CAMPrints: Leveraging the "Fingerprints" **KAIST** of Singapore of Digital Cameras to Combat Image Theft Bangjie Sun (NUS), Mun Choon Chan (NUS), Jun Han (KAIST) 2. Our Solution: *CAMPrints* 1. Problem • Detect online image theft using PRNU-induced noise pattern in • A Surge in Online Image Theft: images as physical evidence of ownership • **Unauthorized** use of copyrighted photos O Incur significant *monetary loss* to photographers 2 Fine-Grained **Coarse-Grained OVER 2.5 BILLION ONLINE IMAGES ARE STOLEN** "A lot of photographers find out about Detection **EVERY DAY, COPYTRACK REPORTS** Detection **CAMPrints** image theft when the culprits tag Join Discussion • Share: 🚹 🗶 🙆 🔽 them in social media' Top social media sites for image theft* Sync 72% Geoff Harris 9 November 2020 / 14:46 GM 19% 15% 21% 2% 1% Suspicious Reference

• Using Camera "Fingerprints" as "Physical Token" • Provide evidence of *ownership* of online photos • **Photo Response Non-Uniformity (PRNU)** is the key



- State-of-the-art Solutions are Limited
 - Sensitive to geometric transformations and distortions • Sensitive to *noise* addition and reduction operations







• Design of *CAMPrints*

• Extract *key features* associated with PRNU-induced noise pattern O Ensure *high similarity* between features originating from same device

Training Phase



3. Challenges and Solutions

4. Evaluation

- Challenge #1: Image Editing Operations
 - A wide range of *types*, *parameters* and *combinations* • Freely edit as long as preserving content/quality
- Solution #1: Representative Image Editing
 - Select a *small yet representative* set of operations
 - Categorize and quantify the effects of operations



- Challenge #2: Multiple Sources of Noise
 - Noise pattern extracted from denoising is imperfect
 - o Contains a *mixture* of content noise and sensor noise



• Experiment Setup

- At least three different instances per make-and-model
- O Train with only four operations and test on 40 other ops. and combs.







CAMPrints Web App

(d) End-to-end Experiment

(c) Experiments on Commercial Software

• Performance of *CAMPrints*

Effect (2)

• Achieve overall *average AUC of 0.92*, outperform baselines by *1.8x*

Reference

Images

o Generalize across varying experimental conditions





o Form triplets using device ID and data augmentation o Control the image content within the triplets o Optimize triplet loss



5. Discussion

Deployment Considerations

O Integration into social media and photo sharing platforms, as well as copyright monitoring services • Extension and Future Directions



O Co-existence of physical and digital "tokens" (e.g., invisible watermarks) • Open standards for authenticity and provenance of digital content o Oline media forensics