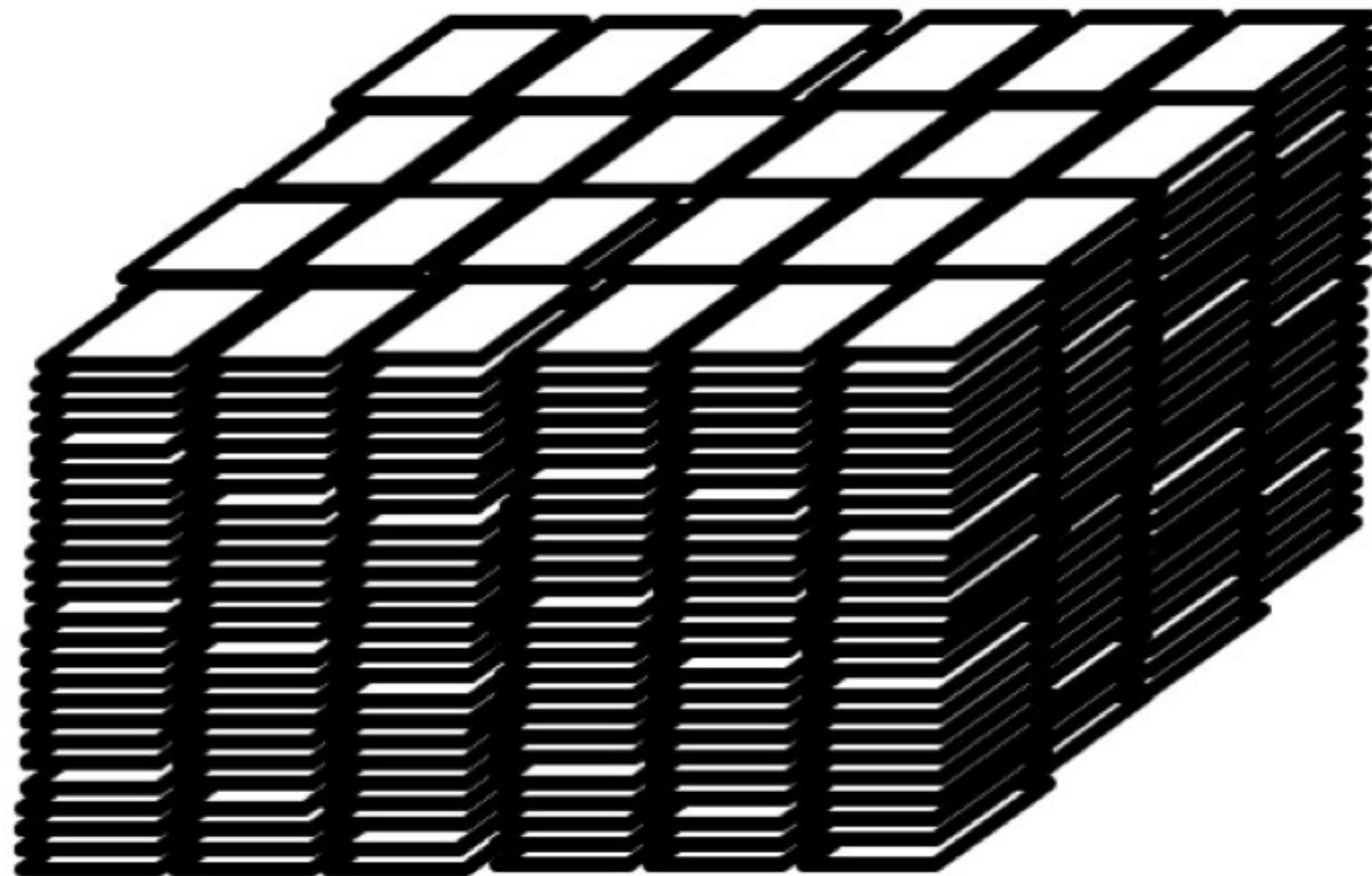


# Self-Consistency

Billions!



Labeled Splice  
Datasets

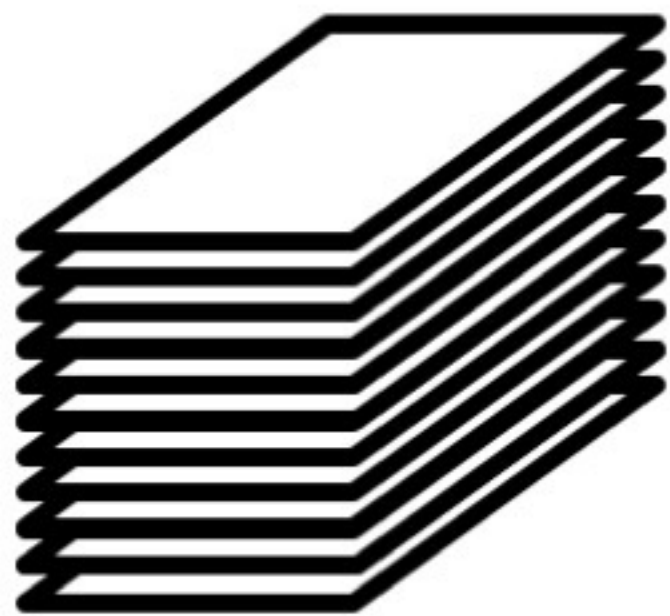


Natural Images

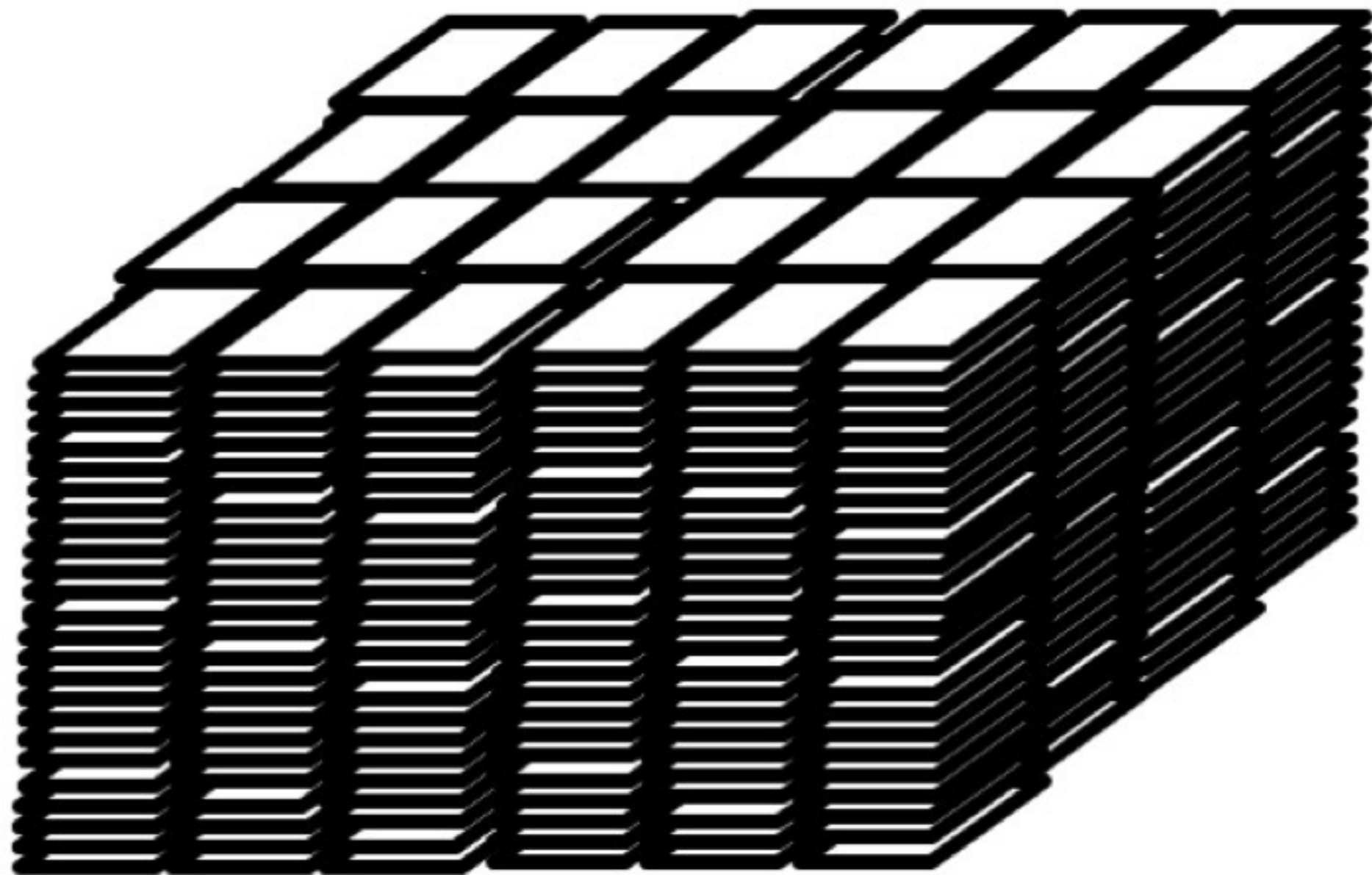
# Self-Consistency

Billions!

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



Labeled Splice  
Datasets



Natural Images

# Self-Consistency

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

Billions!

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

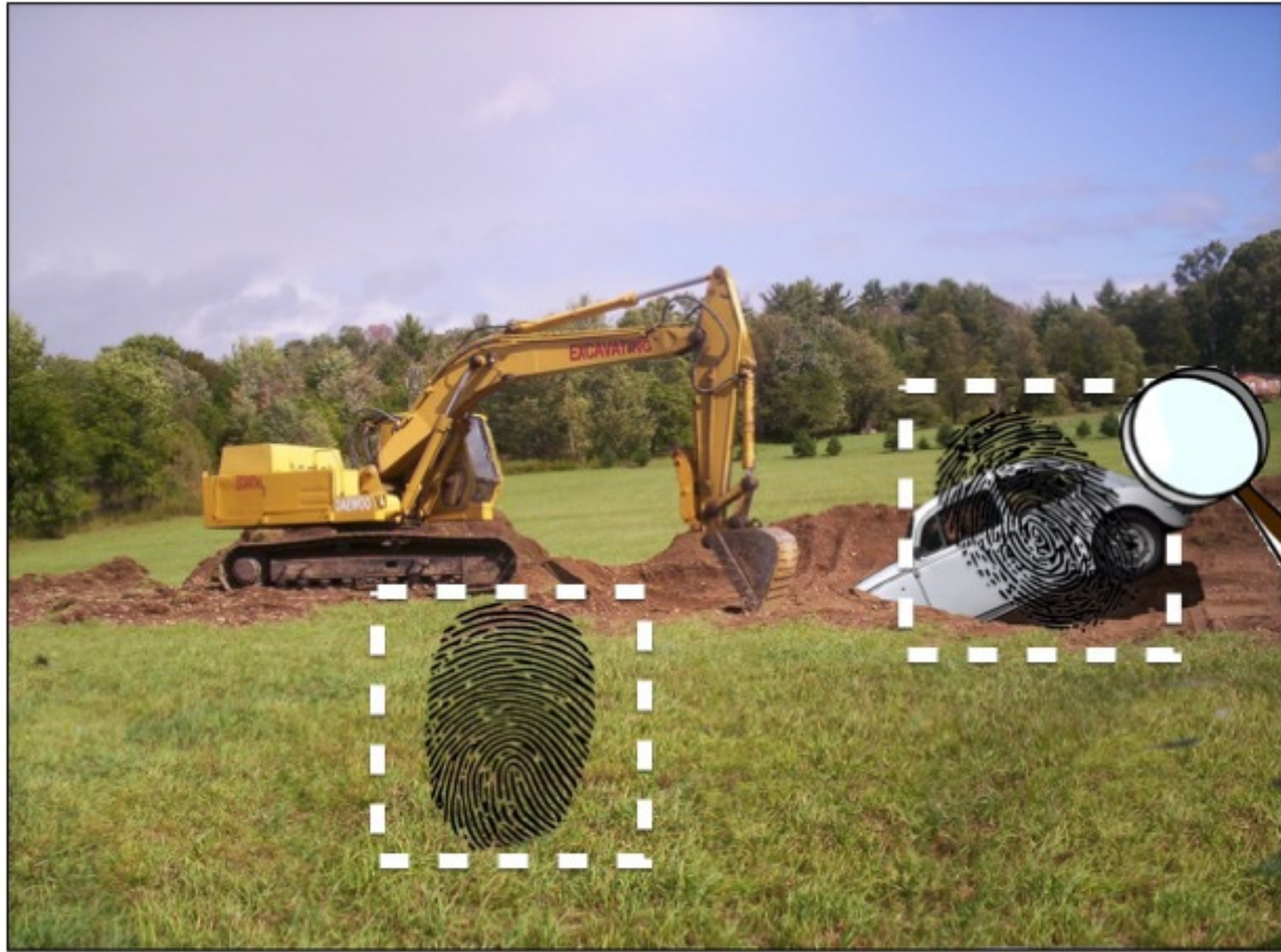
Labeled Splice  
Datasets

Natural Images



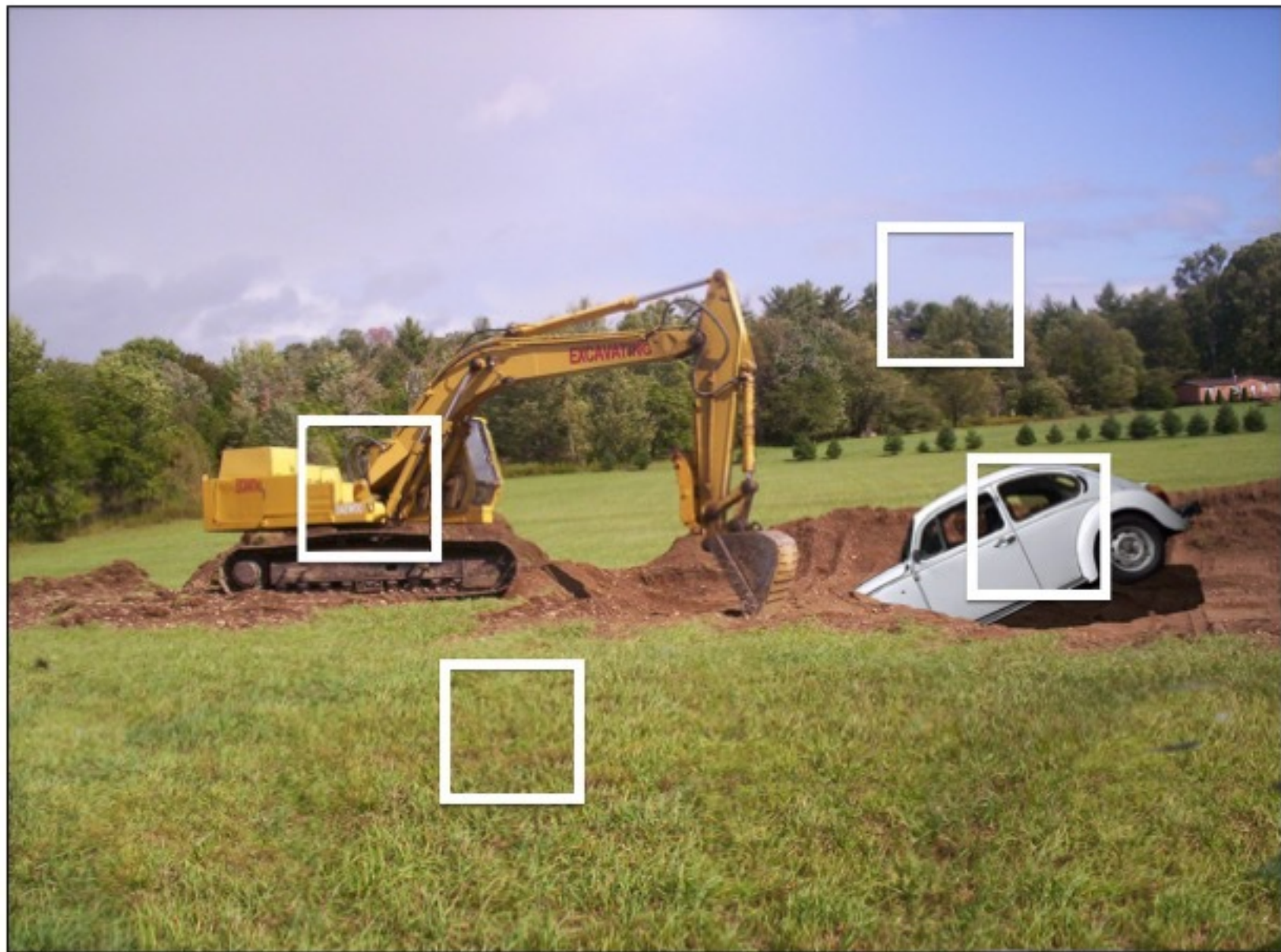
# Self-Consistency











Inconsistent



Consistent

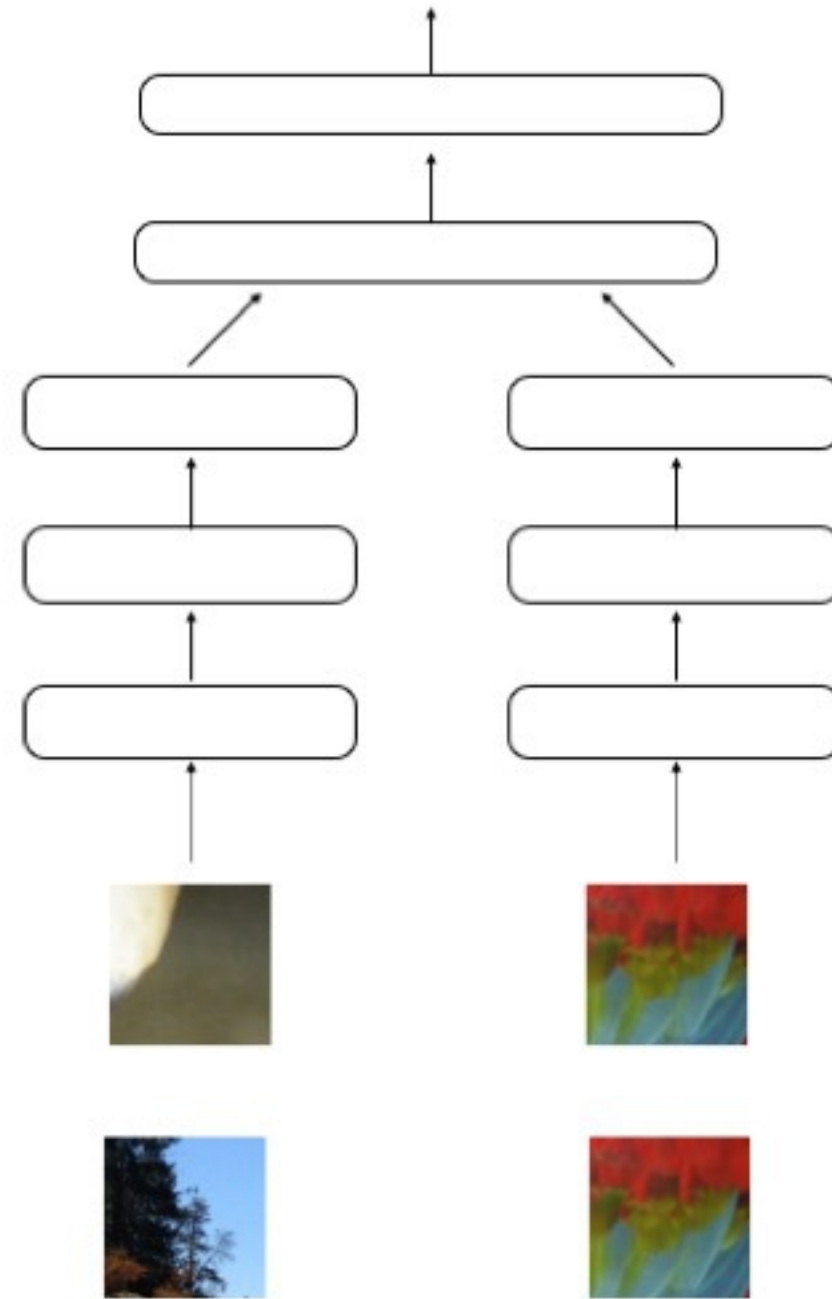
# Learning self-consistency



Consistent

Inconsistent

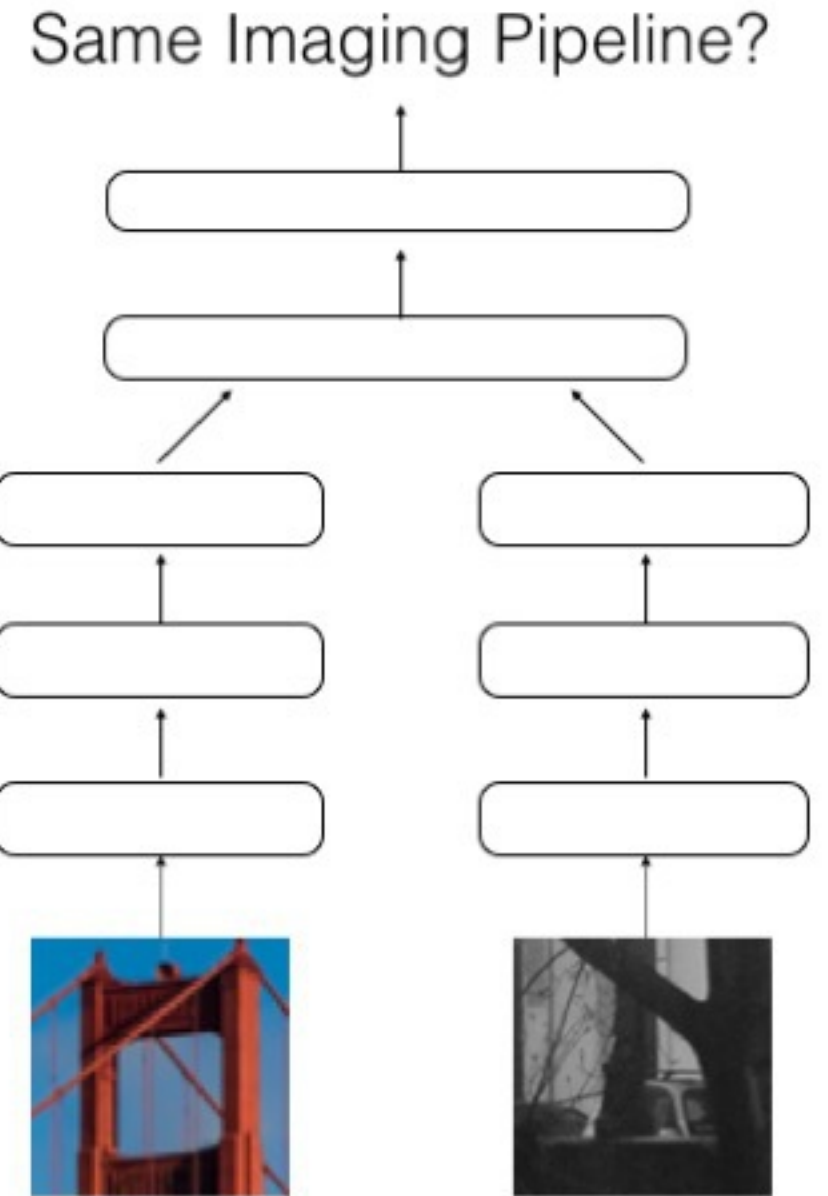
Same Imaging Pipeline?



# Self-consistency not enough



**Negative examples  
are too easy!**



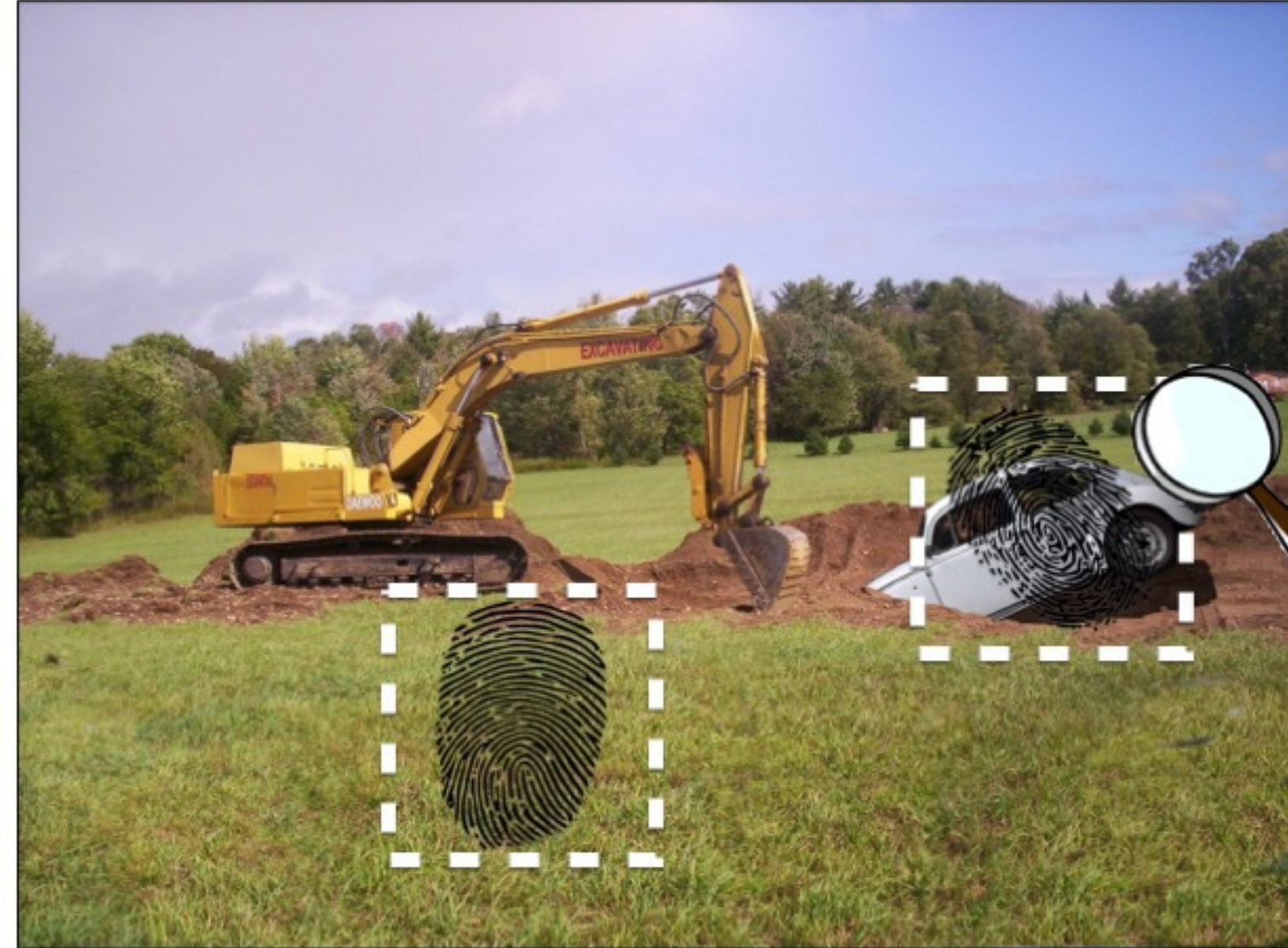
## EXIF metadata

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

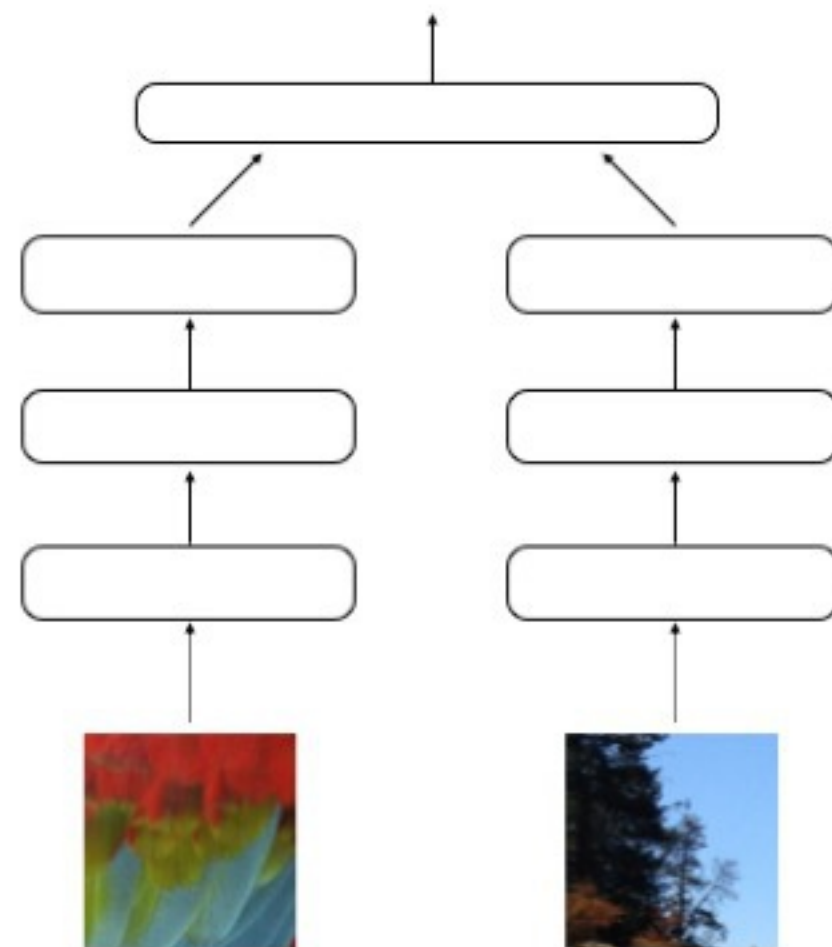


CameraMake: NIKON CORPORATION  
CameraModel: NIKON D3200  
ColorSpace: Uncalibrated  
ExifImageLength: 2472  
ExifImageWidth: 3091  
Flash: Flash did not fire  
FocalLength: 90  
WhiteBalance: Auto  
ExposureTime: 1/100  
...

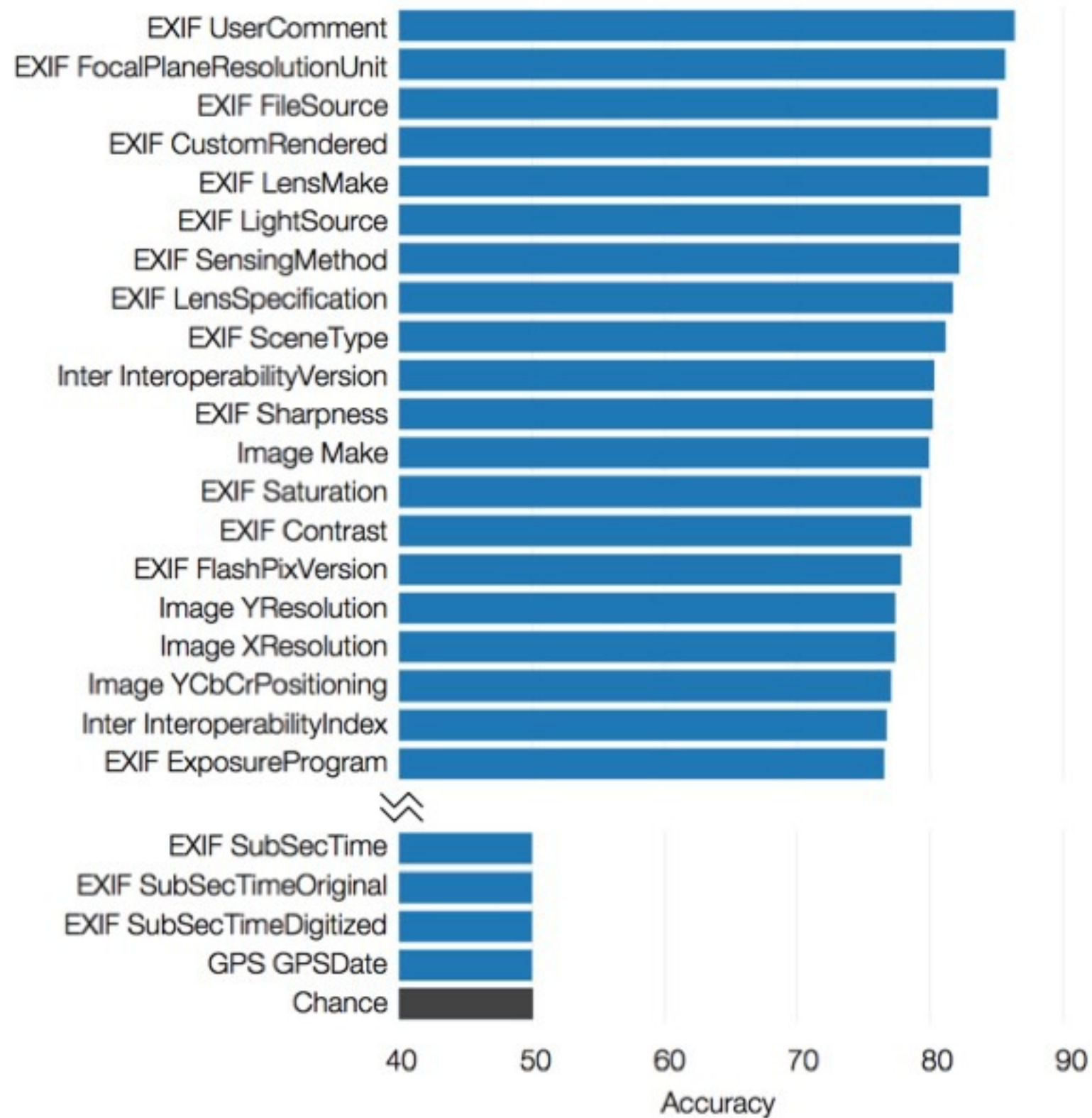


CameraMake: Apple  
CameraModel: iPhone 4s  
ColorSpace: sRGB  
ExifImageLength: 2448  
ExifImageWidth: 3264  
Flash: Flash did not fire  
FocalLength: 107/2  
WhiteBalance: Auto  
ExposureTime: 1/2208  
...

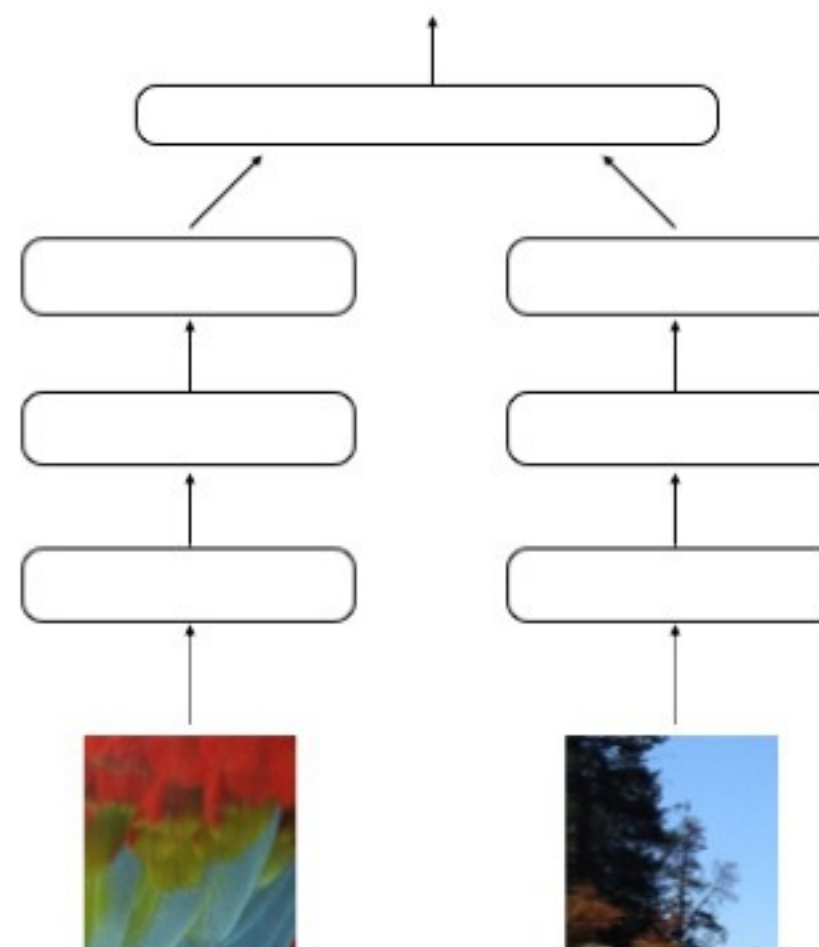
Same Camera Model? Different  
Same WhiteBalance? Same  
Same vs. different EXIF attributes



# Learning self-consistency



Same vs. different EXIF attributes

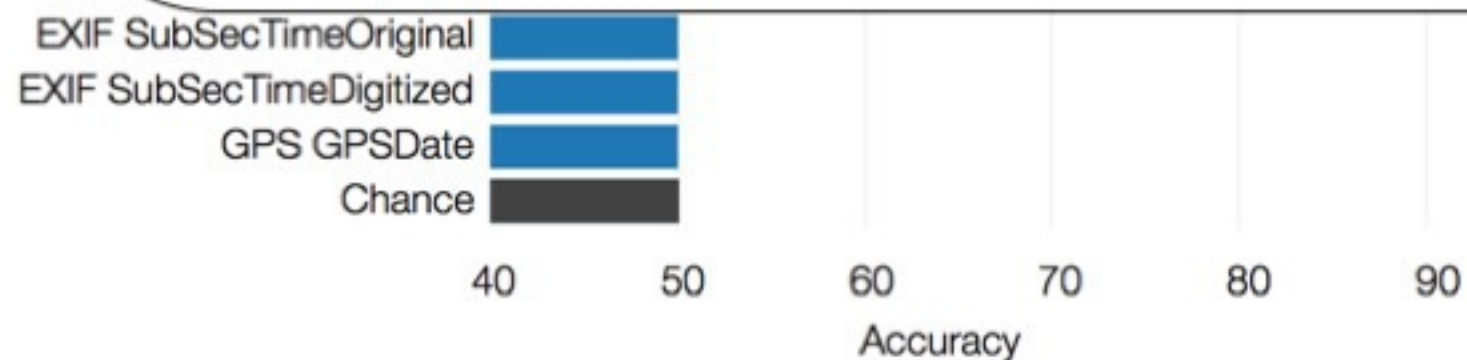


# Learning self-consistency



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

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



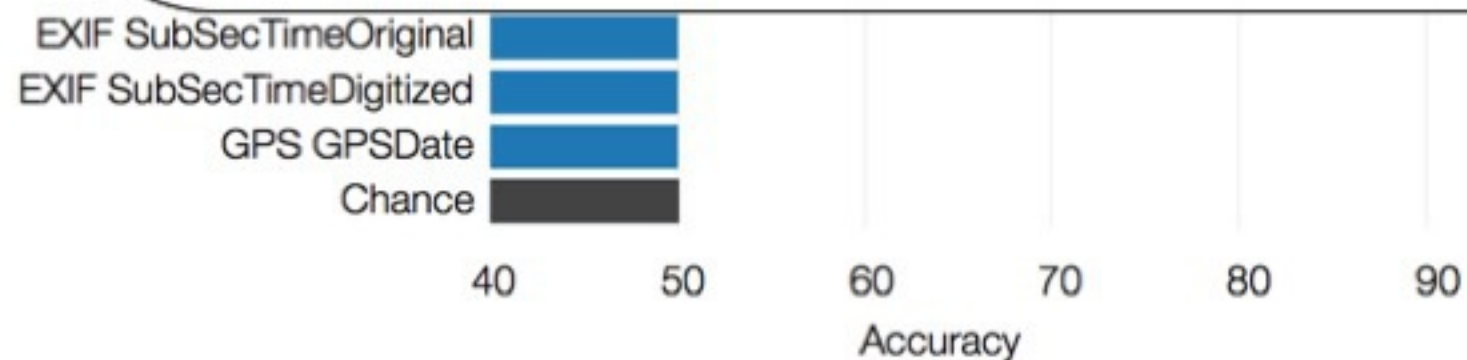


# Learning self-consistency



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

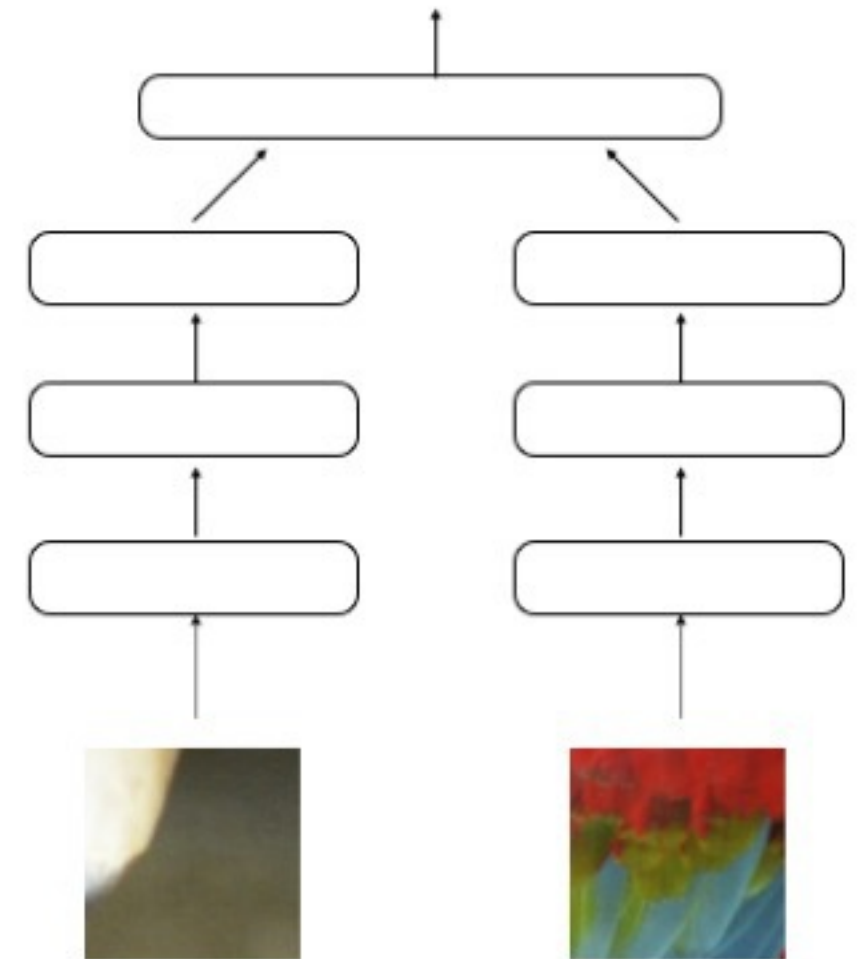
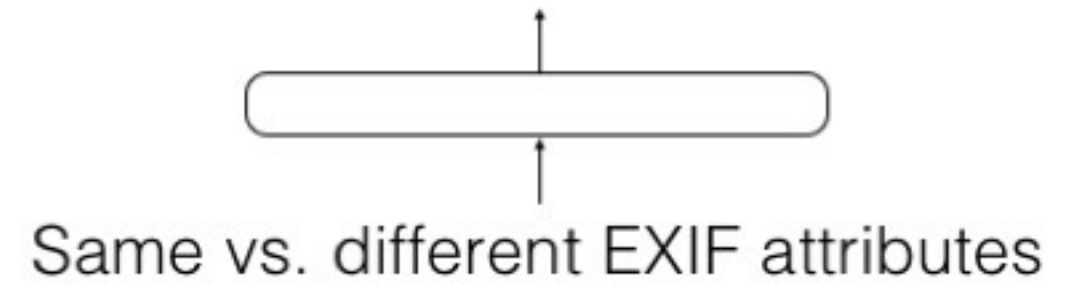
- “Apple”
- “Nokia”
- “Canon”
- “Sony”
- ...



# Learning self-consistency

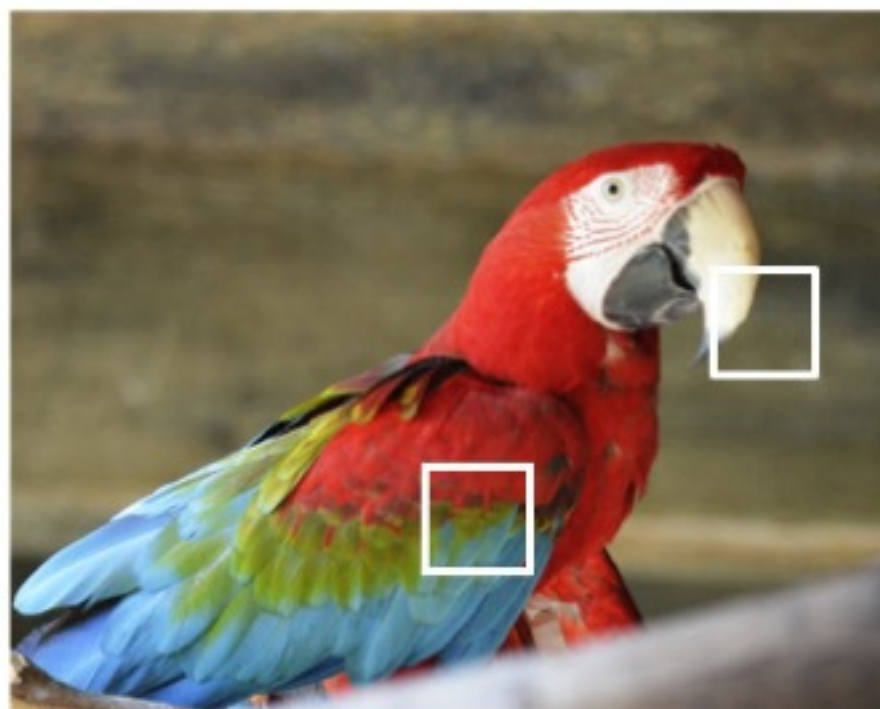


Same Imaging Pipeline?



# Other forms of self-consistency

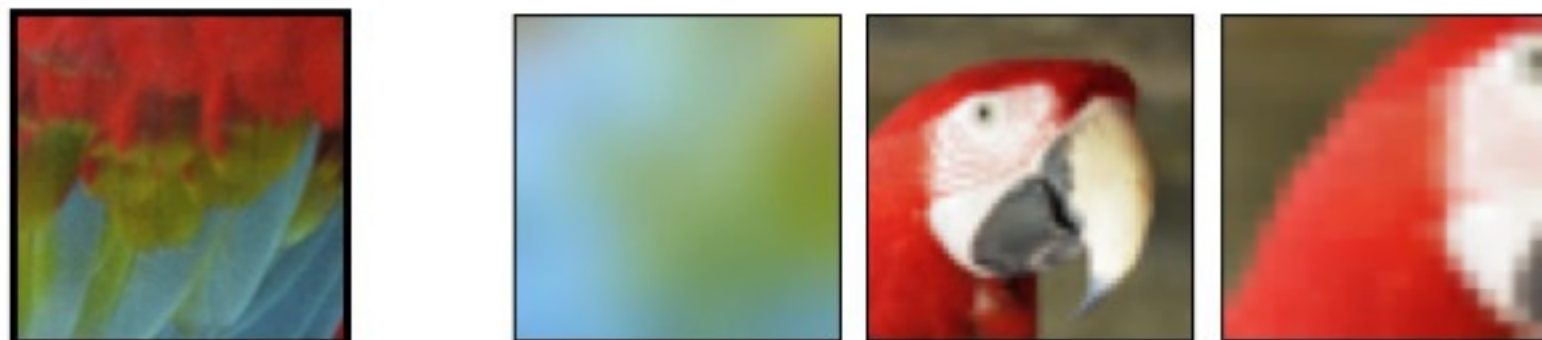
## Image Consistency



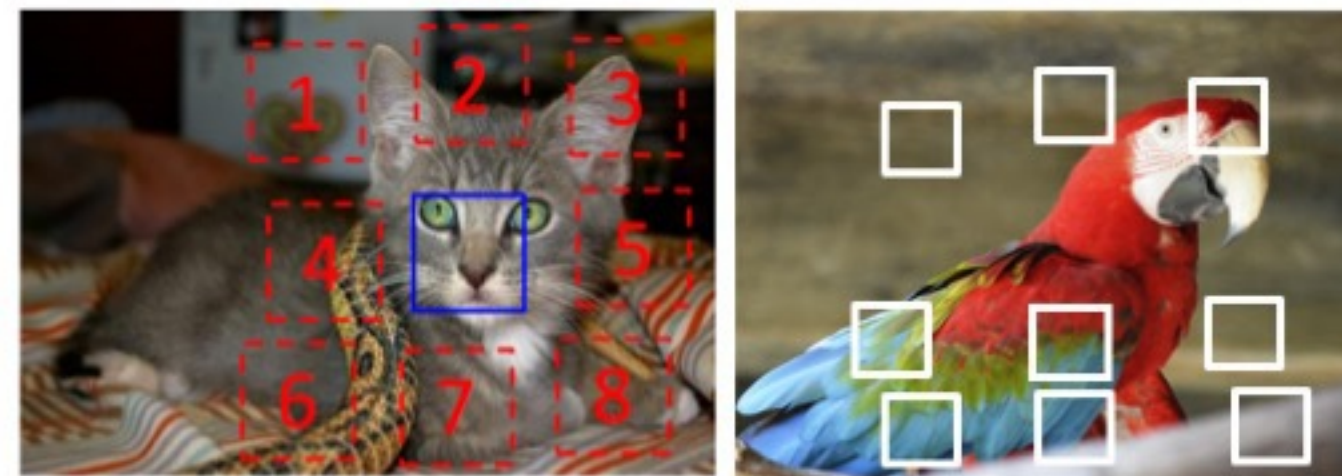
## EXIF Consistency



## Post-processing Consistency



## Spatial Consistency



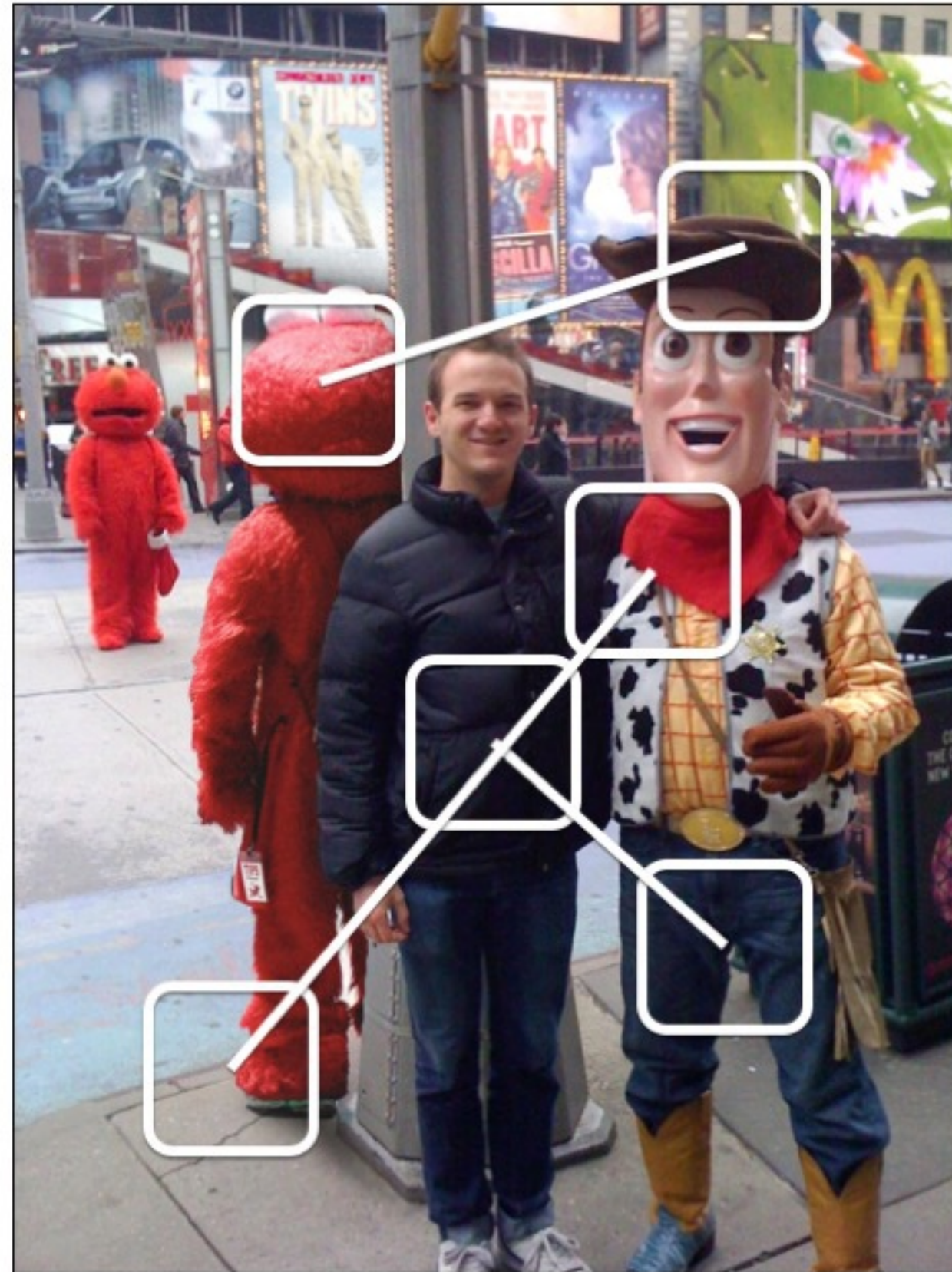
# Unmanipulated Image



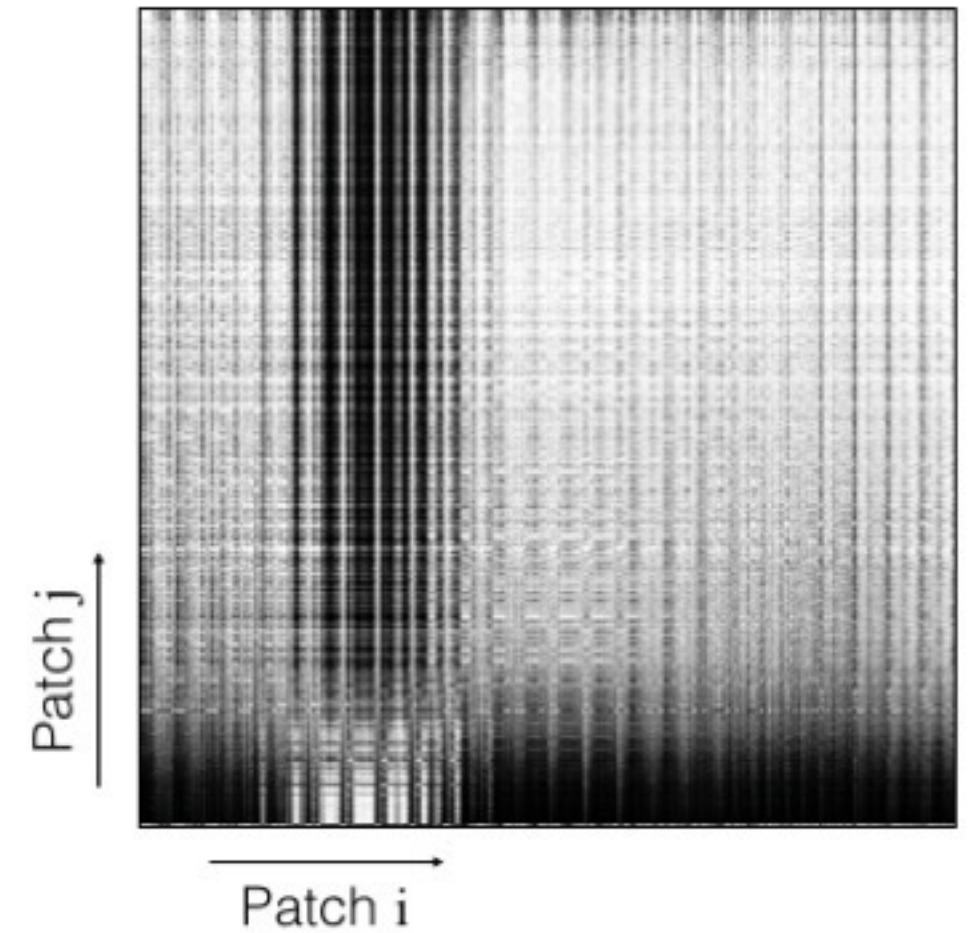
# Manipulated Image



# Manipulated Image



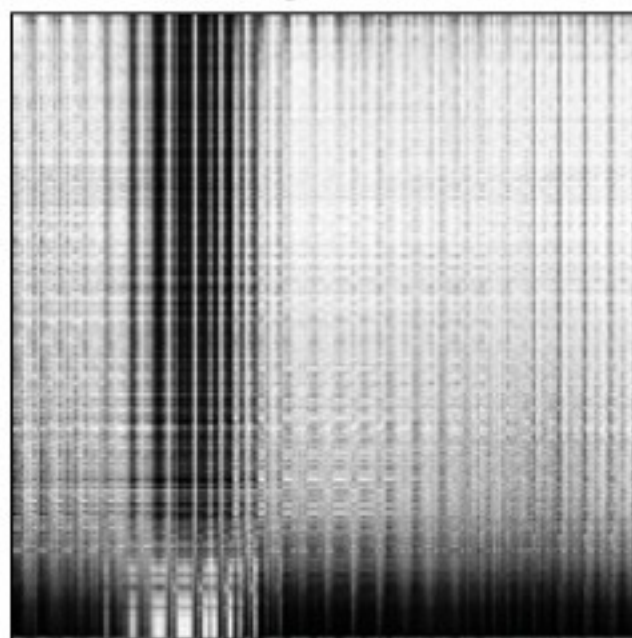
# Affinity Matrix



Manipulated Image



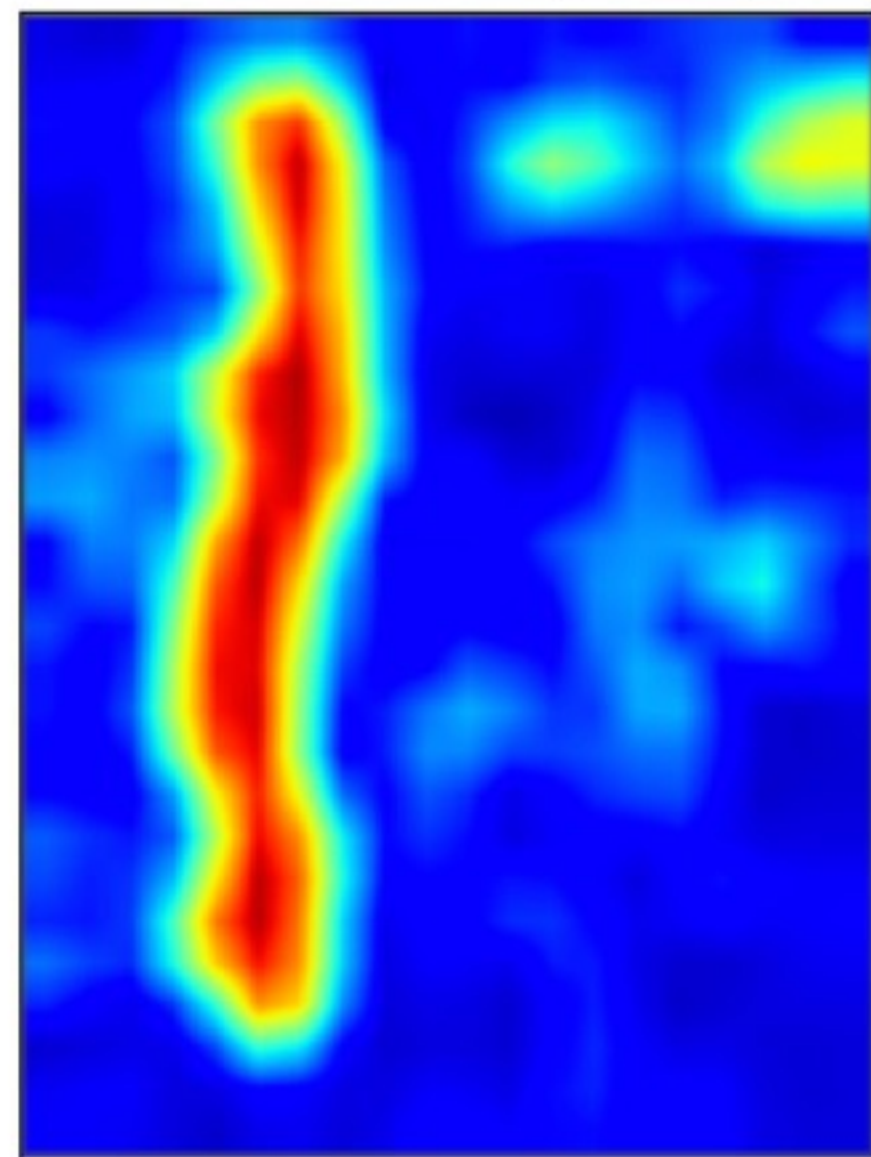
Affinity Matrix



Mean Shift



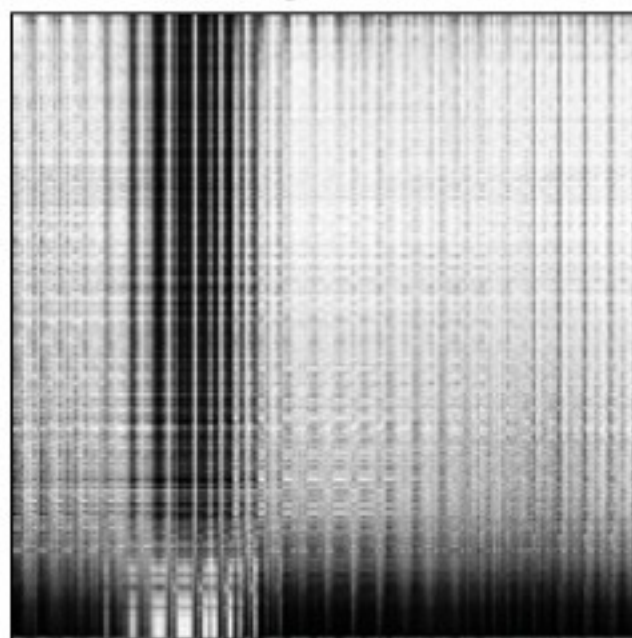
Consistency Map



Manipulated Image



Affinity Matrix



Normalized Cuts



Manipulated Region





Input Image



# Manipulated Region

Our detection

Ground Truth



Input Image

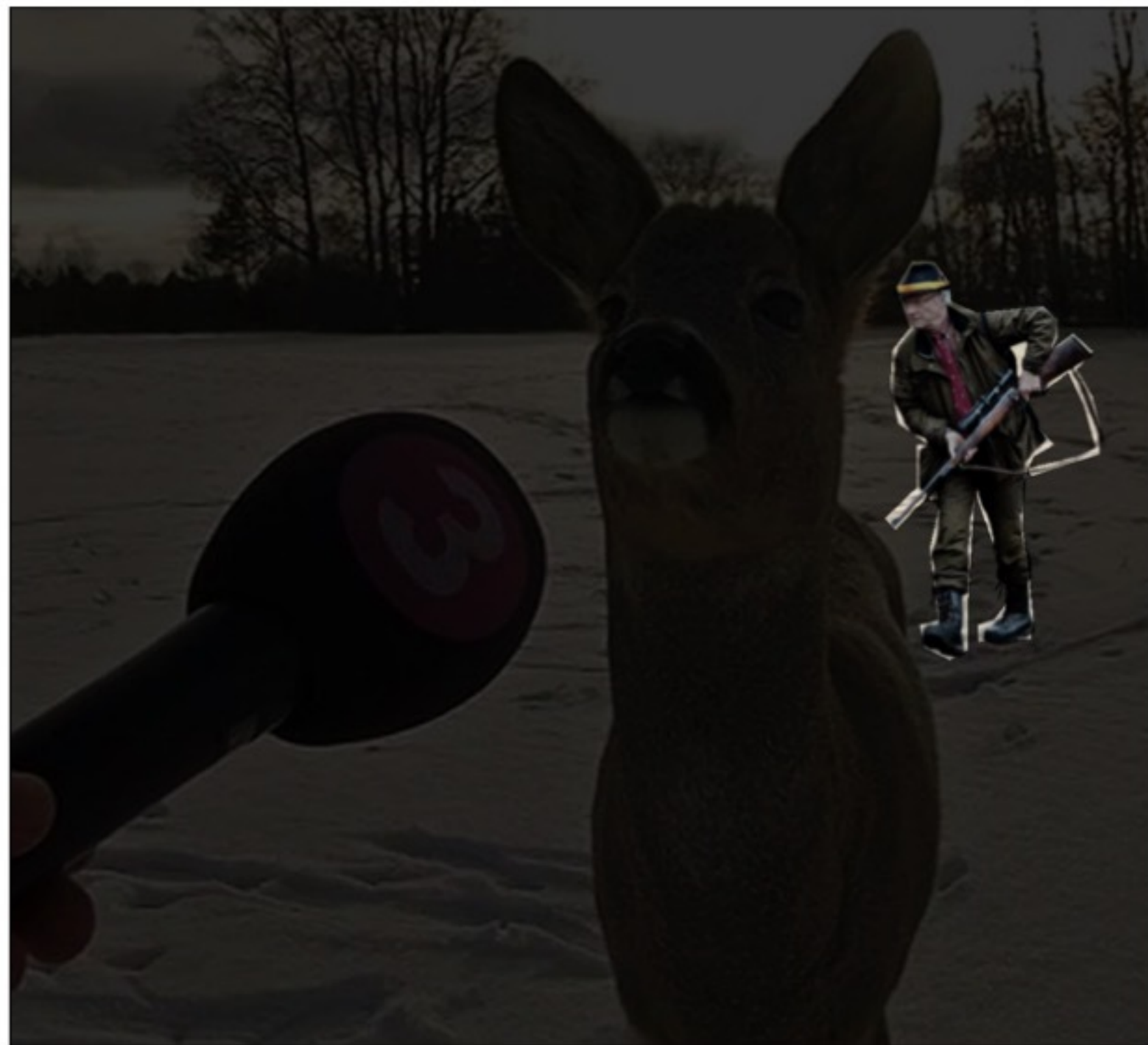


# Manipulated Region

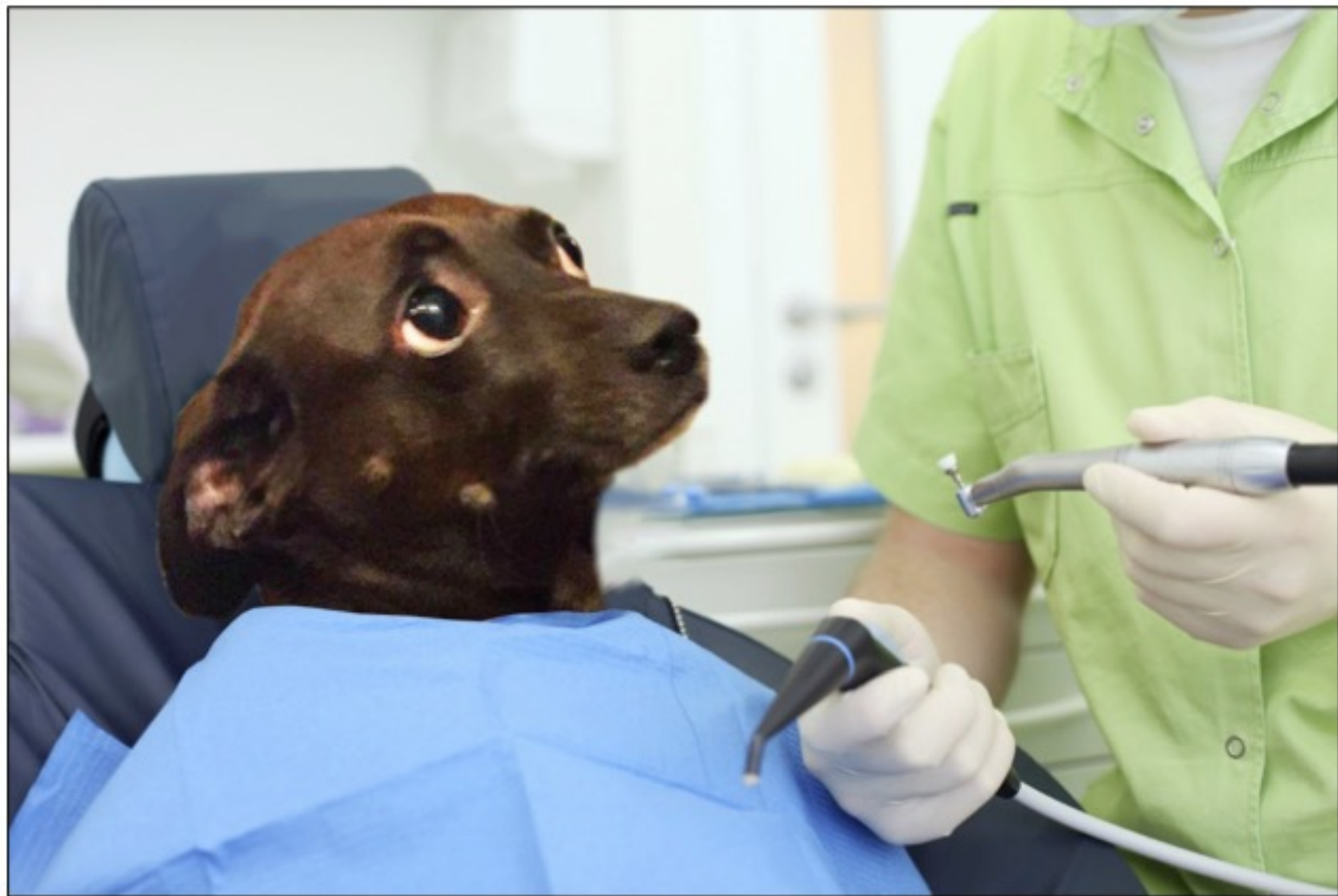
Our detection



Ground Truth



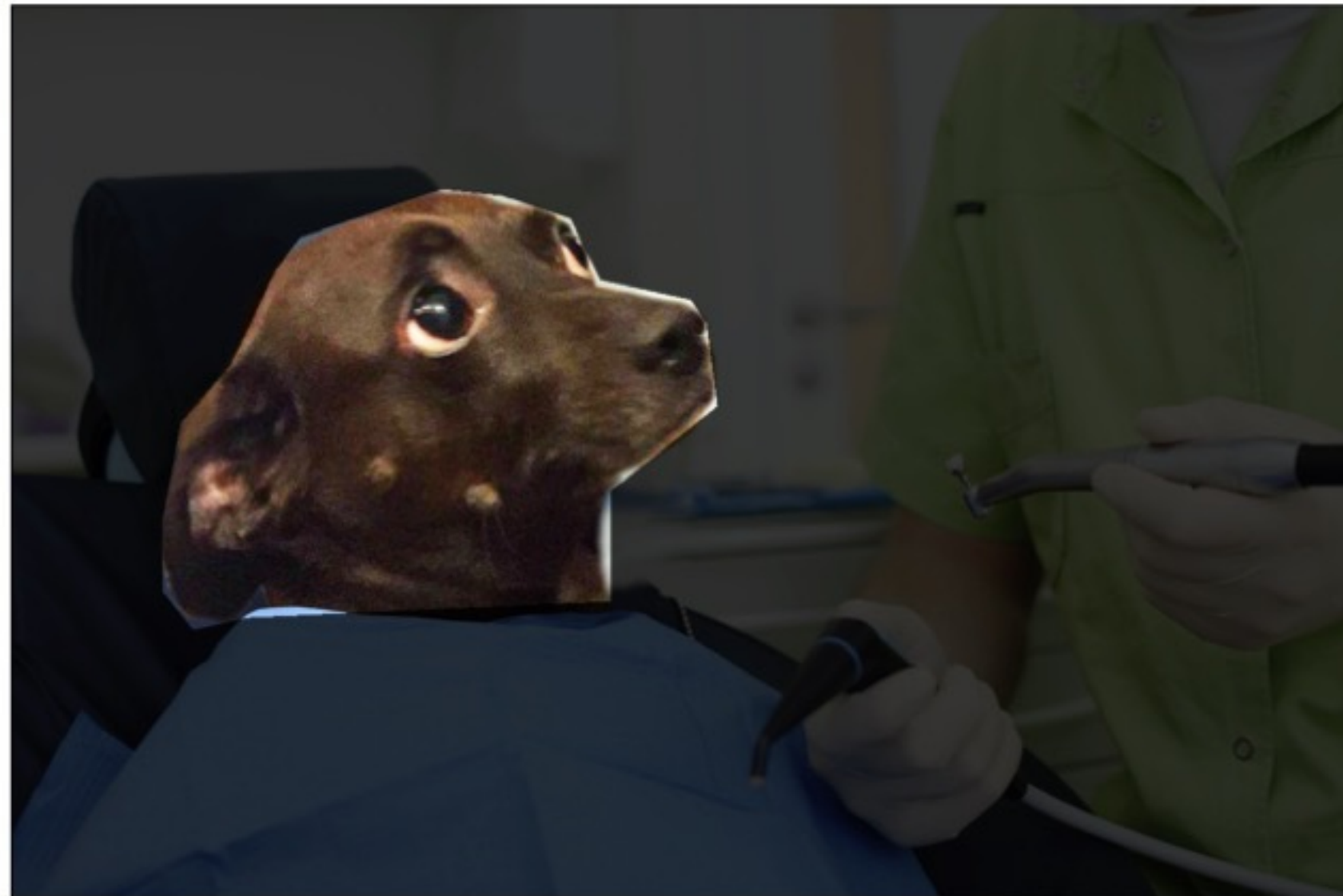
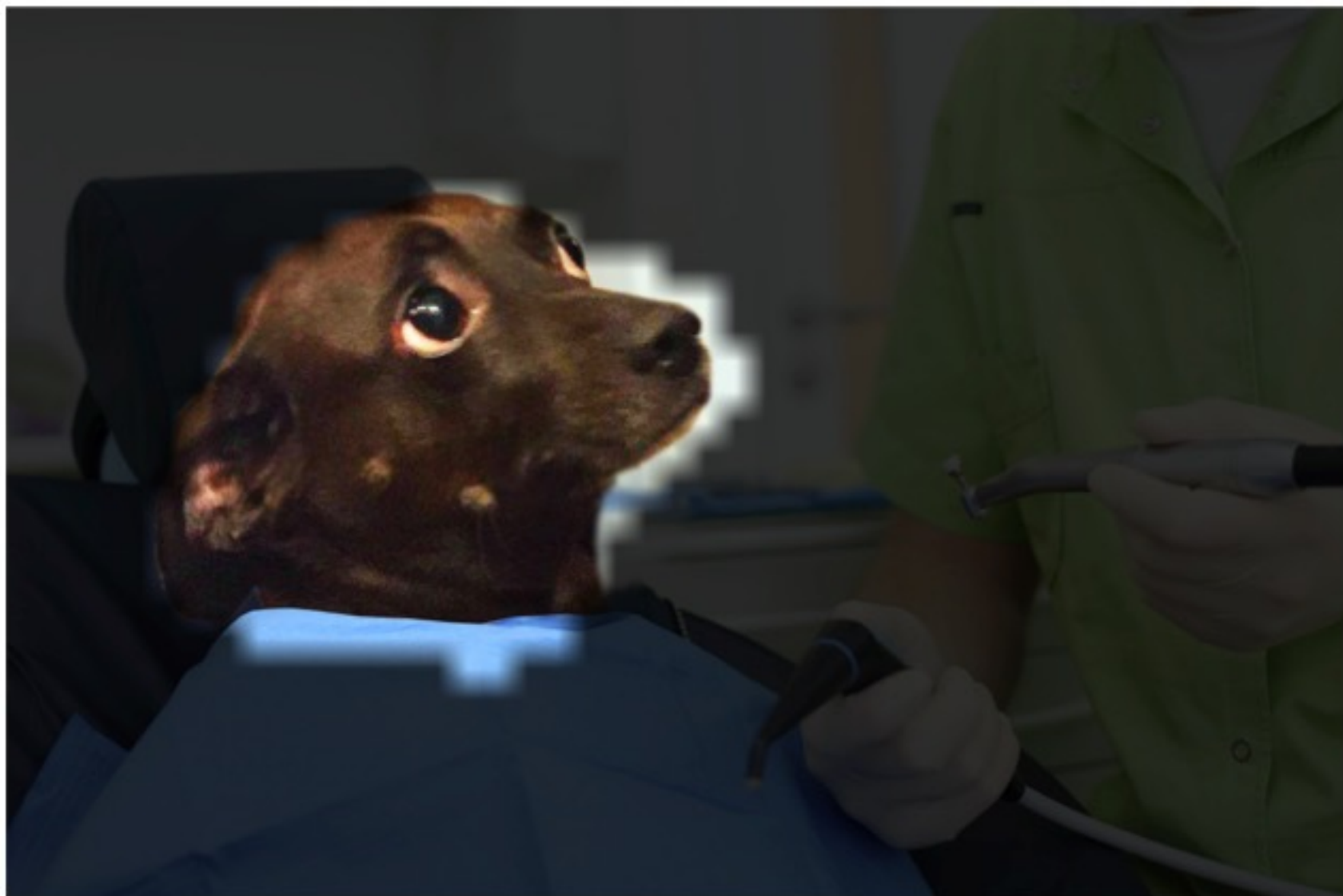
Input Image



# Manipulated Region

Our detection

Ground Truth



Input Image



# Manipulated Region

Our detection



Ground Truth





Input Image



# Manipulated Region

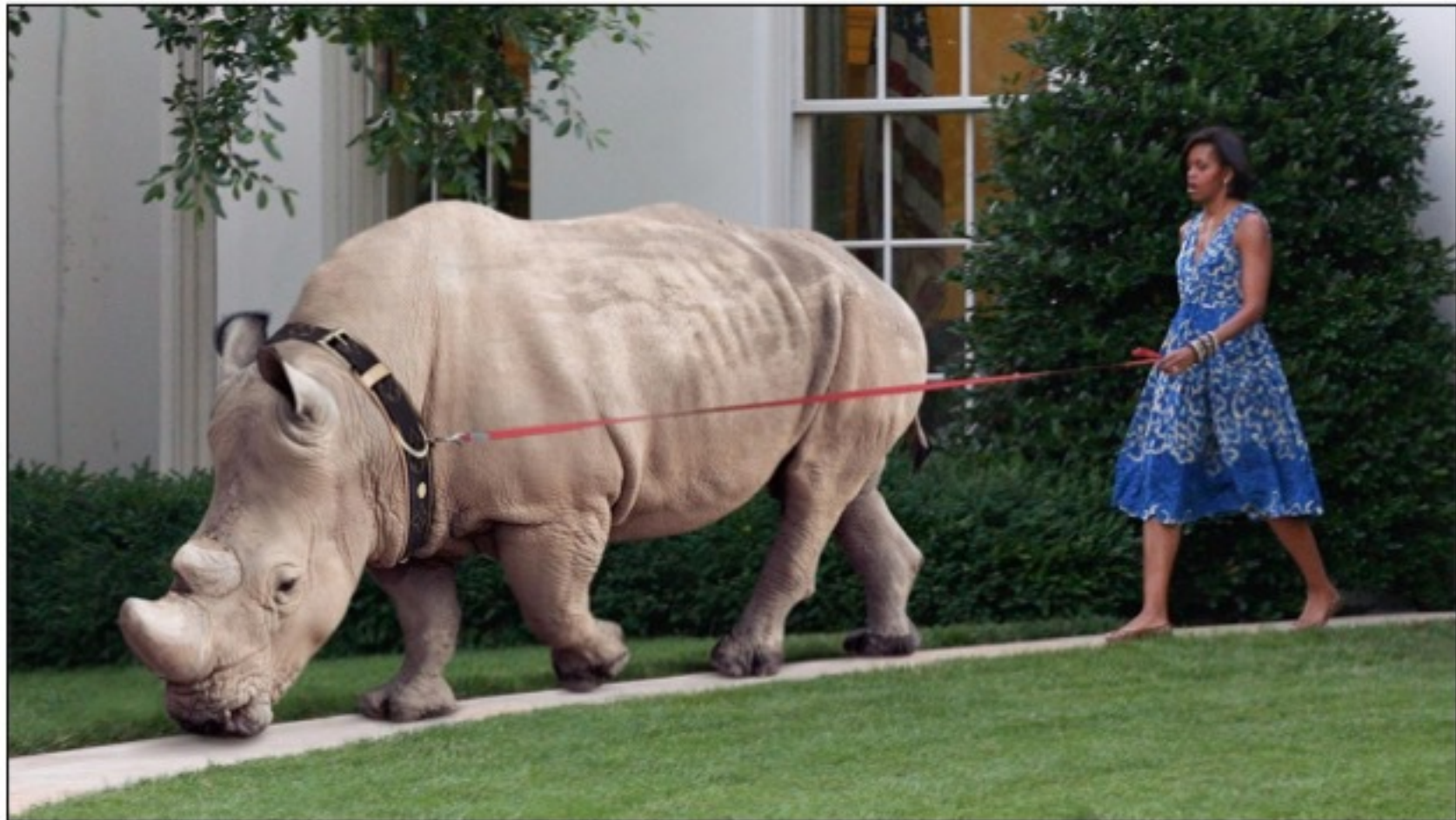
Our detection



Ground Truth



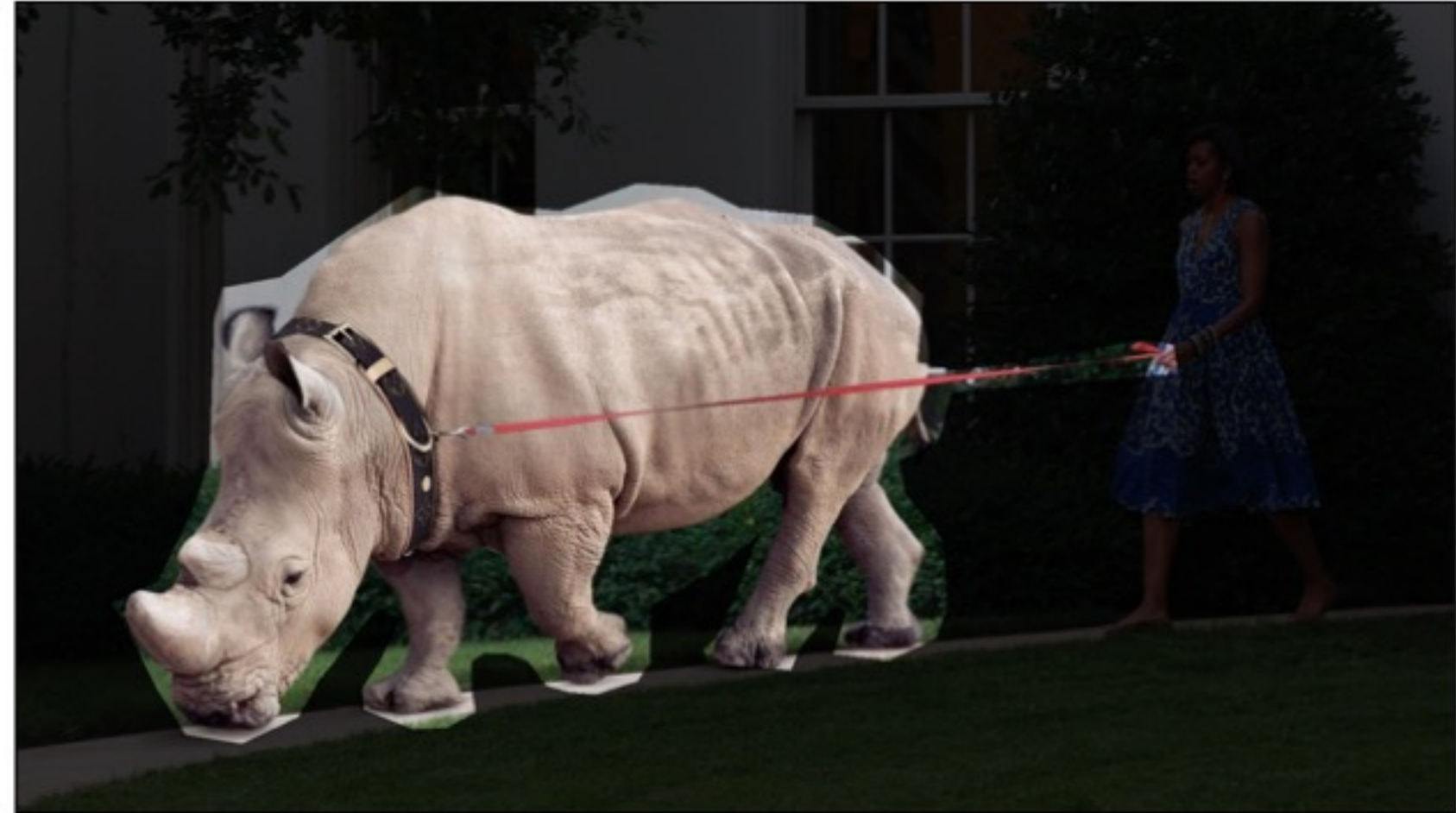
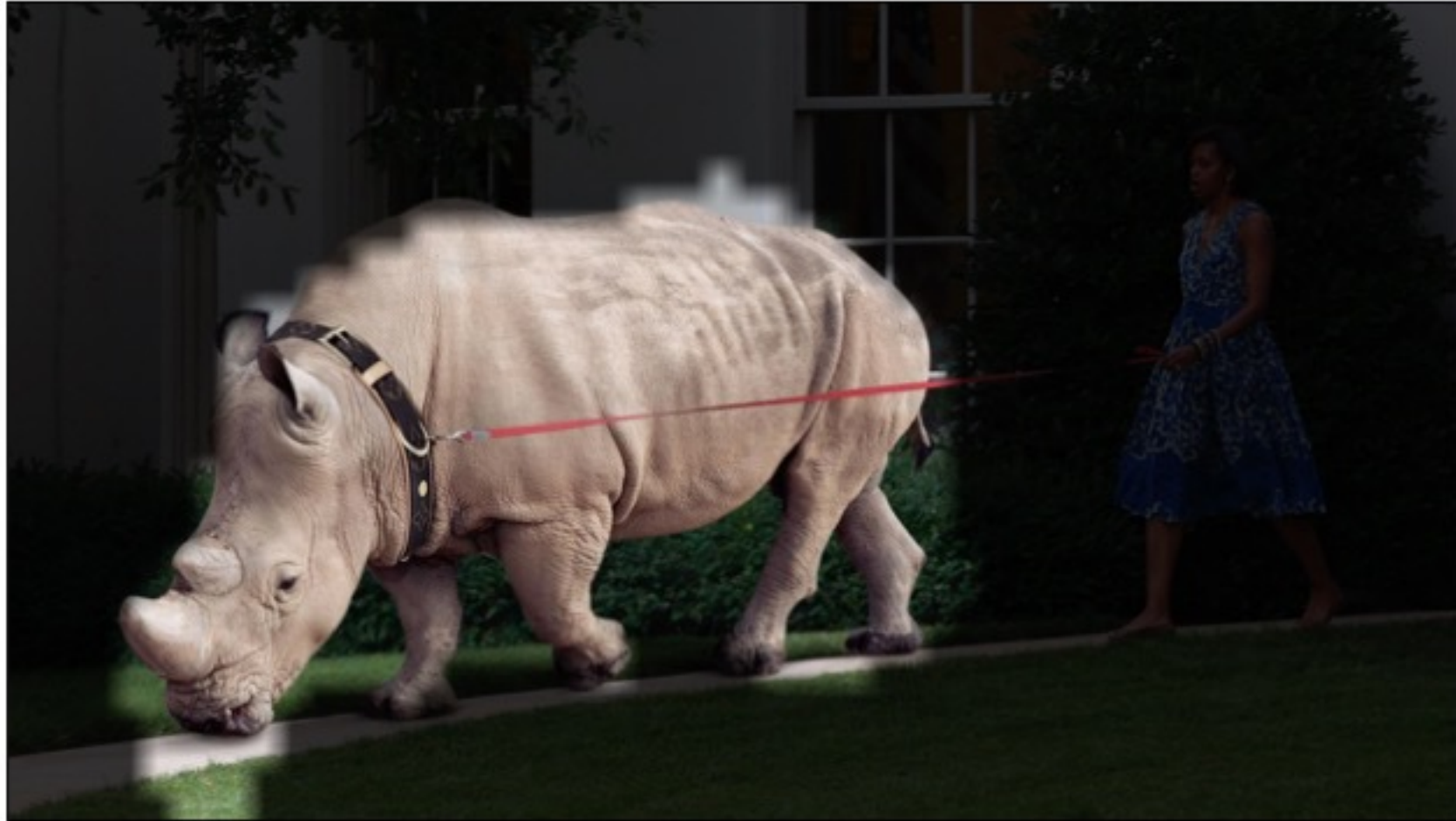
Input Image



# Manipulated Region

Our detection

Ground Truth



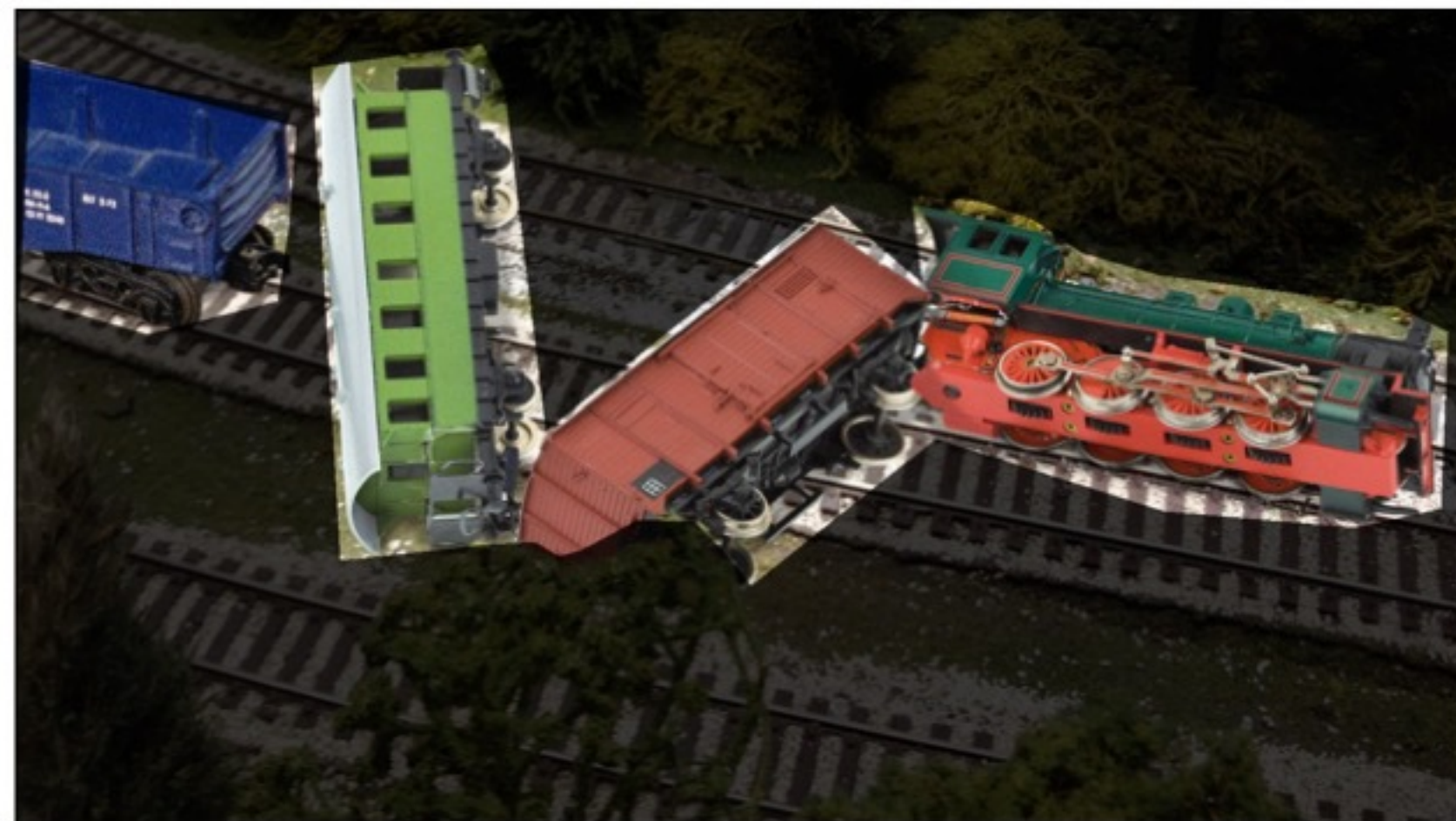
Input Image



# Manipulated Region

Our detection

Ground Truth



## Input Image



# Manipulated Region

Our detection



Ground Truth





# Original Images



## Ground Truth



# Manipulated Region

Our detection



Ground Truth

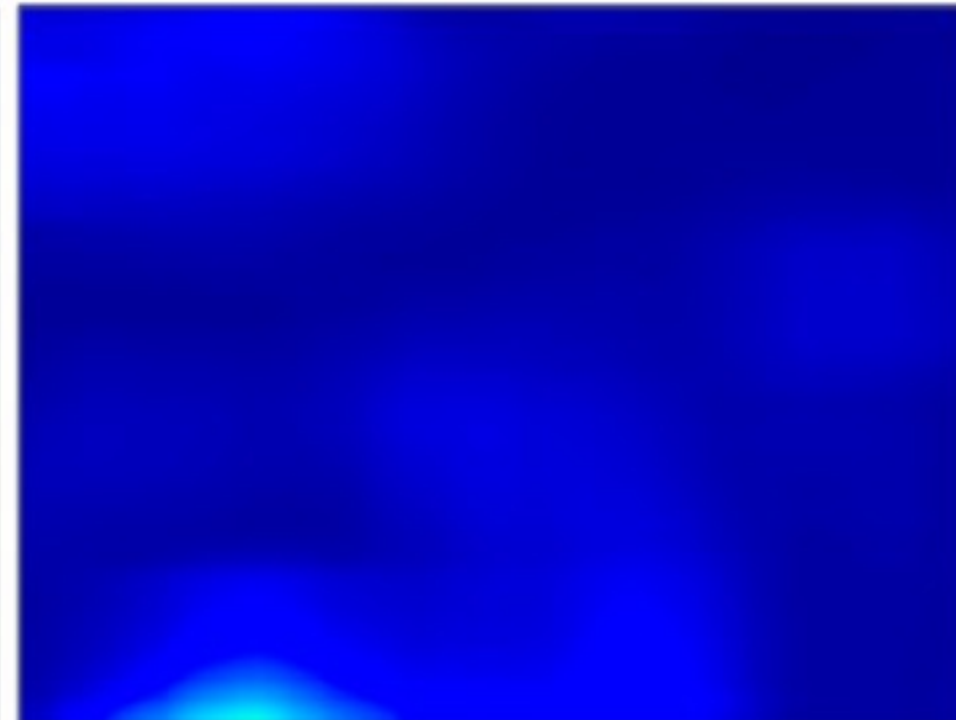
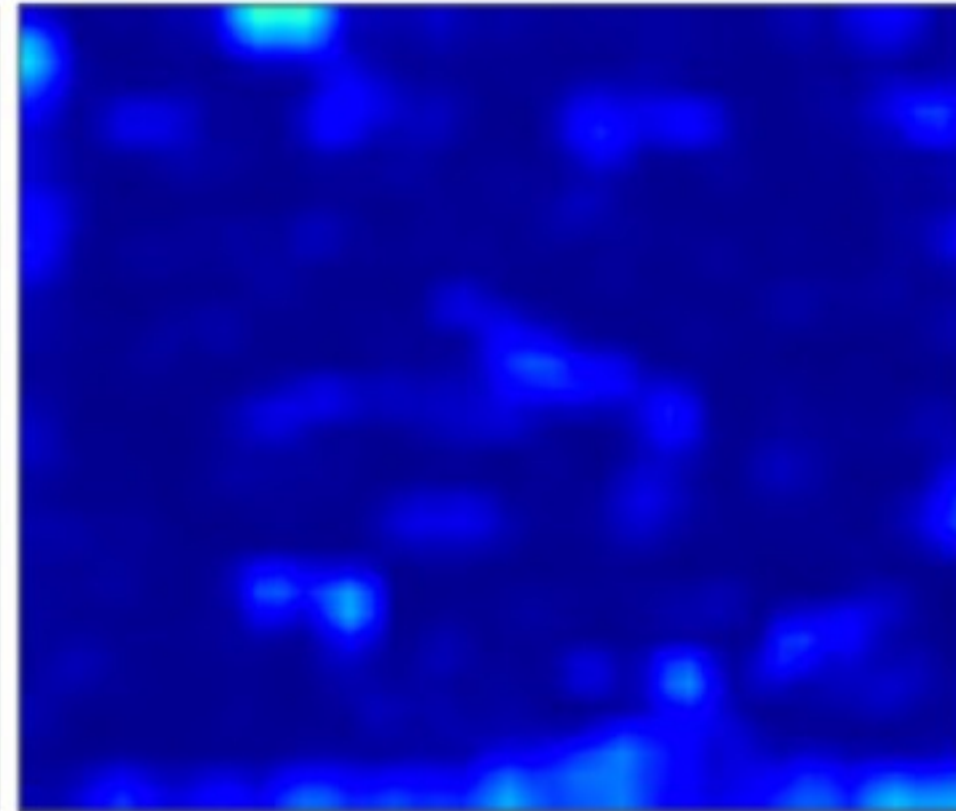


# Authentic Images

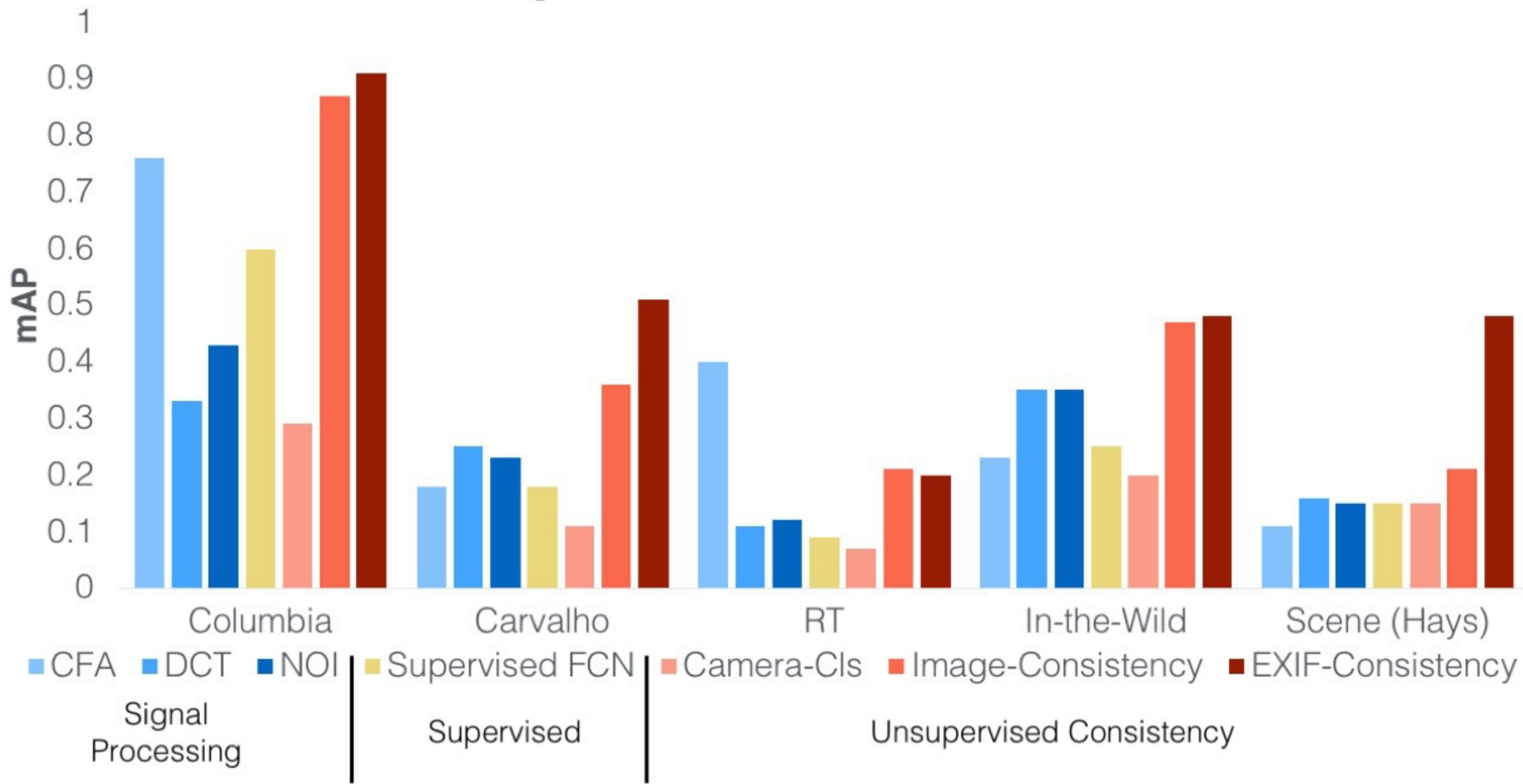
Image

Consistency Map

STATE OF HAWAII		CERTIFICATE OF LIVE BIRTH		DEPARTMENT OF HEALTH	
1. Child's First Name (Type or print)		2. Middle Name		3. Last Name	
BARACK		HUSSEIN		OBAMA, II	
4. Sex	5. This Birth	6. Place or Town, City, County, State	7. Month	8. Day	9. Year
Male	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Honolulu	August	6	1961
10. Name of Hospital or Institution (If not in hospital or institution, give street address)			11. Is Place of Birth Inside City or Town Limits?		
Kapiolani Maternity & Gynecological Hospital			Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>		
12. Usual Residence of Mother (City, Town or Rural Location)			13. County and State or Foreign Country		
Honolulu			Honolulu, Hawaii		
14. Street Address			15. Is Residence Inside City or Town Limits?		
6085 Kalaniana'olaha Highway			Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>		
16. Mother's Mailing Address			17. Is Residence on a Farm or Plantation?		
			Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>		
8. Full Name of Father		9. Name of Father		10. Race of Father	
BARACK HUSSEIN OBAMA		AFRICAN		AFRICAN	
11. Age of Father		12. Kind of Education or Industry		13. Race of Mother	
25		Student		CAUCASIAN	
14. Full Name of Mother		15. Name of Mother		16. Race of Mother	
STANLEY ANN DUSTAK		ANN		CAUCASIAN	
17. Age of Mother		18. Type of Occupation (Outside Home During Pregnancy)		19. Has Ever Worked	
18		None		Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	
I certify that the above stated information is true and correct to the best of my knowledge.					
Signature of Registrar			Date		
<i>Stanley Ann Obama</i>			8-7-61		
I hereby certify that this child was born alive on the date and hour stated above.					
Signature of Nurse			Date		
<i>Harold A. Tomlin</i>			8-8-61		
18. Date Accepted by Local Registrar			19. Date Accepted by Registrar		
AUG - 8 1961			AUG - 8 1961		
20. Evidence for Deferral Filing or Abandonment					

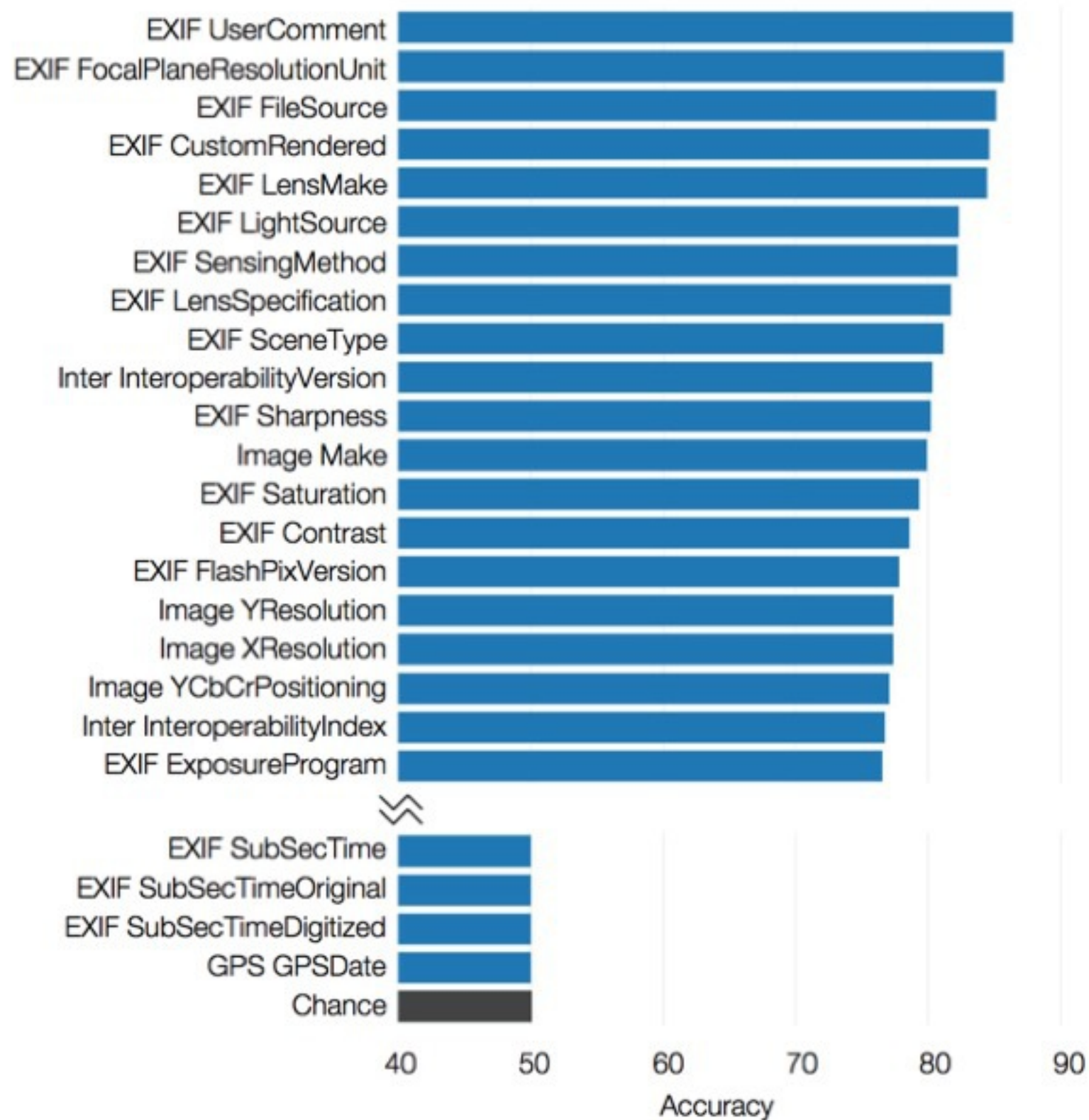


# Splice Localization

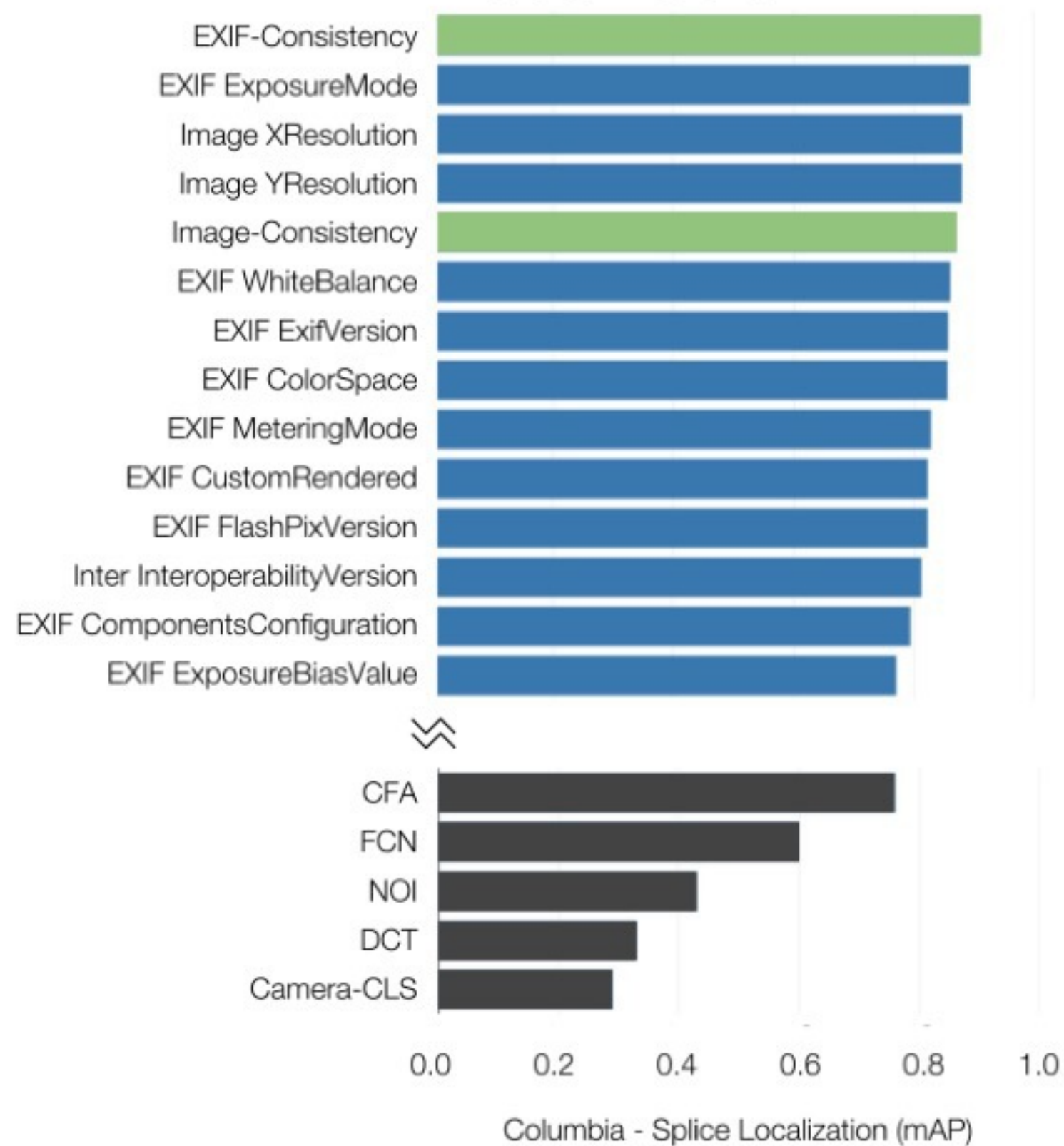


# EXIF Analysis

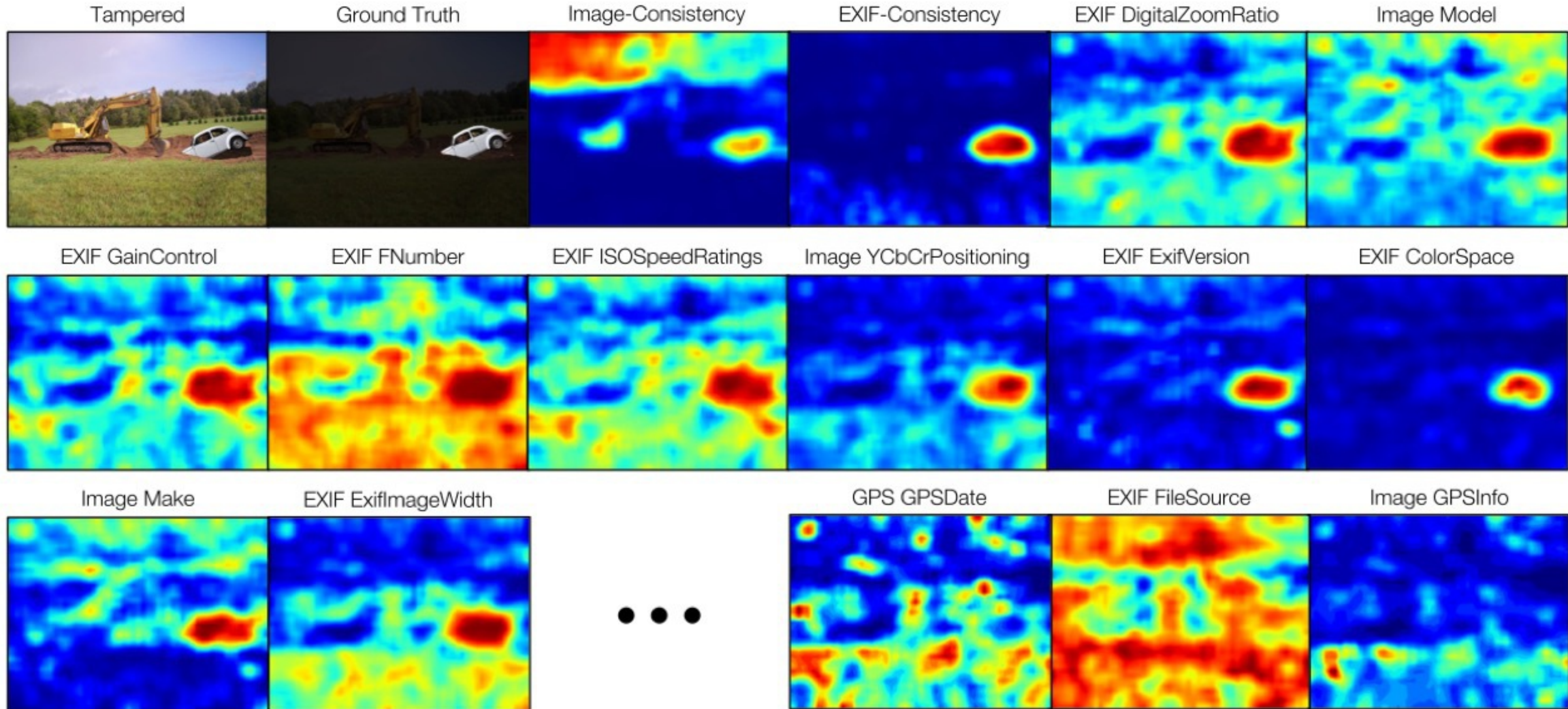
## Distinguishable EXIF



## Localizable EXIF



# EXIF Analysis

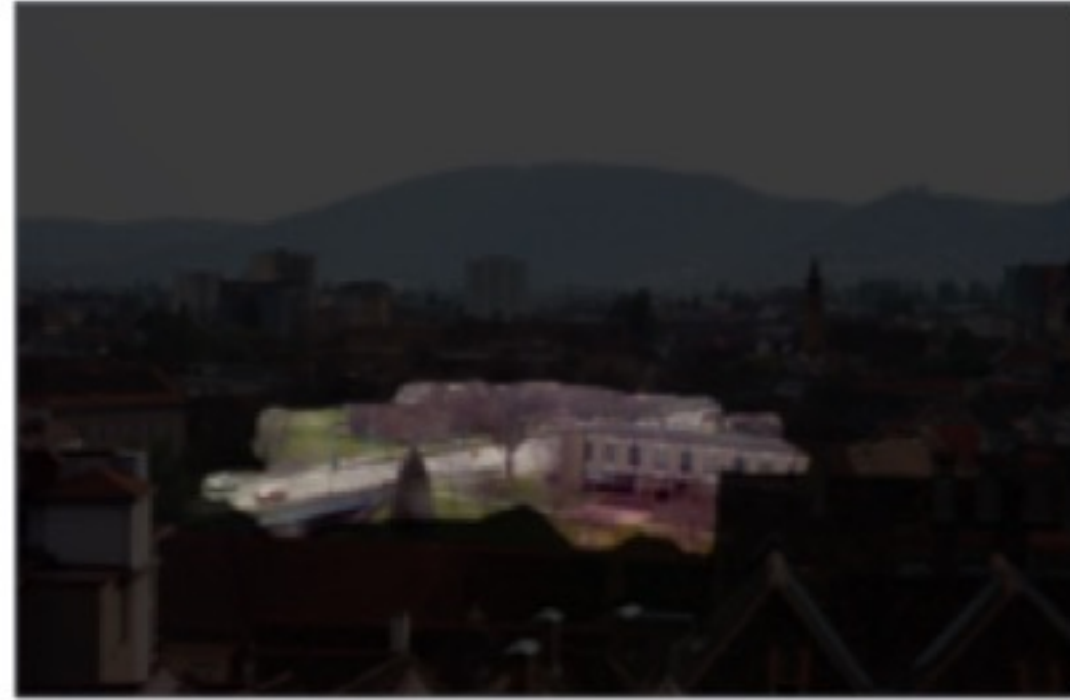


# Failures

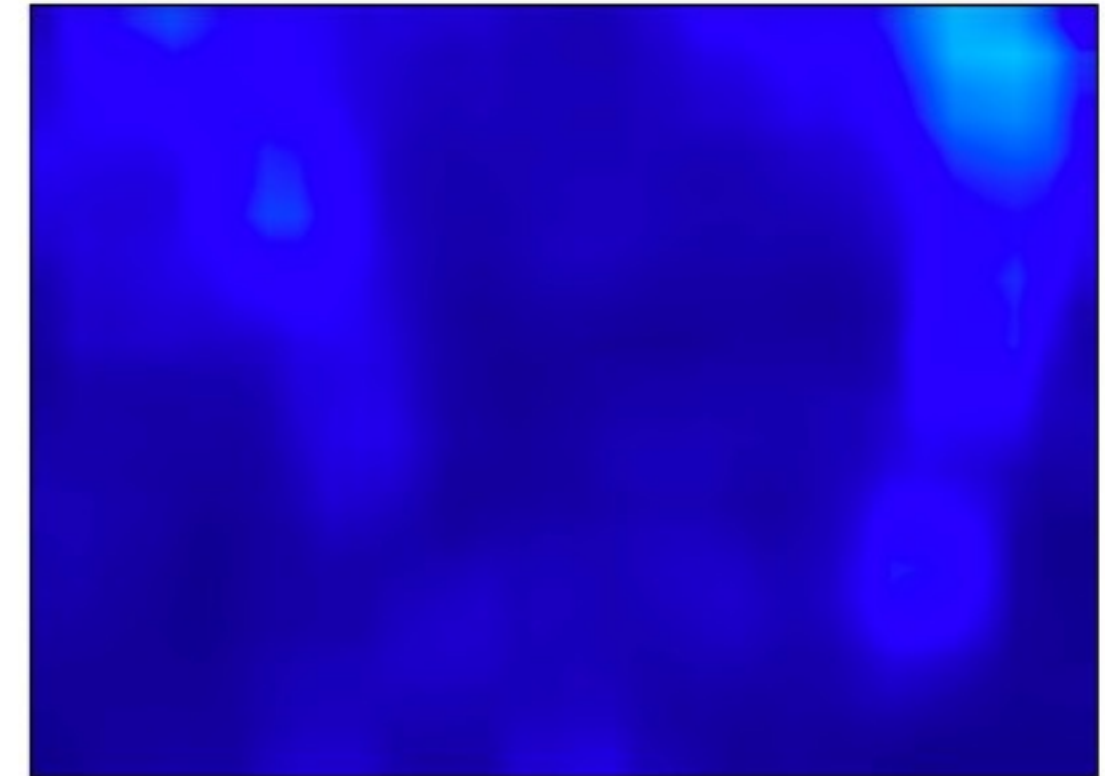
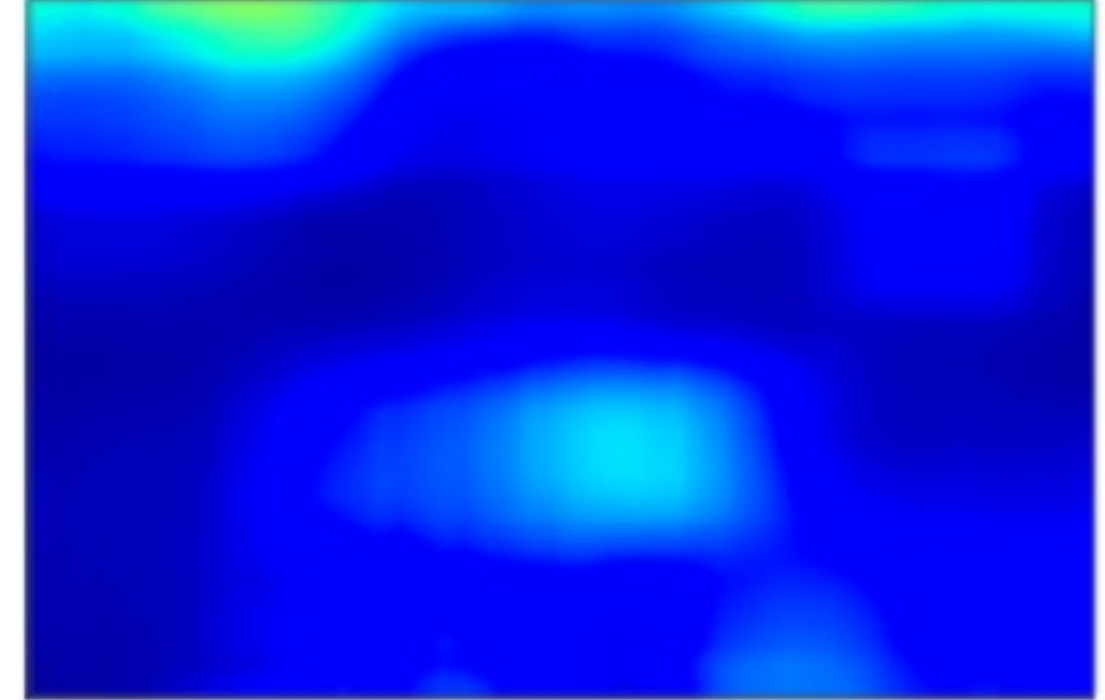
Image



Ground Truth



Consistency Map





Thank you!

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