Modeling Uncertainty

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Review: Dropout

- Dropout can be used to approximate multiple neural networks with a single network.
- The mean of multiple networks is likelier to yield better results.
- During training, randomly dropout neurons at any number of the network's layers with probability P.
- During evaluation/inference instead scale dropout layers by P.

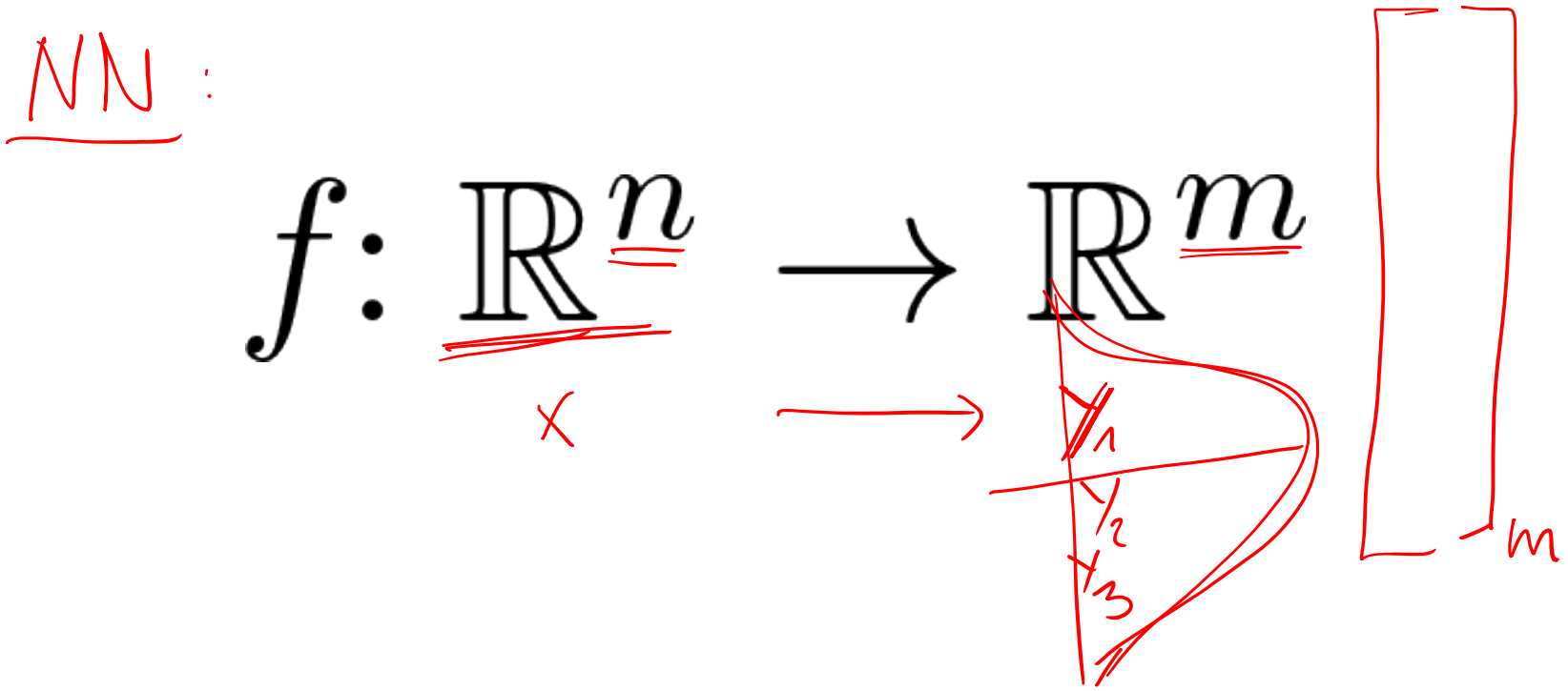
Monte Carlo Dropout

- What if instead at inference, we kept the dropout?
- Monte Carlo (MC) dropout, introduced by Yarin Gal and Zoubin Ghahramani in 2016

Gal Y., Ghahramani Z. (2016). *Dropout as Bayesian Approximation: Representing Model Uncertainty in Deep Learning*

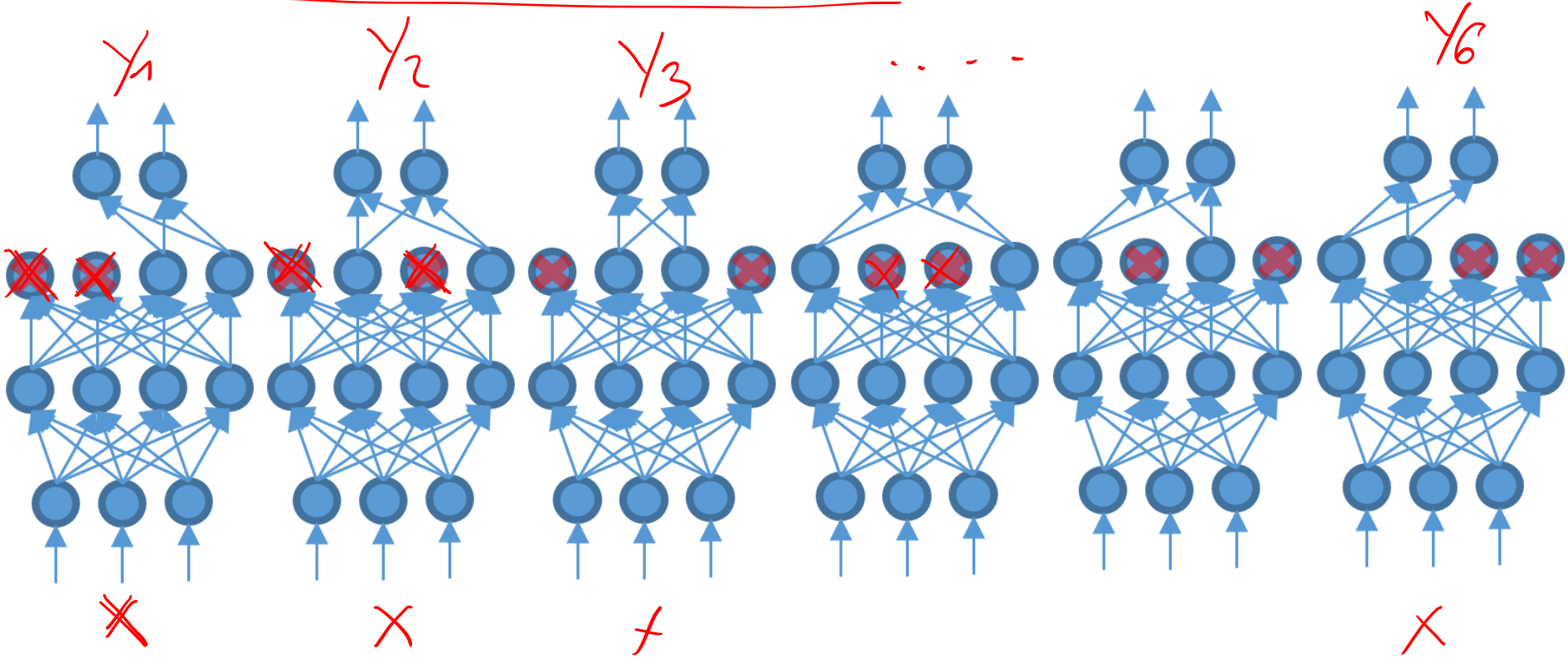
Neural Network as Function

- A typical neural network works as a single mapping of an n-dimensional input to an m-dimensional output.



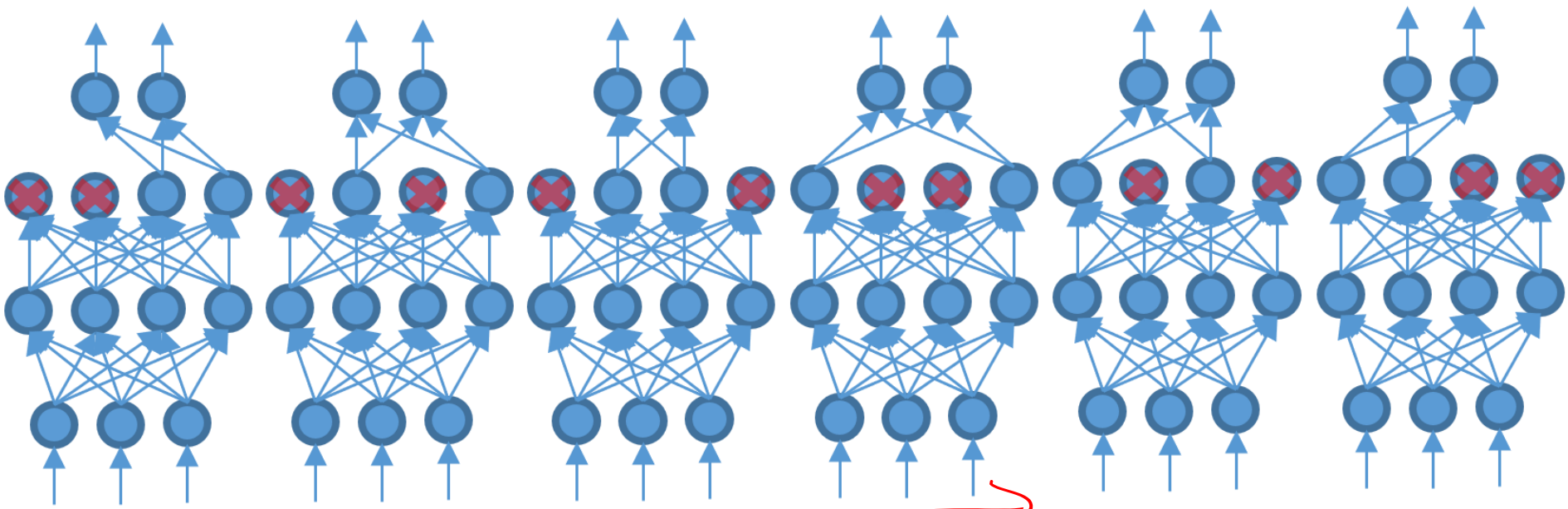
Many Networks in One

- Dropout of a single 4-neuron layer with probability P = .5, yields 6 possible network configurations.



Many Networks in One

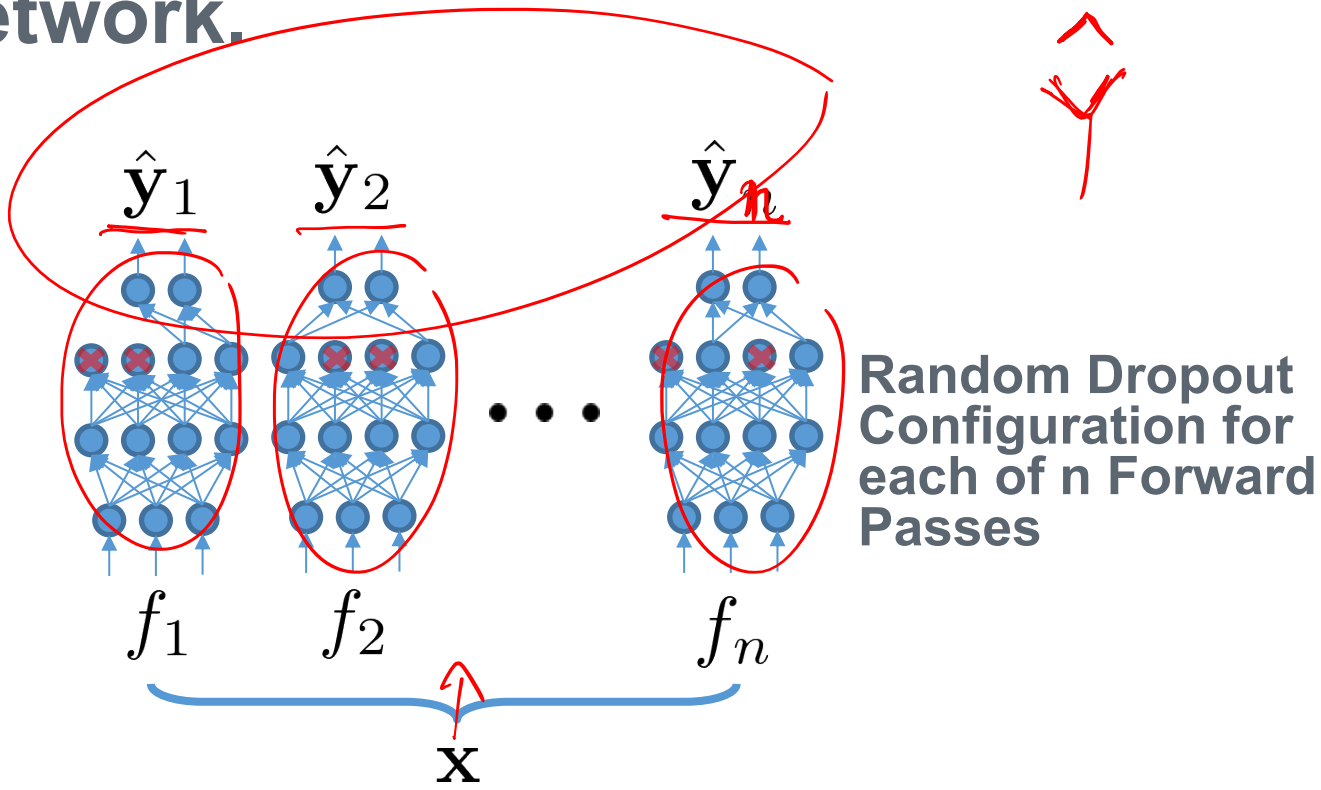
- This means 6 different possible mappings of input to output.



$$f_i: \mathbb{R}^n \rightarrow \mathbb{R}^m$$

Stochastic Forward Passes

- To make our network probabilistic, we make n stochastic forward passes through n sampled configurations of our network.



Distribution of Outputs

- This gives us a distribution of outputs from our network.

$$f_{MC} : \mathbf{x} \rightarrow \hat{\mathbf{Y}} = \{\hat{y}_1 \ldots \hat{y}_n\}$$

mean

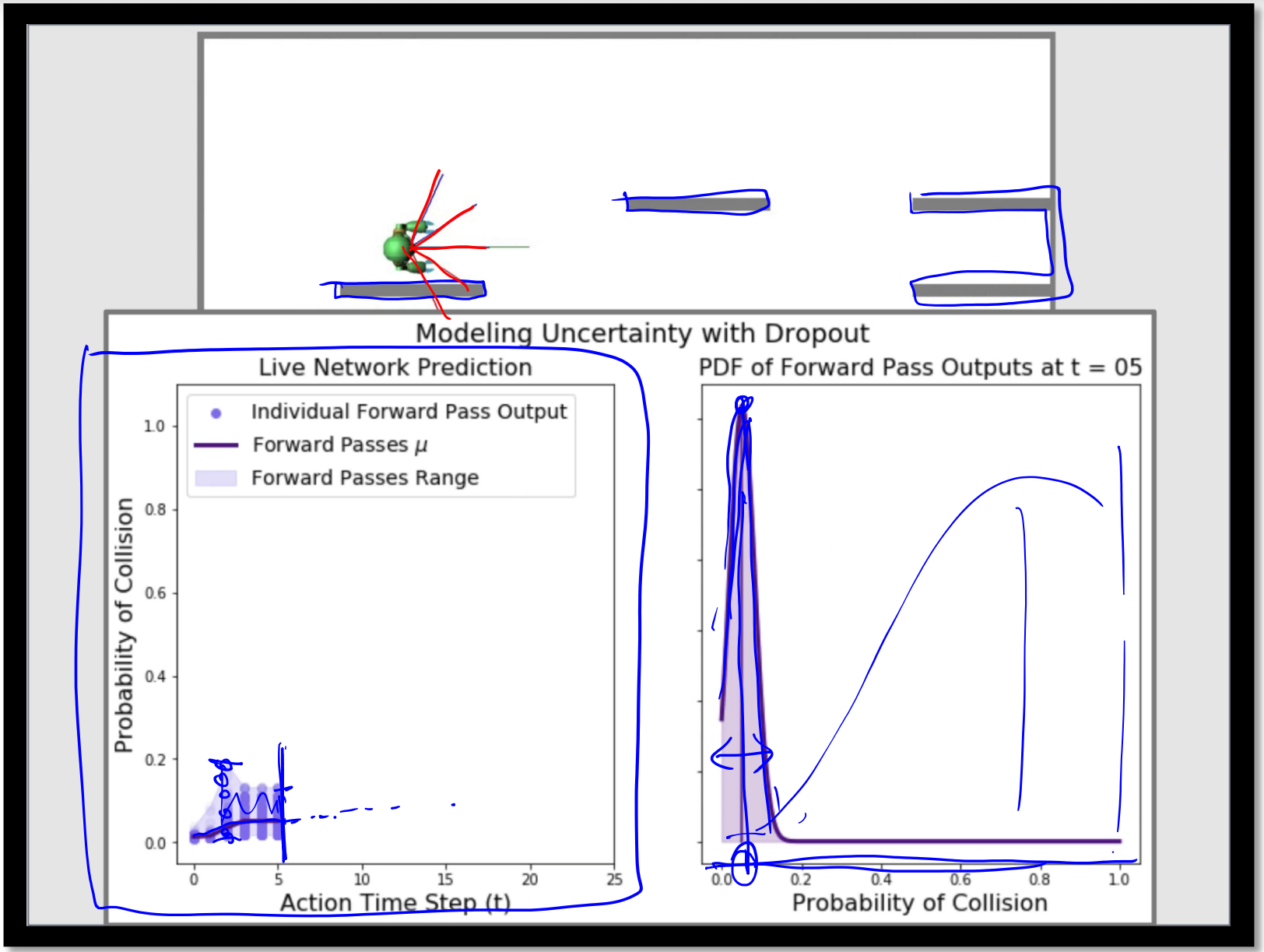
$$\mu = \frac{1}{N}\sum_{i=1}^{N} \hat{\mathbf{y}}_i$$

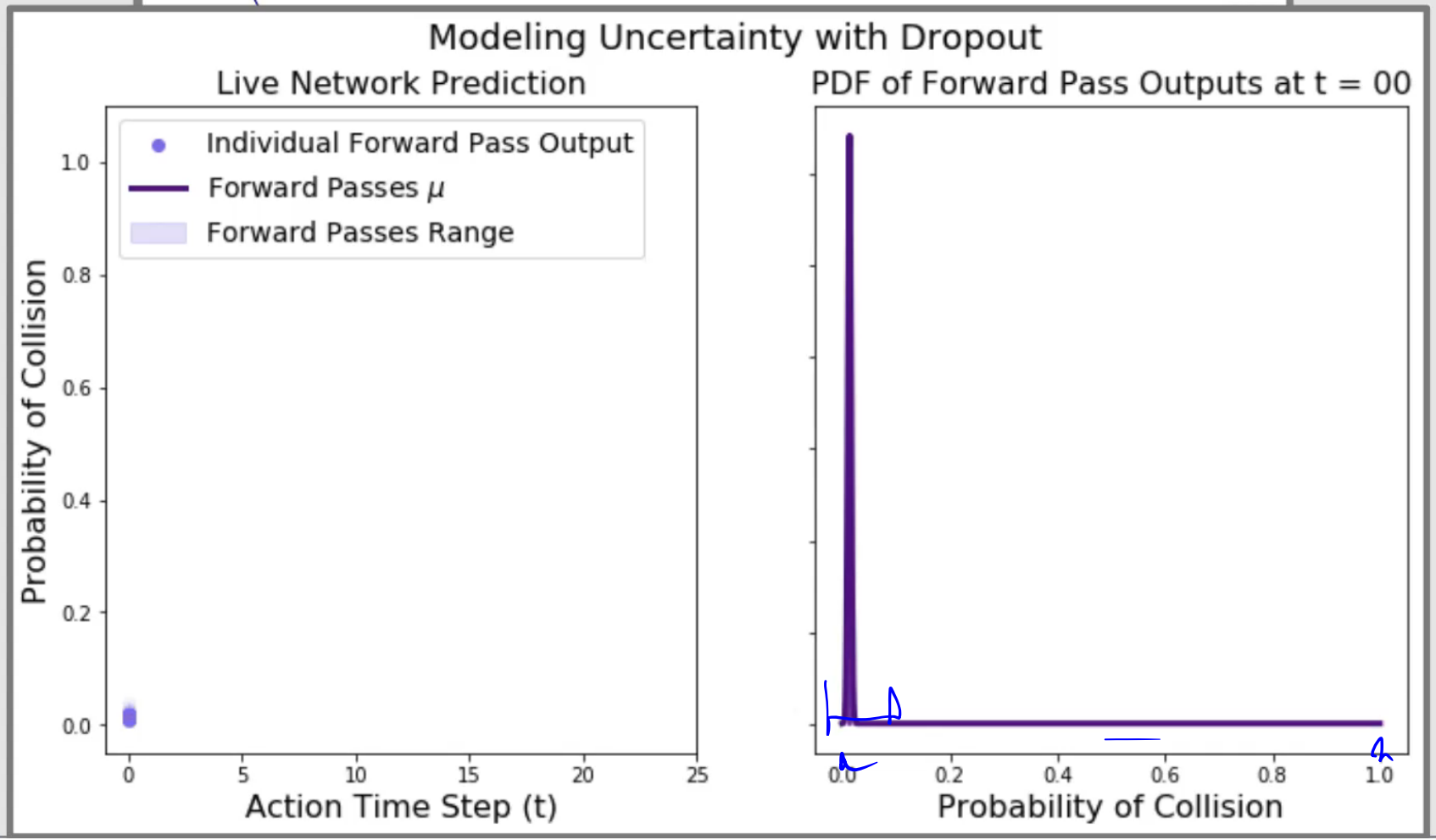
variance

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N} (\hat{\mathbf{y}}_i - \mu)^2$$

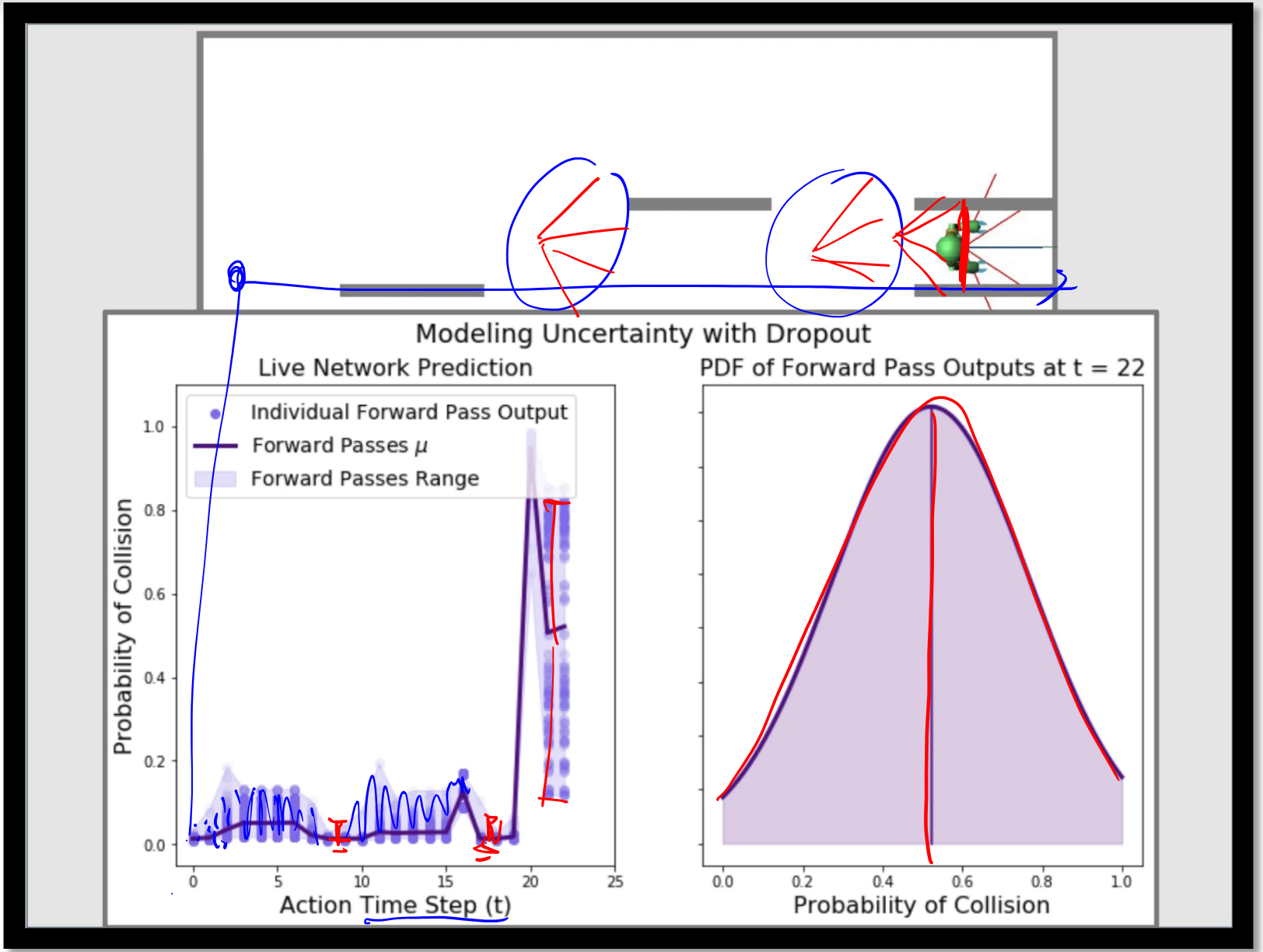
Assumption: Gaussian

Uncertainty in Robot Navigation

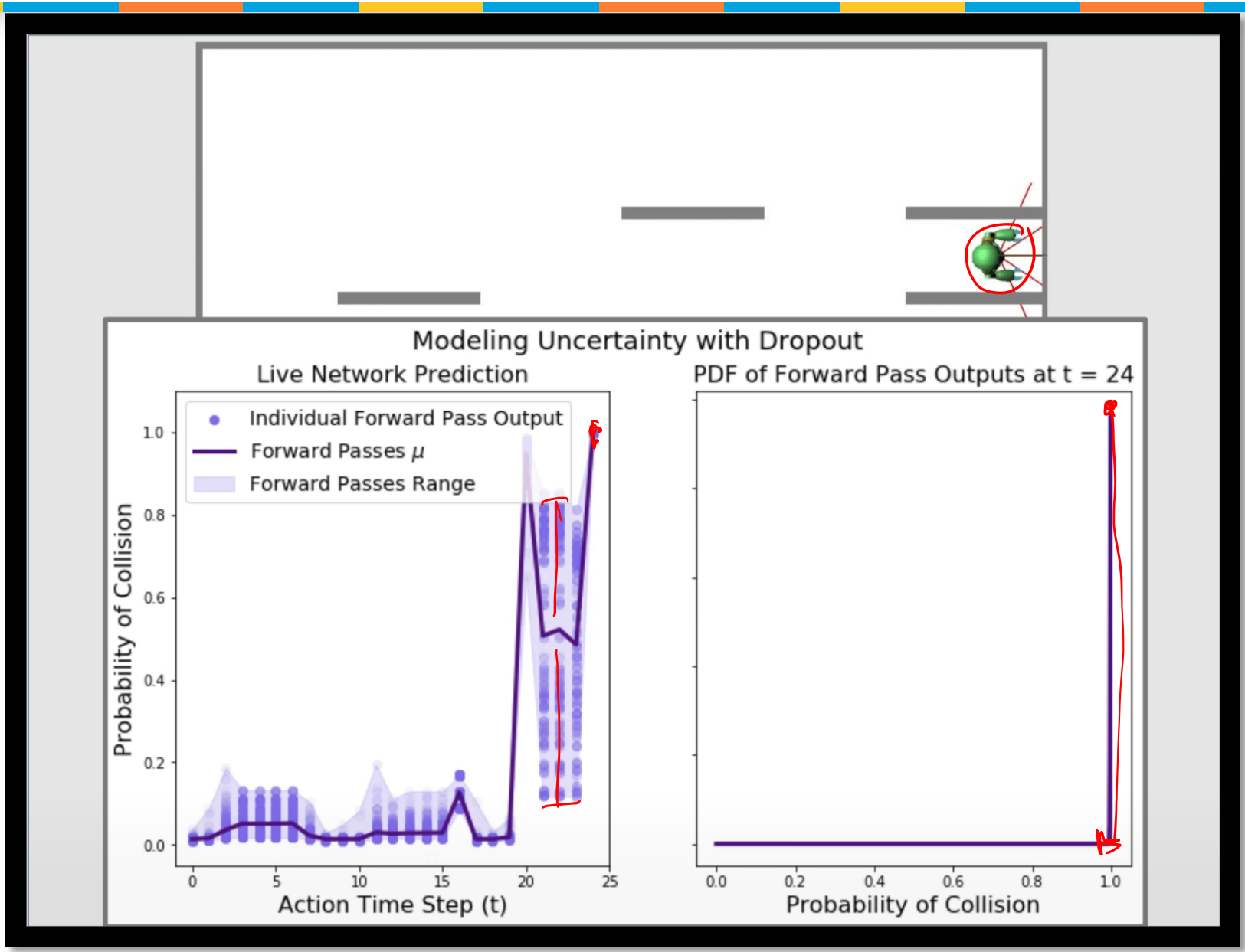



Modeling Uncertainty with Dropout
Live Network Prediction
Individual Forward Pass Output
Forward Passes μ
Forward Passes Range
Probability of Collision
Action Time Step (t)
PDF of Forward Pass Outputs at t = 00
Probability of Collision

High Uncertainty



Low Uncertainty



Summary

- Dropout
- Monte Carlo Dropout
- Stochastic Forward Passes
- Uncertainty with our robot example