Founding the Domain of AI Forensics

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Inevitable Failures

Google apologises for Photos app’s racist blunder

In 2016, a Tesla driver using Autopilot crashed into the side of a truck and was killed. It happened again three months ago, but this time with a completely new version of Autopilot. What’s the heck is going on??
theverge.com/2019/5/17/1862

Robust Physical-World Attacks on Machine Learning Models

Ivan Evtimov, Kevin Eykholt, Earlene Fernandes, Tadayoshi Kohno, Bo Li, Atul Prakash, Amir Rahmati, Dawn Song
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The need for autopsy

- **Problem:** What sequence of events led to the failure?

- **Technical Analysis**
  - Prevention / mitigating
  - Debugging

- **Legal**
  - Liability
  - Responsibility (e.g., criminal negligence, breach of contract)
  - Criminal (e.g., intentional faults, malicious compromise)
Digital Forensics

- **Definition**: “scientifically derived and proven methods toward the *preservation, collection, validation, identification, analysis, interpretation, documentation and presentation* of digital evidence derived from digital sources for the purpose of facilitating or furthering the reconstruction of events ... shown to be disruptive to planned operations” (Palmer 2001)

- **Daubert process** (Farrell 1993): *Testing, Accuracy, Published, Accepted*
**Definition:** Scientific and legal tools, techniques, and protocols for the extraction, collection, analysis, and reporting of digital evidence pertaining to failures in AI-enabled systems.

- **Scope**
  - What were the sequence of events and conditions that led to the failure?
  - Did the failure result from malicious actions?
  - Which party or parties is responsible for the failure?
  - Would it have been possible to prevent the failure?
  - Where (at what stage or component) did the failures take place?
The Landscape of AI Forensics

- **AI Training Forensics**
  - Training Process Forensics
  - Training Chain of Custody
  - Objective / Cost Function Forensics
  - Pre-processing Forensics
  - Dataset Forensics
  - Collection Chain of Custody
  - Labeling Chain of Custody
  - QA Forensics
  - Environment Forensics

- **AI Substrate Forensics**
  - Disk
  - Network
  - Sensor
  - Actuator

- **AI Application Forensics**
  - API
  - Artifacts

- **AI Model Forensics**
  - Model Authentication Forensics
  - Model Fingerprinting / Ballistics Forensics
  - Model Identification / Extraction Forensics
  - Model Performance Forensics
  - Model Malware Forensics
  - Model Chain of Custody
Training Forensics

• Forensic Analysis of faults introduced in training

  • Training Process Forensics - Optimization algorithm and hyperparameters
    • Objective/reward, Exploration strategy, regularization, etc.

  • Dataset Forensics
    • Inconsistent or unrepresentative data
    • Intentional manipulation – e.g., poisoning, Trojan, etc.

  • Environment Forensics
    • Inaccurate representation/model
    • Intentional manipulation
Substrate and Application Forensics

- **Substrate Forensics**: Hardware and software platforms hosting the AI agent.
  - Areas overlap with cyber forensics:
    - Network components
    - Disk and memory – e.g., random bit flips due to cosmic rays
    - Actuators and Sensors – e.g., manipulated servos and sensors

- **Application Forensics**: AI as a component of application
  - API calls
  - Authentication and access control
  - Data sanitization
  - File system / resource allocation
Model Forensics

• Forensic analysis of deployed model (post-training)

  • **Model Authentication**: Is this model tampered with or modified from the original?
  • **Model Identification**: What does this model do?
  • **Model Ballistics**: Who created the model, which platform was used?
  • **Model Internals**: Is there anything unusual under the hood?
    • e.g., activation clustering for backdoor detection (Chen et al. 2018)
  • **Malware Forensics**: Is this model infected? If so, what type of infection? (e.g., backdoor, policy trigger)
Challenges

• Unexplainability of AI
  • Forensic need for explainability and interpretability
  • However, advanced AI and complex models may be difficult or impossible to interpret (Yampolskiy 2019)
  • Potential solution: Higher level abstractions
    • e.g., psychopathological modeling of AI Safety (Behzadan et al., 2018)

• AI Anti-Forensics
  • Malicious actors evolve, too
    • Decoys, false evidence, forensic cleaning
  • Need for techniques for proactive identification and mitigation techniques
Conclusion

• AI safety research is generally focused on prevention.
• AI failures are inevitable.
• We need a new set of techniques for establishing the root cause
• Abundance of open problems and challenges
• We are already late!
Thank You