Determining Image Origin & Integrity

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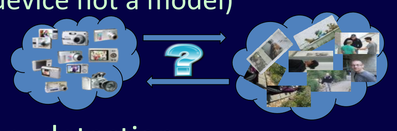
Goals & Motivation

Project Goals

I. Image Source identification

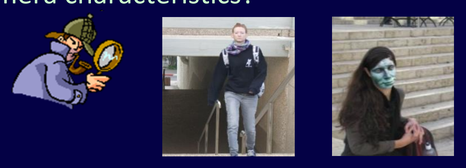
Does a certain image was taken by a certain camera?

(Camera – a device not a model)



II. Image forgery detection

Does the Image contain regions which do not fits the source camera characteristics?



Motivation

- Evidence in court
- Forensics
- Intelligence
- Image copyrights

Forged Image published by Reuters during the 2006 Lebanon War

Forged Image published by the Iranian Revolutionary Guards

Sensor Characterizing

Sensor Uniqueness

- Due to manufacturing inconsistencies each sensor pixel react differently to light
- Pixel output:

$$\begin{Bmatrix}\text{Pixel}\\ \text{Value}\end{Bmatrix} = A \cdot \begin{Bmatrix}\text{Light}\\ \text{Intensity}\end{Bmatrix} + B$$

- A & B values differ from pixel to pixel

$$\begin{Bmatrix}\text{Pixel}\\ \text{Non}\\ \text{Uniformity}\end{Bmatrix} = PNU = B$$

PNU Reference Pattern Estimation

- Many images needed to estimate the camera PNU Reference Pattern
- Noise is extracted using wavelet base denoiser

- PNU is the only constant element → Averaging

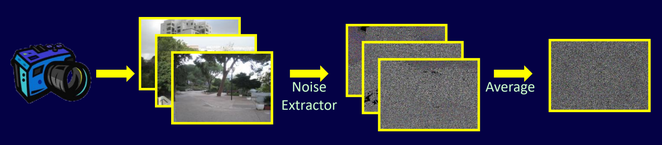


Image Classification

- Assuming we have a set of suspected cameras
- Correlation of the noise residual (n) with the PNU Reference Pattern (P) of each camera

$$cor(n,P) = \frac{(n-\bar{n})\cdot(P-\bar{P})}{\|n-\bar{n}\|\cdot\|P-\bar{P}\|}$$

- Maximum correlation camera is selected:

$$\text{MAX}\left\{\text{Correlation}\left(\text{NOISE}, \text{PNU Reference Patterns}\right)\right\}$$

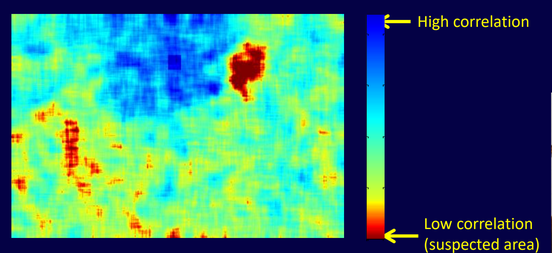
Forgery Detection

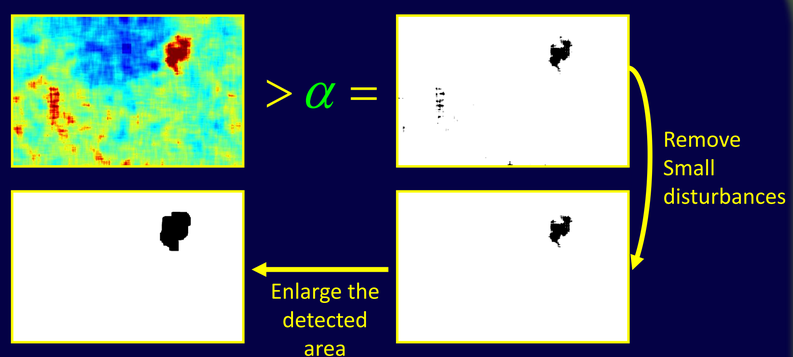
Correlation calculated for each pixel

- Done by correlating the pixel environment

$$\text{Correlation}\left(128 \times 128 \text{ Noise}, \text{PNU Reference pattern}\right) = \text{Correlation Value For a single pixel}$$

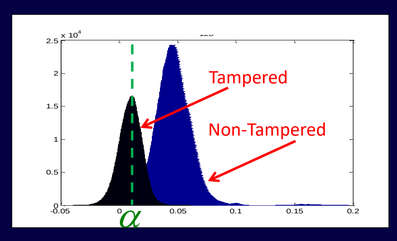
- Correlation image:





Applying a threshold

- Pixel correlation distributions:



- The threshold (α) was set empirically
- Detecting only 50% of tampered pixels
- Minimizing false detection

Experiments & Results

Source camera Identification

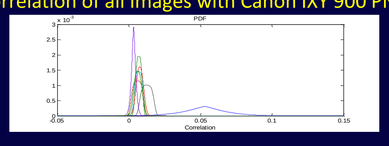
I. We tested 9 different cameras
- 9 x 100 training Images
- 9 x 140 test Images

II. Camera selection for each image

III. Miss identification rate was estimated

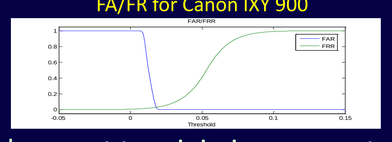
- Correlation distribution estimated

Correlation of all images with Canon IXY 900 PNU



- False Acceptance & False Rejection estimated (as function of the threshold)

FA/FR for Canon IXY 900



- Threshold was set to minimize error rate

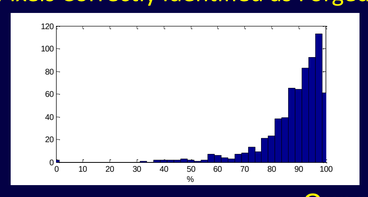
Results

Camera model	Miss Rate Observed For the Tested Images	Miss Rate Estimation for Large Amount of Images
Canon IXY 900	0%	2.9%
Canon A700	0%	0%
Canon S3 (1)	0%	0.75%
Canon S3 (2)	0%	0.61%
Canon A610	0%	0.68%
Nikon D70 (DSLR)	0%	0.5%
Canon A530	0%	0.41%
Fujifilm S5600	10.7%	9.68%
Panasonic DMC-FZ5	0%	1.01%

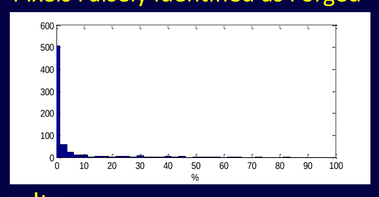
Forgery detection

- 9 x 75 Images forged & tested
- Forgery Method:
  - Random sized rectangle

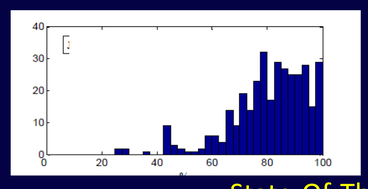
Pixels Correctly Identified as Forged

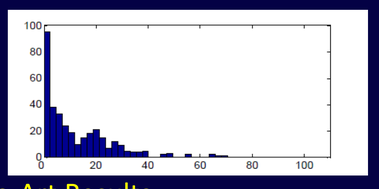


Pixels Falsely Identified as Forged



Our results





State-Of-The-Art Results

Summary

- Source camera Identification
  - For 8/9 cameras no misidentification observed
  - For most of cameras less than 1% misidentification estimated
  - Similar results to published work
- Forgery detection
  - 99.8% of forgeries detected
  - Better than state of the art results
  - Achieved with simpler algorithm

References:

J. Lukáš, J. Fridrich, M. Goljan, "Digital Camera Identification from Sensor Pattern Noise", *IEEE Trans. of Inf. Forensics and Security*, 2006.

J. Fridrich, M. Goljan, M. Chen, "Imaging Sensor Noise as Digital X-Ray for Revealing Forgeries", *Proc. of 9th Inf. Hiding Workshop*, France, 2007.

Winner of the 2011 Thomas Schwartz Award