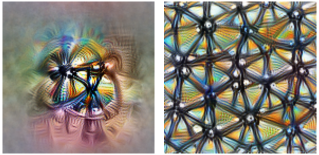
Interpretable Machine Learning

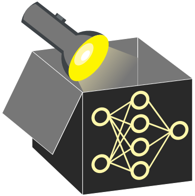
Post-hoc Methods for Neural Networks



Learning goals

- Interpretability in neural networks
- Landscape of interpretability
- The difference between feature visualization and feature attributions

NEURAL NETWORKS AS COMPLEX ML MODELS



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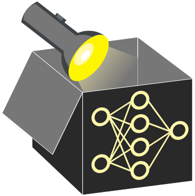

- Neural networks are over parameterised
  - Vision models and Language models routinely have > millions of params
  - Sometimes #parameters > #input instances
  - Which and how do the features, parameters, training instances contribute towards the final decision ?

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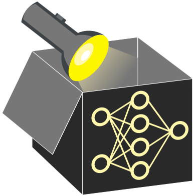

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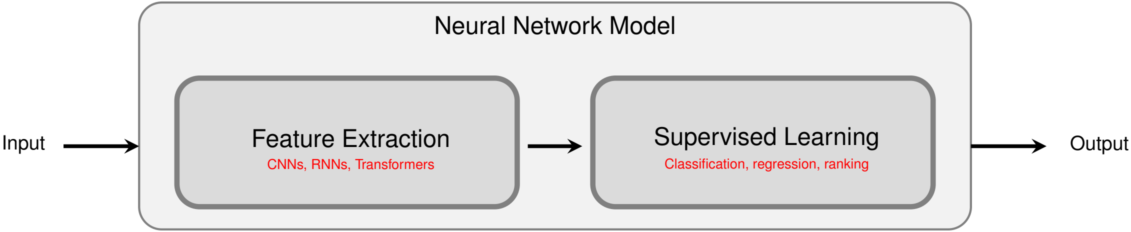

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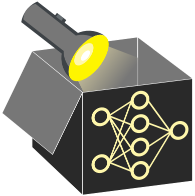
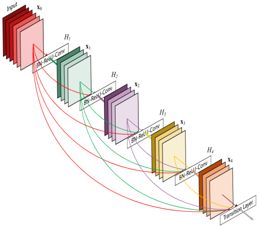
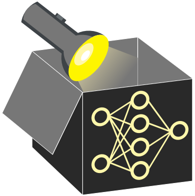


- Neural networks are compositional and non-linear systems
  - The success of neural networks is due to their depth
    - Depth results in compositional behaviour
  - Non-linearity between layers helps capture non-linear relationships

- Depth and non-linearity leads to lack of interpretability

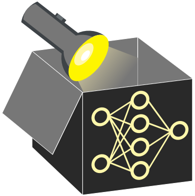


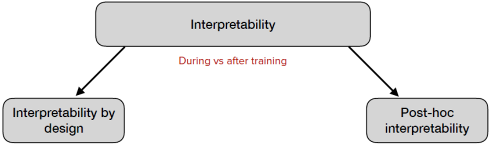
MODEL-SPECIFIC INTERPRETABILITY



- What types of neural models are out there ?
  - For vision: Convolutional Neural Nets
  - For language, speech: Recurrent Neural Nets, Transformer Models
  - For recommendation systems, ranking: Factorization-based Models, Embeddings models
- Each of the domains have their challenges and have developed specific approaches for interpretability
  - We will focus on first principles that can be applied to most models
  - We will discuss adaptations to each data modality as and when required

INTERPRETABILITY LANDSCAPE IN NEURAL NETWORKS





Interpretability

During vs after training

Interpretability by design

Post-hoc interpretability

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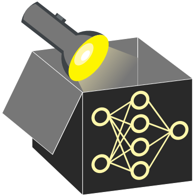

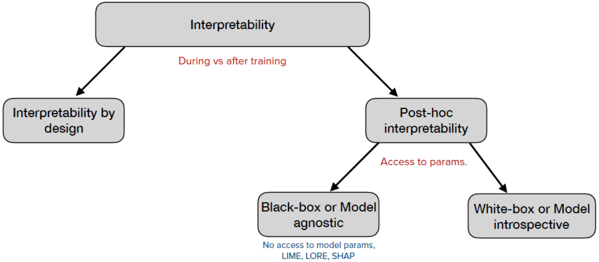

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Access to params.

Black-box or Model agnostic

No access to model params, LIME, LORE, SHAP

White-box or Model introspective

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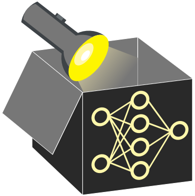

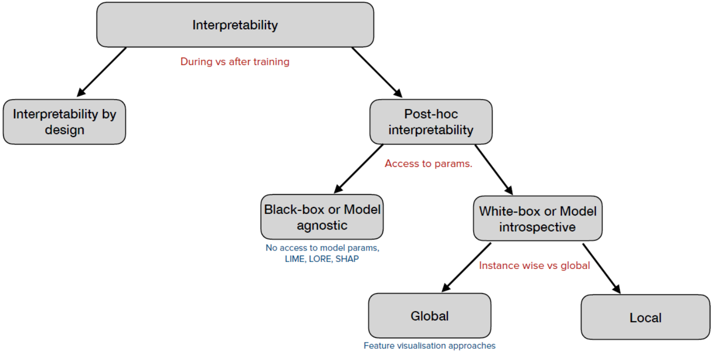

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Global

Feature visualisation approaches

Local

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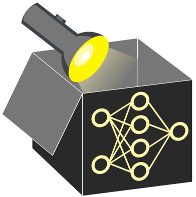

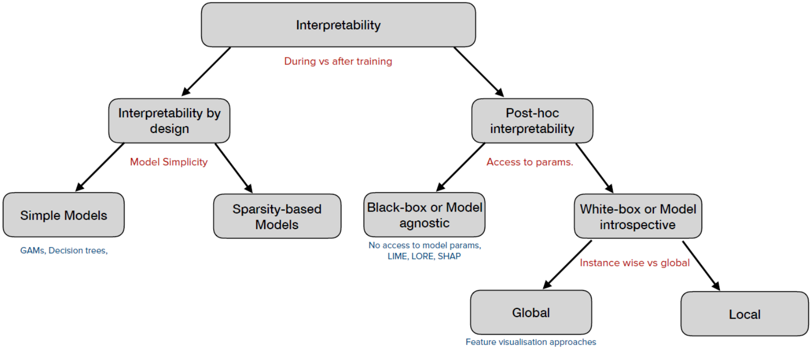

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During vs after training
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Model Simplicity
Access to params.
Simple Models
Sparsity-based Models
Black-box or Model agnostic
White-box or Model introspective
GAMs, Decision trees,
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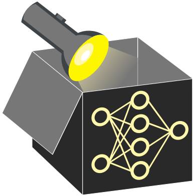

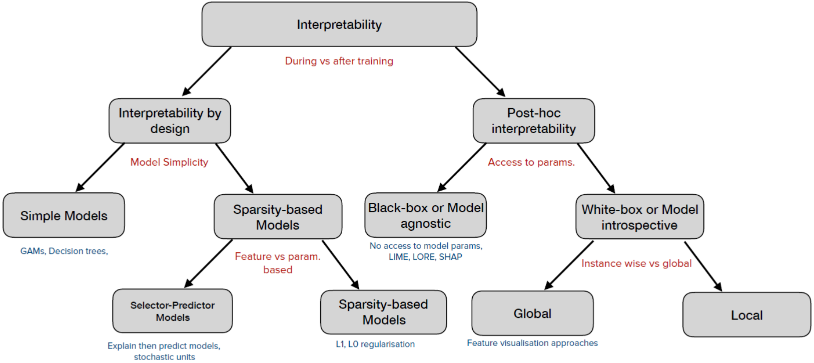

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GAMs, Decision trees,

Feature vs param. based

No access to model params, LIME, LORE, SHAP

Instance wise vs global

Selector-Predictor Models

Sparsity-based Models

Global

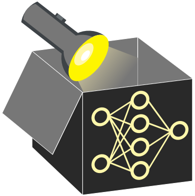
Local

Explain then predict models, stochastic units

L1, L0 regularisation

Feature visualisation approaches

HOW CAN WE INTERPRET NEURAL MODELS ?



- Feature visualization: Visualizing components of the neural networks
  - Activations of neurons
  - Attention values
  - Gradient flow
- Feature attributions: relevant input features
  - Which input features are responsible for the given decision ?
  - Sensitivity analysis using gradient-based methods
  - Using black-box methods like LIME, SHAP, etc.

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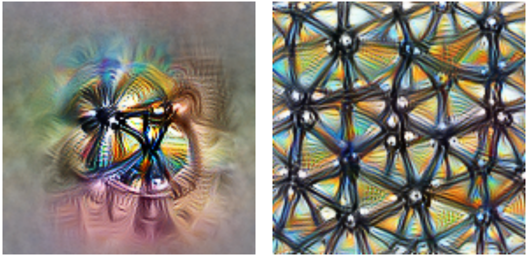

Figure: Feature visualization: Visualizing components of the neural networks

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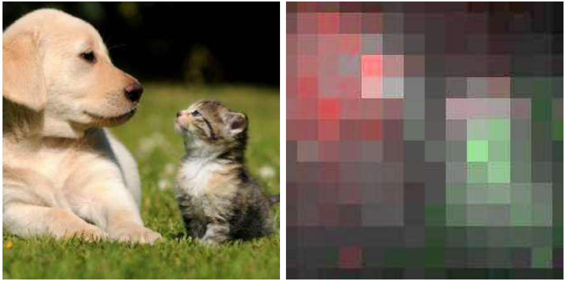

Figure: Feature attributions: relevant input features