Ph.D. in Information Technology
Thesis Defense

April 11th, 2024
at 15:00
Beta, Building 24

Edoardo Daniele CANNAS – XXXVI Cycle

MULTIMEDIA FORENSICS CHALLENGES IN THE MULTIMODALITY DATA ERA

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Abstract:

The main goal of multimedia forensics (MMF) is to assess the integrity of multimedia objects, e.g., images and audio clips. In the past, researchers have used classic signal processing techniques to model forensic footprints (FFs), which are noninvertible traces left by editing operations. However, the MMF community has gradually shifted towards more data-driven approaches, such as neural networks (NNs), which have proven to be more effective on various types of content and tasks. Recently, the volume and variety of multimedia objects on the Internet have become broader. Social media, chat services, and the like rely heavily on videos. Scientific data such as satellite imagery (i.e., images of the ground taken by a moving platform, like an aircraft or satellite) and microscopic images (i.e., western blots) are available from numerous portals. This wide diffusion exposes them to manipulations. On top of that, the birth and rise of editing techniques based on deep learning, e.g., Generative Adversarial Networks (GANs) and similia, poses new challenges to MMF researchers. New methods surface continuously and introduce new FFs that are hard to detect with standard tools. MMF forensics must face these challenges altogether and all at once. However, the state-of-the-art based on data-driven techniques presents some flaws. For instance, data-driven techniques lack interpretability, i.e., knowing what prompted a detector to make a specific decision. Moreover, it is still unclear how to assess the confidence of the decision taken, e.g., if the detector detects an image as manipulated, how can we quantify how sure it is about this decision? On top of that, researchers do not have guarantees that NNs can generalize over modalities of data they have not trained them on. Finally, despite the large availability of forensics techniques, they are often used singularly. Combining the information from different sources might increase the robustness of the final forensic analysis.
This thesis aims to bridge the gap between data-driven techniques and the current forensic needs. We will achieve this objective in several ways. For example, when examining new data types (e.g., overhead images or western blots), we can assess the effectiveness of traditional FFs designed for similar signals or evaluate the adaptability of datadriven tools. Viable solutions to obtain interpretable forensic detectors are integrating FFs knowledge from classic approaches into data-driven pipelines and employing uncertainty estimation techniques to assess the reliability of the analysis executed. Lastly, we can leverage machine learning ensemble techniques when handling forensic information from diverse sources.

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