AUTOMATIC COMPARISON OF PHOTO RESPONSE NON UNIFORMITY (PRNU) ON YOUTUBE

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PRNU as camera signature

- · PRNU Patterns can be extracted using filters
- · PRNU pattern unique for each camera
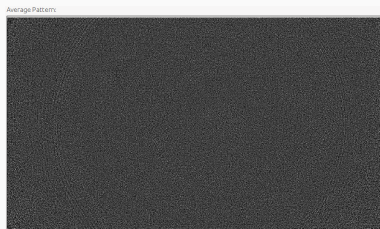- · Result from sensor manufacturing imperfections
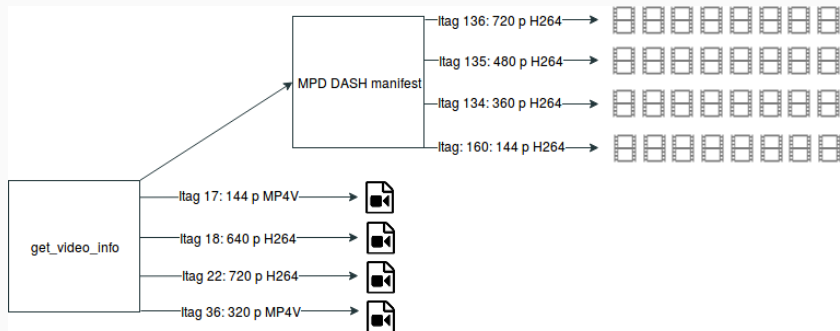

Figure: PRNU pattern

Research questions

· To which extent is it still possible to match camera signature of videos uploaded to YouTube?
· What are the methods and formats that give the optimal performance and most accurate results?
· How feasible is it to automate and scale the process of extracting the PRNU?

YouTube Streaming

· Streaming vs. Downloading
· Video formats on YouTube


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                                        ┌─────────────────→ Itag 136: 720 p H264  ──→ ▯▯▯▯▯▯▯▯
                            ┌──────────────────┐
                            │                  ├──→ Itag 135: 480 p H264  ──→ ▯▯▯▯▯▯▯▯
                            │ MPD DASH manifest│
                            │                  ├──→ Itag 134: 360 p H264  ──→ ▯▯▯▯▯▯▯▯
                            └──────────────────┘
                                        └─────────────────→ Itag: 160: 144 p H264  ──→ ▯▯▯▯▯▯▯▯

        ┌──────────────┐    ── Itag 17: 144 p MP4V ──→ 🎬
        │              │    ── Itag 18: 640 p H264 ──→ 🎬
        │ get_video_info│   ── Itag 22: 720 p H264 ──→ 🎬
        │              │    ── Itag 36: 320 p MP4V ──→ 🎬
        └──────────────┘
```

Remark: The average YouTube video gets encoded in more formats that shown on this image.
This image is meant to show the difference between the Manifest file for DASH streaming and the get_video_info file.
We have seen that there are at least 72 different Itags in use by YouTube

- Provided by the Netherlands Forensic Institute (NFI)
- Extracts PRNU from videos and images
- Compares between PRNU patterns
- Proprietary software, closed source

PRNUCompare software

Extraction methods

- 2nd order (FSTV) extraction filter
- 4th order extraction filter
- Wavelet Coiflet
- Wavelet Daubechies

Correlation calculations

- Normalized cross correlation
- Peak to correlation energy

Experiments

We have conducted the following three experiments:

· Testing different methods and formats.
· Testing the PRNU extraction with a large set of videos.
· Testing the distributed process.

Figure: workflow on one machine

Figure: workflow required for distribution

Figure: Search interface

Experiment environment

Mobile devices' cameras used in the experiments:

Camera	Model	Recorded resolution	Frame rate
1	Apple Iphone 5	1920 x 1080	30
2	Microsoft Lumia 950	1920 x 1080	25
3	Apple Iphone 5	1920 x 1080	30
4	Huawei Y530	1280 x 720	30
5	Samsung S5	1920 x 1080	30
6	Apple Iphone 6	1920 x 1080	30
7	Apple Iphone 6s	1920 x 1080	30
8	Apple Iphone 5s	1920 x 1080	30
9	Samsung GTI9301I	1920 x 1080	30
10	Samsung SM-G531F	1920 x 1080	30
11	Samsung Galaxy Note 2	1920 x 1080	30
12	Huawei P8 Lite	1920 x 1080	30

Table: Mobile devices and the corresponding cameras' specifications

Conducted Experiments (1)

Experiment 1:
Testing different methods and formats

The different methods and formats we have tested in this experiment are the following:

Format	Method
17 (Resolution: 176 x 144)	2nd Order
18 (Resolution: 640 x 360)	4th Order
22 (Resolution: 1280 x 720)	Wavelet Coiflet
36 (Resolution: 320 x 180)	Wavelet Daubechies

Testing different methods and formats

· Collecting videos (flatfield and natural videos).

Testing different methods and formats

- Collecting videos (flatfield and natural videos).
- Upload natural videos to YouTube.(Uploading the flatfield videos appeard to give less accurate results).

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· Upload natural videos to YouTube.(Uploading the flatfield videos appeard to give less accurate results).

· Download natural videos in four different formats.

· Feed the downloaded videos to PRNUCompare software in four different methods (averaging 200 frames).
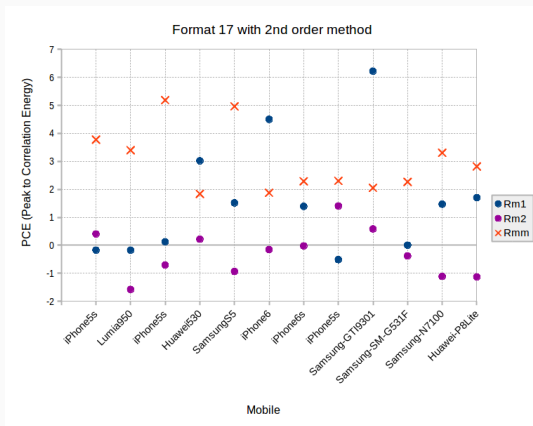
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- Re-encode the flatfield videos in four different formats.(with least possible compression)

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· Re-encode the flatfield videos in four different formats.(with least possible compression)

· Feed the re-encoded videos to PRNUCompare software in four different methods.
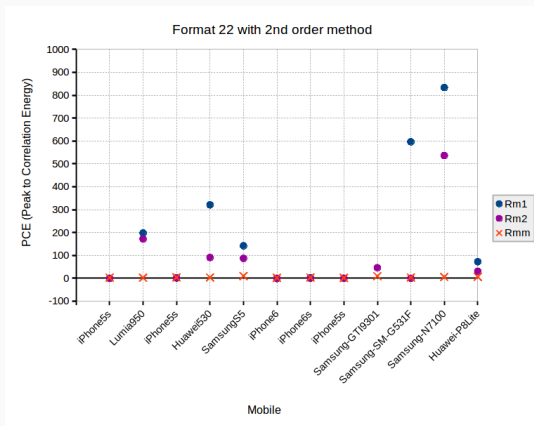
Testing different methods and formats

- · Looking at the results from 12 mobiles' cameras in 4 different formats processed with 4 different methods.
- · Low resolution videos gave much less accurate results.
- · We excluded low resolution videos.

Format 17 with 2nd order method

**Testing different methods and formats**

- 2nd Order method implemented in PRNUCompare software gave the most accurate results.
- Not all the tested cameras gave optimal results in our experiment settings. (i.e. iPhone mobiles' cameras)

Format 22 with 2nd order method

Testing different methods and formats

- · 4th Order method gave results that are close to the 2nd order method results yet less accurate.
- · Both Wavelet Daubechies and Wavelet Coiflet which are implemented in the software gave wrong results in our test settings.
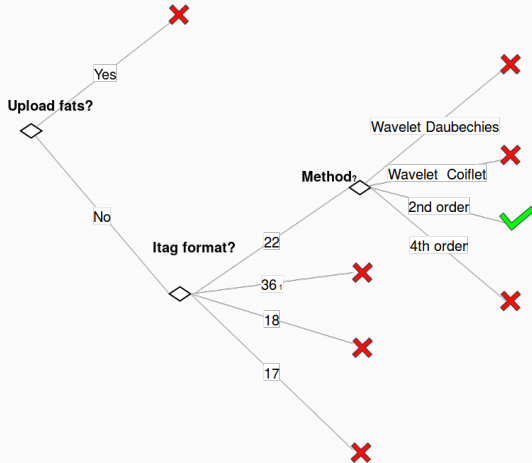

Format 22 with Wavelet-Daubechies method
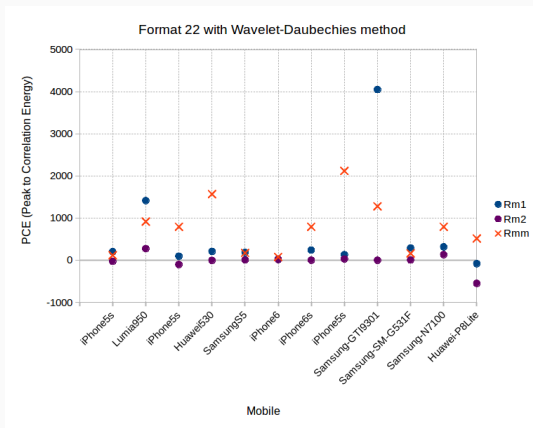
Figure: Flow

Experiment 2:
Testing PRNU extraction with a large set of videos

· Add 1000 YouTube videos to the software queue(including videos used in the experiment).
· Run software.
· Compare a flatfield video with the set.

Testing the automated process

- For some cameras it is still possible to match the PRNU of a camera when comparing with a set of 1000 videos.

- Some cameras gave different results than the first experiment when comparing with a set of 1000 videos.

Set of 1000 videos in 22 format with 2nd order method
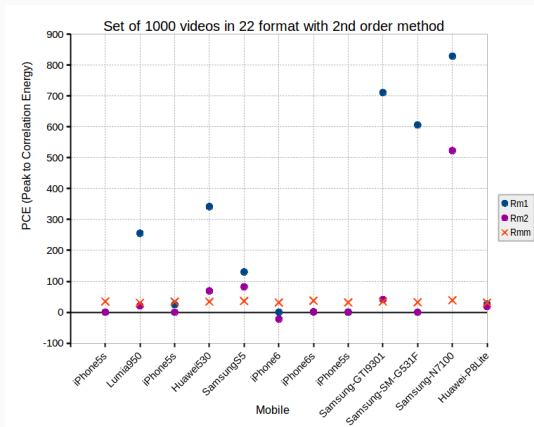
Experiment 3:
Testing the distribution process

- · Set up the software on 2 machines.
- · Add 1000 YouTube videos to the queue.
- · Both servers have: Intel(R) Xeon(R) CPU E3-1240L v5 @ 2.10GHz
- · Run software.

Testing the automated process

We have conducted the second and the third experiments **three times on the same set of videos** and averaged the results:

Measure (Avg.)	1 server	2 servers[1]
Successfully processed videos	974.3	971
Time (minutes)	203.2	97
Avg. Videos/hour	288	601

4.16 GB of data transferred from YouTube

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[1]In the presentation as presented on 6 feb 2017 the results for the two server setup were different with a lower success rate. We re-ran the tests for the two server setup again after the presentation.

Conclusion

- Higher resolution gives more correct results.
- 2nd order method which is implemented in PRNUCompare software is the method that is giving more accurate results in our setting.
- Extracting PRNU from YouTube is possible but not for all cameras (ie. iPhone Mobile cameras, in our test)
- Depending on the camera and the video, videos from a large set of YouTube videos can be matched to the correct PRNU pattern.
- Distribution implemented in the experiment achieves high speed gain.

QUESTIONS?