Report of "Image Source Identification" project*

Master's degree in Artificial Intelligence Systems

Trends and Applications of Computer Vision; A.Y 2022/2023

Cecilia Pasquini, Zhun Zhong

Joy Battocchio Davide Guidolin Alessio Belli Alberto Casagrande

***Abstract*— This document is a model and instructions for LaTeX. This and the IEEEtran.cls file define the components of your paper [title, text, heads, etc.]. *CRITICAL: Do Not Use Symbols, Special Characters, Footnotes, or Math in Paper Title or Abstract.**

***Index Terms*—component, formatting, style, styling, insert**

I. Introduction

Source identification is one of the most important tasks in digital image forensics. In fact, the ability to reliably associate an image with its acquisition device may be crucial both during investigations and before a court of law. The key assumption of forensic source identification is that acquisition devices leave traces in the acquired content, and that instances of these traces are specific to the respective (class of) device(s). This kind of traces is present in the so-called device fingerprint. A major impulse to research in this field came with the seminal work of Lukas et al. showing that reliable device identification is possible based on the camera photo-response non uniformity (PRNU) pattern. This is a multiplicative noise component caused by the inhomogeneity of silicon wafers and imperfections of the sensor manufacturing, which, in turn, cause a non-uniform sensitivity to light among the sensor photo-diodes. This means that a pixel could be slightly brighter or darker than expected by camera design, and each pixel is individually affected by this issue. Each camera is characterized by its unique PRNU pattern, which can be regarded as a sort of camera fingerprint. All photos taken by a given camera carry traces of its fingerprint which, under suitable hypotheses, can be retrieved, enabling reliable device identification and, with some further processing, also brand and model identification. In order to compose your camera fingerprint, the best possible scenario and condition is flat images of blue or cloudy sky. Due to spatial transformations, filtering, AI post-processing and more in general in-device or out-device post-processing, PRNU is today more than ever compromised. Even for media coming from the exact same device, it is really difficult that we can compare the two PRNUs of these ones straightforwardly, but we need to resynchronize one with respect to the other. In fact, Mandelli et al.'s work is based on the assumption that the images are already geometrically synchronized. Its main contribution is using a 2 channel CNN network that for every device d $\in$ DT is fed using noise residuals coming from device d, paired with PRNU K_d (coherent pair) and with PRNU K_d^- coming from a different device (non-coherent pair). The CNN is able to learn a similarity measure Cs for the source identification task. This method proves to be generally faster than PCE, in particular when a large amount of potential provenance devices is investigated, requiring much less query image content to obtain enhanced attribution accuracy.

II. Related works

Of all the related works cited in the main paper, it has been decided to focus on three:

- **Kharrazi et al.** "Blind source camera identification" [8]
- **Lukáš et al.** "Digital camera identification from sensor pattern noise" [9]
- **Bondi et al.** "First Steps Toward Camera Model Identification with Convolutional Neural Networks" [10]

The choice is motivated by the influence that these three works had on the Mandelli's one. They all represent important milestones in the solution of the source identification problem. For this reason it has been decided to present them in temporal order of publication, because each one of them gives an additional contribution and it's logically dependent on the previous ones.

A. Kharrazi et al.

The authors of "Blind source camera identification" propose to extract handcrafted features from images in order to use them as input for a SVM classifier.
The chosed features are the ones that bring more evidence of the CFA configuration and the color processing carried out by the camera, which should be unique for each sensor and therefore useful for their identification.
In particular they are:

- **Average pixel value**. Average values in RGB channels of an image should average to gray assuming that the images has enough color variations.
- **RGB pairs correlation**. Capture the fact that depending on the camera structure, the correlation between different color bands could varies.
- **Neighbor distribution Center of mass**. Calculating the number of pixel neighbors for each pixel value, where the pixel neighbors are defined as all pixels having a difference in value of 1 or -1, from the pixel value in question. This is calculated for each color band.
- **RGB pairs energy ratio**. It is used in the process of white point correction.
- **Wavelet domain statistic**. Decompose each color band of the image using separable quadratic mirror filters and then calculate the mean for each of the 3 resulting sub-bands.

In addition to these features, different cameras produce images of different quality, so we can extract the Image Quality Metrics as features to aid in distinguishing between cameras. These metrics are:

- **Pixel difference based measures**. Mean squared error, mean absolute error, ...
- **Correlation based measures**. Normalized cross correlation, ...
- **Spectral distance based measures**. Spectral phase and magnitude errors.

As it is written above, these features are then used by a SVM to classify the right source camera. insert cons??

B. Lukáš et al.

In the paper "Digital camera identification from sensor pattern noise" the authors proposed a new method for the camera identification problem that is based on the sensor's pattern noise. The basic idea is to compute for each camera a pattern noise that can act as a unique fingerprint. Then, if you want to identify the camera that shoot a specific photo, the paper suggests to use a correlation filter in order to compare the noise residual of the image with the fingerprint of all the cameras inside the dataset.

In the image acquisition process, there are many sources of imperfections and noise that can enter into various phases. Among these noises, we can identify two types of noise: *shot noise* (a random component) and *pattern noise*. The latter is a deterministic component that has the characteristic of remaining approximately the same if different images of the same scene are taken. This is why this type of noise can be used for the camera identification problem.

C. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

D. Units

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as "3.5-inch disk drive".
- Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
- Do not mix complete spellings and abbreviations of units: "Wb/m^2" or "webers per square meter", not "webers/m^2". Spell out units when they appear in text: ". . . a few henries", not ". . . a few H".
- Use a zero before decimal points: "0.25", not ".25". Use "cm^3", not "cc".)

E. Equations

Number equations consecutively. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \tag{1}$$

Be sure that the symbols in your equation have been defined before or immediately following the equation. Use "(1)", not "Eq. (1)" or "equation (1)", except at the beginning of a sentence: "Equation (1) is . . ."

F. LaTeX-Specific Advice

Please use "soft" (e.g., `\eqref{Eq}`) cross references instead of "hard" references (e.g., `(1)`). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

Please don't use the `{eqnarray}` equation environment. Use `{align}` or `{IEEEeqnarray}` instead. The `{eqnarray}` environment leaves unsightly spaces around relation symbols.

Please note that the `{subequations}` environment in LaTeX will increment the main equation counter even when there are no equation numbers displayed. If you forget that, you might write an article in which the equation numbers skip from (17) to (20), causing the copy editors to wonder if you've discovered a new method of counting.

III. CNN-BASED FAST SOURCE DEVICE IDENTIFICATION

IV. INITIAL EXPERIMENTS

BibTeX does not work by magic. It doesn't get the bibliographic data from thin air but from .bib files. If you use BibTeX to produce a bibliography you must send the .bib files.

LaTeX can't read your mind. If you assign the same label to a subsubsection and a table, you might find that Table I has been cross referenced as Table IV-B3.

LaTeX does not have precognitive abilities. If you put a `\label` command before the command that updates the counter it's supposed to be using, the label will pick up the last counter to be cross referenced instead. In particular, a `\label` command should not go before the caption of a figure or a table.

Do not use `\nonumber` inside the `{array}` environment. It will not stop equation numbers inside `{array}` (there won't be any anyway) and it might stop a wanted equation number in the surrounding equation.

A. Some Common Mistakes

- The word "data" is plural, not singular.
- The subscript for the permeability of vacuum μ_0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o".
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
- A graph within a graph is an "inset", not an "insert". The word alternatively is preferred to the word "alternately" (unless you really mean something that alternates).
- Do not use the word "essentially" to mean "approximately" or "effectively".
- In your paper title, if the words "that uses" can accurately replace the word "using", capitalize the "u"; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones "affect" and "effect", "complement" and "compliment", "discreet" and "discrete", "principal" and "principle".
- Do not confuse "imply" and "infer".
- The prefix "non" is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the "et" in the Latin abbreviation "et al.".
- The abbreviation "i.e." means "that is", and the abbreviation "e.g." means "for example".

An excellent style manual for science writers is [7].

B. Authors and Affiliations

The class file is designed for, but not limited to, six authors. A minimum of one author is required for all conference articles. Author names should be listed starting from left to right and then moving down to the next line. This is the author sequence that will be used in future citations and by indexing services. Names should not be listed in columns nor group by affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization).

C. Identify the Headings

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is "Heading 5". Use "figure caption" for your Figure captions, and "table head" for your table title. Run-in heads, such as "Abstract", will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced.

D. Figures and Tables

a) Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation "Fig. 1", even at the beginning of a sentence.

TABLE I
TABLE TYPE STYLES

Table Head	**Table Column Head**		
	Table column subhead	***Subhead***	***Subhead***
copy	More table copy[a]		

[a]Sample of a Table footnote.

Fig. 1. Example of a figure caption.

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity "Magnetization", or "Magnetization, M", not just "M". If including units in the label, present them within parentheses. Do not label axes only with units. In

the example, write “Magnetization (A/m)” or “Magnetization {A[m(1)]}”, not just “A/m”. Do not label axes with a ratio of quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

ACKNOWLEDGMENT

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks . . .”. Instead, try “R. B. G. thanks. . .”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

REFERENCES

Please number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use “Ref. [3]” or “reference [3]” except at the beginning of a sentence: “Reference [3] was the first . . .”

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors’ names; do not use “et al.”. Papers that have not been published, even if they have been submitted for publication, should be cited as “unpublished” [4]. Papers that have been accepted for publication should be cited as “in press” [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

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