The secret life of JPEG images

Forgery detection using compression traces

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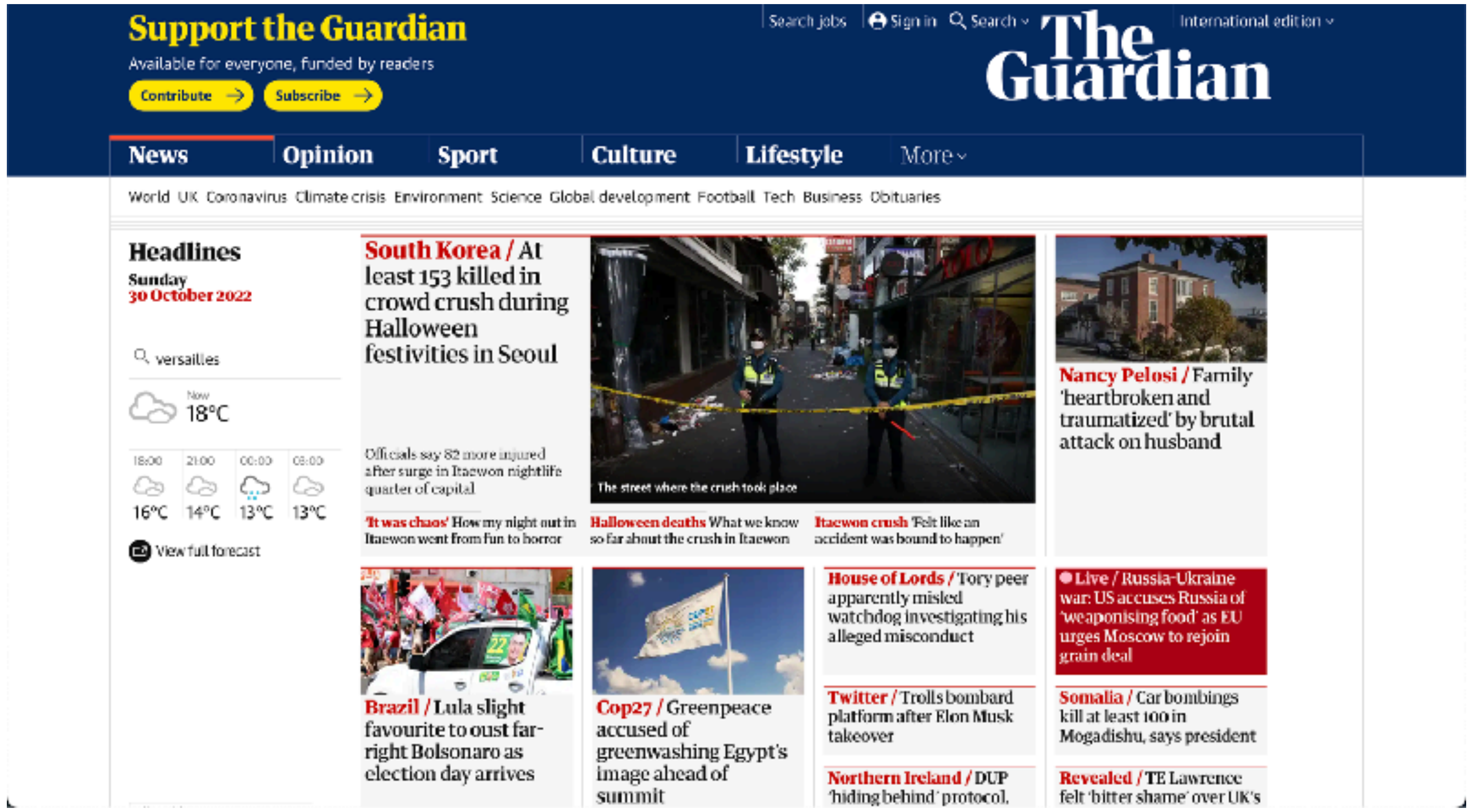
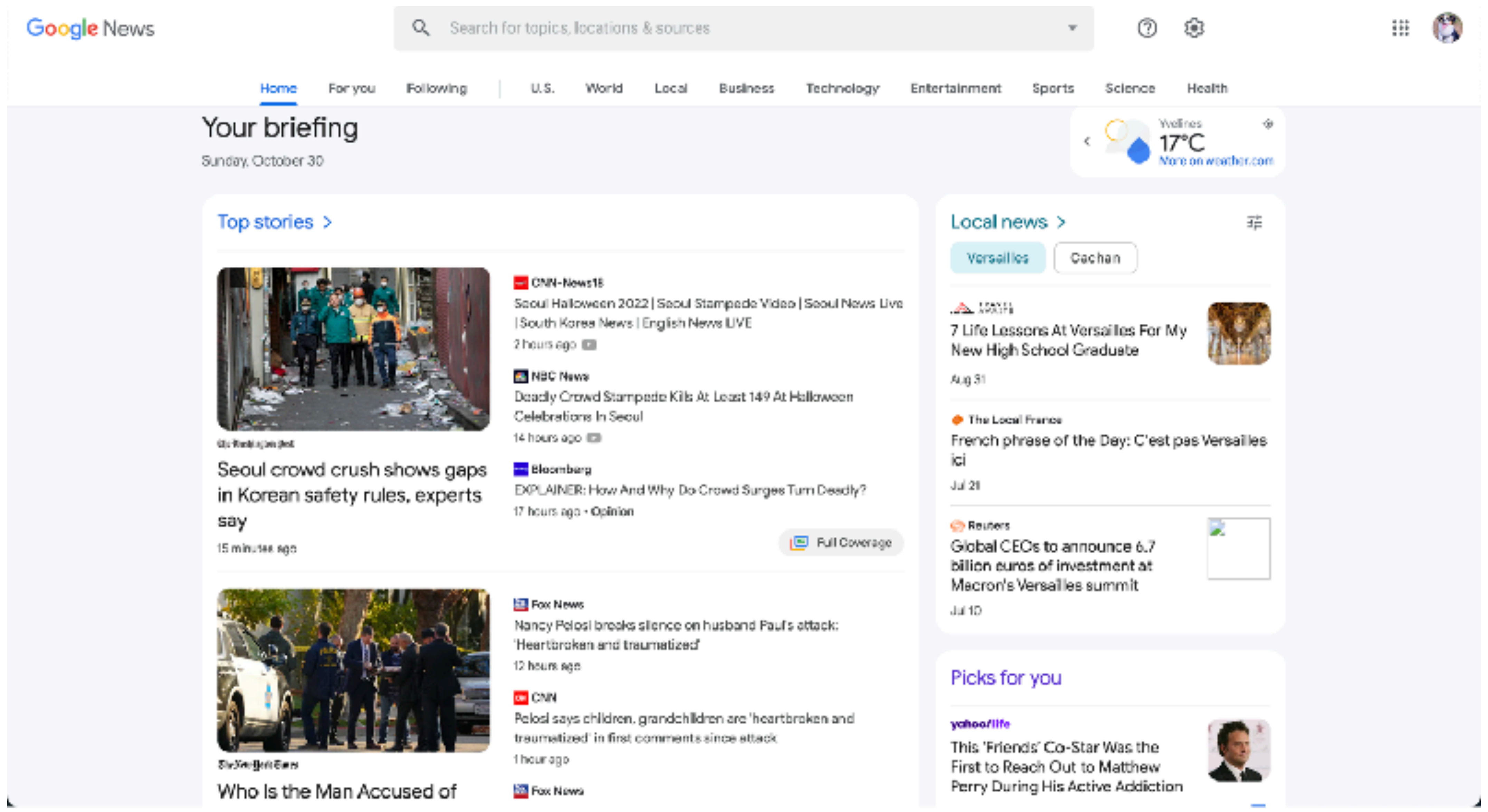
Image forgery

Images have become an important source of communication

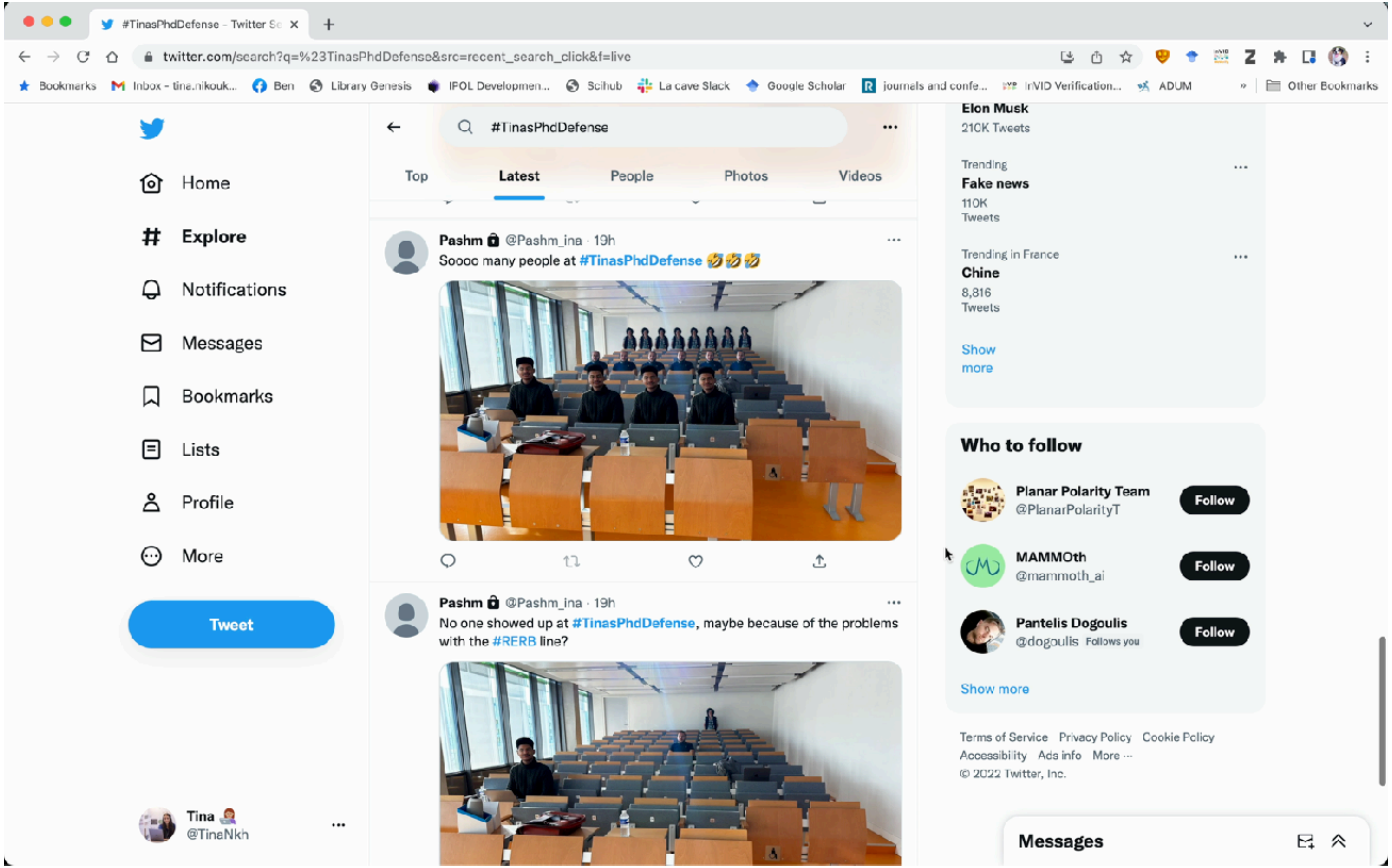




theguardian

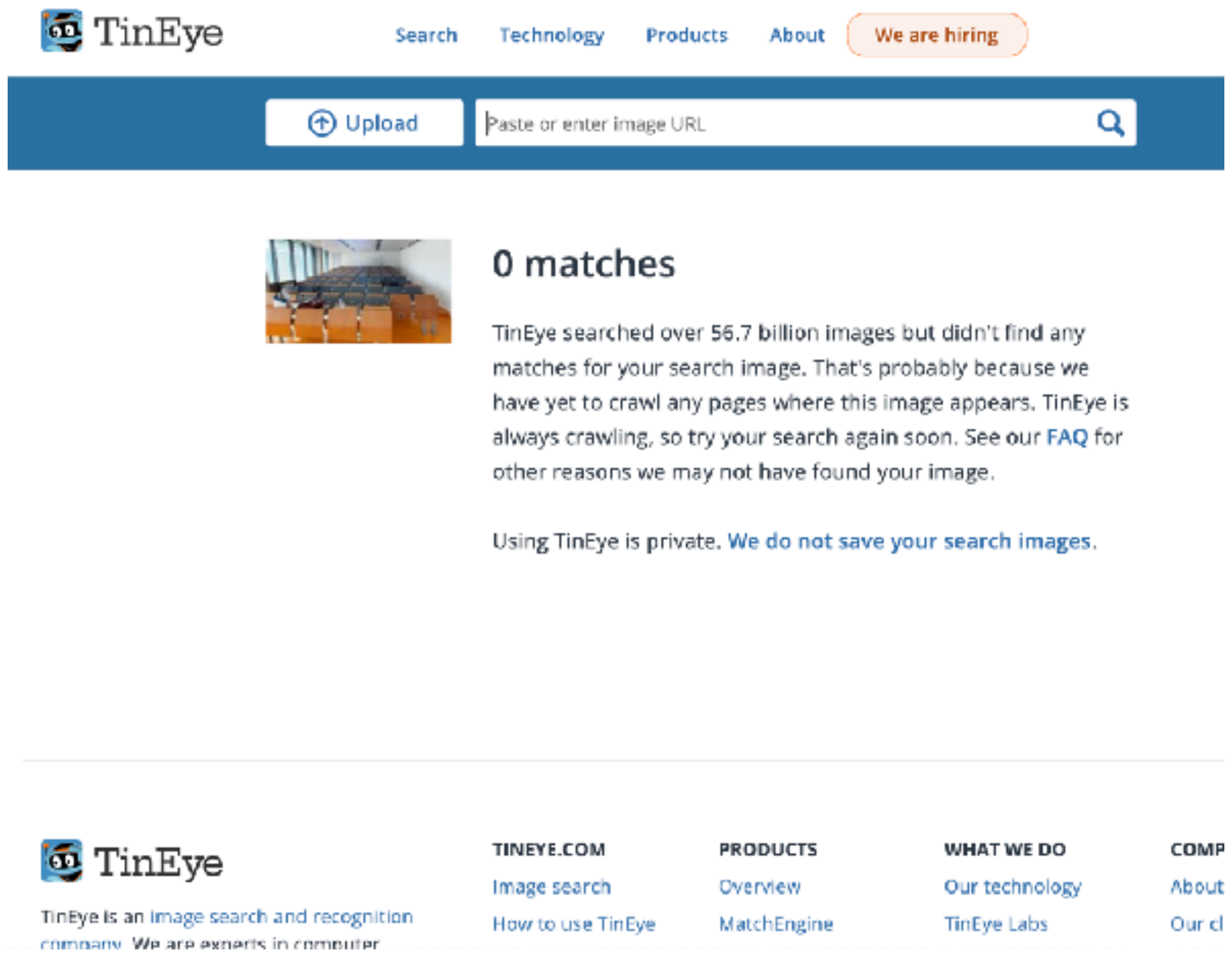
Google News

A picture is worth a thousand words



First reflexes to have

- Look at the image.
- Analyse the image file, but there are no EXIF metadata!
- Perform image reverse search on the Internet, to identify the image's source.



Fake information

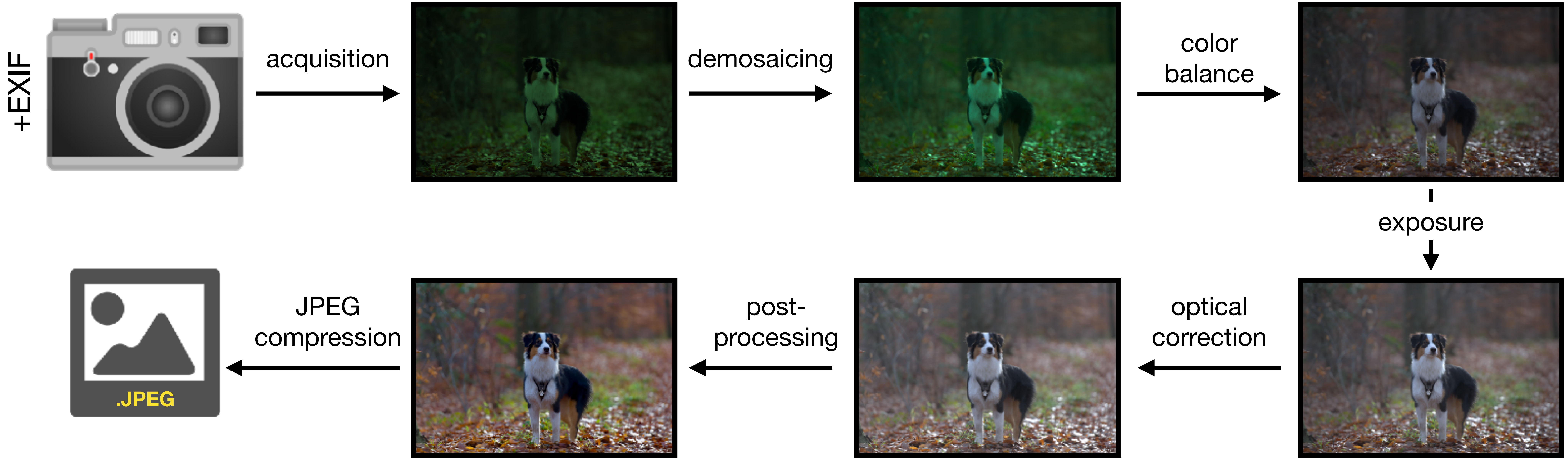
How to verify an image just with the image itself?

An overview on image forensics

- Active
  - [W. Puech, J. M. Rodrigues 2006]
  - [I. Cox et al. 2008]
  - [M. Gaata, W. Puech, S. Sadkhan 2011]
  - [P. Singh, H. Farid 2019]
- Passive
  - Physical integrity
    - Shadows
    - Illumination
    - Perspective
    - [M. Johnson, H. Farid 2007]
    - [E. Kee, J. O’Brien, H.Farid 2013]
    - [T. De Carvalho et al. 2013]
    - [H. Farid 2022]
  - Digital integrity
  - Semantic integrity
    - [C. Maigrot et al. 2017]
    - [Y. Wu et al. 2017]

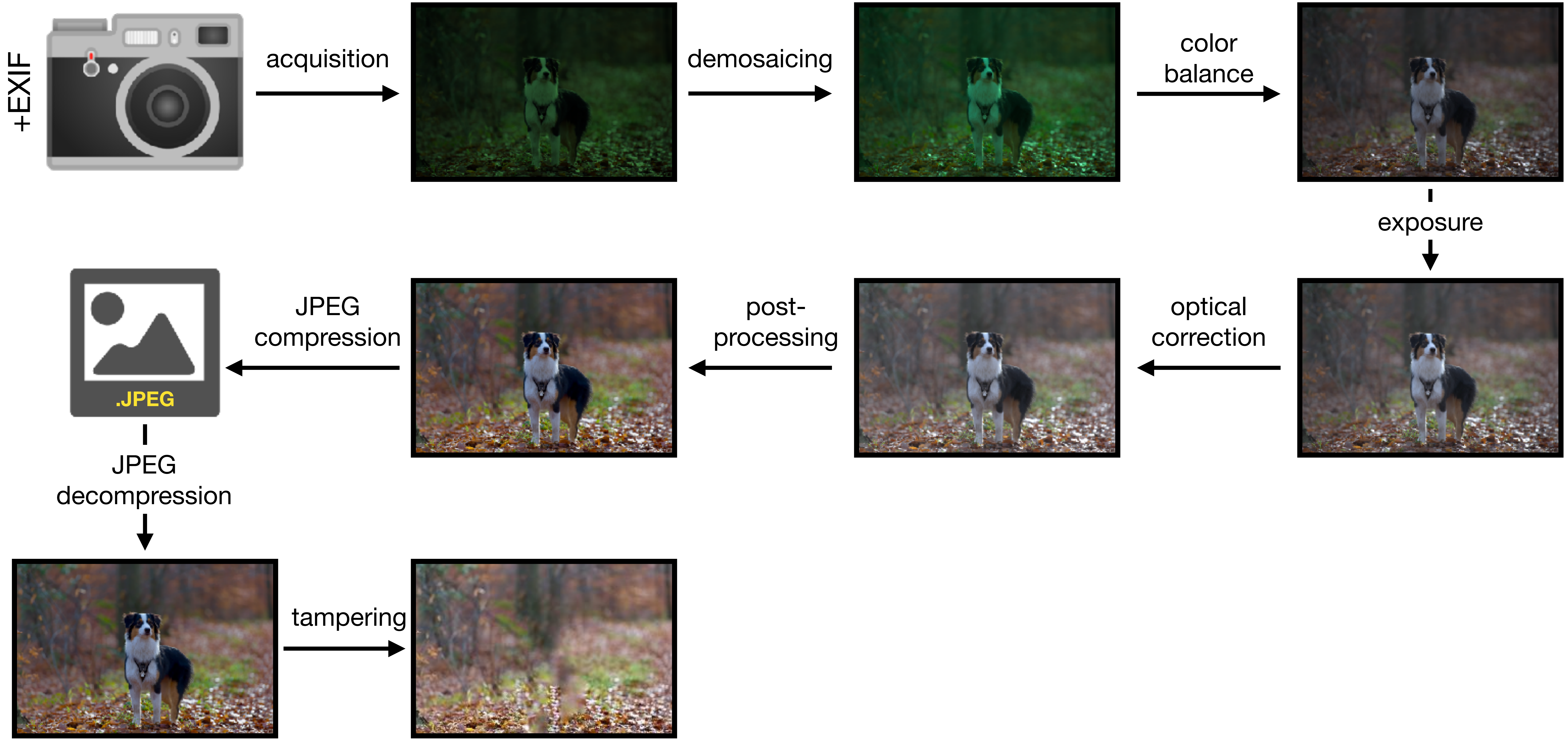
Kim Jong-Un with Elvis. Photoshop: Lazaro Gamio/Axios

Image processing pipeline



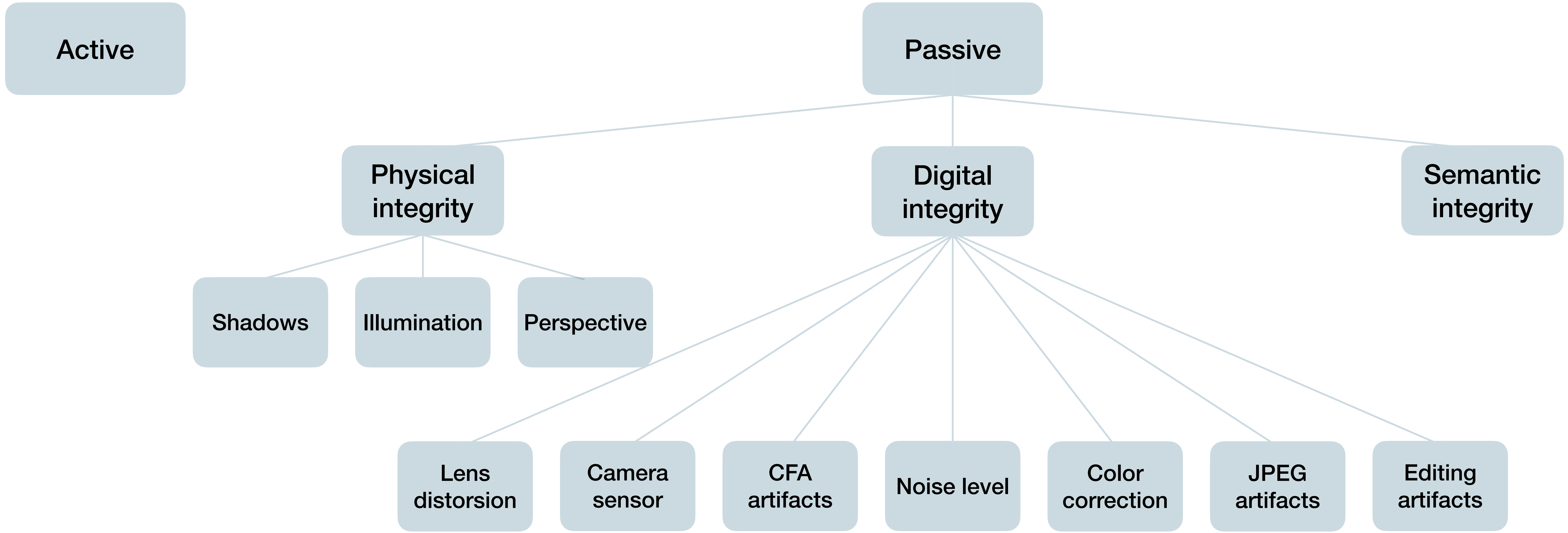
Simplified processing pipeline of an image.

Image processing pipeline



All these operations provide important clues that are exploited in the image forensic analysis.

An overview on image forensics



[M. Johnson, H. Farid 2006]
[T. Gloe et al. 2010]
[O. Mayer, M. Stamm 2018]

[I. Yerushalmy, H. Hel-Or 2011]

[A. Popescu, H. Farid 2005]
[A. Gallagher, T. Chen 2008]
[C. Choi et al. 2011]
[P. Ferrara et al. 2012]
[Q. Bammey et al. 2020]

[A. Popescu, H. Farid 2004]
[B. Mahdian, S. Said 2009]
[X. Pan et al. 2011]
[D. Cozzolino et al. 2015]
[D. Cozzolino, L. Verdoliva 2020]
[M. Gardella et al. 2021]

[Z. Fan, R. de Queiroz 2003]
[H. Farid 2006]
[W. Li et al. 2009]
[Z. Lin et al. 2009]
[H. Farid 2009]
[T. Bianchi, A. Piva 2012]
[C. Pasquini et al. 2017]
[S. Agarwal, H. Farid 2017]
[C. Iakovidou et al. 2018]
[H. Marreen et al. 2022]

[K. Bahrami et al. 2015]
[Y. Wu et al. 2019]
[S.-Y. Wang et al. 2019]

[J. Fridrich et al. 2003]
[I. Amerini et al. 2011]
[D. Cozzolino et al. 2015]
[T. Ehret 2019]

Forgery: *inpainting*

Original image.

Fake post: parts of the image have been erased.

Forgery: *copy-move*

Original image.

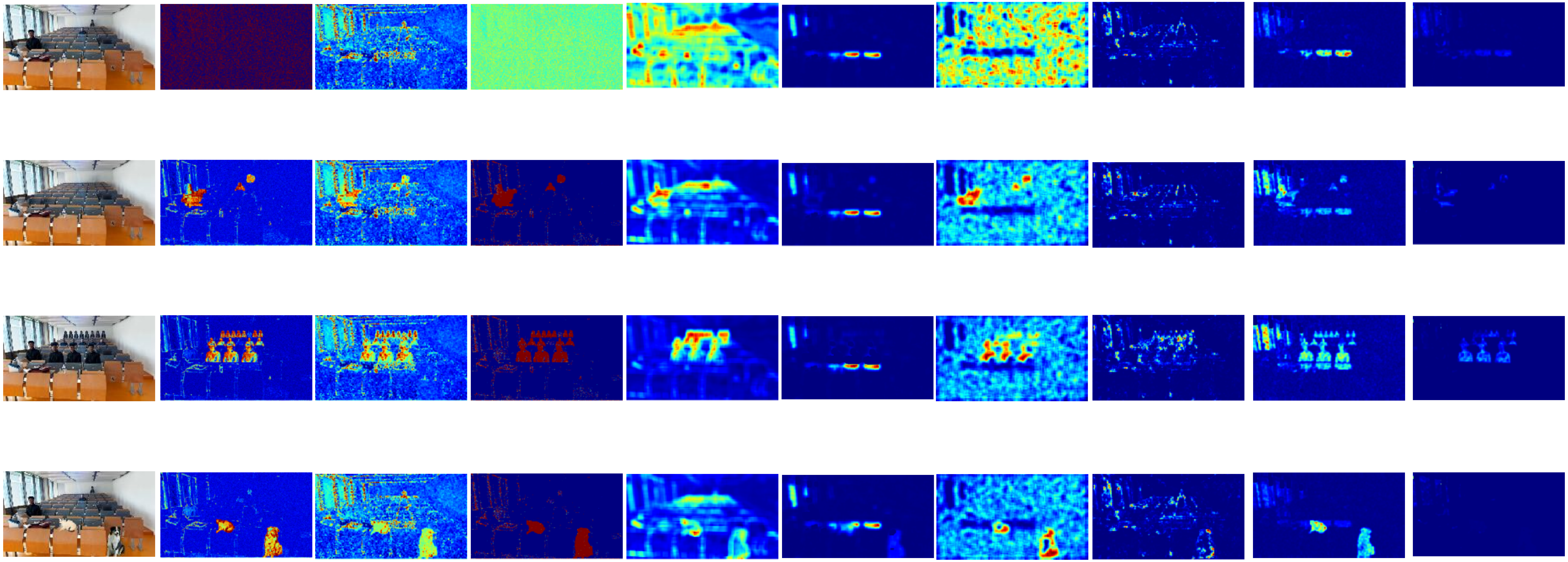
Fake post: parts of the image have been duplicated.

Forgery: *splicing*

Original image.

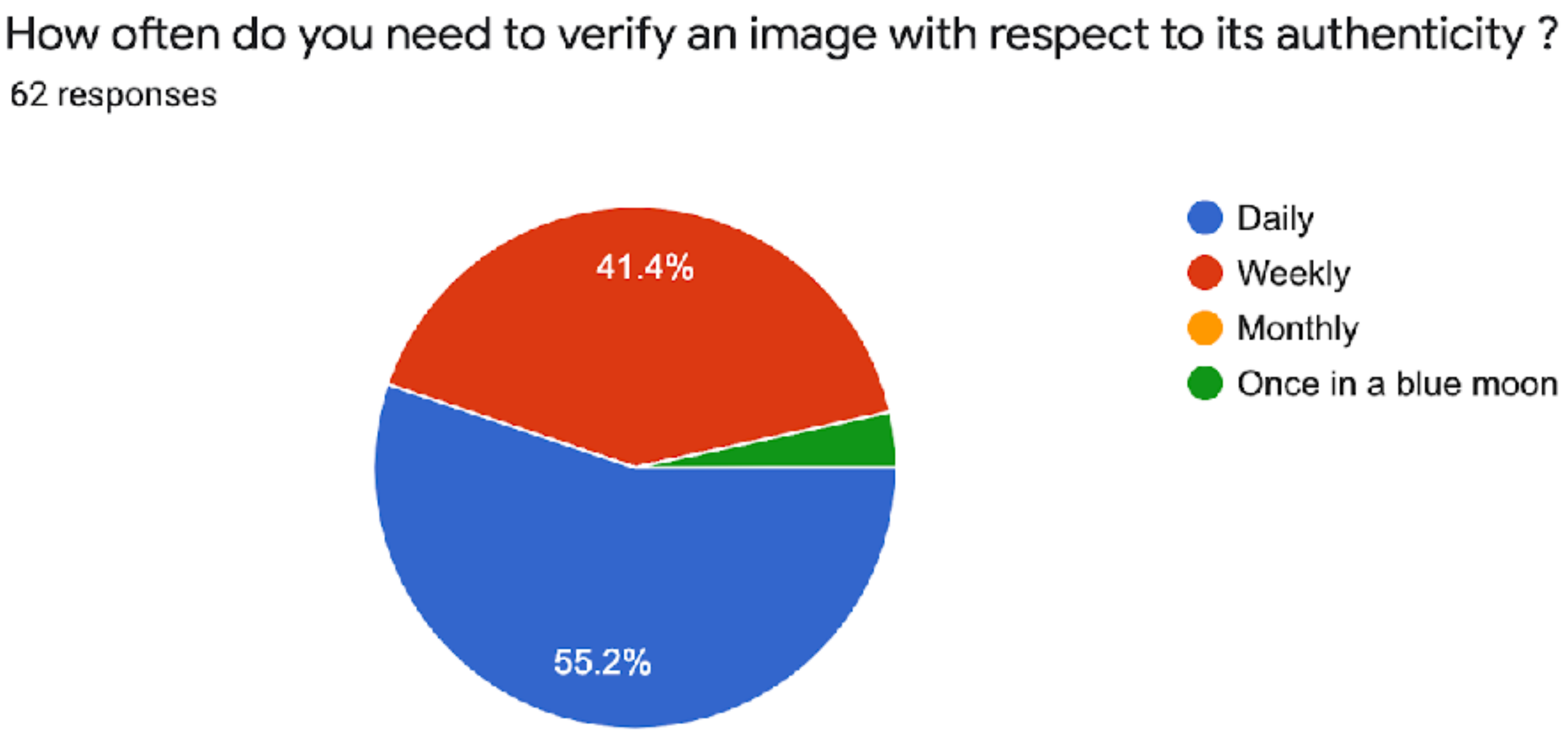
Fake post: new objects have been inserted in the image.

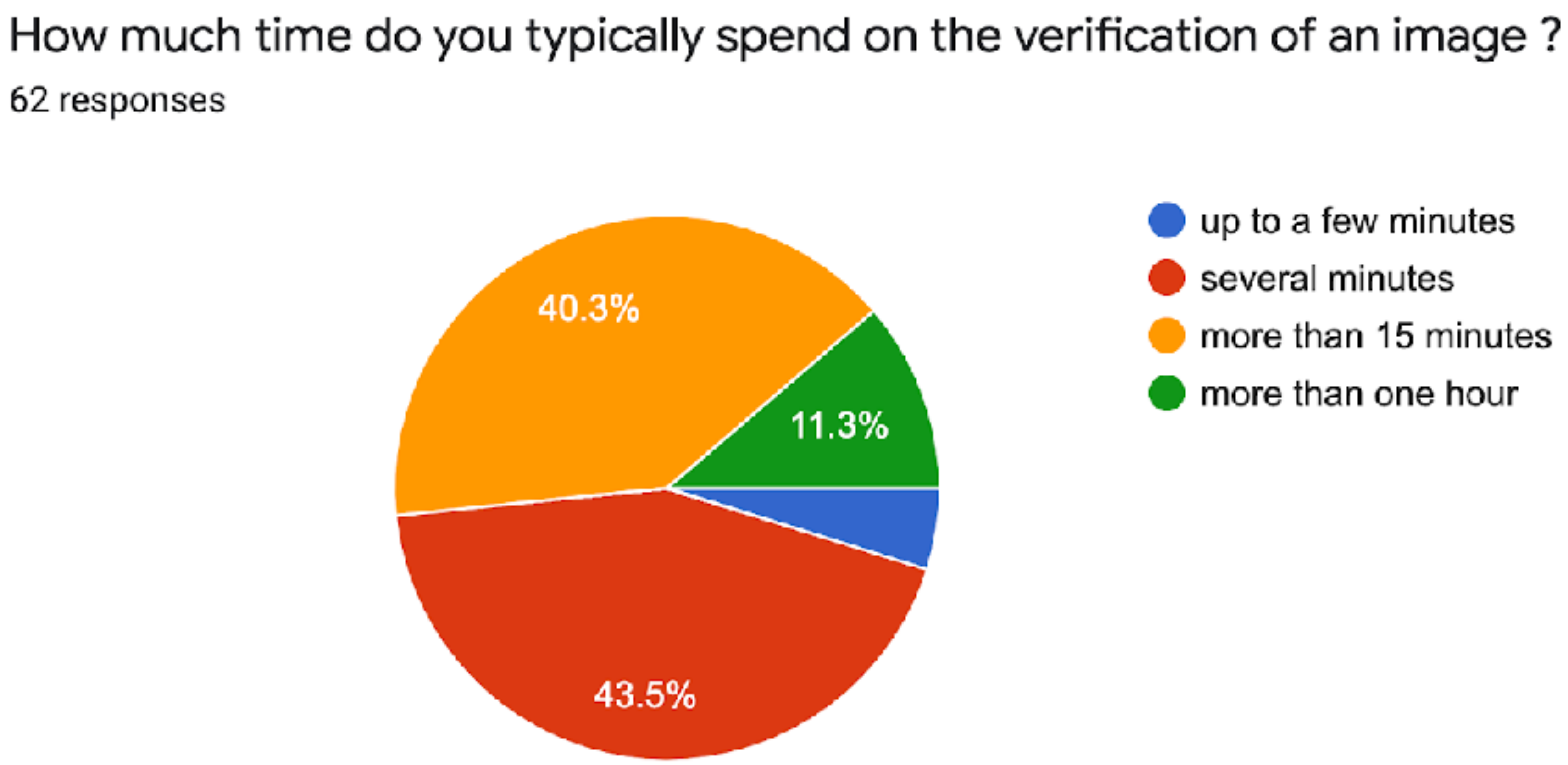
Passive image forgery detection methods



input | DCT [Ye et al. 2007] | BLK [Li et al. 2009] | DQ [Lin et al. 2009] | Ghost [Farid 2009] | Splicebuster [Cozzolino et al. 2015] | CAGI [Iakovidou et al. 2018] | ManTraNet [Wu et al. 2019] | Noiseprint [Cozzolino et al. 2020] | Comprint [Mareen et al. 2022]

Short survey among AFP fact-checkers during the Envisu4 project



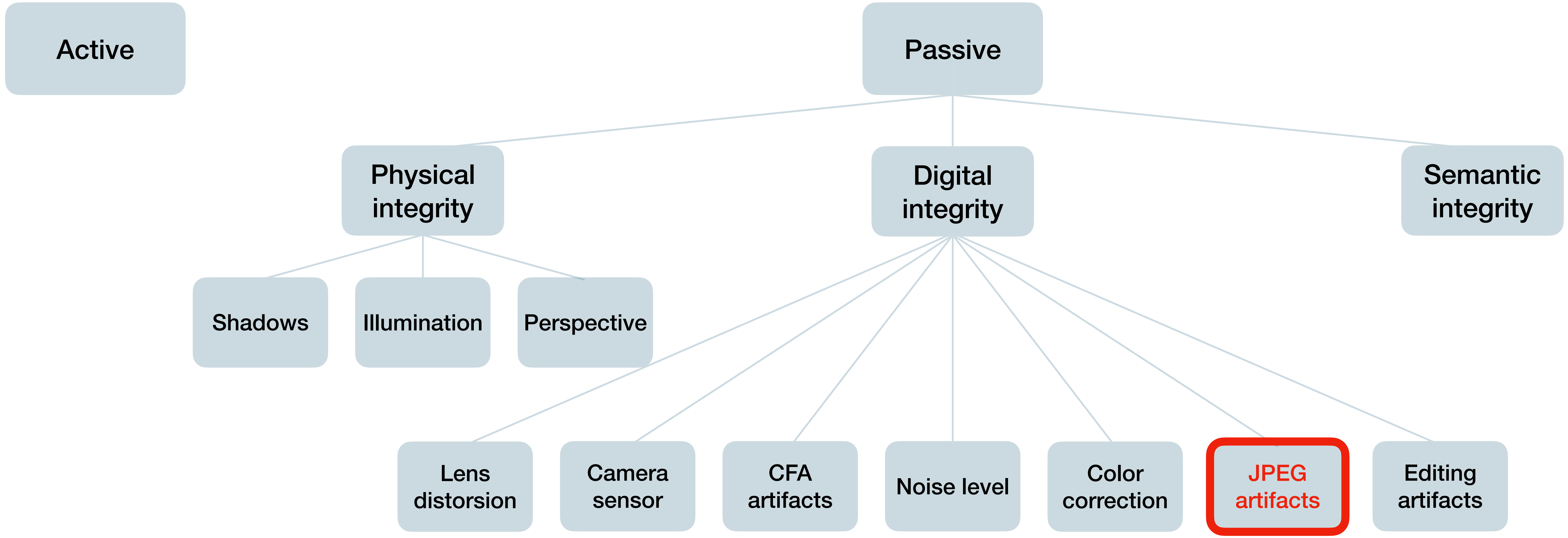


- The tools are “interesting” and “attractive”, but they are also “difficult to use”.
- They wish “more explanation”, “less false positives” and “interpretability”.

"It’s a bit hard to understand and therefore not as useful as it could be.” - AFP journalist

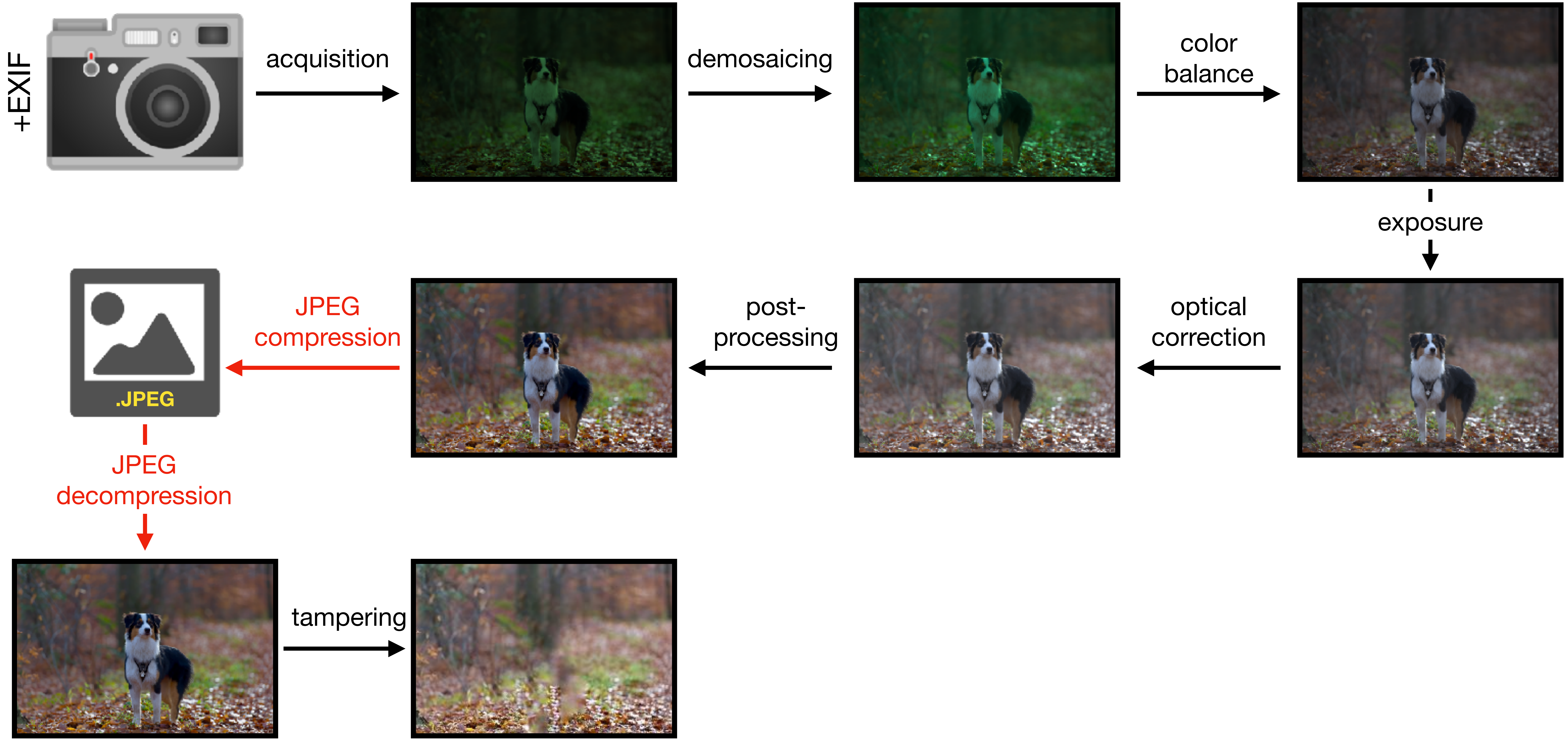
D. Teyssou et al. "Enhanced Image Forensic Tools for Fact-Checkers". TTO 2021.

Where do we stand?

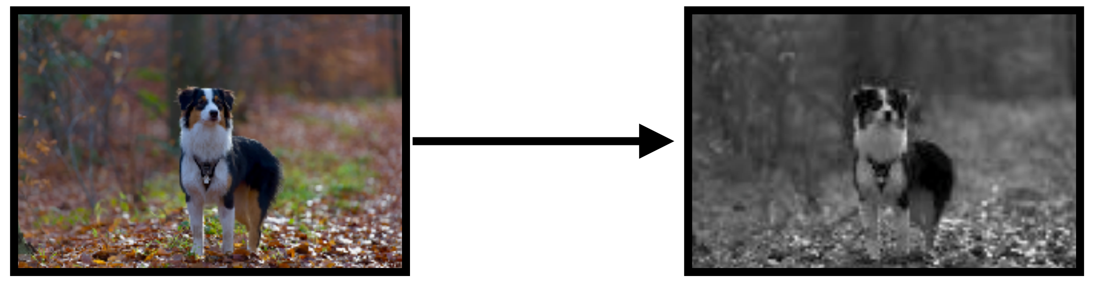


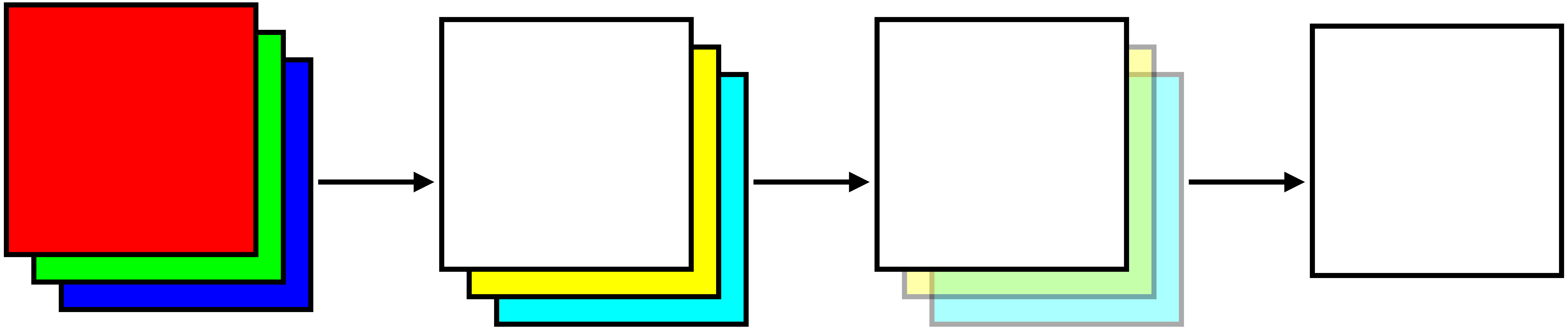
Automatic task-based algorithms with controlled false alarms.

Image processing pipeline



JPEG compression pipeline





Source image

RGB

Colorspace transformation

$\mathrm{YC_BC_R}$

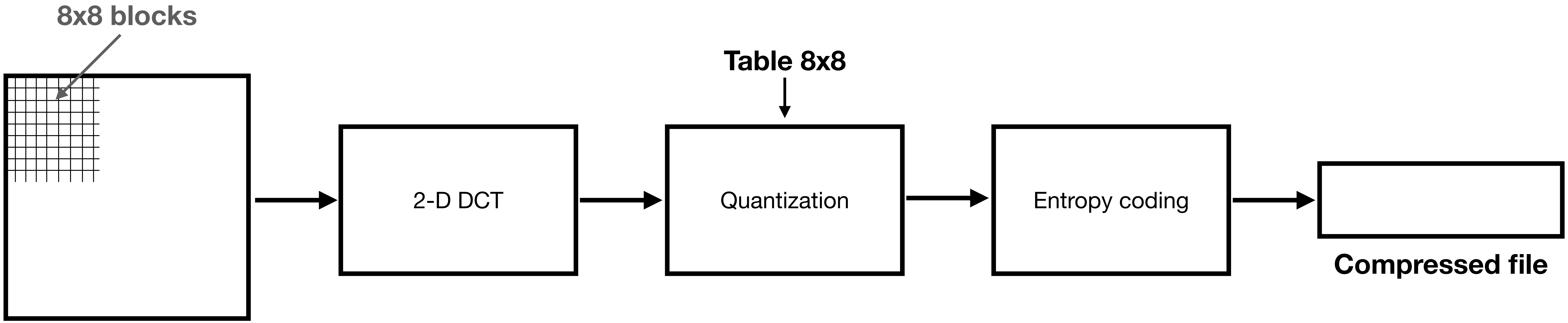
Color information sub-sampling

Luminance channel

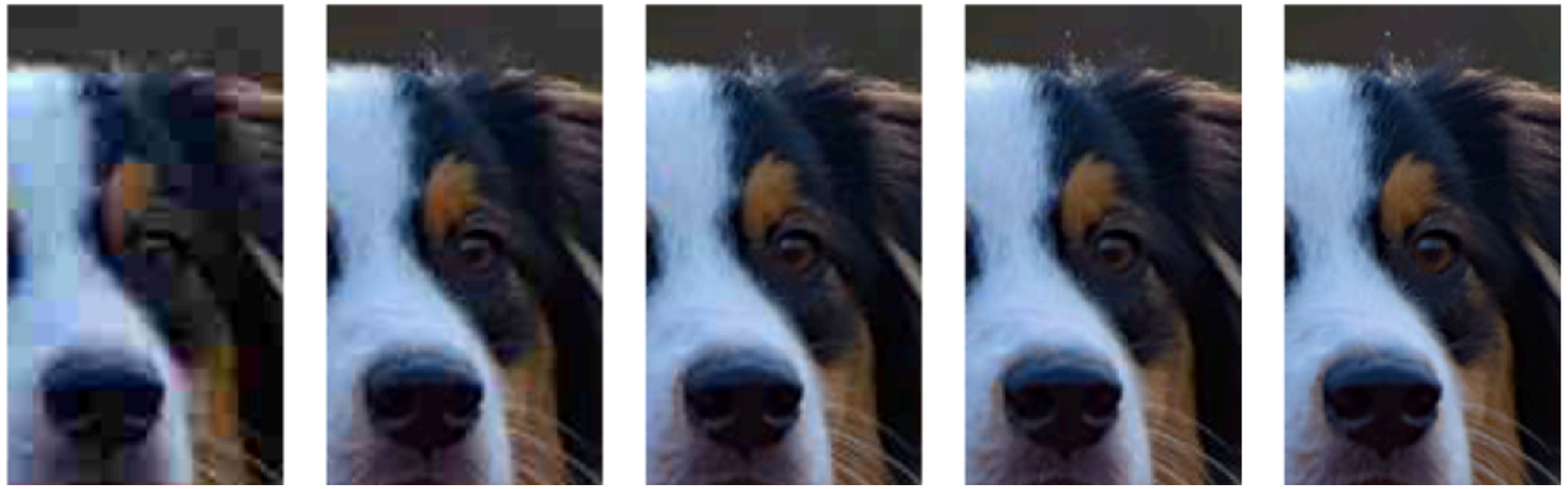
Y

$$\begin{pmatrix} Y \\ C_\mathrm{B} \\ C_\mathrm{R} \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ -0.169 & -0.331 & 0.5 \\ 0.5 & -0.419 & 0.081 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix} + \begin{pmatrix} 0 \\ 128 \\ 128 \end{pmatrix}$$

JPEG compression pipeline



Quality factor
QF = {1…100}



QF = 10
398 Ko

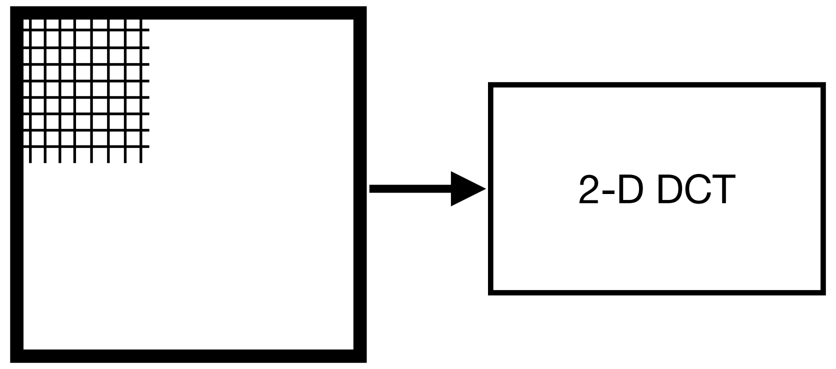
QF = 30
793 Ko

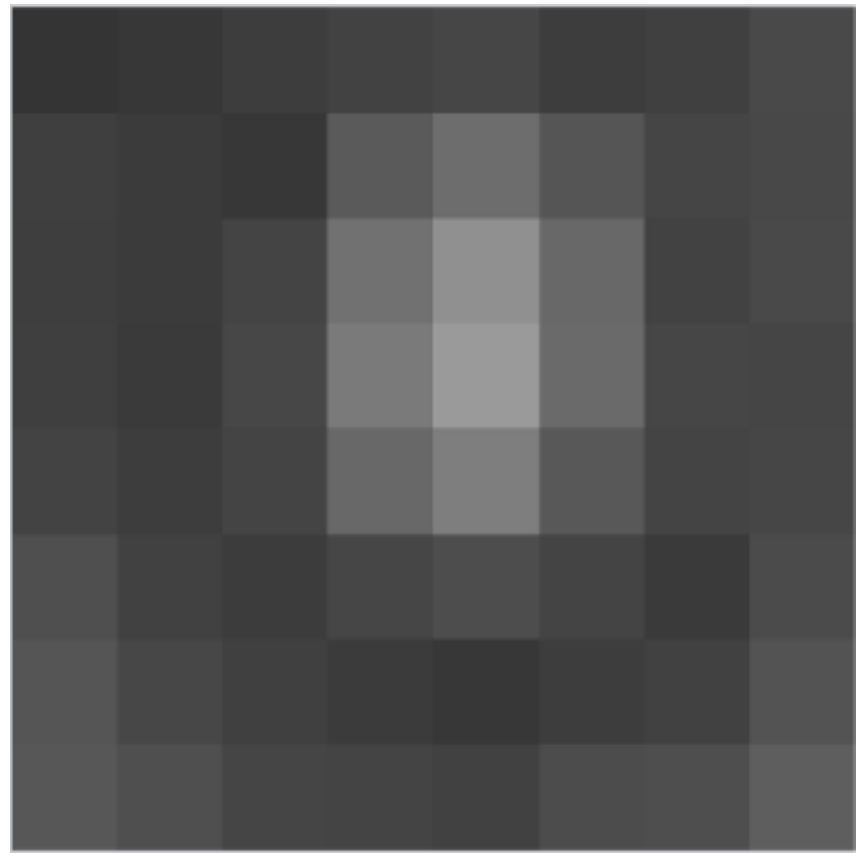
QF = 50
1.2 Mo

QF = 70
2.0 Mo

QF = 90
5.3 Mo

JPEG compression pipeline





8x8 block

-76	-73	-67	-62	-58	-67	-64	-55
-65	-69	-73	-38	-19	-43	-59	-56
-66	-69	-60	-15	16	-24	-62	-55
-65	-70	-57	-6	26	-22	-58	-59
-61	-67	-60	-24	-2	-40	-60	-58
-49	-63	-68	-58	-51	-60	-70	-53
-43	-57	-64	-69	-73	-67	-63	-45
-41	-49	-59	-60	-63	-52	-50	-34

Pixel values - 128: Y

2-D DCT

-415.4	-30.19	-61.20	27.24	56.12	-20.10	-2.39	0.46
4.47	-21.86	-60.76	10.25	13.15	-7.09	-8.54	4.88
-46.83	7.37	77.13	-24.56	-28.91	9.93	5.42	-5.65
-48.53	12.07	34.10	-14.76	-10.24	6.30	1.83	1.95
12.12	-6.55	-13.20	-3.95	-1.87	1.75	-2.79	3.14
-7.73	2.91	2.38	-5.94	-2.38	0.94	4.30	1.85
-1.03	0.18	0.42	-2.42	-0.88	-3.02	4.12	-0.66
-0.17	0.14	-1.07	-4.19	-1.17	-0.10	0.50	1.68

DCT coefficients: I

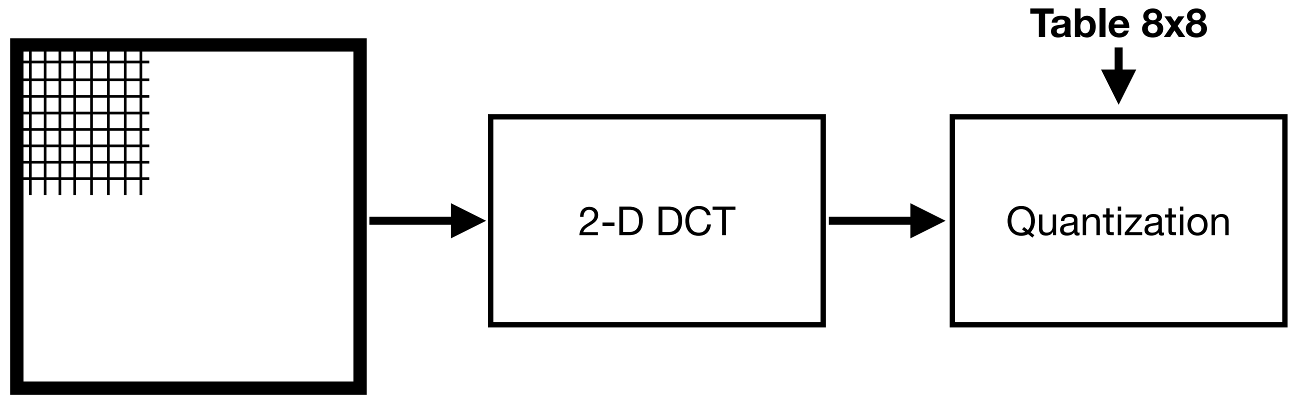
$$I(u,v) = \frac{1}{4} T_u T_v \sum_{i=0}^{7} \sum_{j=0}^{7} Y(i,j) \cos\left(\frac{(2i+1)u\pi}{16}\right) \cos\left(\frac{(2j+1)v\pi}{16}\right),$$

$$\text{where } T_u = \begin{cases} \frac{1}{\sqrt{2}} & \text{for } u = 0. \\ 1 & \text{for } u > 0. \end{cases}$$

u is the horizontal spatial frequency

v is the vertical spatial frequency

JPEG compression pipeline



Quantization table: Q

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

-415.4	-30.19	-61.20	27.24	56.12	-20.10	-2.39	0.46
4.47	-21.86	-60.76	10.25	13.15	-7.09	-8.54	4.88
-46.83	7.37	77.13	-24.56	-28.91	9.93	5.42	-5.65
-48.53	12.07	34.10	-14.76	-10.24	6.30	1.83	1.95
12.12	-6.55	-13.20	-3.95	-1.87	1.75	-2.79	3.14
-7.73	2.91	2.38	-5.94	-2.38	0.94	4.30	1.85
-1.03	0.18	0.42	-2.42	-0.88	-3.02	4.12	-0.66
-0.17	0.14	-1.07	-4.19	-1.17	-0.10	0.50	1.68

DCT coefficients: I

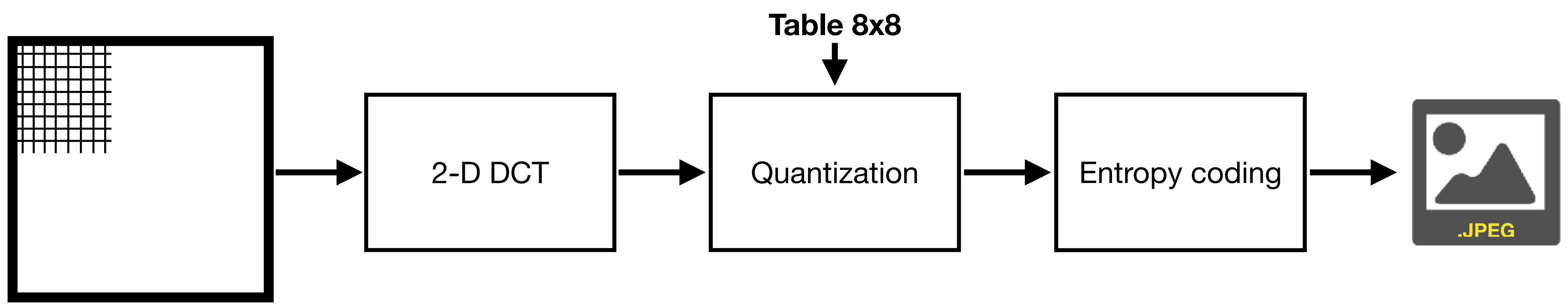
Quantization

$$D(u,v) = \text{round}\left(\frac{I(u,v)}{Q(u,v)}\right)$$

-26	-3	-6	2	2	-1	0	0
0	-2	-4	1	1	0	0	0
-3	1	5	-1	-1	0	0	0
-3	1	2	-1	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Quantized DCT coefficients: D

JPEG compression pipeline



Quantization table: Q

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

-415.4	-30.19	-61.20	27.24	56.12	-20.10	-2.39	0.46
4.47	-21.86	-60.76	10.25	13.15	-7.09	-8.54	4.88
-46.83	7.37	77.13	-24.56	-28.91	9.93	5.42	-5.65
-48.53	12.07	34.10	-14.76	-10.24	6.30	1.83	1.95
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-7.73	2.91	2.38	-5.94	-2.38	0.94	4.30	1.85
-1.03	0.18	0.42	-2.42	-0.88	-3.02	4.12	-0.66
-0.17	0.14	-1.07	-4.19	-1.17	-0.10	0.50	1.68

DCT coefficients: I

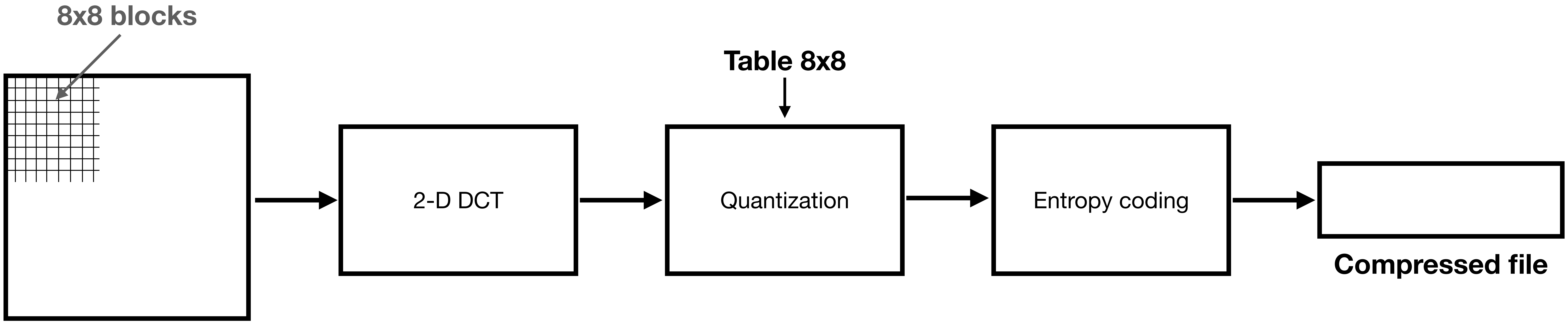
Quantization

$$D(u,v) = \text{round}\left(\frac{I(u,v)}{Q(u,v)}\right)$$

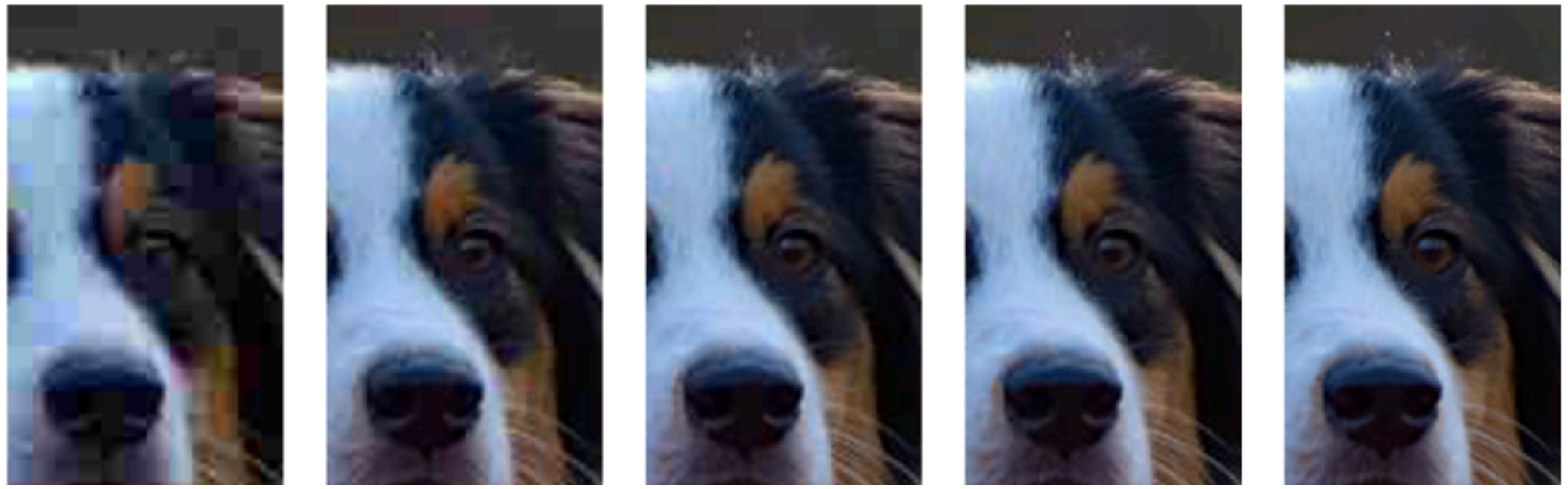
-26	-3	-6	2	2	-1	0	0
0	-2	-4	1	1	0	0	0
-3	1	5	-1	-1	0	0	0
-3	1	2	-1	0	0	0	0
1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Quantized DCT coefficients: D

JPEG compression pipeline



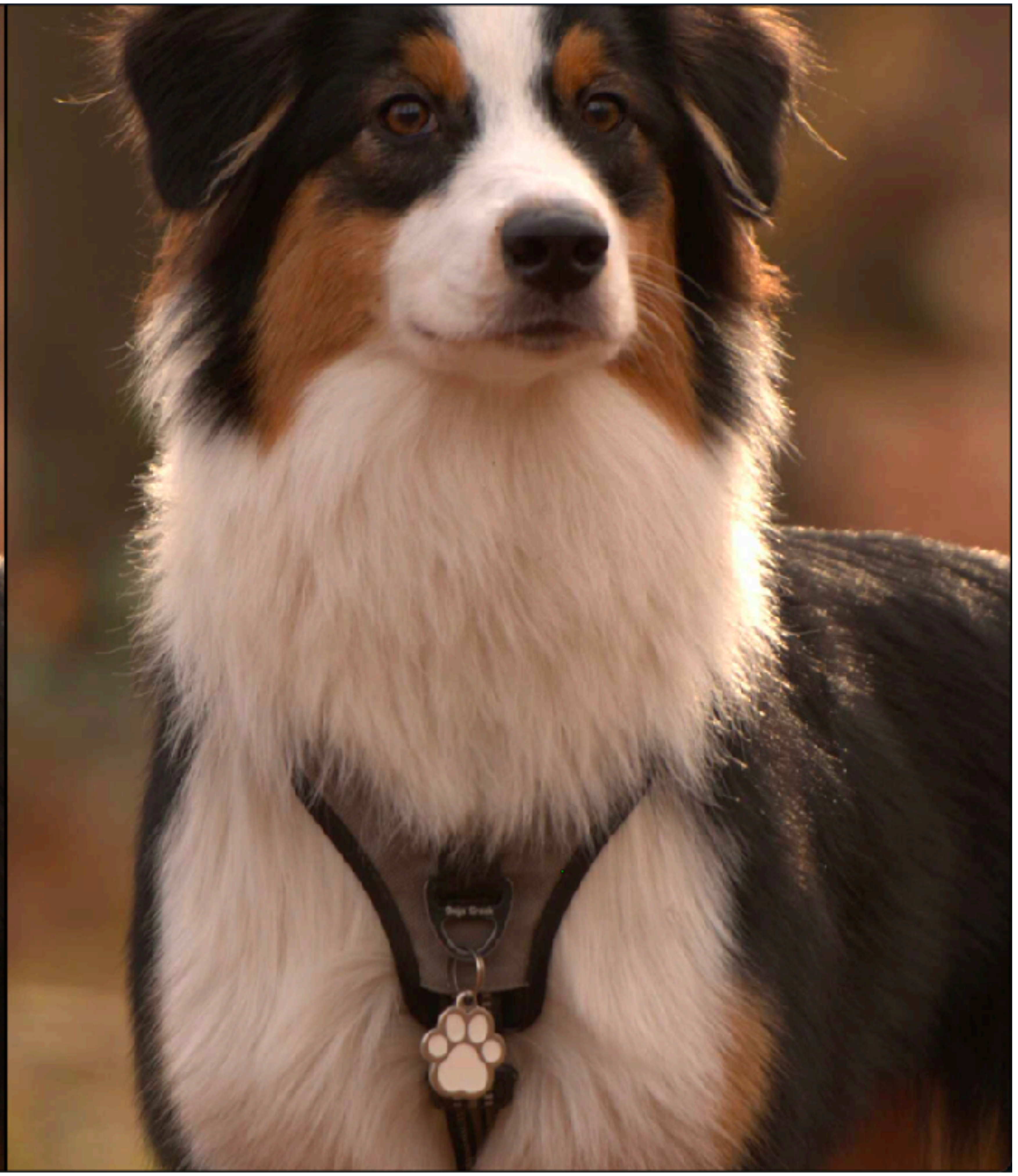
Quality factor
QF = {1…100}



QF = 10 398 Ko | QF = 30 793 Ko | QF = 50 1.2 Mo | QF = 70 2.0 Mo | QF = 90 5.3 Mo

JPEG grid artifact

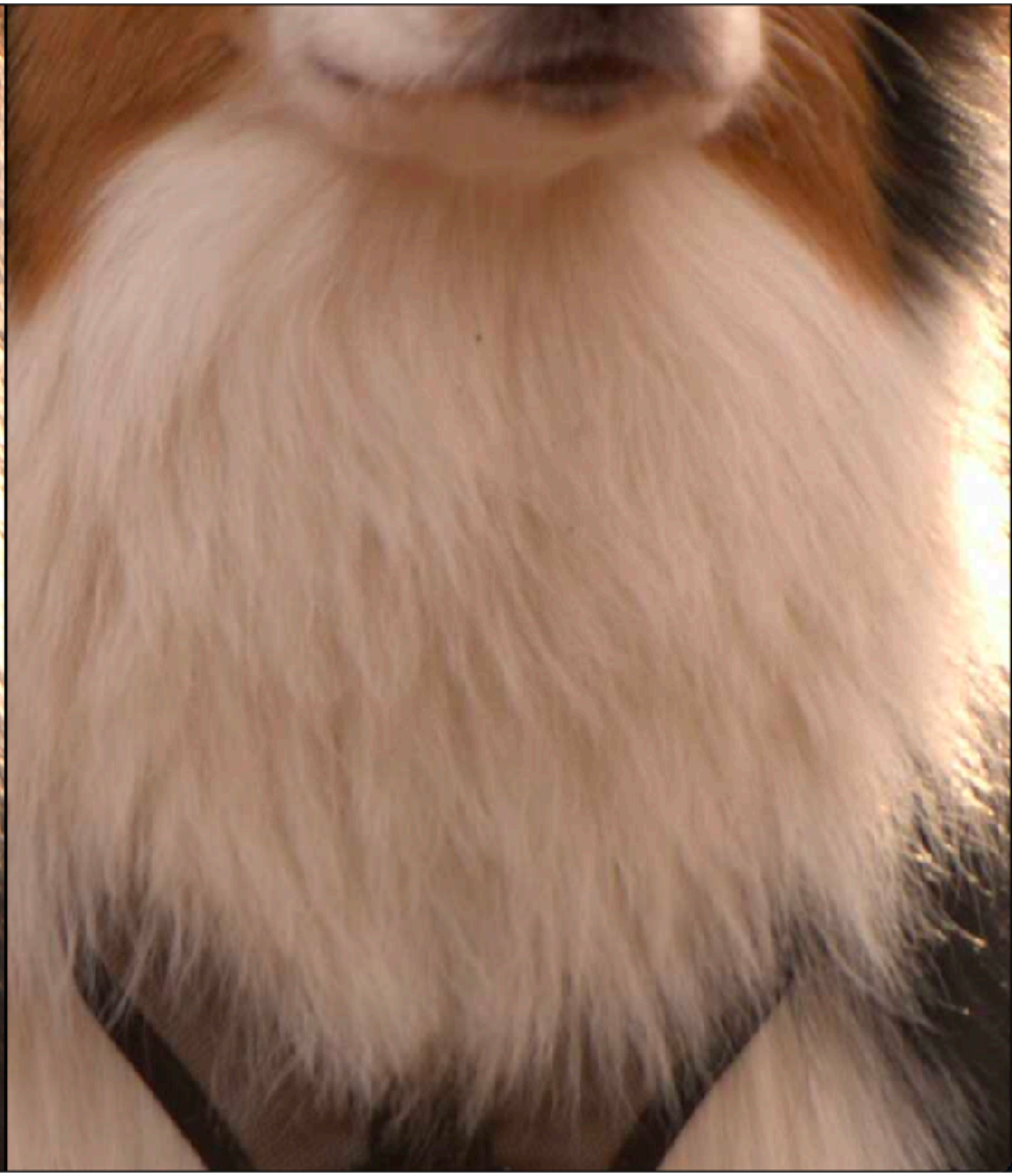
Uncompressed image



Compressed image at QF = 50

JPEG grid artifact

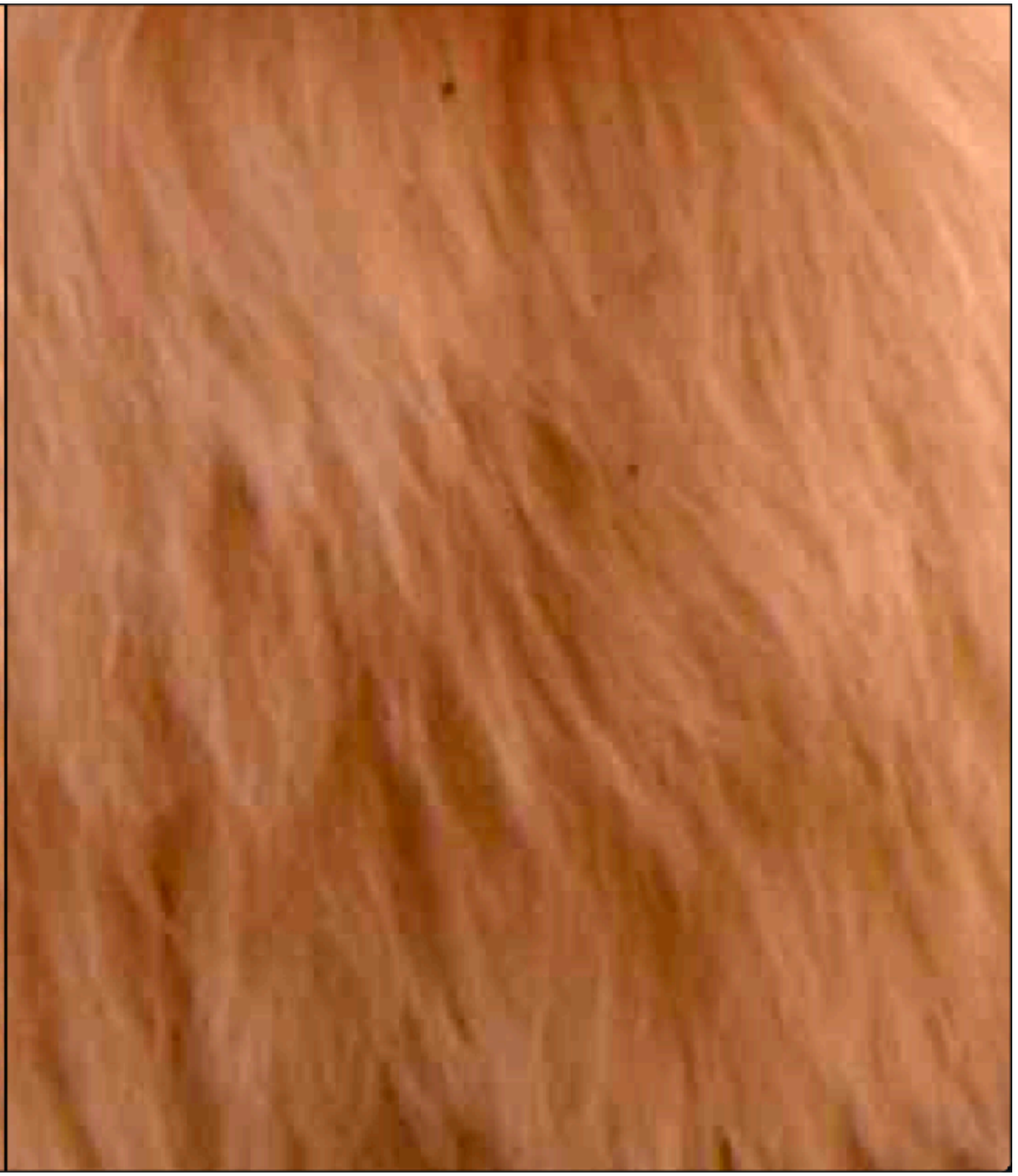
Uncompressed image



Compressed image at QF = 50

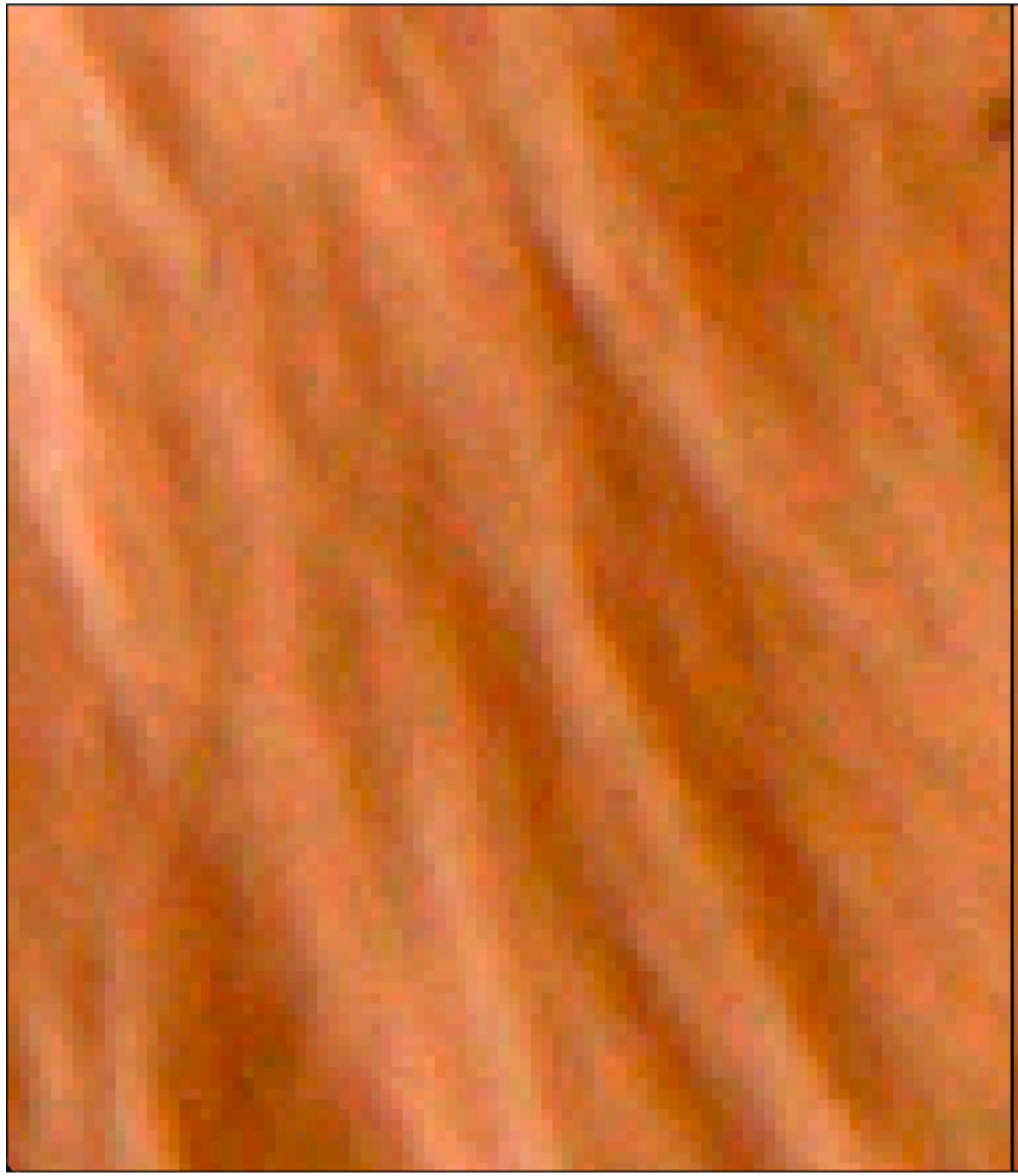
JPEG grid artifact

Uncompressed image



Compressed image at QF = 50

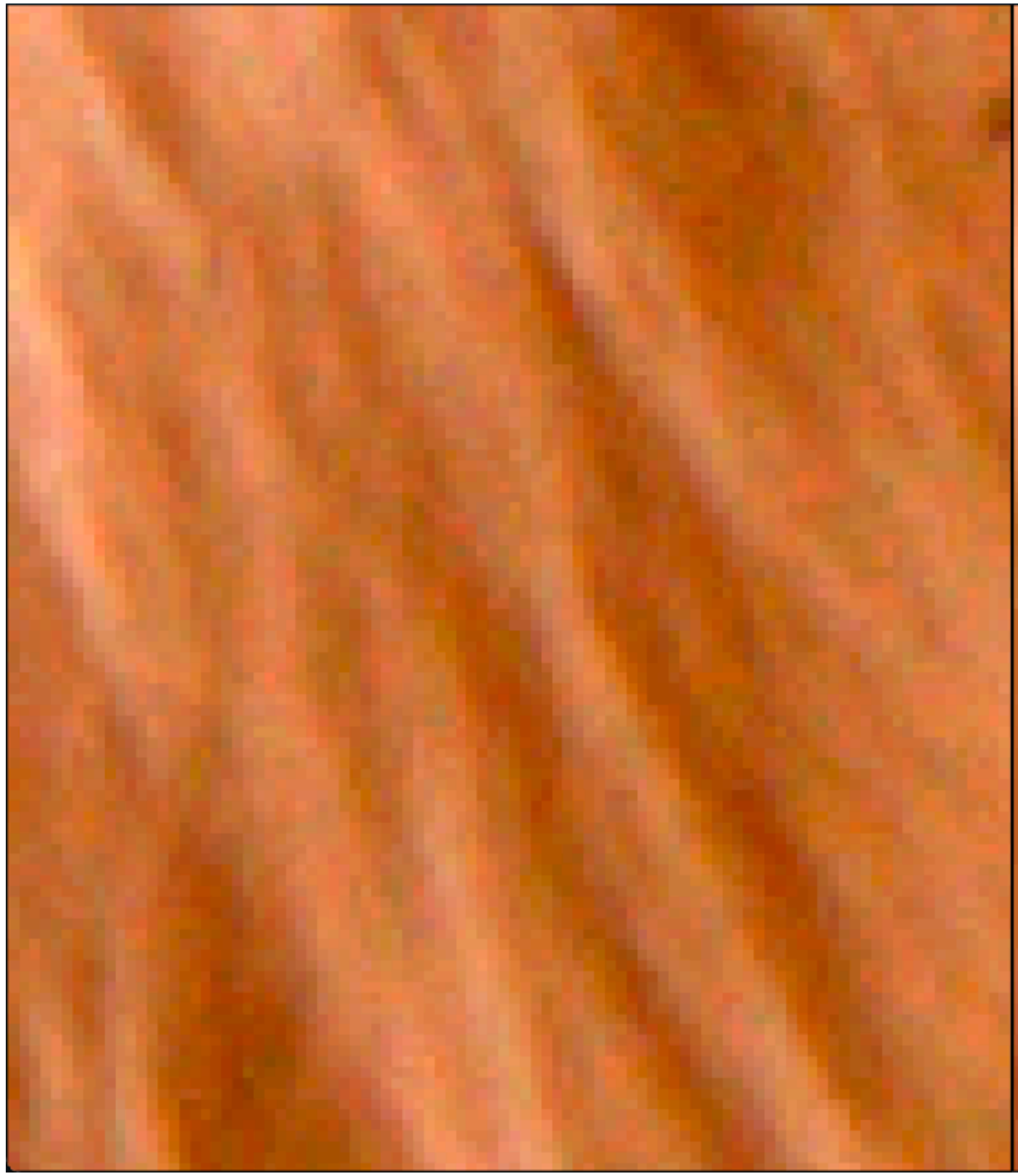
JPEG grid artifact



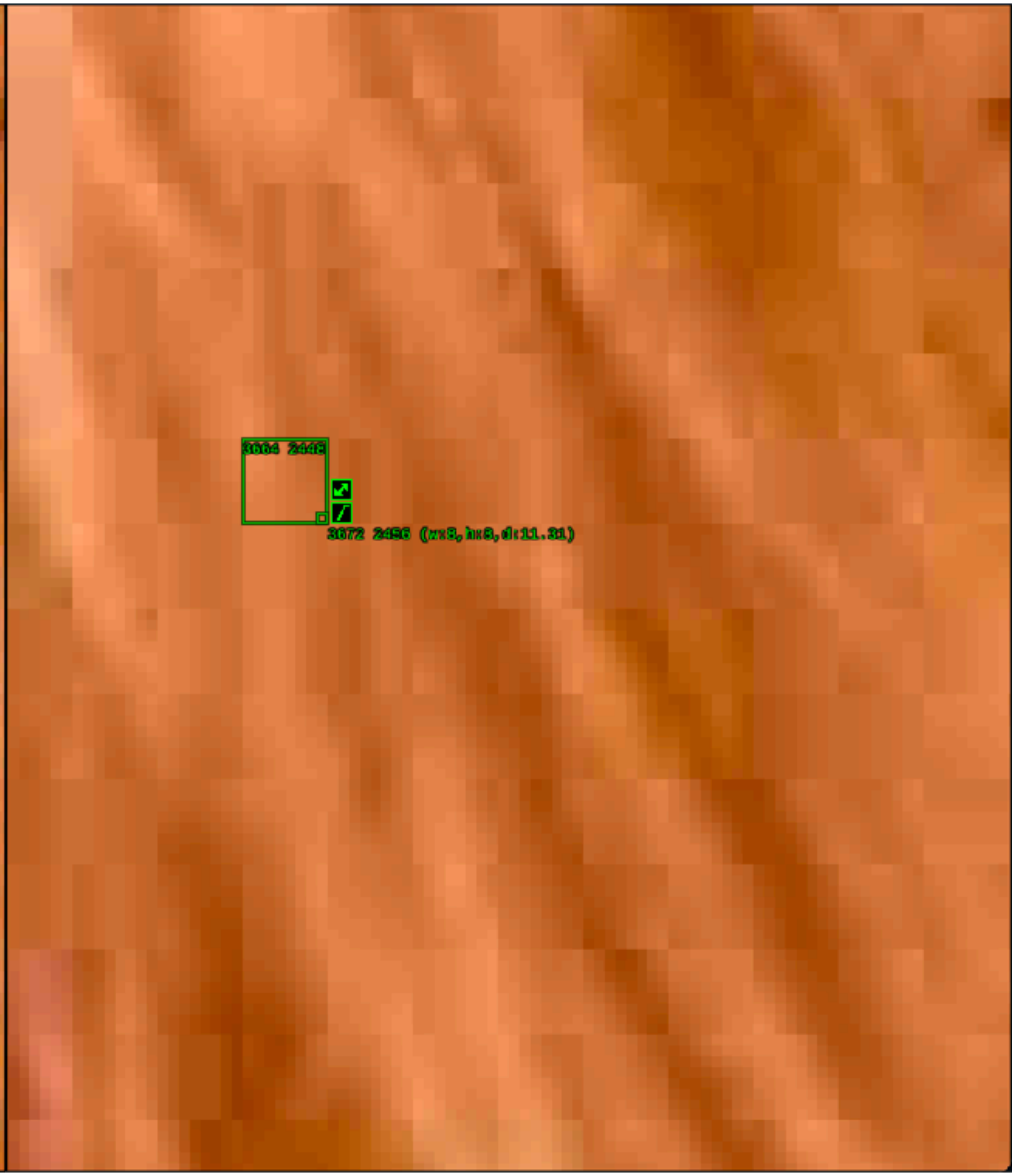
Uncompressed image

Compressed image at QF = 50

JPEG grid artifact

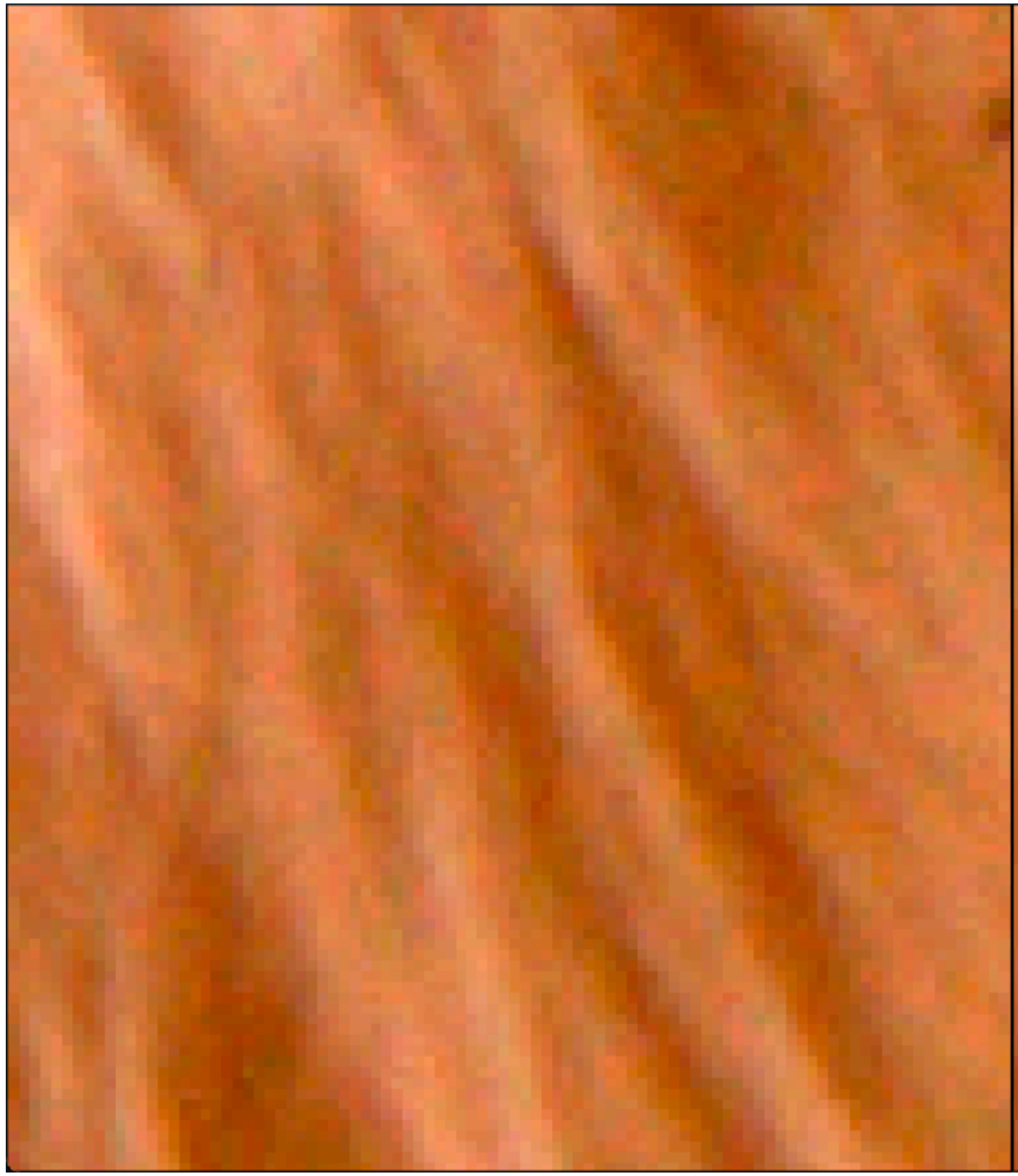


Uncompressed image

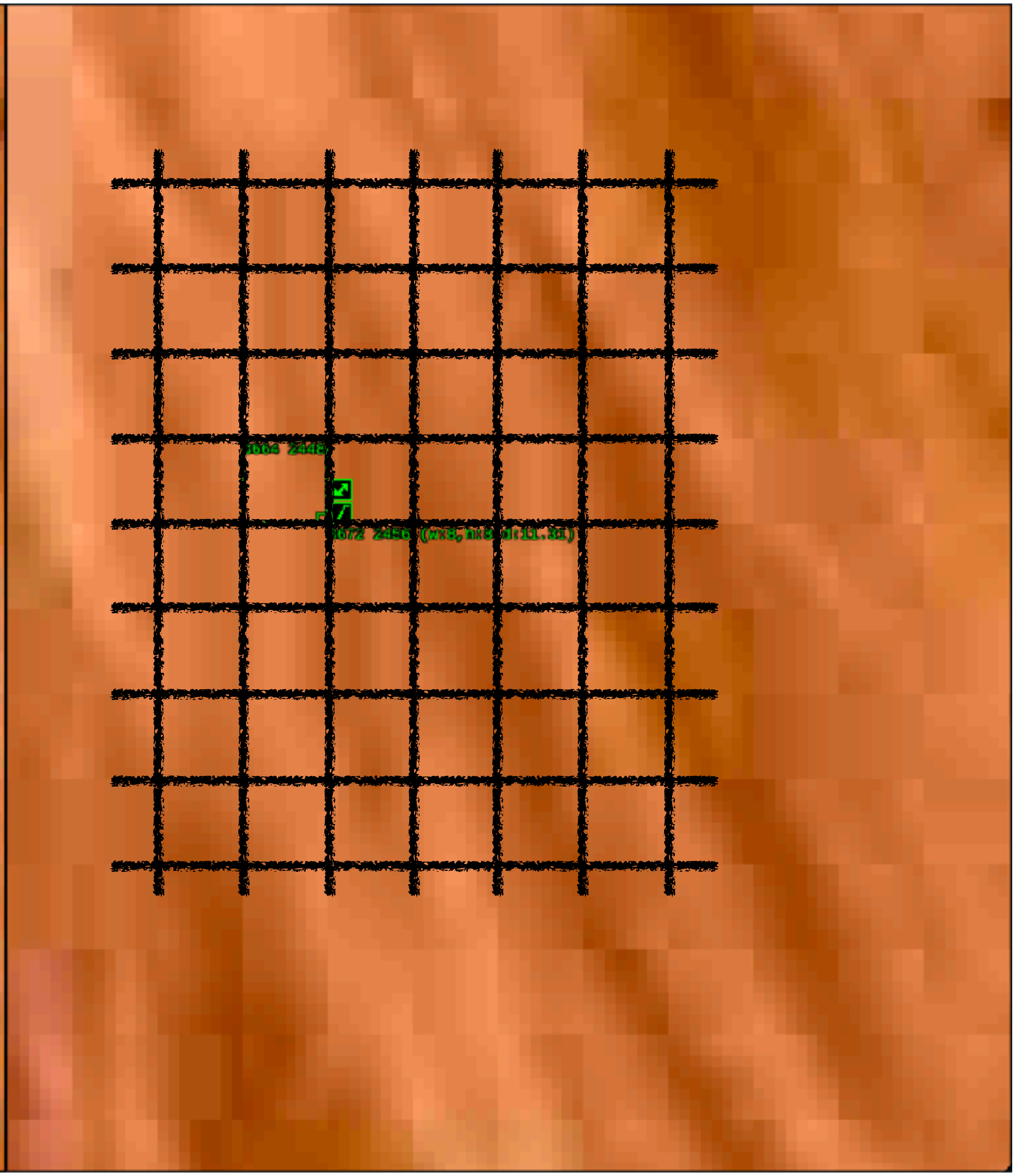


Compressed image at QF = 50

JPEG grid artifact

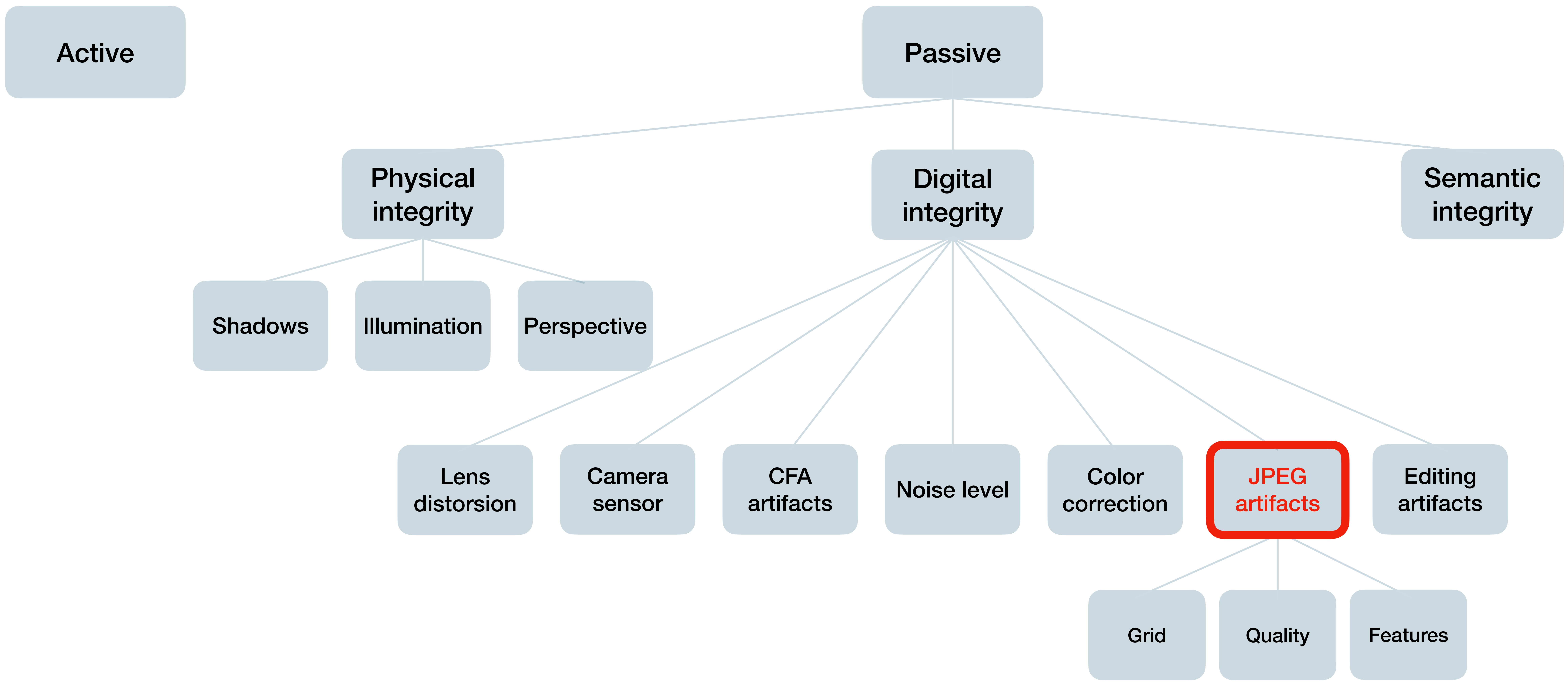


Uncompressed image

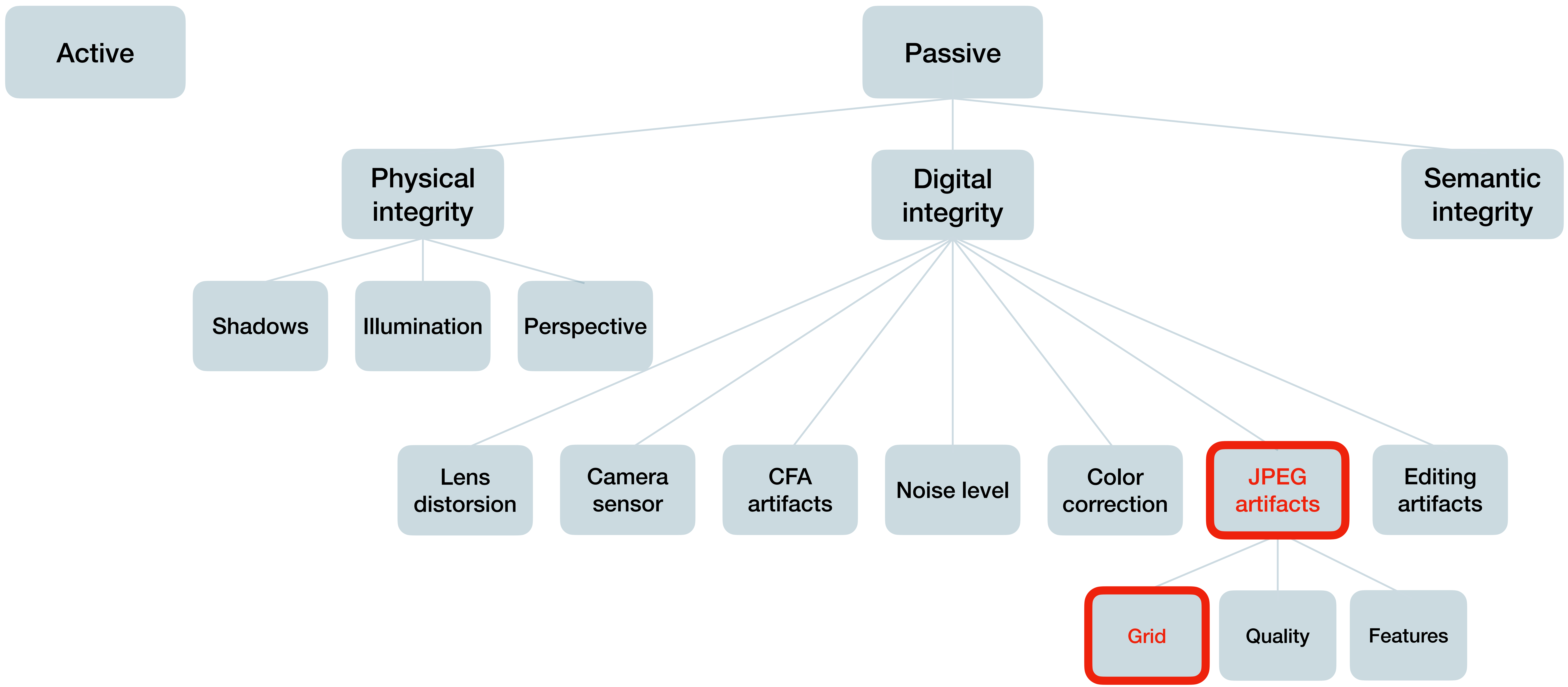


Compressed image at QF = 50

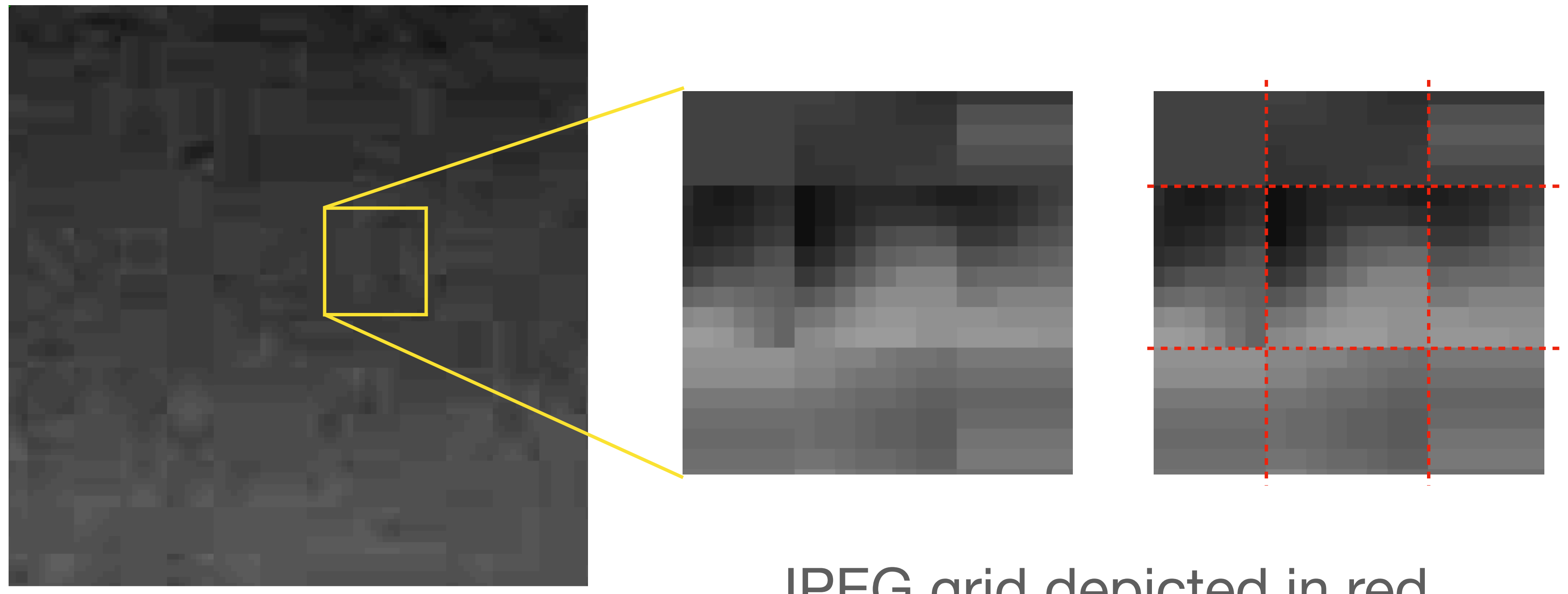
Where do we stand?



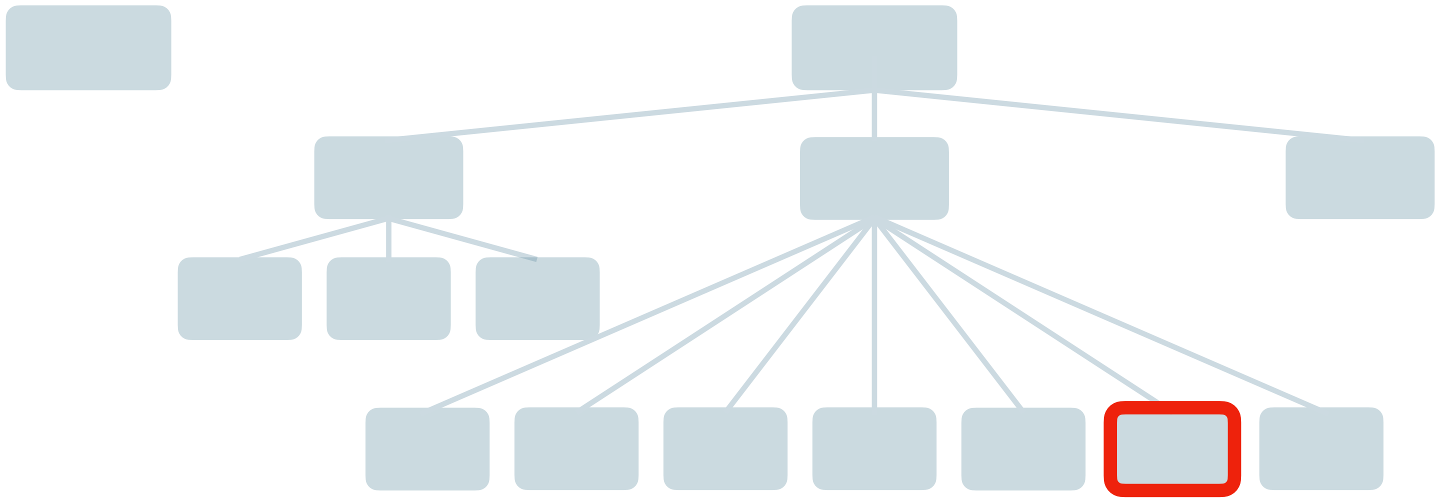
Where do we stand?



JPEG grid detection



JPEG grid depicted in red.



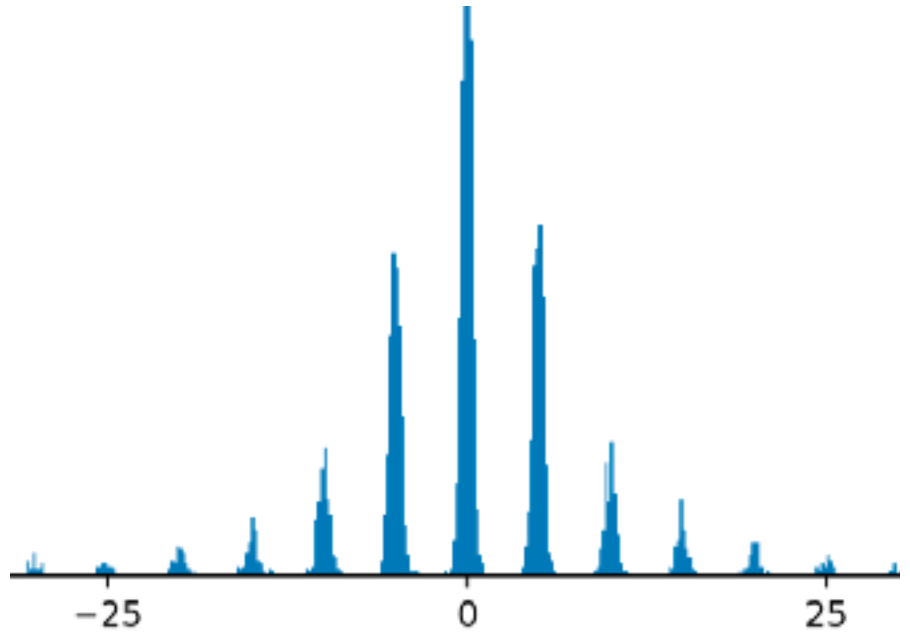
An overview on image forensics

JPEG grid

Block artifacts
Chapter 2

Cross-difference image
[Y.L. Chen et al. 2008].

DCT coefficients
Chapter 3



Histogram of a DCT coefficient.

File sizes
Chapter 4

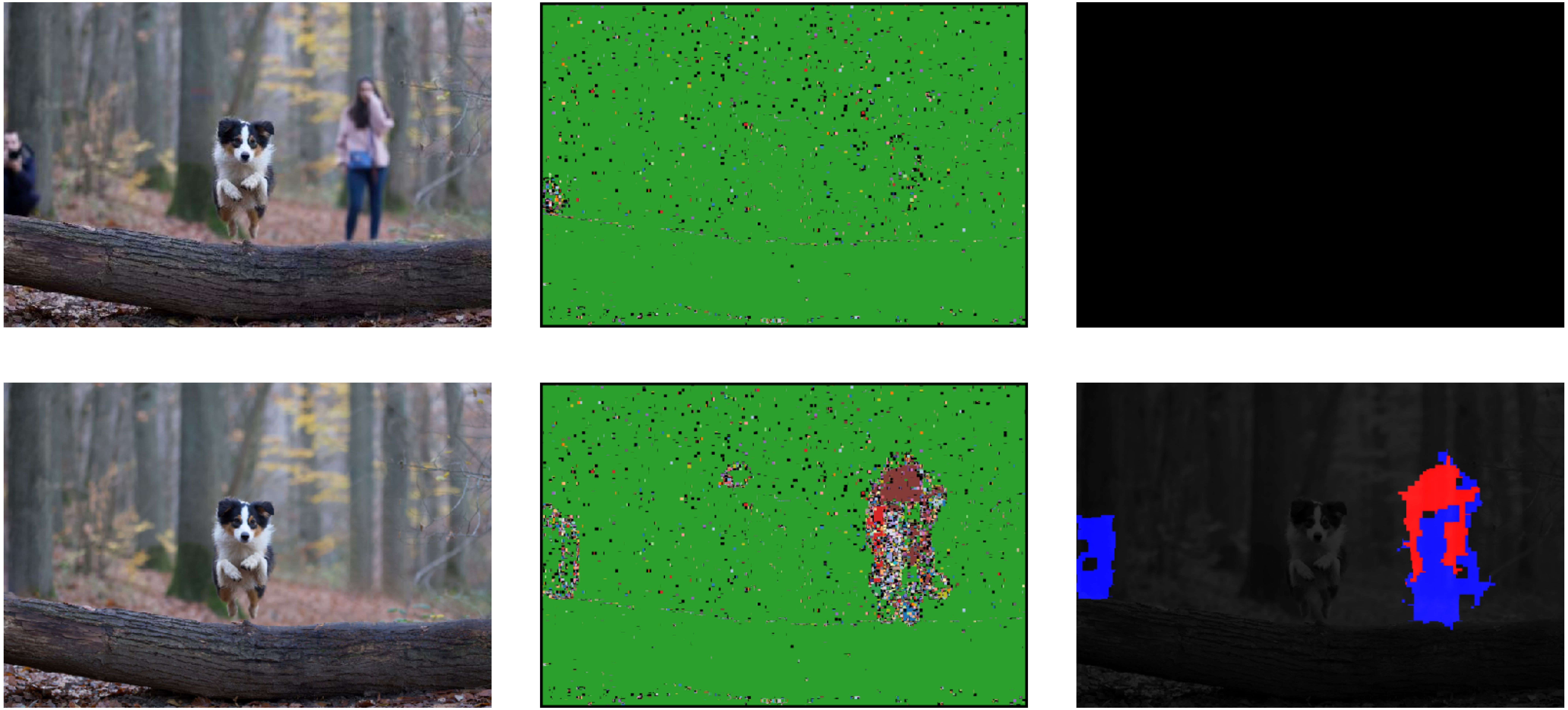
DCT zeros
Chapter 5

ZERO

Automatic JPEG grid-based algorithm with controlled false alarms.

Original image

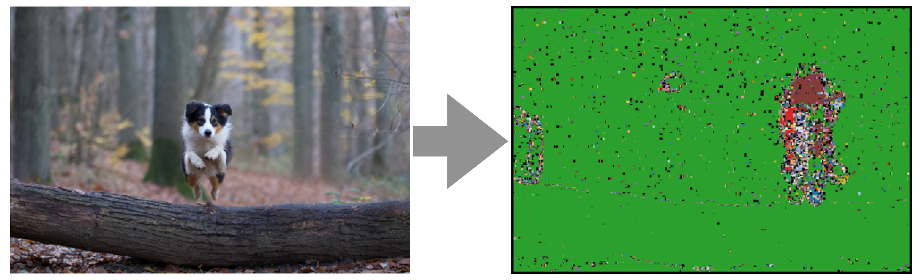
Forged image

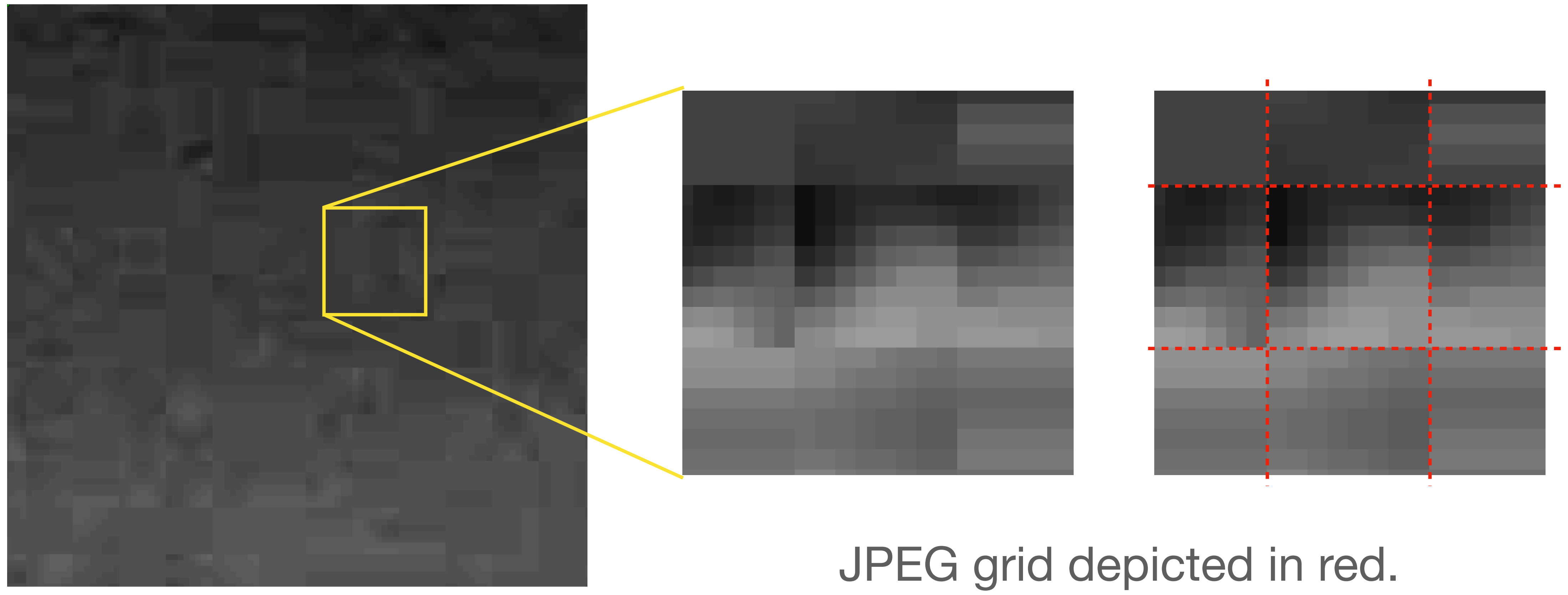


Vote maps

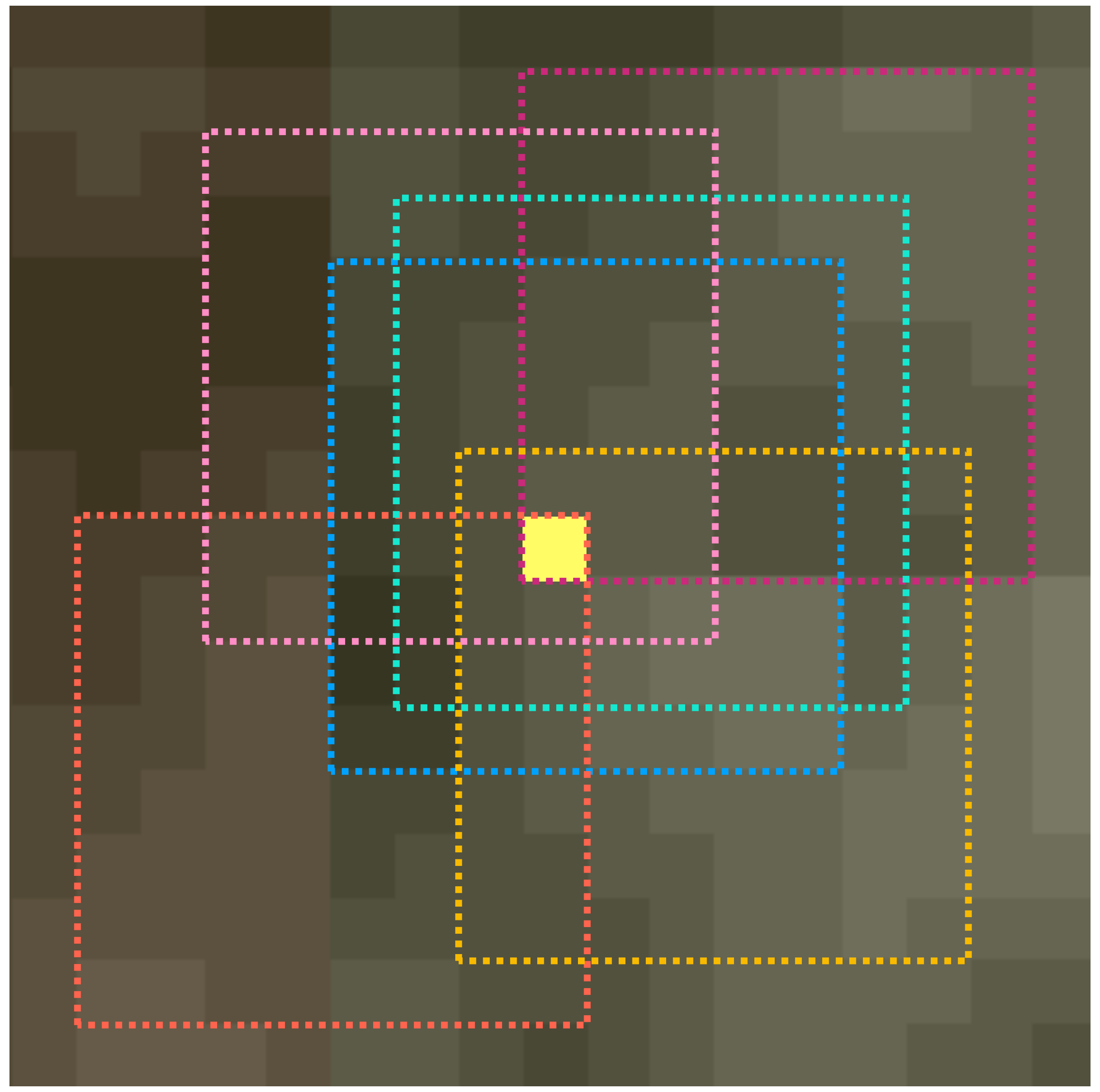
Detection results

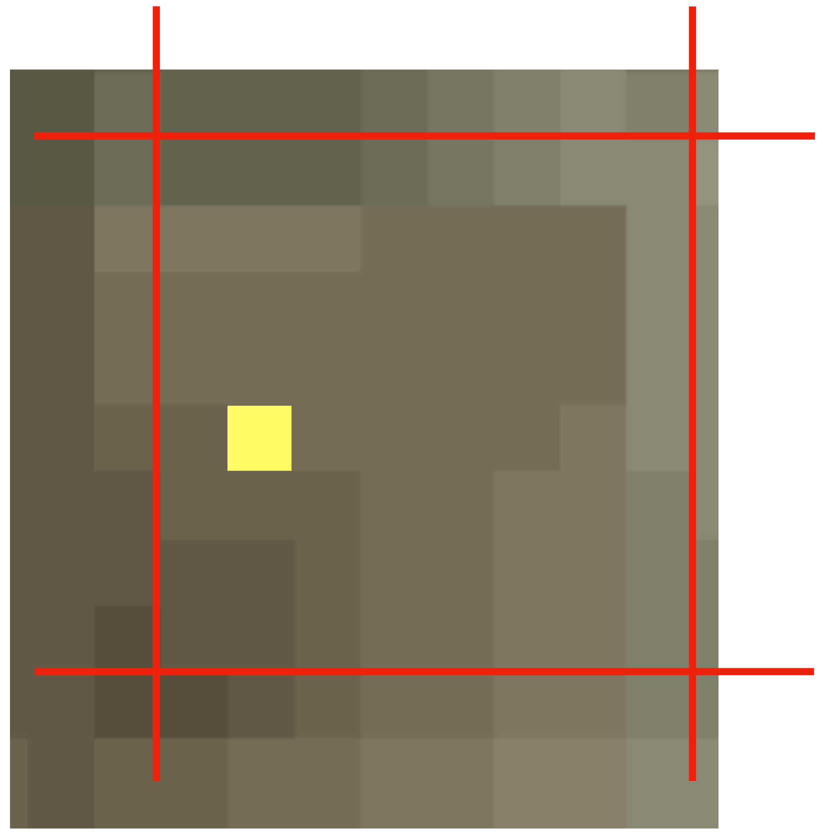
Voting process



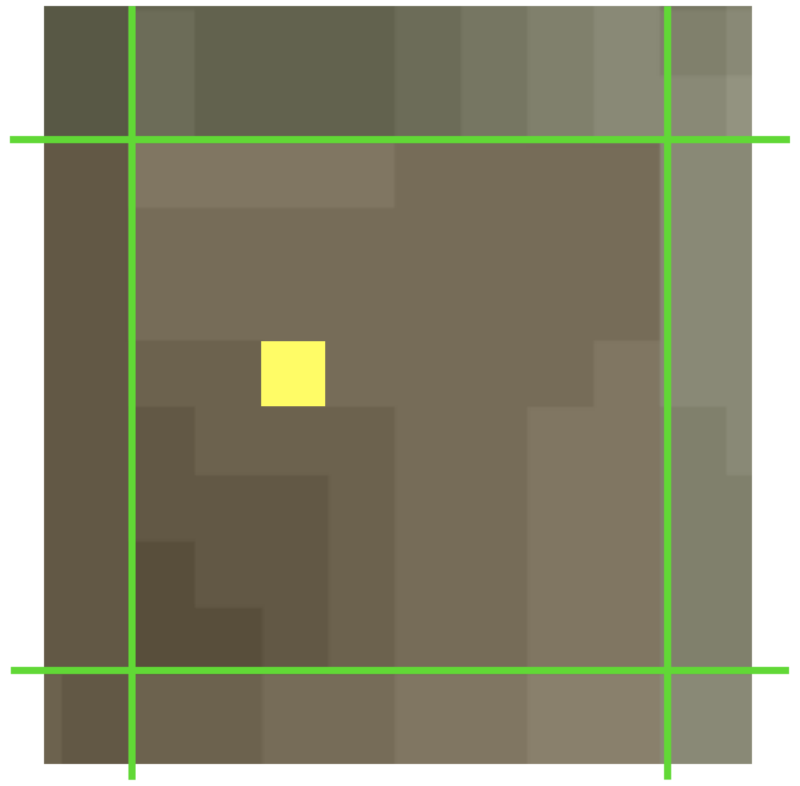


JPEG grid depicted in red.





(1,7)

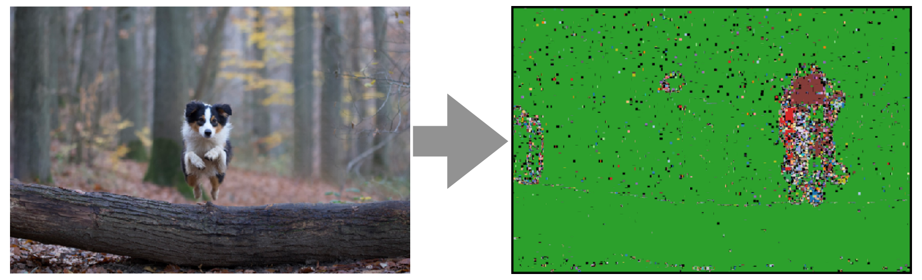


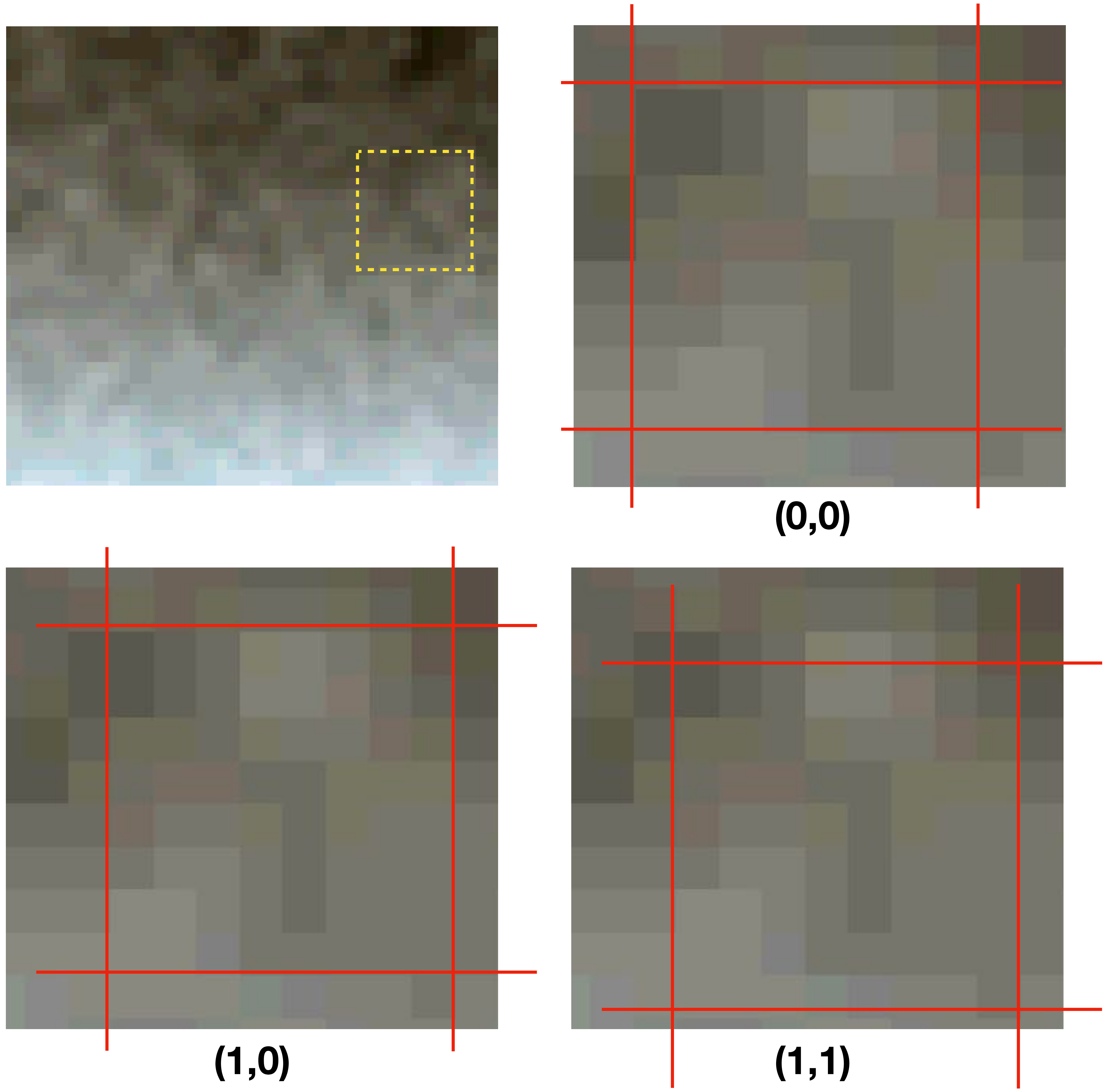
(0,0)

A grid ***g*** is defined by the coordinates of its origin **(g_x, g_y)**.

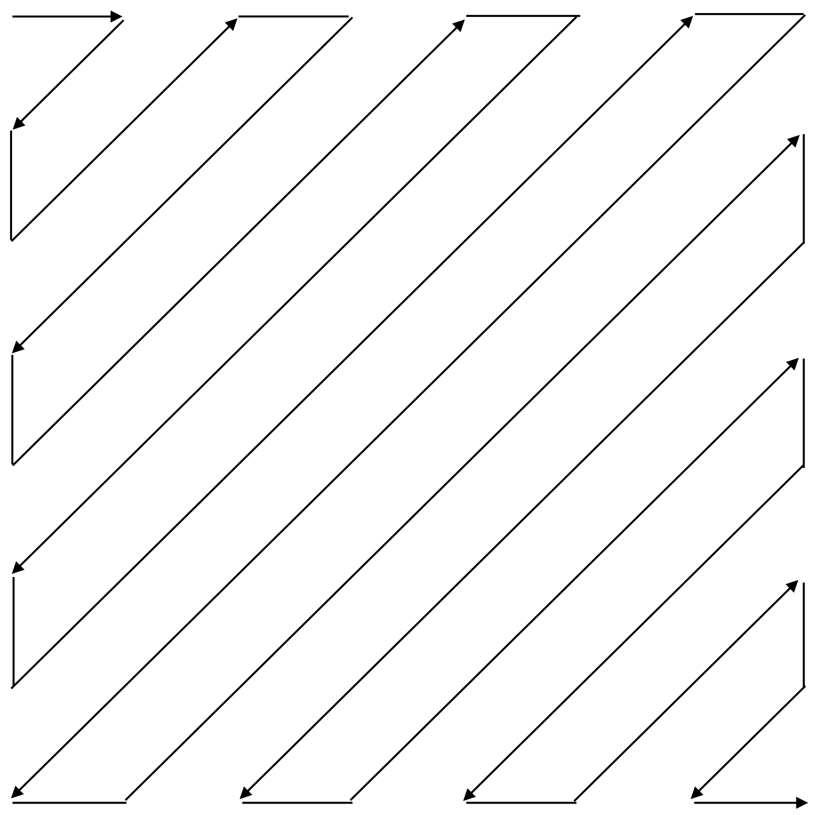
A pixel votes for the grid origin it belongs to.
There are 64 different candidates.

Voting process





Uncompressed image



641	-6	-15	1	-1	3	4	1
-34	-2	3	0	3	-1	-3	3
-15	1	4	2	-2	-3	2	-2
-7	3	4	-1	1	1	-1	2
-2	0	-4	-1	-2	4	0	-2
6	4	2	-3	1	-2	1	-1
4	2	-1	-2	1	2	0	-1
3	1	-1	-4	0	2	0	2

Uncompressed

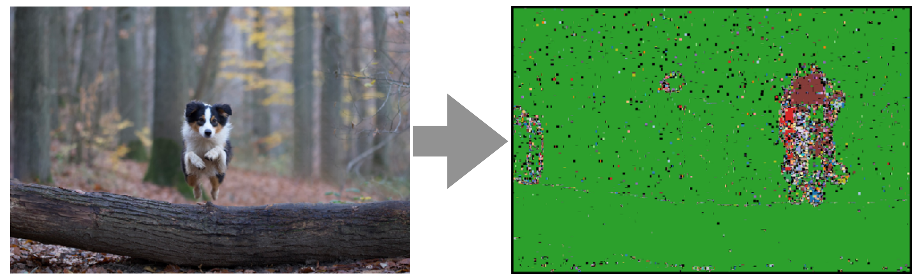
589	3	6	-3	0	2	-2	0
-16	6	0	4	-1	-1	-2	-2
32	-1	4	-4	-1	1	-2	0
-4	-3	4	1	-1	-2	-4	2
-12	-15	0	3	-2	-3	-1	-1
-21	-11	1	3	-2	-4	-1	1
-23	5	8	2	1	-2	-1	0
-6	7	2	0	2	-1	0	1

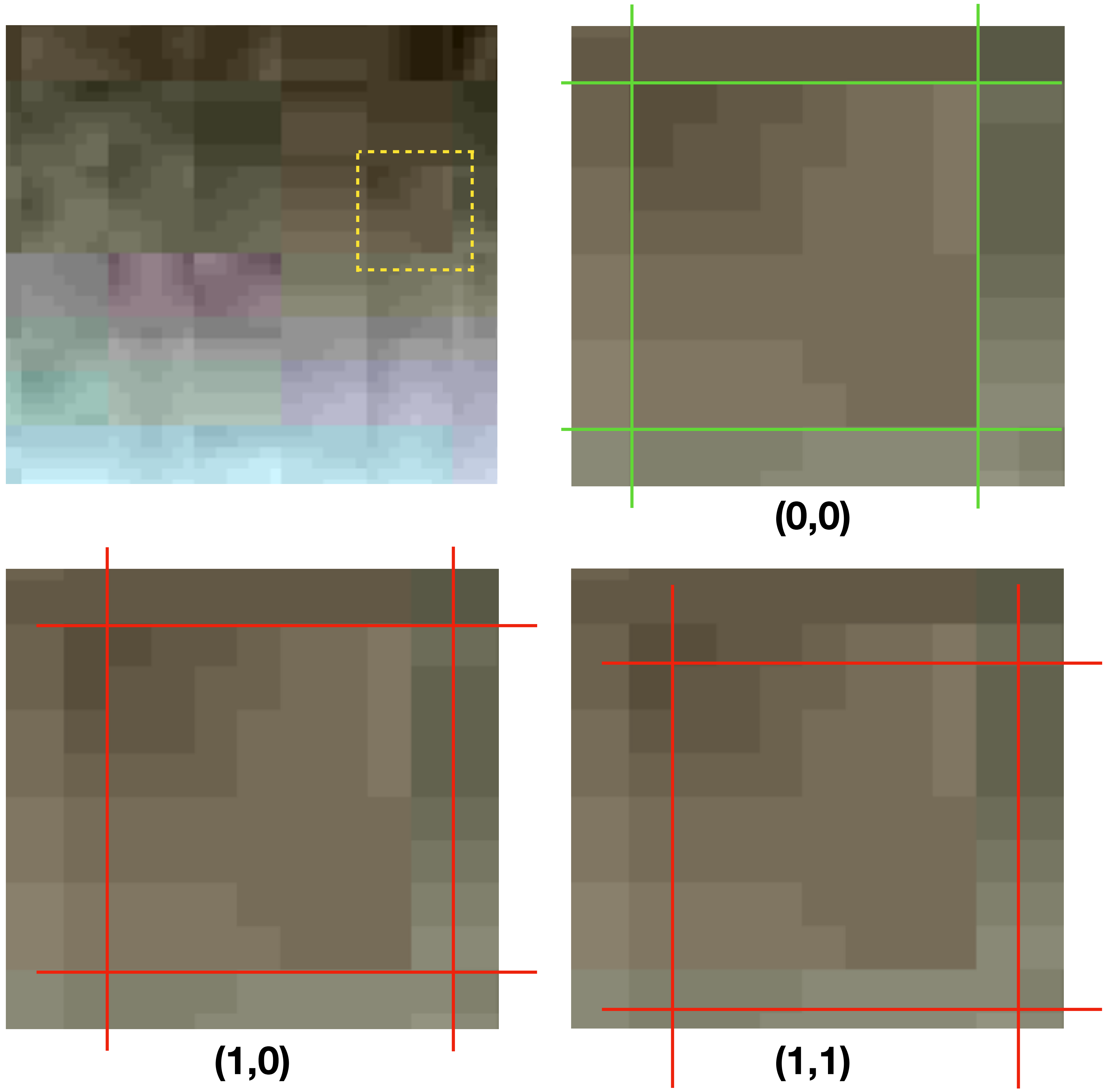
Uncompressed

641	-6	-15	1	-1	3	4	0
-34	-2	3	0	3	-1	-3	0
-15	1	4	2	-2	-3	2	-2
-7	3	4	-1	1	1	-1	2
-2	0	-4	-1	-2	4	0	-2
6	4	2	-3	1	-2	1	-1
4	2	-1	-2	1	2	0	-1
3	1	-1	0	1	2	0	0

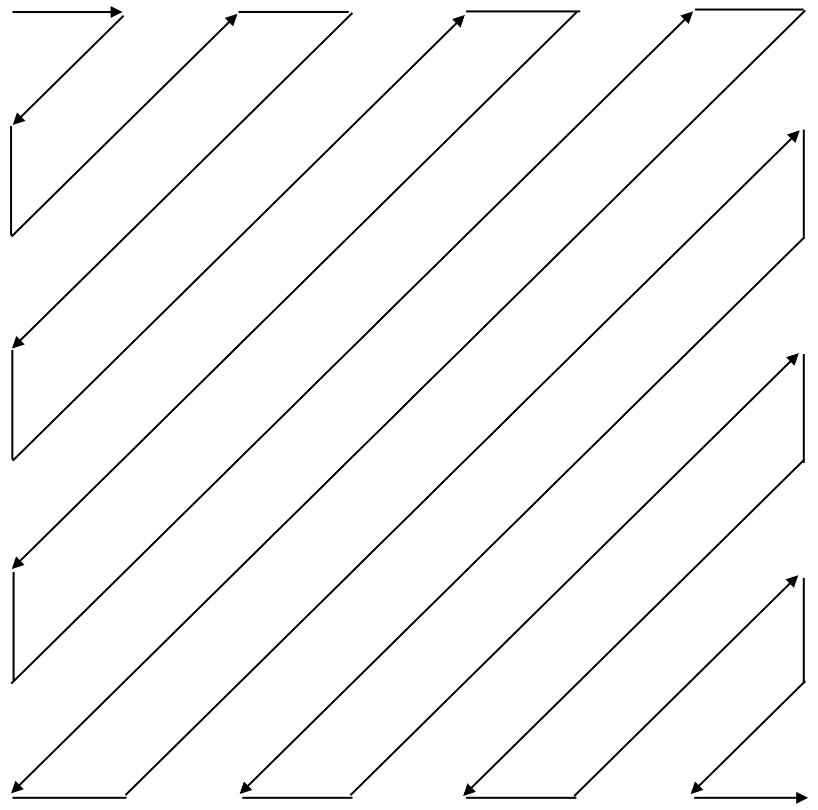
Uncompressed

Voting process





Compressed image



586	-3	6	-1	0	1	-1	1
-15	5	-1	8	0	0	0	1
30	1	6	0	0	0	0	0
-7	-7	0	0	0	-1	0	0
-14	-18	1	0	0	0	0	0
-20	-14	0	0	0	0	0	0
-20	0	0	0	0	0	0	0
0	0	0	-1	0	0	0	0

Compressed correct position

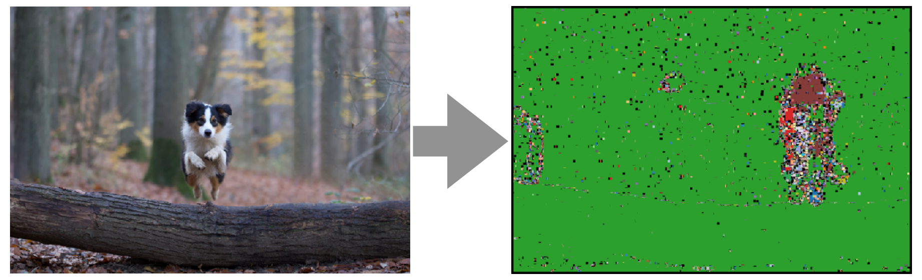
589	3	6	-3	0	2	-2	0
-16	6	0	4	-1	0	-2	-2
32	-1	4	-4	-1	1	-2	1
-4	-9	4	1	-1	-2	-4	0
-12	-15	4	0	-2	-3	-1	-1
-21	-11	7	3	-2	-4	-1	1
-23	5	8	2	1	-2	-1	0
-6	7	2	2	0	-1	0	1

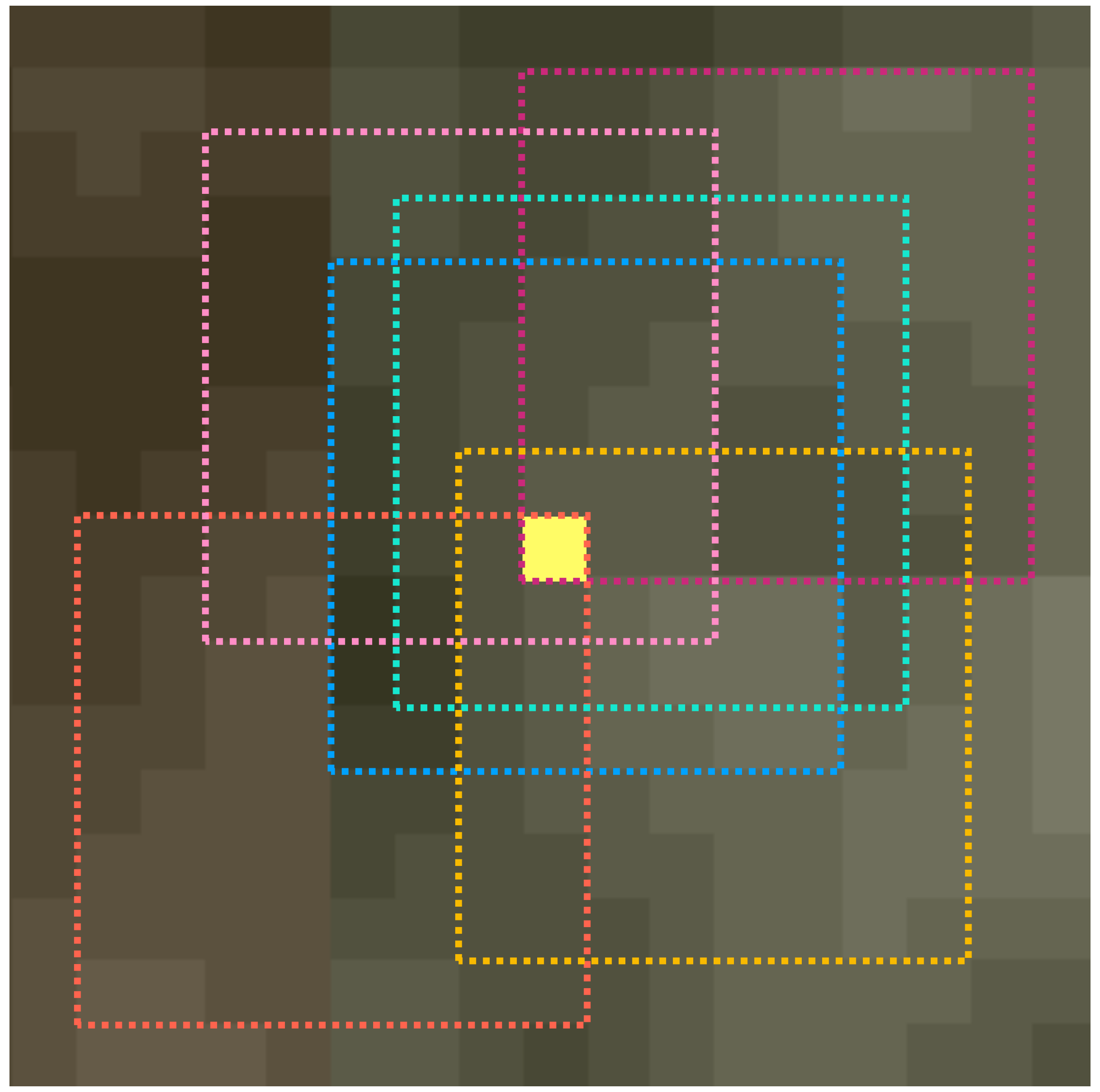
Compressed wrong position

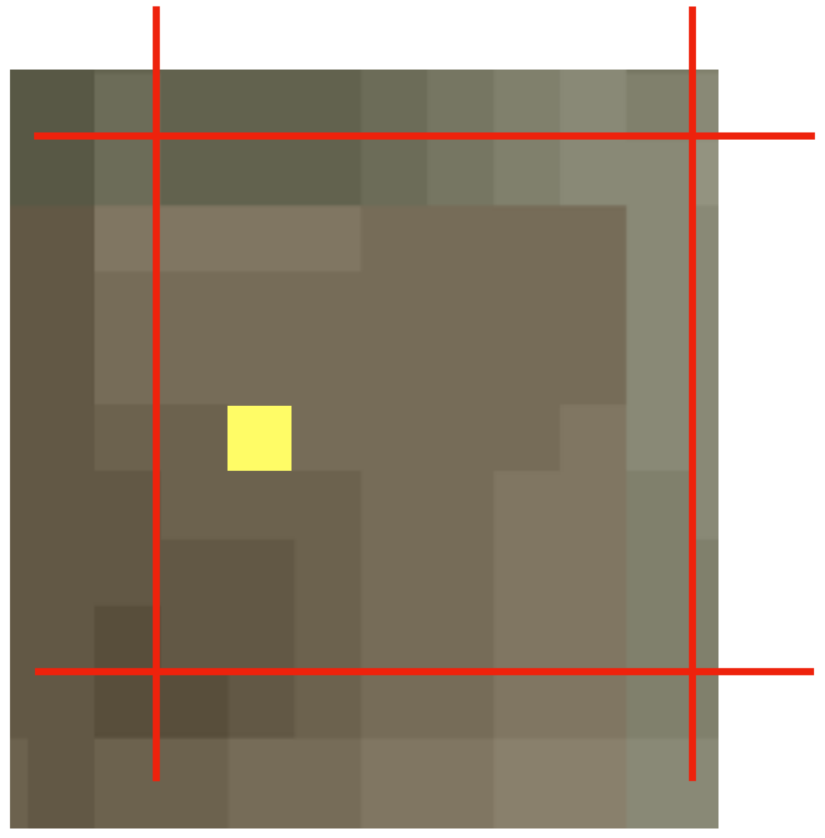
641	-6	-15	1	-1	3	4	0
-34	-2	3	0	3	-1	-3	1
-15	1	4	2	-2	-3	2	-2
-7	3	4	-1	1	1	-1	2
-2	0	-4	-1	-2	4	0	-2
6	4	2	-3	1	-2	1	-1
4	0	-1	-2	0	2	0	-1
3	1	-1	1	0	2	1	0

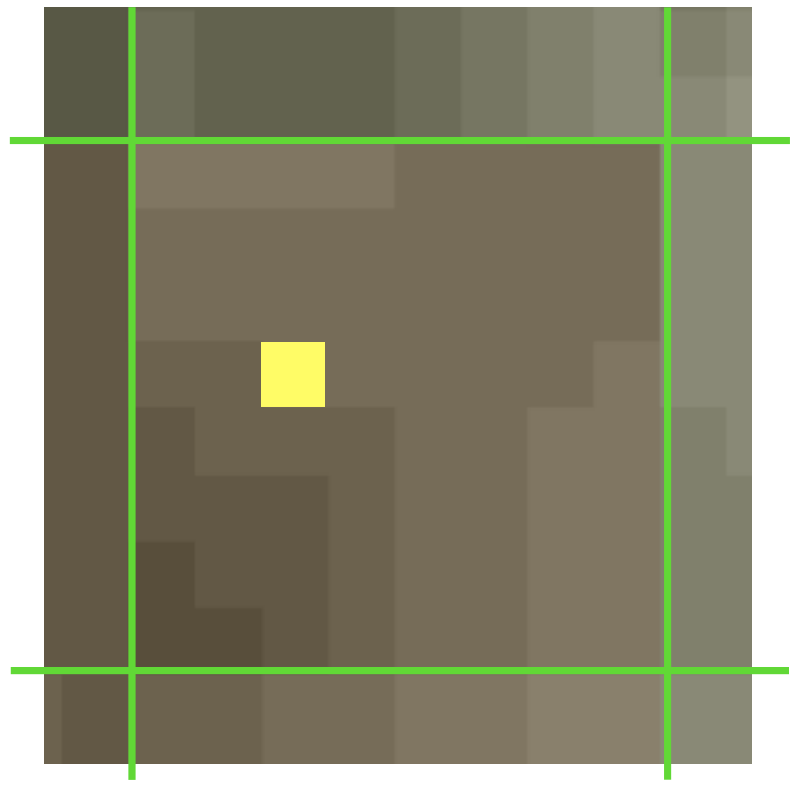
Compressed wrong position

Voting process



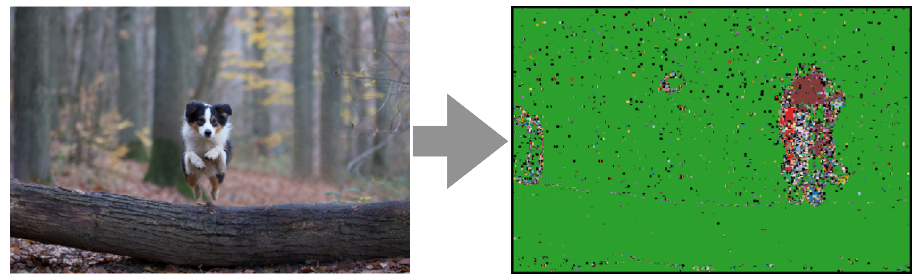




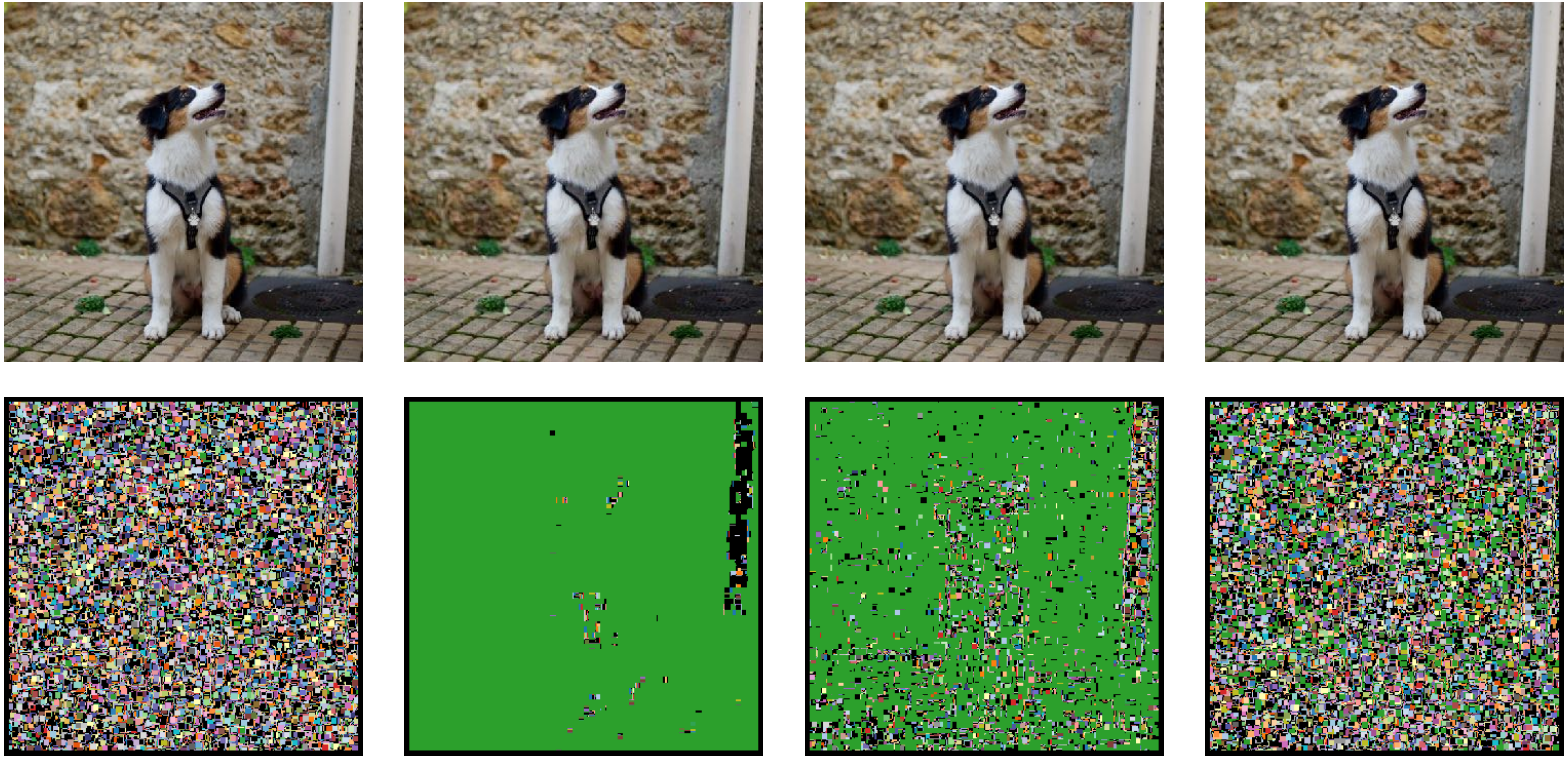


A pixel votes for the grid origin of the DCT block having the most zeros.
There are 64 different candidates (64 different colors).

Voting process

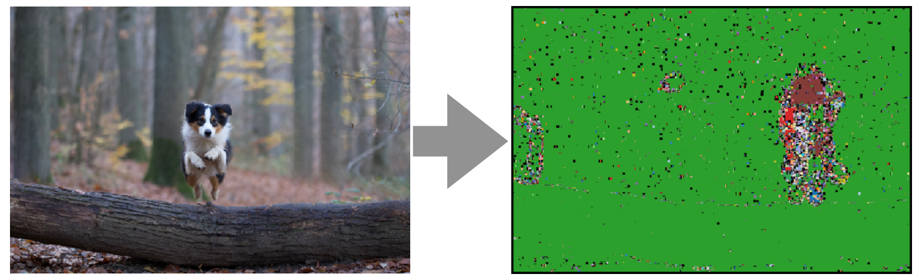


Uncompressed | Compressed (QF = 80) | Compressed (QF = 98) | Compressed (QF = 99)

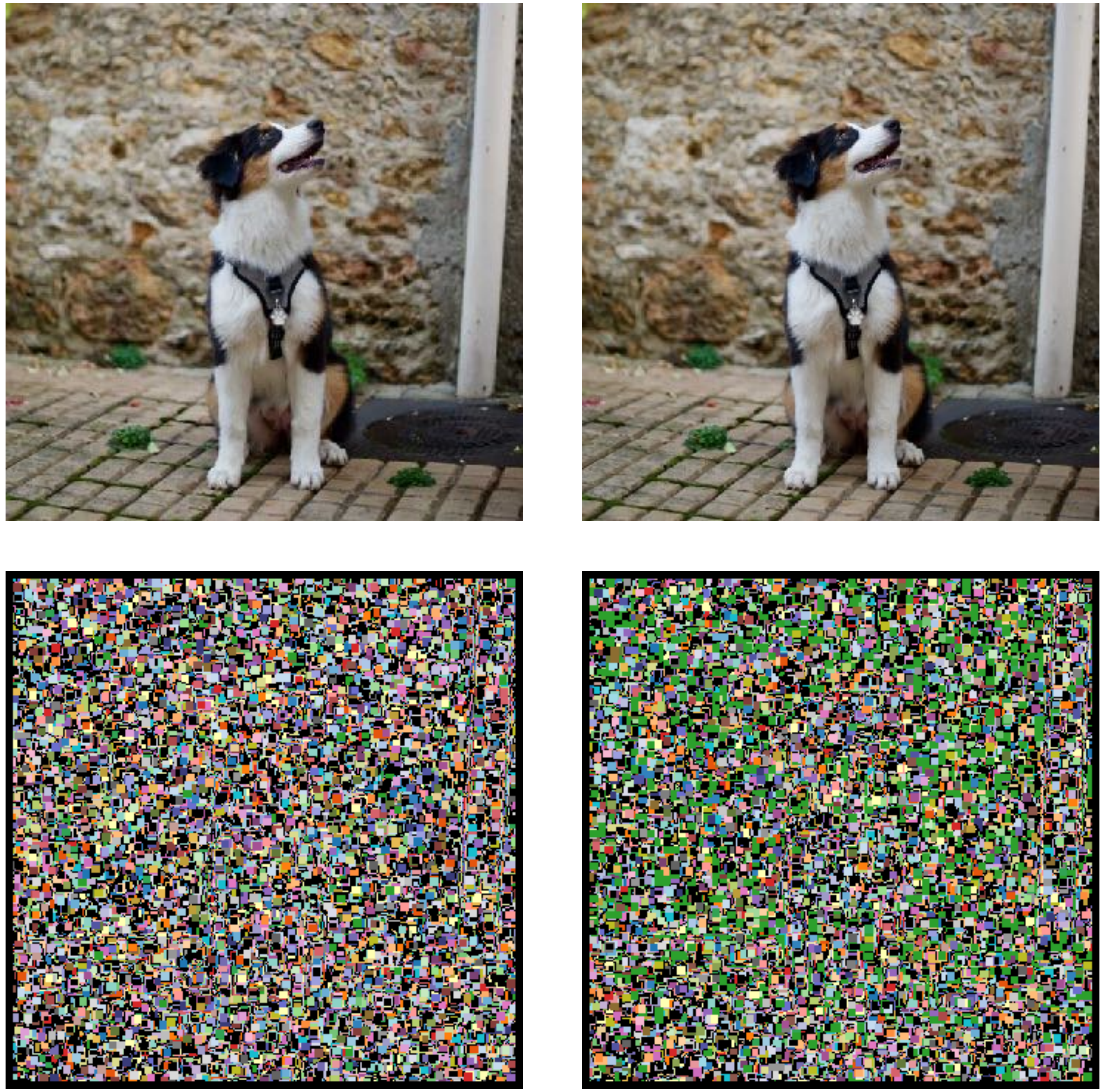


Each color represents a grid origin. Black corresponds to a non-valid vote, in case of a tie for example.

How to decide?

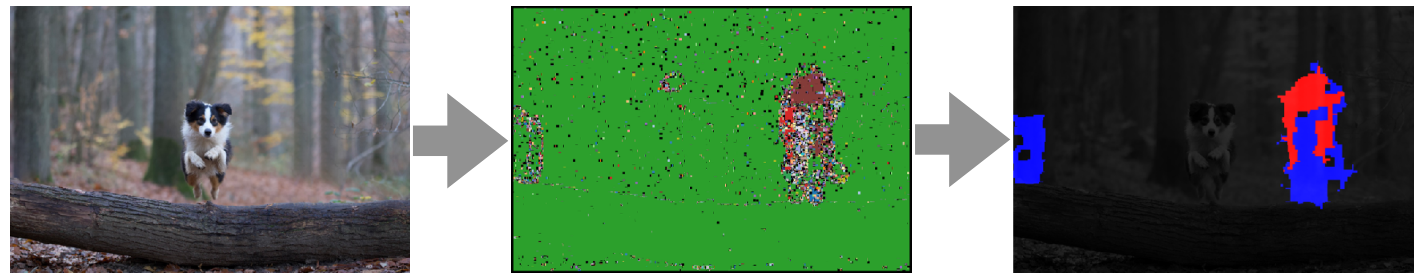


Uncompressed | Compressed (QF = 99)



Each color represents a grid origin. Black corresponds to a non-valid vote, in case of a tie for example.

Validation step

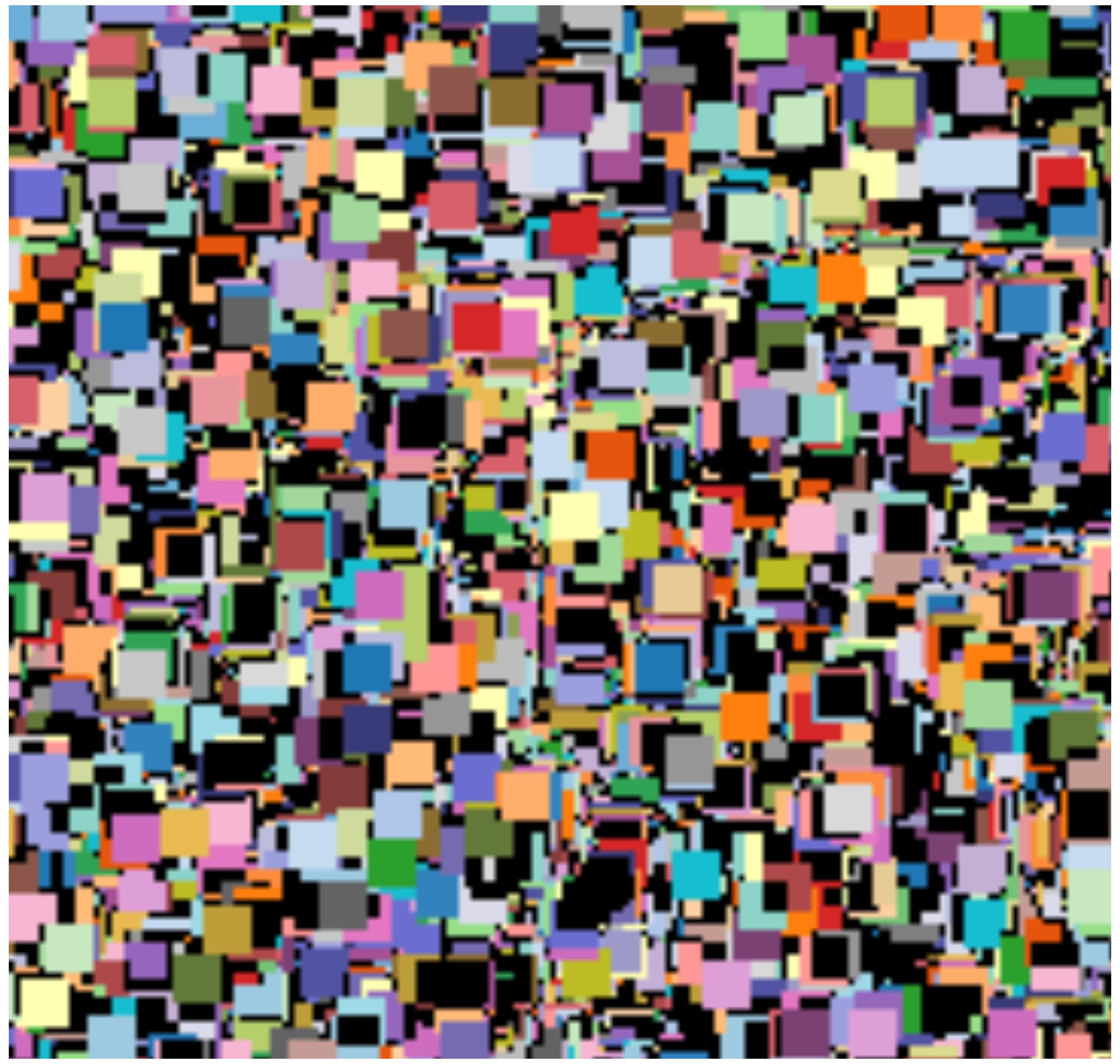


Given a window of an image, is a vote for the candidate (0,0) significant?

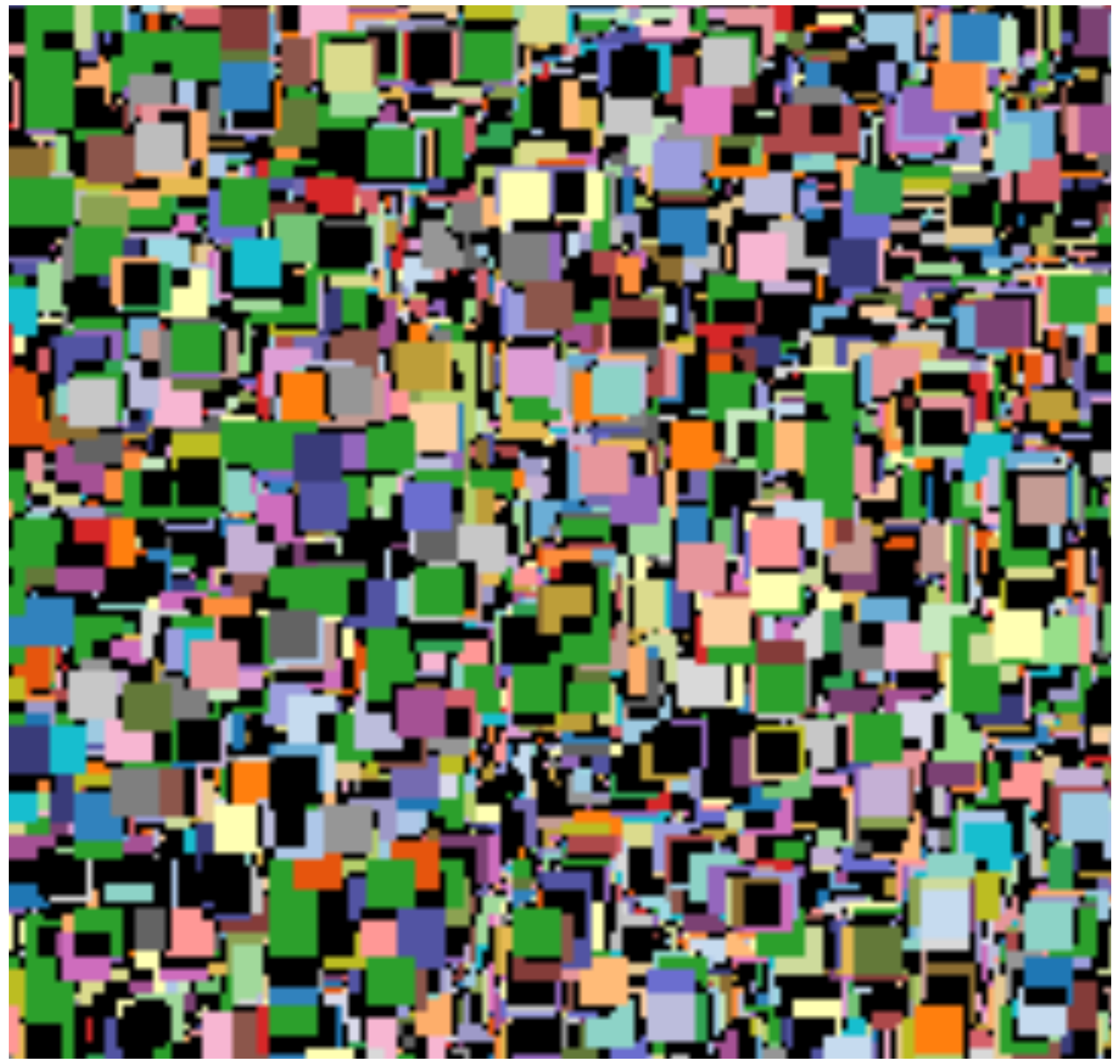
Among the **n = 625** votes, **k = 30** voted for (0,0)

4.8% votes

> 1.56% = 1/64



Part of a vote map of an uncompressed image.



Part of a vote map of a compressed image.

Among the **n = 625** votes, **k = 56** voted for (0,0)

8.9% votes

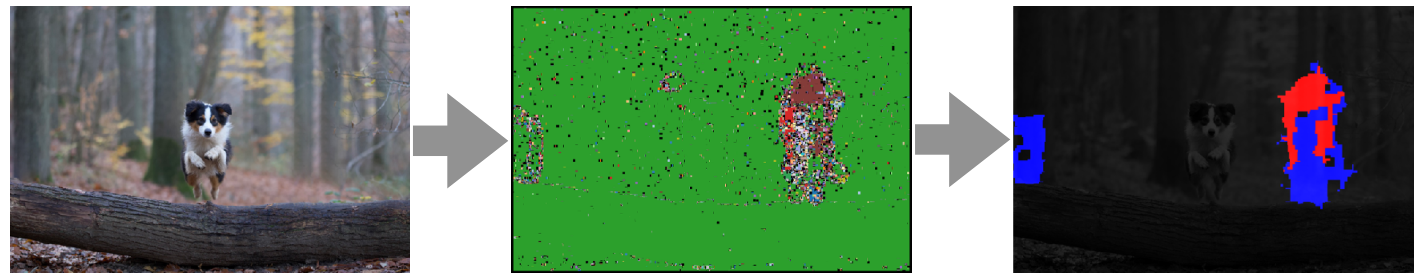
> 1.56% = 1/64

The detection threshold is based on the *non-accidentalness principle:*
An observed structure is meaningful only when the relation between its parts is too regular to be the result of an accidental arrangements of independent parts.

The *a contrario* detection theory is based on a statistical formulation of this *non-accidentalness principle*.

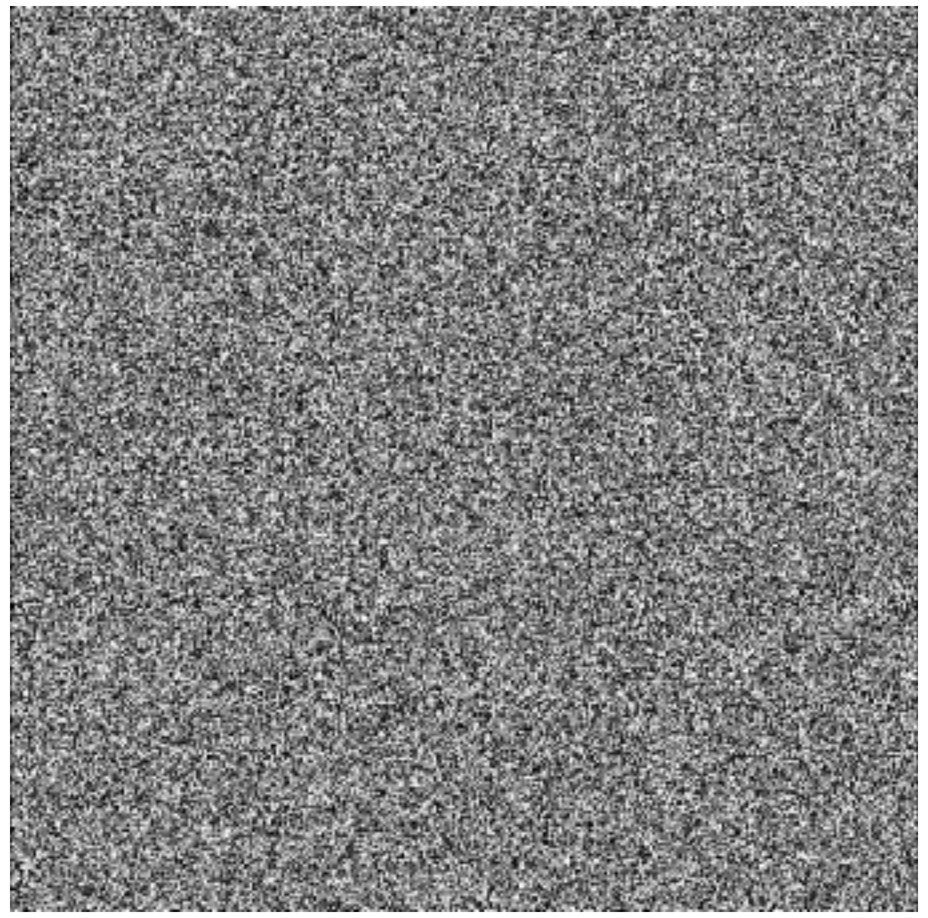
[Wagemans 1992]
[Albert, Hoffman 1995]
[Desolneux et al. 2000]
[Desolneux et al. 2008]

A contrario validation framework

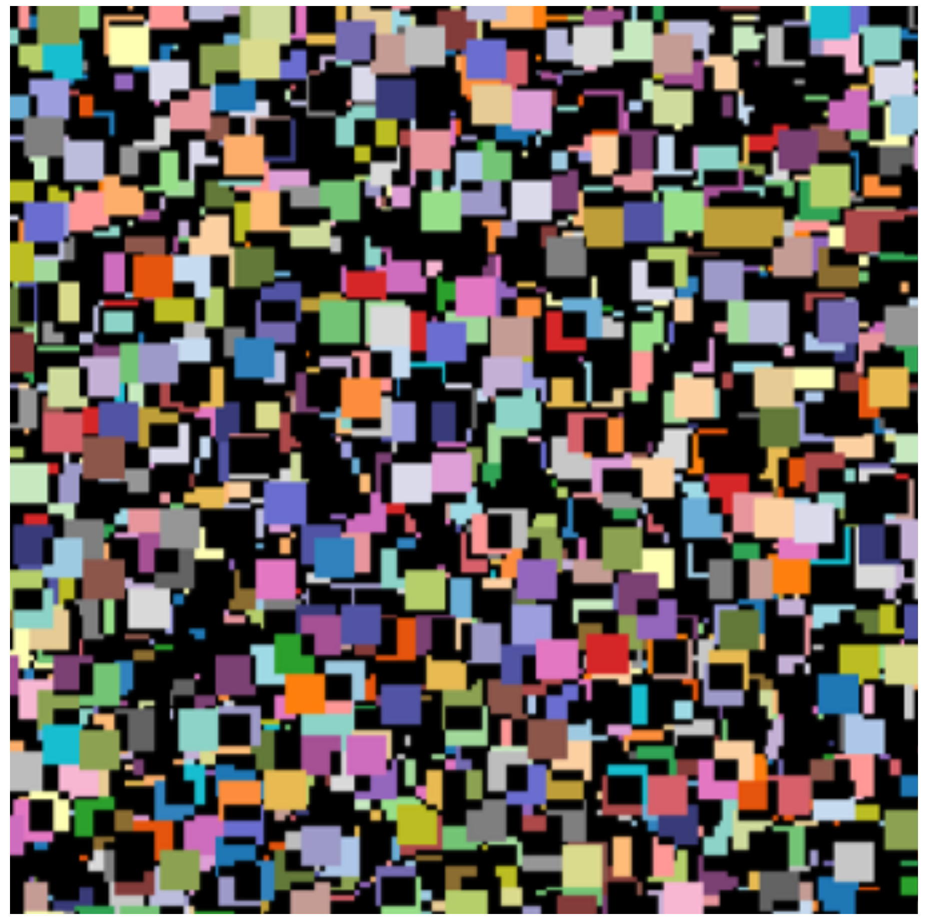


We define for an image of size X x Y,

Background model H_0: the votes at distance larger than 8 are i.i.d. ~ U{1,…,64}
Family of tests:
Observation for each test:



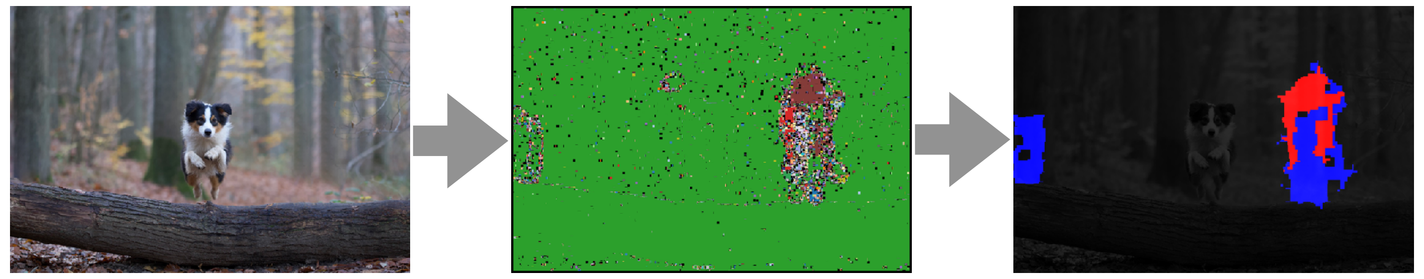
Gaussian noise



Vote map

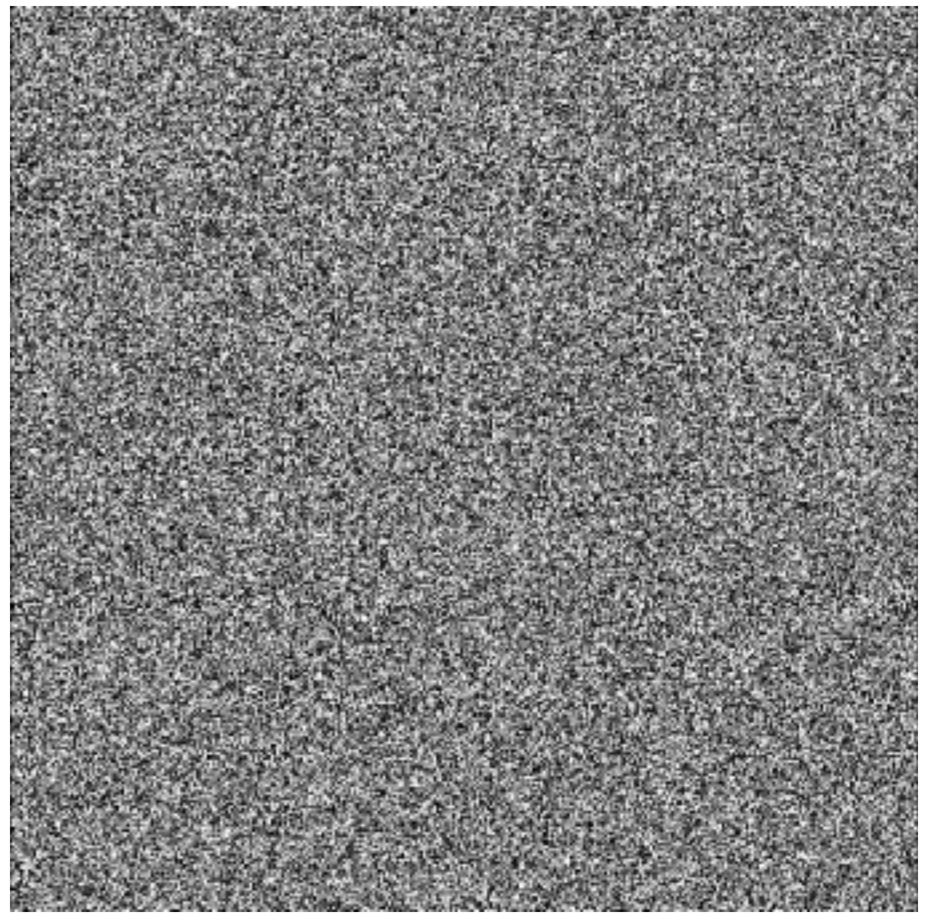
H_0 hypothesis: votes at distance 8 are independent and uniformly distributed among all the 64 grid origins.

A contrario validation framework

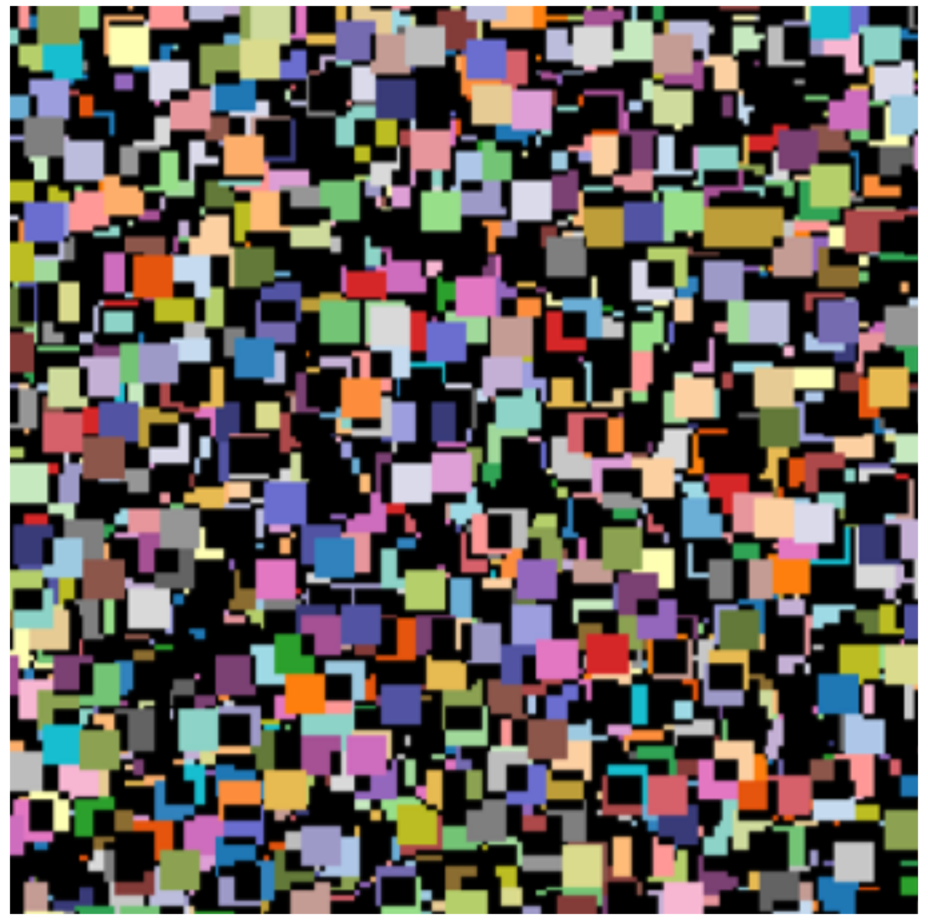


We define for an image of size $X \times Y$,

Background model H_0: the votes at distance larger than 8 are i.i.d. ~ U{1,…,64}
Family of tests: all the windows in the image and all the 64 candidate grid origins
Observation for each test:

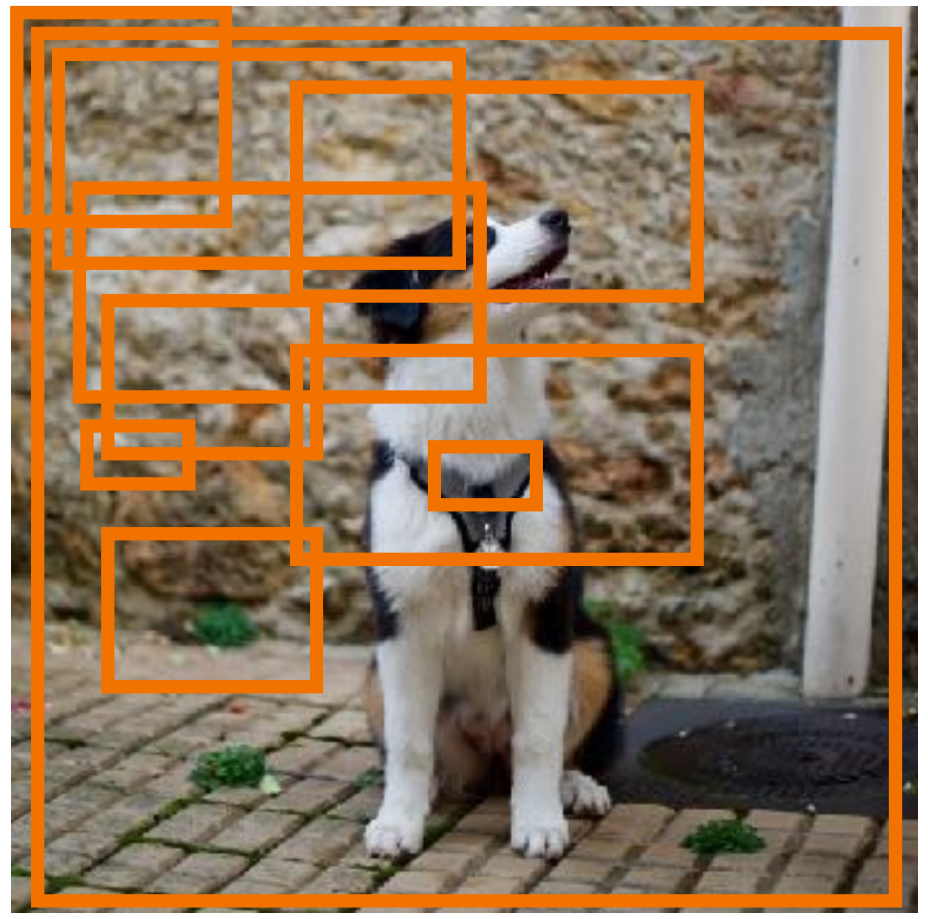


Gaussian noise



Vote map

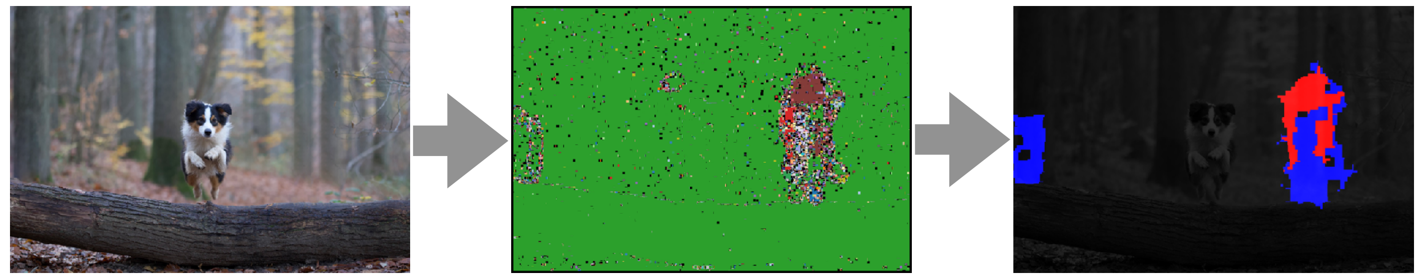
H_0 hypothesis: votes at distance 8 are independent and uniformly distributed among all the 64 grid origins.



Family of tests: all the windows in the image for votes taken at distance 8, and all the 64 different candidates.

$$N_T = 64 \times (XY)^2 \times 64$$

A contrario validation framework



We define for an image of size X x Y,

Background model H_0: the votes at distance larger than 8 are i.i.d. ~ U{1,…,64}
Family of tests: all the windows in the image and all the 64 candidate grid origins
Observation for each test: number of votes for a candidate grid origin *g*

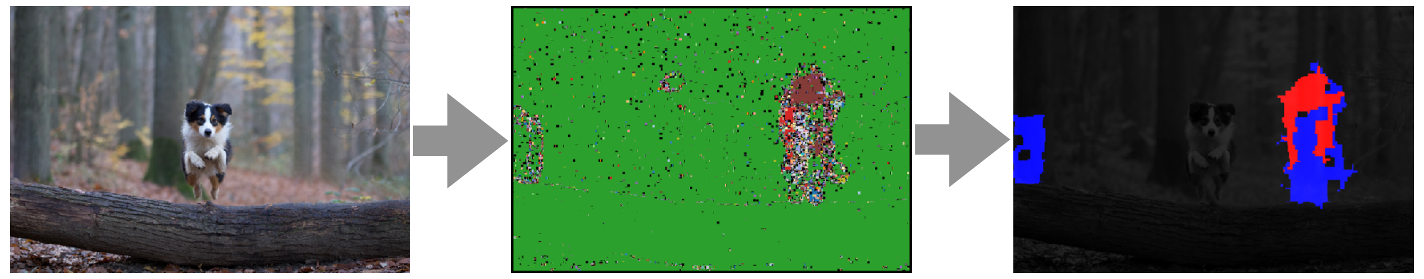
Given a window **w**, **k** is the observed number of votes for a candidate grid origin ***g*** among **n** votes.
Under H_0, votes for the grid ***g***, become a Binomial distributed random variable **K** with probability **p = 1/64**.

$$P(K \geq k) = \mathcal{B}(n,k,p) = \sum_{j=k}^{n} \binom{n}{j} p^j (1-p)^{n-j}$$

Probability of obtaining at least k votes under H_0.

When this probability is small enough, there exists evidence to reject the H_0 hypothesis and declare that the votes for the grid origin ***g*** are significant.

A contrario validation framework



We define for an image of size X x Y,

Background model H_0: the votes at distance larger than 8 are i.i.d. ~ U{1,…,64}
Family of tests: all the windows in the image and all the 64 candidate grid origins
Observation for each test: number of votes for a candidate grid origin *g*

If the hypothesis is rejected, then the detection is significant.

Given a window **w**, **k** is the observed number of votes for a candidate grid origin ***g*** among **n** votes.
Under H_0, votes for the grid ***g***, become a Binomial distributed random variable **K** with probability **p = 1/64**.

$$P(K \geq k) = \mathcal{B}(n,k,p) = \sum_{j=k}^{n} \binom{n}{j} p^j (1-p)^{n-j}$$

Probability of obtaining at least k votes under H_0.

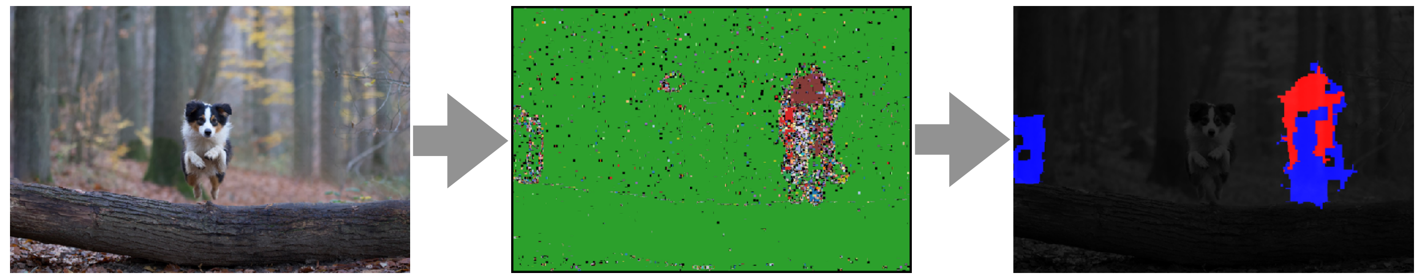
When this probability is small enough, there exists evidence to reject the H_0 hypothesis and declare that the votes for the grid origin ***g*** are significant.

Following the *a contrario* methodology, we define the Number of False Alarms (**NFA**) of a candidate grid ***g*** on a given window **w** as

$$\mathrm{NFA}(g,w) = N_T P(K \geq k)$$

We compute the **NFA** for all the candidates ***g*** and we say that a JPEG grid is detected when at least one is < ε.

A contrario validation framework



We define for an image of size X x Y,

Background model H_0: the votes at distance larger than 8 are i.i.d. ~ U{1,…,64}
Family of tests: all the windows in the image and all the 64 candidate grid origins
Observation for each test: number of votes for a candidate grid origin *g*

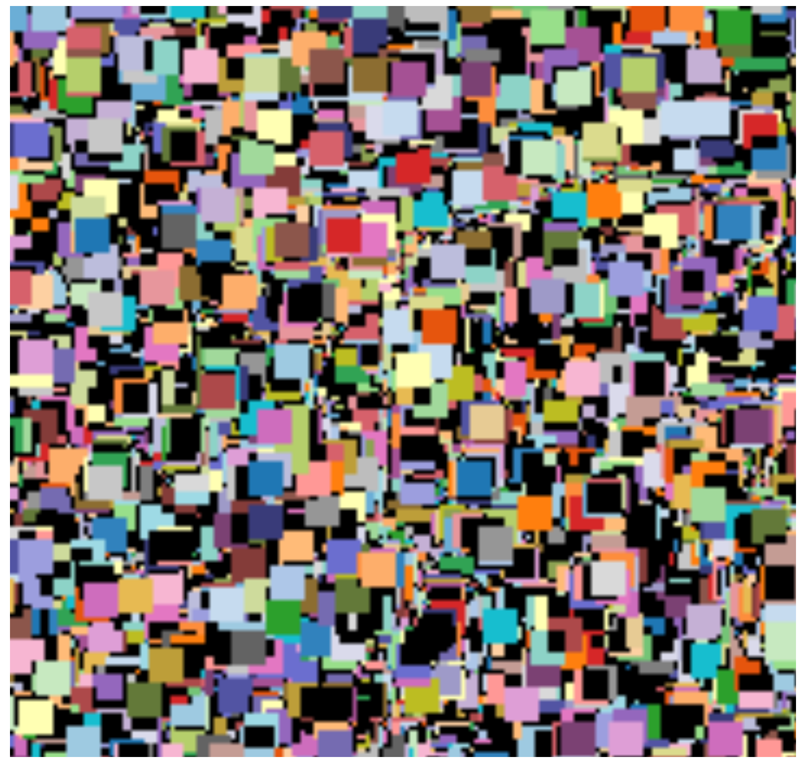
If the hypothesis is rejected, then the detection is significant. ε = 1

Among the **n = 625** votes,
k = 30 voted for (0,0)

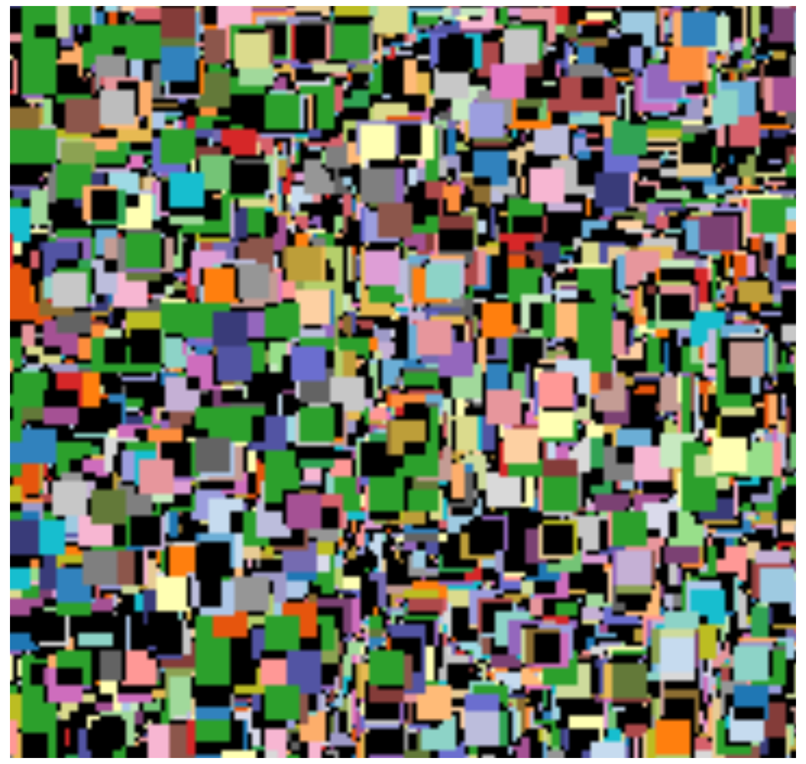
$$\mathrm{NFA}((0,0),w) = 10^{5.84598} > 1$$

$$\forall g \in \{1,\ldots,63\}, \mathrm{NFA}(g,w) > 1$$

No JPEG grid detected



Part of a vote map of an uncompressed image.



Part of a vote map of a compressed image.

Among the **n = 625** votes,
k = 56 voted for (0,0)

$$\mathrm{NFA}((0,0),w) = 10^{-11.5489} < 1$$

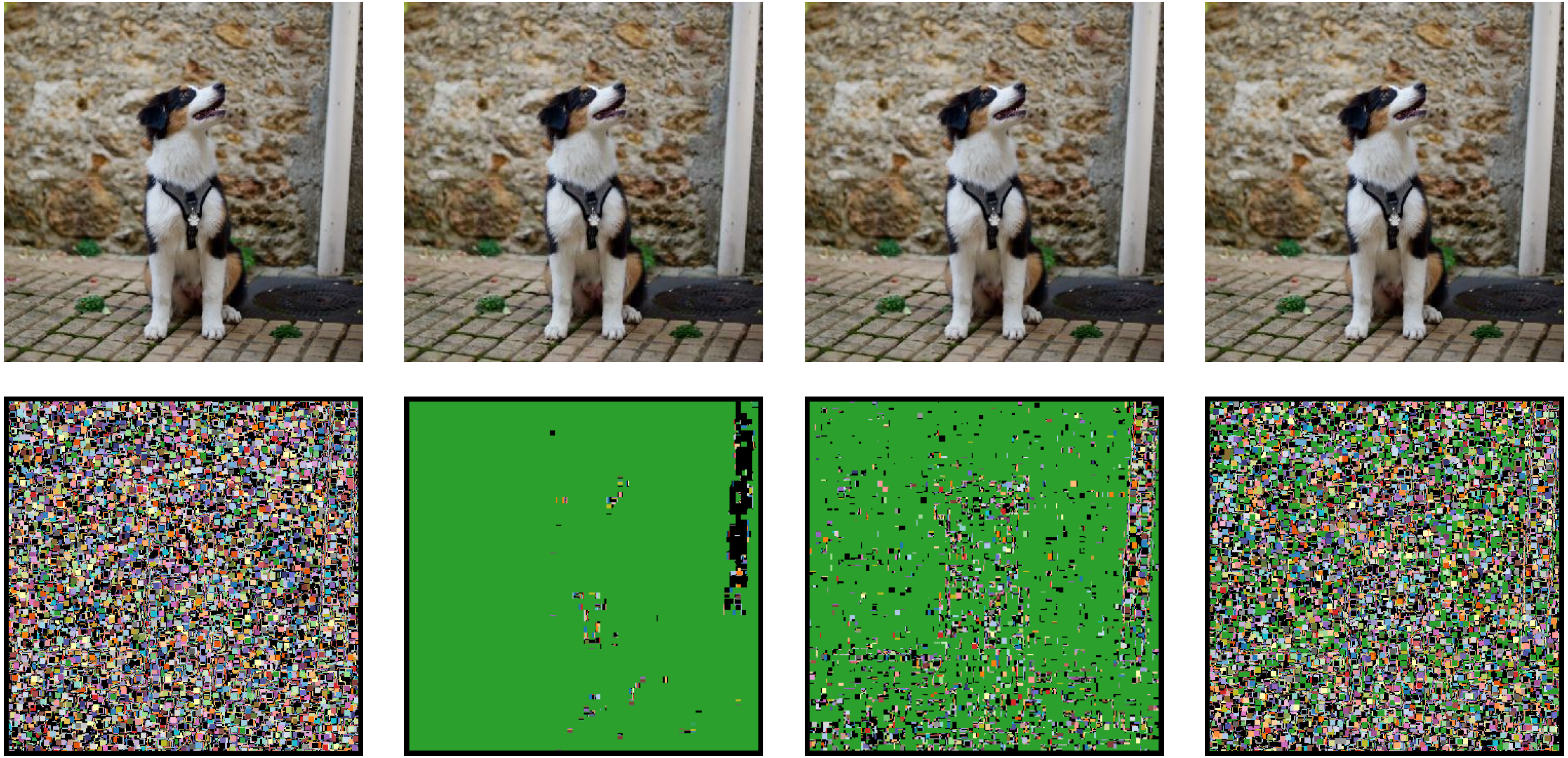
$$\forall g \in \{1,\ldots,63\}, \mathrm{NFA}(g,w) > 1$$

JPEG grid origin (0,0)

$$\mathrm{NFA}(g,w) = 64^2 \cdot (XY)^2 \cdot \mathcal{B}\left(n, k, \frac{1}{64}\right)$$

ZERO applied to the whole image

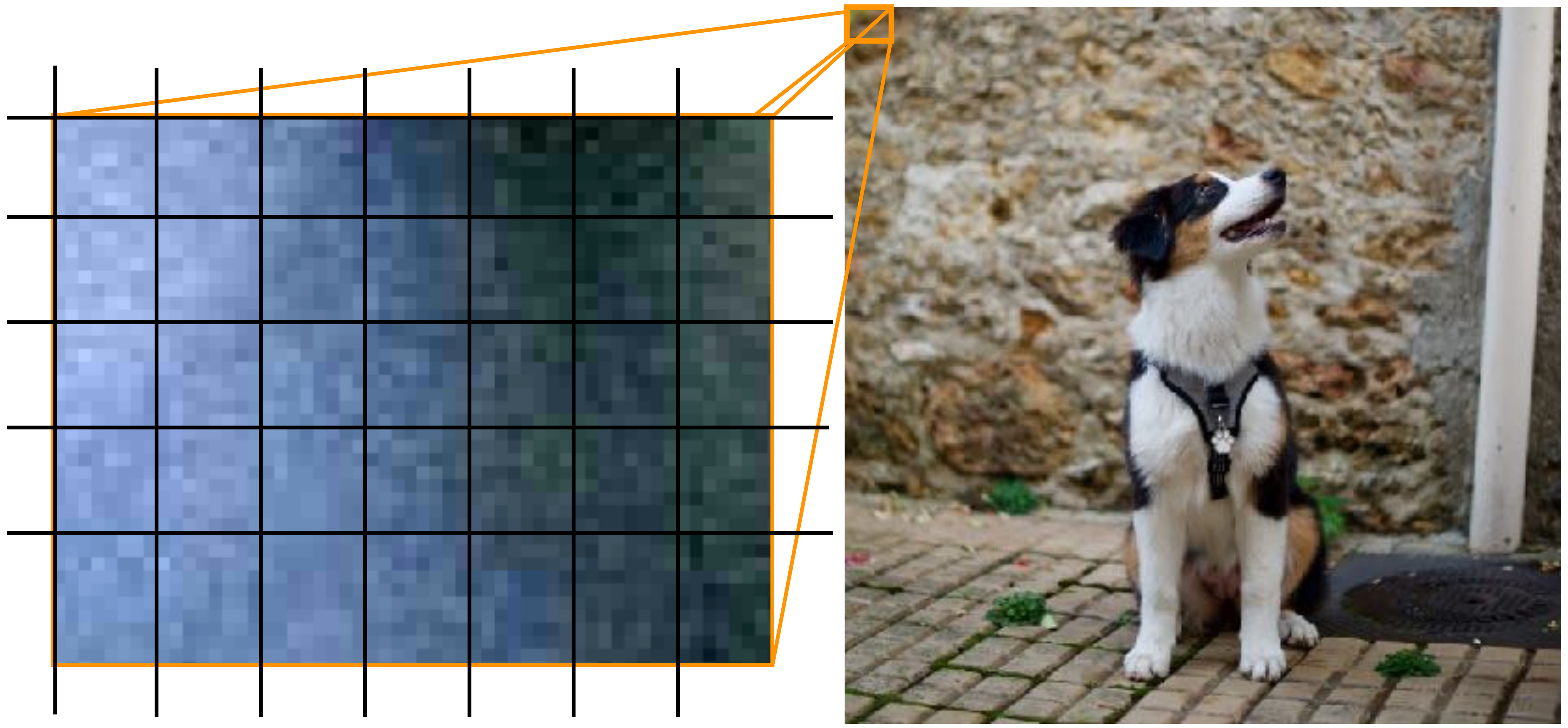
Uncompressed	Compressed (QF = 80)	Compressed (QF = 98)	Compressed (QF = 99)

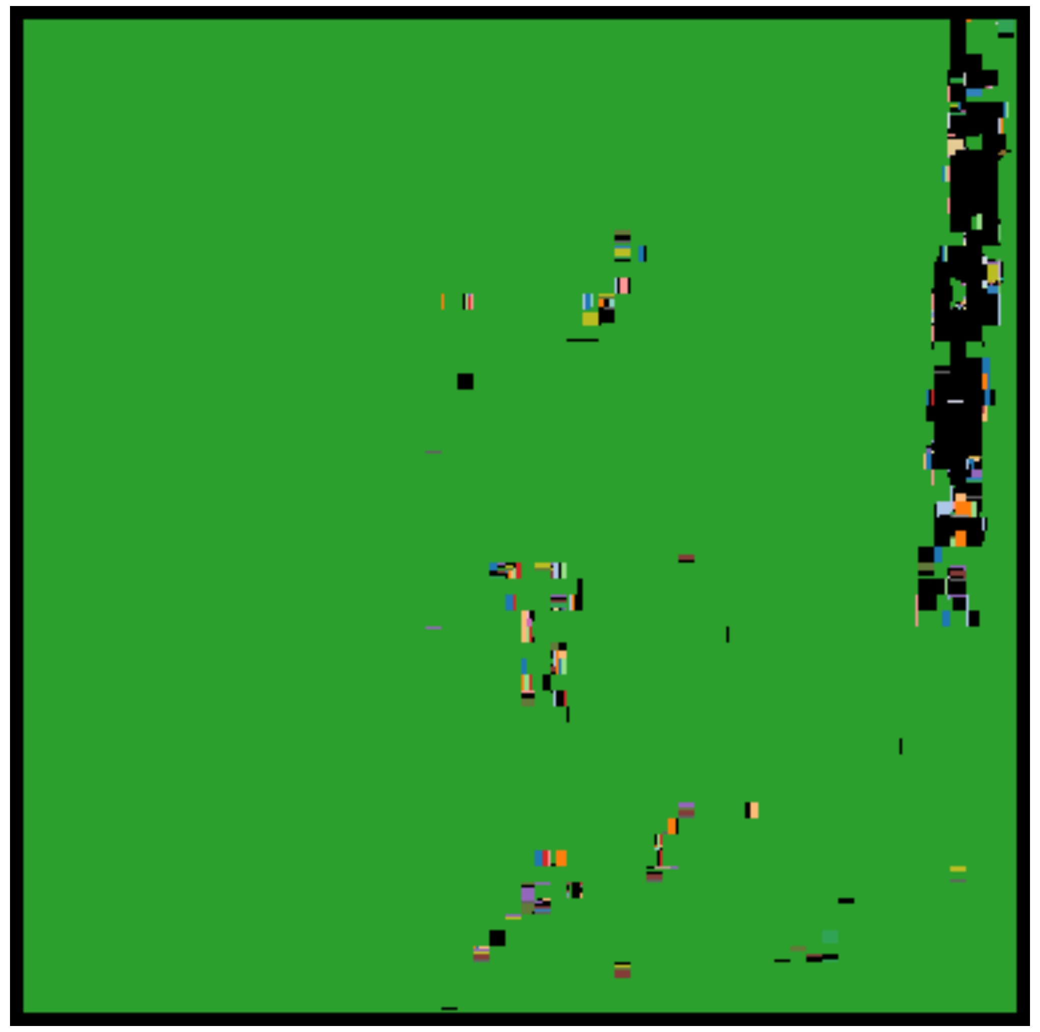


No JPEG grid detected	JPEG grid origin (0,0)	JPEG grid origin (0,0)	JPEG grid origin (0,0)

ZERO: a crop detector

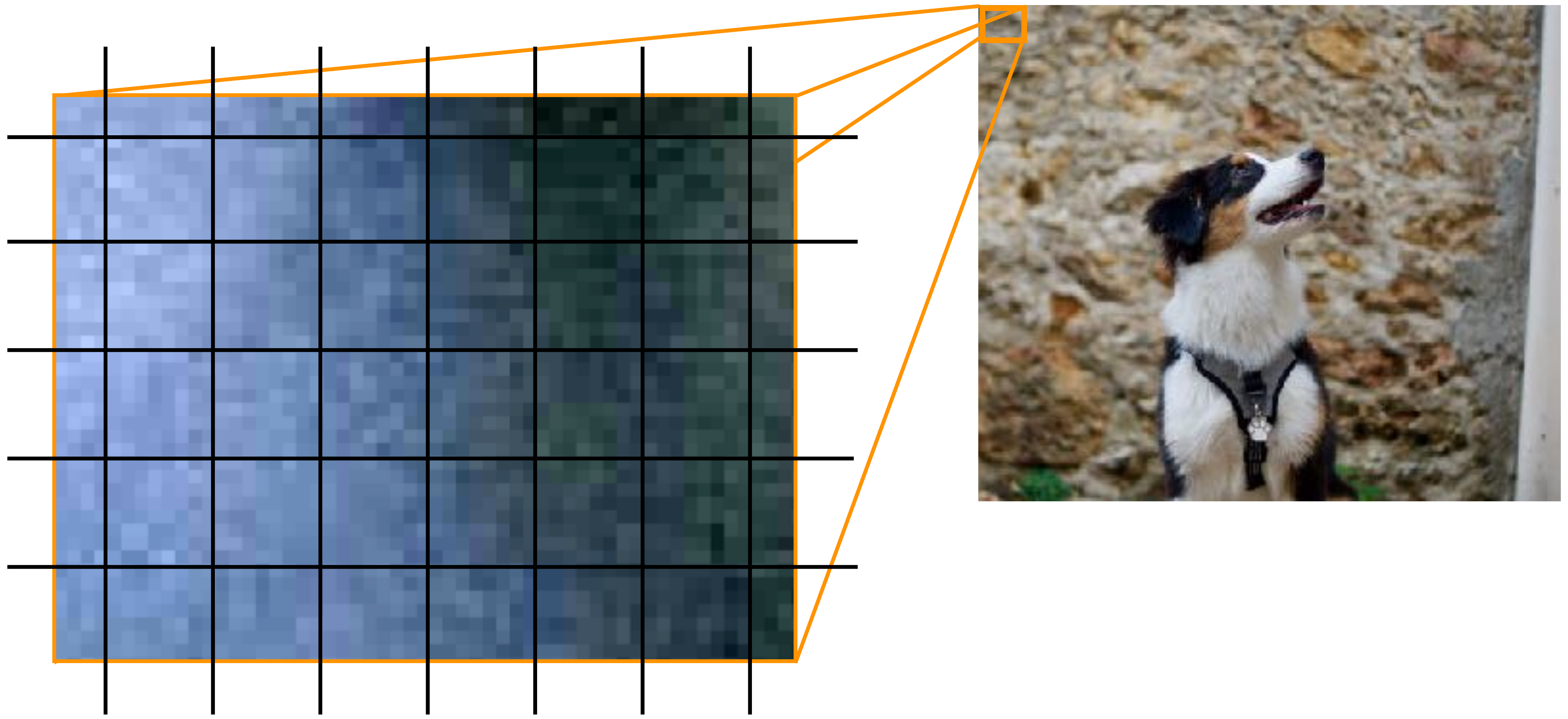
Main grid (0,0)

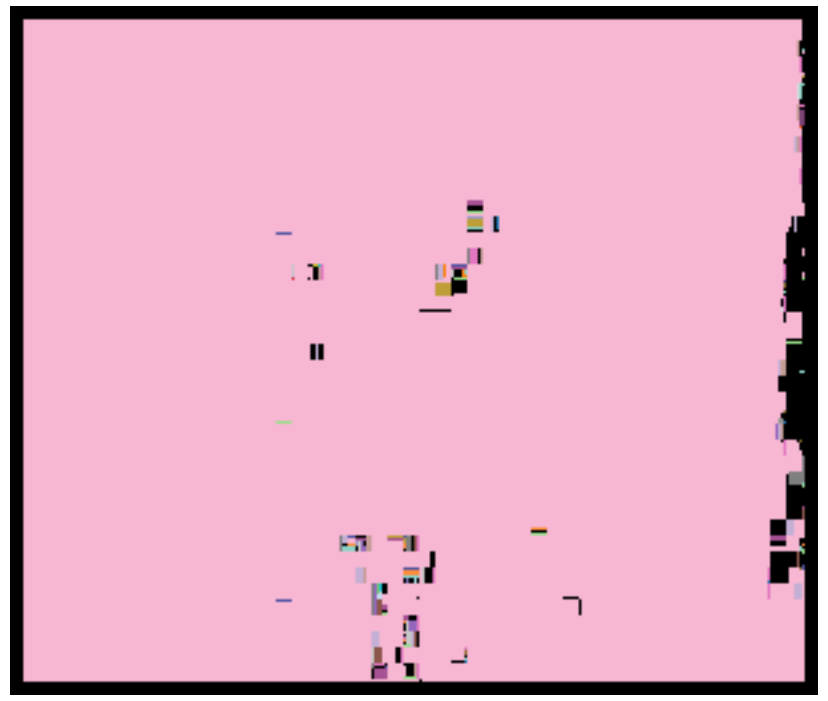




JPEG grid origin (0,0)

Main grid (6,6)

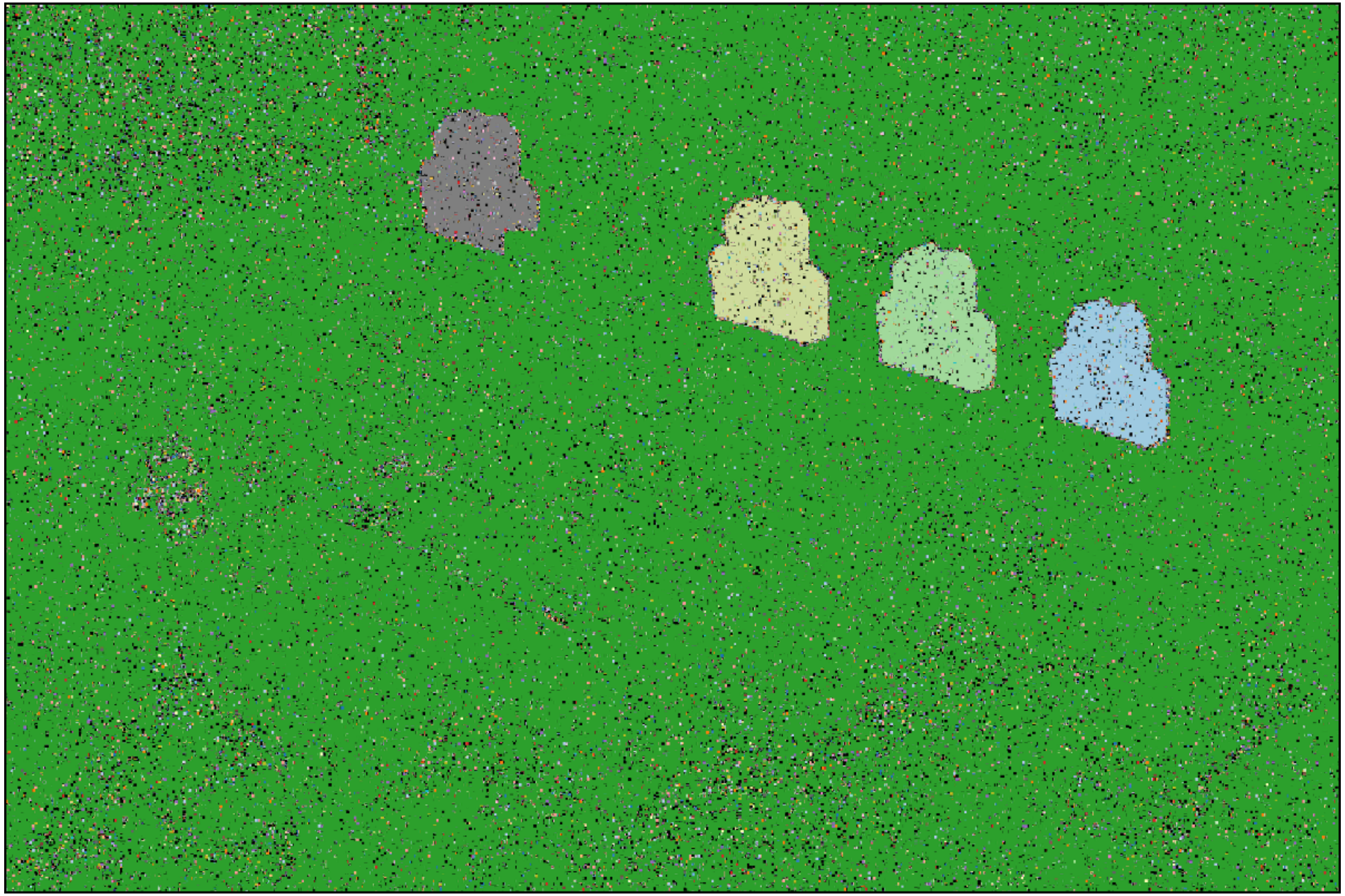




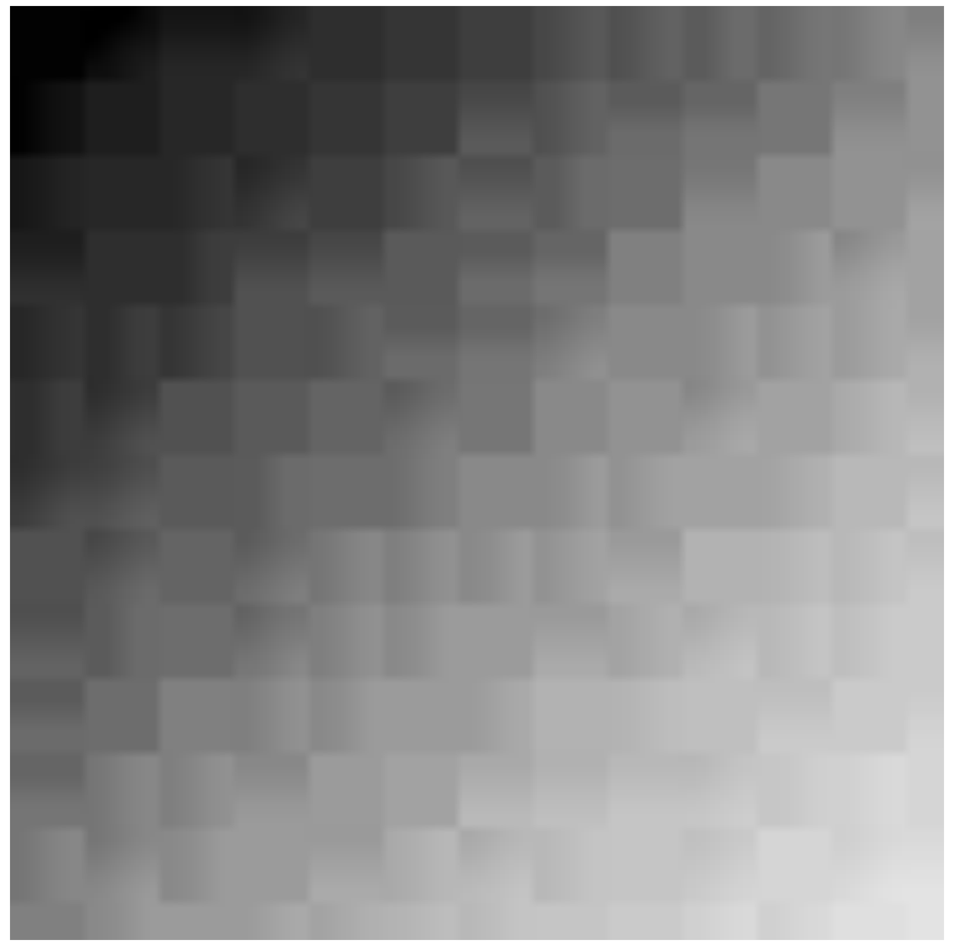
JPEG grid origin (6,6)

How to detect forgeries?

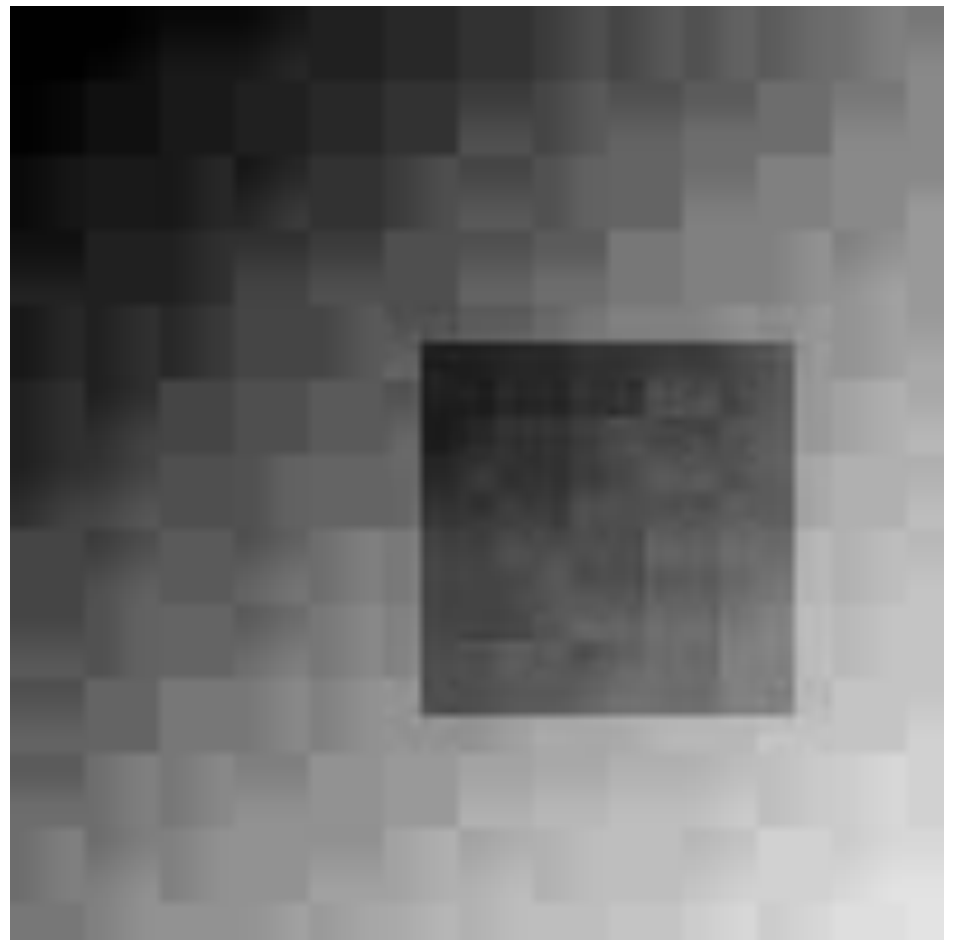
ZERO: a forgery detector



Vote map. JPEG grid origin (0,0).

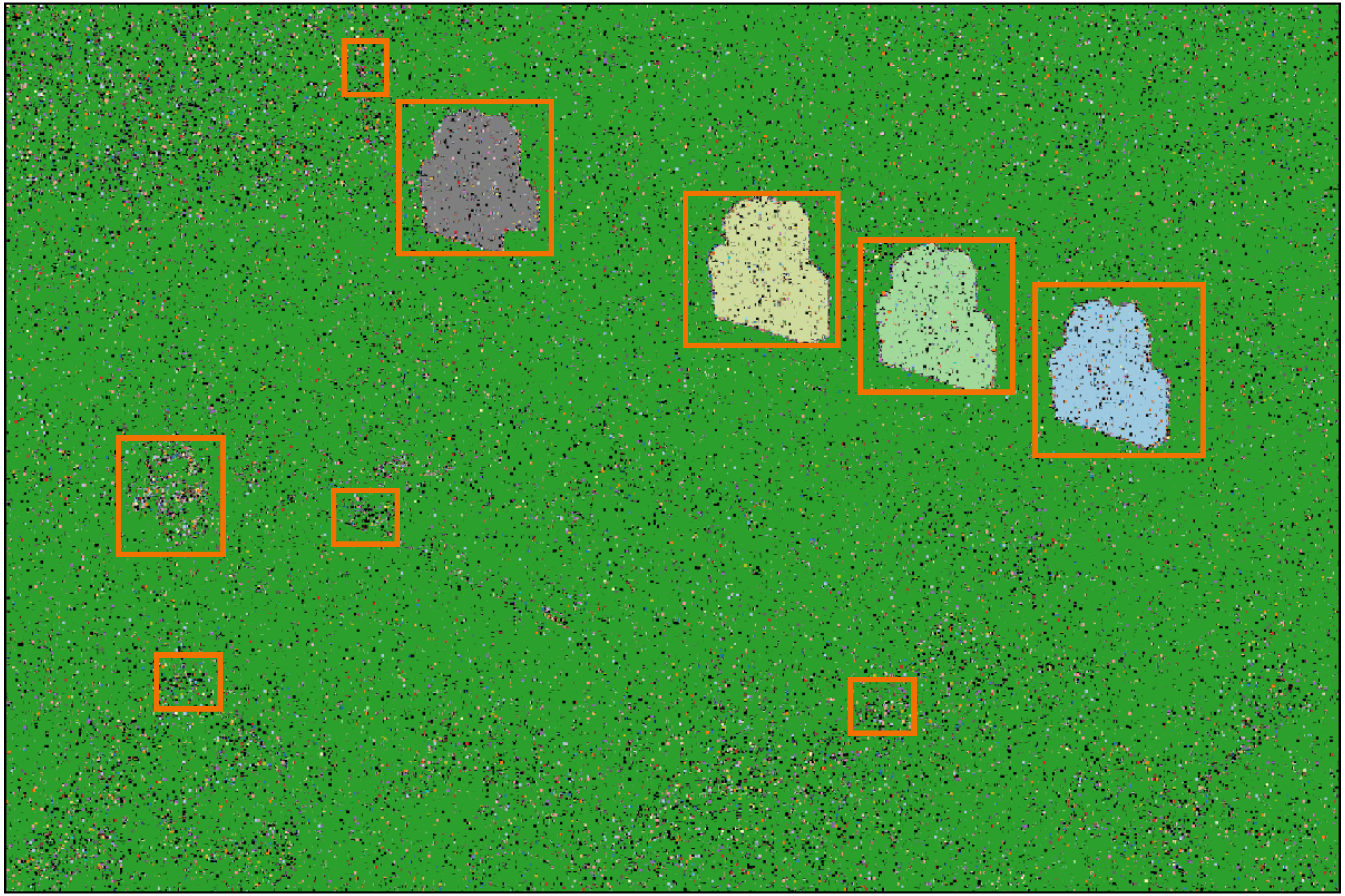


Authentic



Local shifted grid.

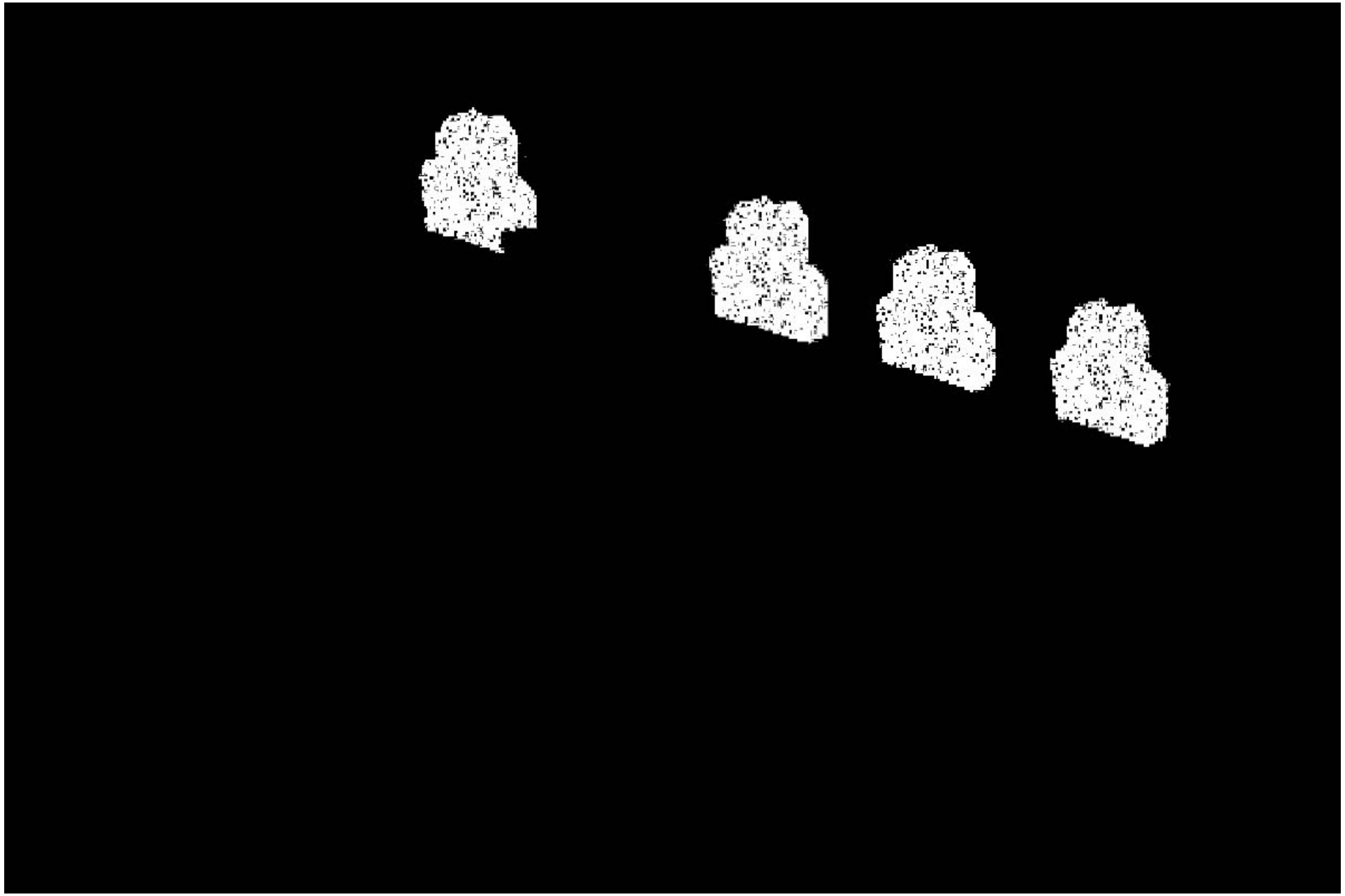
ZERO: a forgery detector



Bounding boxes around grouping of pixels which did not vote for the main grid.

- Compute the **vote map**
- Detect global grids and **main grid**
- Partition the image into groups of connected pixels which vote alike and different from the main grid
- Create bounding boxes

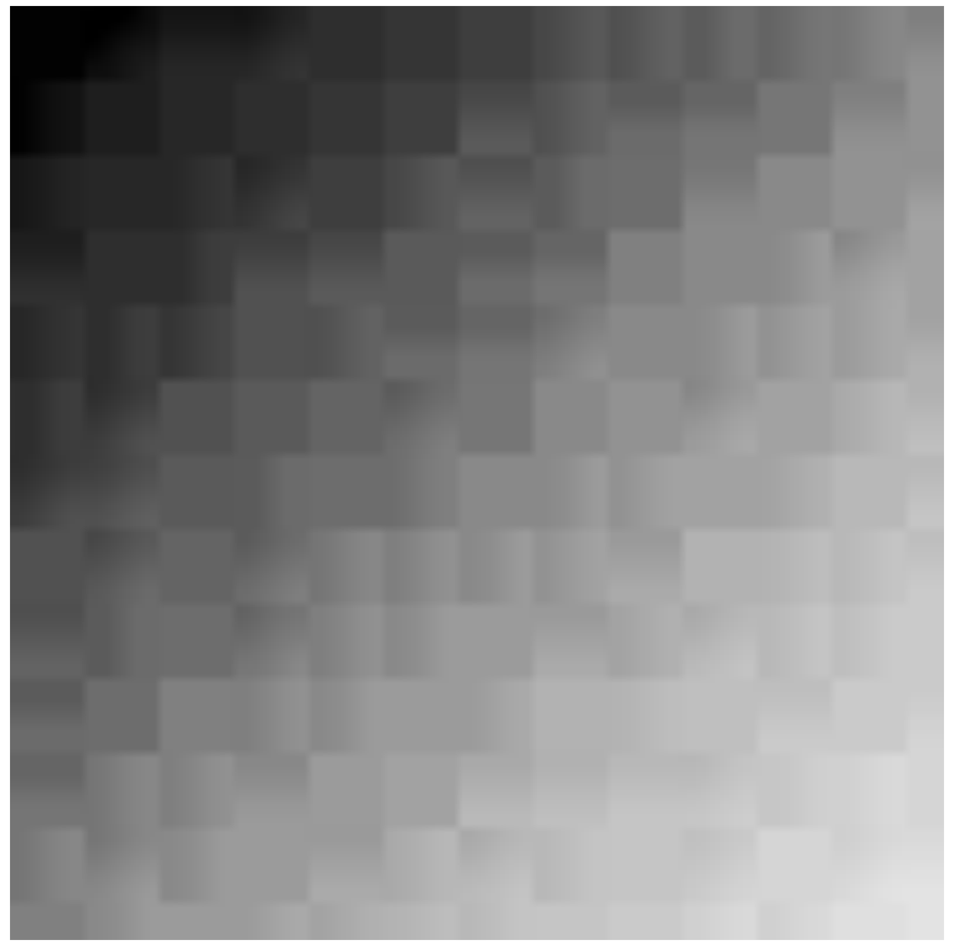
ZERO: a forgery detector



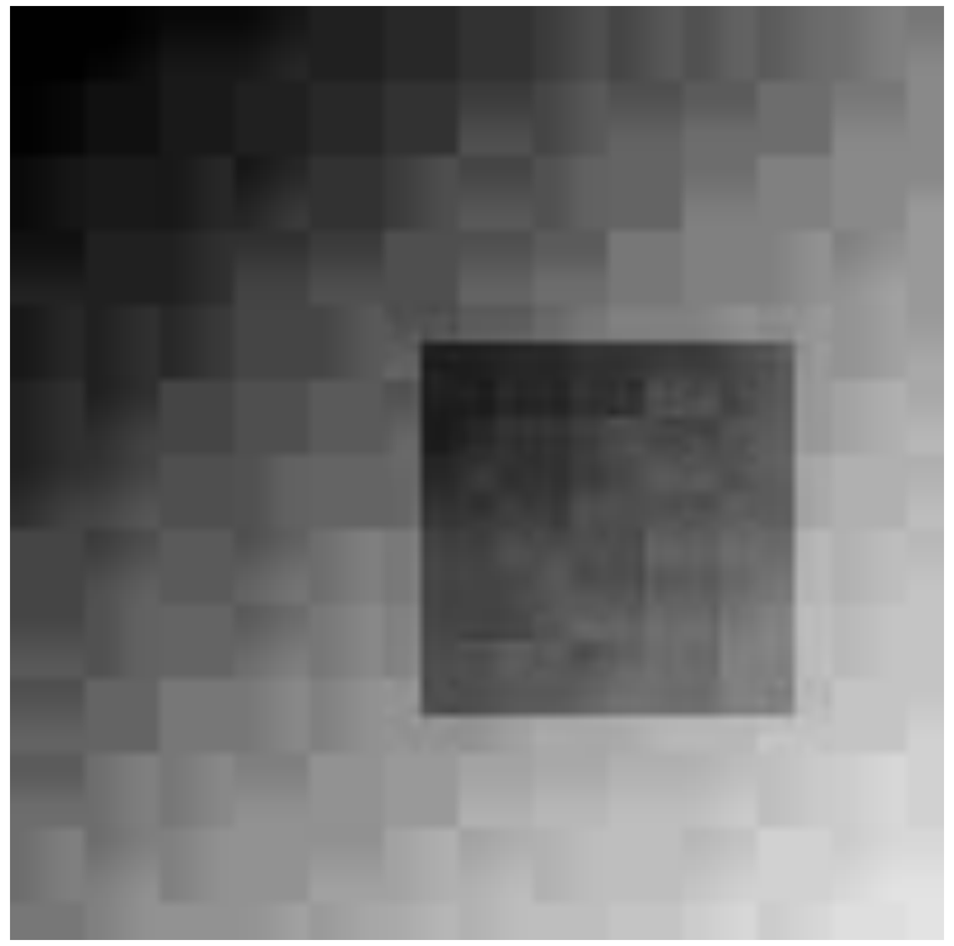
If the window's vote is significant, then the pixels are marked.

- Compute the **vote map**
- Detect global grids and **main grid**
- Partition the image into groups of connected pixels which vote alike and different from the main grid
- Create bounding boxes
- Apply the *a contrario* validation
- Compute **forgery map**

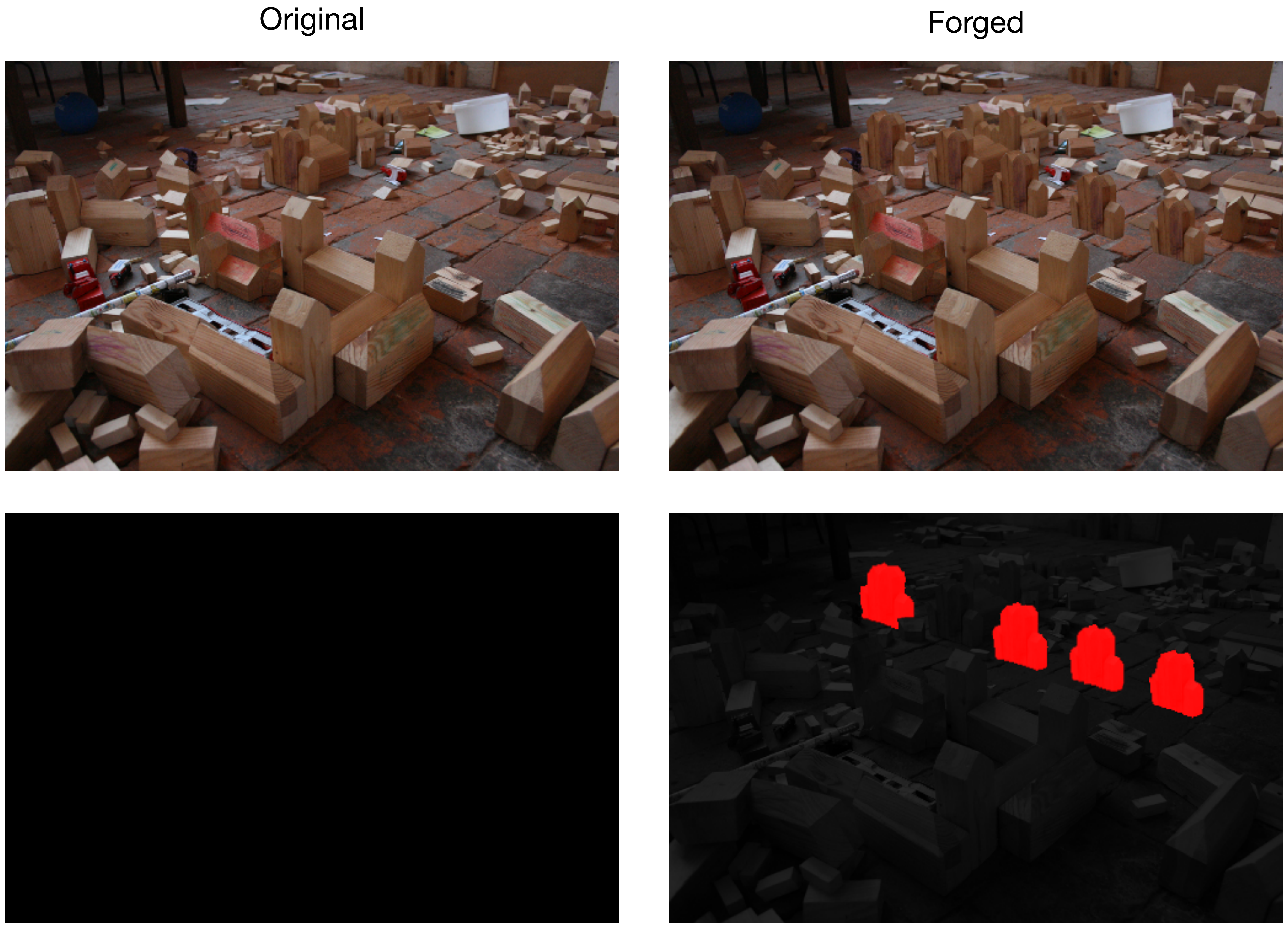
ZERO: a local foreign grid origin detector



Authentic

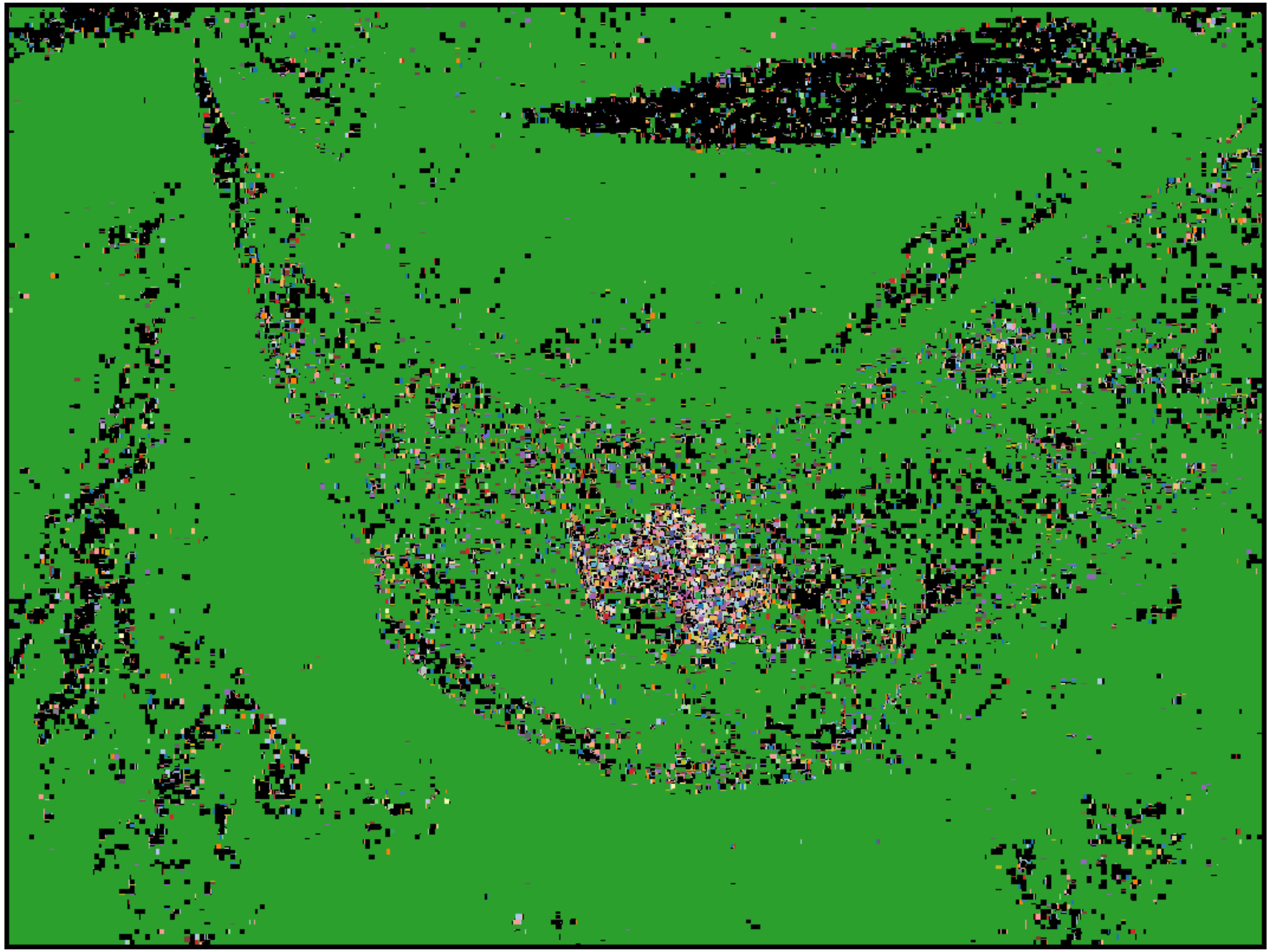


Local shifted grid.

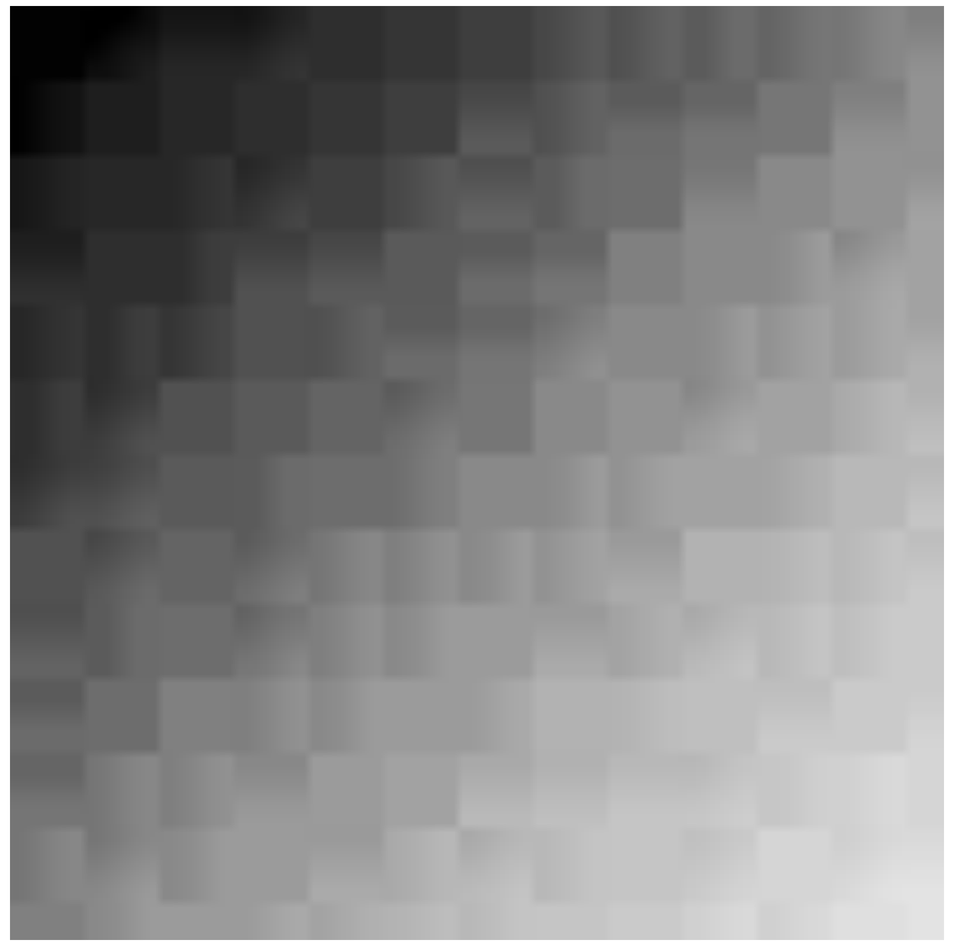


Detection results of images from FAU dataset.

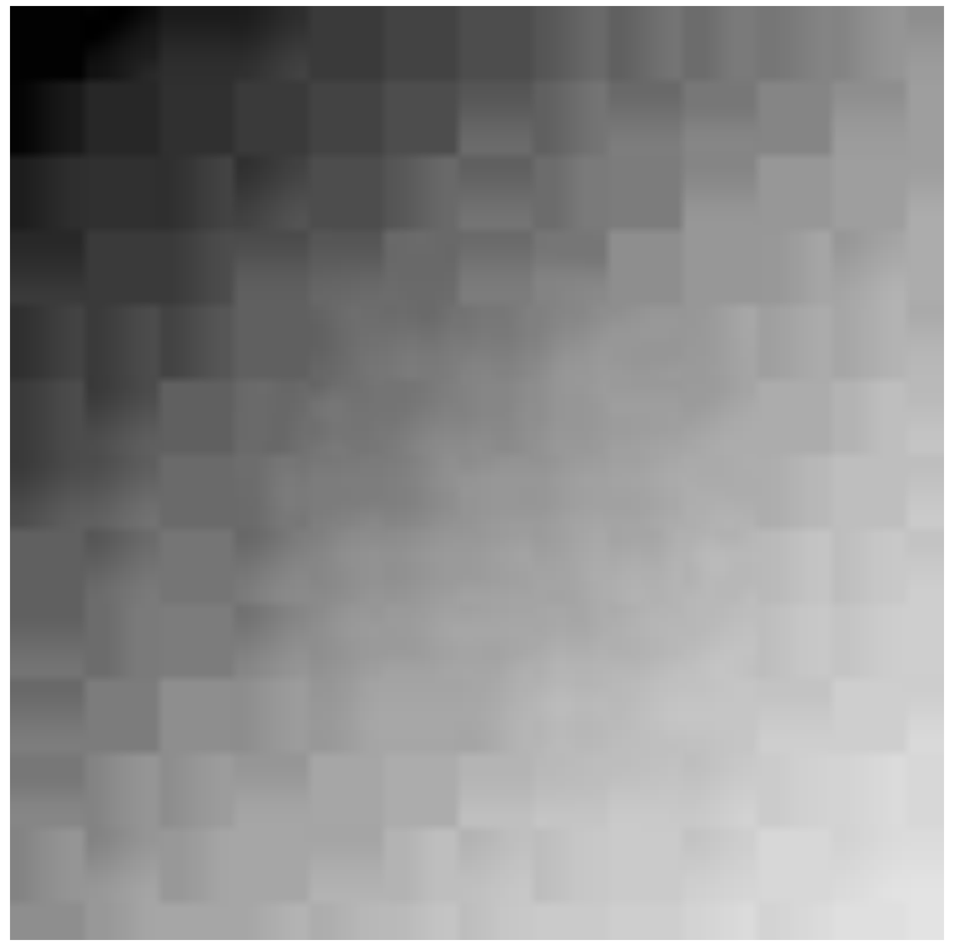
ZERO: a forgery detector



Vote map. JPEG grid origin (0,0).

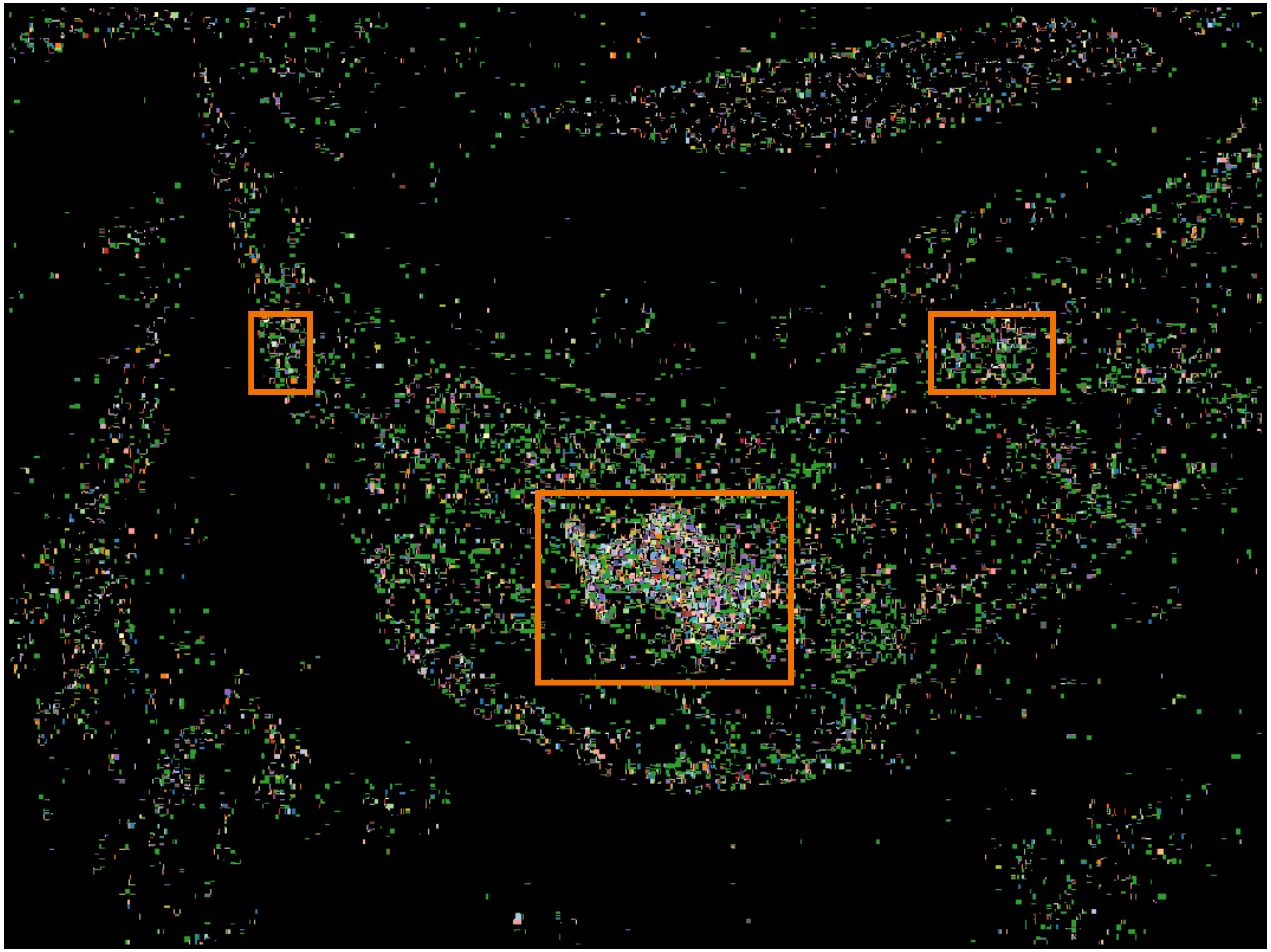


Authentic



Local missing grid.

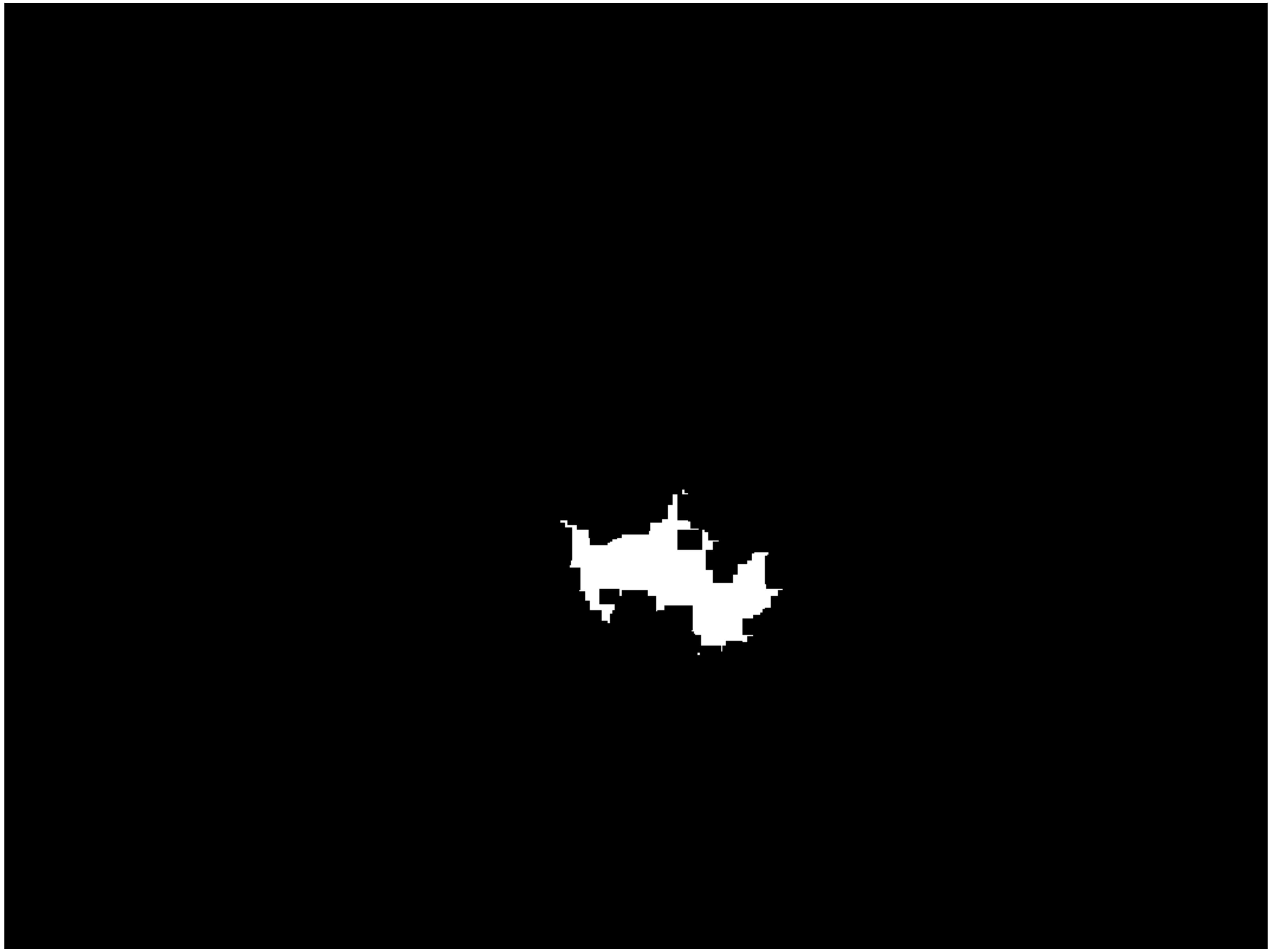
ZERO: a forgery detector



New vote map. Pixels which voted for grid (0,0) before do not vote again.

- Compute the **vote map**
- Detect global grids and **main grid**
- Create compressed version of the image (QF = 99)
- Compute the **new vote map** where the pixels which voted for the main grid are removed
- Partition the image into groups of connected pixels which vote for (0,0)
- Create bounding boxes

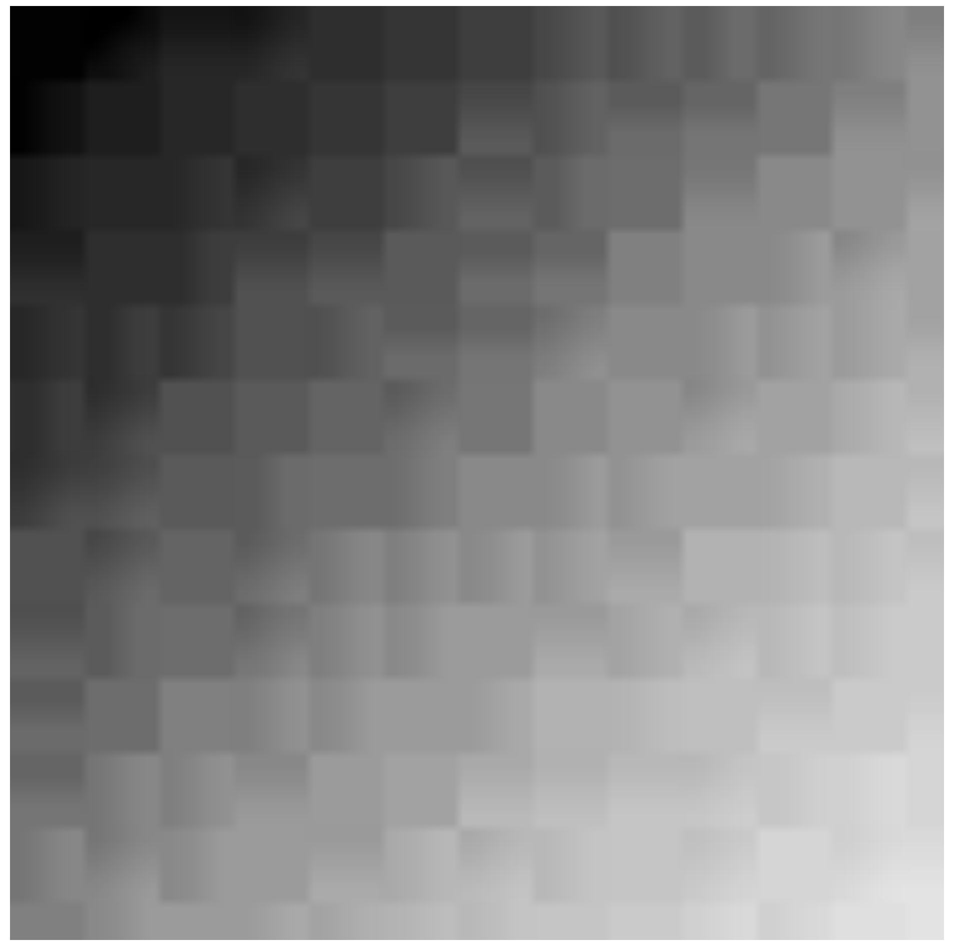
ZERO: a forgery detector



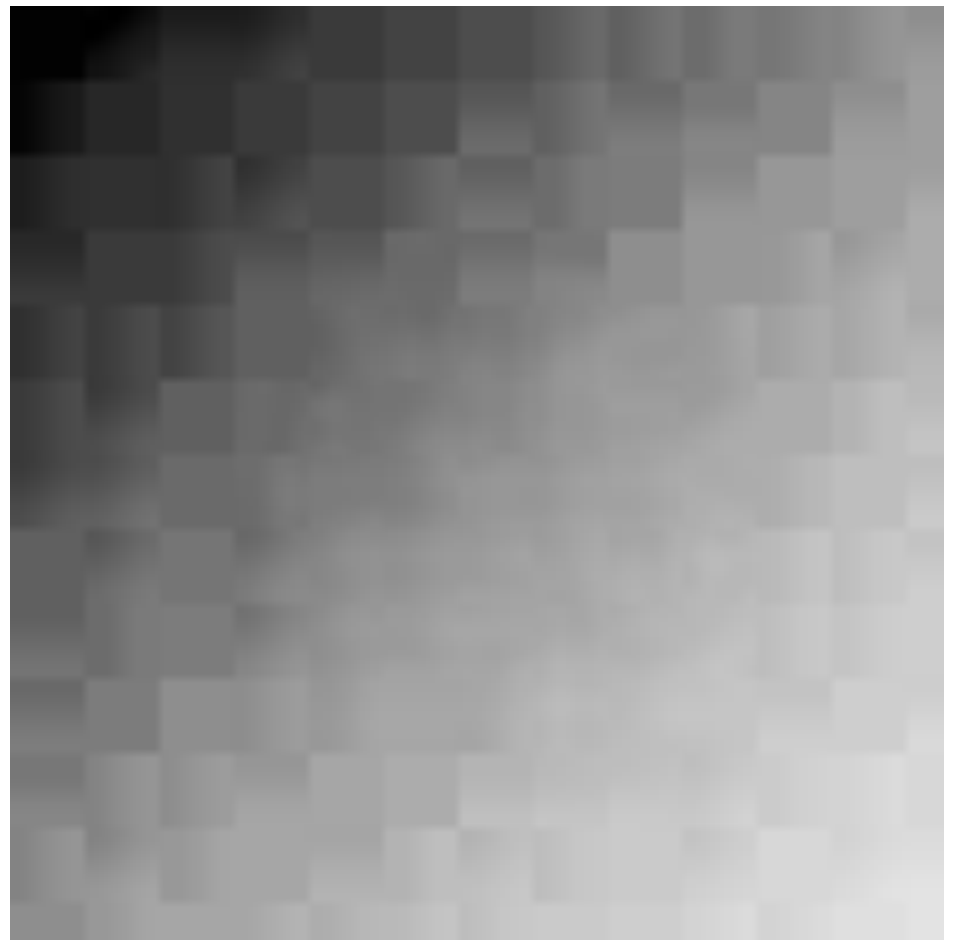
If the window's vote for (0,0) is significant, then the pixels are marked.

- Compute the **vote map**
- Detect global grids and **main grid**
- Create compressed version of the image (QF = 99)
- Compute the **new vote map** where the pixels which voted for the main grid are removed
- Partition the image into groups of connected pixels which vote for (0,0)
- Create bounding boxes
- Apply the *a contrario* validation
- Compute **forgery map**

ZERO: a local missing grid origin detector



Authentic



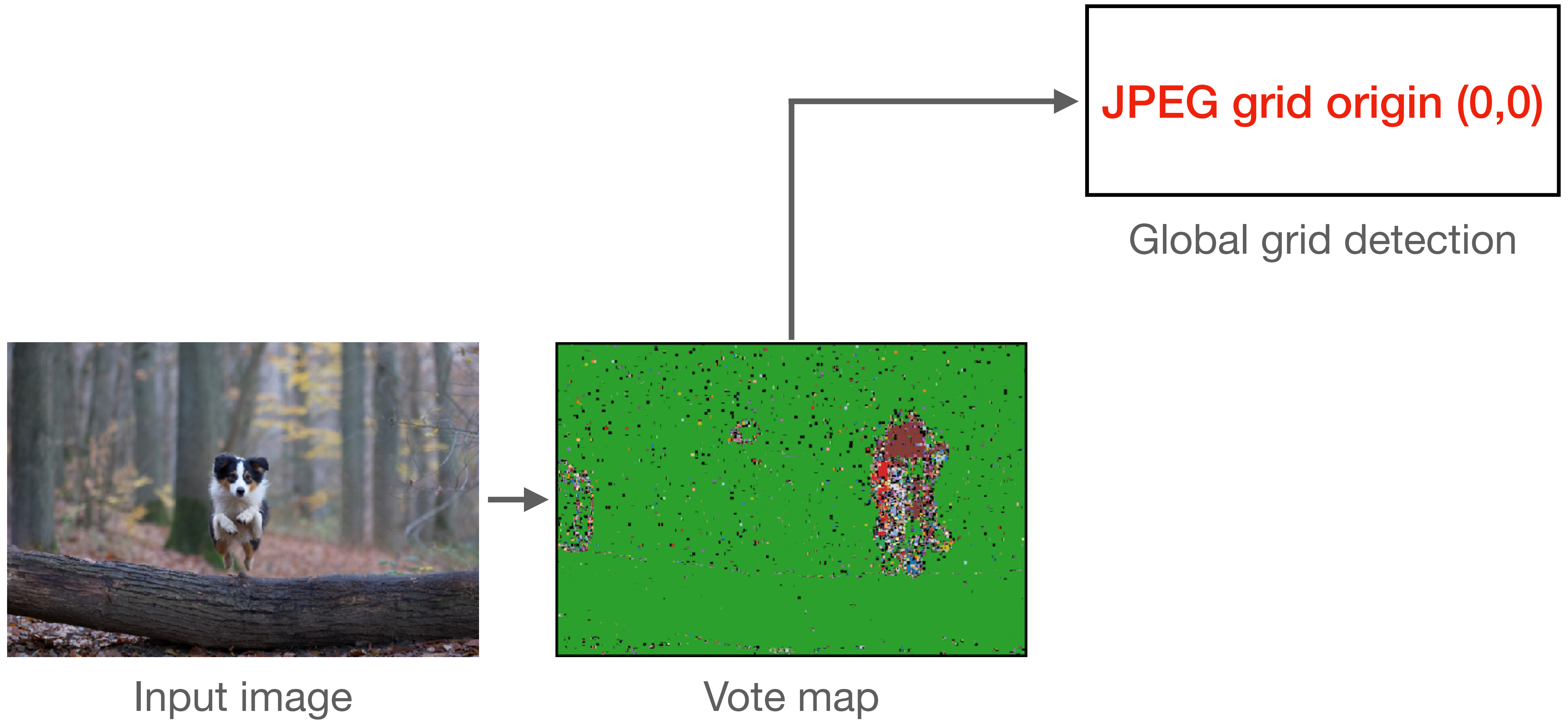
Local missing grid.

Original

Forged

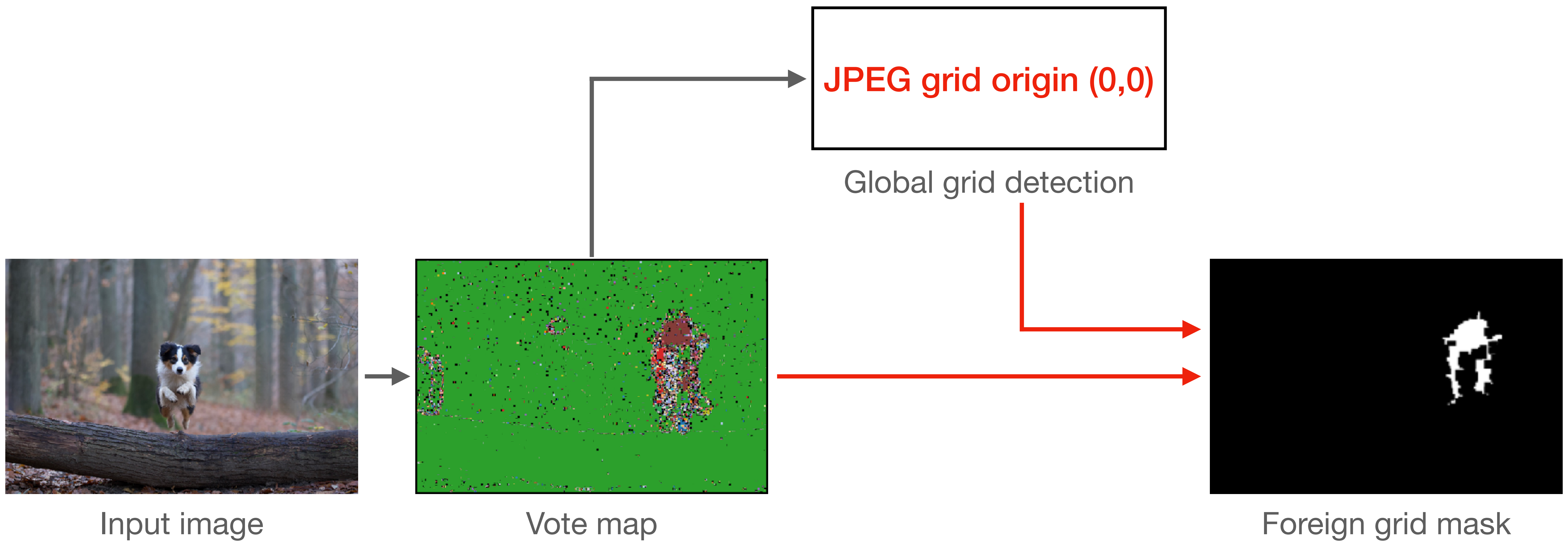
Detection results.

ZERO



JPEG grid detection based on the number of DCT zeros and its application to automatic and localized forgery detection. T. Nikoukhah, J. Anger, T. Ehret, M. Colom, J.-M. Morel, and R. Grompone von Gioi. IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRw), 2019.
ZERO: a Local JPEG Grid Origin Detector Based on the Number of DCT Zeros and its Applications in Image Forensics. T. Nikoukhah, J. Anger, M. Colom, J.-M. Morel, and R. Grompone von Gioi. Image Processing On Line, 2021.

ZERO



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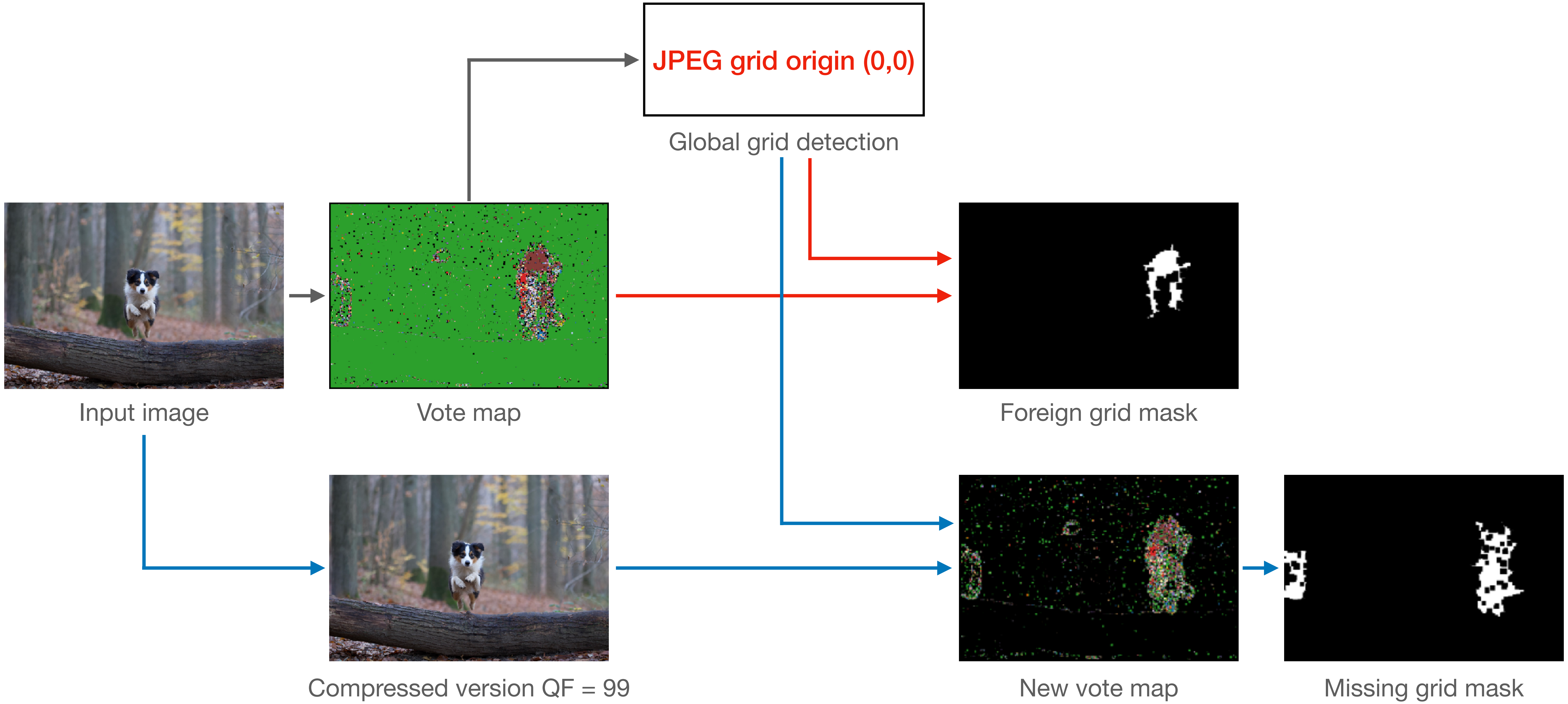
ZERO: a Local JPEG Grid Origin Detector Based on the Number of DCT Zeros and its Applications in Image Forensics. T. Nikoukhah, J. Anger, M. Colom, J.-M. Morel, and R. Grompone von Gioi. Image Processing On Line, 2021.

ZERO



JPEG grid detection based on the number of DCT zeros and its application to automatic and localized forgery detection. T. Nikoukhah, J. Anger, T. Ehret, M. Colom, J.-M. Morel, and R. Grompone von Gioi. IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRw), 2019.
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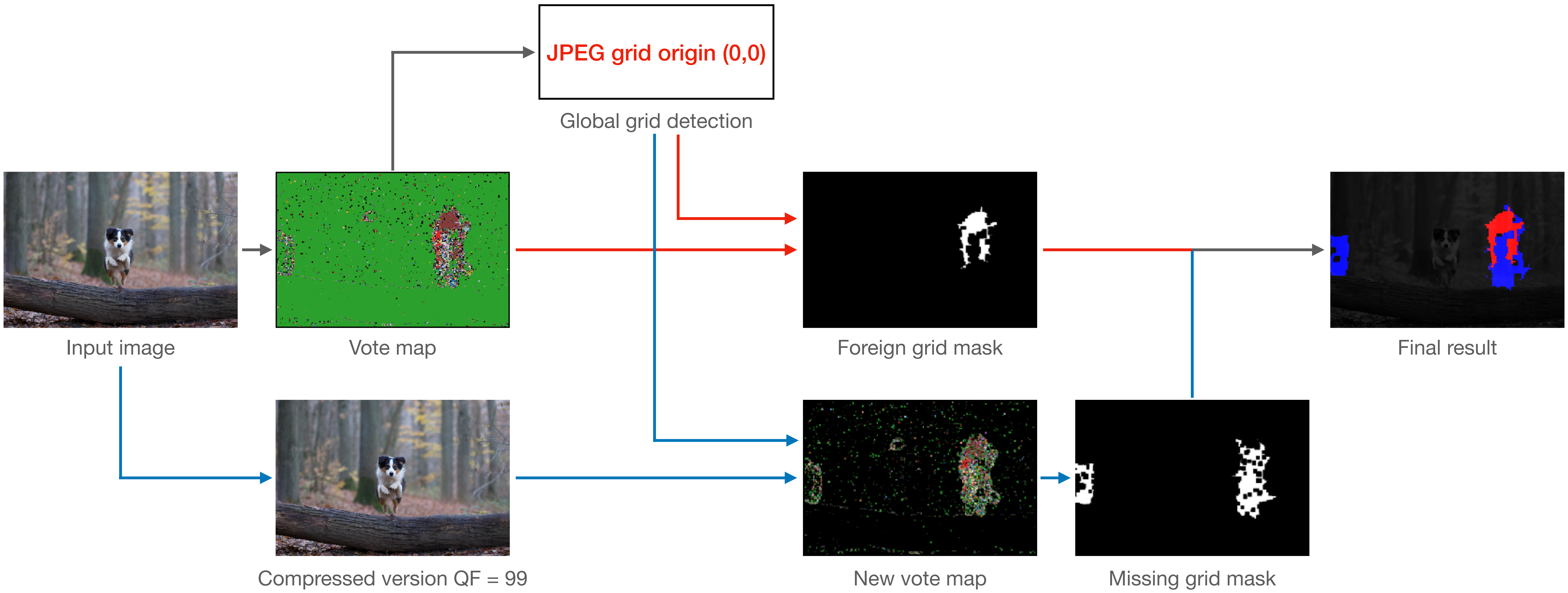
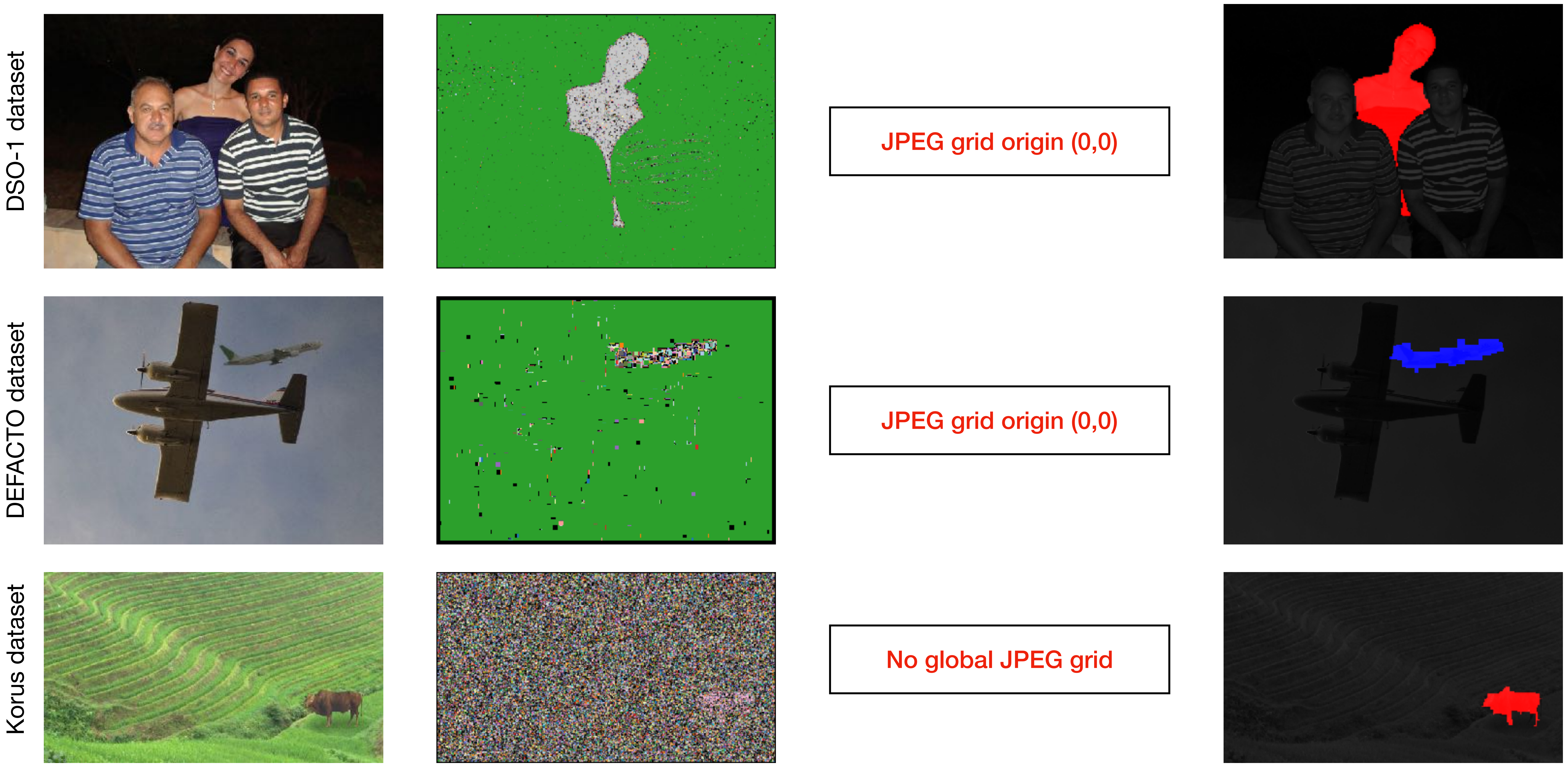
ZERO



JPEG grid detection based on the number of DCT zeros and its application to automatic and localized forgery detection. T. Nikoukhah, J. Anger, T. Ehret, M. Colom, J.-M. Morel, and R. Grompone von Gioi. IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRw), 2019.
ZERO: a Local JPEG Grid Origin Detector Based on the Number of DCT Zeros and its Applications in Image Forensics. T. Nikoukhah, J. Anger, M. Colom, J.-M. Morel, and R. Grompone von Gioi. Image Processing On Line, 2021.

ZERO: a forgery detector



Forged images from datasets. Vote maps Detection results

Image processing pipeline

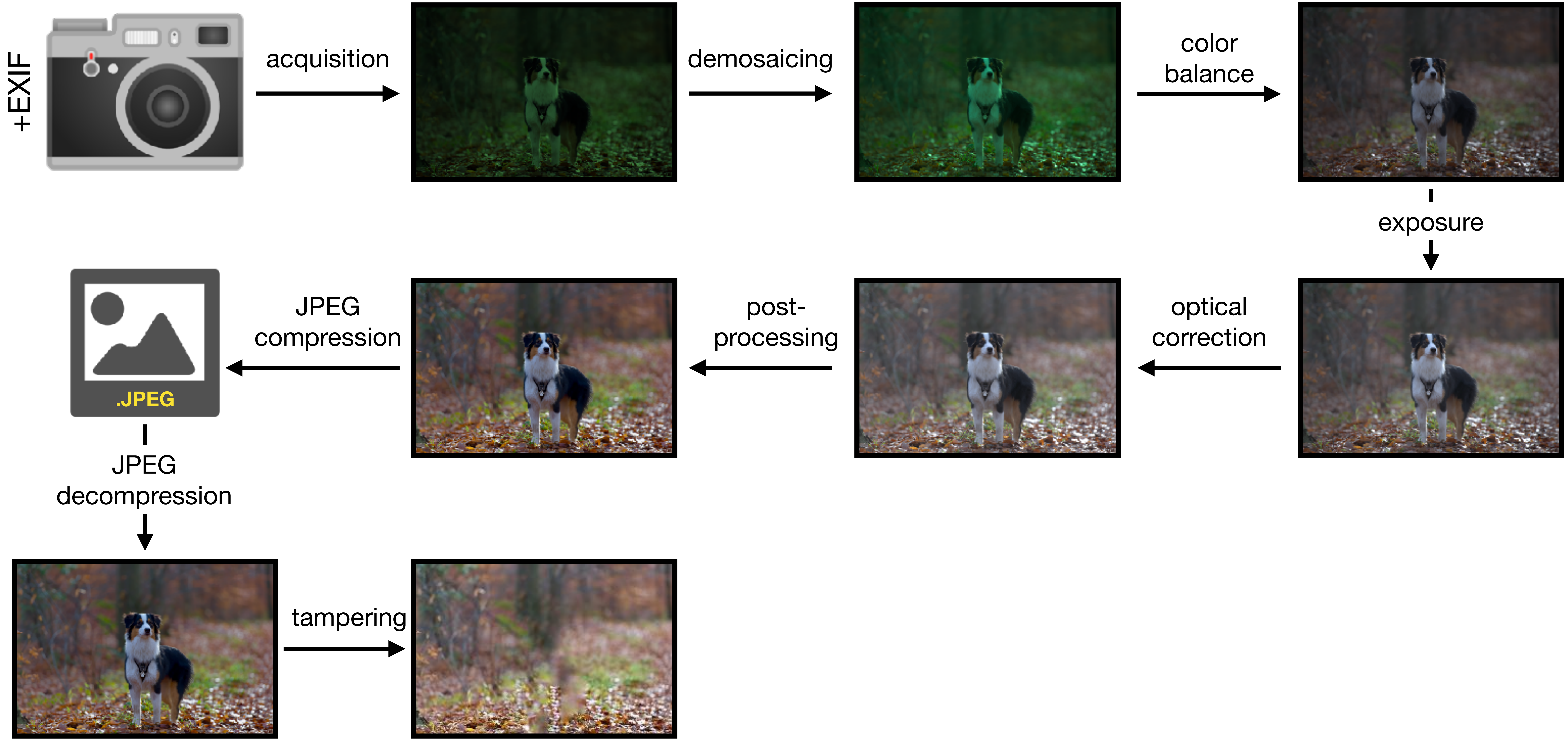
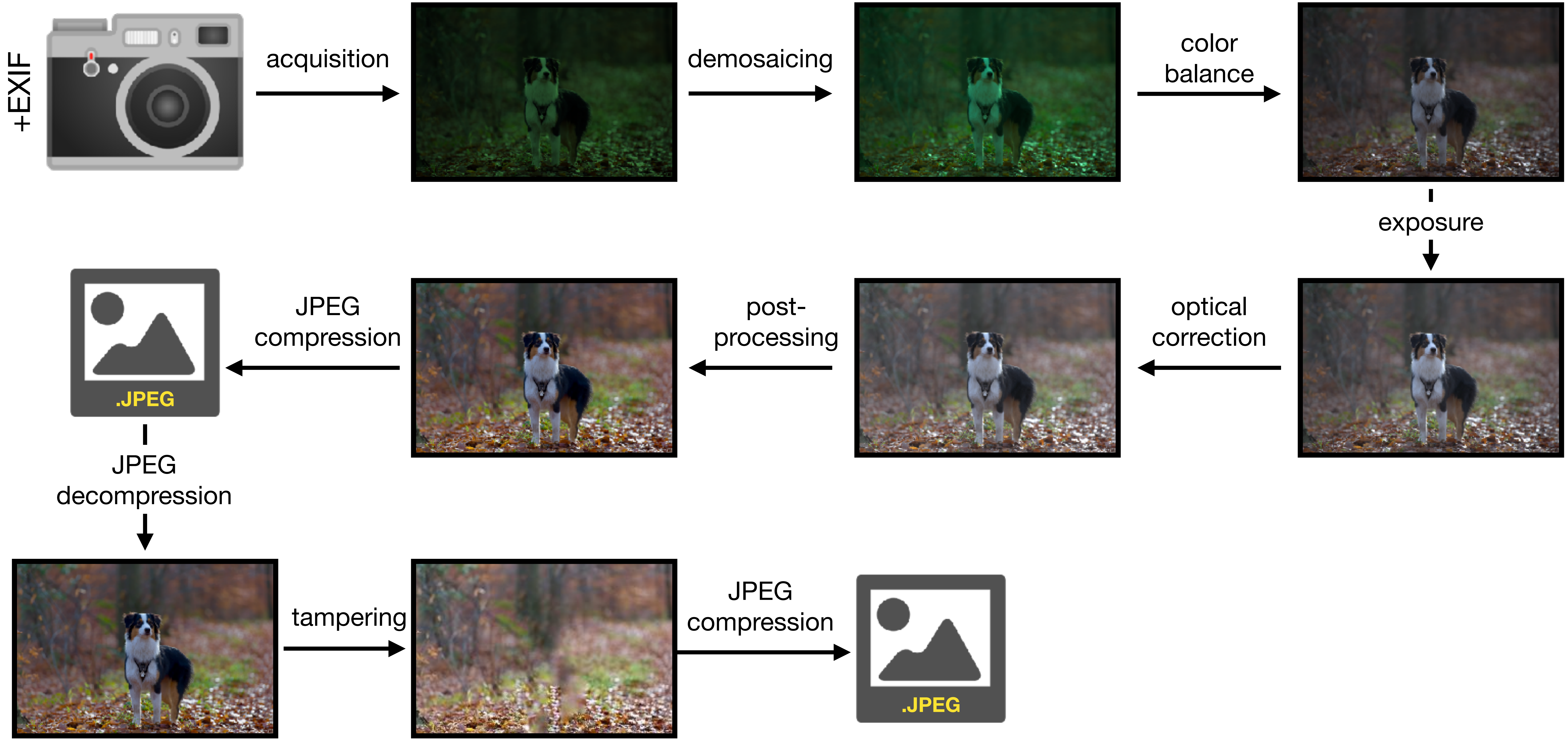


Image processing pipeline



Forged images posted online

Original

ENS Paris-Saclay
@ENS_ParisSaclay

Rehearsal of #TinasPhdDefense, sound check, video check, internet check 😟😟😟

10:49 AM · Nov 1, 2022 · Twitter Web App

Copy-move

Movers
@troll

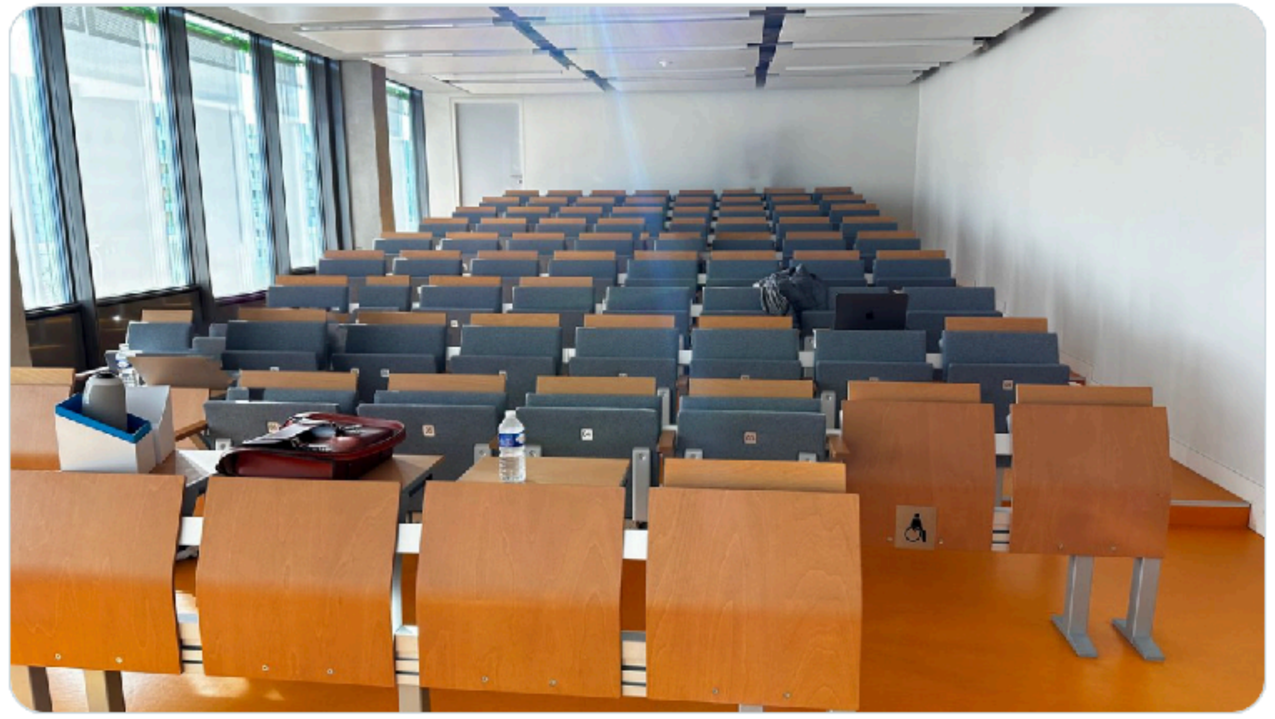
Soooo many people at #TinasPhdDefense 🤣🤣🤣

4:02 PM · Nov 8, 2022 · Twitter App

Inpainting

Alicia Keys
@aliciakeys

No one, no one, no one 🎶 #TinasPhdDefense



4:02 PM · Nov 8, 2022 ·

Splicing

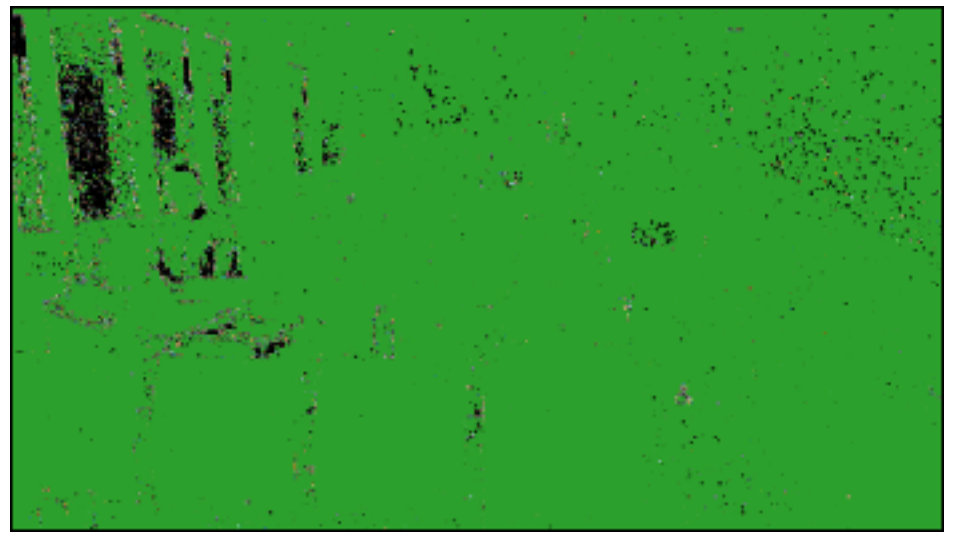
Pashmina fan club
@Pashm_ina

Her pets came to #TinasPhdDefense !! 😺🐶

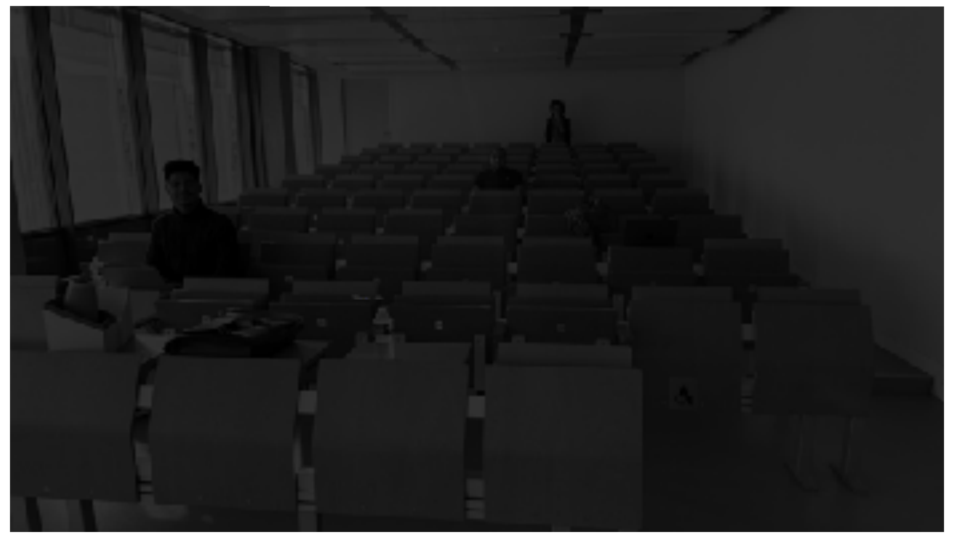
4:05 PM · Nov 8, 2022 · Twitter Web App

ZERO: a forgery detector

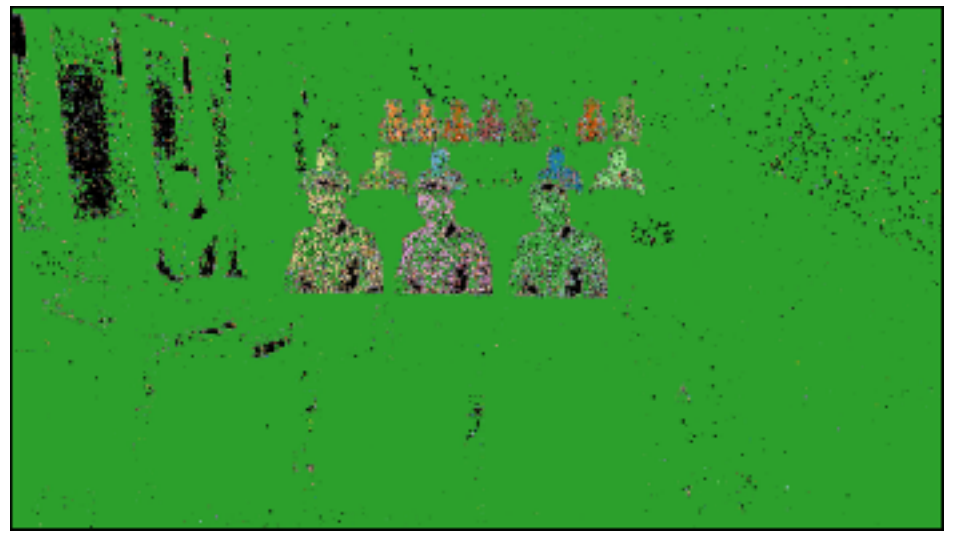
Original



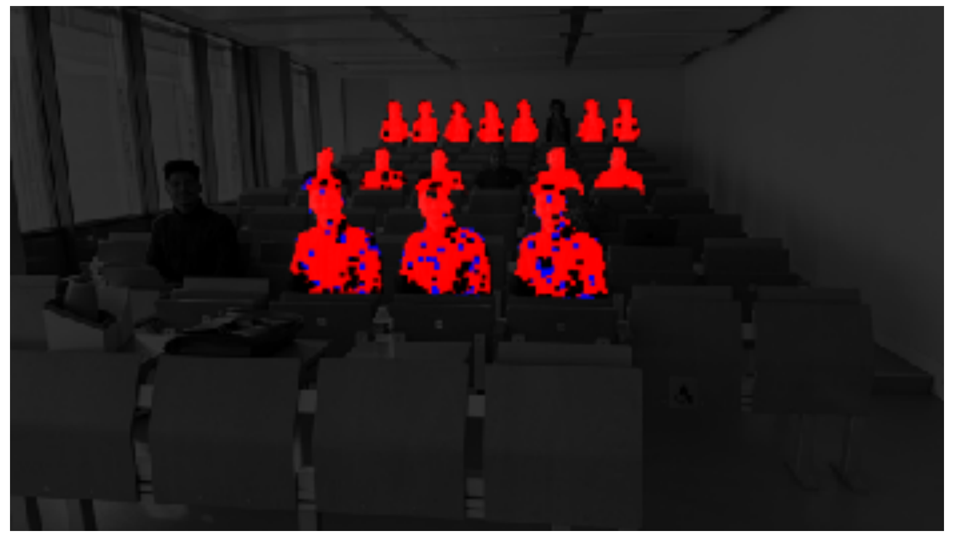
JPEG grid origin (0,0)



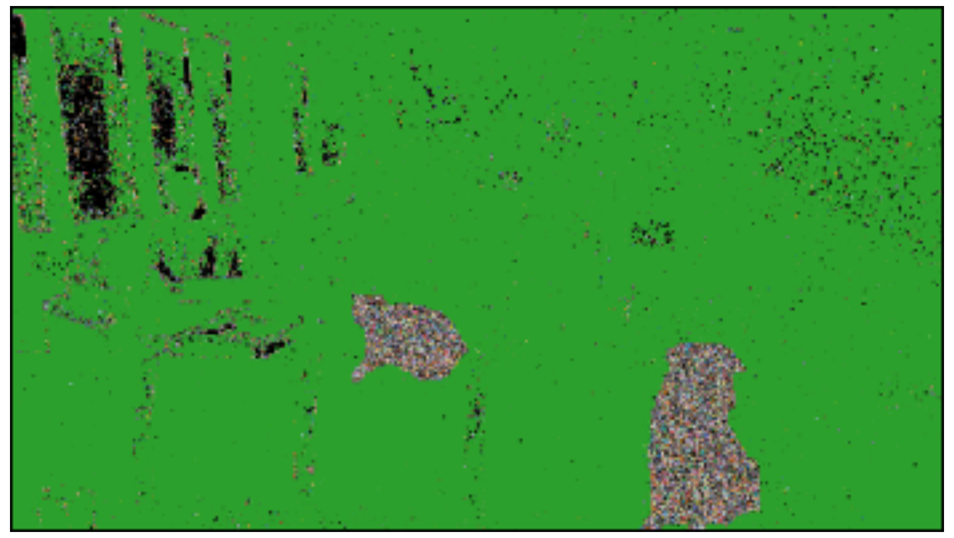
Copy-move



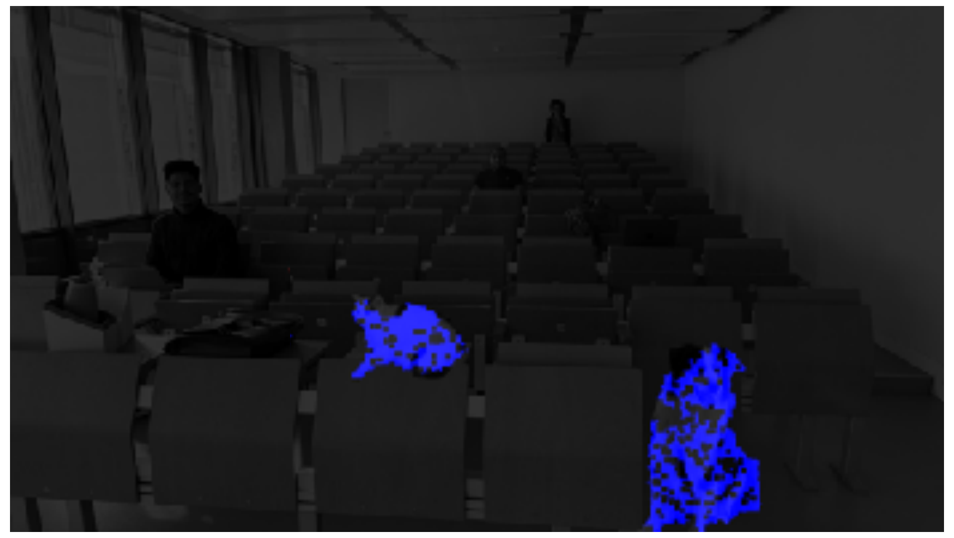
JPEG grid origin (0,0)



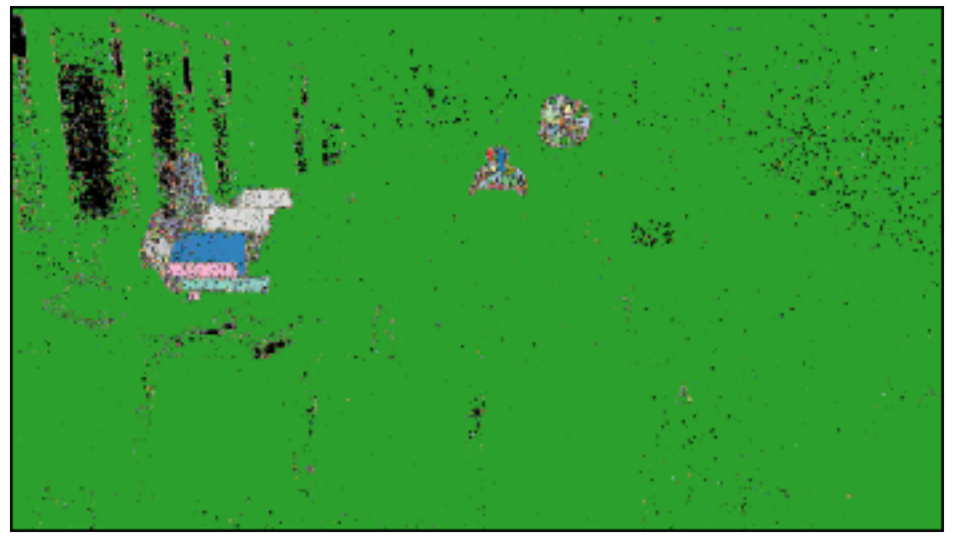
Splicing



JPEG grid origin (0,0)



Inpainting



JPEG grid origin (0,0)

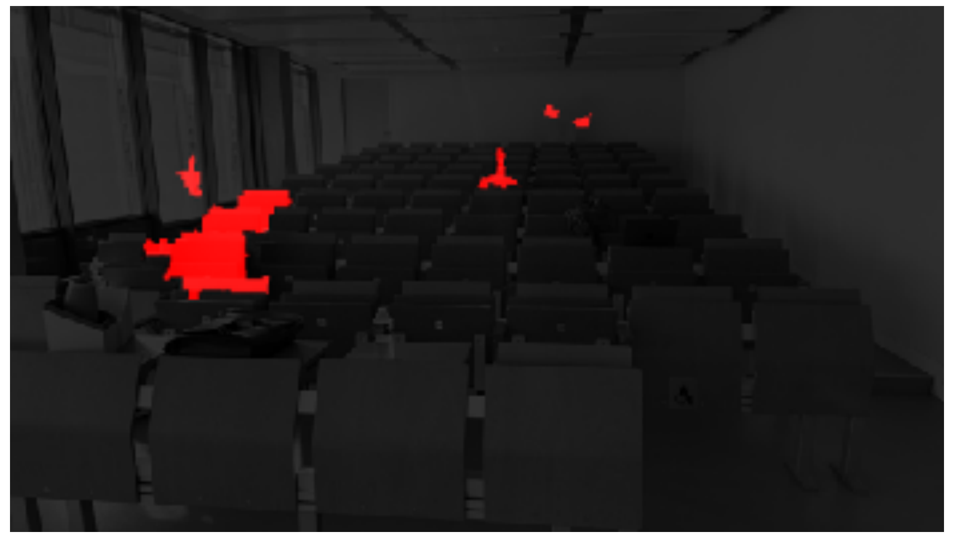
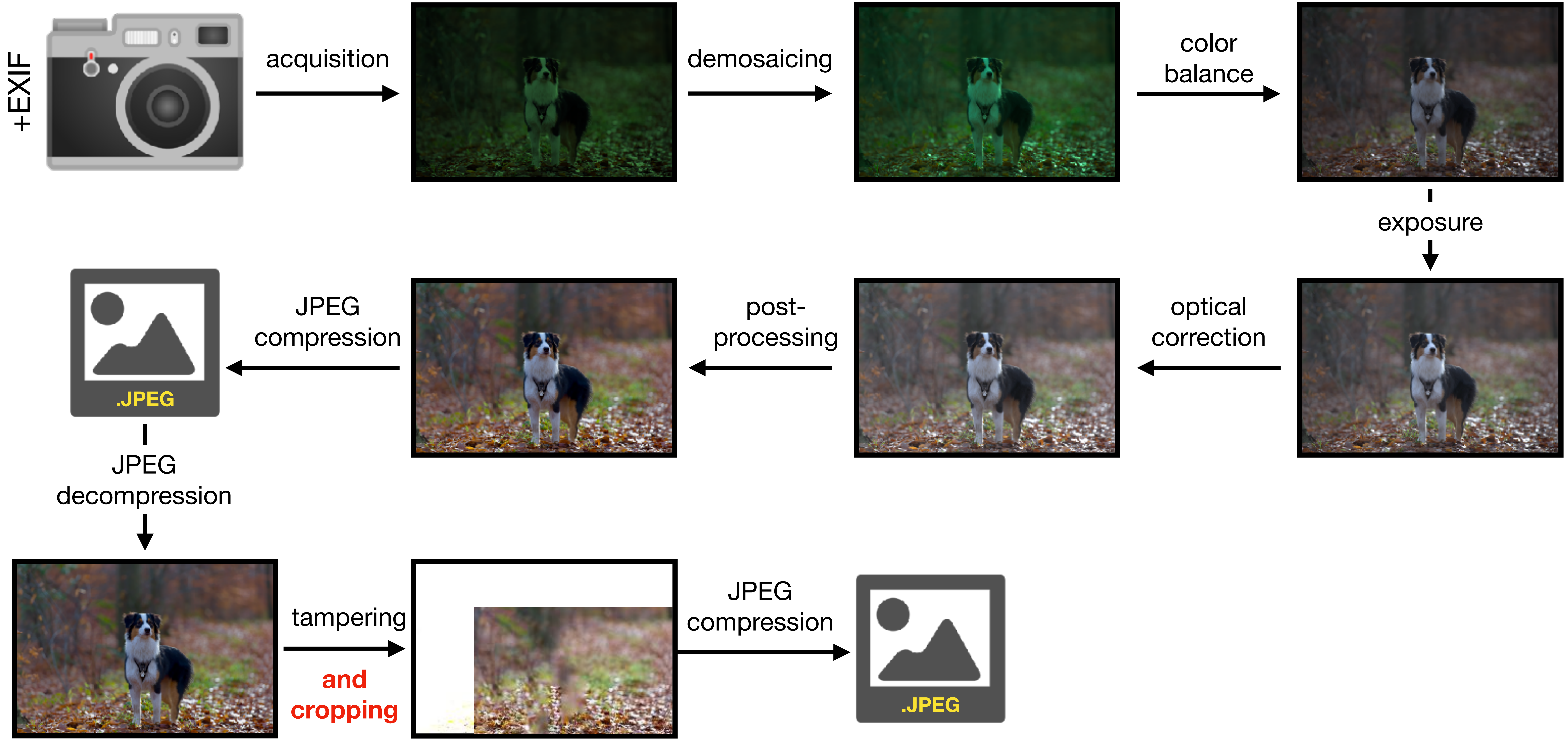


Image processing pipeline



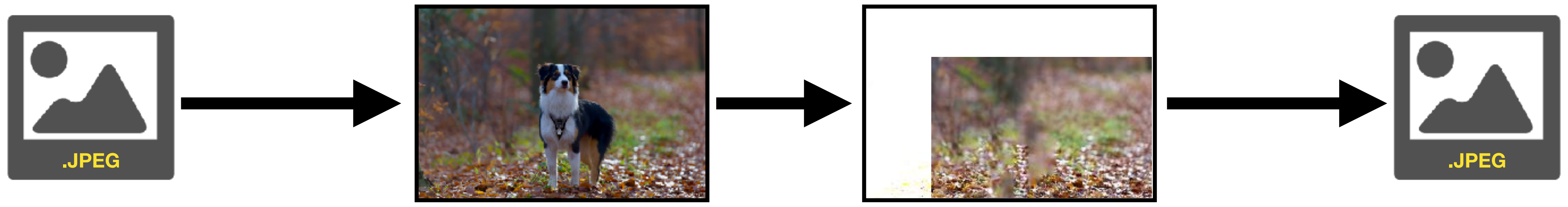
Forged image posted online

Tina
@TinaNkh

Can you detect these forgeries? #TinasPhdDefense

4:10 PM · Nov 8, 2022 · Twitter Web App

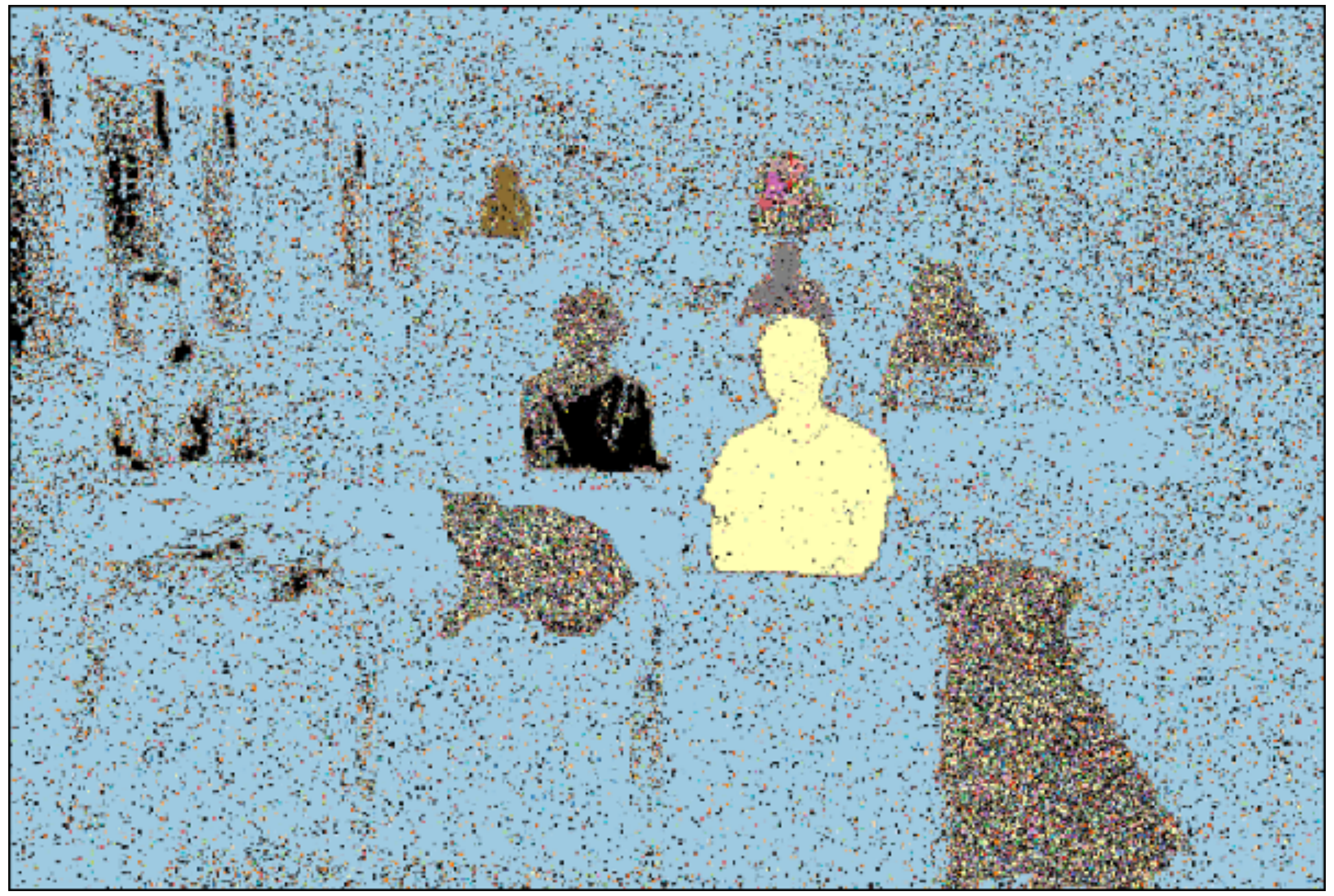
Forged image



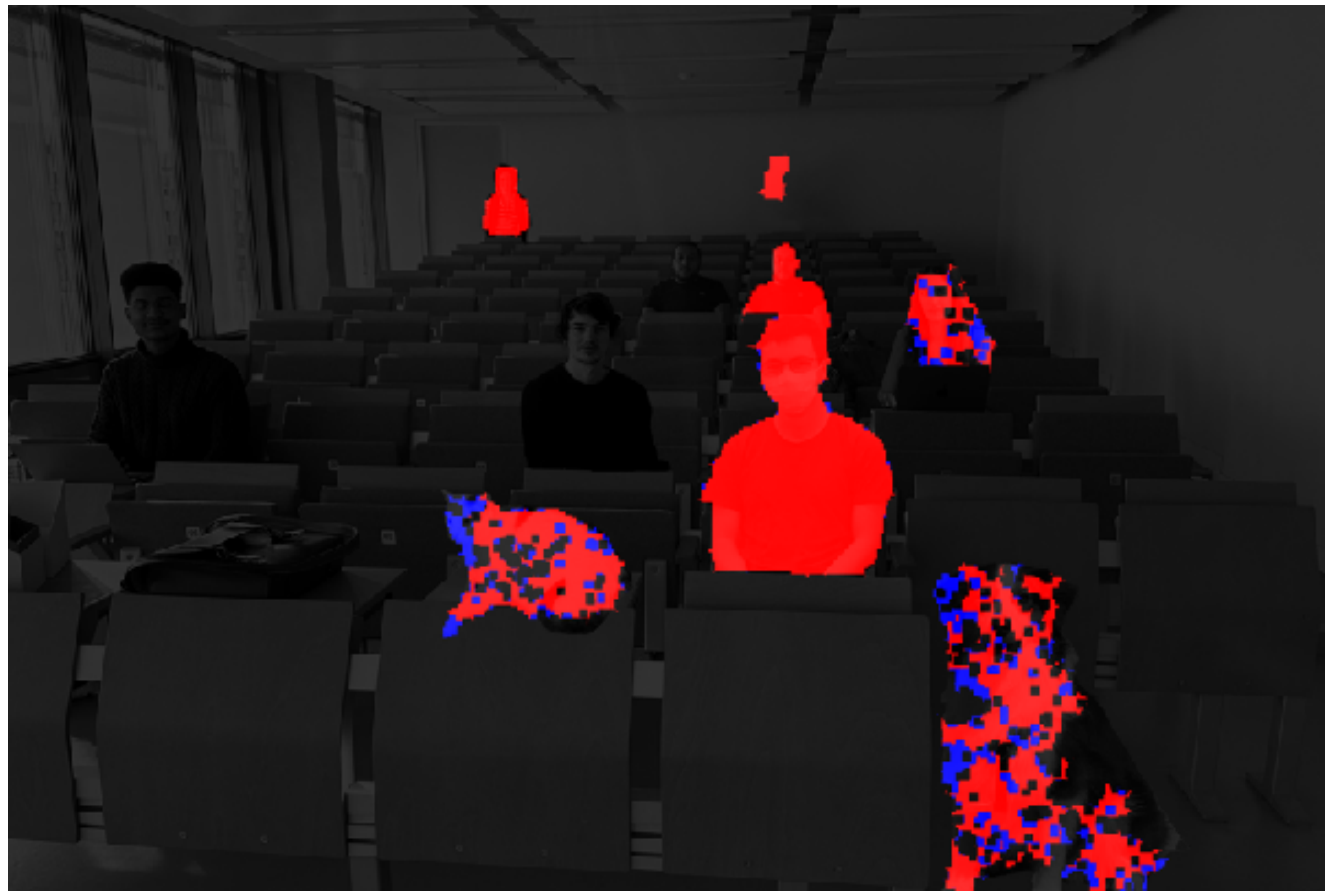
Forged image

JPEG grid origin (2,5)
JPEG grid origin (0,0)

Main grid (2,5)



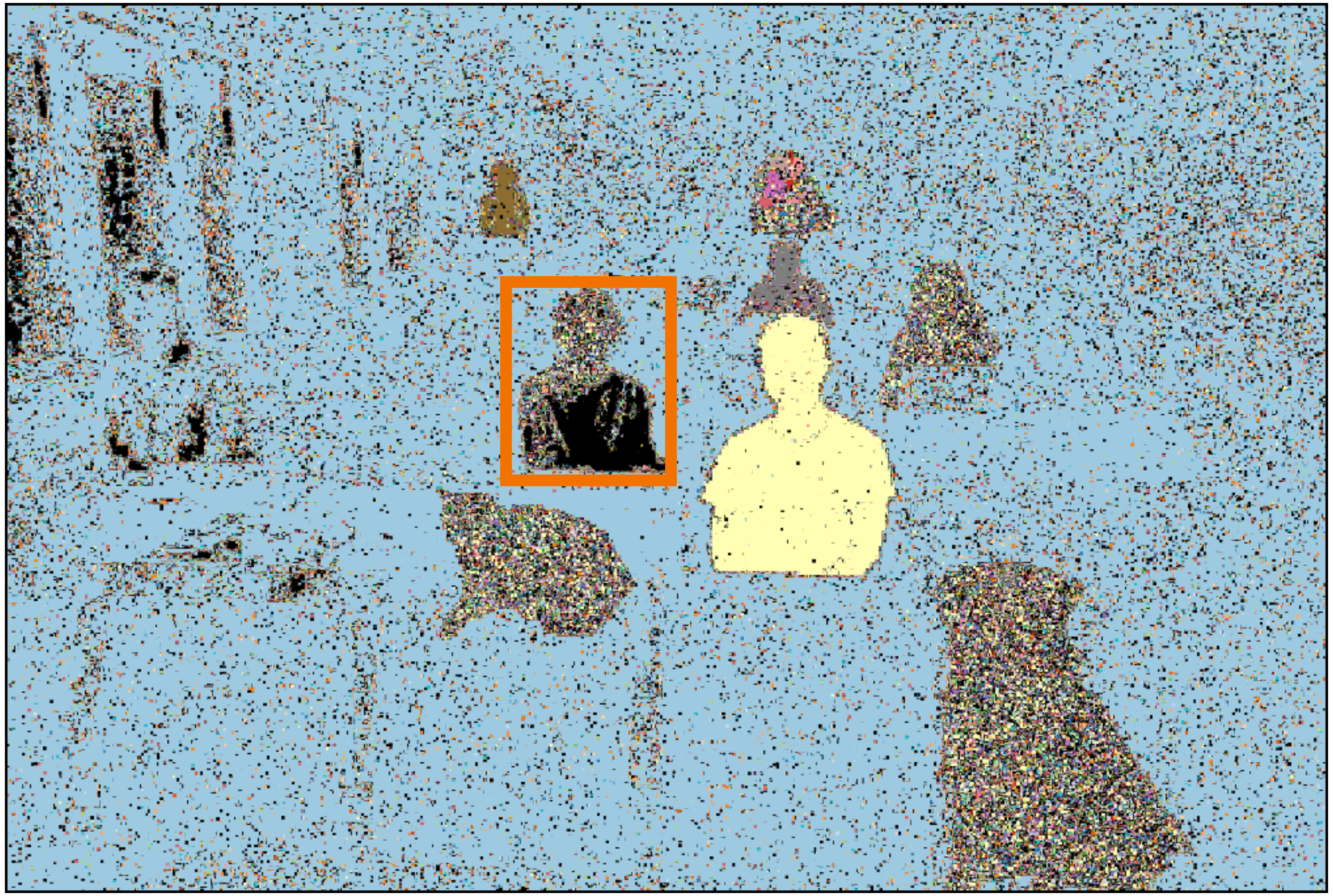
Vote map



Detection result

ZERO: missed detections

Limitations: saturation, size



Vote map: each color represents a grid origin. Black corresponds to a non-valid vote, in case of a tie for example.

Forged image posted online

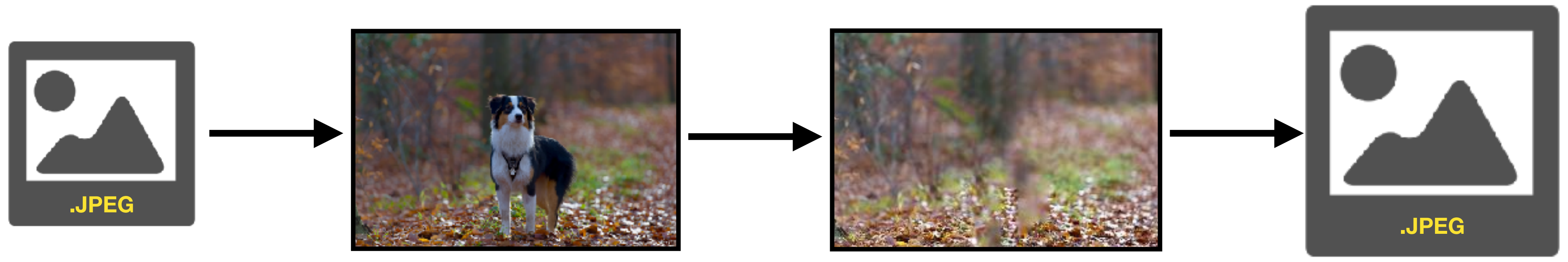
Tina
@TinaNkh

Can you detect these forgeries? #TinasPhdDefense

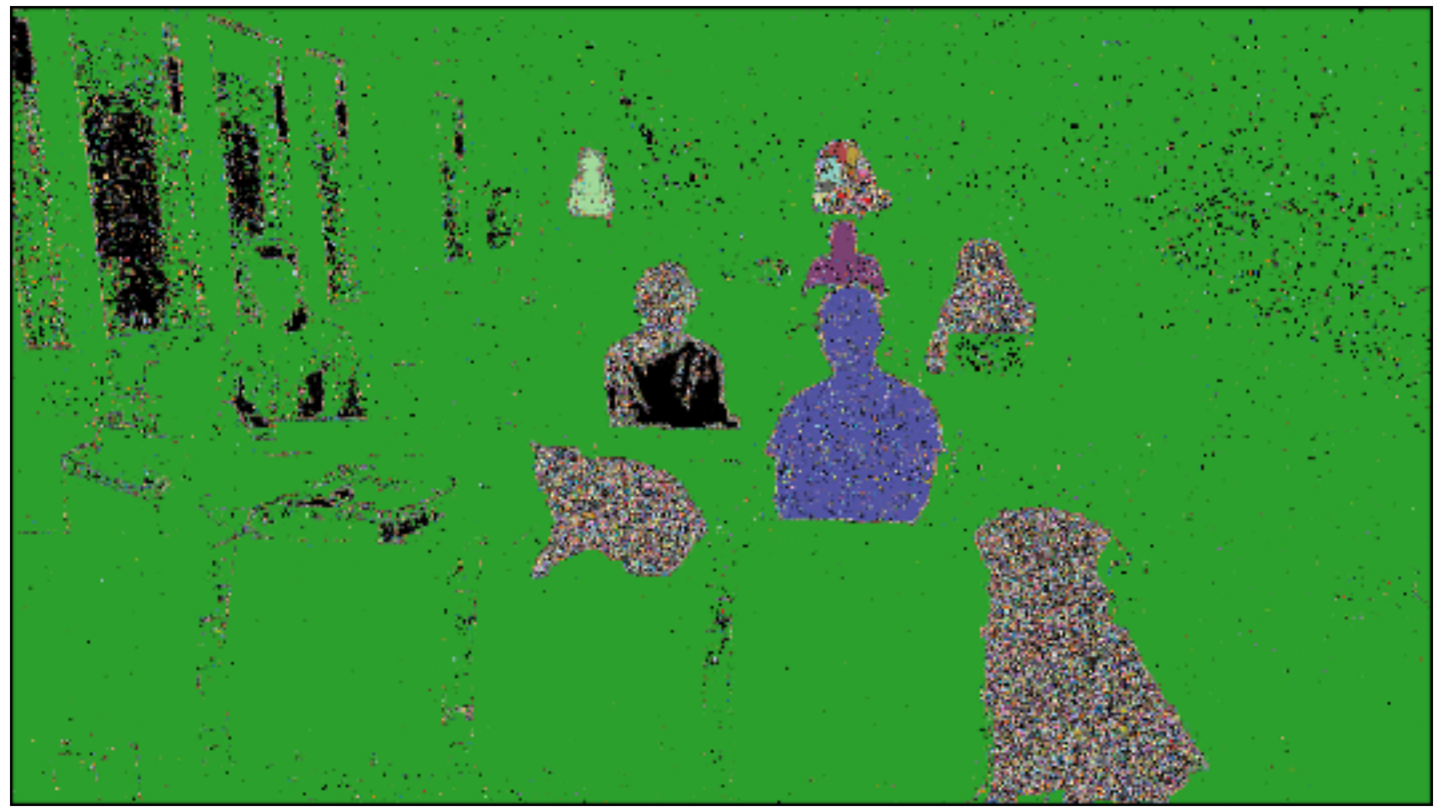
4:10 PM · Nov 8, 2022 · Twitter Web App

ZERO and double compression

Second compression QF2 = 100

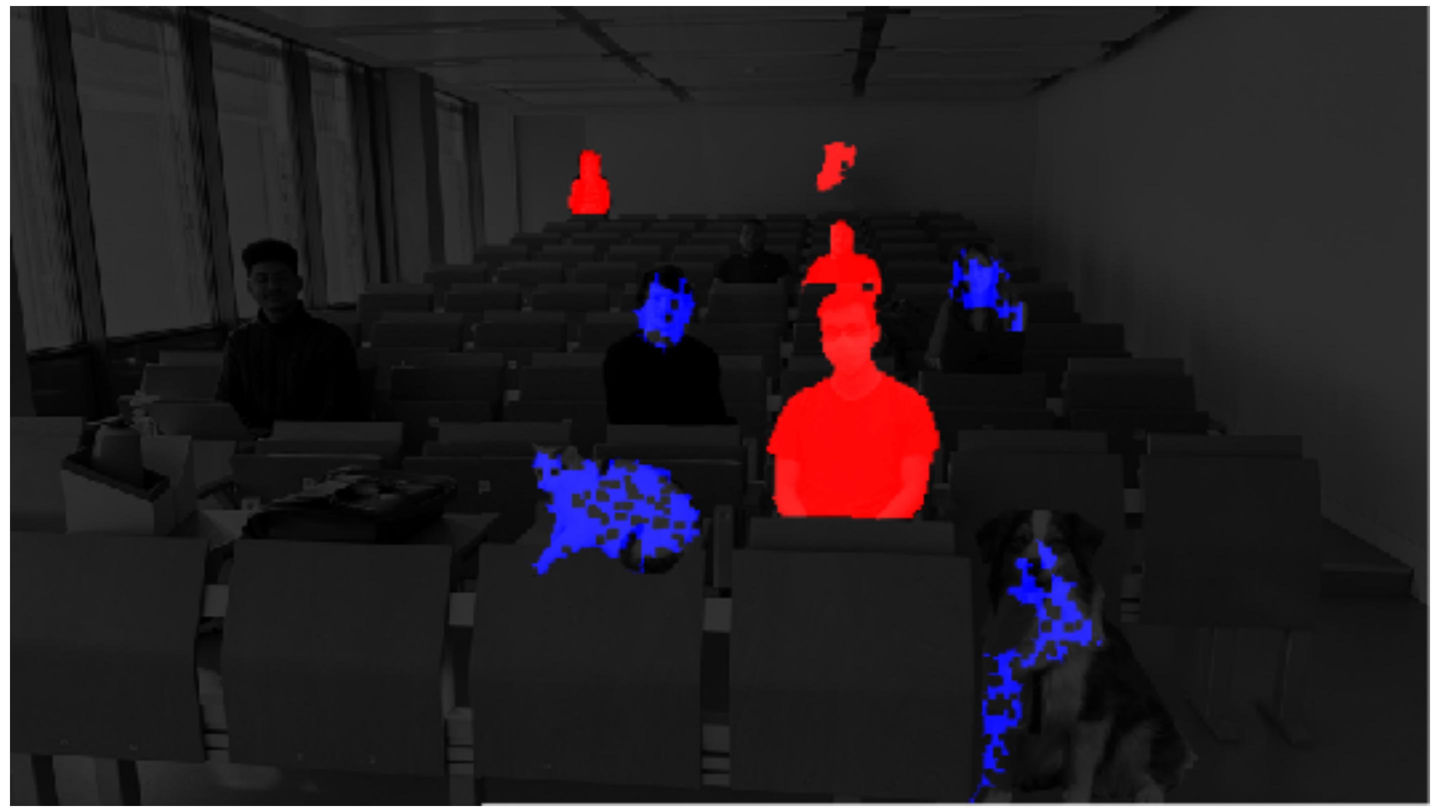


Forged image



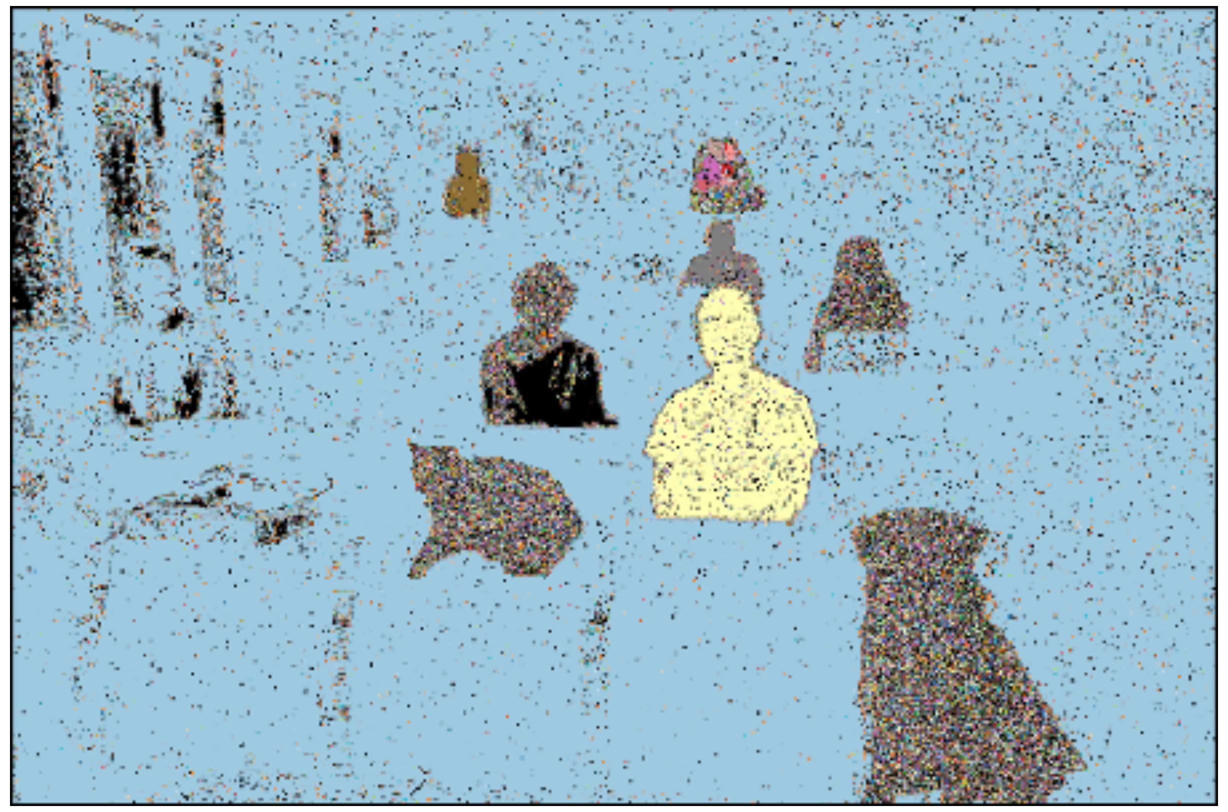
Vote map

JPEG grid origin (0,0)



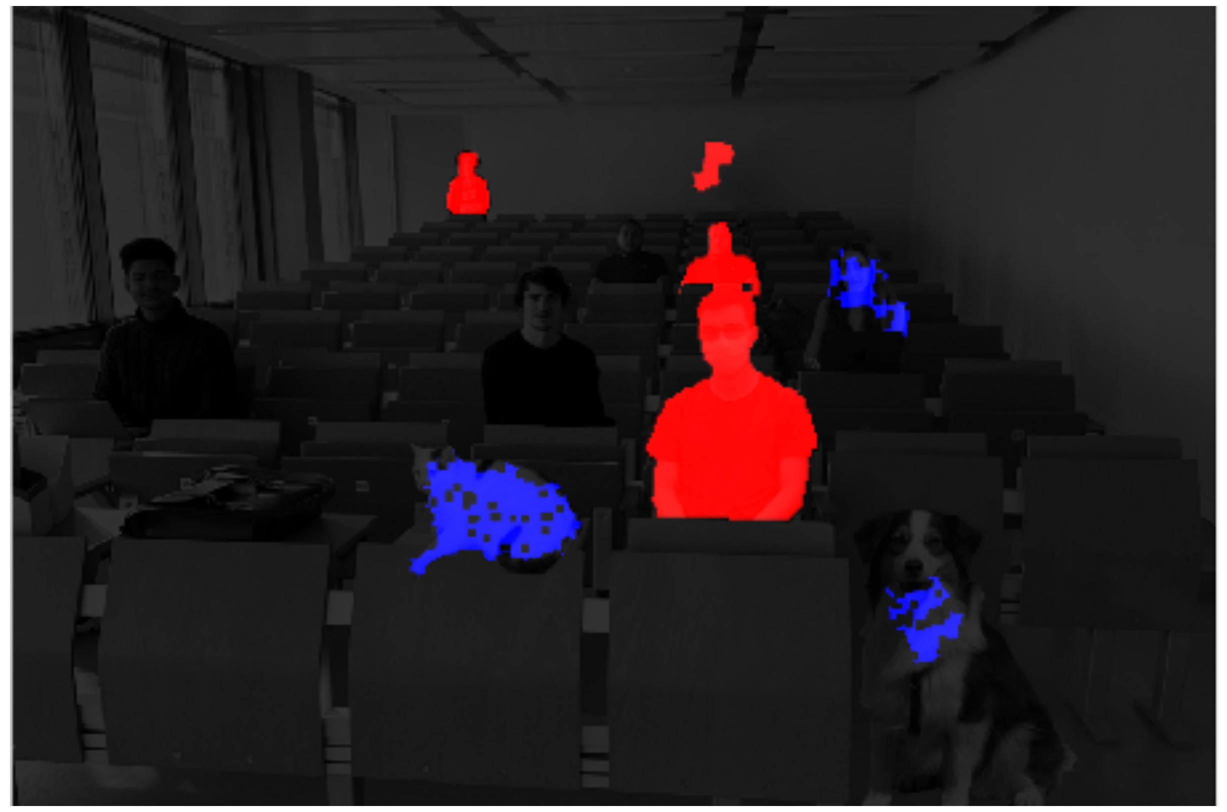
Detection result

Forged and cropped image



Vote map

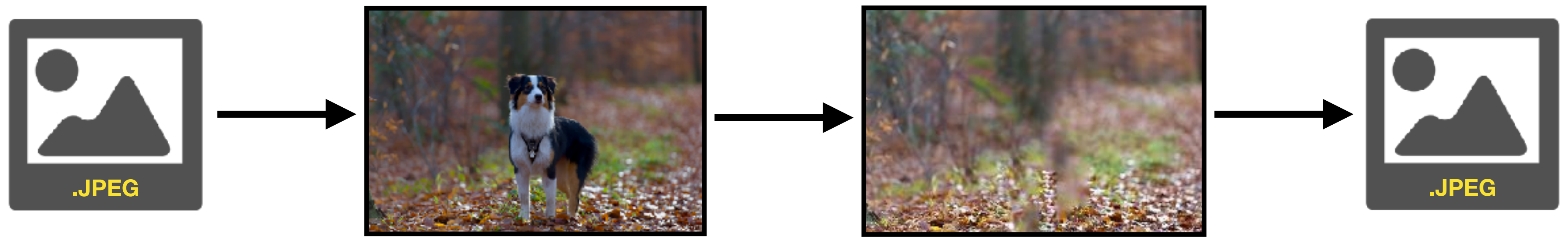
JPEG grid origin (2,5)



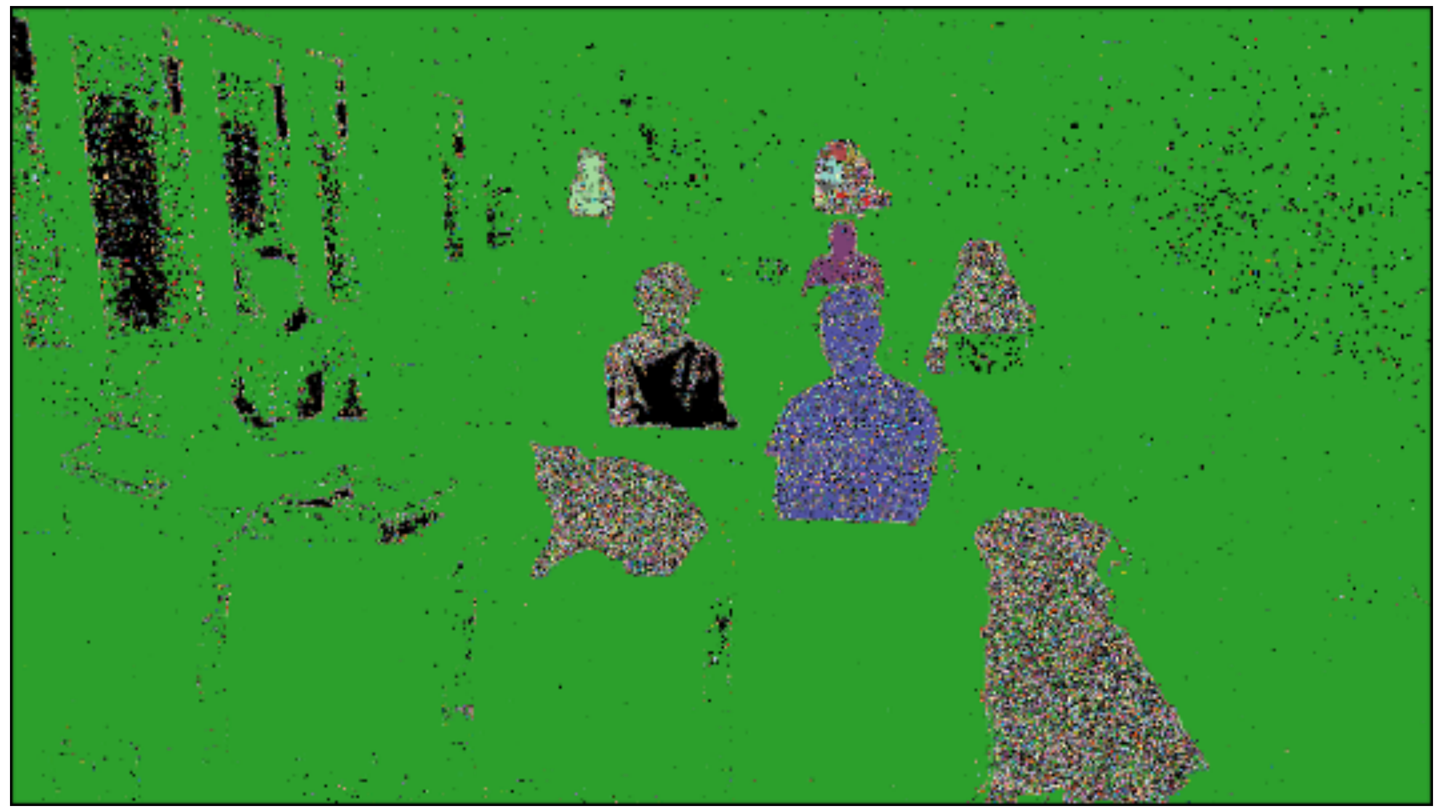
Detection result

ZERO and double compression

Second compression QF2 ≥ QF1

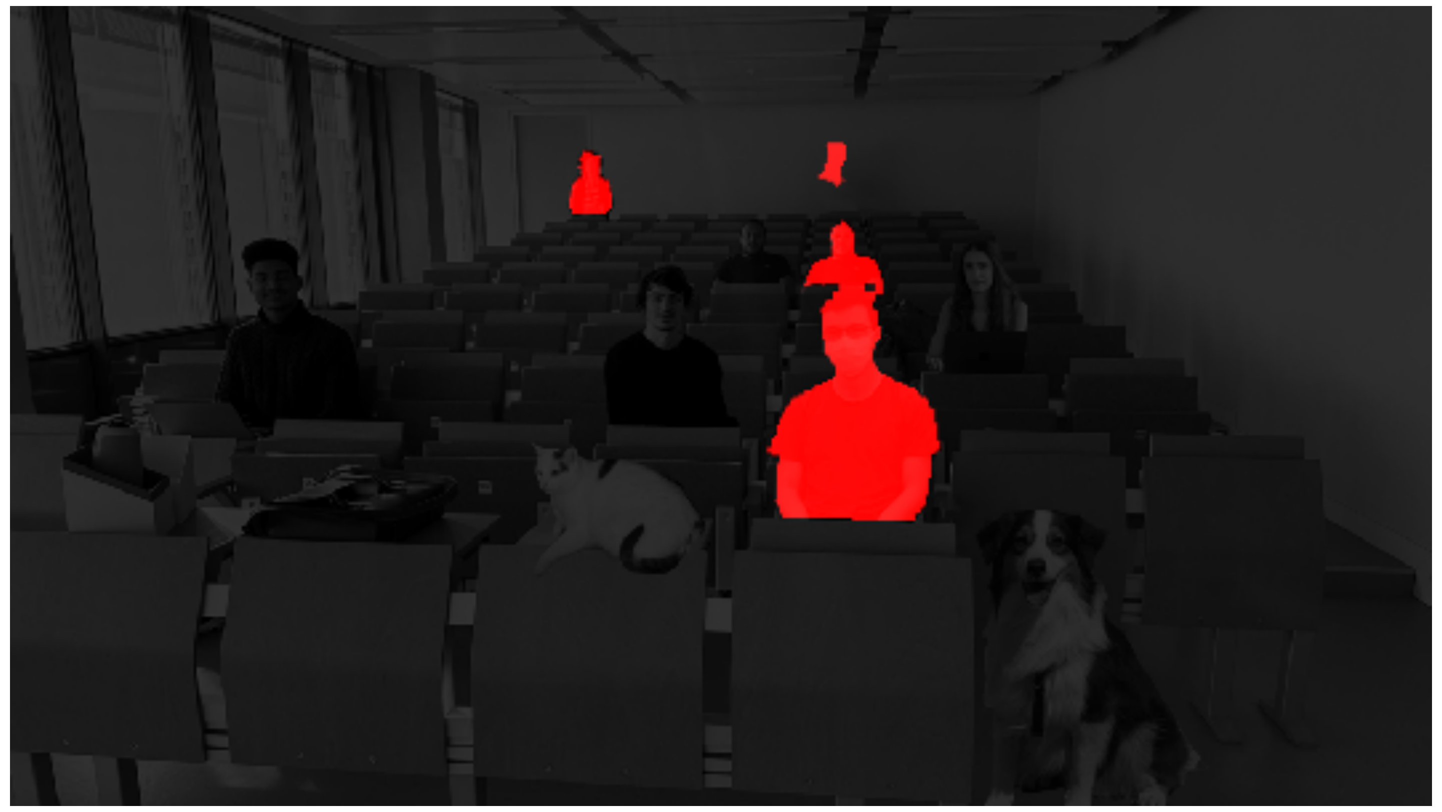


Forged image



Vote map

JPEG grid origin (0,0)



Detection result

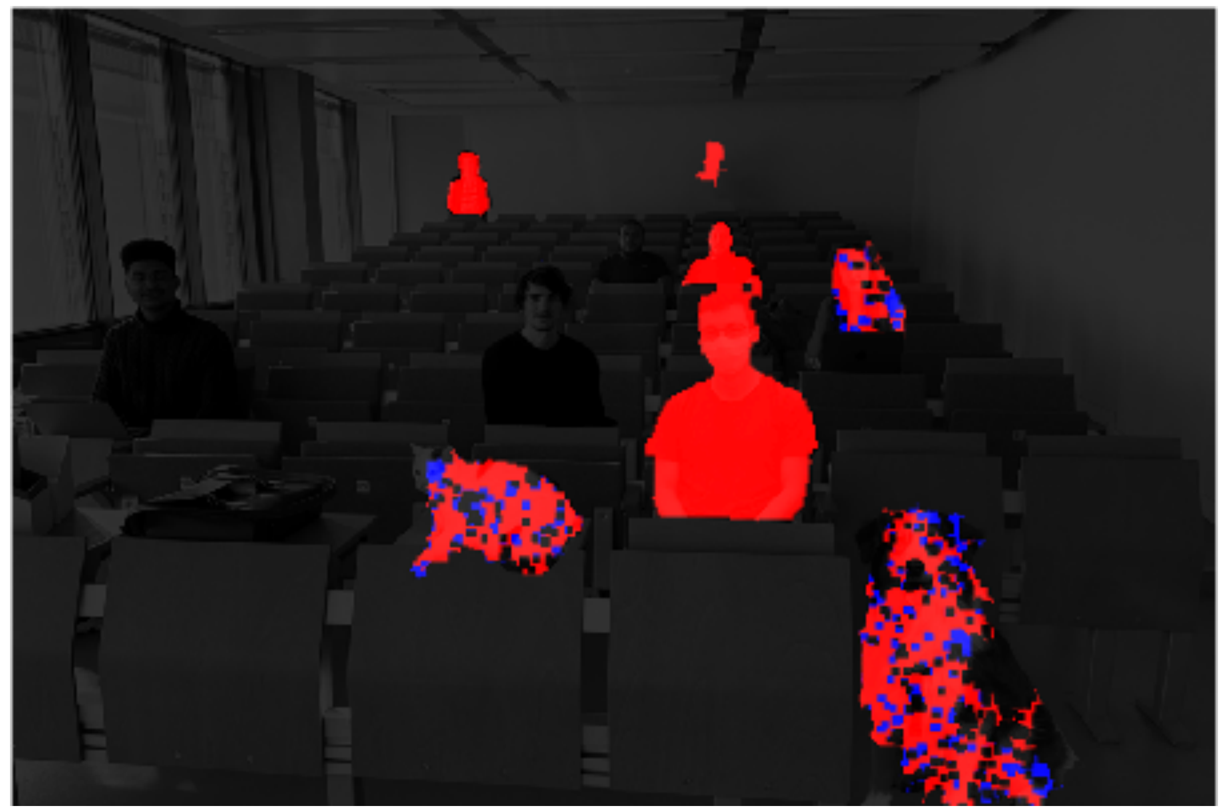
Forged and cropped image

Vote map

JPEG grid origin (2,5)

JPEG grid origin (0,0)

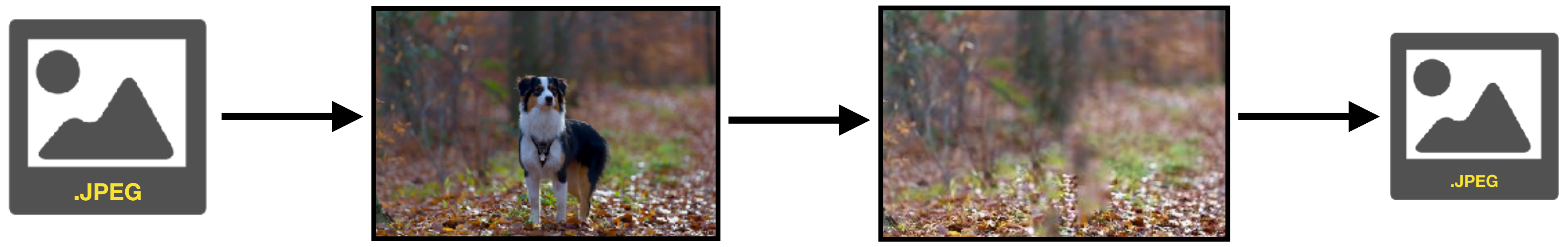
Main grid (2,5)



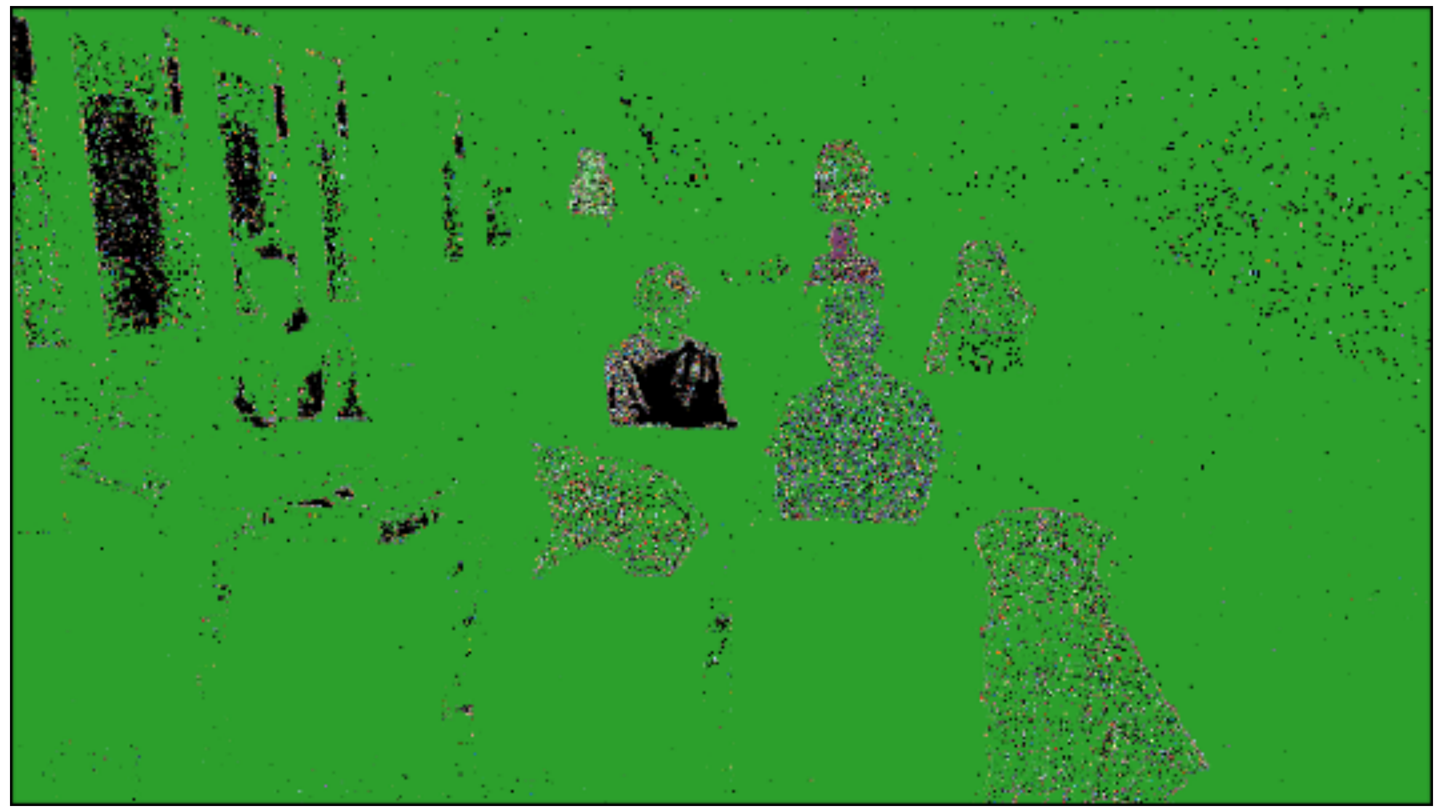
Detection result

ZERO and double compression

Second compression QF2 < QF1

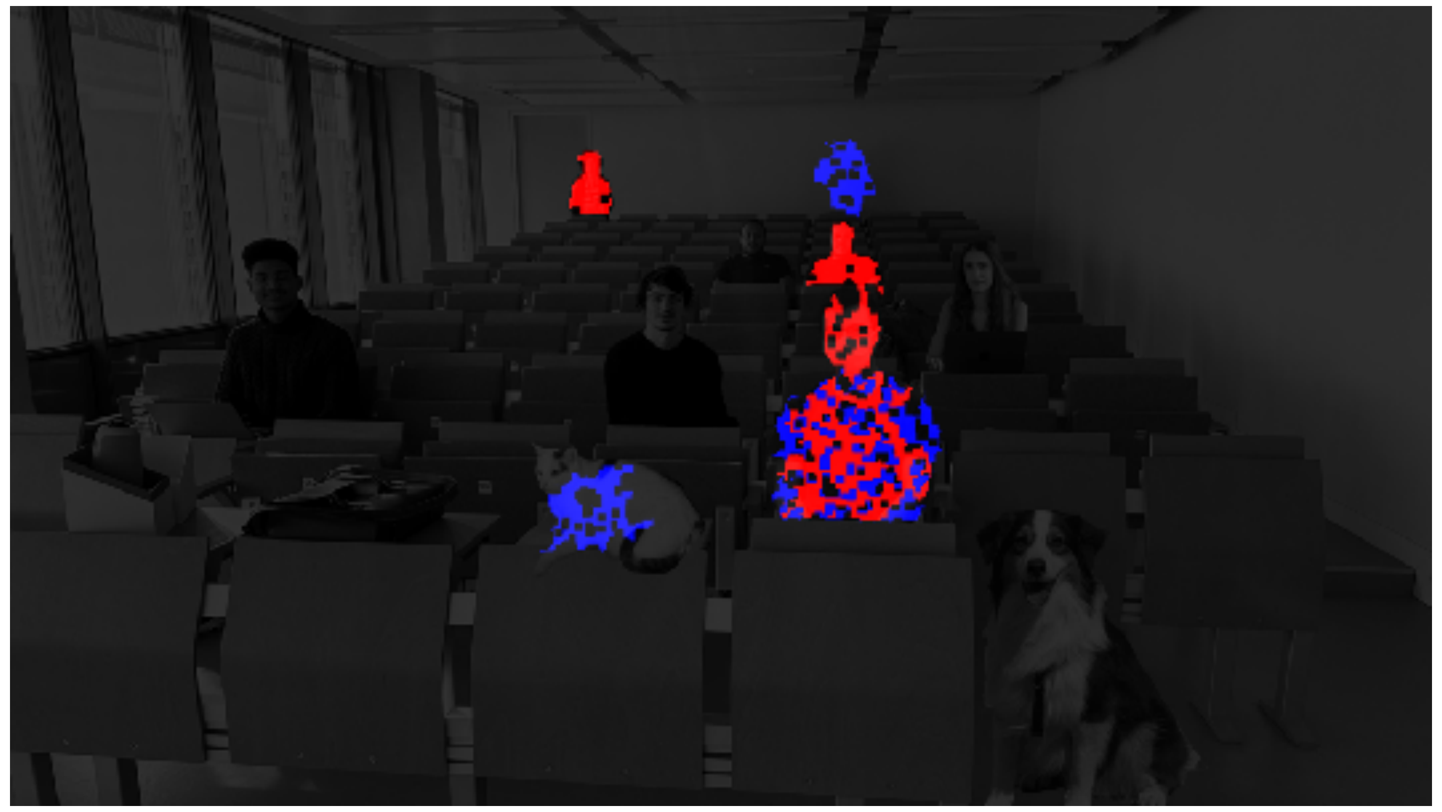


Forged image



Vote map

JPEG grid origin (0,0)



Detection result

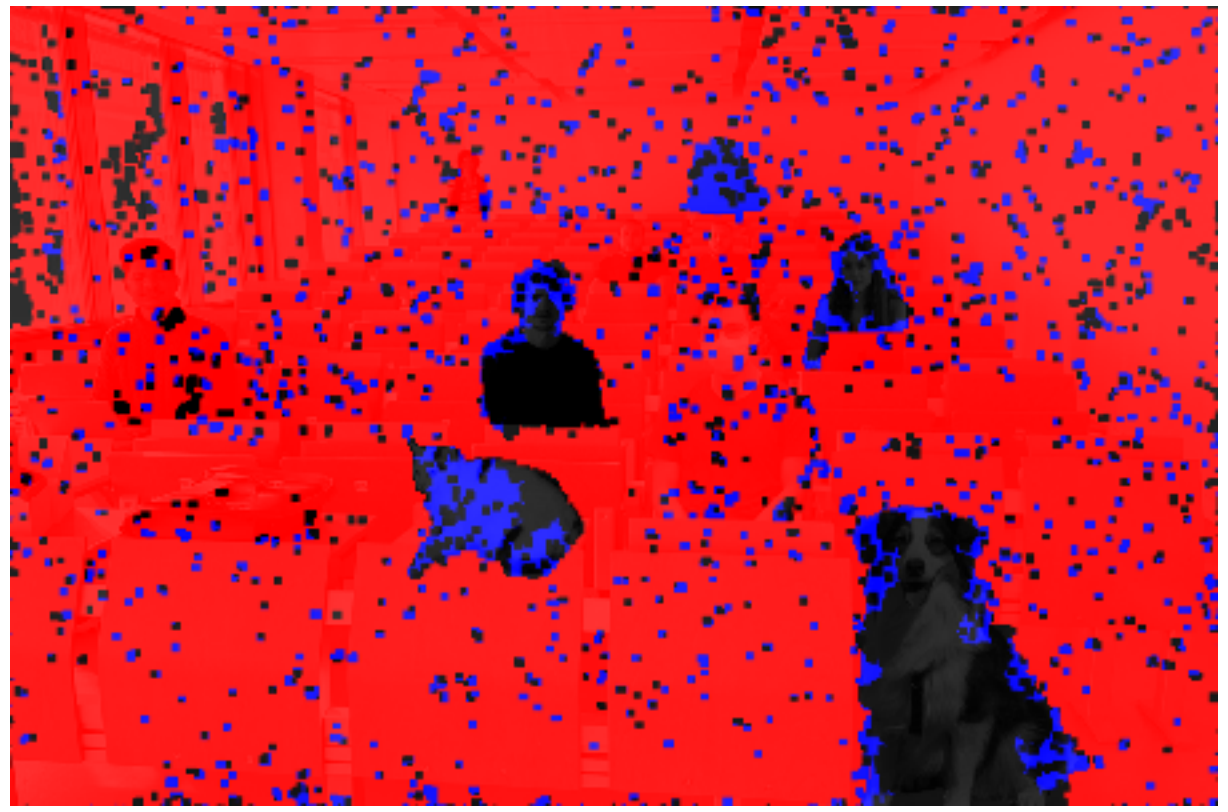
Forged and cropped image

Vote map

JPEG grid origin (0,0)

JPEG grid origin (2,5)

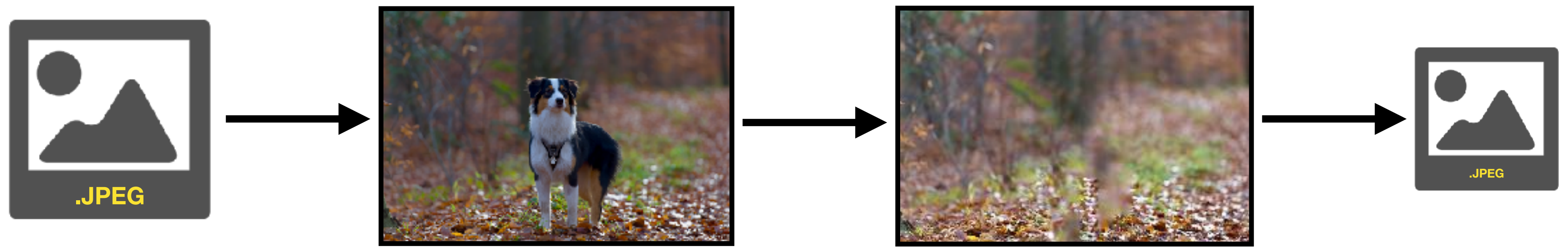
Main grid (0,0)



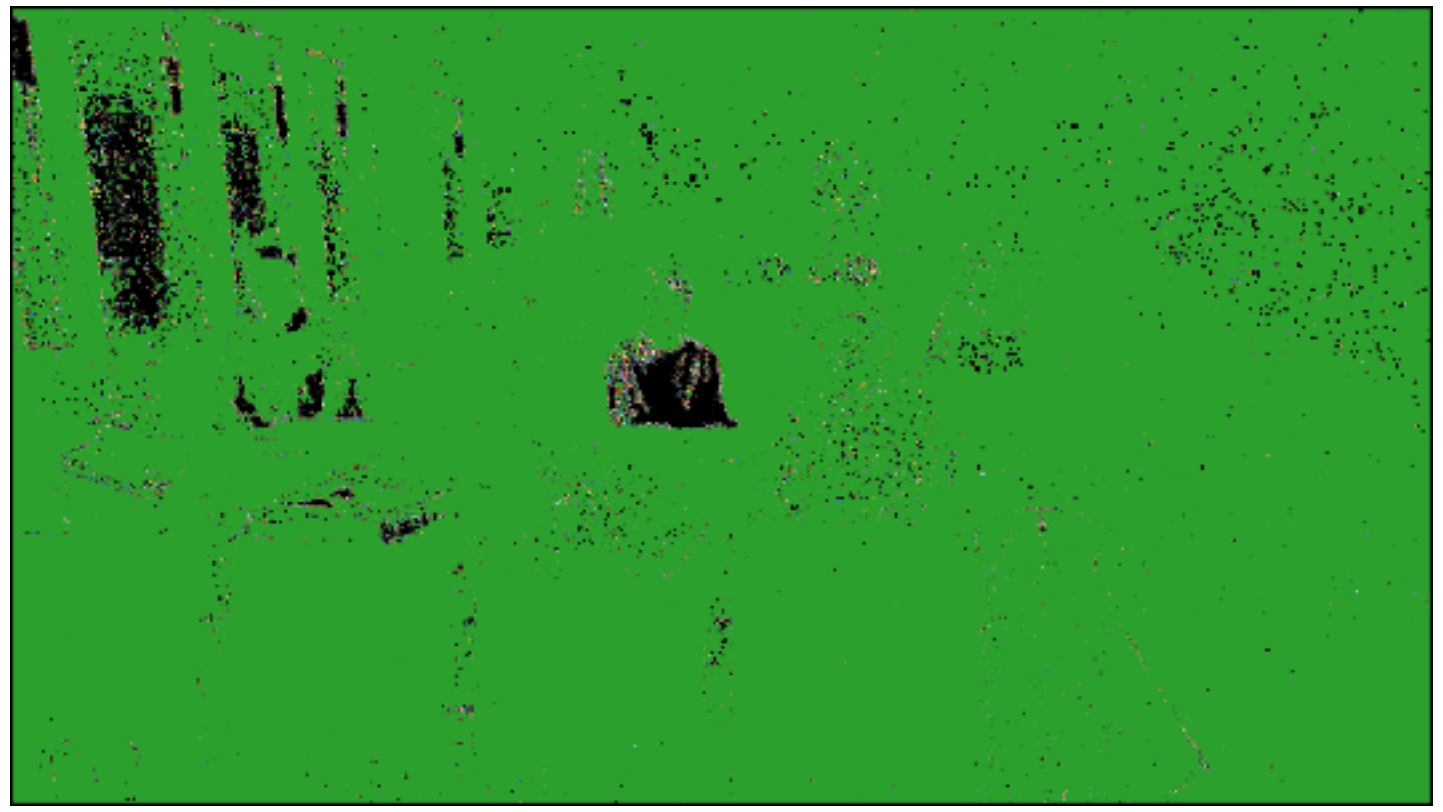
Detection result

ZERO and double compression

Second compression QF2 << QF1



Forged image

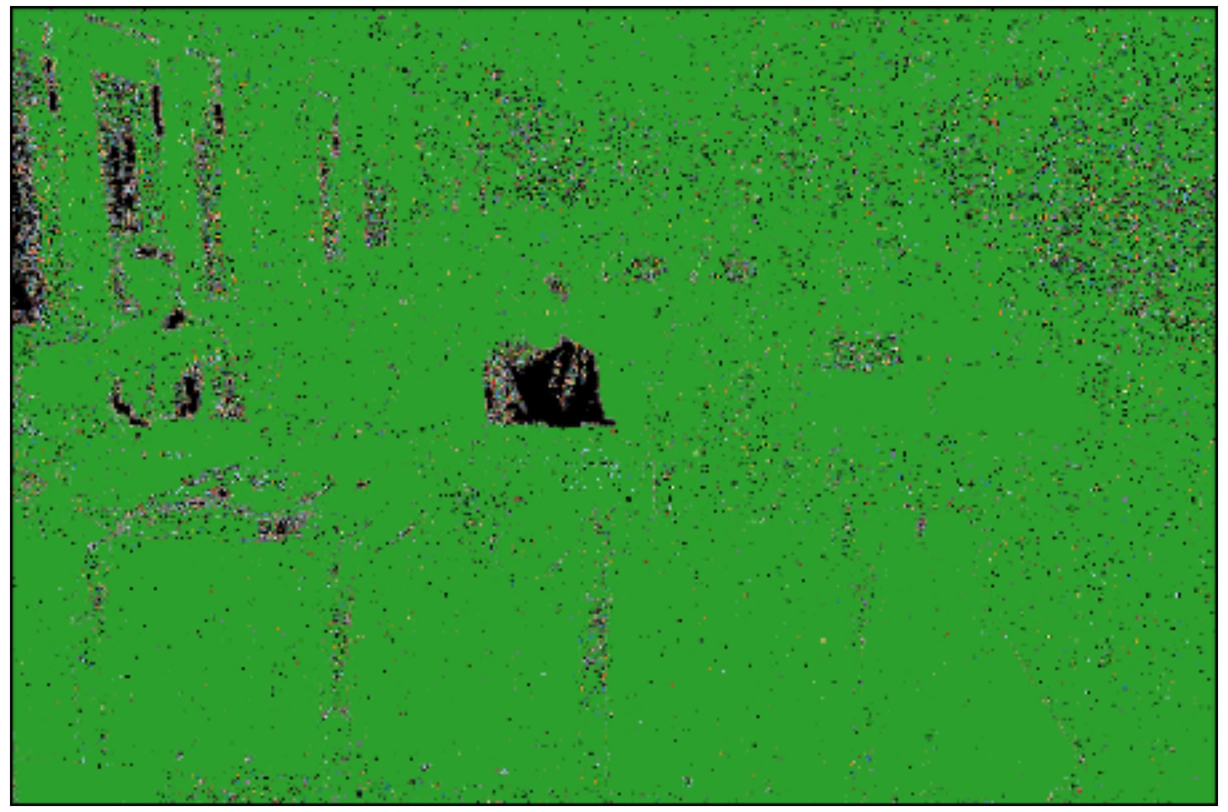


Vote map

JPEG grid origin (0,0)

Detection result

Forged and cropped image



Vote map

JPEG grid origin (0,0)

Main grid (0,0)

Detection result

ZERO and resampling

Downsizing at 90%

Forged and resampled image

Vote map

No JPEG grid detection

Detection result

Rotation

Forged and rotated image

Vote map

No JPEG grid detection

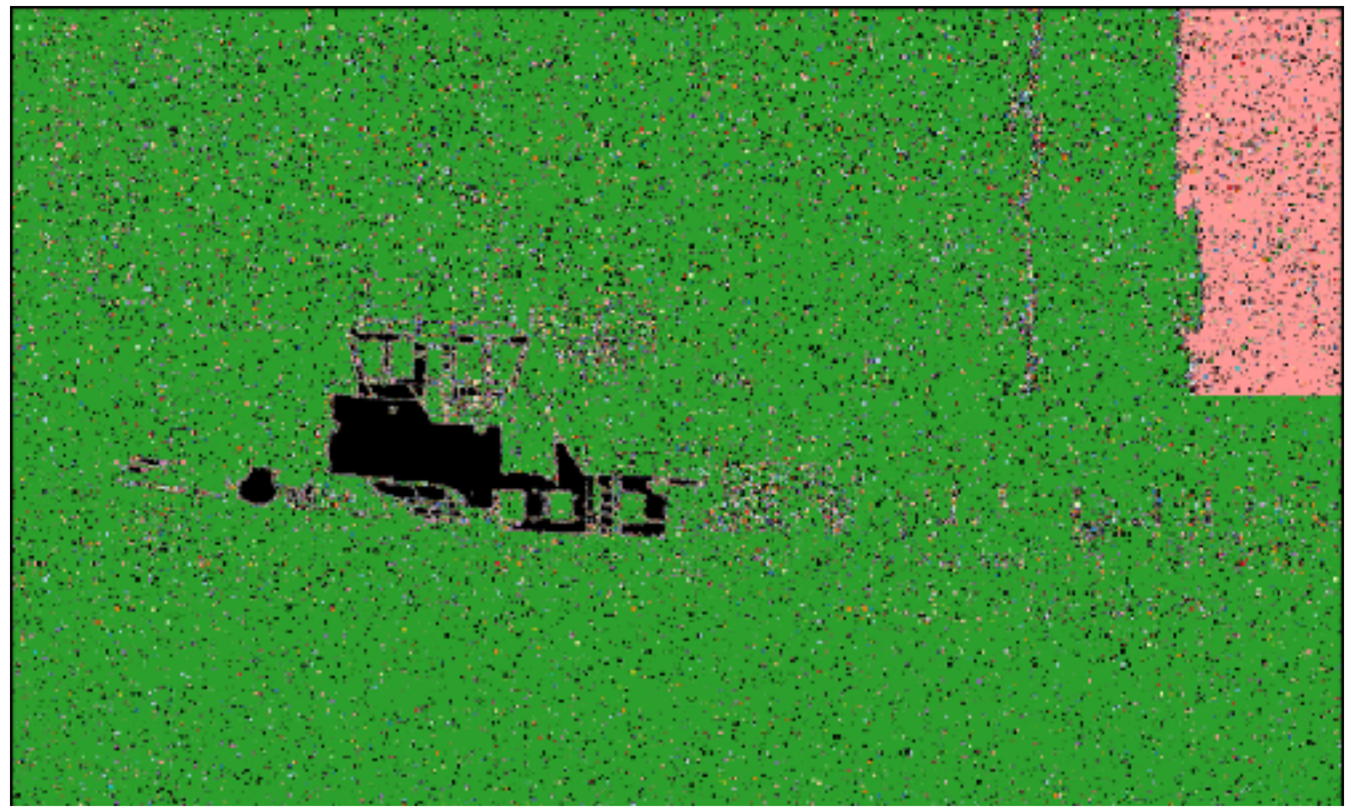
Detection result

ZERO and natural limitations

Grid in the correct position with probability 1/64 for a copy-move

Forged image from FAU dataset.

Ground truth



Vote map

JPEG grid origin (0,0)

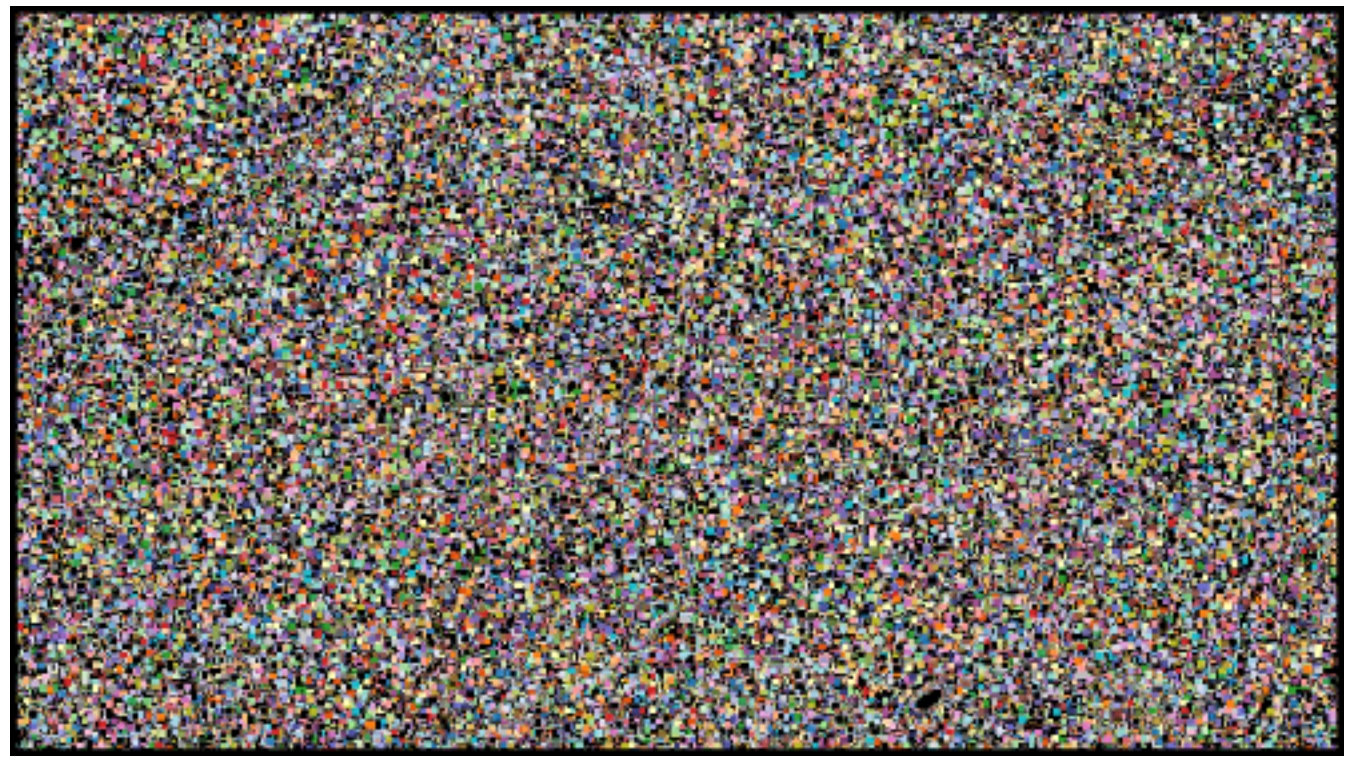
Detection result

ZERO and natural limitations

Uncompressed images

Forged image from Korus dataset.

Ground truth



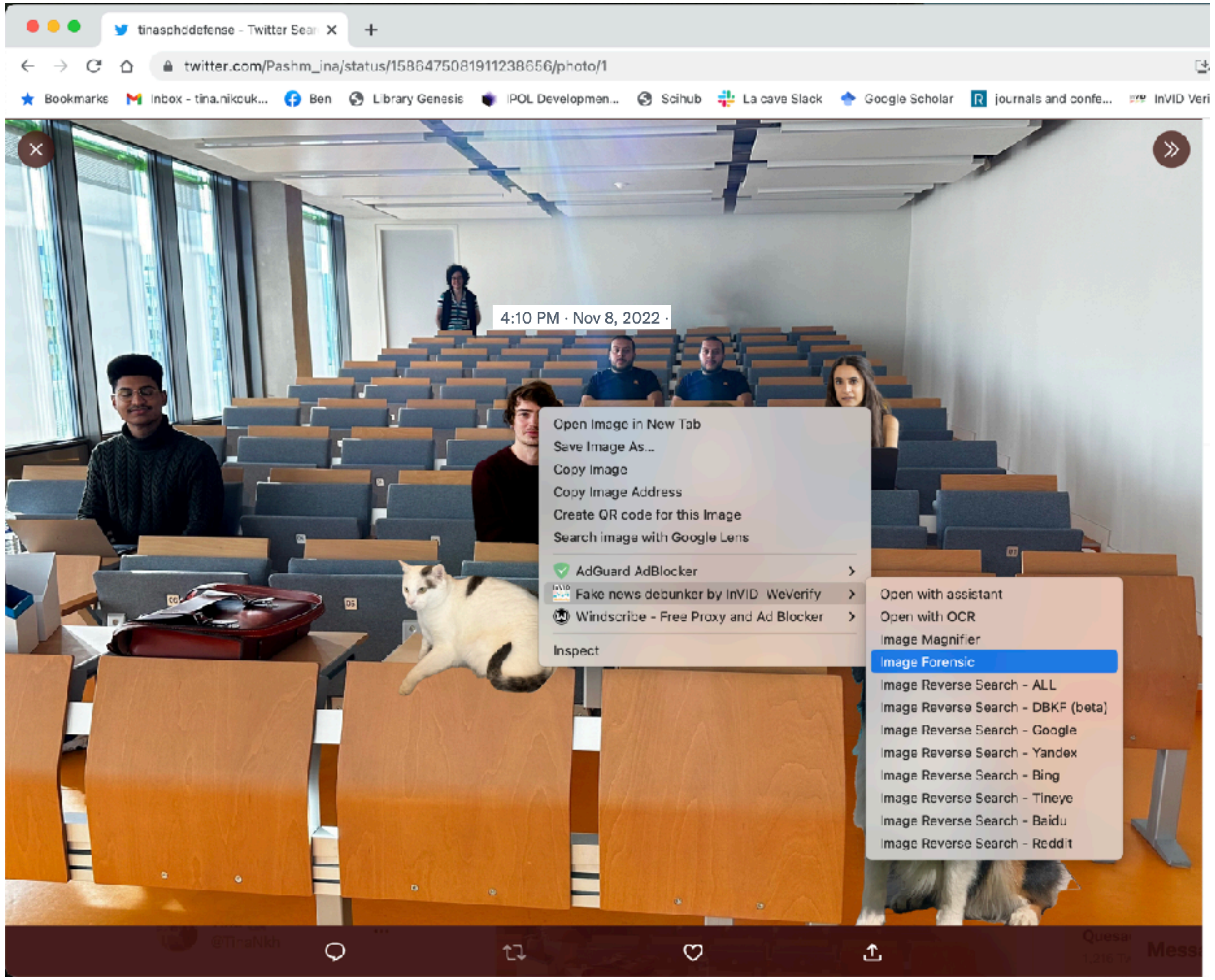
Vote map

No JPEG grid detection

Detection result

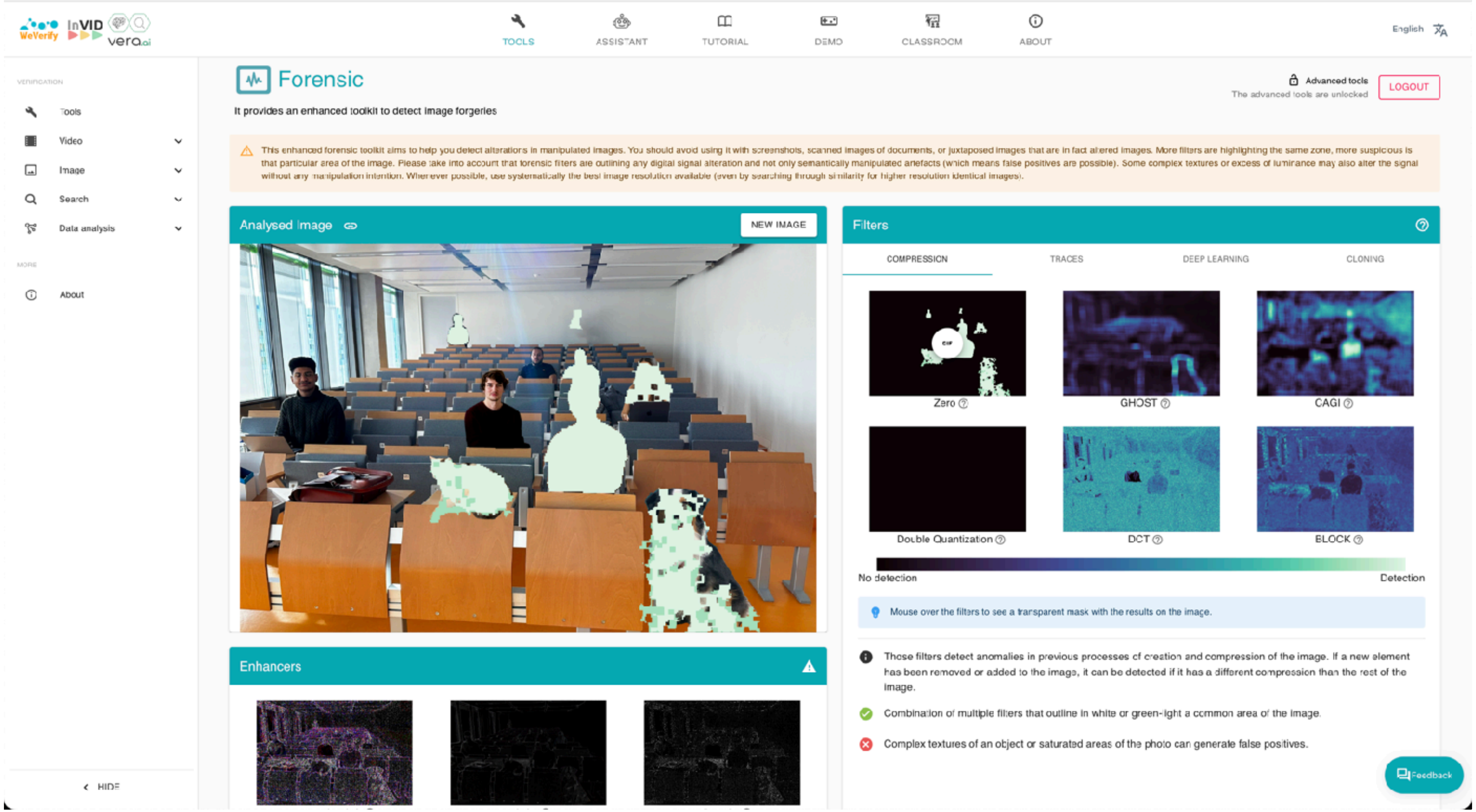
~~First~~ New reflexes to have

- Look at the image.
- Analyse the image file, but there are no EXIF metadata!
- Perform image reverse search on the Internet, to identify the image's source.
- Use forensic tools.
- Add InVID-WeVerify plug-in to your browser to save time and be more efficient in fact-checking!



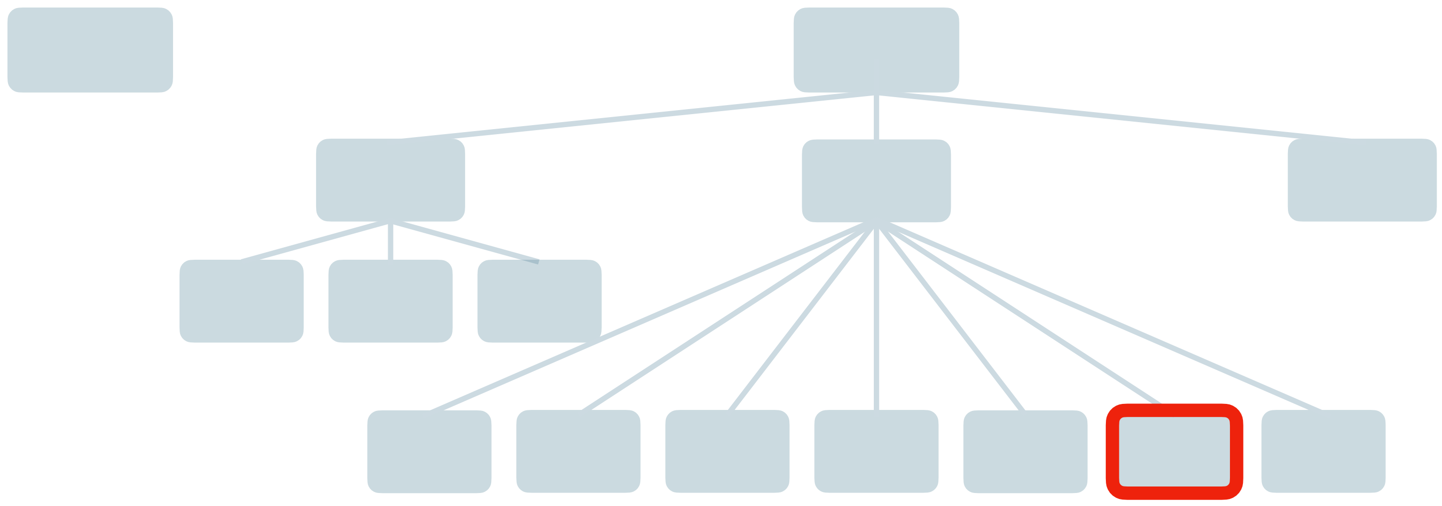
Right-click on the image to use the InVID-WeVerify plug-in from AFP news agency.

An image forensic tool tailed for daily use



InVID-WeVerify plug-in from AFP news agency.

Summary of contributions



An overview on image forensics

JPEG artefacts

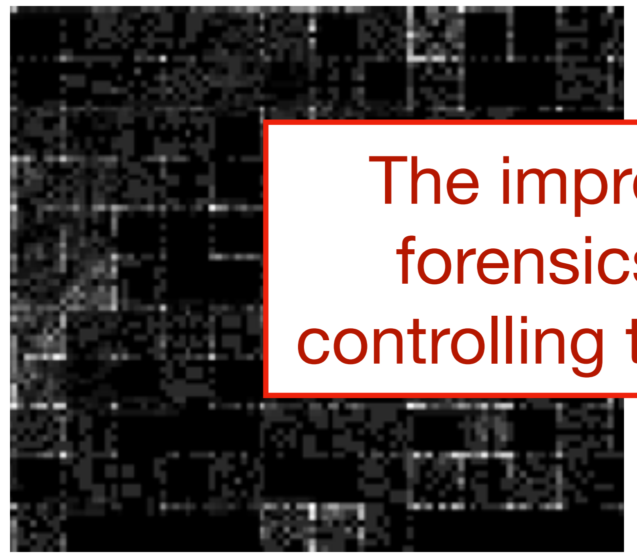
Trace database

GOD

Q-table

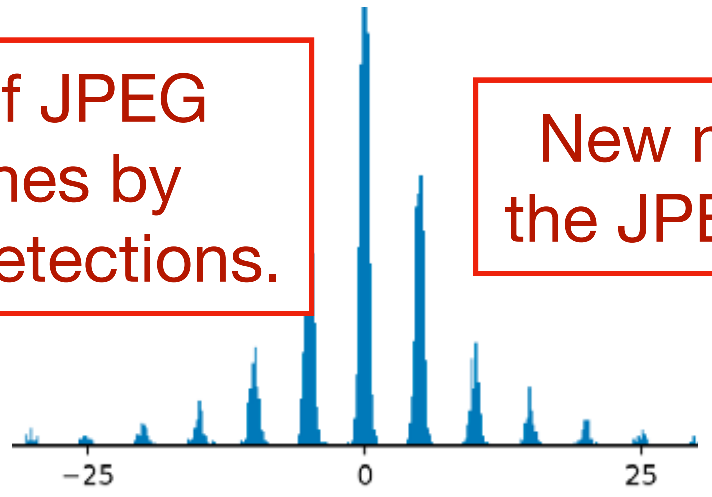
SGOD

ZERO

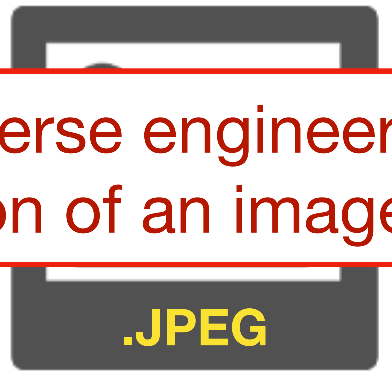


The improvement of JPEG forensics approaches by controlling the false detections.

Block artifact grid

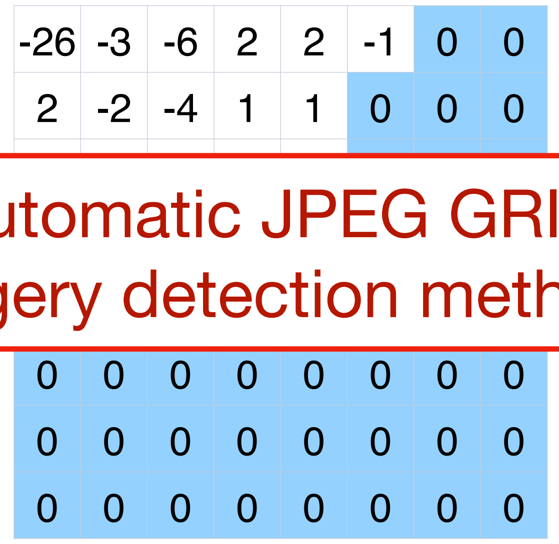


DCT coefficients



New methods to reverse engineer the JPEG compression of an image.

File size



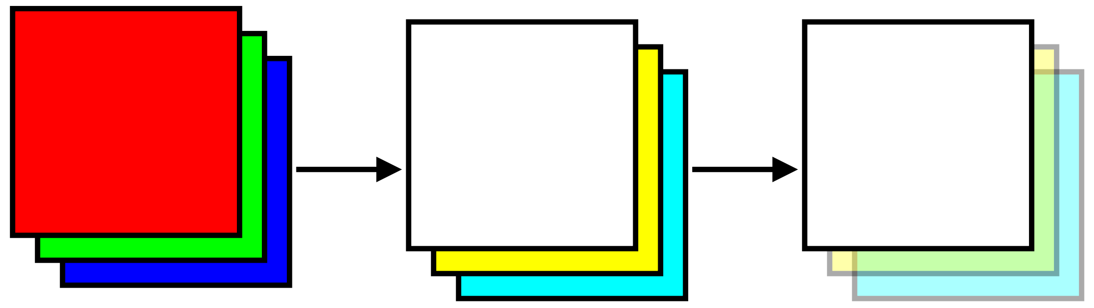
A new automatic JPEG GRID-based forgery detection method.

DCT zeros

A new non-semantic methodology to evaluate forensic tools.

Future lines of research

Short-term



- Adapting the existing methods to the **chroma channels**.
- Improving the robustness of the local **missing grid** detection.
- Creating a new automatic JPEG QUALITY-based forgery detection method.
- Adding **post-processing operations** and **new datasets** to the Trace database.

Long-term

- New/other **compression algorithms** for images and video.
- Fake images generated by **text-to-image** diffusion models!

Future lines of research

Short-term

- Adapting the existing methods to the **chroma channels**.
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Long-term

- New/other **compression algorithms** for images and video.
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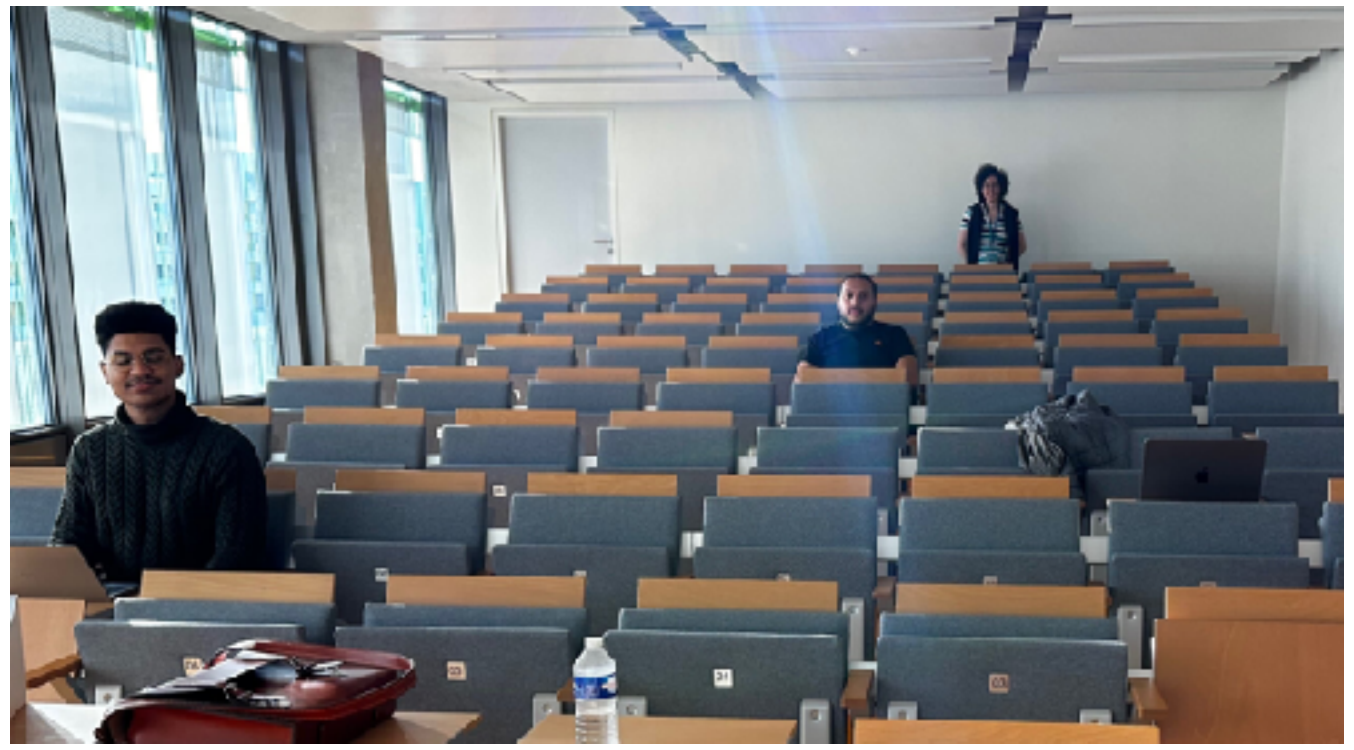
The future of image forgery with diffusion models



Crop of an original JPEG compressed image

"students in the classroom"

"Taylor Swift"

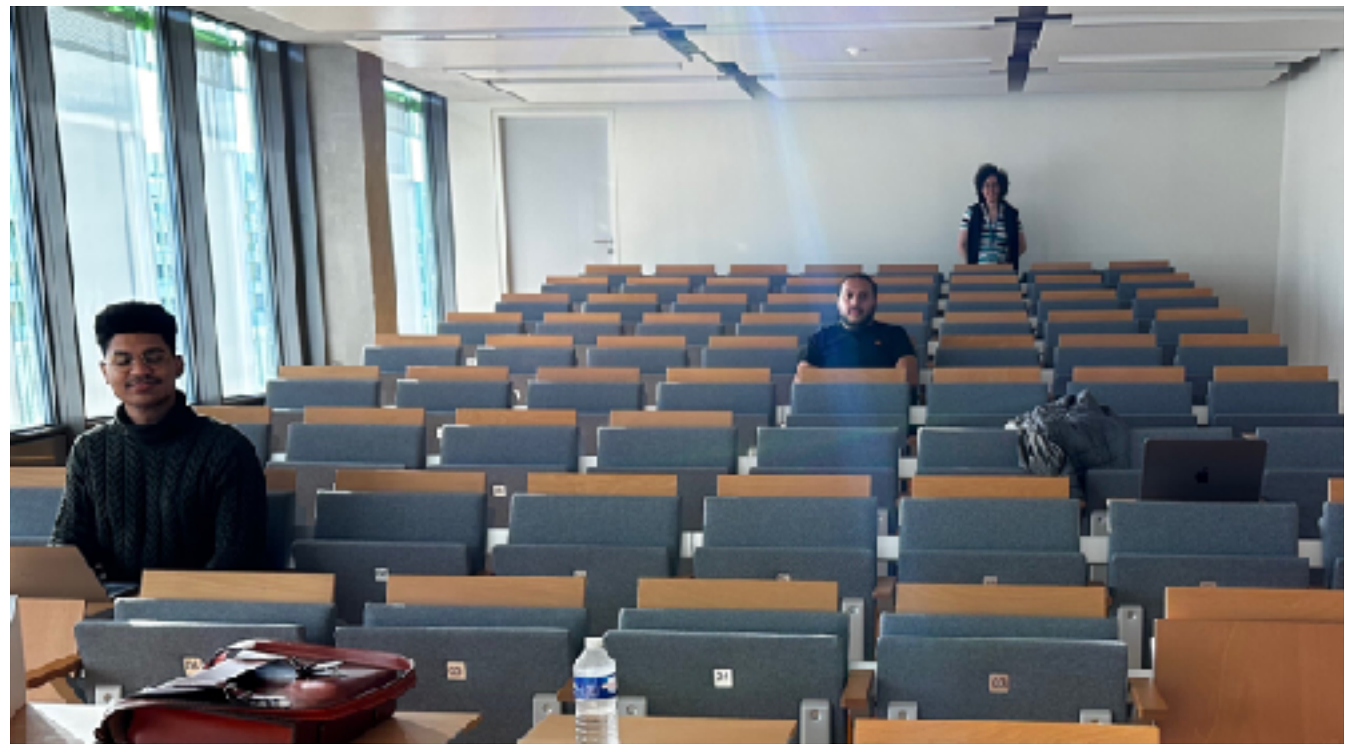
"classroom"

"Santa Claus using a laptop"

Text

Mask

The future of image forgery with diffusion models


Crop of an original JPEG compressed image

“students in the classroom”

“Taylor Swift”

“classroom"

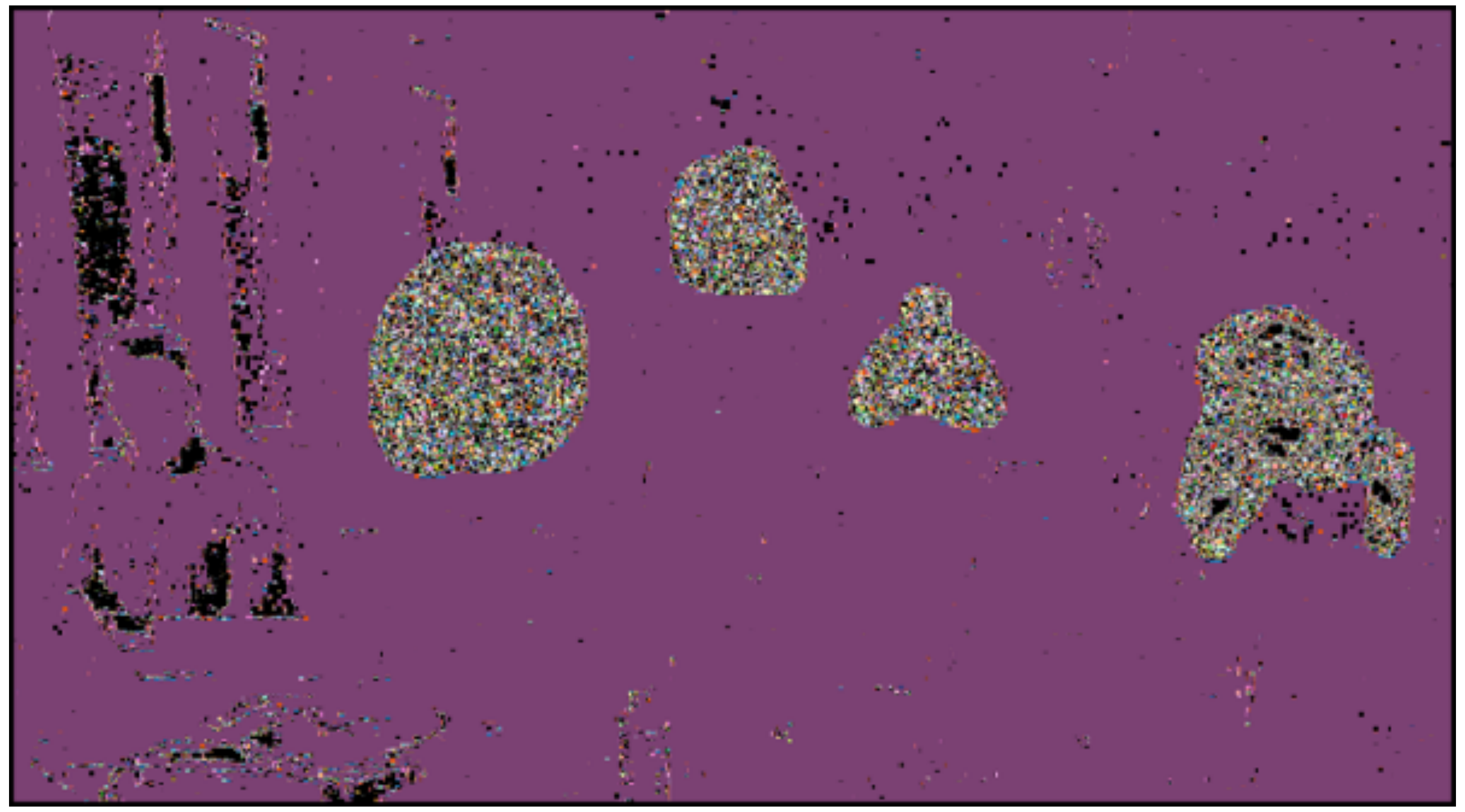
“Santa Claus using a laptop”

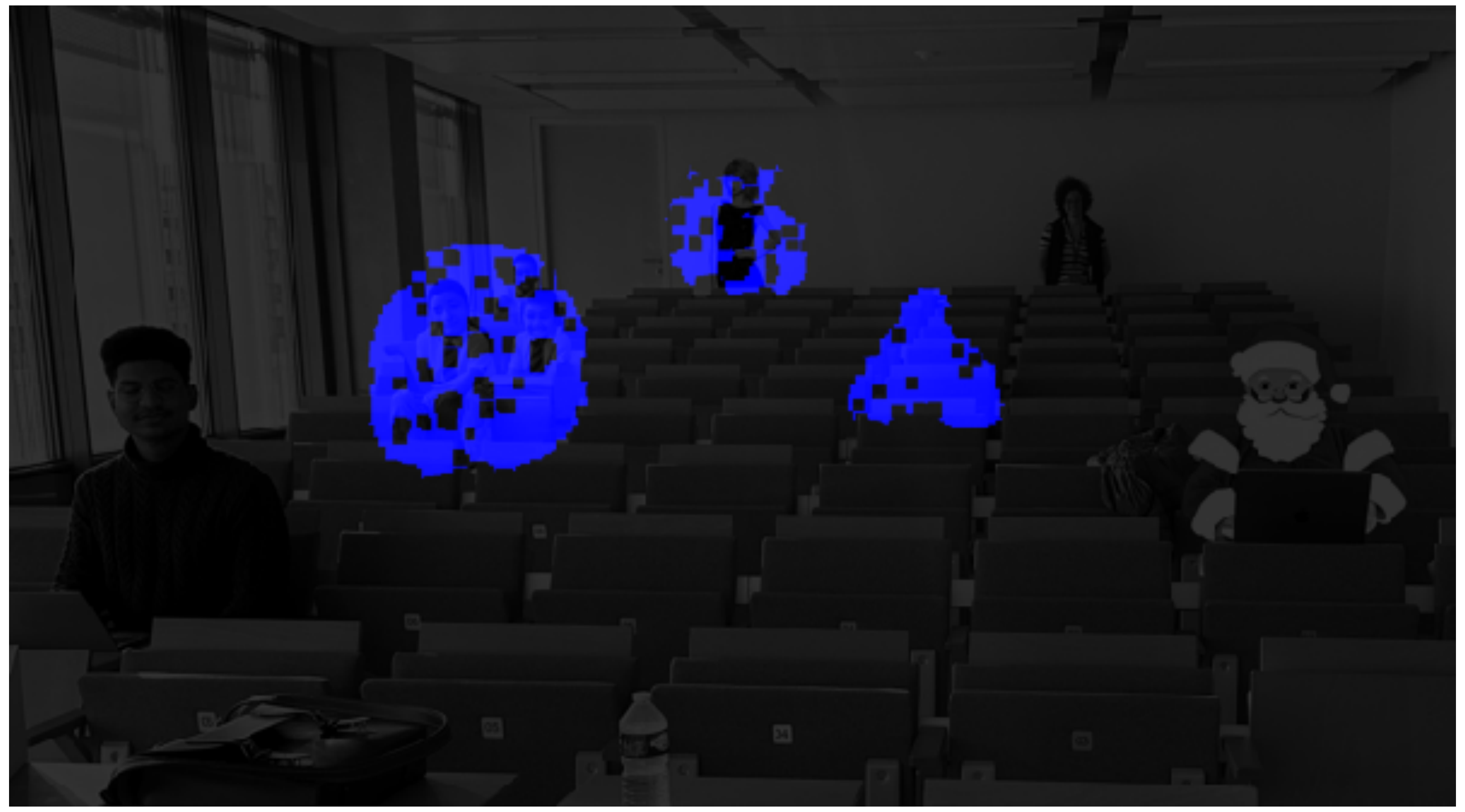
Text


Mask

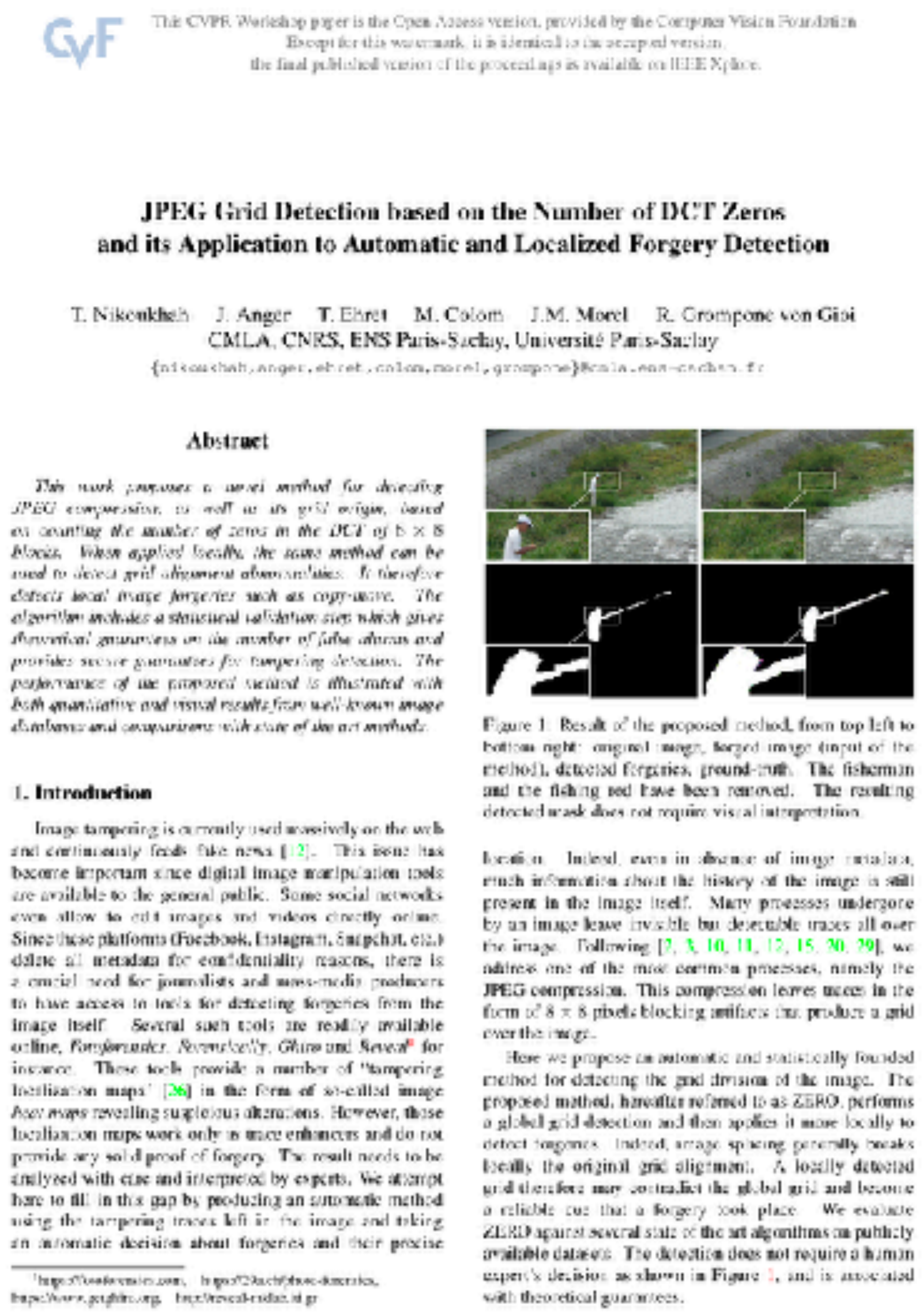

Forged image by stable diffusion v1.5

[R. Rombach et al. 2022]


Vote map


Detection result

From zero to research, projects, teaching, popular science



The CVPR Workshop paper is the Open Access version, provided by the Computer Vision Foundation.
Except for this watermark, it is identical to the accepted version;
the final published version of the proceedings is available on IEEE Xplore.

JPEG Grid Detection based on the Number of DCT Zeros
and its Application to Automatic and Localized Forgery Detection

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Conferences
Publications with code
Online demos

Research projects

Master's level class to journalists
Conferences for the general public
Workshops during science festivals

Radio shows
Interviews
Science magazines

Since November

- Forgery detection
- Deepfake detection
- Fake images generated by diffusion models
- Image restoration
- Video compression analysis
- Satellite imagery
- Scene-text detection (OCR)

Research topics

vera.ai

APATE

IMPROVED

vizzia

Research projects

Diplôme éducation aux Médias et à l'Information

BREVET Ai

IPOL IMAGE PROCESSING ON LINE

Master's level class to journalists
Educational platform
Online journal

MATh.en.JEANS

maths en herbe

LES ASSISES DES MATHEMATIQUES

YouTube

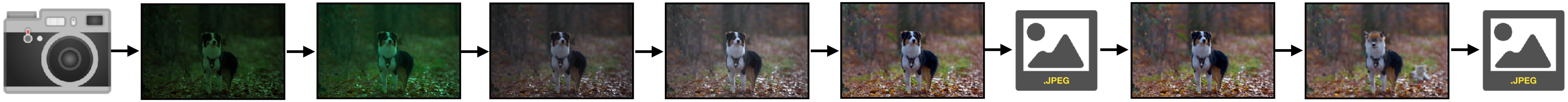
- Middle school, High school, Université Paris-Saclay L3, M1

Conferences for the general public
Online videos

Thank you for your attention

The secret life of JPEG images

Forgery detection using compression traces



These slides are from the thesis defense I
conducted on November 8th, 2022

https://nikoukhah.com/tina/phd.html