Image Provenance Analysis for Disinformation Detection

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Part 1: Provenance Analysis

Telling the Story of Composite Images

The Problem

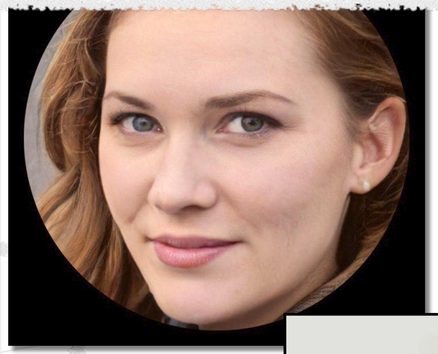
c|net

SCI-TECH

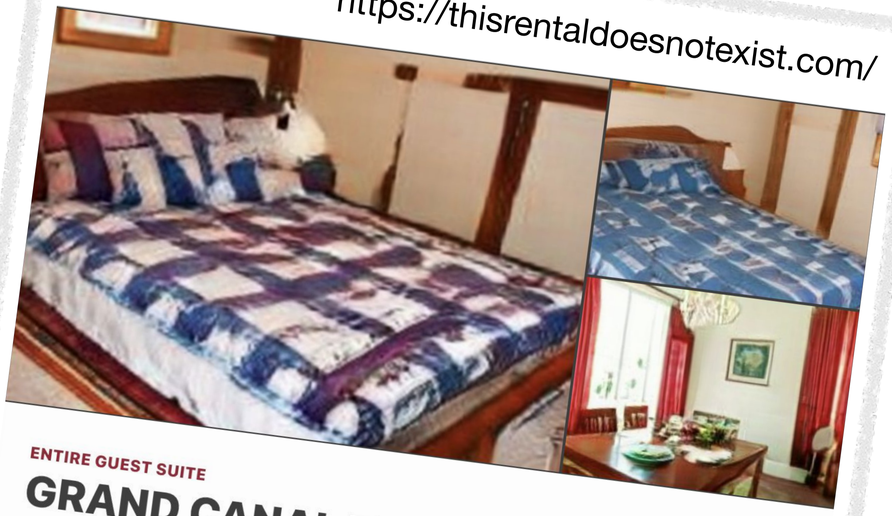
Spy reportedly used AI-generated photo to connect with targets on LinkedIn

A fake account had links to politically connected figures in Washington, the Associated Press reports.

BY STEVEN MUSIL | JUNE 13, 2019 5:13 PM PDT



https://thisrentaldoesnotexist.com/



ENTIRE GUEST SUITE

GRAND CANAL TOUR VIEW 3 BED 1/2 BATH

Adobe

Crafting new images with photo manipulation.

https://www.youtube.com/watch?v=p7-B8S734T4

The Problem

Journals adopt AI to spot duplicated images in manuscripts

A few publishers are using automated software to catch flaws in submitted papers.

Richard Van Noorden

nature

HEALTH

SEC Investigating Cassava Sciences, Developer of Experimental Alzheimer's Drug

Cassava, one of best-performing U.S. stocks this year, denies claims that it manipulated research results

THE WALL STREET JOURNAL.

By Dave Michaels and Joseph Walker
Updated Nov. 17, 2021 4:55 pm ET

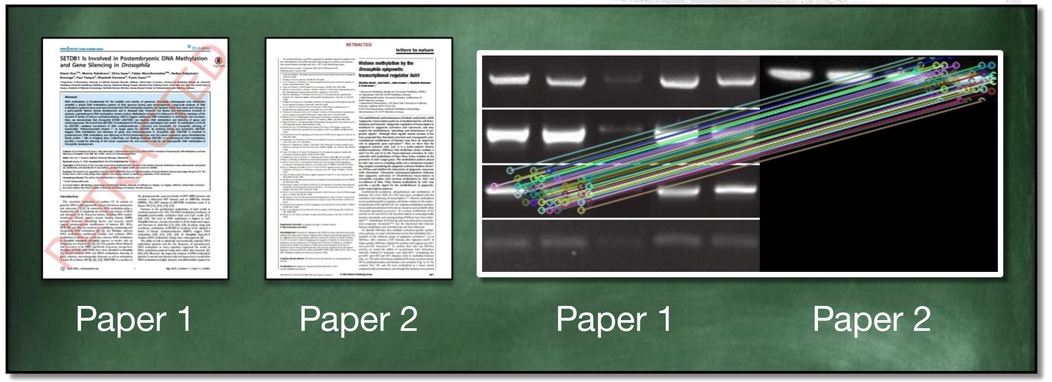
REUTERS GRAPHICS

Speed Science

The risks of swiftly spreading coronavirus research

By **Manas Sharma, Simon Scarr** and **Kate Kelland**

PUBLISHED FEBRUARY 19, 2020



Provenance Analysis

What
is Provenance Analysis?

How
do we do it?

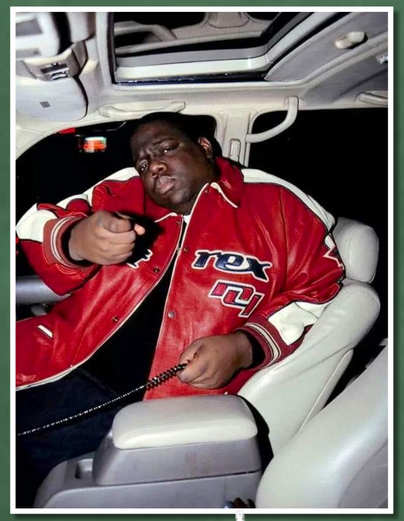
What's up **Next**?

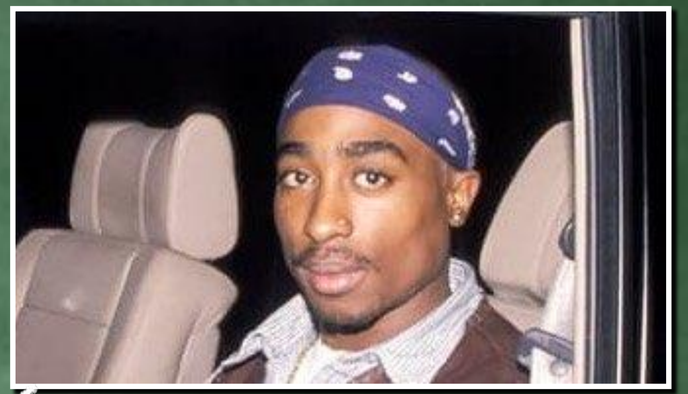
Moreira et al. "Image Provenance Analysis at Scale" IEEE T-IP 2018

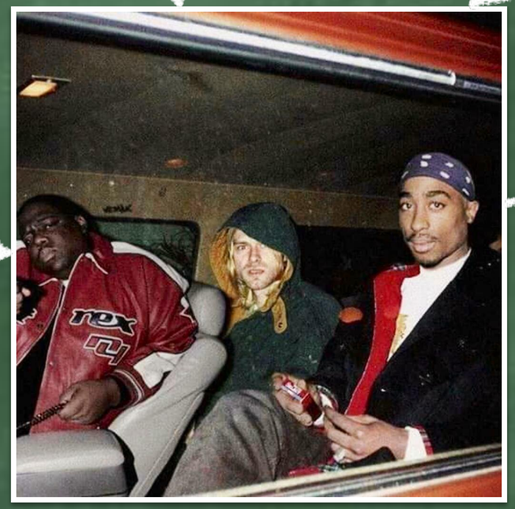

The Notorious B.I.G.
NY scene rapper
HANGING OUT?
Kurt Cobain
Grunge scene musician


rex

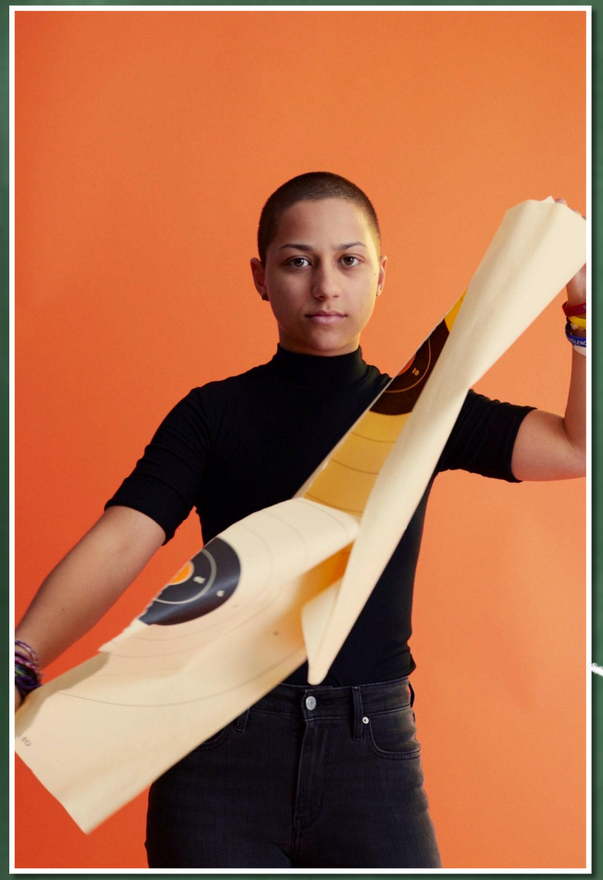

Tupac Shakur
LA scene rapper

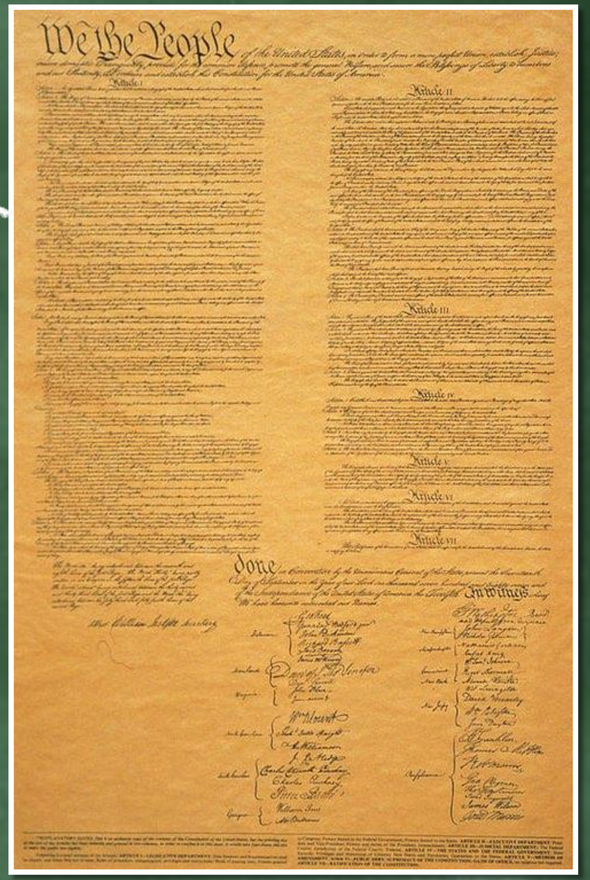






Provenance Graph






Russian Federation
Turkey

Russian Federation

Turkey

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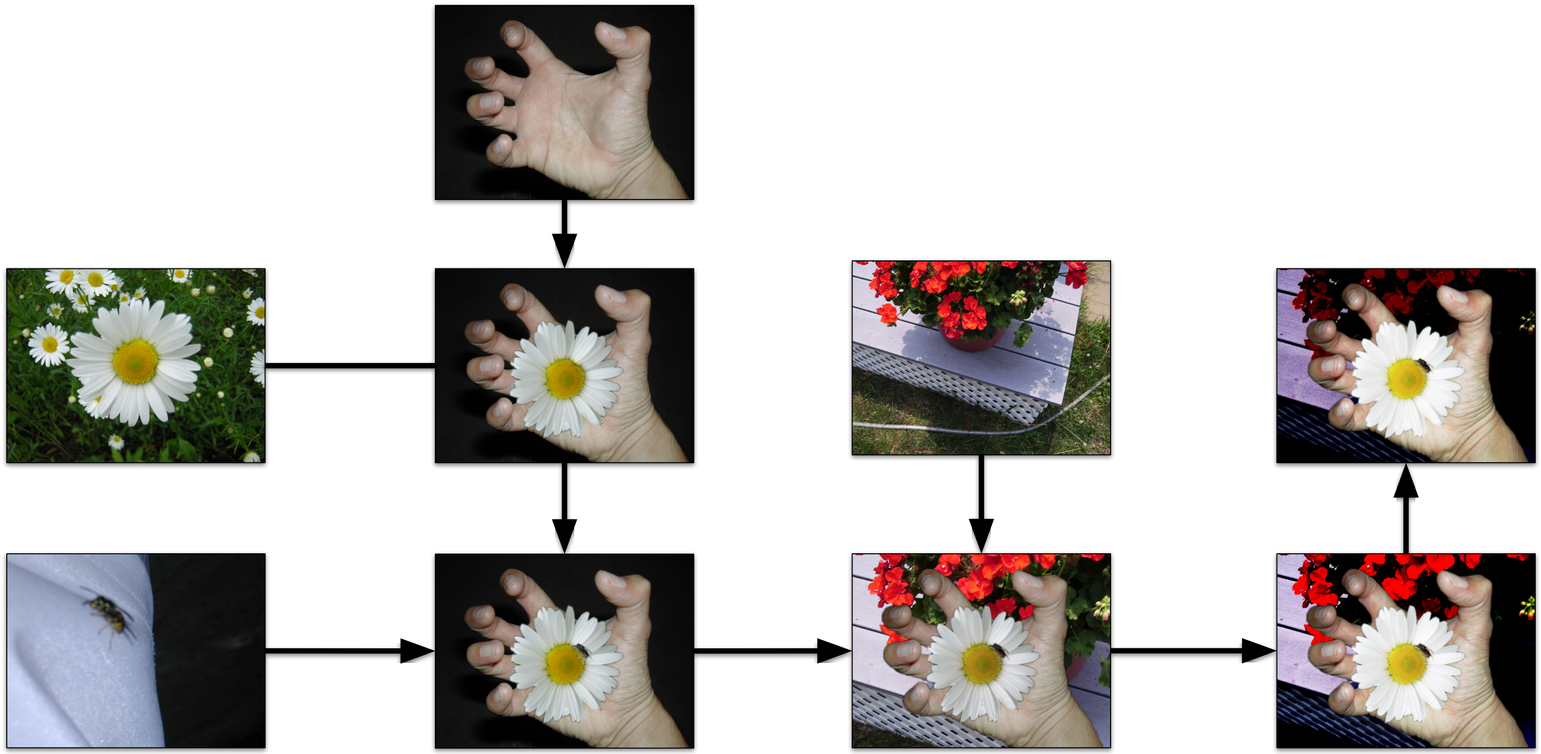
Datasets

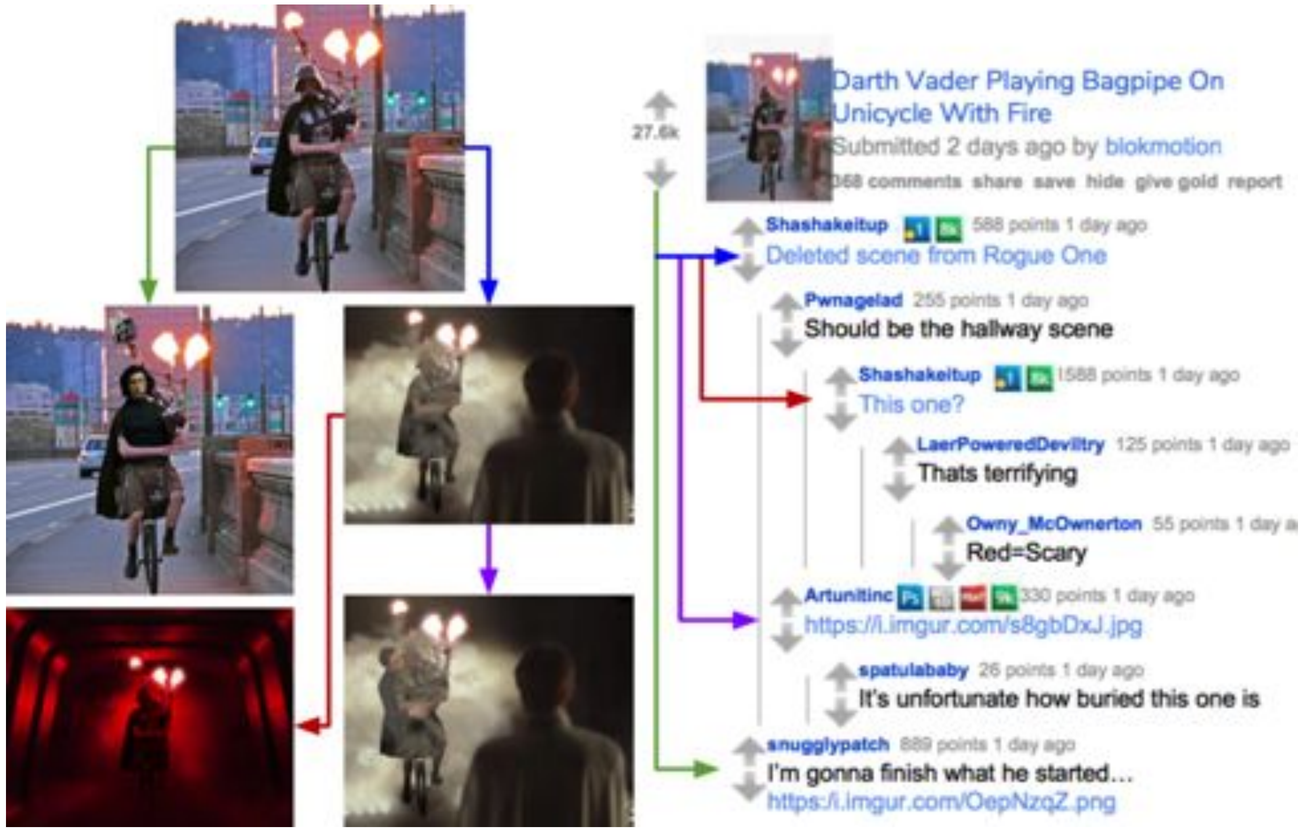
https://www.nist.gov/publications/
nimble-challenge-2017-evaluation-data-and-tool



Datasets

Reddit Photoshop Battles

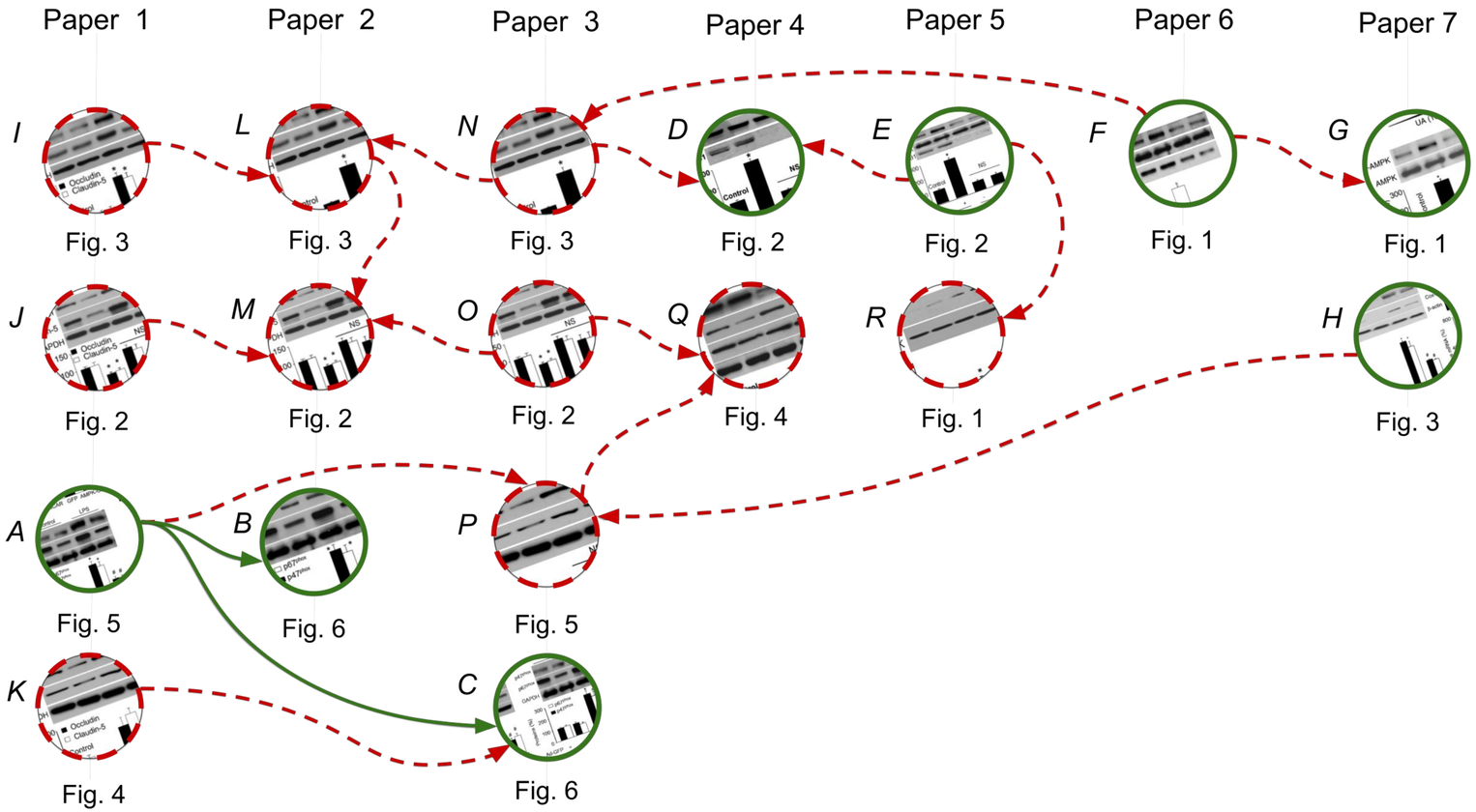
https://github.com/CVRL/Reddit_Provenance_Datasets



Datasets

Scientific Integrity Dataset

https://github.com/danielmoreira/sciint/tree/dataset



Datasets

Scientific Integrity Dataset

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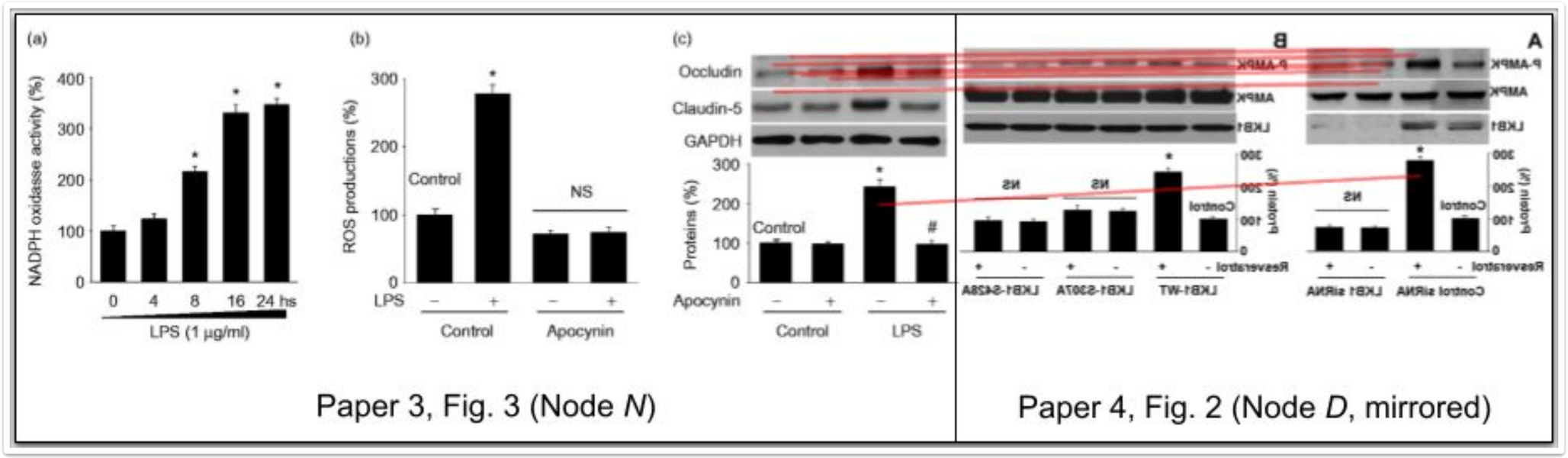

Part 2: Provenance Analysis Algorithms

The Implementation

Two-Task Approach

Input

Solution

Output

Two-Task Approach

Input

questioned image

image database
(e.g., Internet)

Solution

Output

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Solution

1. Image Retrieval





Output

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Solution

1. Image Retrieval

2. Graph Construction

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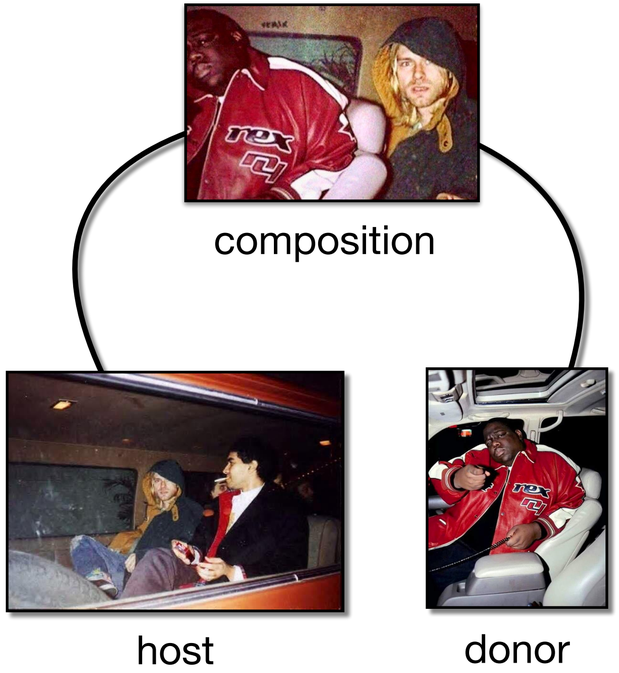


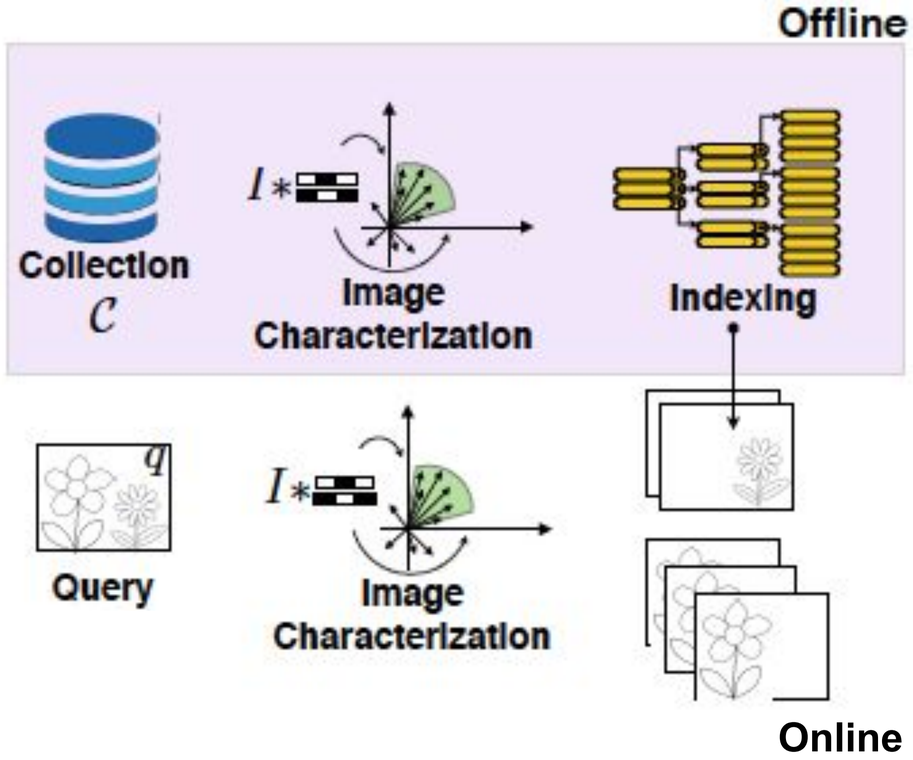
composition

host

donor

Image Retrieval

https://arxiv.org/pdf/1706.00447.pdf



Pinto et al. “Provenance Filtering for Multimedia Phylogeny” IEEE ICIP 2017

Image Retrieval

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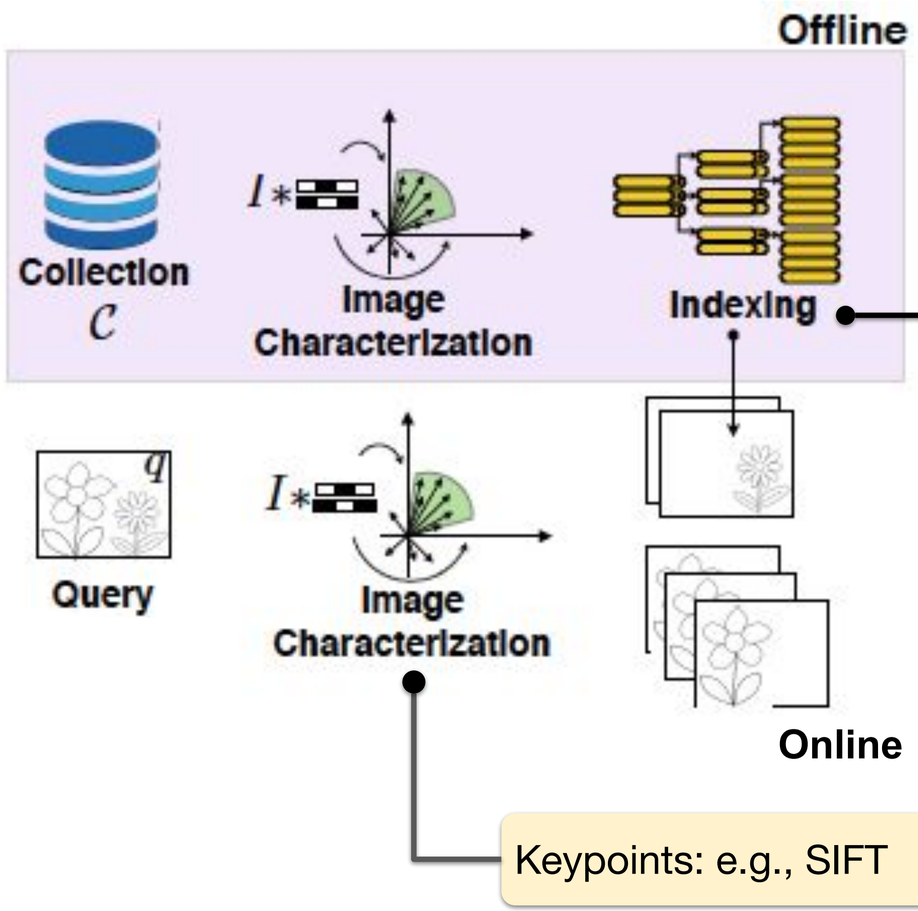


Keypoints: e.g., SIFT

Inverted File Index

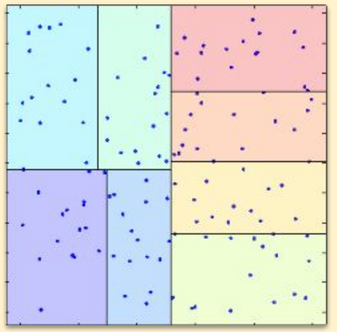
(x, y)

SIFT

Image ID

Each feature of *C* is indexed.

KD-tree



https://www.mathworks.com/help/stats/classification-using-nearest-neighbors.html

Image Retrieval

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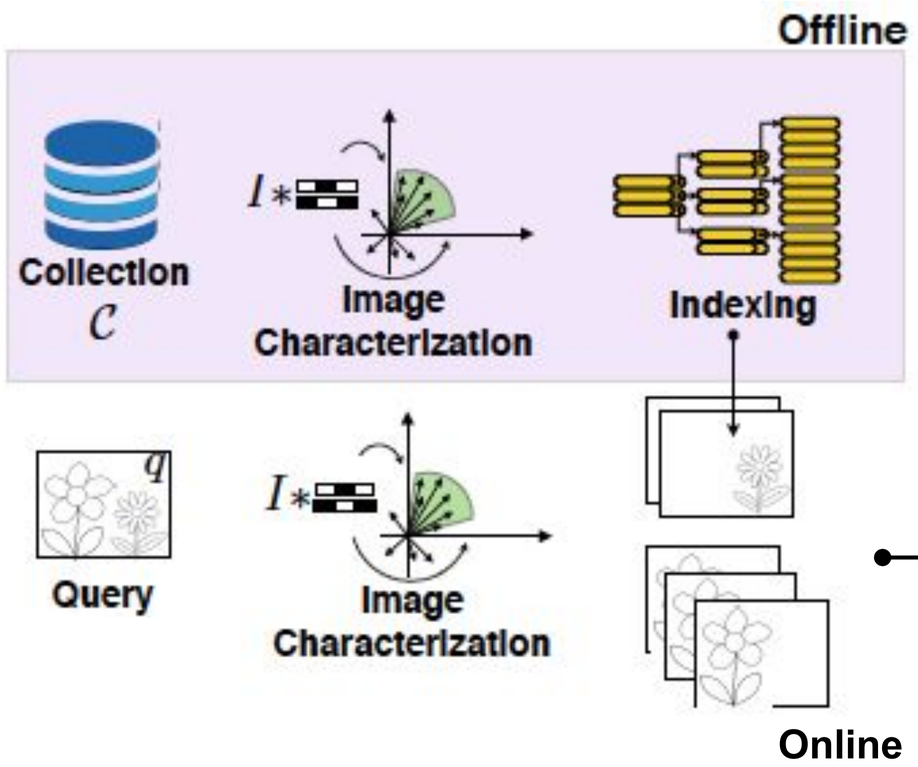
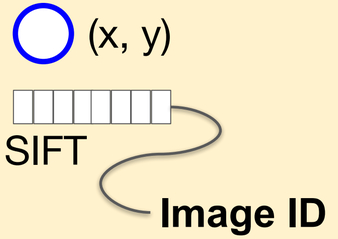
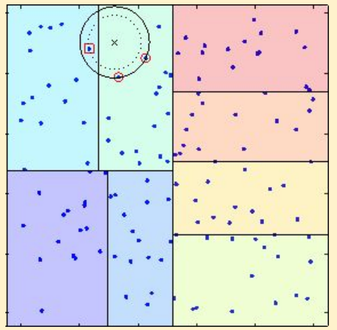


Inverted File Index



For each feature of the query, find the *k* nearest ones.

KD-tree



https://www.mathworks.com/help/stats/classification-using-nearest-neighbors.html

The k respective images get one vote.

Image Retrieval

https://arxiv.org/pdf/1706.00447.pdf

Rank Example

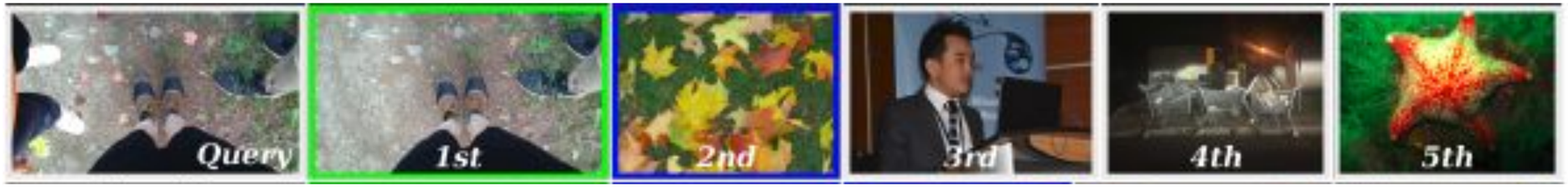


Image Retrieval

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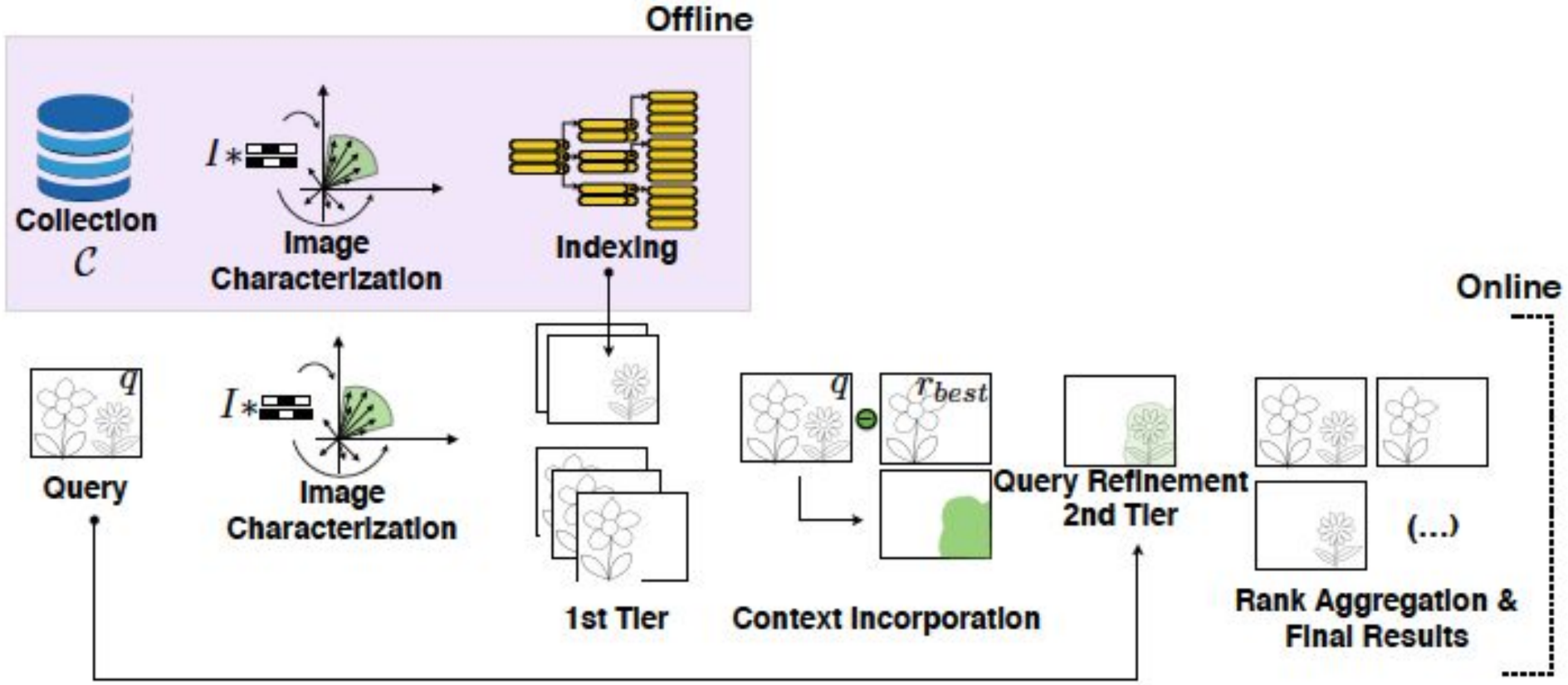
Rank Example

Provenance Image Retrieval

https://arxiv.org/pdf/1706.00447.pdf



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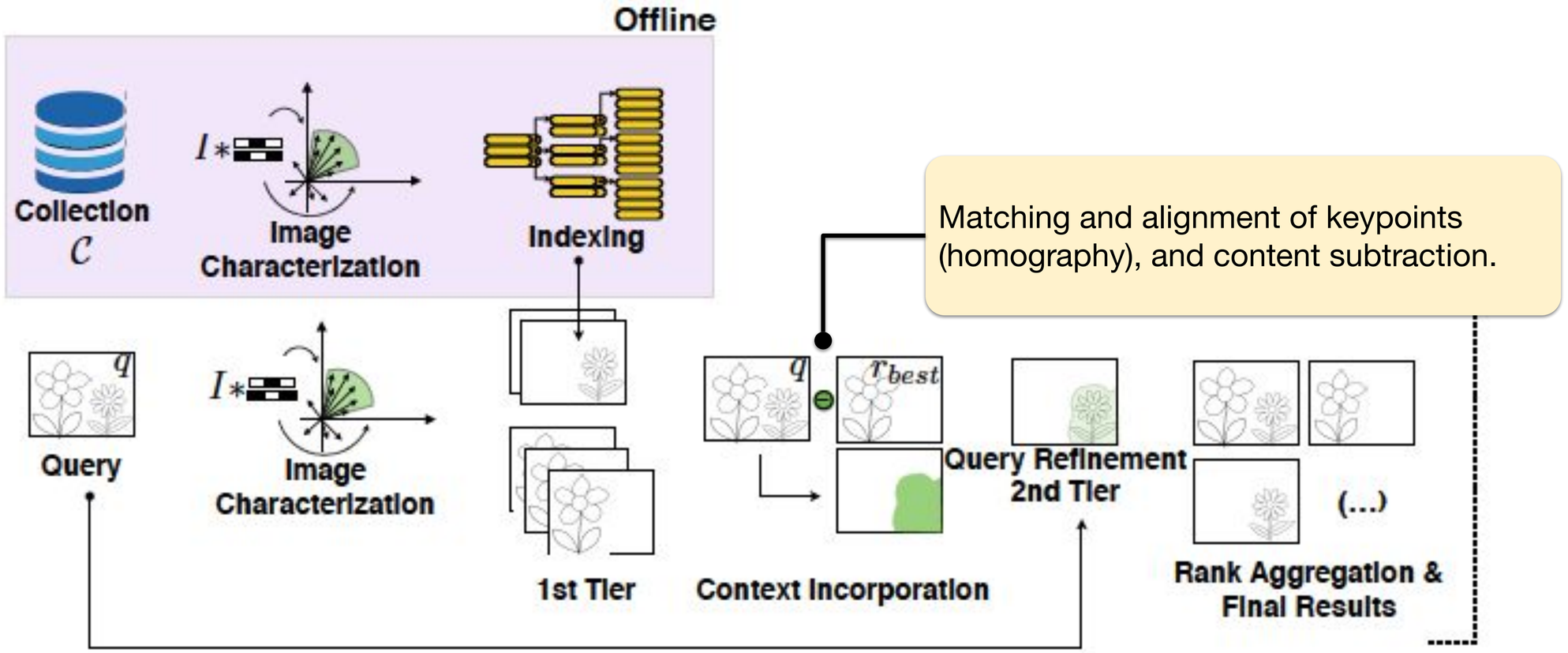

Context Incorporation

https://ieeexplore.ieee.org/document/7305756

De Oliveira et al. “Multiple Parenting Phylogeny Relationships in Digital Images” IEEE T-IFS 2015

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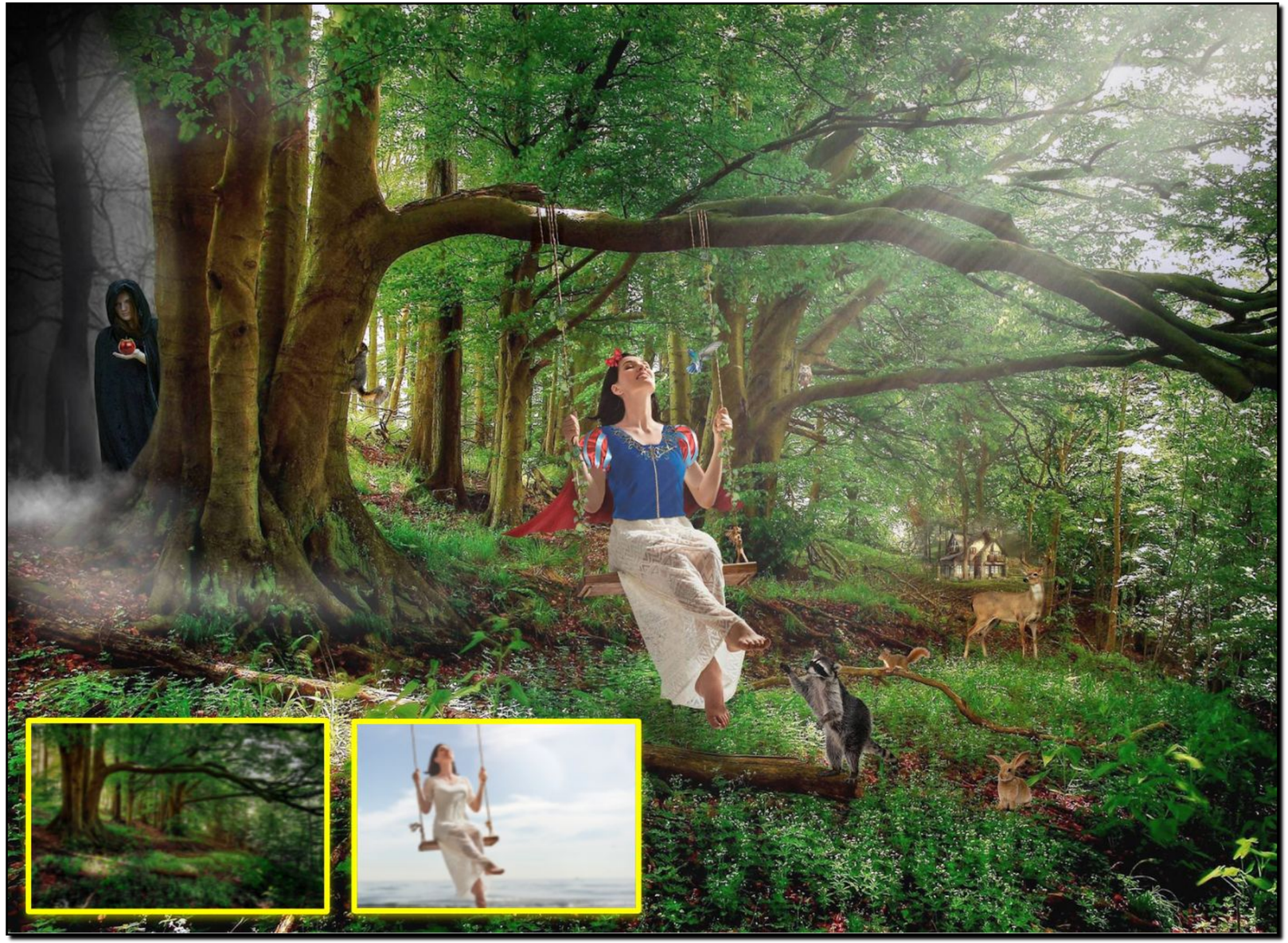
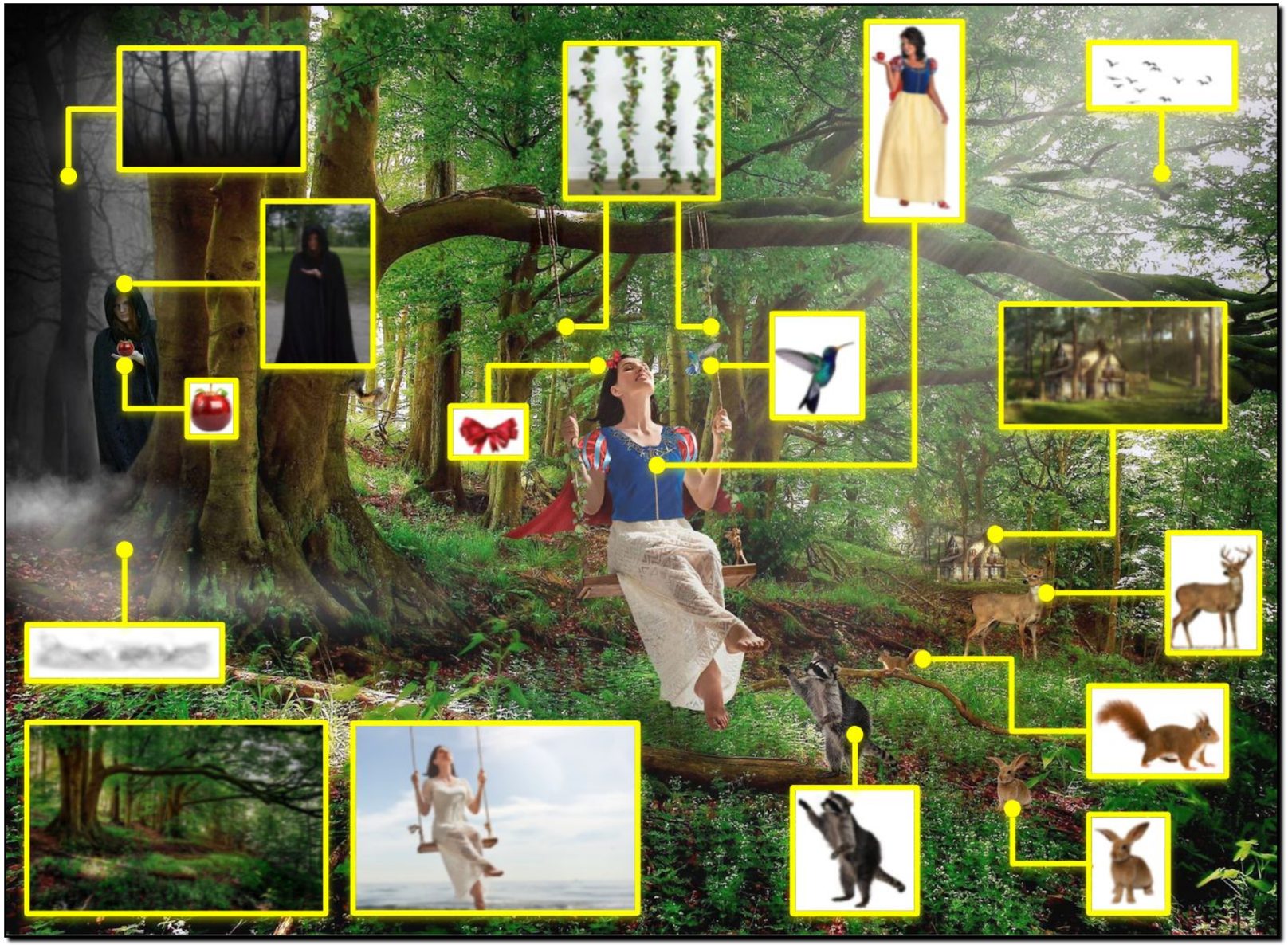
Rank Improvement



Brogan et al. “Fast Local Spatial Verification for Feature-Agnostic Large-Scale Image Retrieval” IEEE T-IP 2021



Two-Task Approach

Input

questioned image

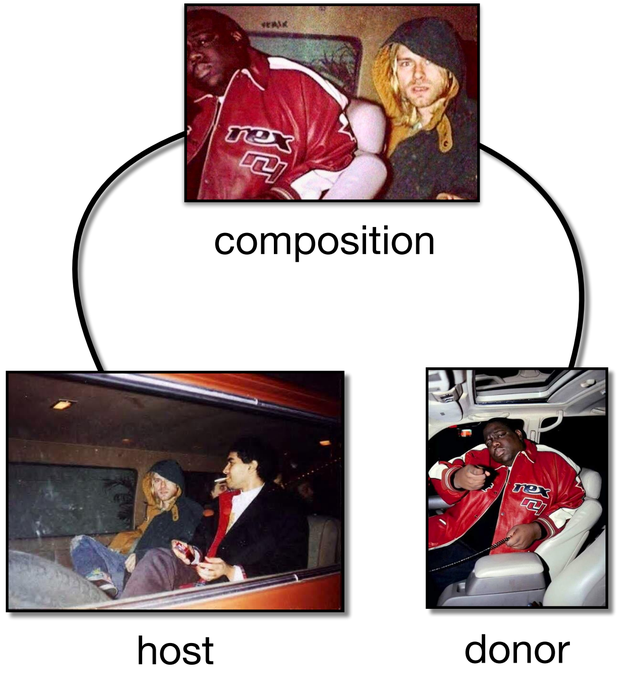
image database
(e.g., Internet)

Solution

1. Image Retrieval

2. Graph Construction

Output



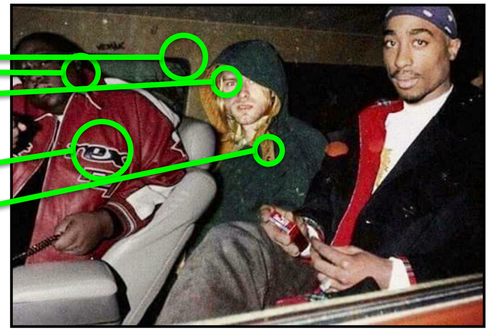
composition

host

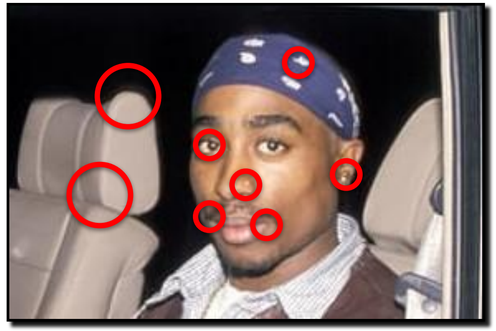
donor

Graph Construction

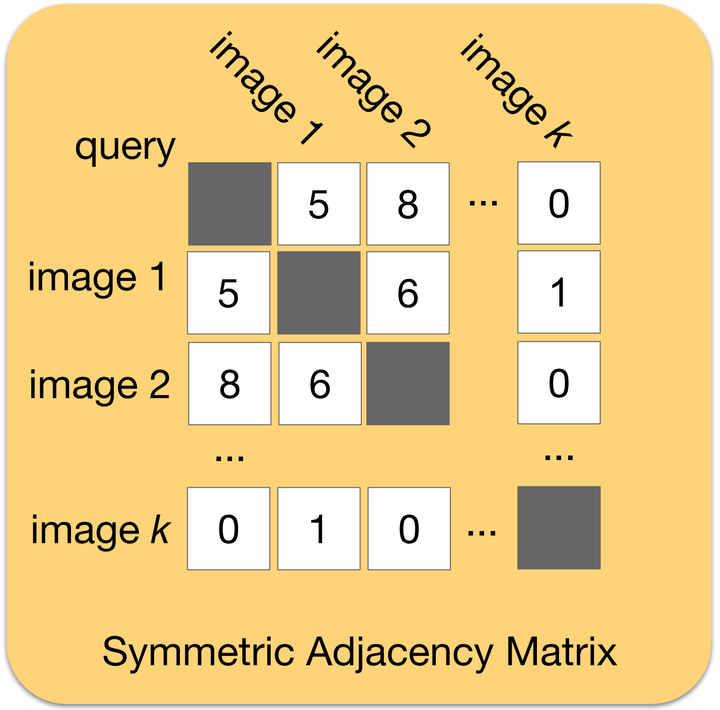
For every image pair…



7 matches



no matches



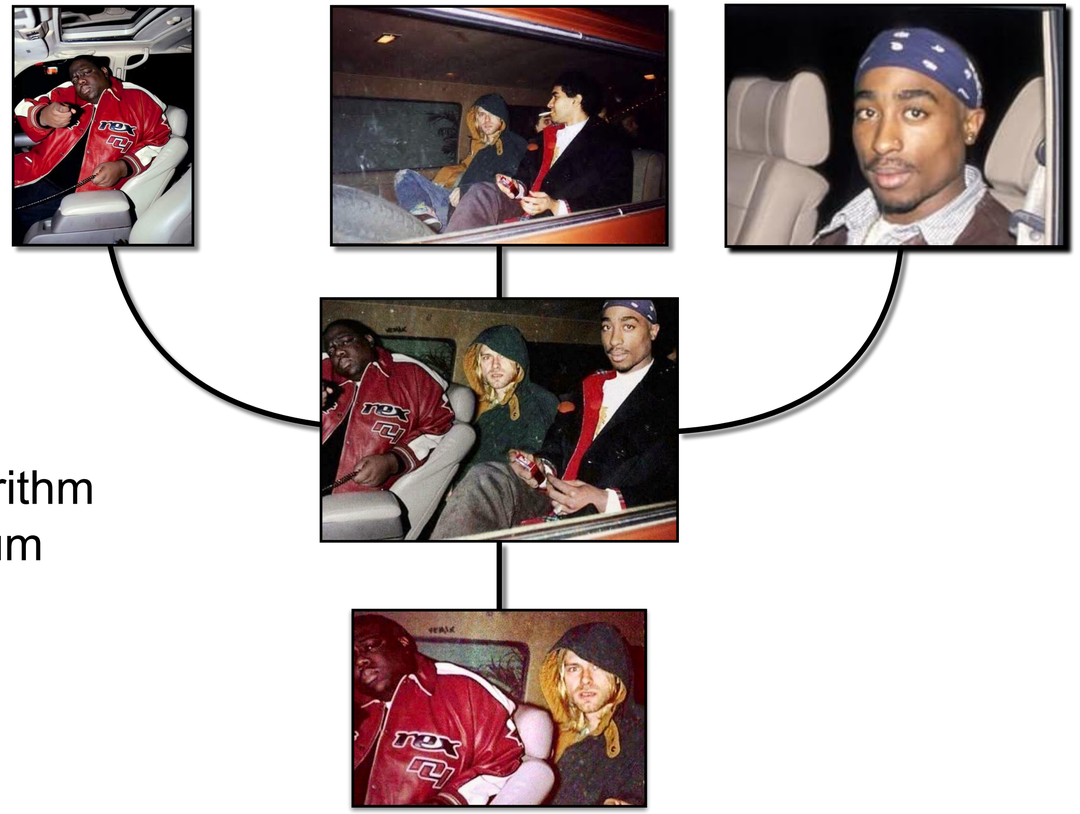
Rationale: shared content is proportional to the number of matched keypoints.

Graph Construction

	image 1	image 2	...	image *k*
query		5	8	0
image 1	5		6	1
image 2	8	6		0
...	...			...
image *k*	0	1	0	

Symmetric Adjacency Matrix

Kruskal's algorithm to find maximum spanning tree.



Rationale: shared content is proportional to the number of matched keypoints.

Provenance Analysis

What
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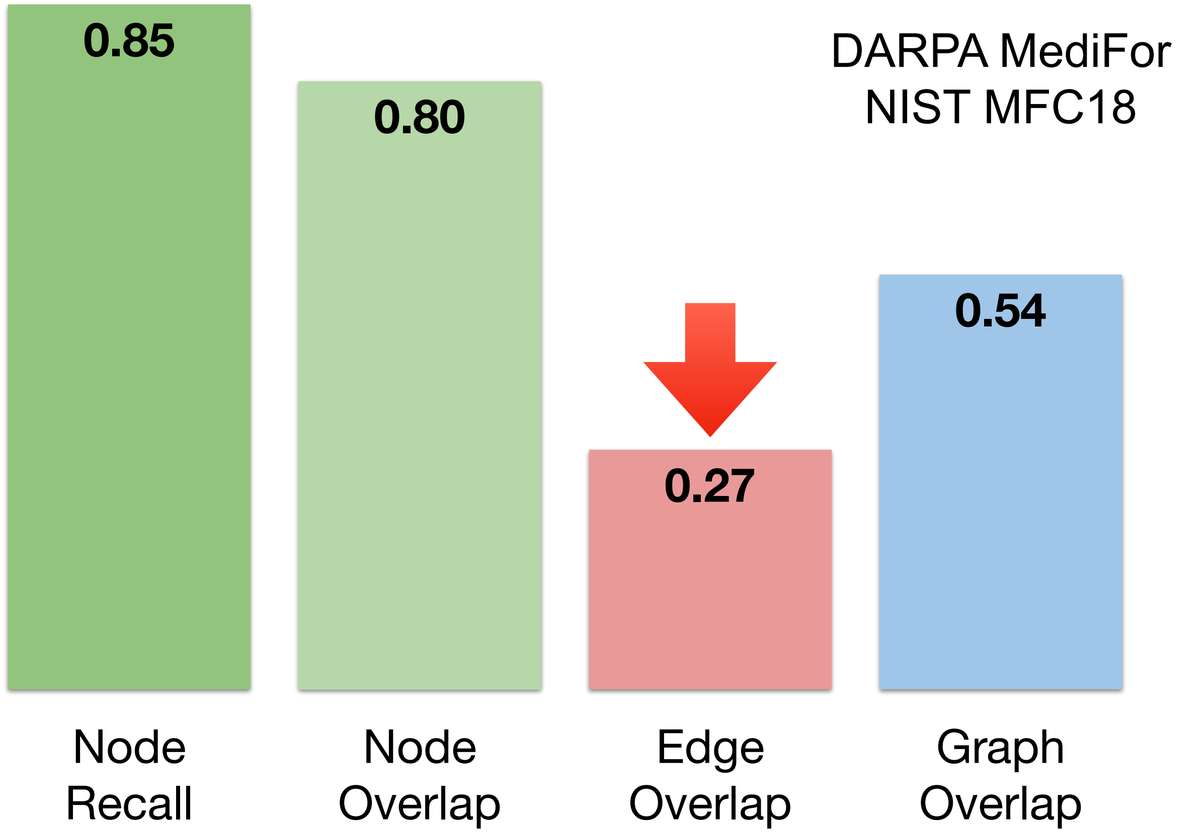
How
do we do it?

What's up **Next**?

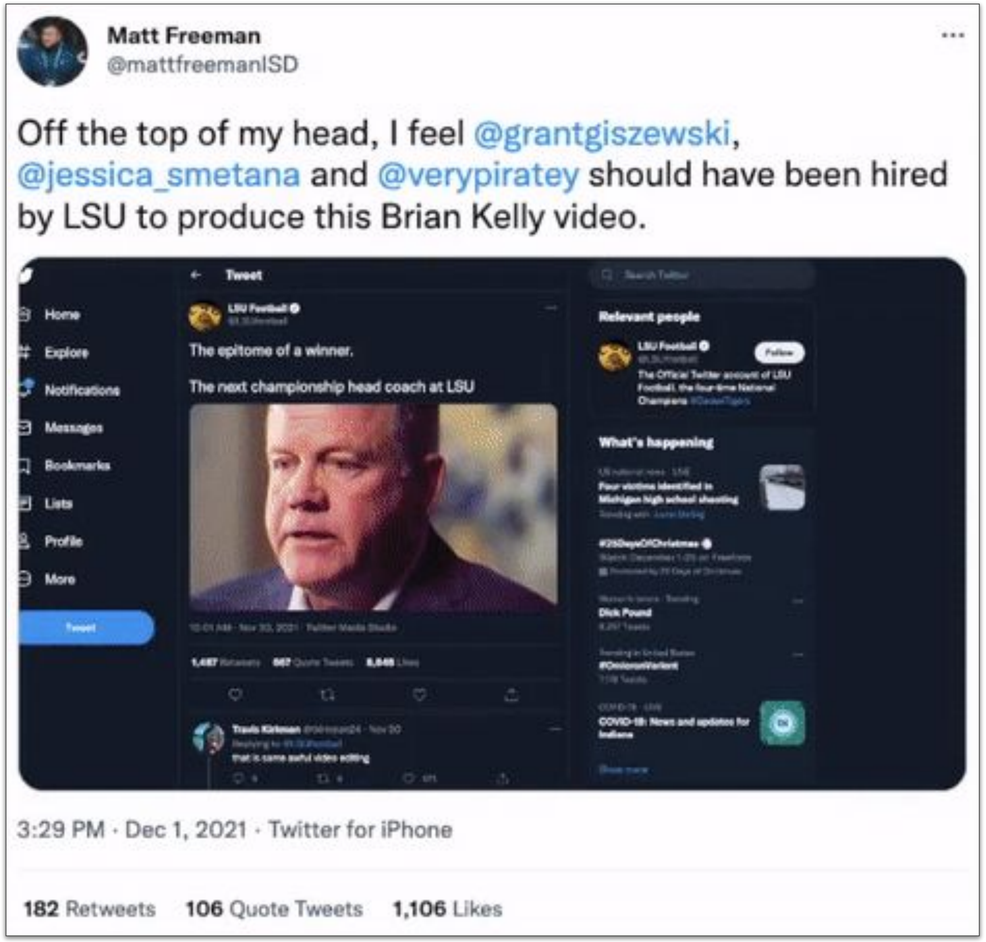
Best Results



Video Provenance Analysis

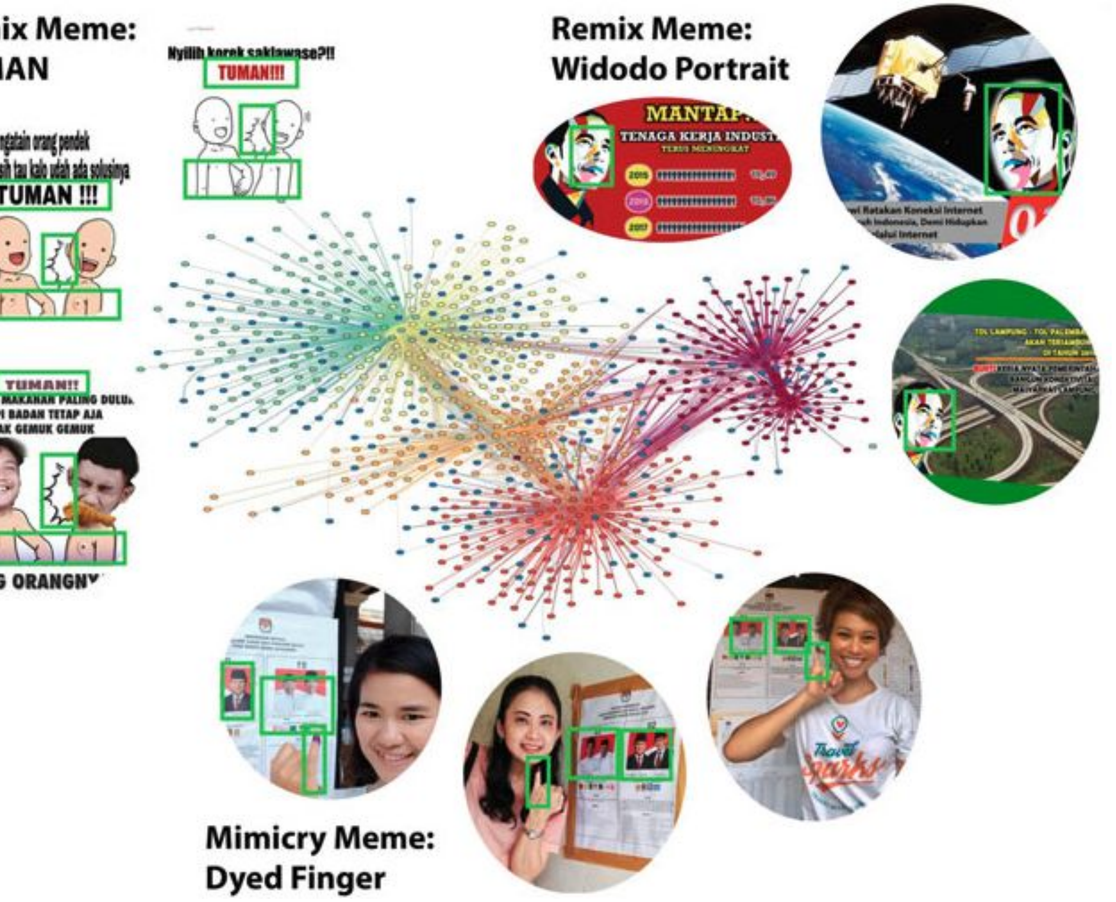
https://www.youtube.com/watch?v=vd09WdOgOeg

Video Provenance Analysis

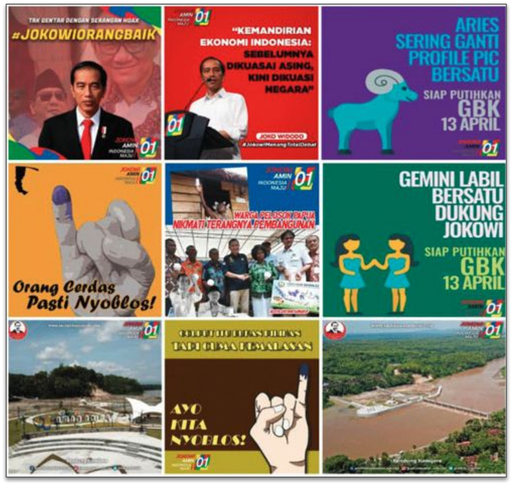


https://twitter.com/mattfreemanISD/status/1466142469914075144

Viral Content Clustering



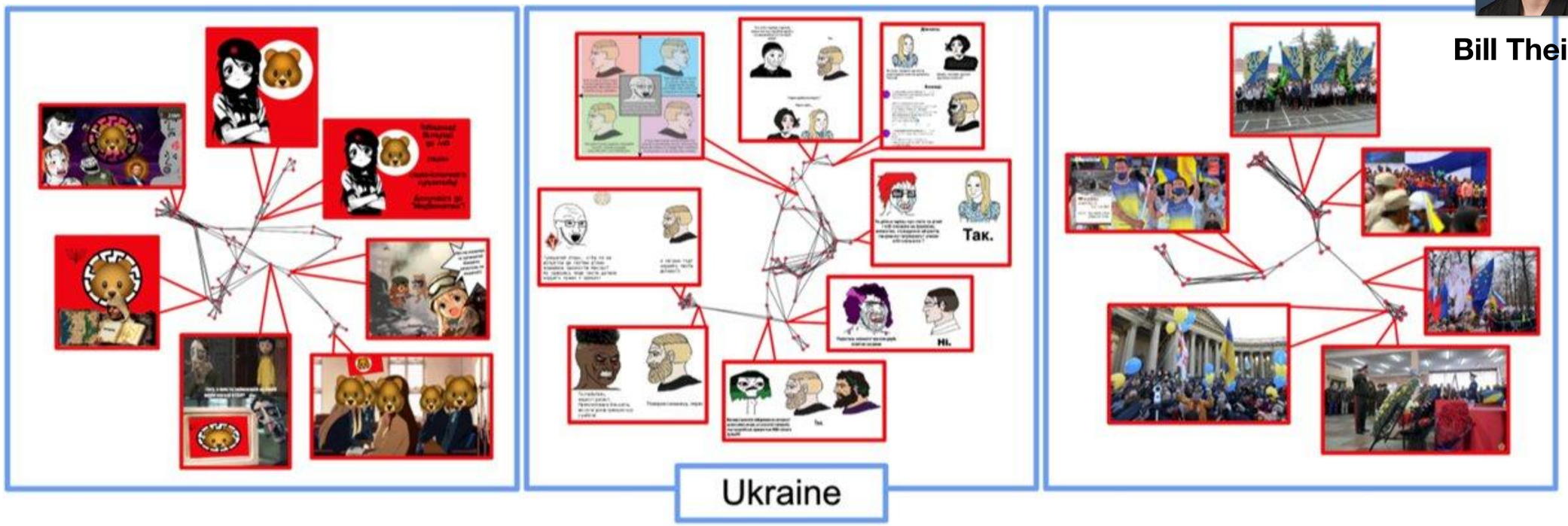
Bill Theisen



2019 Indonesian Elections
(social media memes)

Viral Content Clustering

Bill Theisen



Russo-Ukrainian War
(Telegram posts since 2016)

And the largest challenge…

Scale

Summary

We highlighted the inherent difficulty of interpreting visual disinformation.

We introduced the new image analysis problem of Provenance Analysis.

We discussed emerging algorithms for Provenance Analysis

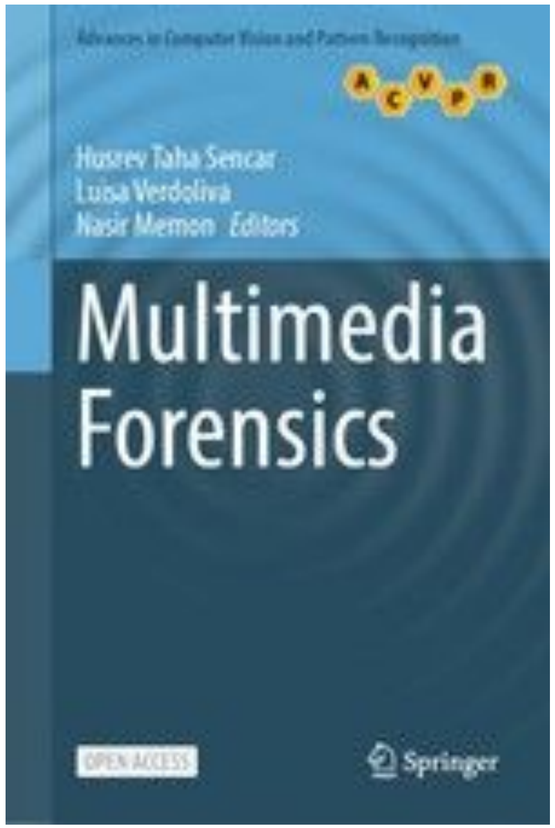
We issued a challenge to solve the open problems. Join us!

Source

Publications, source codes, github links, etc.

Please refer to:
Moreira et al.
Image Provenance Analysis
2022 Springer Book Chapter (open access)
Table 15.8

https://link.springer.com/chapter/10.1007/978-981-16-7621-5_15



Collaboration upstream project: https://github.com/eldritchjs/pyifd