The Case for Machine Learning

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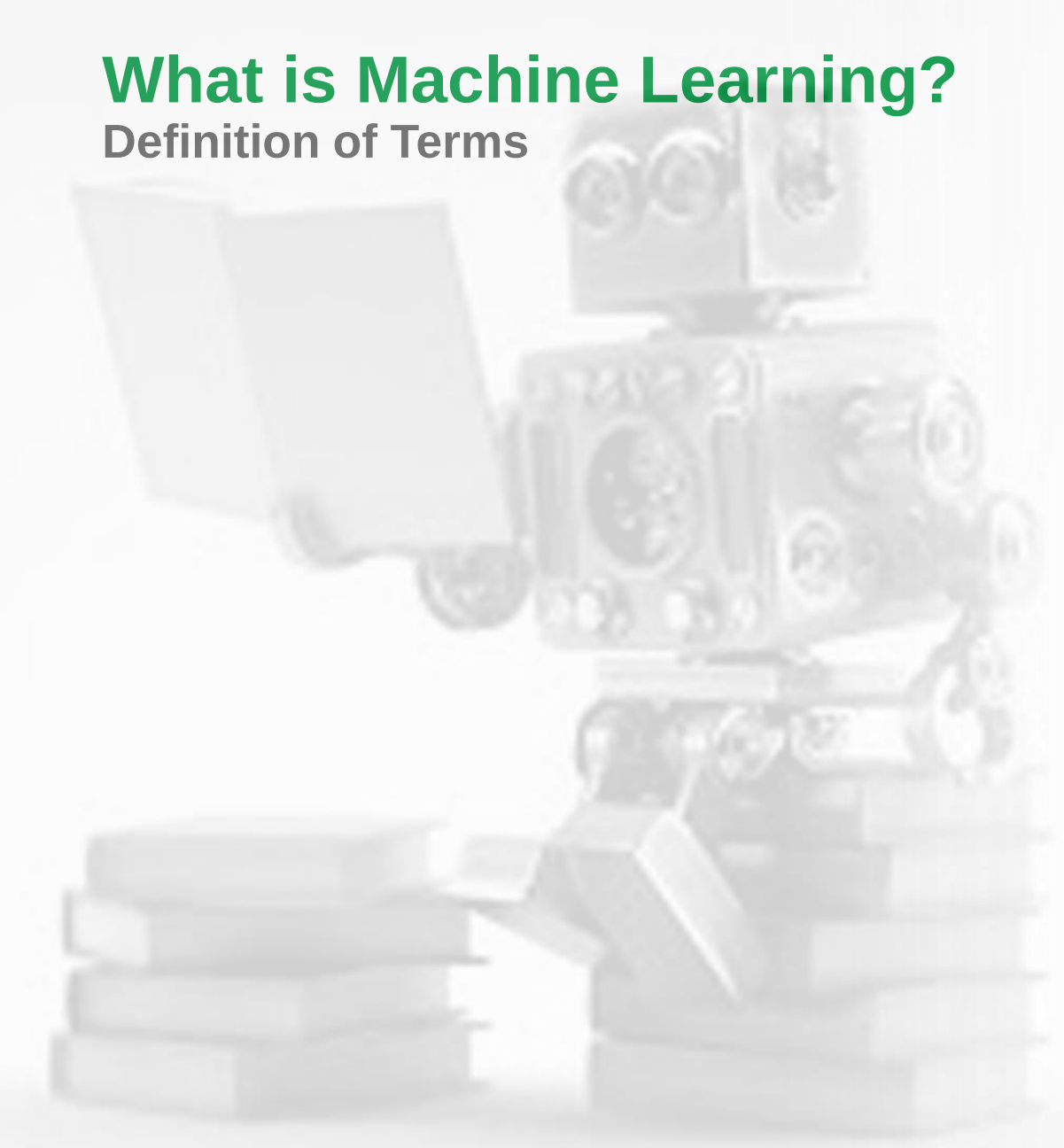
TRL Technology

What is Machine Learning?

Definition of Terms



Big Data

Volumes of data that exceed memory and/or traditional processing techniques

Data Science

Modelling trends and clusters (classes) within big data

Machine Learning

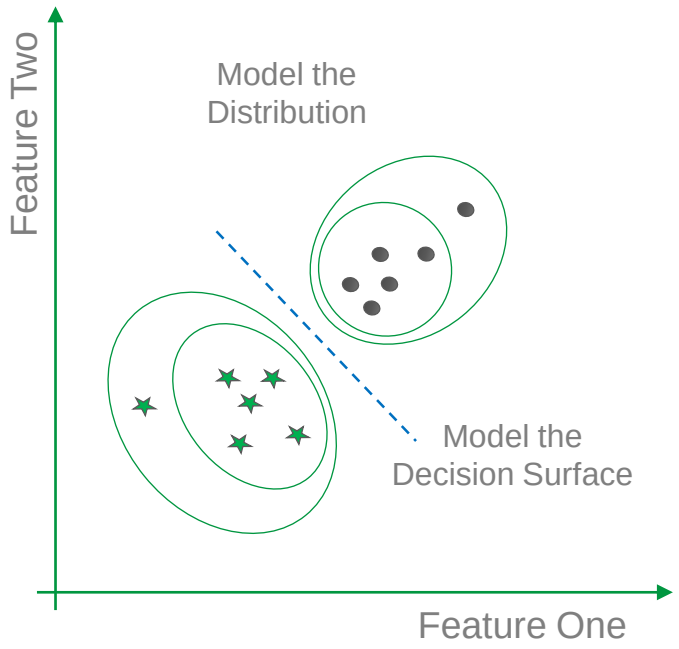
Use of models to classify or predict trends or classes within data

Artificial Intelligence

Use of Machine Learning techniques to automatically react to a situation

Machine Learning

Surprisingly Simple…



Applications:

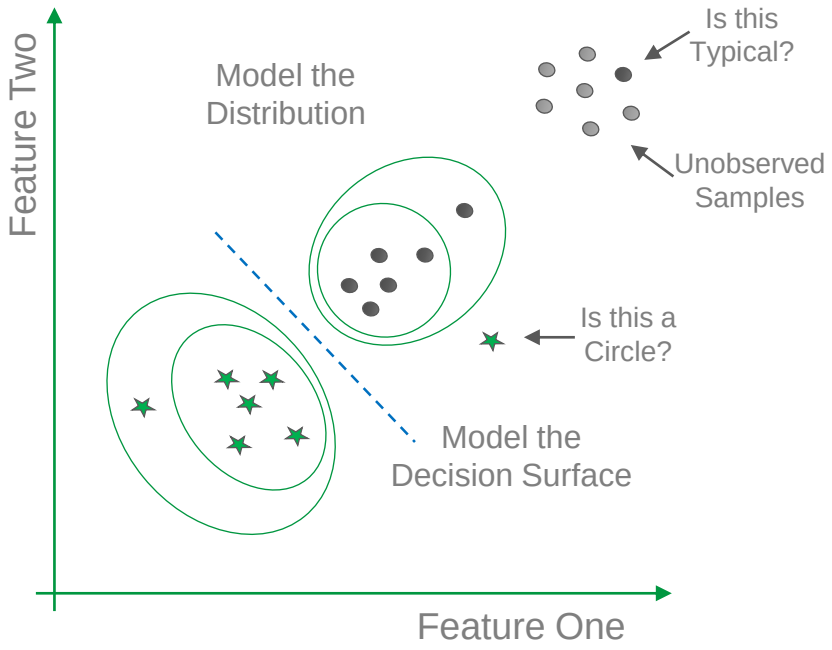
- Identify Clusters
- Separate to Classify (Label)
- Anomaly Detection
- Assign Probabilities and Confidence

And with a little tweaking:

- Prediction

Machine Learning

The Challenges…



Challenges:

- Outliers
- Dependencies
- Chaotic and/or Noisy systems
  - Non-linear data
  - Hidden variables
  - Perturbation
- Too little (sparse) data
- Too much (big) data
- Curse of Dimensionality
- Regularisation and Quantisation
- Training Bias

Machine Learning
A long history

	First Established	Example	Advantages	Disadvantages
Bayesians	1763	Refinement Hypothesis and a-priori Knowledge	Measurement of Uncertainty	Need for Good Data Coverage
Connectionists	1951 2006	Neural Networks Deep Learning	Automatic Feature Extraction	Accountability
Analogises	1967 1995	Nearest Neighbour Support Vector Machines	Good out-of-sample Generalization	Model Selection
Symbolists	1970s	Inverse Deduction Rule Based	Potentially Short Learning	Brittleness & Scalability
Evolutionists	1992	Genetic Algorithms	Avoid Local Minima Adapt to the Unknown	Dependency on Encoding

The unspoken truth: There are few new ideas in Machine Learning!

The Case for Machine Learning

On a CEMA Battlefield

Operating Scenario:

- **Autonomous CEMA Adversary**
  Well equipped and devolved chains of command
- **Contested and/or Congested Environment**
  - Loss of Strategic Backhaul
  - Disrupted Tactical Communications
  - Loss of Position, Timing, and Navigation
- **Information Overload from Big Data**
  Volume, velocity, diversity, and sparsity

Operational Needs:

- **Automated Decision Support**
  Reduced Cognitive Burned
- **Utilise increased Situational Awareness**
  Every soldier and platform is a Sensor
- **Legal, Accountable, and Proportional Actions**
  Driven by Rules of Engagement
- **Threat Signal Prioritisation**
  Automate or support faster decision making

Benefits of Machine Learning:

- **Distributed Analytics**
  To support Situation Awareness
- **Decentralised Decision Support**
  To support loss of communications
- **Authorised Autonomous Decision Making**
  To expedite decisions
- **Trusted Edge based Computing**
  To support Machine Learning

Operational Timeline

Evolving CEMA Environment

		Pre Deployment	Deployment	Operations	Recovery	Post Mission
Dependencies	Networking & Bandwidth	• Structured • Known	• Mobile • Dynamic	• Localised • Limited	• Disrupted • Limited	• Structured • Known
	Position, Timing & Navigation	• Established • Trusted	• Disrupted • Known	• Denied • Unreliable	• Limited • Known	• Established • Trusted
CEMA Tasking Pipeline	Situation Awareness	• Establish • Disseminate	• Validate • Update	• Maintain • Distribute	• Maintain • Consolidate	• Achieve • Analyse
	Decision Making	• Centralised • Disseminate Intent	• Distributed • Dynamic	• Decentralised • Inform	• Distributed • Dynamic	• Centralised
	Action	• Exploratory	• Pro-active	• Support	• Defensive	• Validation
Machine Learning	Detect, Locate, Classify, & Predict	• Centralised • Planning	• Distributed • Optimisation	• Decentralised • Inform	• Distributed • Dynamic	• Centralised • Classification

Operational Timeline

Potential Application Areas for Machine Learning

Machine Learning Tasks	Pre Deployment	Deployment	Operations	Recovery	Post Mission
Detect	• Emitters • Sensors	• Emitters • Sensors	• Emitters • Sensors	• Emitters • Sensors	
Locate	• Adversaries • Disruptors	• Adversaries • Blue Forces	• Adversaries • Blue Forces	• Blue Forces • Adversaries	
Classify	• Participants • Patterns of Life	• Behaviours	• Behaviours • Responses		• Analysis
Predict	• Effectiveness • Mission Outcomes	• Reactions • Alternatives	• Reactions • Alternatives		• Alternatives
Optimise	• Routes • Asset Placement	• Evolve Response • Evolve Assets	• Adapt Response • Adapt Assets	• Expedite	
Change Detection	• Characterisation	• Anomaly • Evolve	• Monitor • Respond	• Monitor • Protect	• Monitor • Protect
Network Characterise	• Detect • Enumerate	• Refine • Monitor Response	• Feed SA Picture		

The Case for Machine Learning
On a CEMA Battlefield

Any Questions?

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