Possibilities and Challenges for Artificial Intelligence in Military Applications

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DL Boosts Performance in a Large Number of Applications
Potential Advantages of DL

- **Efficiency:**
  - Reduced development costs and development time

- **Availability:**
  - No programming skills required (software 2.0)

- **Complexity:**
  - Computer generated programs perform better than any human implementation

- **Creativity:**
  - Computers provide creative solutions to problems that humans can study and learn from

- **Objective:**
  - Computers are unbiased and fair whereas humans can be corrupt, unfair, racist and so on
Examples of Military AI-Applications

- Maritime surveillance
  - Unsupervised machine learning
  - Low probability events are anomalies
- Underwater mine warfare
  - Supervised machine learning
  - Image classification

- Intrusion detection
  - Supervised machine learning
  - Signature classification
- Penetration testing
  - Deep reinforcement learning
  - Planning of mitigation strategies
Challenges

- Optimization:
  - Local vs. global
- Generalization:
  - Under-fitting vs. over-fitting
- Hyper-parameter tuning:
  - Meta-learning
- Production grade AI:
  - Reproducibility
  - Version control for data
  - Power efficiency
  - Real-time processing
  - Up to date after deployment
- AI-compute and data centers

- Black-box:
  - Transparency, interpretability, explainability
- Vulnerabilities:
  - Adversarial examples, transfer learning and data poisoning
- Data:
  - Learning with limited data
Transparency, Interpretability, and Explainability

- Types of need
  - Trust
  - Causal relationships
  - Generalizability
  - Inform decision making
  - Fairness
Approaches for Transparency

- **Interpretable models**
  - Linear models, Rule-based systems, Decision trees
  - Predictability, Decomposability, Training method

- **Explanations**
  - Textual or visual
  - Perceived beliefs, desires, and intentions
  - Abnormality, Preferences, Norms, Recency, Controllability
  - Contrast relative other recommendation
  - Selective
  - Conversations for transfer of knowledge
Examples of Interpretable Models

- Bayesian Rule List
- Stroke Prediction
Examples of Feature Visualization: Activation maximization

- Semantic information in images is spread out
- Multifaceted features
- Synthesize images with GAN for
  - Coherent global structure
  - Realistic looking colors
  - Sharpness
Examples of Feature Visualization: DNN explanation

- Highlight discriminative features or regions
- Sensitivity methods are vulnerable to occlusion
- Relevance propagation considers both presence and reaction
Vulnerabilities

- **Adversarial examples:**
  - It is easy to adjust the input so that the classification system fails completely.
  - The main idea is to use SGD and back-prop as usual, but instead of updating weights the input signal is updated.
  - When input dimensionality is large then the changes are often imperceptible.
  - Black-box attacks are also possible.

- **Transfer learning:**
  - The idea is to exploit hidden backdoors in pre-trained DNNs.
Example 1: Manipulation of Input Signal
Example 2: Manipulation of Input Signal
Example 3: Manipulation of Input Signal

100% success

Class: Rifle

Adversarially Perturbed Model

STO-MP-IST-160, S1-5
Vulnerabilities

- Even though this is a hot research area, there are no solutions to these problems
- Defence mechanisms exist but they do not always work
- Recommendation:
  - Always protect the model, its architecture and weights
  - Minimize the possibility for outsiders to interact with the model
  - Be careful when using transfer learning
  - When reusing training data, always check for poisoning
Learning with Limited Data

- Data for military ML-applications is limited:
  - Data is collected but typically not for ML-purposes
  - Data is not easily shared

- Techniques that can be used to learn with limited data:
  - Transfer learning
  - Generative Adversarial Networks (GANs)
  - Modeling and simulation
Conclusions

- There is currently no silver bullet for the challenges highlighted in this talk
- But, the AI-field is moving fast:
  - Partial solutions continues to emerge
  - Keeping up-to-date is a challenge
- More AI-applications are reaching human or even superhuman performance
- Many AI-services are now available as products on the cloud (transcribing, sentiment analysis, face recognition, etc.)
- Deep learning solves domain specific tasks only:
  - Other breakthroughs are needed for AGI
Questions?

Thanks for listening
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