DIGITAL FORENSICS
Seeing is not believing

EARLY PHOTOGRAPH
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Would you choose this “post-nuclear-holocaust” place for your holidays?
Seeing is not believing

Well... You’re there!...

(Villasimius, Sardinia)
Villasimius è un comune costiero di 13.000 abitanti circa, situato nell’estrema punta Sud Est della Sardegna, in provincia di Cagliari a circa 50 km. dal capoluogo. Villasimius, insieme alla Costa Smeralda e ad Alghero, è la località turistica più frequentata di tutta la Sardegna, per le bellissime e lunghe spiagge di sabbia fine e bianca ed acqua smeraldina, per la vita notturna, con decine di ristoranti, le discoteche che si animano a ferragosto, i bar e locali notturni e lo shopping serale nel paese, che dista circa 2 km dal mare. Le discoteche a Villasimius specialmente a Ferragosto sono le più frequentate dai turisti di tutta la Sardegna meridionale rendendo la destinazione una delle più frequentate e consigliate per le vacanze giovani.

Per le tue vacanze a Villasimius consulta la nostra offerta di hotel a Villasimius, villaggi, residence a Villasimius, case vacanze ed appartamenti a Villasimius, agriturismo e b&b a Villasimius o chiamo il nostro booking. Le principali spiagge di Villasimius è un comune costiero di 13.000 abitanti circa, situato nell’estrema punta Sud Est della Sardegna, in provincia di Cagliari a circa 50 km. dal capoluogo. Villasimius, insieme alla Costa Smeralda e ad Alghero, è la località turistica più frequentata di tutta la Sardegna, per le bellissime e lunghe spiagge di sabbia fine e bianca ed acqua smeraldina. A Villasimius non troverete mai una spiaggia mal tenuta come nella foto a sinistra o l’acqua sporca come nell’immagine qui a destra.
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Bias in the use of images

"global warming"

bias? interests behind information? complete opinion overview?
Information trustworthiness

Web today
Social networking websites, image hosting websites, online community platforms:
- high number of digital image collections in the Web
- important role of images and visual messages in the communication process.

In this scenario...
modified data may influence people opinions and even alter their attitudes in response to the represented event.
It is important to be able to automatically verify the fidelity and authenticity of digital images in order to guarantee their truthfulness.
Information trustworthiness

UNCONTROLLED MULTIMEDIA CONTENTS

DIGITAL MULTIMEDIA FORENSICS

DIGITAL MULTIMEDIA AUTHENTICATION
General digital camera model is here summarized
Multimedia Forensics

• Forensic techniques capture a set of intrinsic information carried out by the digital content
  – by resorting only on the analyzed data, without any previously embedded information (passive approach)
  – without knowledge of original data (blind method).
• Idea: inherent traces (like digital fingerprints or footprints) are left behind in a digital media during creation phase and any other successive process.
• These digital traces are extracted and analyzed for understanding the history of digital content.
**Digital traces**

- **Acquisition fingerprints**: each component in a digital acquisition device modifies the input and leaves intrinsic fingerprints in the final output, due to the specific optical system, image sensor, camera software.
Digital traces

- **Coding fingerprints**: Lossy compression inevitably leaves itself characteristic footprints, which are related to the specific coding architecture.
- Most of the literature has focused on studying the processing history of JPEG-compressed images.
Digital traces

• **Editing fingerprints**: each processing applied to digital media modifies their properties leaving peculiar traces accordingly to the processing itself.
Image source identification

All images acquired by a digital device have particular intrinsic characteristics because of their image formation pipeline and unique hardware components.

Computer generated vs natural
Computer generated vs natural

Phographic

Photorealistic
Analysis of photorealistic versus photographic faces

- current techniques rely on statistics
- novel geometric-based approach based on asymmetry evaluation

Splicing detection
Splicing detection
Splicing detection

Double JPEG compression traces
- perturbation of blocking artifacts
- different statistics of DCT coefficients
CFA traces
- inconsistencies of demosaicing artifacts
Splicing detection

Not Aligned Double JPEG compression

Analysis of inconsistencies of demosaicing artifacts

Bianchi, Piva, "Detection of Nonaligned Double JPEG Compression Based on Integer Periodicity Maps", IEEE TIFS, April 2012.
Contrast manipulation

Images can be used to influence the attitude of the reader.

Contrast modification can impact on human feeling.

Text manipulation in images

Forensics tool able to determine if a text in a given image is authentic or if it has been inserted and manipulated (planar surfaces).

When text is manipulated, it is unlikely to precisely satisfy correct geometric mapping.

Conotter, Boato, Farid, "Detecting Photo Manipulation on Signs and Billboards", ICIP 2010.
Video tampering detection

A geometric technique to detect physically implausible trajectories of objects in video sequences.

Decision fusion for image forensics

- There exists several tools for detecting image forgeries
- Tools search for a footprint left by a specific kind of tampering, or work on different modalities, or make different assumptions on the adversary’s behavior ...
- We want to give a “global” judgment about the integrity of the image

- Typical information fusion problem
- Fusion can be performed at several levels:
  - Feature level: feature selection & train a classifier ➡️ Need lot of training
  - Abstract level: fuse binarized outputs ➡️ Discard much information
  - Measurement level: fuse the soft output of each tool ➡️ Aurea mediocritas
- A system working at the measurement level
**Decision Fusion: problem formulation**

- **Hypothesis:**
  - Set of tools $T_A$, $T_B$ ... $T_K$
  - $T_j$ outputs a value $D_j$ and has a reliability score $R_j$
  - Relationships exist between the traces searched by tools

- **Goals:**
  - Obtain an aggregated output
  - Handle tool errors exploiting information about traces dependencies
  - Avoid cross-tool training
Proposed frameworks

• A framework based on:
  – Dempster-Shafer Theory of Evidence

• Useful features:
  – Uncertainty and conflicting data are handled
  – No need for a-priori probabilities
  – Allow to explicitly model knowledge about existing relationships between traces
  – Models are easy to extend when new tools are made available
  – No cross-tool training is needed (avoid use of enormous and expensive datasets)
**Scope**: user can manually select whatever region he wants, or can use automatic detection of salient regions (built in funct.) to check if it is a splicing

**Tools**: 3 tools to detect different traces left by JPEG recompression

**Output**: output is automatically fused and interpreted

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**An Example**


An Example
Future research directions

Is a modification of data required to judge an information fake?

Human in the loop:
- Impact of manipulation on users
- Definition of modifications which modify opinion of users
Future research directions

Research in multimedia forensics has recently started focusing on anti-forensics or counter-forensics, i.e., on techniques with which a knowledgeable adversary might want to impede making forensic analysis.

Anti-forensic techniques operate by disguising manipulation fingerprints or falsifying device specific fingerprints introduced during acquisition.
Game-theoretic approach

Source identification game

The Analyst (FA) wants to know whether a sequence was generated by a source X or not
The Adversary (AD) takes a sequence generated by a different source Y and modifies it so that it looks as if it was generated by X
Payoff: false negative probability for a given false positive rate

Asymptotic Nash equilibrium found for

Known memoryless sources
Sources known through training data

Insights for development of practical schemes
First-order universal anti-forensics

- Fool a detector: force it to misclassify
  - If we make the processed image statistics sufficiently close to those of an untouched image, the detector incurs either a false-positive or a false-negative error.

- Assumptions:
  - Analyst's detector relies only on first-order statistics
  - Adversary has a database (DB) of untouched images

- So the adversary:
  - Processes the image
  - Searches the DB for the nearest untouched histogram
  - Computes an histogram transformation map
  - Applies the transformation, minimizing perceptual distortion
Pixel mapping

- Once the best mapping is found, we apply it in such a way to minimize perceptual impact
- Method based on iterative evaluation of SSIM map
Results

- Evaluated against the Contrast-Enhancement detector proposed by Stamm.
- Tested with two different processing:
  - histogram stretching
  - gamma correction
- Afacker has a DB of 25,000 histograms of untouched images.

![ROC curves for Contrast Enhancement (γ-correction) detection before (solid line) and after (marked lines) CF attack.](image)

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<th>$D_{max}$</th>
<th>PSNR (db)</th>
<th>SSIM</th>
<th>AUC</th>
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<tr>
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<td>0.994</td>
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<td>0.981</td>
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</tbody>
</table>
Thank you for your attention!

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