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Safeguarding ML: A comprehensive security plan

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Artificial Intelligence… What are we talking about?

Artificial Intelligence

Any technique that enables computers to mimic human intelligence

Machine Learning

A subset of Artificial Intelligence focusing on data-based learning by opposition to symbolic AI (aka knowledge-based learning).

Deep Learning

A subset of Machine Learning methods, based on Artificial Neural Networks with many layers (aka Deep) Neural Networks). There are many types of ANN (e.g. CNN: Convolutional Neural Network, RNN: Recurrent Neural Network).

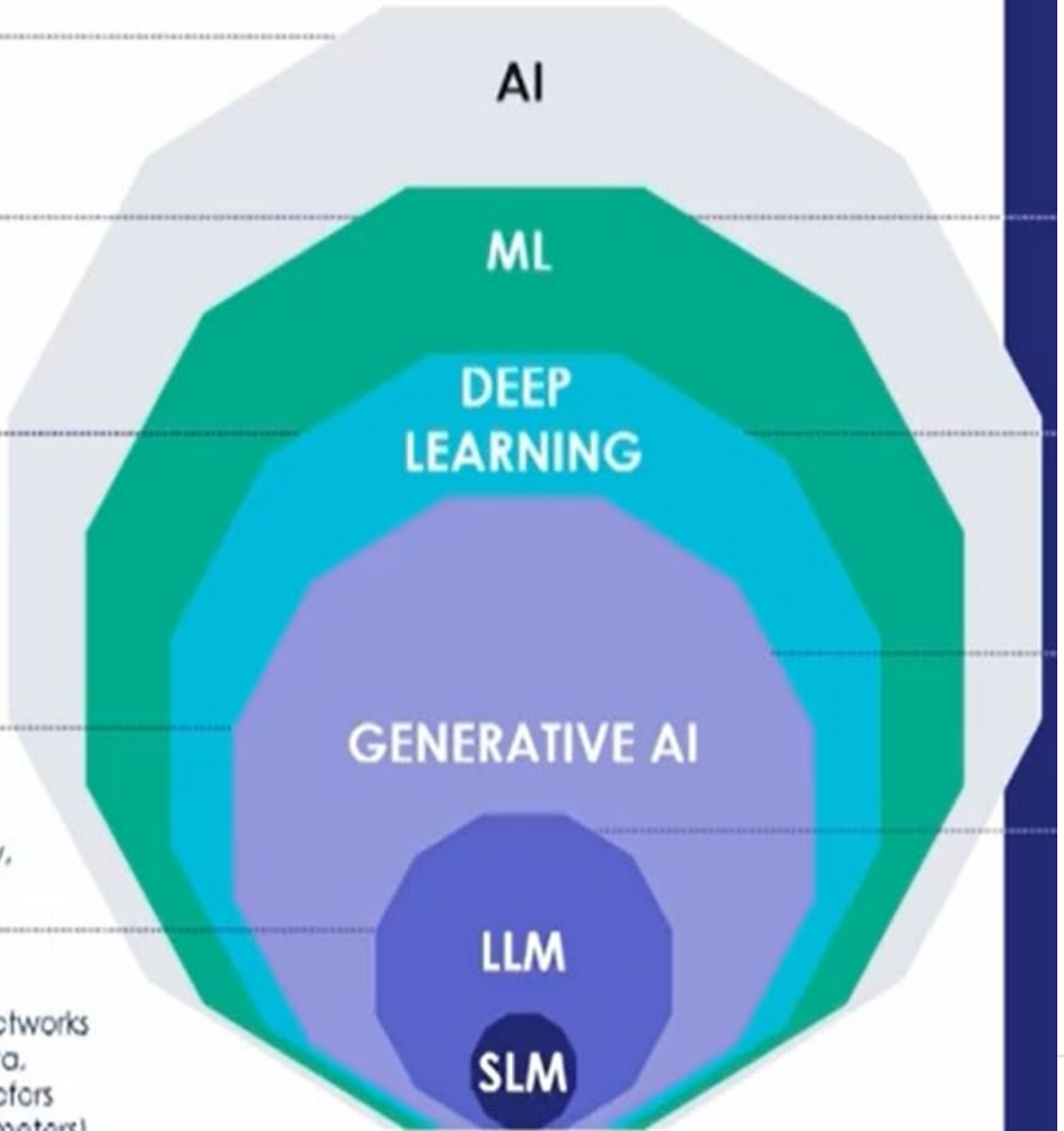
Generative AI

A type of artificial intelligence technology that can produce various types of content, including text, imagery, audio and synthetic data. Examples: GAN*, LLM…

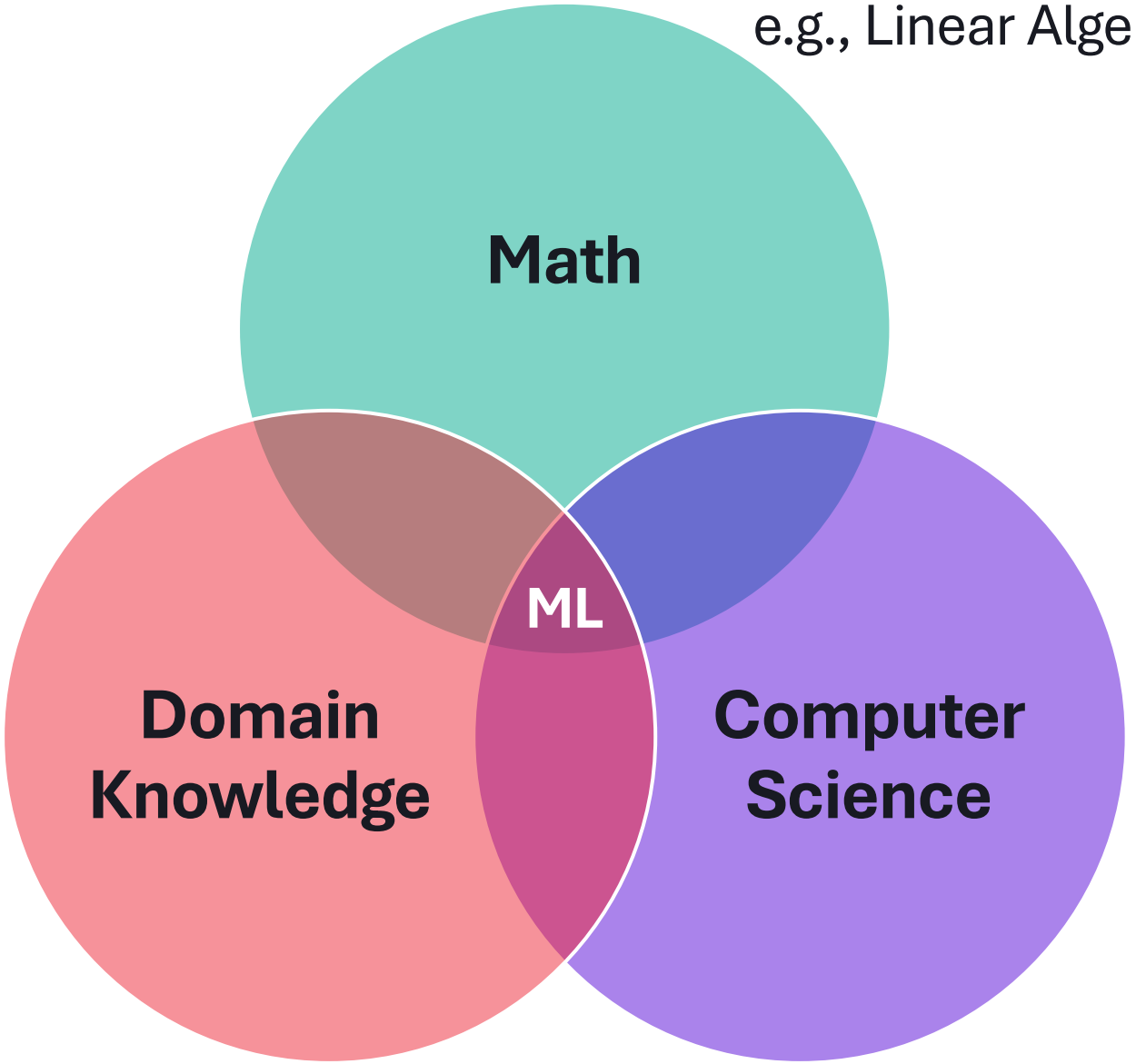
Large Language Models

Specific application of GenAI using a variety of neural networks (the transformers), trained on a very large amount of data, commonly coming with XX+ billions of parameters. SLM refers to Small Language Model (in millions or X billions of parameters).

*GAN: Generative Adversarial Network



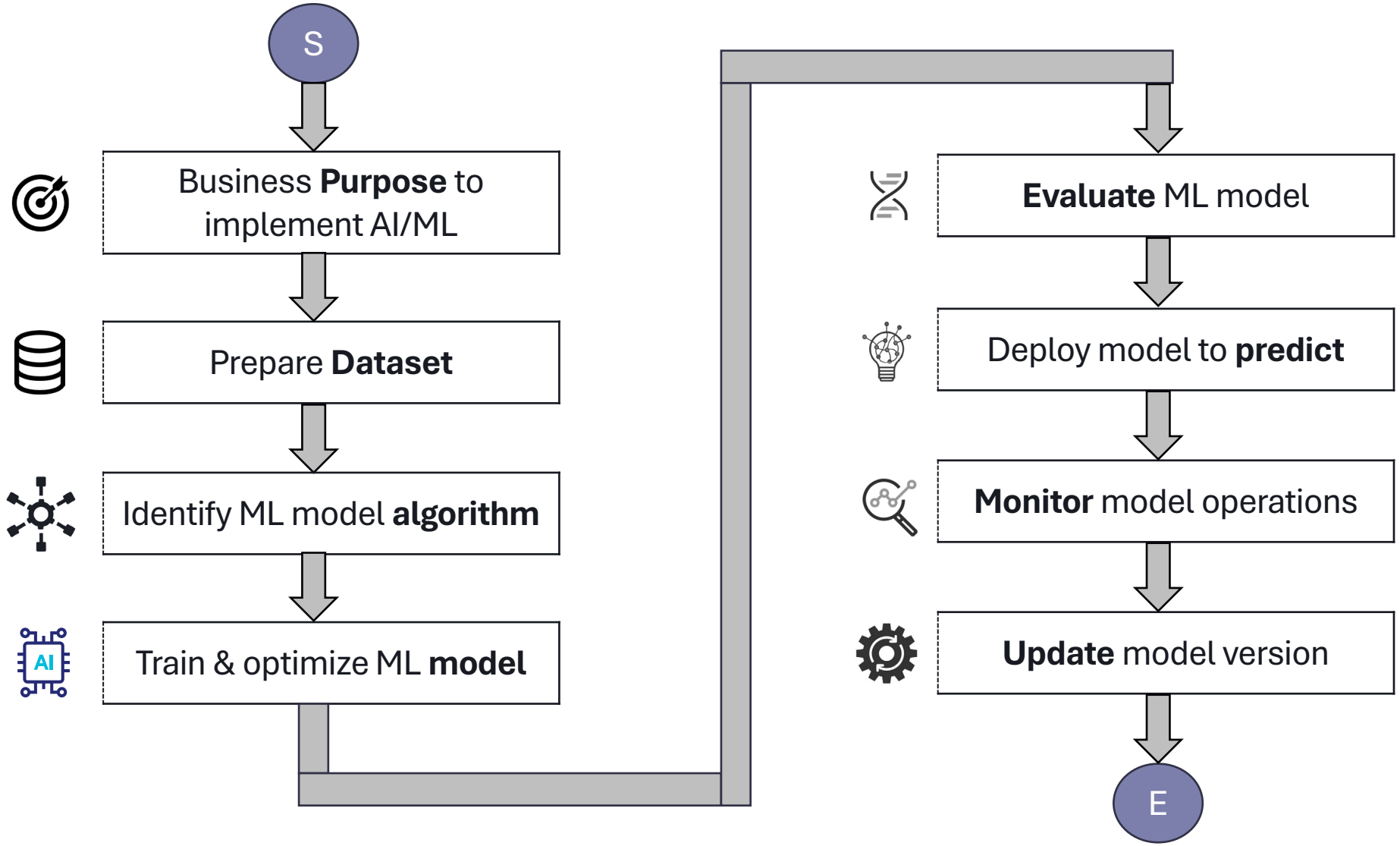
e.g., Linear Algebra



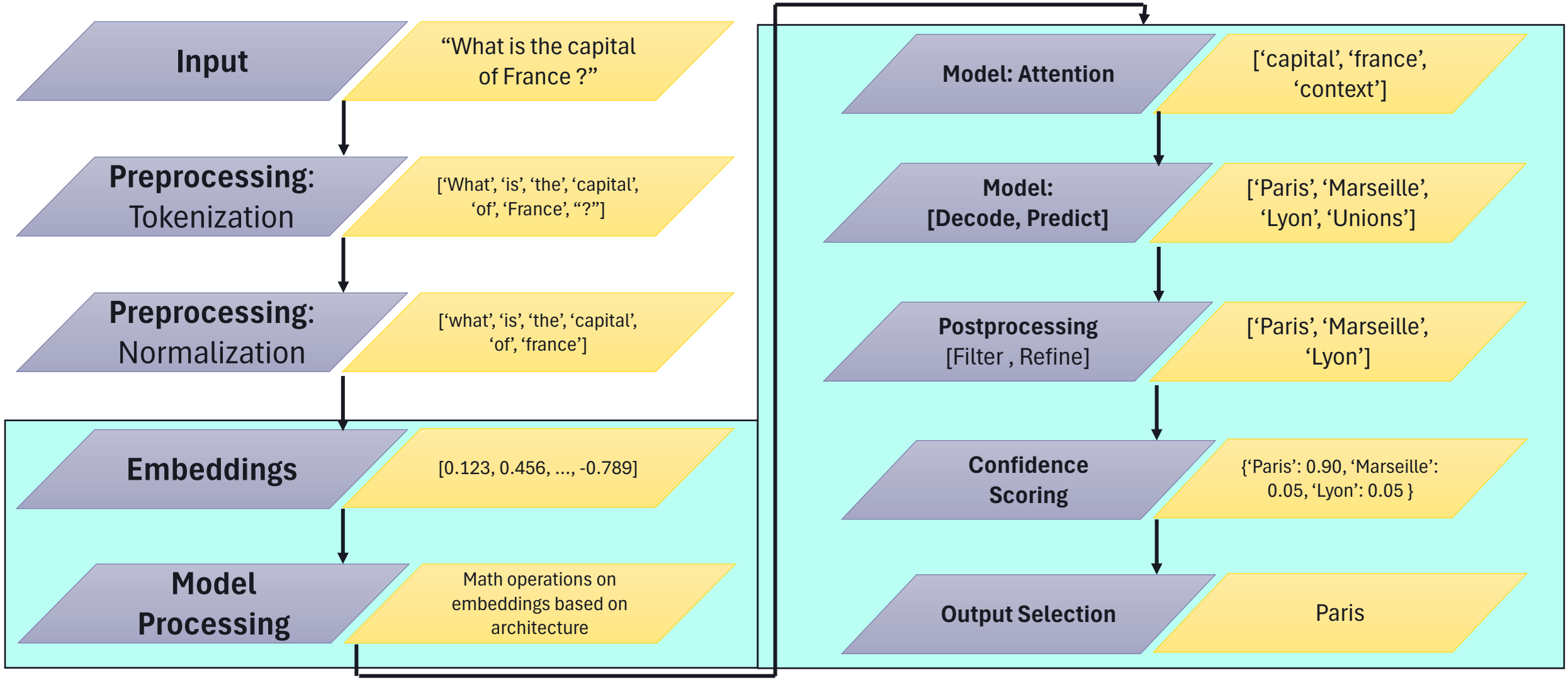
e.g., Cybersecurity

e.g., Python

Machine Learning Workflow



What happens when you input something into LLMs in production? (with example)



Artificial Intelligence and Cybersecurity

AI for Cybersecurity

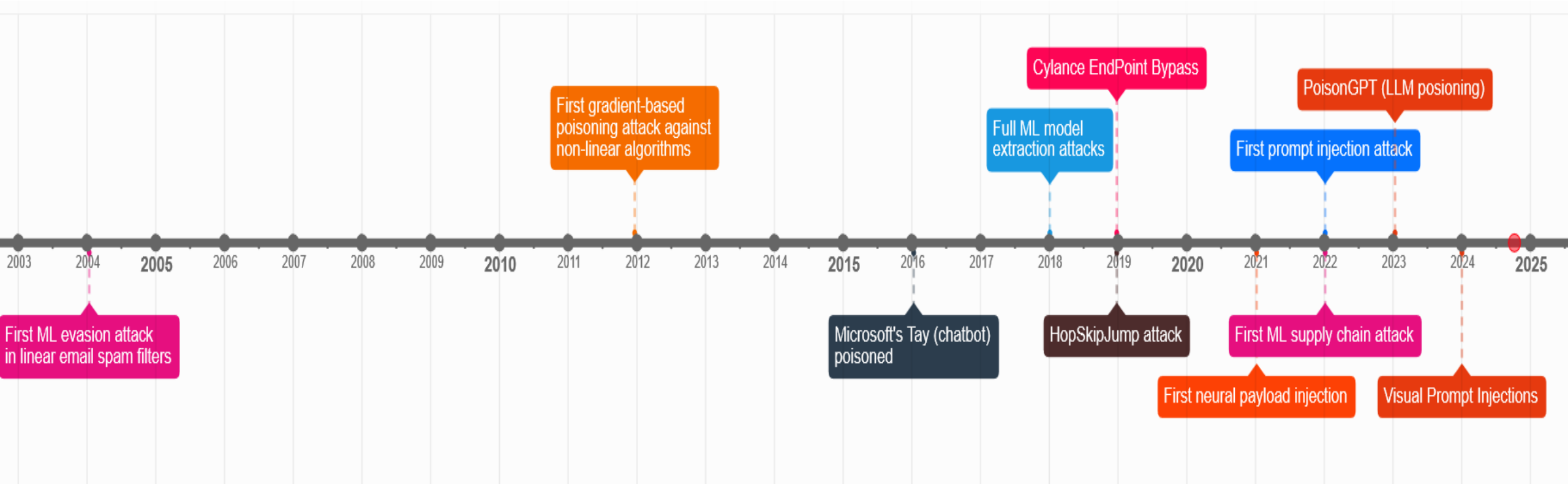
- Implementing AI/ML to protect systems (defense) e.g., AI for improved Data Protection
- Implementing AI/ML to hack systems (attack) e.g., AI generated malware, AI to scan for vulns
- Implementing AI/ML in forensics or incident handling (resolve) e.g., AI for threat hunting
- Implementing AI/ML in management (report) e.g., AI for Cybersecurity metrics / KPIs

Cybersecurity for AI

- Implementing security in AI/ML business usecases (Trusted AI/ML) e.g., Securing LLMs

Evolution of Cyberattacks in AI/ML

Source: HiddenLayer

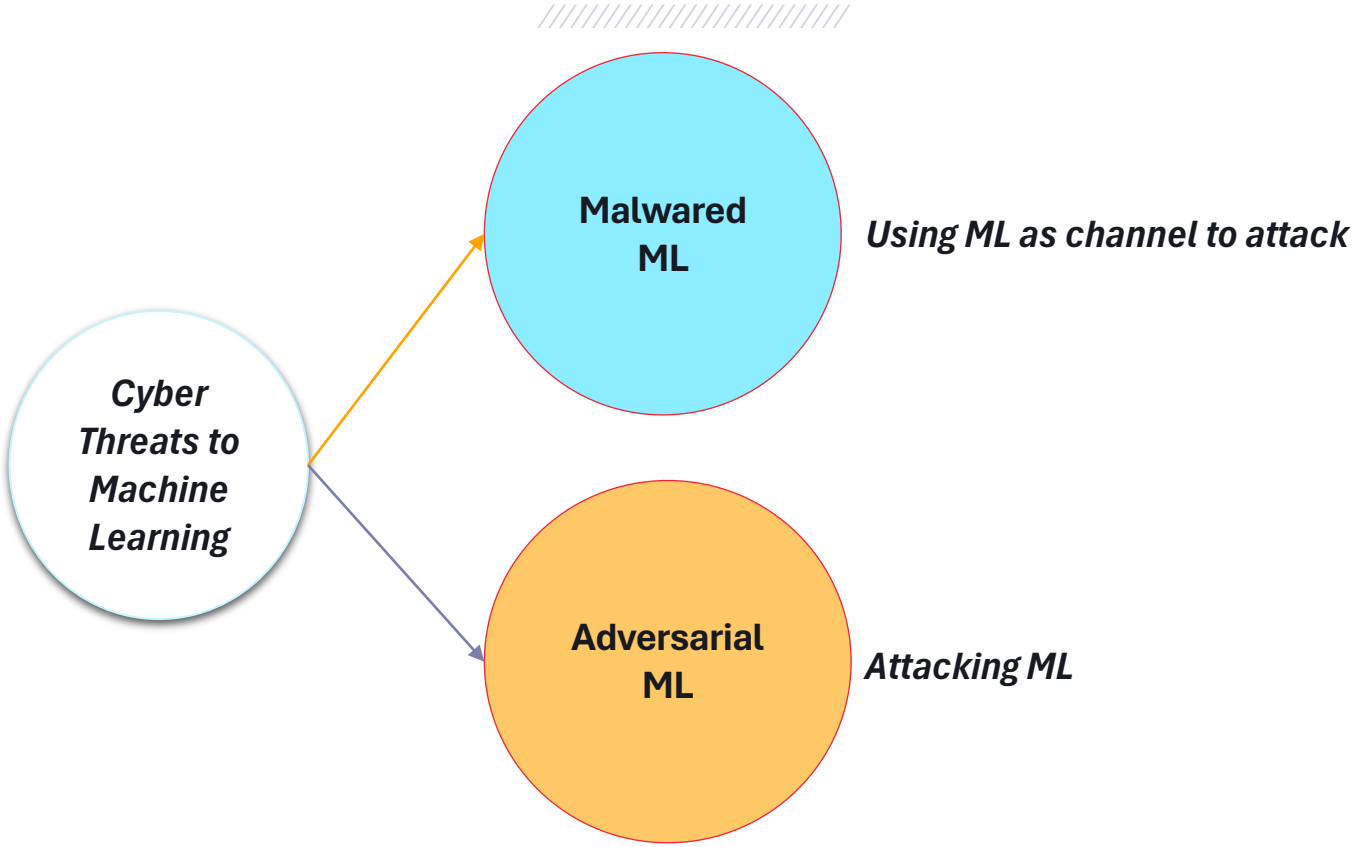


https://oecd.ai/en/incidents
https://airisk.io/
https://avidml.org/database/
https://incidentdatabase.ai/
https://atlas.mitre.org/studies

BUSINESS RISKS TO IMPLEMENT AI / ML

- Harmful Content Creation
- Deepfakes
- Copyright Violation
- Reputational Damage
- Increased Costs
- Regulatory Fines
- Intellectual Property Loss
- Business Continuity Disruption
- Customer Loss

CYBER THREAT CATEGORIES TO MACHINE LEARNING



Cyber Threats to Machine Learning

Malwared ML

ML datasets, pre-trained models, or underlying ML libraries like TensorFlow, PyTorch, scikit-learn, etc. containing **malware** to spread across networks.

- Virus
- Worms
- Trojan horse
- Spyware
- Adware
- Botnets
- Ransomware

Adversarial ML

Manipulate ML datasets, models, or systems with the goal of compromising the confidentiality, integrity, or availability of the business use case.

- Model Evasion
- Model Extraction / Theft
- Model Backdoor
- Model Denial of service
- Data Poisoning / Data Backdoor
- Data Theft / Model Inference
- Generative AI: Prompt / Code Injection / Jailbreaking

AI/ML: Regulations, Standards, Frameworks

Regulations

- US White House EO 14110
- EU AI Act
- Canada AI & Data Act
- UK AI Bill
- PDPC Singapore

Standards

- NIST AI RMF
- ENISA & ETSI
- OWASP Top 10 (ML & LLM)
- ISO 27090
- IEEE P3119

Frameworks

- MITRE ATLAS
- Gartner AI TRiSM
- Linux Foundation AIOSS
- Google SAIF
- IBM Secure Gen AI
- Thales Secure ML

ThalesGroup's **Secure Machine Learning** Framework

- We open sourced this secure-machine-learning framework
  - https://github.com/ThalesGroup/secure-ml [License: CC BY-ND 4.0]

- Includes:
  - Corporate Security Policy: Framework for ML systems [Link]
  - Security Requirements & Guidelines [Link]
  - Privacy-Preserving Techniques [Link]
  - Recommended Security Tools [Link]
  - Industry references on regulations, standards [Link]
  - Cyber threats to ML & Taxonomy [Link]

ML Security Policy – highlights

- **Data Security**: It refers to securing data that can be training data, validation data, data stored in vector databases, etc.
- **Model Security**: It refers to hardening the model in both development and inference time.
- **Platform Security**: It refers to hardening of the underlying platform where the ML model is being developed or operated, along with any associated data.
- **Security Compliance**: It refers to being compliant to both internal and external regulations, standards, and best practices as application to the Trusted AI principles.
- **Human Security**: It refers to humans being well trained, authenticated, authorized, and capable to handle security incidents around ML ecosystem.

	DATA SECURITY	MODEL SECURITY	PLATFORM SECURITY	SECURITY COMPLIANCE	HUMAN SECURITY
GOAL	• Confidentiality • Integrity • Availability • Authentication • Authorization • Non-repudiation • Privacy	• Integrity in computation • Accuracy and precision in output	• API security • System security • Network security	• Comply with internal and external policies, standards and regulations	• People involved are aware of security risks • Only authorized people are involved
TECHNIQUE	• Encryption • Access Controls • Data backups & Recovery • Data anonymization • Data quality control • Secure data sharing • Data classification	• Secure development • Input and Output validation • Model explainability • Adversarial training • Robustness testing • Monitoring and alerting • Secure deployment	• Vulnerability scanning & Penetration Testing • Patch management • Access Controls • Encryption • Hardening • Secure Configuration	• Regulatory compliance • Ethical considerations • Data retention and deletion • Audit trails • Security assessments • Third-party risk management	• Training and awareness • Background checks • Incident response • Governance and oversight • Continuous monitoring

ML Security Requirements – DATA SECURITY

WHAT?

Data Security Techniques

ID	Technique	Activity
DS1	Encryption	- Encrypt sensitive data in transit and at rest. - Use strong algorithms (e.g., AES, RSA). - Securely manage encryption keys.
DS2	Access Controls	- Implement strict access controls. - Ensure authorized personnel access only. - Utilize user authentication, role-based access, and MFA.
DS3	Data Classification, Backups, and Recovery	- Classify data by sensitivity. - Regularly back up data. - Develop a disaster recovery plan.
DS4	Data Anonymization	- Remove personally identifiable information (PII). - Use data masking or tokenization techniques to protect privacy.
DS5	Data Quality Control	- Implement processes for data quality and integrity. - Conduct data validation and antivirus scans.
DS6	Secure Data Sharing	- Ensure security measures for third-party data sharing. - Use secure transfer protocols and establish data usage agreements.

Key Takeaways

1. Implement Robust Security Measures: Focus on encryption, access controls, and data quality.
2. Protect Sensitive Information: Anonymization and secure sharing are essential.
3. Plan for Recovery: Regular backups and disaster recovery plans ensure data integrity.

ML Security Requirements – MODEL SECURITY

WHAT?

Model Security Techniques

ID	Technique	Activity
MS1	**Secure Development**	- Implement version control for AI models. - Use code repositories and branching. - Conduct code reviews and maintain a secure development environment.
MS2	**Input/Output Validation**	- Validate inputs and outputs for accuracy and reliability. - Employ data validation, normalization, and transformation to eliminate untrusted inputs.
MS3	**Model Explainability**	- Ensure AI models are explainable and transparent. - Utilize feature importance analysis and model visualization. - Conduct threat modeling.
MS4	**Adversarial Training & Robustness Testing**	- Perform robustness testing against malware and adversarial attacks. - Implement scanning, adversarial training, and model hardening techniques.
MS5	**Monitoring and Alerting**	- Monitor AI models in production for anomalies. - Set up logging and alerting mechanisms for unexpected behavior.
MS6	**Secure Deployment**	- Ensure secure deployment of AI models. - Use secure communication protocols and access controls. - Implement authentication and reverse engineering protection.

Key Takeaways

1. Integrity and Resilience: Focus on secure development and robustness against attacks.
2. Transparency: Prioritize model explainability for better understanding and trust.
3. Continuous Monitoring: Regularly monitor models to detect anomalies and ensure secure deployment.

ML Security Requirements – PLATFORM SECURITY

WHAT?

Platform Security Techniques

ID	Technique	Activity
PS1	**Vulnerability Scanning**	- Perform vulnerability scanning and penetration testing. - Identify and mitigate vulnerabilities in AI/ML infrastructure and systems.
PS2	**Patch Management**	- Implement a robust patch management process. - Ensure timely installation of software and firmware updates to address known vulnerabilities.
PS3	**Access Controls**	- Enforce strict access controls for AI/ML infrastructure. - Use user authentication, role-based access control, and multi-factor authentication.
PS4	**Encryption**	- Utilize encryption for data in transit and at rest. - Implement TLS for secure communications and full-disk encryption for storage.
PS5	**Network Hardening**	- Apply network security measures such as firewalls and intrusion detection/prevention systems. - Implement network segmentation to defend against attacks.
PS6	**Hardware Security**	- Secure hardware components (e.g., GPUs, TPUs) against tampering and physical attacks.
PS7	**Secure Configuration**	- Ensure secure configuration of ML systems. - Follow best practices for hardening networks, systems, and applications, both in cloud and on-premises.

Key Takeaways

1. Proactive Security: Regular vulnerability scanning and patch management are essential.
2. Controlled Access: Implement robust access controls to safeguard infrastructure.
3. Comprehensive Protection: Ensure both hardware and software configurations are secure.

ML Security Requirements – SECURITY COMPLIANCE

WHAT?

Security Compliance Techniques

ID	Technique	Activity
SC1	**Regulatory Compliance**	- Ensure AI/ML systems comply with regulations (e.g., HIPAA, GDPR, PCI-DSS, ISO 27001). - Implement data protection, security controls, and privacy requirements.
SC2	**Ethical Considerations**	- Consider ethical implications, focusing on bias, fairness, and accountability. - Employ bias mitigation techniques and promote algorithmic transparency.
SC3	**Data Retention and Deletion**	- Establish policies for data retention and deletion to meet regulatory requirements. - Implement data minimization, anonymization, and destruction practices.
SC4	**Audit Trails**	- Create audit trails to track data access and usage. - Utilize logging, monitoring, and reporting, especially in regulated industries.
SC5	**Security Assessments**	- Conduct security assessments to identify vulnerabilities and ensure compliance. - Perform security risk assessments, audits, and compliance evaluations.
SC6	**Third-Party Risk Management**	- Ensure third-party vendors comply with regulatory requirements and security standards. - Assess risks associated with vendors accessing sensitive data or systems.

Key Takeaways

1. Compliance Matters: Adhere to regulations to protect data and privacy.
2. Ethical Frameworks: Address ethical considerations to ensure fairness and accountability.
3. Thorough Assessments: Regularly assess security and third-party risks for robust compliance.

OPEN

ML Security Requirements – HUMAN SECURITY

WHAT?

Human Security Techniques

ID	Technique	Activity
HS1	**Training and Awareness**	- Provide training programs for employees and stakeholders. - Implement security awareness campaigns and conduct phishing simulations to highlight risks.
HS2	**Background Checks**	- Conduct background checks on employees and contractors with access to sensitive data. - Focus on regulated industries and government agencies.
HS3	**Incident Response**	- Develop an incident response plan for handling security incidents. - Include incident management, forensics, and communication plans with designated personnel.
HS4	**Governance and Oversight**	- Establish governance structures for secure and ethical AI/ML system development and deployment. - Implement compliance frameworks and security dashboards.

Key Takeaways

1. Empower Employees: Training and awareness are crucial for understanding security risks.
2. Vetting Access: Background checks enhance security for sensitive data access.
3. Preparedness: An effective incident response plan ensures readiness for security incidents.

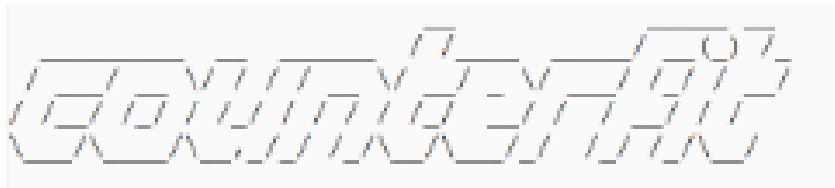
HOW?

ML Security Guidelines

	GUIDELINES
DATA SECURITY	OWASP ASVS, ISO27001, GDPR, IEEE, + custom guidelines
MODEL SECURITY	SHAP/LIME, ProtectAI' s LLM-guard, Microsoft AI Threat modeling + custom guidelines
PLATFORM SECURITY	Custom guidelines
SECURITY COMPLIANCE	FHE & FL (w/ multiple libraries), + custom guidelines
HUMAN SECURITY	Custom guidelines

Security tools for Machine Learning

Azure/PyRIT



QData/TextAttack

Privacy-Preserving Techniques for Machine Learning

Differential Privacy for Machine Learning

- https://github.com/OpenMined/PyDP
- https://github.com/tensorflow/privacy
- https://github.com/opendp/opendp

Federated Learning

- https://github.com/tensorflow/federated
- https://github.com/OpenMined/PySyft
- https://flower.dev/

Homomorphic Encryption

- https://github.com/OpenMined/TenSEAL
- https://github.com/zama-ai/concrete-ml
- SEAL (Simple Encrypted Arithmetic Library): https://www.microsoft.com/en-us/research/project/microsoft-seal/
- https://github.com/homenc/HElib
- More at https://github.com/jonaschn/awesome-he

Secure Multi-Party Computation (SMPC)

- https://github.com/data61/MP-SPDZ
- https://sharemind.cyber.ee/sharemind-mpc/
- https://github.com/easy-smpc/easy-smpc

Privacy-Preserving Data Synthesis

- https://github.com/pytorch/opacus
- https://github.com/sdv-dev/SDV
- https://github.com/sdv-dev/CTGAN
- https://github.com/DataResponsibly/DataSynthesizer

Secure ML Program Roadmap: 3, 6, 12-Month Plan

3

Foundation

1. Draft/refine corporate security policy for ML systems.
2. Plan/red team AI/ML systems (create team if needed).
3. Analyze security regulations and standards for AI/ML
4. Raise awareness among ML engineers on security risks.

6

Build

1. Research security tools for your ML tech stack.
2. Build guidelines for securing data pipelines and models.
3. Explore privacy-preserving techniques (e.g., FHE, FL).
4. Begin threat modeling for ML risks.

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Launch

1. Deliver secure ML solutions to clients.
2. Implement continuous monitoring for threats.
3. Automate security compliance for ML datasets & models.
4. Train stakeholders on new ML attack vectors.

Learn by hands-on exercises

1. **Exploring Adversarial Machine Learning** by NVIDIA

- https://learn.nvidia.com/courses/course-detail?course_id=course-v1:DLI+S-DS-03+V1

2. **Adversarial Machine Learning**

- https://secml.readthedocs.io/en/v0.15/tutorials.adv.html

3. **Dreadnode's crucible (CTF)**

- https://crucible.dreadnode.io/

4. **Lakera's Gandalf (8-levels) for prompt injection attack (CTF)**

- https://gandalf.lakera.ai/baseline

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Thank you

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