Deep Active Learning using Monte Carlo Dropout

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Introduction

Motivation

- Deep Learning is a growing field with state-of-the-art results in several areas.

- Image Classification, Machine Translation

However...

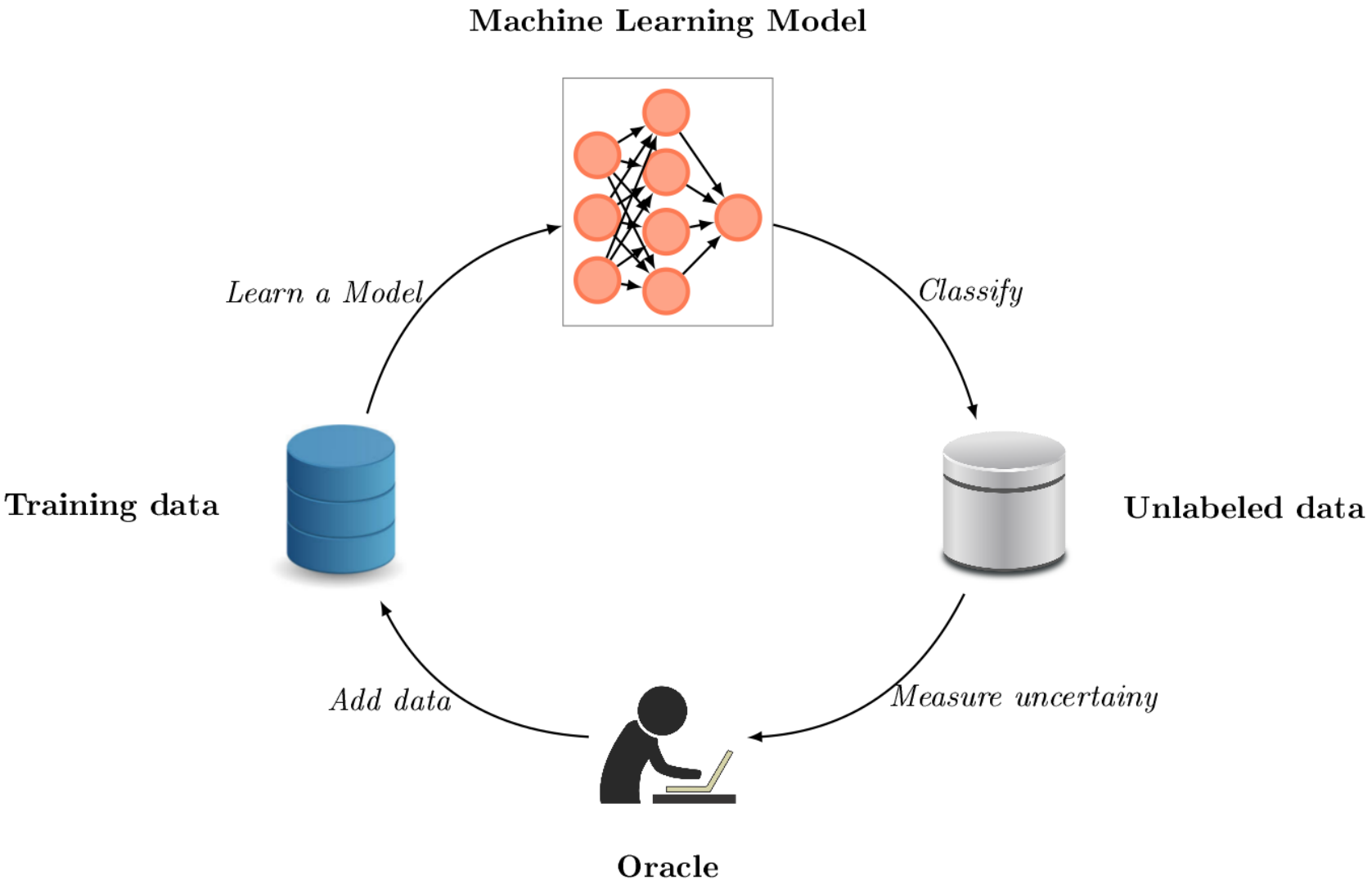
- Training Deep Learning models require a huge amount of labeled data
- For the task of image classification on the ImageNet database, 1.2 million labeled images were used [1]
- This restriction causes huge difficulties on applying Deep Learning techniques to a wide range of problems, such as Sentiment Analysis

Sentiment Analysis

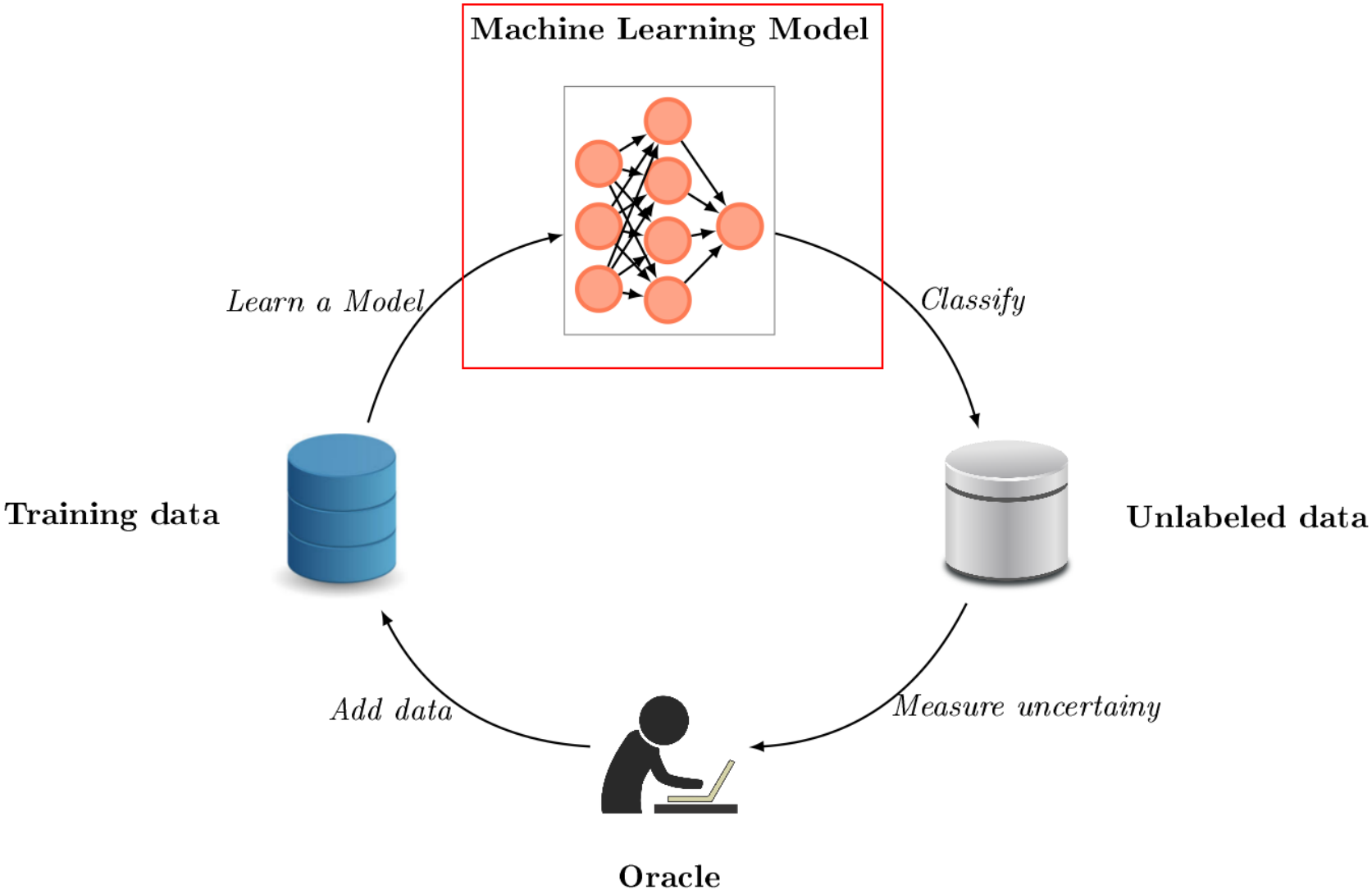
- Verify if a text is expressing negative or positive feelings.
- Huge amount of data, but few labeled.

Active Learning

Active Learning



Active Learning



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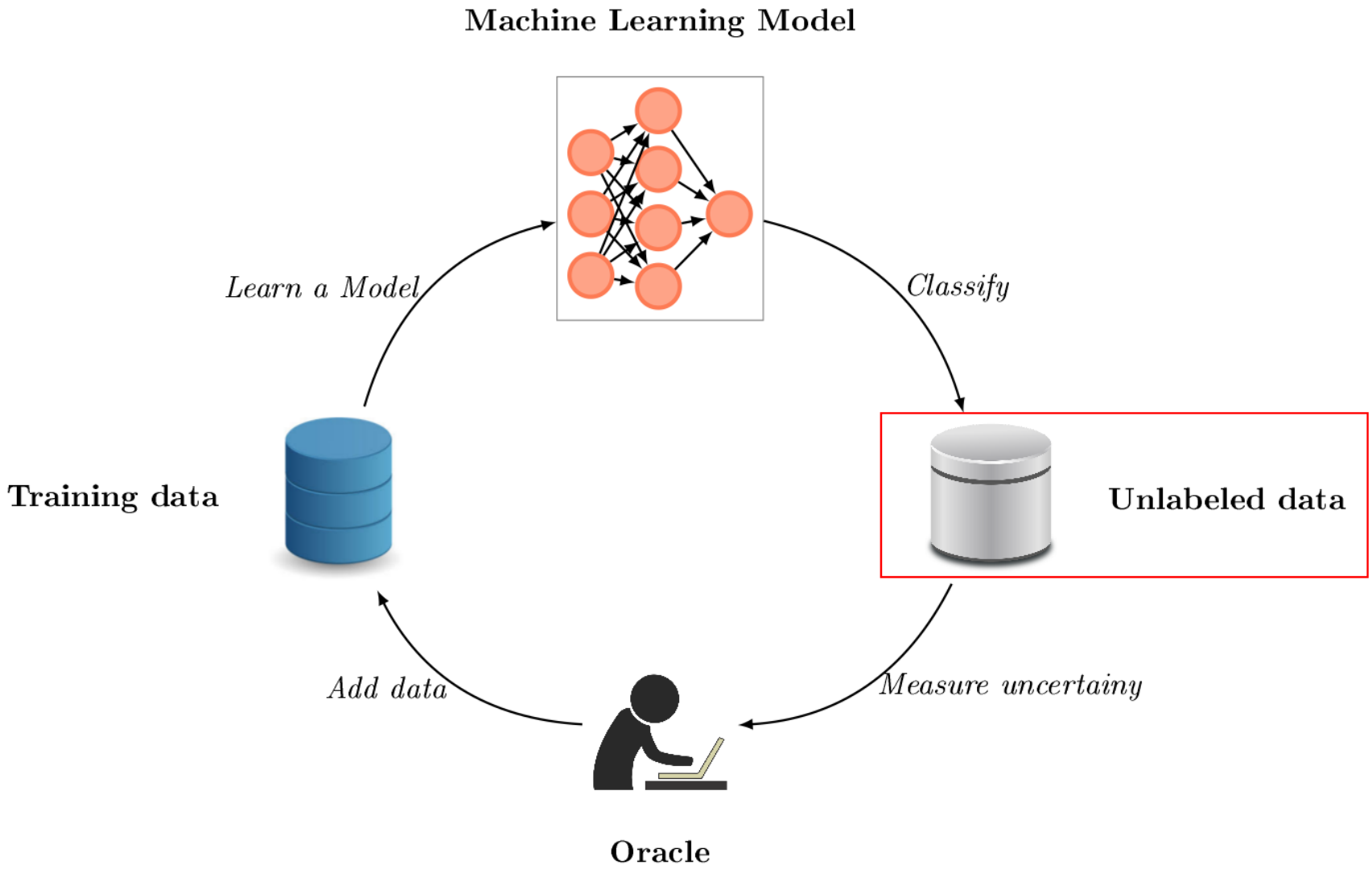

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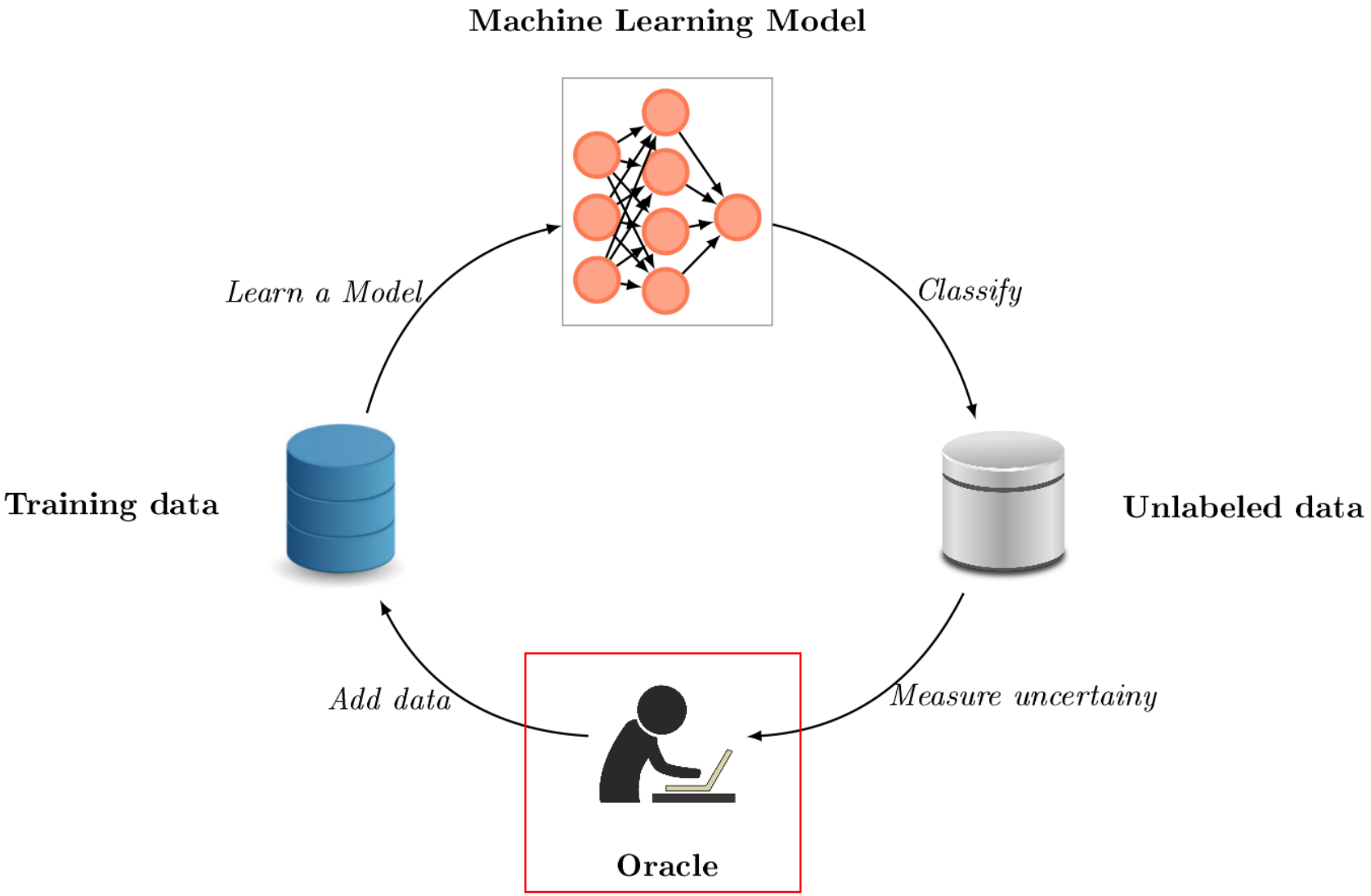

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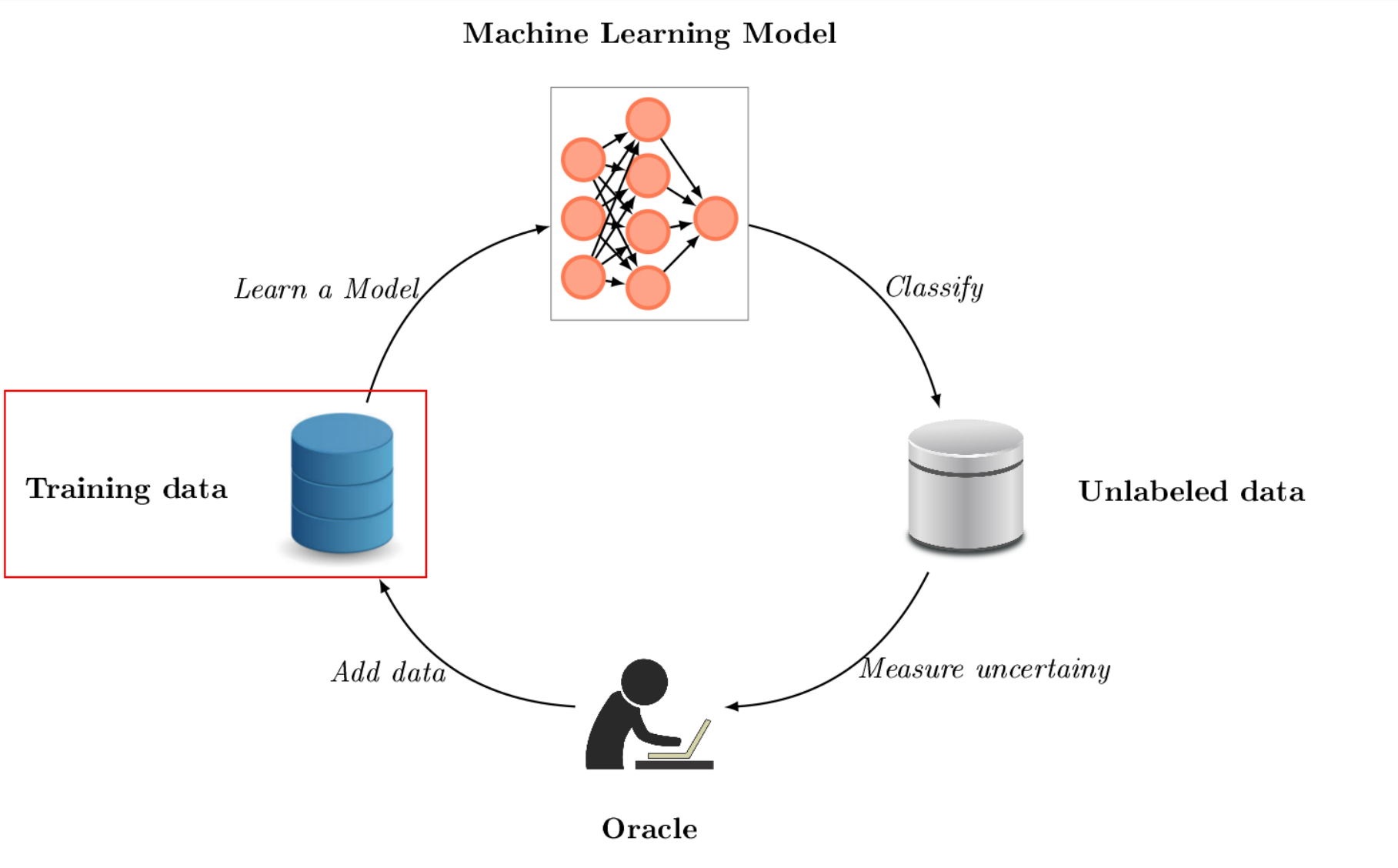

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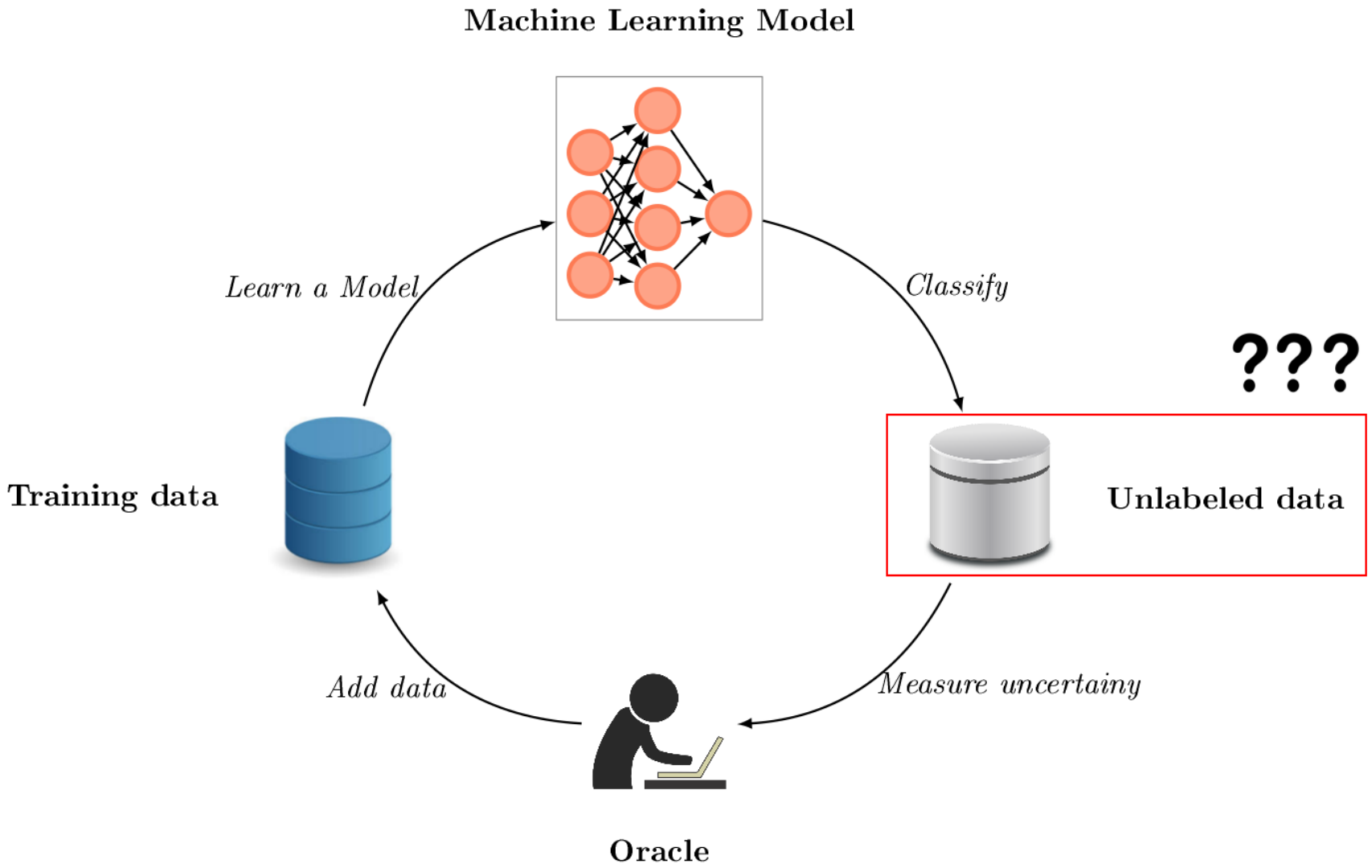
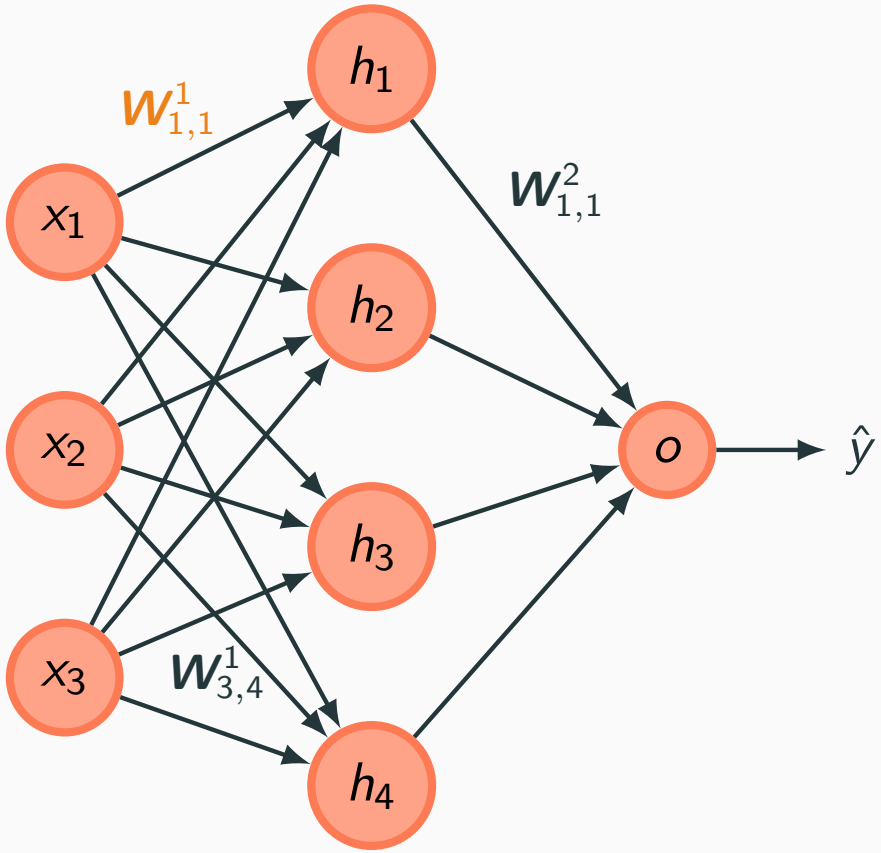


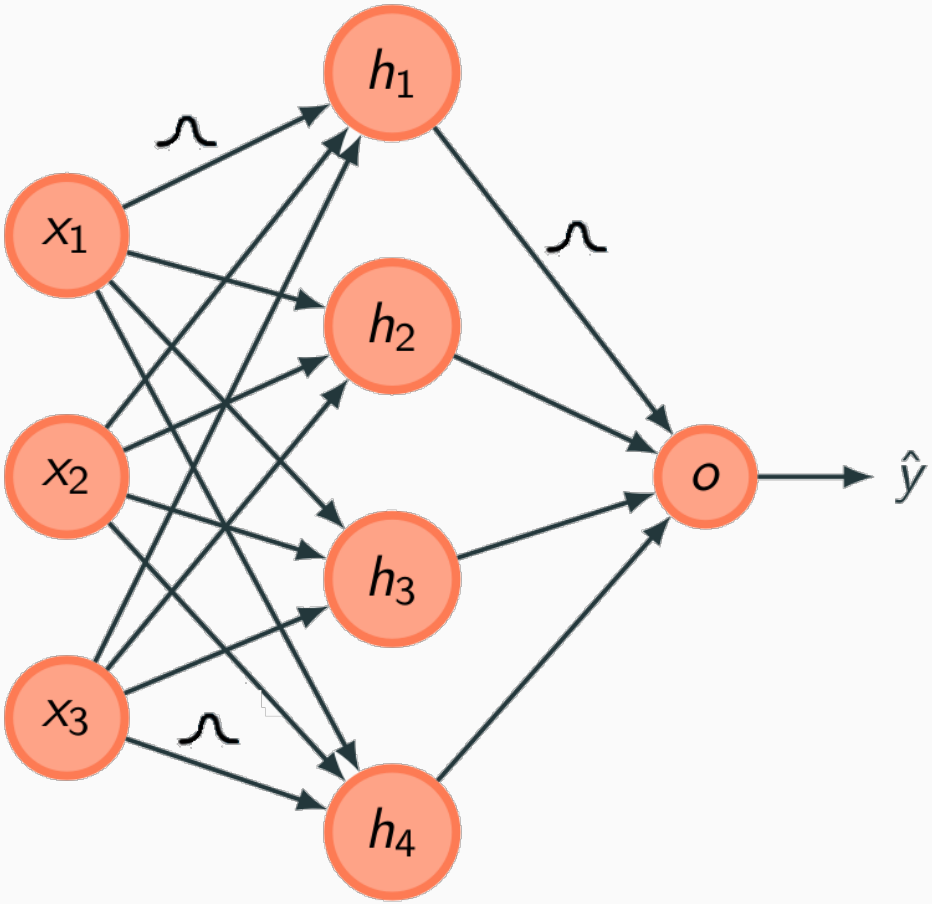
Uncertainty measurement

- To select informative samples, it is necessary to measure the uncertainty of the model prediction.

Neural Network



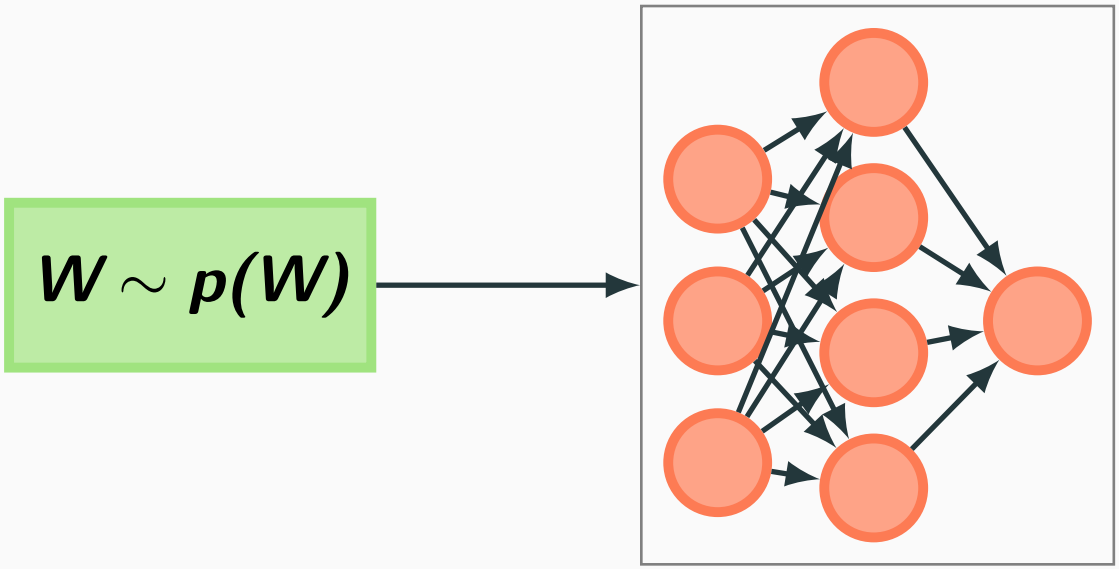
Bayesian Neural Network



Bayesian Neural Network

$$W \sim p(W)$$

Bayesian Neural Network



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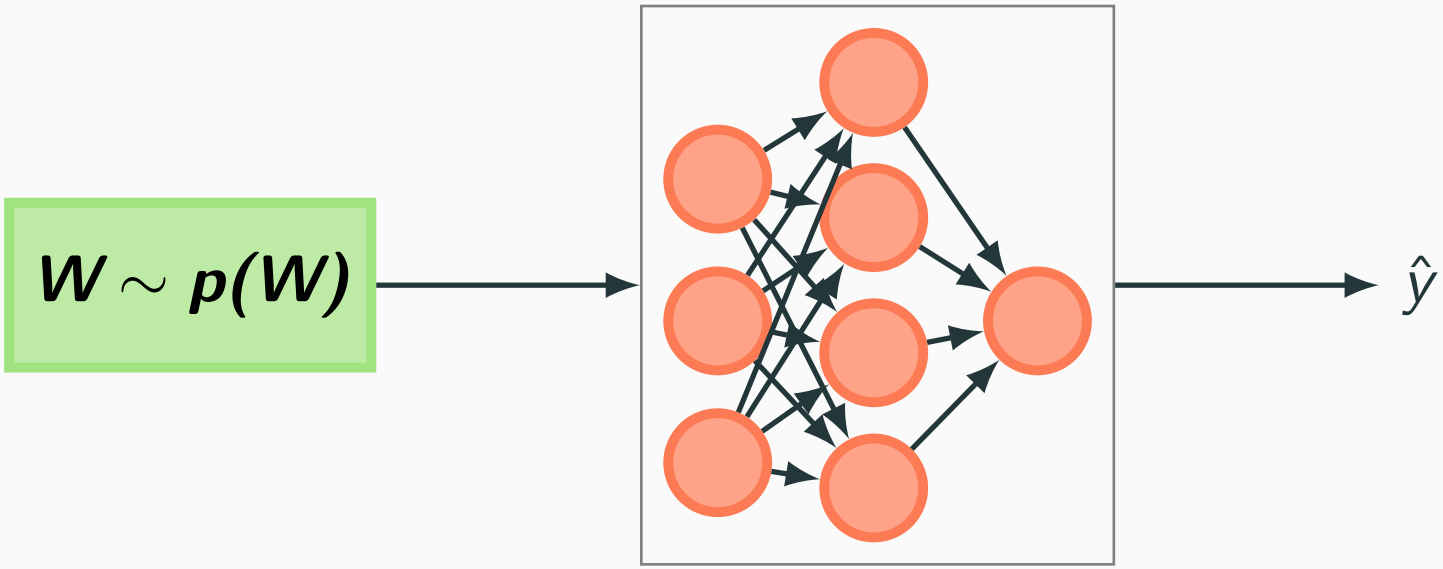
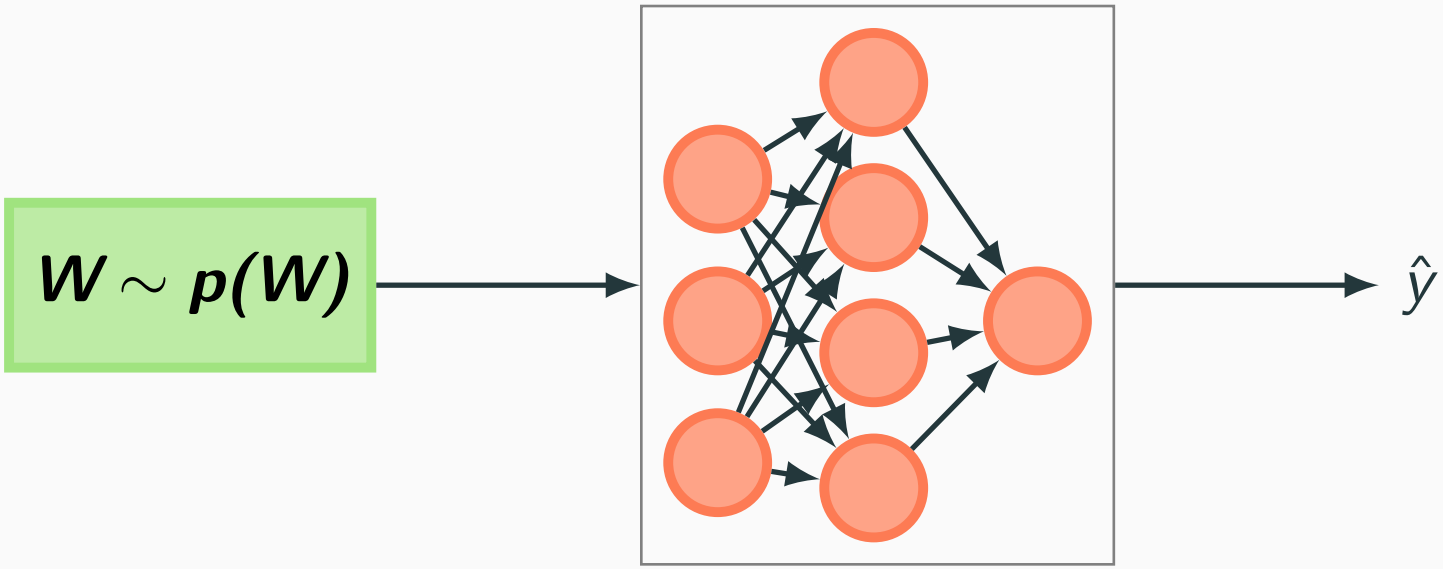
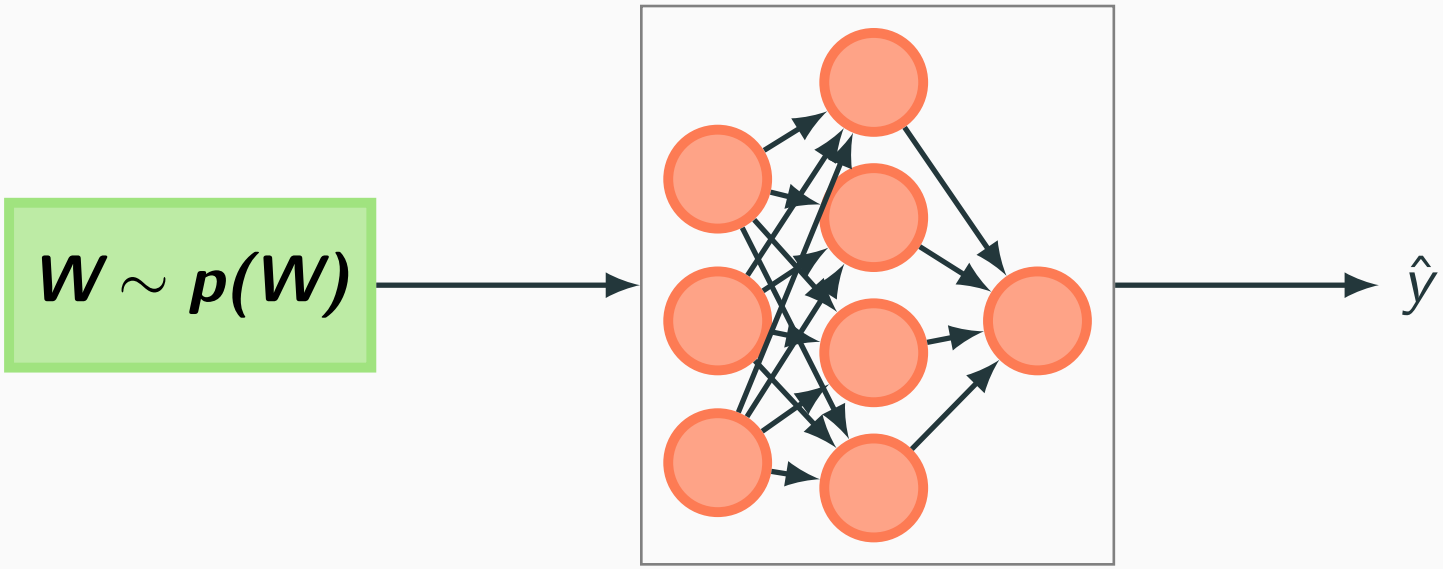


Bayesian Neural Network



Get T Classifications

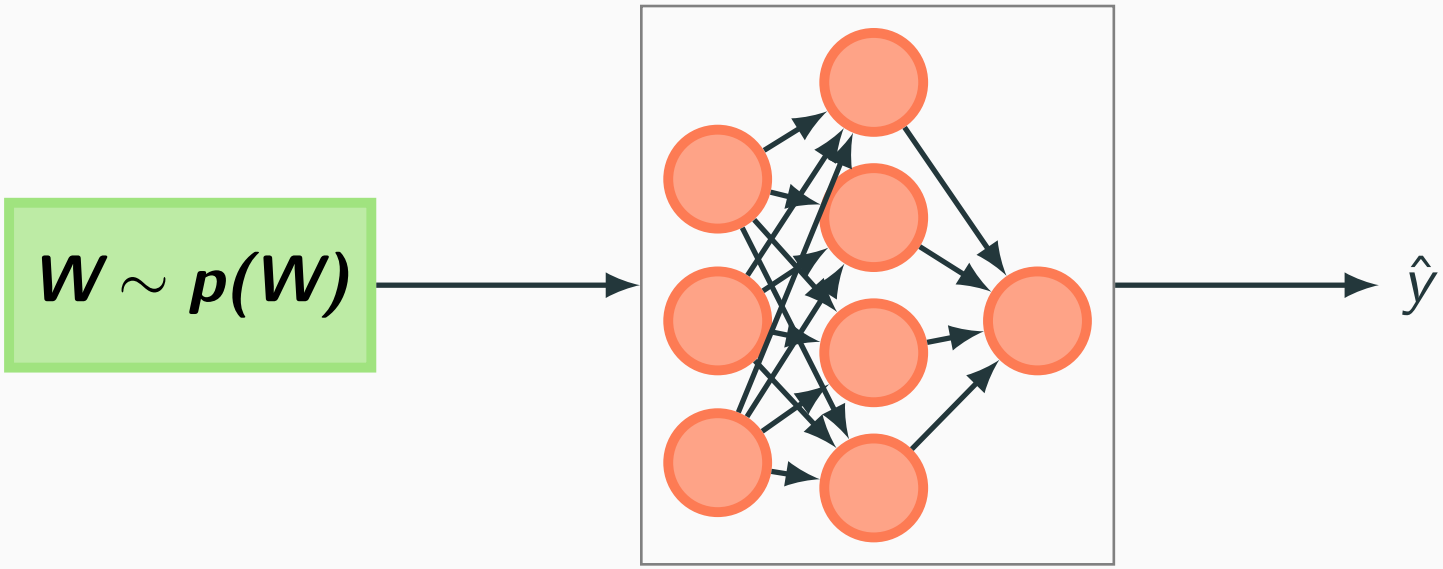
Bayesian Neural Network



Get T Classifications

$$Classifications = \begin{bmatrix} \hat{y}_1 \end{bmatrix}$$

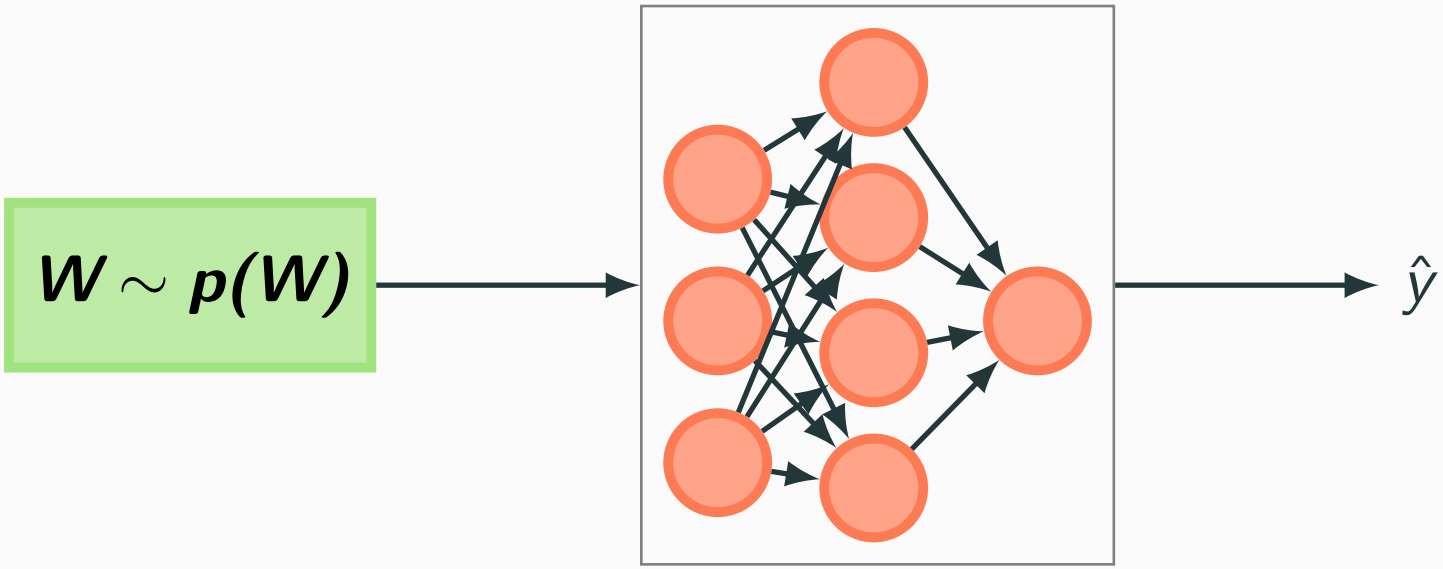
Bayesian Neural Network



Get T Classifications

$$Classifications = \begin{bmatrix} \hat{y}_1 & \hat{y}_2 \end{bmatrix}$$

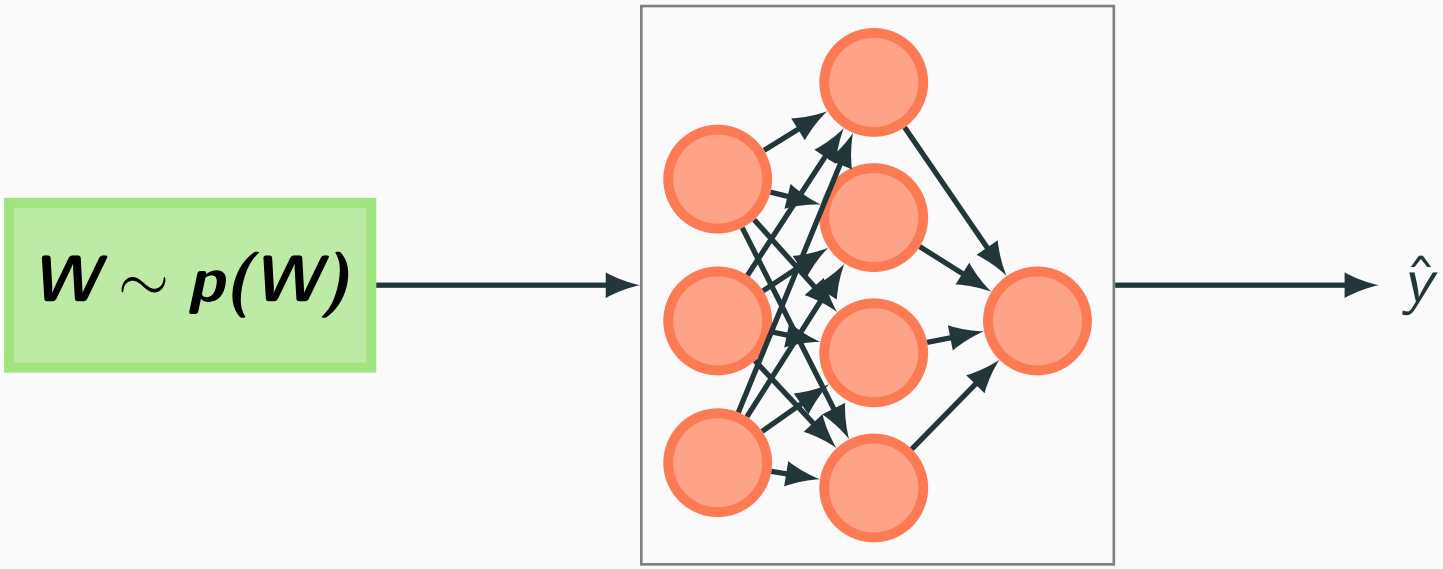
Bayesian Neural Network



Get T Classifications

$$Classifications = \begin{bmatrix} \hat{y}_1 & \hat{y}_2 & \hat{y}_3 \end{bmatrix}$$

Bayesian Neural Network



Get T Classifications

$$Classifications = \begin{bmatrix} \hat{y}_1 & \hat{y}_2 & \hat{y}_3 & \dots & \hat{y}_T \end{bmatrix}$$

Bayesian Neural Network

- Training Bayesian networks is a costly process
- Use techniques such as Variational Inference and Monte Carlo Estimation

Bayesian Neural Network

- What if we could extract uncertainty measurements from current Deep Learning models if they use stochastic regularization techniques such as Dropout ?

- Uncertainty in Deep Learning (Yarin Gal, 2017)

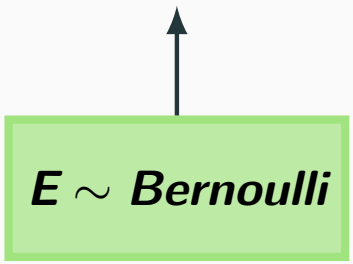
Dropout

Monte Carlo Dropout

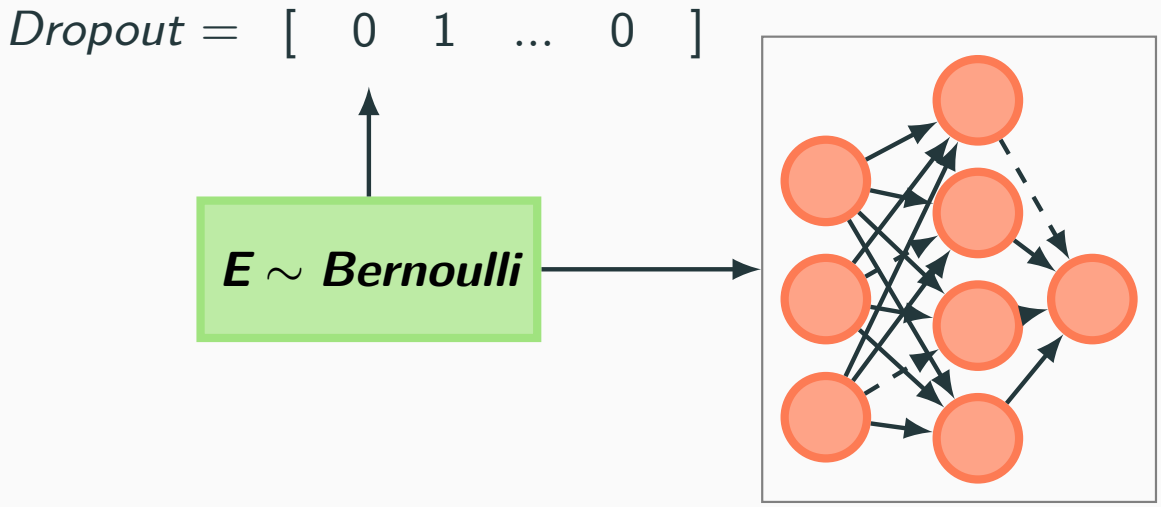
$$E \sim Bernoulli$$

Monte Carlo Dropout

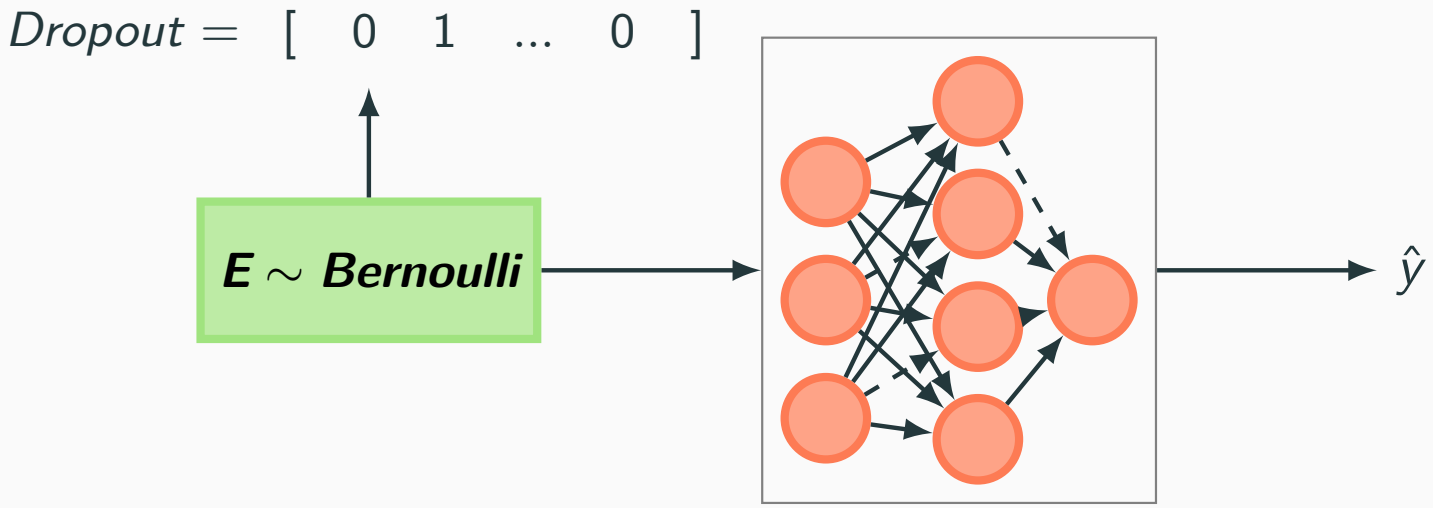
$$Dropout = [\quad 0 \quad 1 \quad \ldots \quad 0 \quad]$$



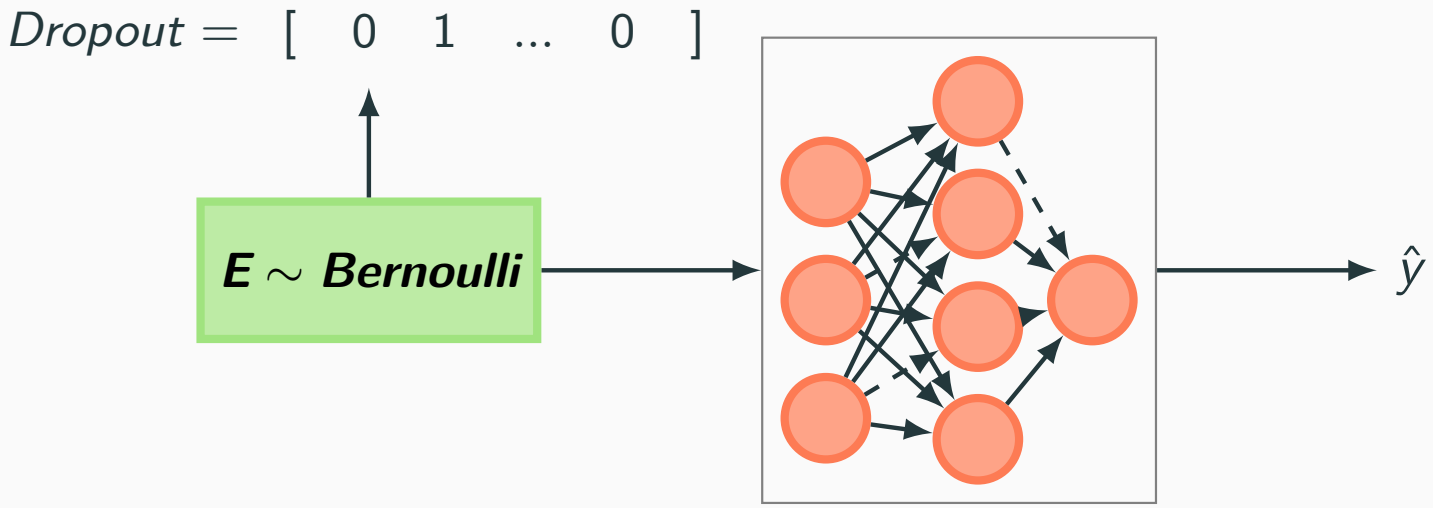
Monte Carlo Dropout



Monte Carlo Dropout

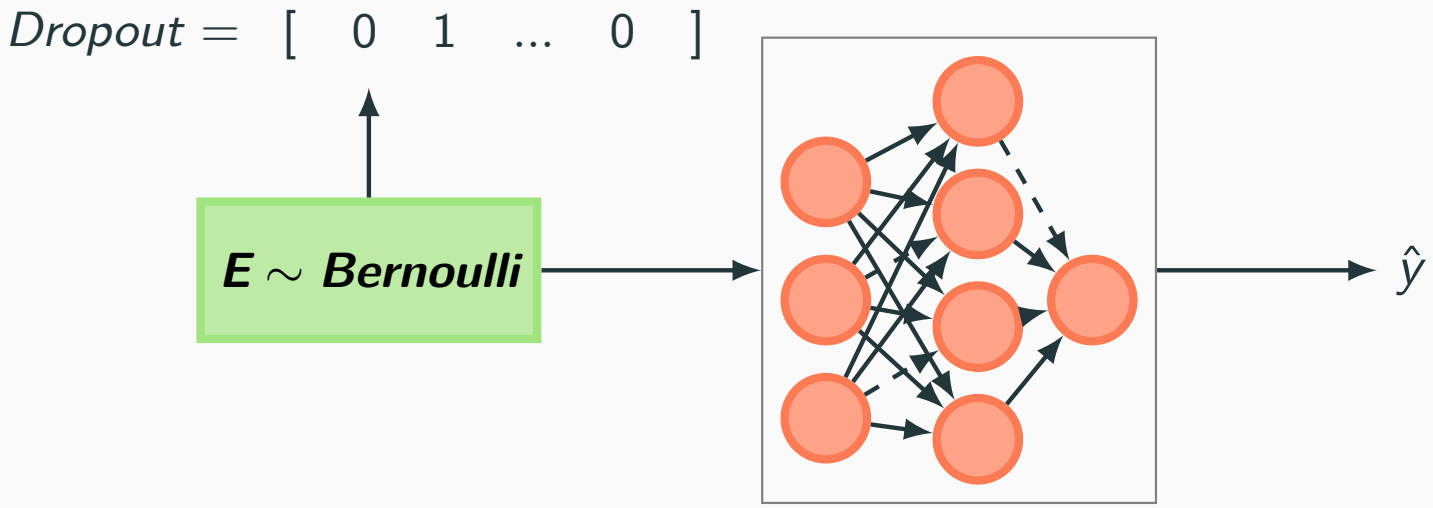


Monte Carlo Dropout



Get T Classifications

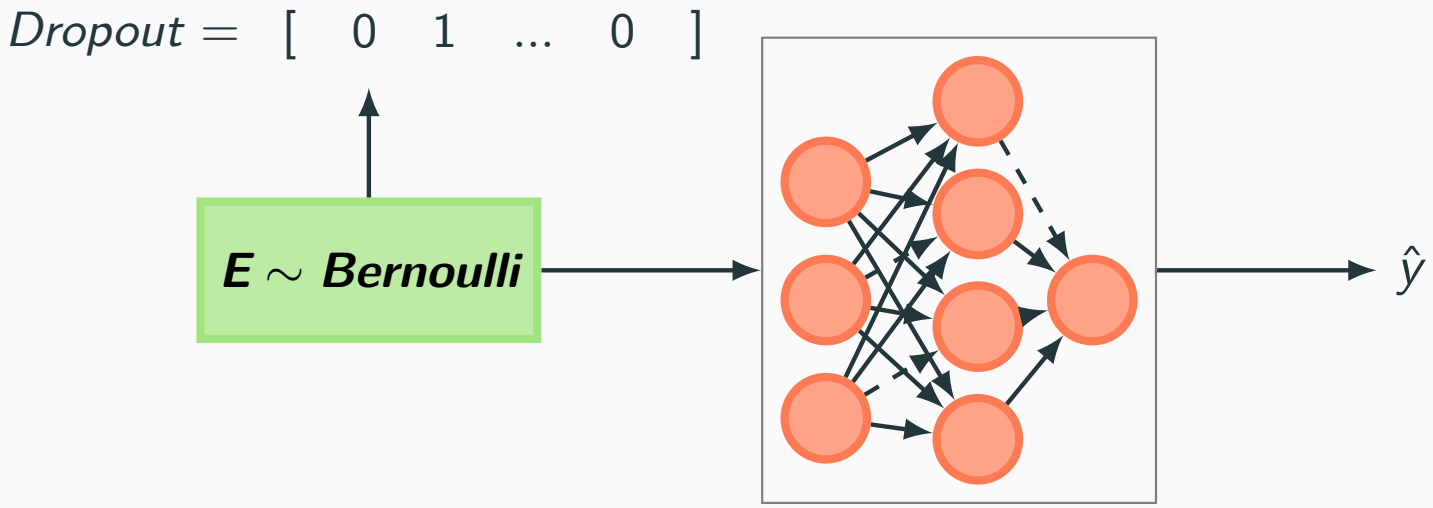
Monte Carlo Dropout



Get T Classifications

$Classifications = [\ \hat{y}_1\ ]$

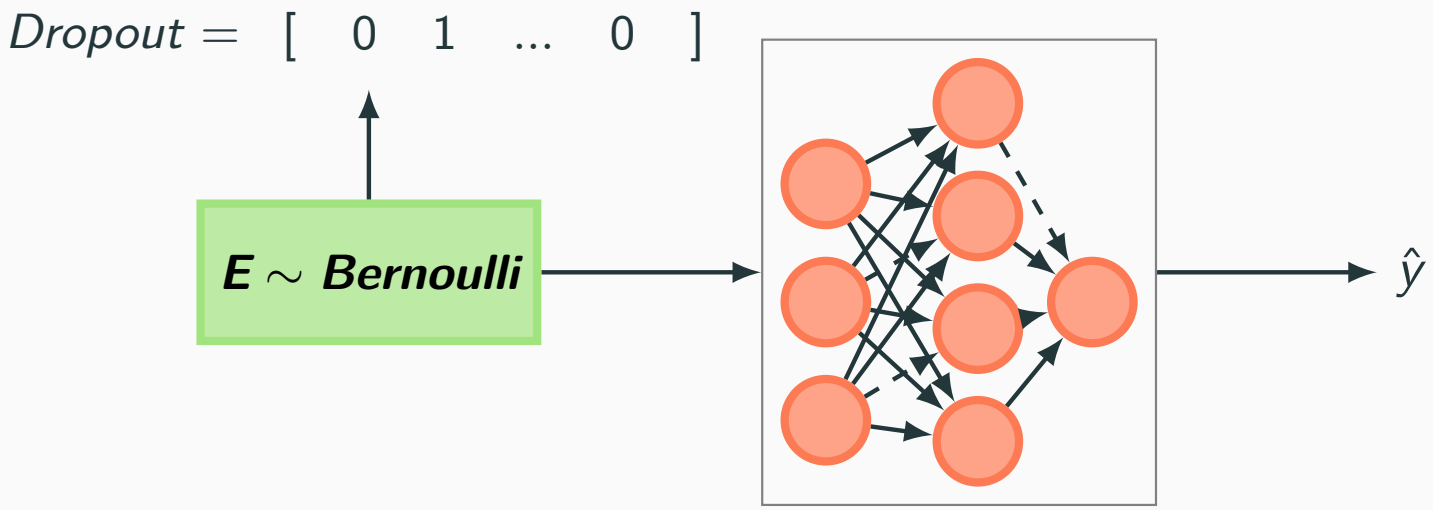
Monte Carlo Dropout



Get T Classifications

$$Classifications = [\ \hat{y}_1 \quad \hat{y}_2\ ]$$

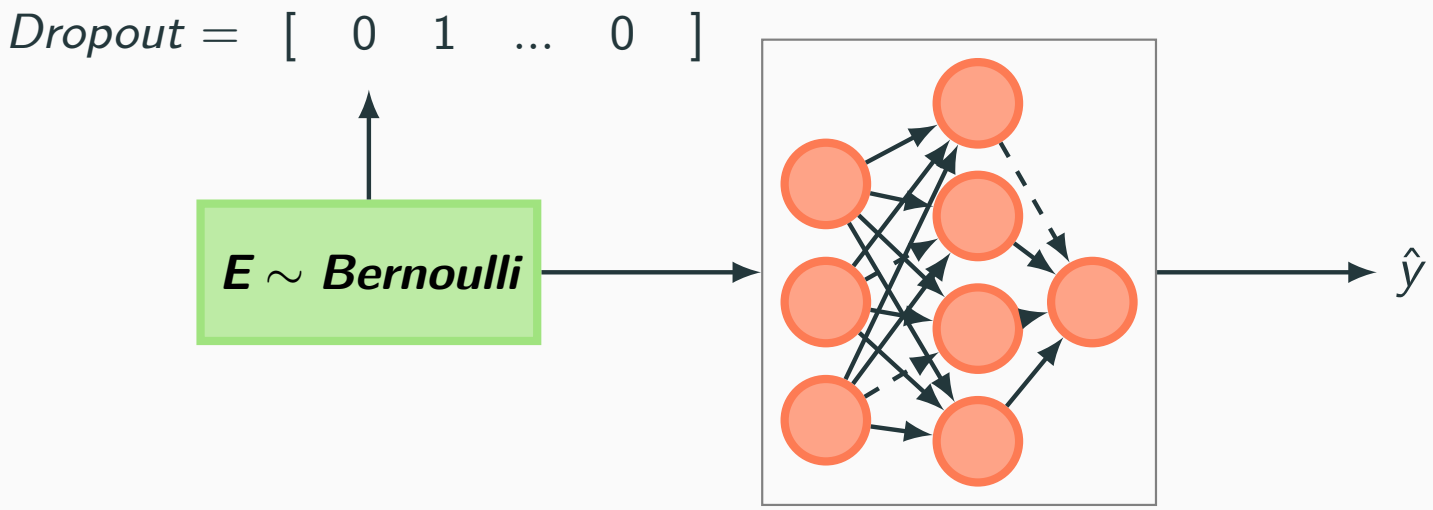
Monte Carlo Dropout



Get T Classifications

$$Classifications = [\ \hat{y}_1 \quad \hat{y}_2 \quad \hat{y}_3\ ]$$

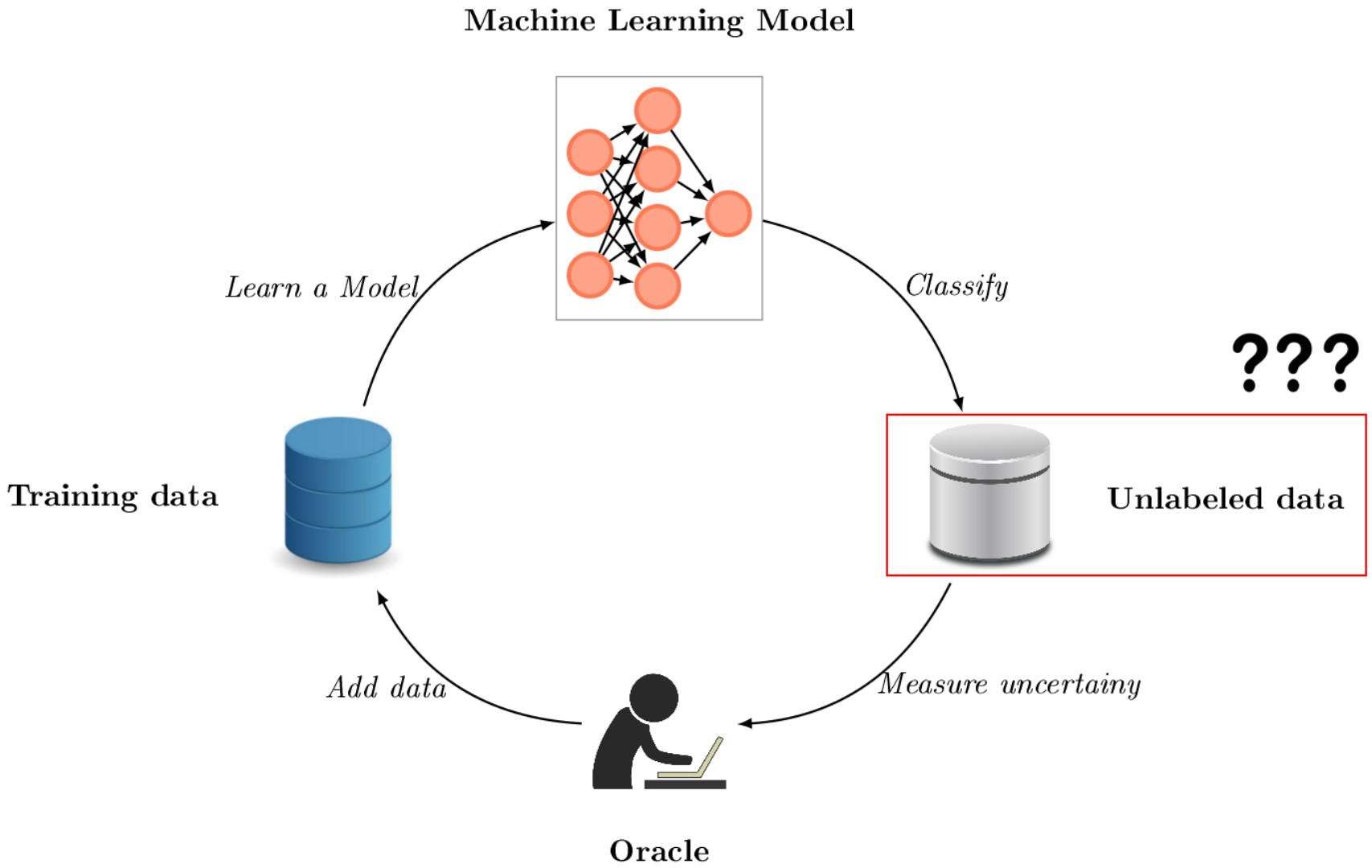
Monte Carlo Dropout



Get T Classifications

$$Classifications = [\ \hat{y}_1 \quad \hat{y}_2 \quad \hat{y}_3 \quad \dots \quad \hat{y}_T\ ]$$

Active Learning



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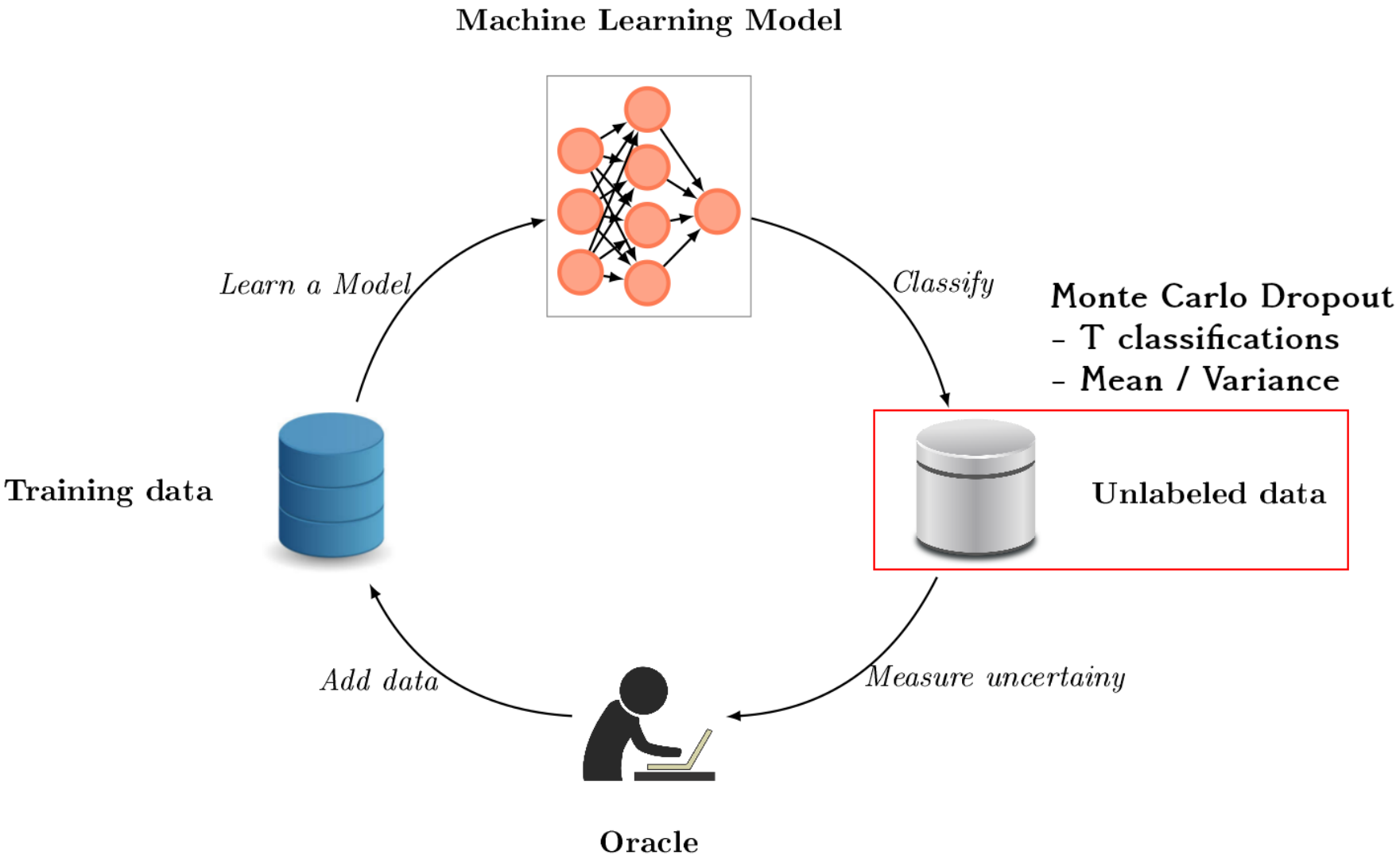


Experimental Design

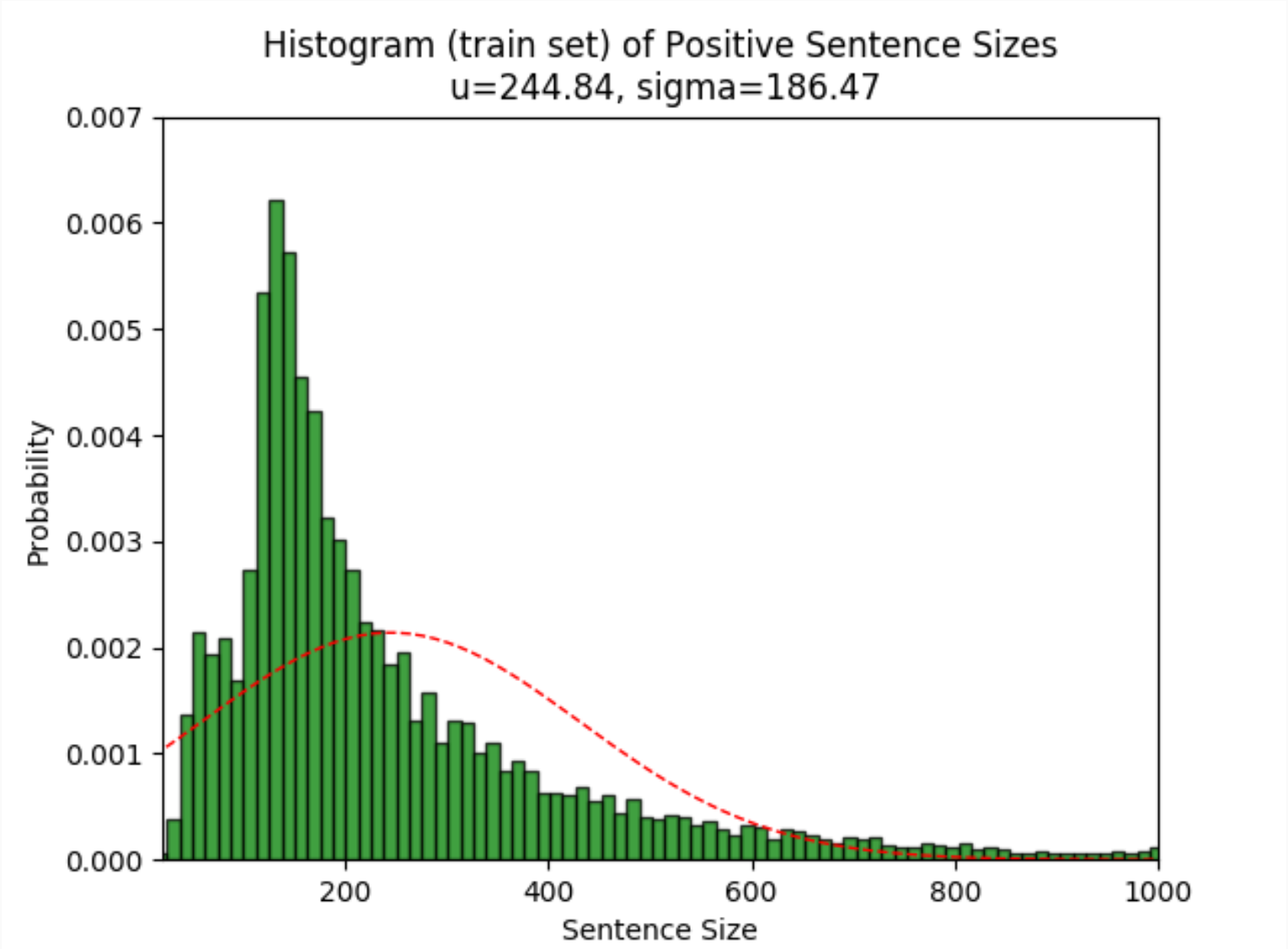
Objective

- Combine Monte Carlo Dropout with Active Learning for the task of Sentiment Analysis and answer the folling research questions:
  - Q1: On the task of sentiment analysis, can we achieve the same accuracy of a standard Deep Learning model by using Active Learning with uncertainty measurements, but with fewer labeled data ?
  - Q2: Does modelling uncertainty in a Deep Learning model helps achieving a better result when using Active Learning ?

Dataset

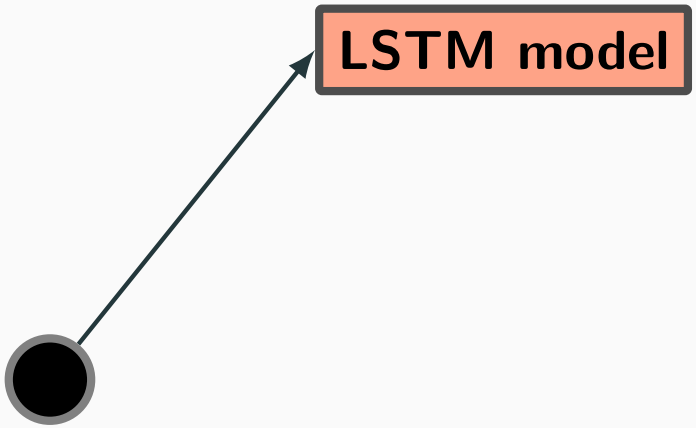
- Large Movie Review Dataset
- 25000 train reviews and 25000 test reviews
- Both train and test datasets have an equal number of positive and negative reviews

Dataset


Histogram (train set) of Positive Sentence Sizes
u=244.84, sigma=186.47
Probability
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
200
400
600
800
1000
Sentence Size

Experimental Design

Experimental Design



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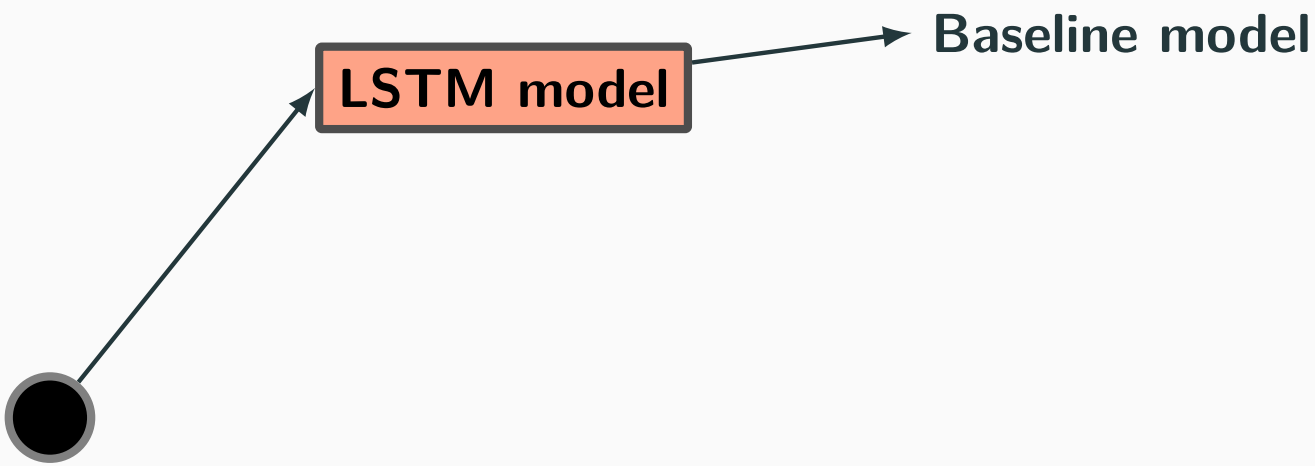

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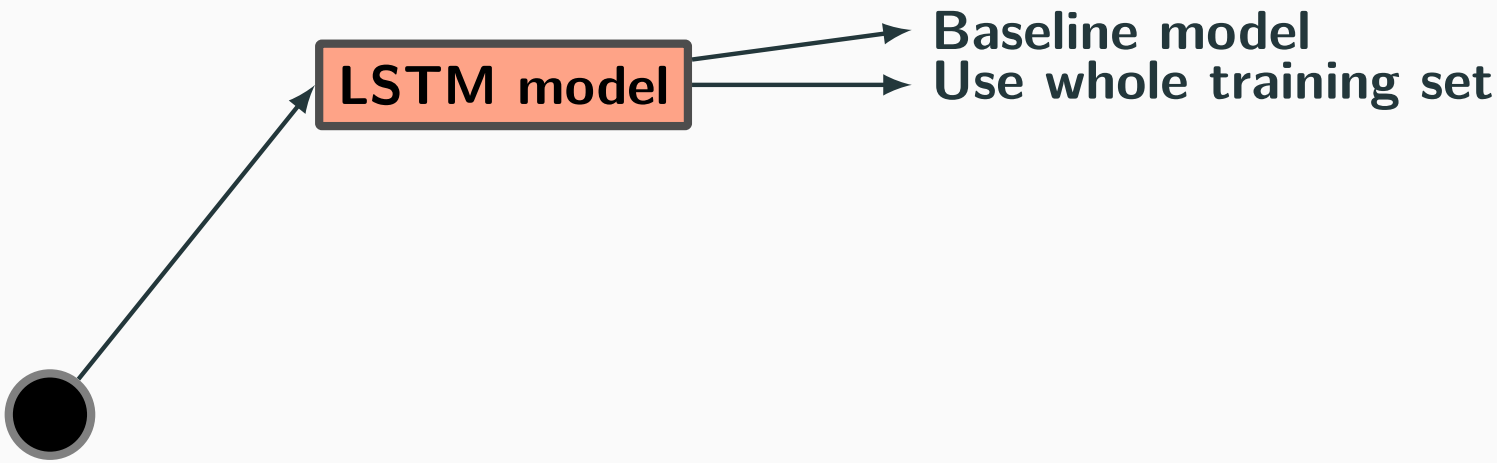

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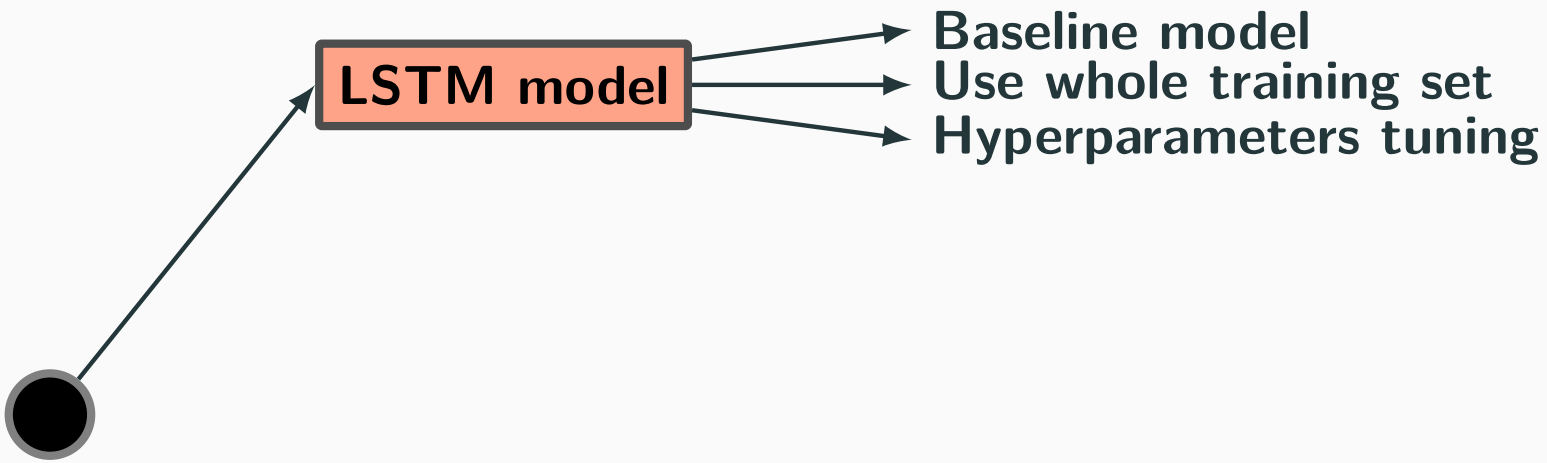

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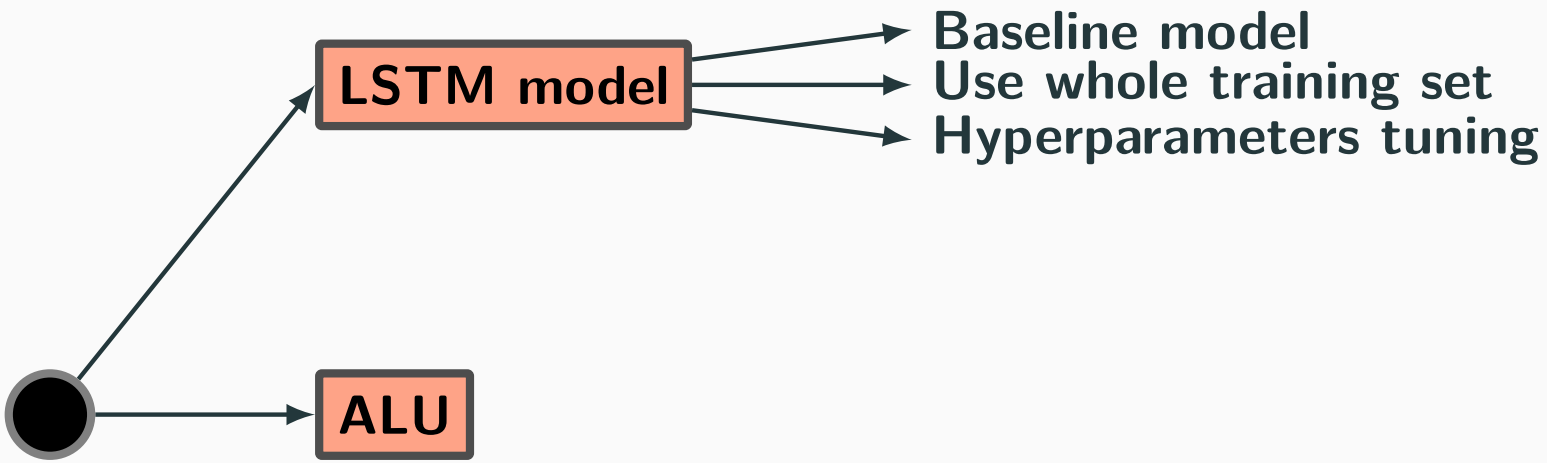

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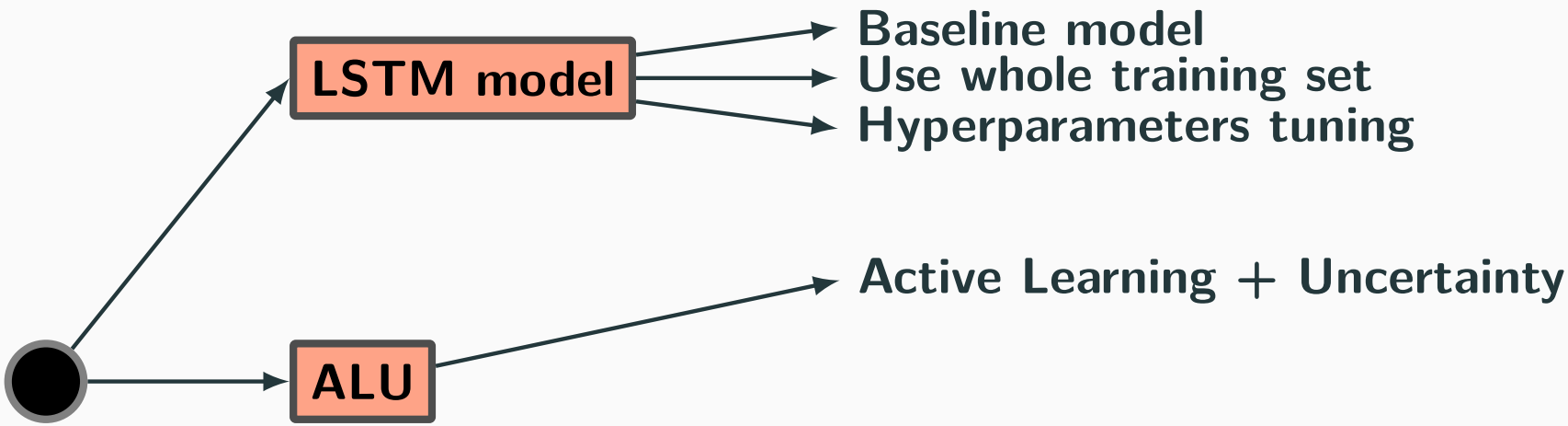

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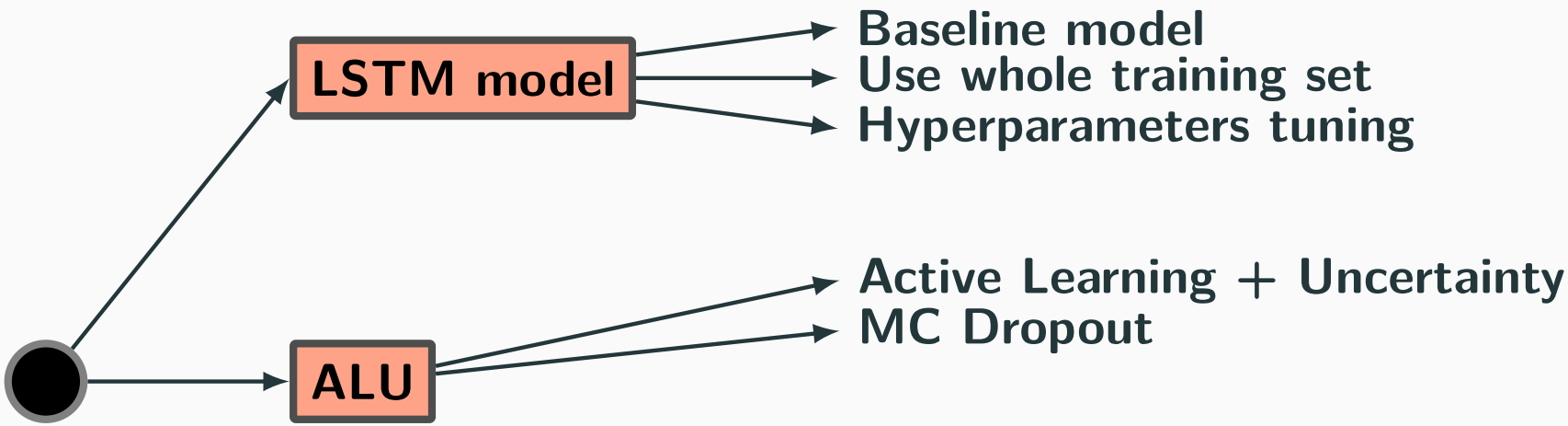

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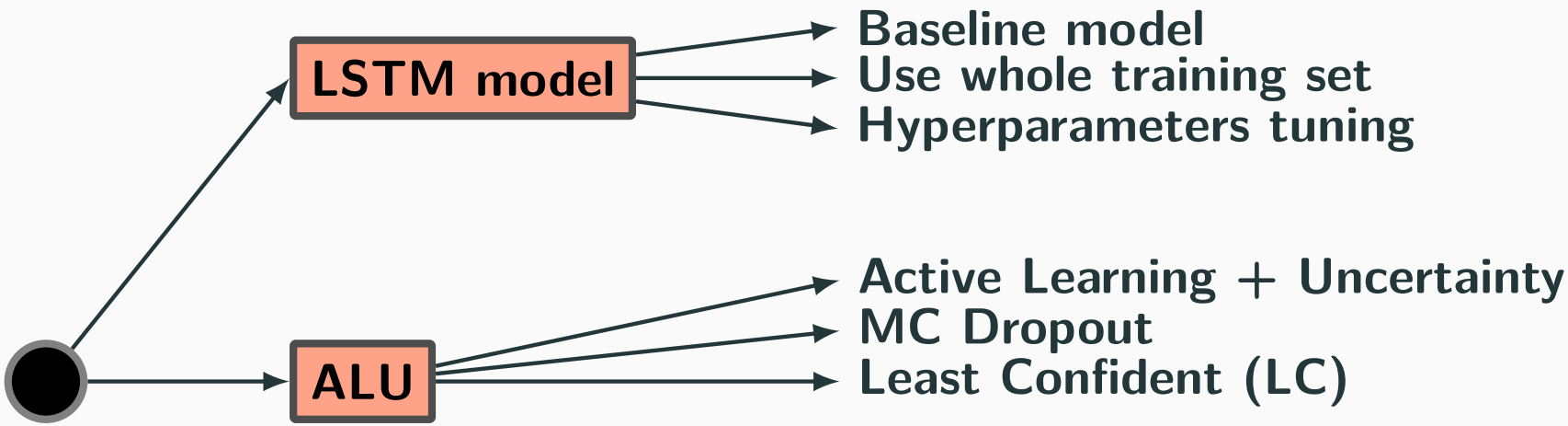

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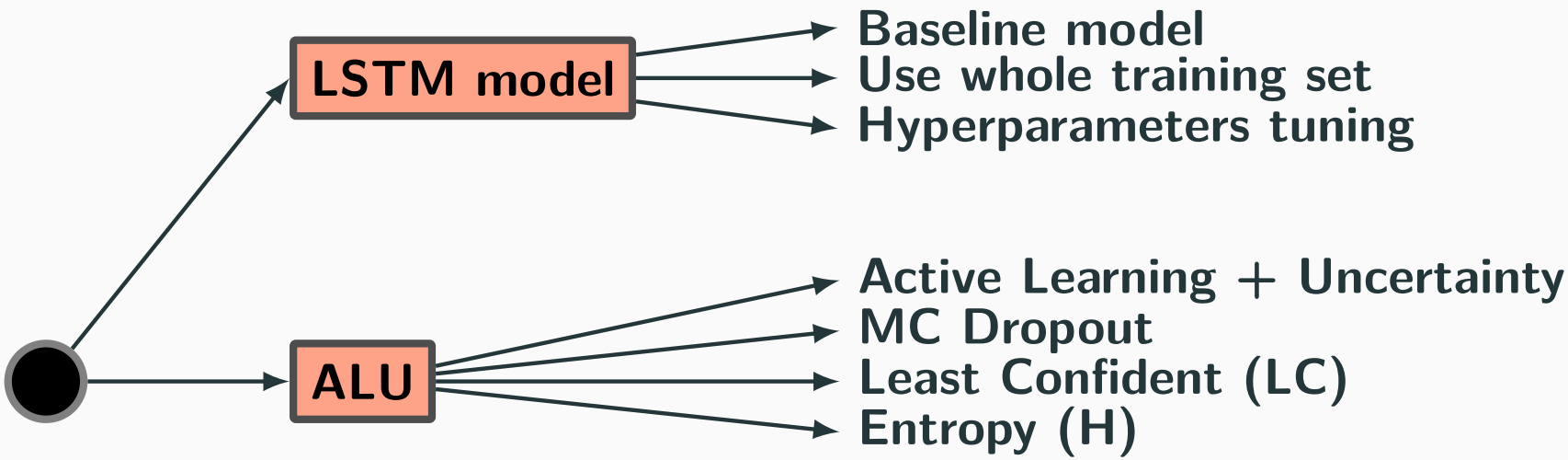

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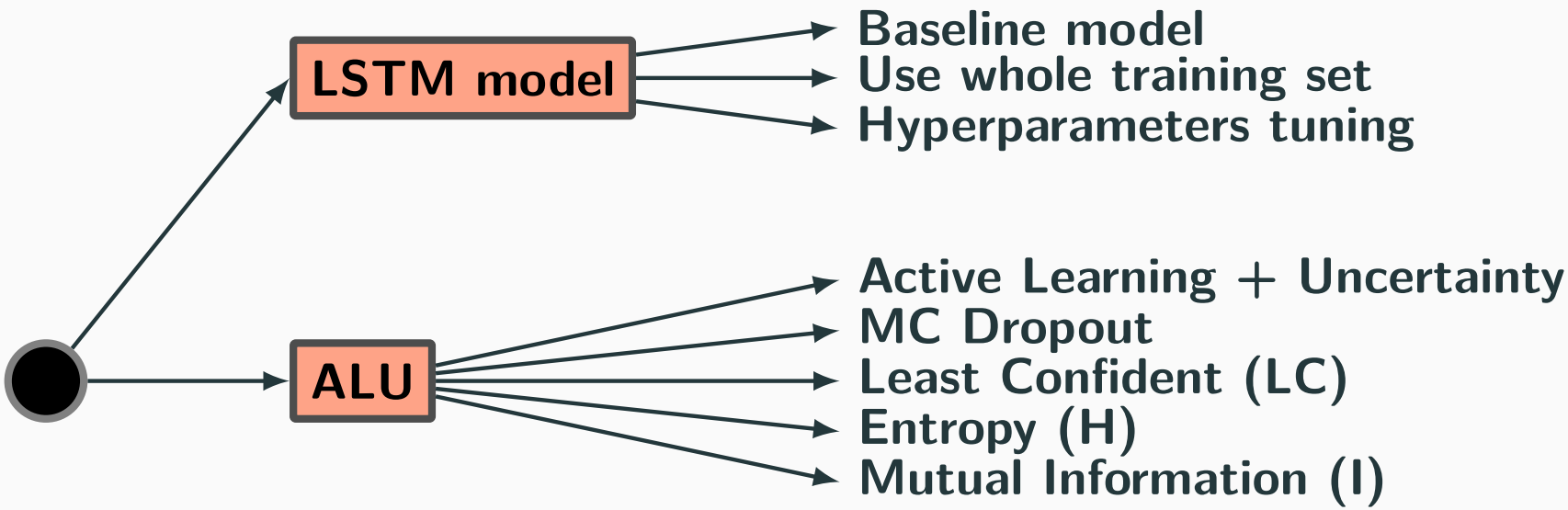

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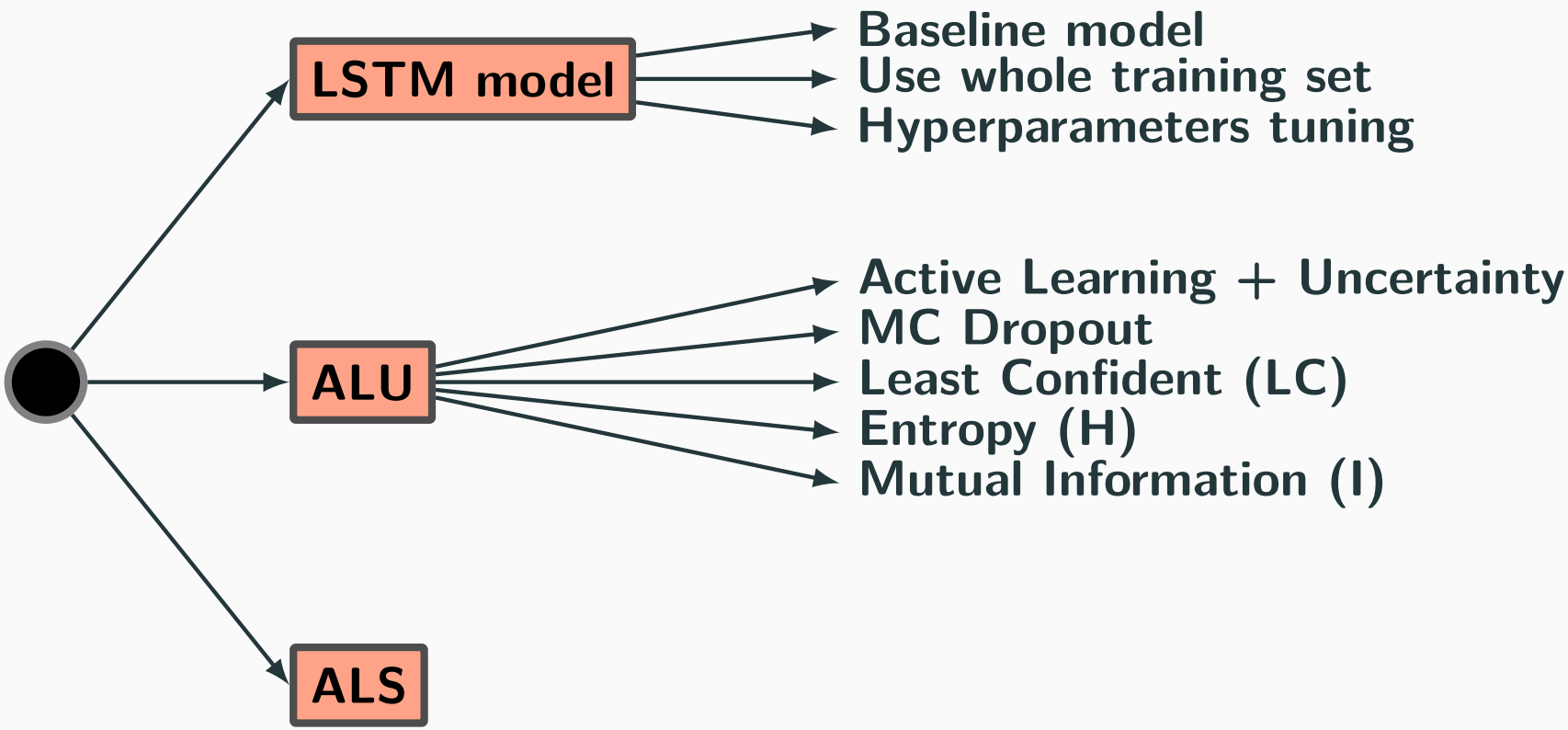

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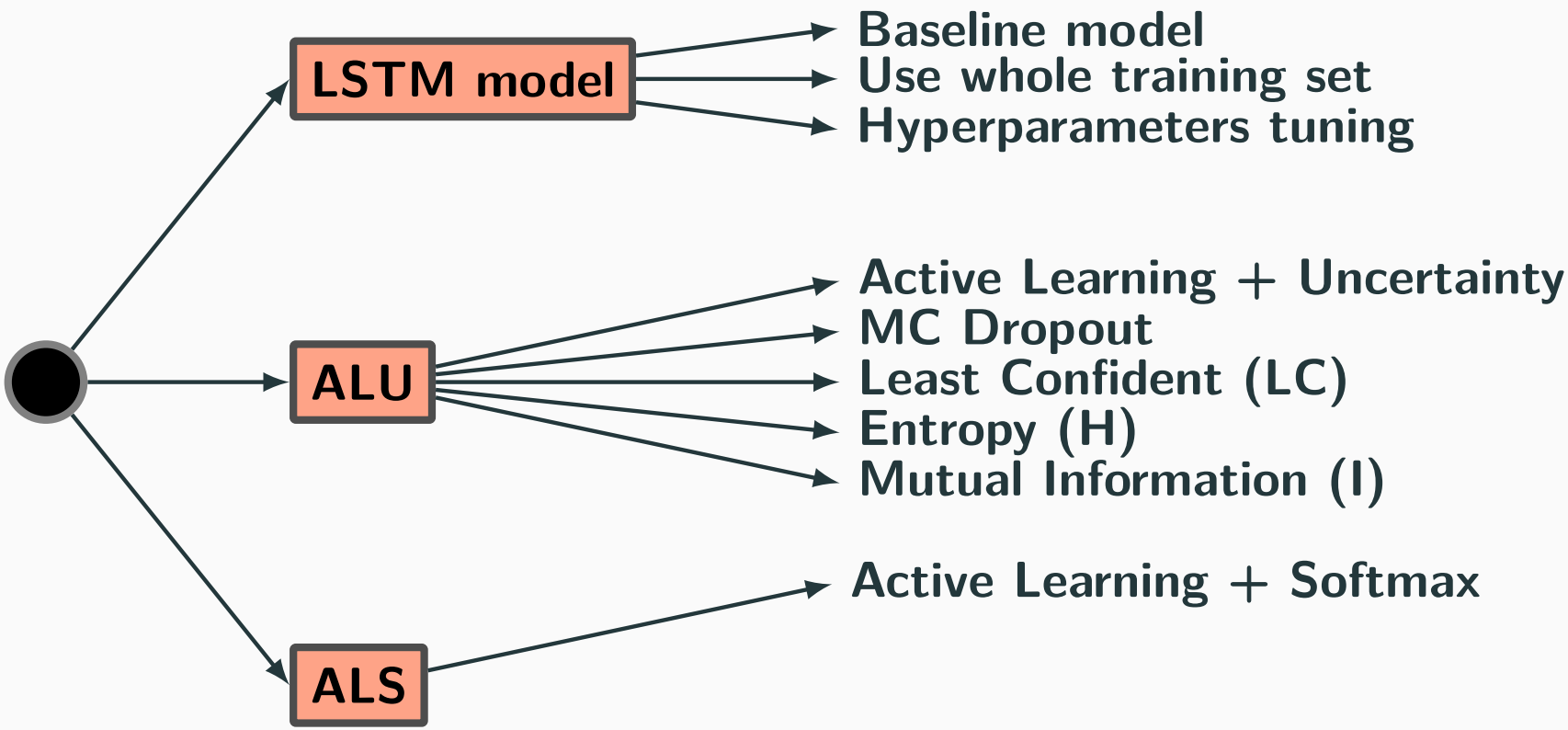

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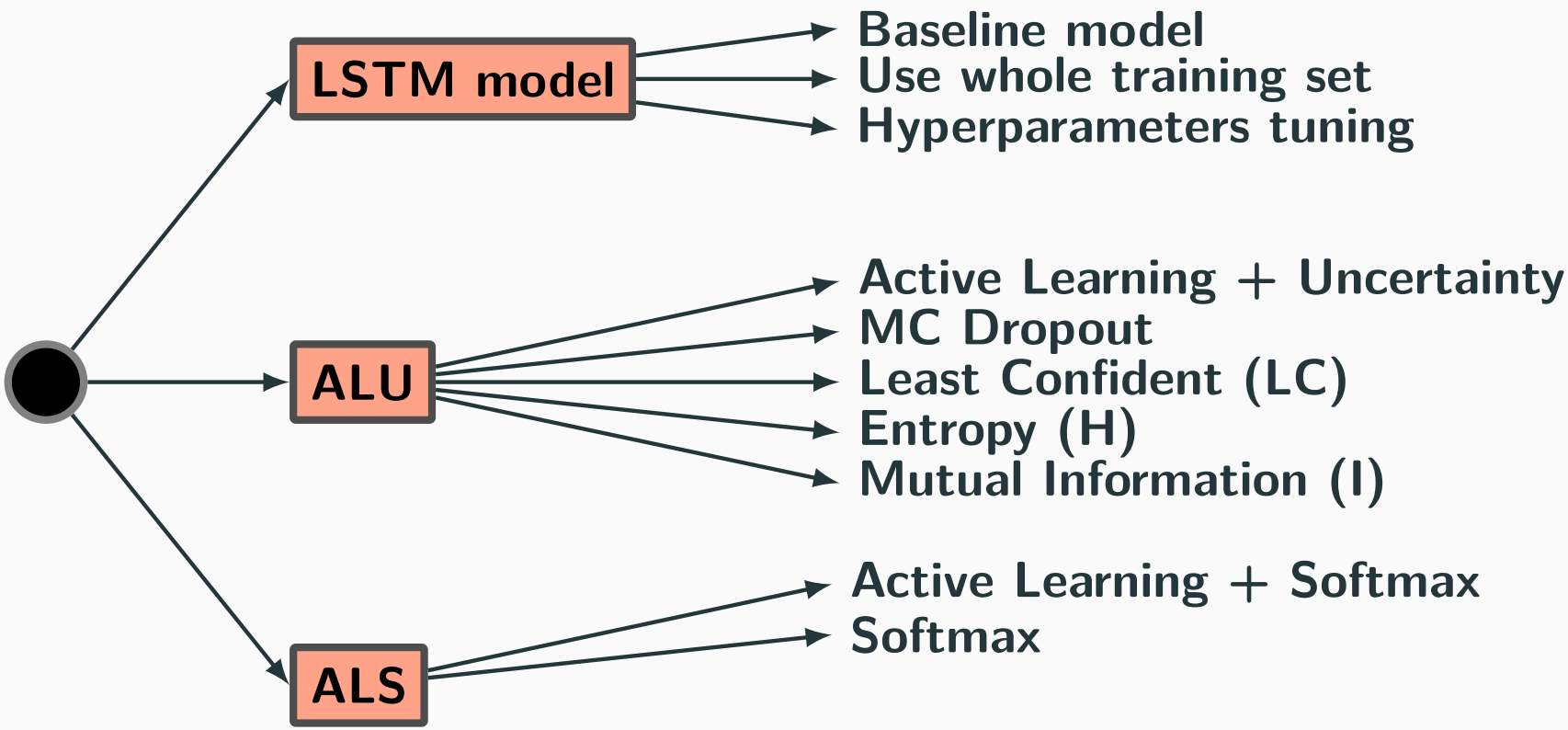

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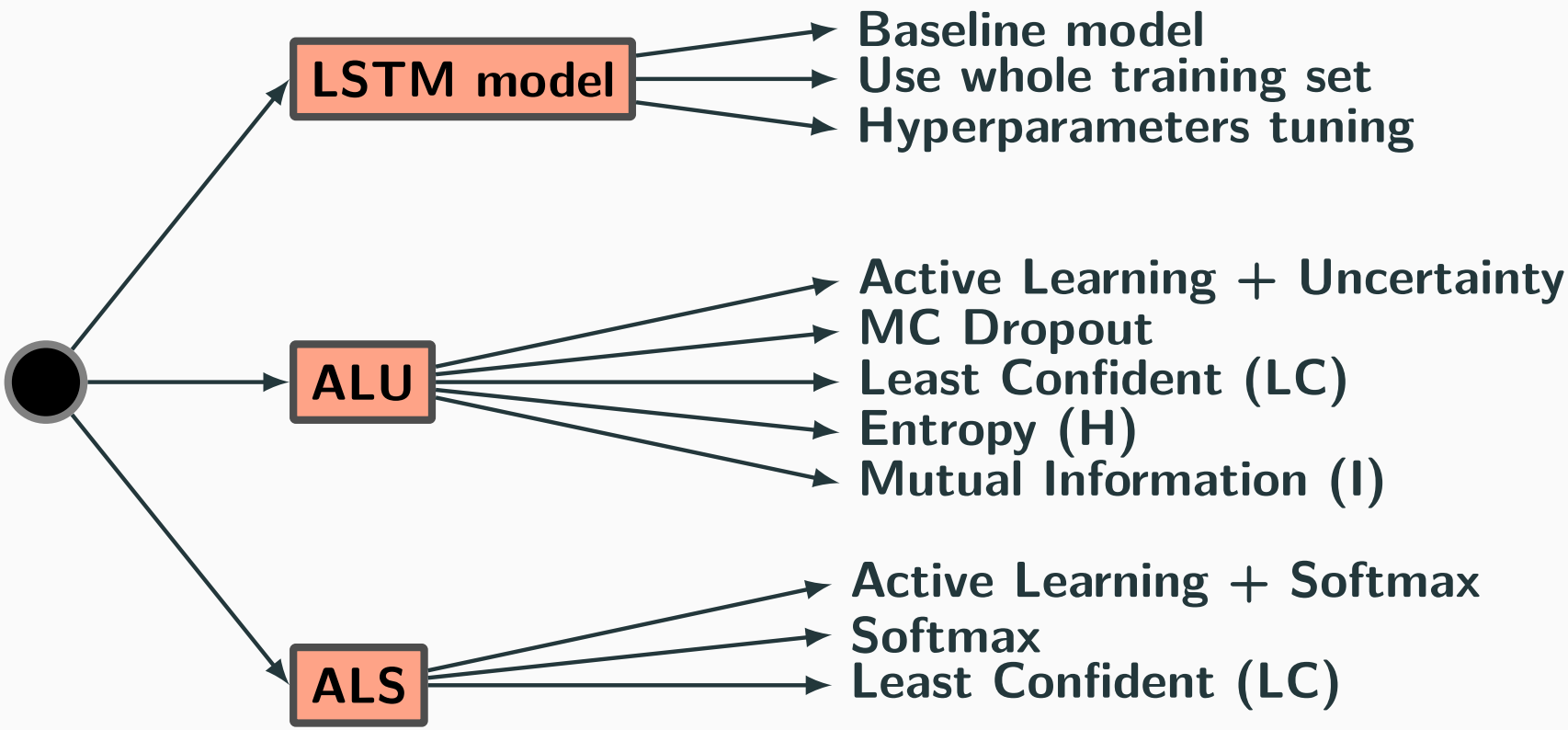

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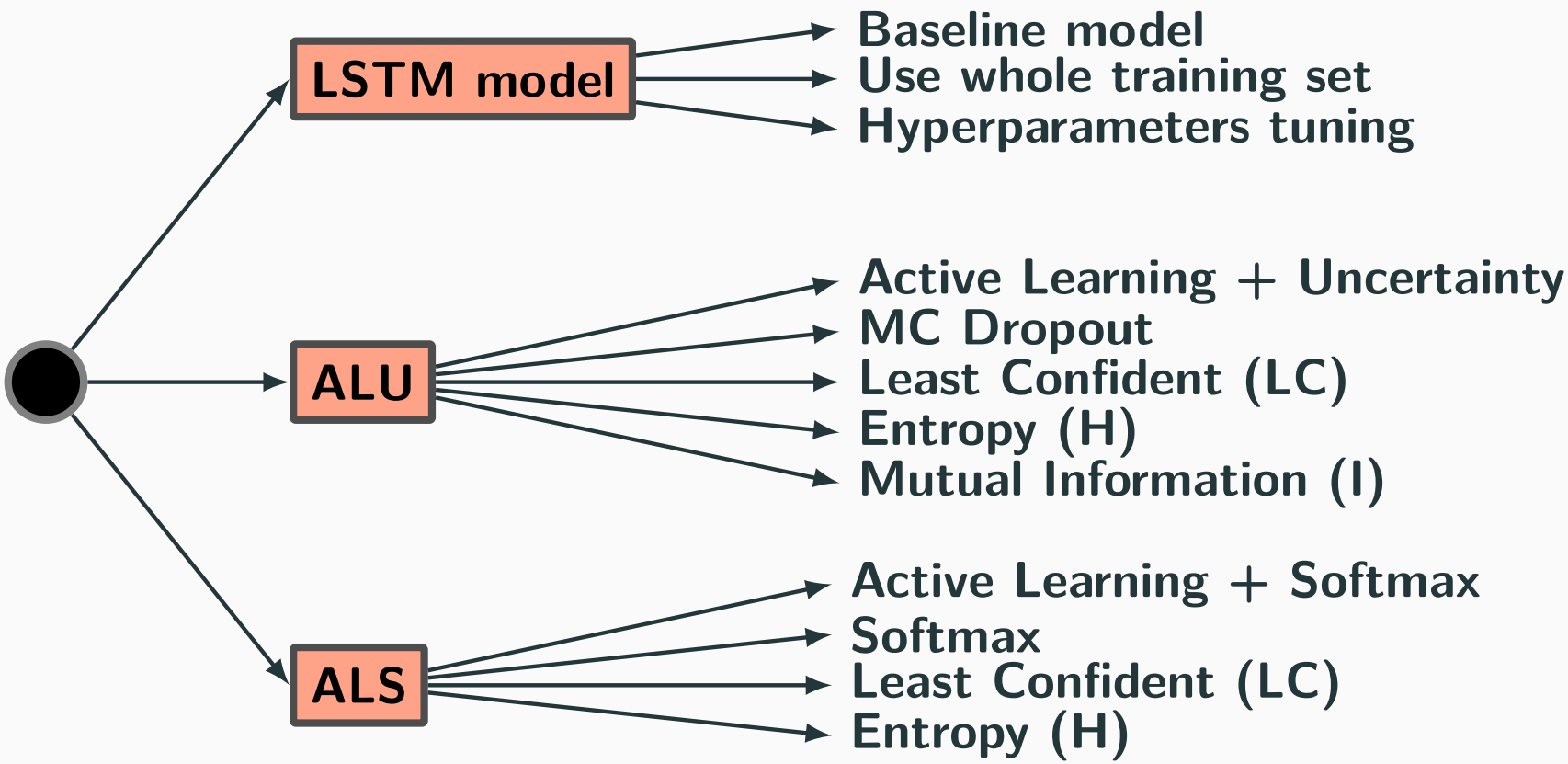

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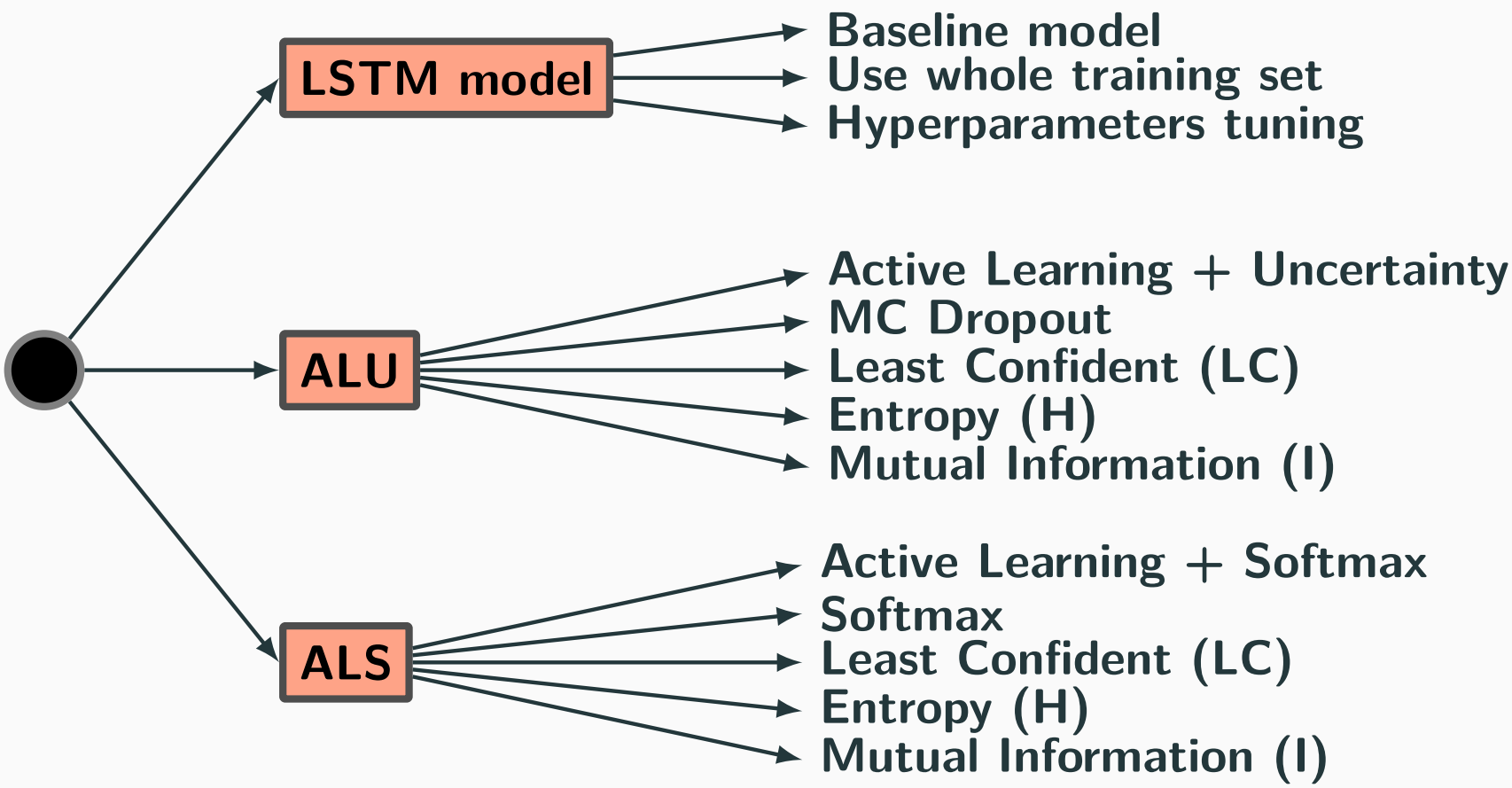
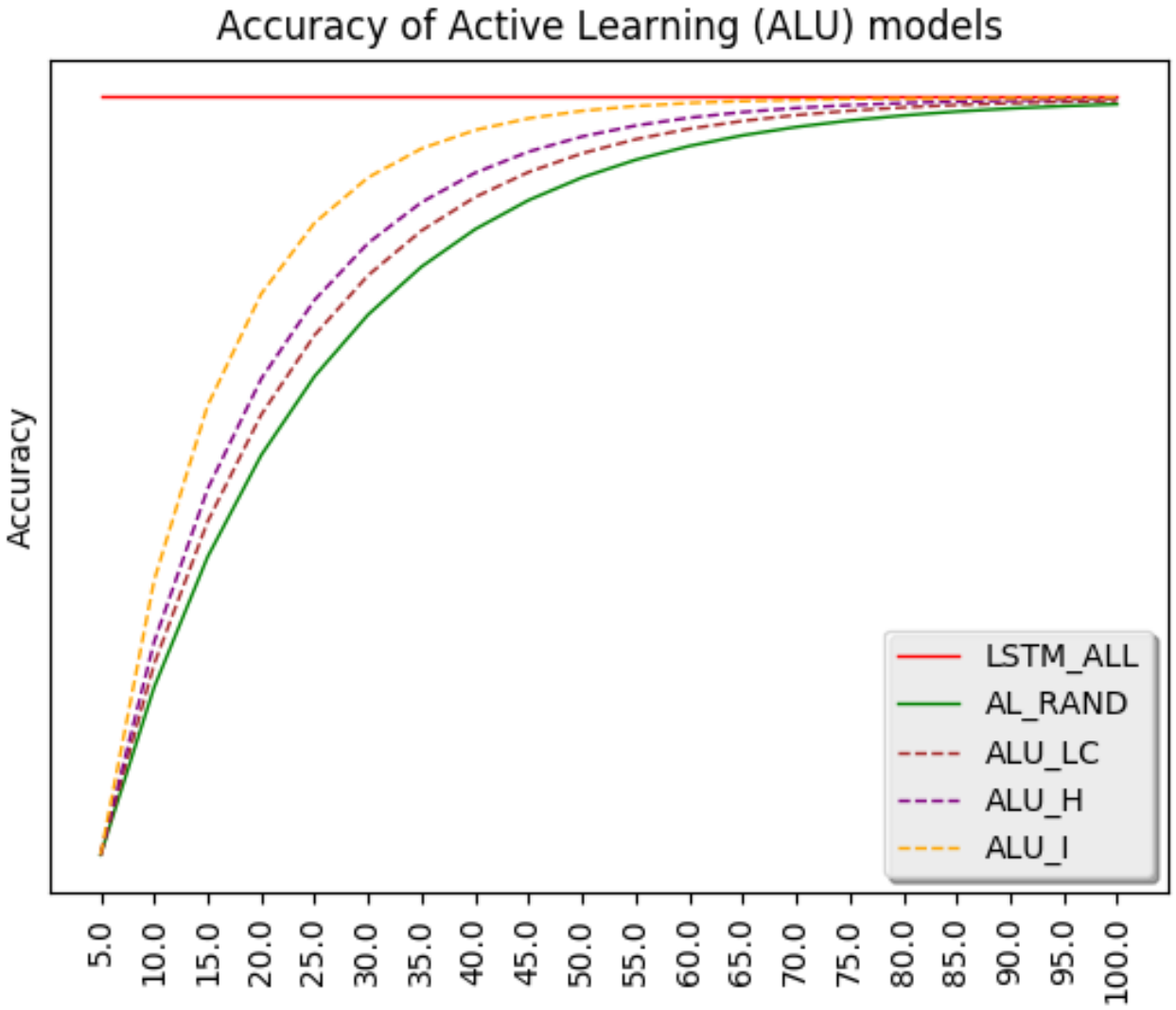


Active Learning

- Q1: On the task of sentiment analysis, can we achieve the same accuracy of a standard Deep Learning model by using Active Learning with uncertainty measurements, but with fewer labeled data ?

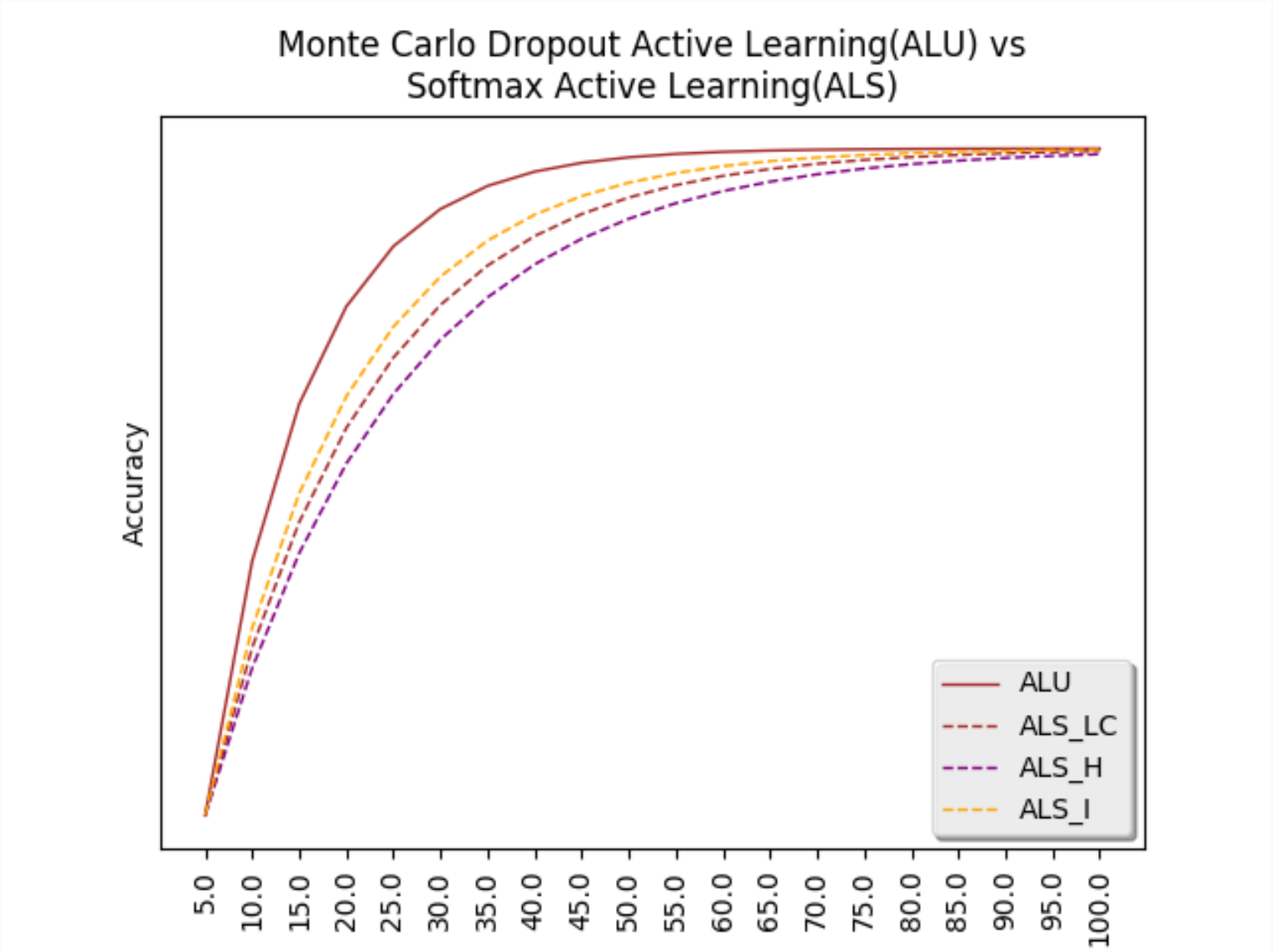
Active Learning



Active Learning

- Q2: Does modelling uncertainty in a Deep Learning model helps achieving a better result when using Active Learning ?

Active Learning



Active Learning

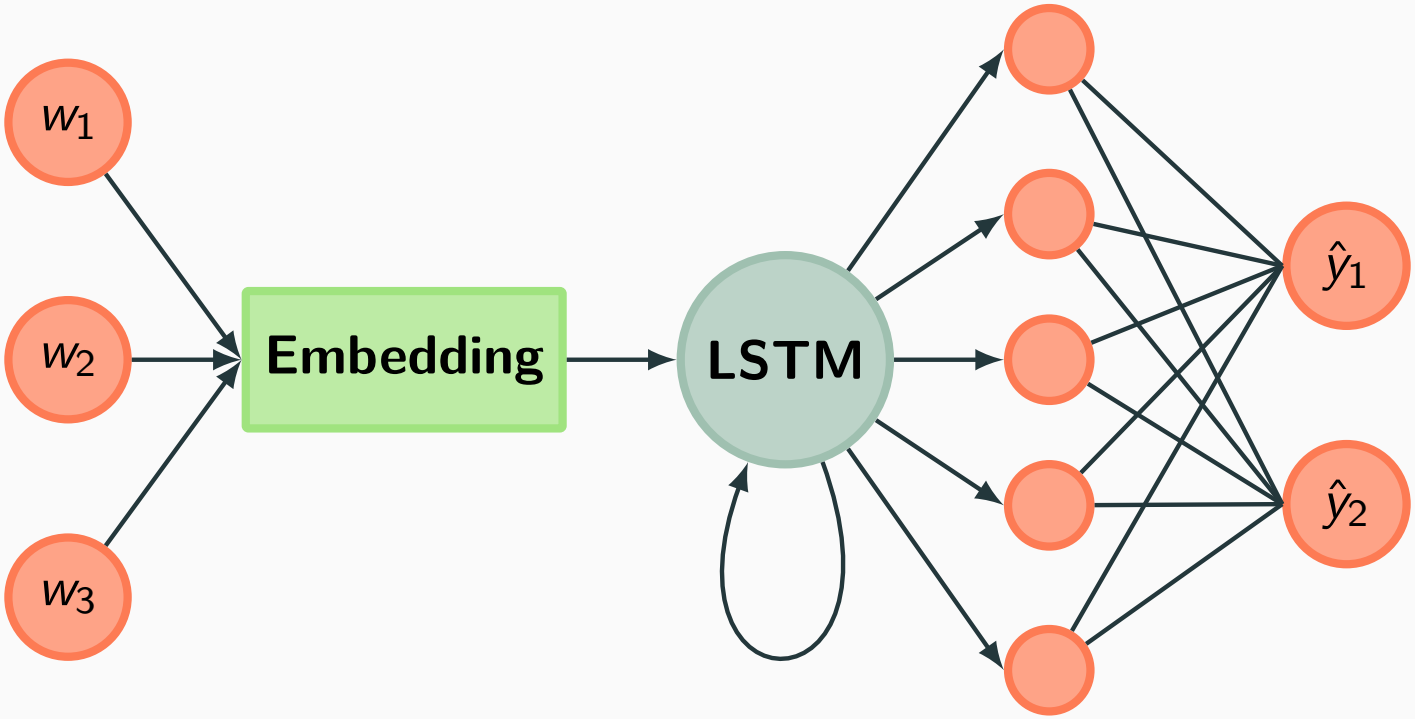
	2017		2018							
	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
Implement LSTM model	x	x	x							
Implement **ALU** models				x	x					
Perform **ALU** experiments						x				
Implement **ALS** models							x			
Perform **ALS** experiments							x	x		
Update Models and Experiments								x	x	
Write thesis								x	x	
Masters defense										x

References i

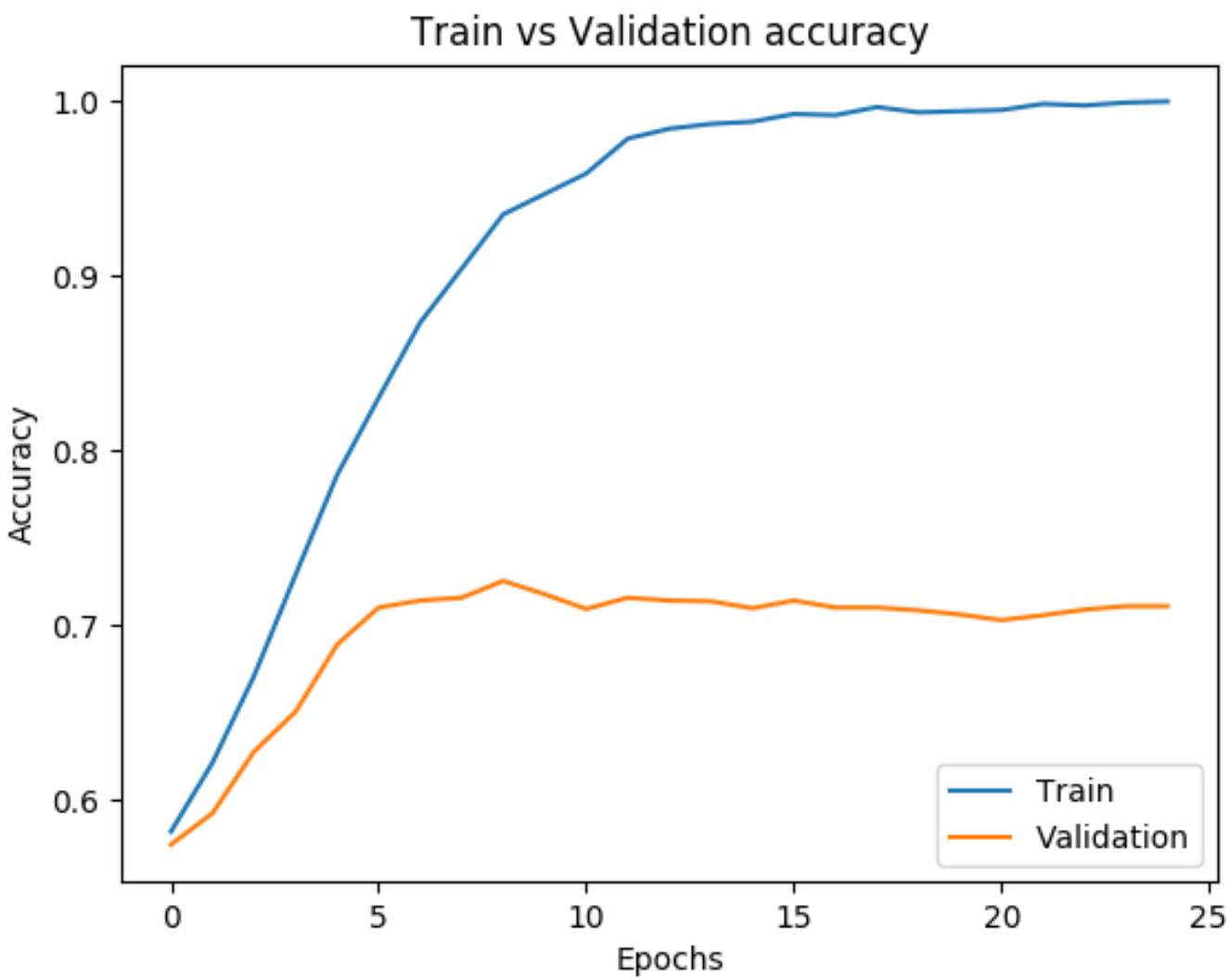

A. Krizhevsky, I. Sutskever, and G. E. Hinton.
Imagenet classification with deep convolutional neural networks.
Commun. ACM, 60(6):84–90, May 2017.

Backup Slides

Architecture



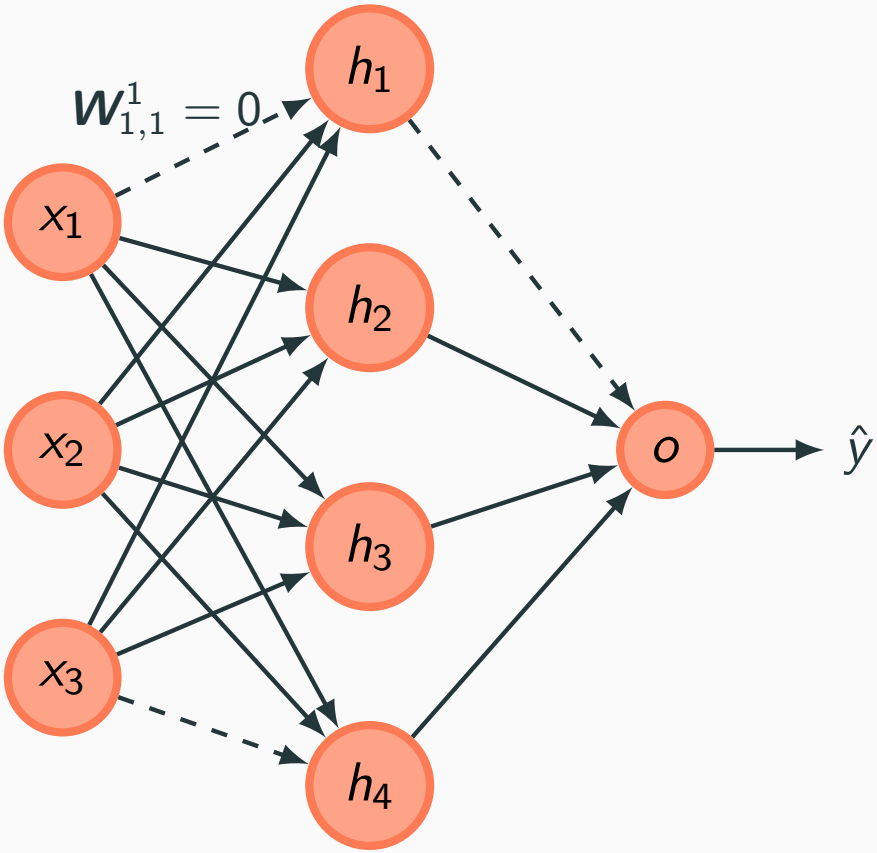
Active Learning



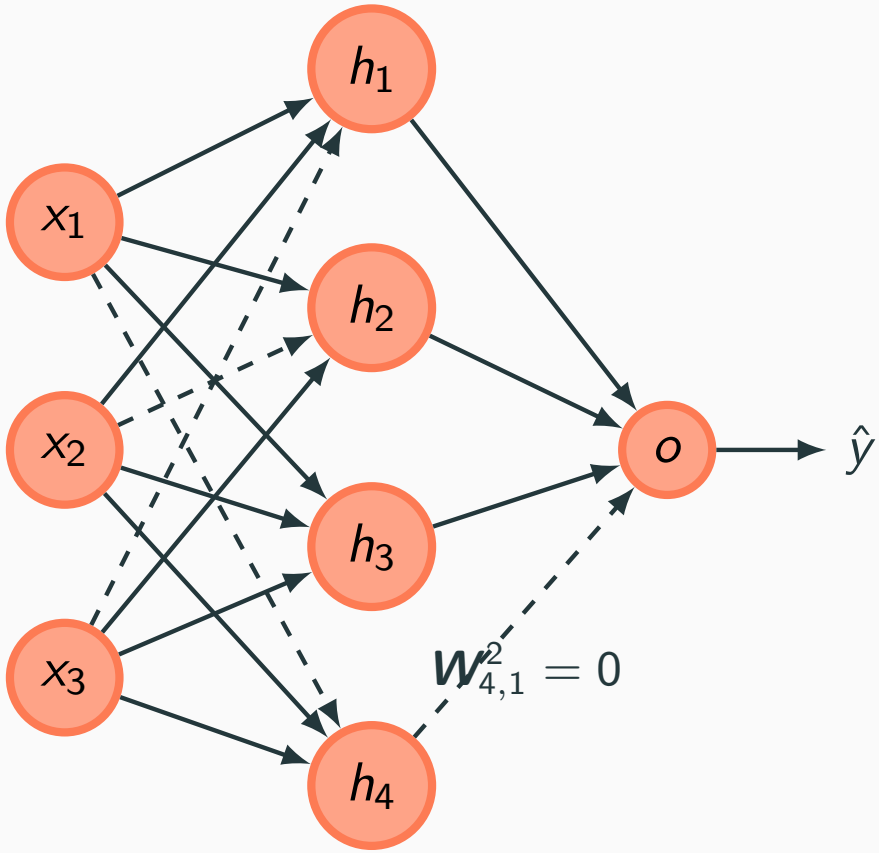
Dropout

- During training some weights are dropped from the network

Dropout



Dropout



Dropout

- The optimization function of Neural Networks using Dropout is practically the same as the optimization function of a Network trained with Variational Inference.

- Therefore it is possible to extract uncertainty measures from these networks, a technique called Monte Carlo Dropout.