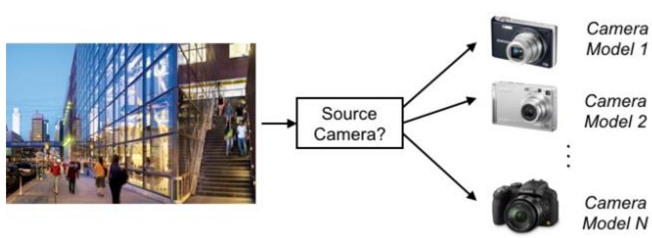
2018 IEEE Signal Processing Cup:
Forensic Camera Model Identification Challenge

This competition is sponsored by the IEEE Signal Processing Society

Introduction

The IEEE Signal Processing Society's 2018 Signal Processing Cup (SP Cup) competition will be a forensic camera model identification challenge. In this year's SP cup competition, teams will be tasked with designing a system to determine which camera model captured a digital image without relying upon information in the image's metadata. This topic lies at the intersection of signal processing, machine learning, and information security, and has been an important area of signal processing and information forensics research for more than a decade.



The IEEE Signal Processing Cup is designed to provide teams of undergraduate students with an opportunity solve a challenging real-world problems using signal-processing techniques and methods. The SP Cup was first launched in 2014, and SP Cup 2018 is now the fifth edition of the competition. This year, the SP cup will not only give students an opportunity to test their signal processing skill, but it will also enable students to see how their signal processing knowledge can be used to solve new information security problems. This topic will broaden students' vision of what type of challenges can be addressed using signal processing and can help demonstrate the wide ranging applications of signal processing to the general public. Furthermore, this topic will help expose students to the important synergy between signal processing, machine learning, and data science. In order to build their camera model identification systems, students will need to design signal processing algorithms to extract forensic traces from digital images, design machine learning algorithms to identify a camera model on the basis of these traces, and train their systems on a large dataset of images.

In addition to the technical component of this competition, participating teams will also contribute to the collection of a new dataset. Upon the completion of the 2018 Signal

Processing Cup, images collected by each team will be used to form this new dataset that will be made publicly available to both educators and researchers.

Technical Background

Determining the make and model of the camera that captured an image has been an important research area in information forensics for over a decade [1], [2], [3]. Information about which type of camera captured an image can be used to help determine or verify the origin of an image, and can form an important piece of evidence in scenarios such as analyzing images involved in child exploitation investigations. While metadata may contain information about an image's source camera, metadata is both easy to falsify and is frequently missing from an image. As a result, signal processing researchers have developed information forensic algorithms that can exploit traces intrinsically present in the image itself. To understand how information forensic algorithms are able to determine which type of camera captured an image, it is important to first review how a digital camera captures an image.

A digital camera's internal processing pipeline is composed of several different components, as is shown below in Figure 1. Light enters a camera through its lens, which focuses the light on the camera's optical sensor. Since a sensor can typically measure only one of the three primary colors of light at each pixel location on the sensor, an optical filter known as a color filter array (CFA) is placed in between the lens and the sensor. The CFA, which normally consists of a repeating 2×2 pixel pattern, allows only one color band of light to fall incident upon the sensor at each pixel location.

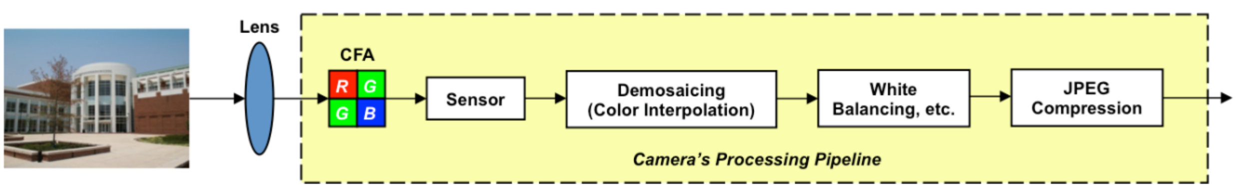


Figure 1: A typical digital camera's internal processing pipeline.

The resulting image produced by the sensor consists of three partially sampled color layers in which only one color value is recorded at each pixel location. Next, the remaining two color values at each pixel location are interpolated through a process known as demosaicing. After this, the image may be subject to internal processing such as white balancing and JPEG compression before the final output image is produced.

A significant amount of information forensics research has shown that many of the components that make up a camera's internal processing pipeline introduce statistical traces or other artifacts into an image. Since different camera models use different implementations of each physical and algorithmic component in their internal processing pipeline, the traces left in an image by each component can be linked to the make and model of the camera that captured the image. For example, different camera models typically use different proprietary demosaicing algorithms to perform color interpolation. Several forensic algorithms have been developed to model and estimate the demosaicing filter used by a camera or to capture pixel value dependencies introduced by the demosaicing process [4], [5], [6]. Statistical models of sensor noise and other noise sources have been used to determine the make and model of an image's source camera [7], [8], as have traces left by proprietary quantization tables used by a camera during JPEG compression [9]. Additionally, statistical techniques from steganalysis [10] and heuristcally designed feature sets [11] have been designed to capture camera model traces. Several survey papers exist that can provide participating teams a broad overview of existing research in this area [1], [2], [3].

Broadly speaking, camera model identification algorithms typically operate by designing a signal processing algorithm to extract a particular forensic trace from an image. Camera model "fingerprints" are then learned by extracting traces from many images taken by a particular camera model, then repeating this process for several different camera models. After this, these traces are used as classification features when training a machine learning algorithm such as a support vector machine or neural network to recognize an image's source camera model.

The lead organizer's research group has already gathered a dataset of images captured by several different camera models. While this dataset is not yet publicly available, it has been used to experimentally validate several published camera model identification algorithms. A manageable subset of these images will be used to create the dataset for this competition.

Competition Organization

The goal of this competition is for teams to build a system capable of determining type of camera (manufacturer and model) that captured a digital image without relying on metadata. Teams will use their signal processing expertise to extract traces from images that can be linked with different camera models. The competition will consist of two stages; an open competition that any eligible team can participate in and an invitation-only final competition. Teams participating in the open competition must submit their entries no later than **February 8, 2018**. The three teams with the highest performance in the open competition will be selected as finalists and will be invited to participate in the final competition. Finalists will be announced on **February 17, 2018**. The three teams invited to participate in the final competition will be judged at ICASSP 2018, which will be held **April 22-27, 2018**.

<u>Open Competition - Part 1</u>

Part 1 of the open competition is designed to give teams a well-defined problem and dataset that they can use to become familiar with forensic camera model identification. Participants will be provided with a dataset that they can use to train and test their camera model identification systems. This dataset will consist of images from 10 different camera models (including point-and-shoot cameras, cellphone cameras, and DSLRs), with 200 images captured using each camera model. All images will be captured and stored as a JPEG using the device's default settings.

On the Kaggle website, a new evaluation dataset will be released. This dataset will contain unseen images that may have been captured using any of the 10 camera models in the original dataset (but taken by different devices). Teams will use their systems to identify the camera model used to capture each image in the evaluation dataset. This evaluation phase will be run using Kaggle or a similar platform.

To prevent "brute force" attempts to guess the camera model associated with each evaluation set image, teams will be allowed to submit a limited number of classification attempts per day during the evaluation period. Additionally, images in the evaluation set will be taken using different devices than those used to create the training dataset. This will prevent matches on the basis of an individual camera's sensor using photo response non-uniformity (PRNU) sensor noise traces as opposed to general traces left by all cameras of a common make and model.

Open Competition - Part 2

Part 2 of this competition is designed to present teams with a more challenging scenario: determining the source camera model of images that have been post processed. In this part of the competition, teams will be presented with images that have been post-processed using one of several operations and will be asked to determine the make and model of the camera that captured them. While post-processing operations are commonly applied to images before they are shared online, these operations can potentially alter forensic traces present in images.

In this competition, images will be altered using post-processing operations such as JPEG-recompression, cropping, contrast enhancement, etc. Teams will be provided with a list of all possible post-processing operations that will be considered at the launch of the open competition. Additionally, teams will be provided with a Matlab script that they can use to generate post-processed images from the original dataset of unaltered images (this is intended to reduce the amount of data that each team must download) that they can use for training and testing purposes.

Similarly to Part 1 of the open competition, this portion of the competition will also be run using Kaggle or a similar platform. The evaluation dataset of post-processed images from the 10 camera models used to create the original dataset (but with different devices). Teams will use their camera model identification system to determine which camera model captured each of these images and upload their results in the same manner as Part 1 of the competition.

Open Competition - Data Collection Task

This task is designed to give teams experience performing data collection. Teams will be asked to capture 250 images using a camera model that is not provided in the original dataset. Data collection guidelines will be provided to teams along with dataset upload instructions.

This portion of the competition will not contribute to the team's overall score, however teams that do not participate in this task will be ineligible to compete in the final competition. Data collected as part of this task will be used to create an additional dataset that will be used during the final competition. After the conclusion of the final competition, this dataset will be released to the public to promote research efforts.

Final Competition

The three highest scoring teams from the open competition stage will be selected as finalists who are invited to compete in the final competition. These teams will be provided with an additional dataset consisting of images captured using new camera models collected from the Data Collection Task portion of the open competition. This dataset will contain both unaltered images and post-processed images. Teams will be asked to update their systems and identify the camera models used to capture each image in the new dataset. To ensure fairness, no images captured by any team selected as a finalist will be included in this additional dataset.

Formation of Competition Teams

Each team participating in the 2018 SP Cup should be composed of one faculty member (as the team supervisor), at most one graduate student (as a tutor), and at least three but no more than ten undergraduate students. At least three of the undergraduate team members must hold either regular or student memberships of the IEEE Signal Processing Society. Undergraduate students who are in the first two years of their college studies as well as high school students who are capable to contribute are welcome to participate in a team. A participant should not be on more than one team.

Evaluation Criteria

Teams participating in the open competition will be assessed on the basis of their performance in Part 1 and Part 2 outlined above, their successful completion of the Data Collection Task, and the quality of their project and report. The performance of each team in Part 1 and Part 2 of the open competition will be assessed using camera model identification accuracy as defined below:

$$\text{Accuracy} = \left(\frac{\text{Number of images with correct camera model identifications}}{\text{Total number of images}}\right) \times 100$$

The camera model identification accuracies achieved in each part will be combined using the formula below to assign each team an overall accuracy score:

$$\text{Score} = 0.7 \times \text{Part 1 Accuracy} + 0.3 \times \text{Part 2 Accuracy}$$

A judging panel will assess each team's performance on their report and to select the three teams invited to participate in the final competition. The overall winner will be selected on the bases of their performance on the final evaluation dataset, as well as the quality of their report and demo at ICASSP 2018.

Open Competition Submissions

Teams that wish to participate in the open competition should submit the following material by January 21, 2018 in order to be considered for the final competition:

1. A report in the form of an IEEE conference paper describing the technical details of their system. This should include a description of the signal processing techniques used to extract forensic features from images as well as a description of how their classifier was designed and trained.
2. Camera model identification results submitted via the Kaggle competition page.
3. A dataset of 250 images taken using a camera model that was not included in the original dataset provided in the open competition. This dataset must be collected by the team itself (i.e. it cannot be downloaded from an online source).
4. An executable with a specific user interface or a Matlab implementation of their camera model identification system. This should be able to accept an input in the form of a directory of images and produce a text file identifying the camera model used to capture each image in the directory.

Prize for Finalists

According to the guideline from the IEEE Signal Processing Society, a maximum of three members from each of the three finalist teams will receive travel support to attend ICASSP2017 for the final competition (up to $1,200 for continental travel or $1,700 for intercontinental travel per member, and at most three people from each team will be supported). The participants can claim their travel expenses on a reimbursement basis.

More team members are also welcome to attend. Although these additional members will not be provided with any travel grant, those members who will not be presenting a paper at the conference will be offered a complimentary ICASSP registration. The finalist teams will also be invited to join the Conference Banquet as well as the Student Career Luncheon, so that they can meet and talk to SPS leaders and global experts.

A Judging Panel will be set up to select the ultimate winners at the conference. The teams will present the technical details of their approach to solve the challenge, demonstrate their results at a scheduled session, and answer questions raised at the session. The winner will be selected on the basis of the obtained results, the quality of the final presentation, and the capability to address questions. The champion team will receive a grand prize of $5,000. Combining the grand prize, travel grant, and complimentary conference registrations, the total value received by the championship team can be $10,000+. The first and the second runner-up will receive a prize of $2,500 and $1,500, respectively, in addition to the above mentioned travel grants and complimentary conference registrations.

Important Dates

August 15, 2017	Competition webpage and preliminary info are available
August 25, 2017	Dataset available
January 12, 2018	Deadline for team registration to join the open competition
February 8, 2018	Deadline for submitting open competition results
February 17, 2018	Announcement of the three finalist teams
April 22-27, 2018	Final competition at ICASSP 2018

Online Resources

Main page of SP Cup on the SPS Website:
http://signalprocessingsociety.org/get-involved/signal-processing-cup

For technical details of the competition project, please visit:
https://piazza.com/ieee_sps/other/spcup2018/home

General information and resources are available on Piazza without requiring login; in order to access datasets and references as well as to participate in the discussions and Q&A, please visit this link: https://piazza.com/ieee_sps/other/spcup2018
to set up a free account and use the access code “spcup2018” to join as a student to “SPCUP 2018: IEEE Signal Processing Cup 2018”.

Kaggle Competition Webpage
https://www.kaggle.com/c/sp-society-camera-model-identification

Organizers

The organization of 2018 SP Cup Competition is led by members of the IEEE Information Forensics and Security Technical Committee (IFS-TC) in collaboration with colleagues.

The main organizer is Matthew C. Stamm (Drexel University, USA) with Paolo Bestagini (Politecncio di Milano, Italy) acting as co-organizer.

The SP Cup is overseen by the Student Service Committee of the IEEE Signal Processing Society (Patrizio Campisi, Chair).

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